Nieuwe Nederlandse Bijdragen tot de Geschiedenis der Geneeskunde en der Natuurwetenschappen

No. 12

Editors: M.J. van Lieburg
G.A. Lindeboom
H.A.M. Snelders

1. G.A. Lindeboom, *Descartes and Medicine* (1979)
2. G.A. Lindeboom, *Adriaan van den Spiegel (1578-1625) hoogleraar in de ontleed- en heelkunde te Padua* (1978)
3. M.J. van Lieburg, *Het medisch onderwijs te Rotterdam (1467-1967)* (1978)
4. H.A.M. Snelders, *Het Gezelschap der Hollandsche Scheikundigen: Amsterdamse chemici uit het einde van de achttiende eeuw* (1980)
5. A.A.A.M. Brinkman, *De alchemist in de prentkunst* (1982)
6. P. Dumaître, *La curieuse destinée des planches anatomiques de Gérard de Lairesse* (1982)
7. M.J. van Lieburg en R. Toellner (Hrsg.), *Deutsch-Niederländische Beziehungen in der Medizin des 17. Jahrhunderts* (1982)
8. L.C. Palm and H.A.M. Snelders (Ed. by), *Antoni van Leeuwenhoek 1632-1723* (1982)
9. K. van Berkel, *Isaac Beeckman (1588-1637) en de mechanisering van het wereldbeeld* (1983)
10. P. van der Star (ed.), *Fahrenheit's letters to Leibniz and Boerhaave* (1983)
11. M.J. van Lieburg en Prof. dr. G.J. Kloosterman (ed.), *C.G. Schrader's Memoryboeck van de vrouwens* (derde druk) (1984)

THE ZOOLOGICAL WORK OF PETRUS CAMPER (1722-1789)

Het zoölogisch werk van
Petrus Camper (1722-1789)

(met een samenvatting in het Nederlands)

by

ROBERT PAUL WILLEM VISSER

Rodopi

AMSTERDAM 1985

CIP-GEGEVENS KONINKLIJKE BIBLIOTHEEK, DEN HAAG

Visser, R.P.W.

The zoological work of Petrus Camper (1722-1789) / by R.P.W. Visser. – Amsterdam – Rodopi. – (Nieuwe Nederlandse bijdragen tot de geschiedenis der geneeskunde en der natuurwetenschappen ; no. 12)
Met lit. opg., index. – Met samenvatting in het Nederlands.
ISBN 90-6203-976-6
SISO 591 UDC 591(492)"17"
Trefw.: dierkunde ; Nederland ; 18e eeuw / Camper, Petrus.

Printed in The Netherlands

CONTENTS

INTRODUCTION

Systematics dominated eighteenth-century zoology, but certainly did not monopolize it, as is sometimes suggested. Zoology was by no means restricted to the classification and the description of the external appearance of animals. There was a growing interest in other research programmes. The anatomical approach, usually called comparative anatomy because of the role assigned to comparison, was the most successful of these programmes. Early in the nineteenth century it was to become the key-stone of zoology.

Eighteenth-century comparative anatomy is still one of the least studied branches of the history of biology. This book deals with one of the aspects of this neglected science. Its subject is Petrus Camper, its objective the analysis of the aims, methods, and achievements of his comparative anatomy.

Camper was one of the pioneers of the new morphological school in zoology. Together with Daubenton he stood at the threshold of the renaissance that took place in comparative anatomy after it had been in a rather dormant state in the first half of the eighteenth century. Camper contributed to the definitive incorporation of this discipline in zoology.

The beginning of Camper's active interest in comparative anatomy dates from the 1740's, when he was a student at Leiden University. During his professional career as a medical practitioner and professor he continued and expanded his zoological studies. After he resigned his professorate, in 1773, Camper entirely devoted himself to comparative anatomy and became one of the best known scientists in this field.

Camper attracted the attention of his comtemporaries

with the anatomical description of rare animals, such as the orangutan, the elephant, the rhinoceros, and the whales, with the discovery of the facial angle, and with his ideas about the structural uniformity of the vertebrates. These and other original results gave Camper a considerable reputation. For Goethe he was "ein Meteor von Geist, Wissenschaft, Talent und Thätigkeit"[1] and Kant considered him "einer der grosten [sic] Naturforscher."[2]

Camper explicitly dissociated himself from the prevailing systematics. It was in his view of marginal significance for the naturalist. He thought it unsuited to obtain real knowledge of living organisms. Camper replaced the ideals of classification and nomenclature by the conviction that progress in zoology is possible, but with the aid of anatomy. It stood central in his own investigations. Camper made it his primary task to increase the knowledge of the structural properties of animals. He never forgot, however, that this is only the first step in zoological science; the discovery of the laws underlying the animal creation was regarded by Camper as the ultimate goal of zoology.

It is a pleasure for me to express my gratitude to Professor Pieter Smit for his encouragement and criticism and to Professor Harry Snelders for his valuable comments on the second part of the first chapter. I should like to offer my special thanks to Nicolette van Splunder for typing the manuscript and preparing it for the printer, to Carry Dikshoorn for translating the first version of the book, and to Bert Theunissen for his suggestions and assistance in correcting the proofs.

Chapter I

BACKGROUND: CAMPER'S LIFE AND IDEAS ON SCIENTIFIC METHOD

Petrus Camper (1722-1789)

Petrus Camper was born in Leiden on 11 May, 1722. He was the eighth and second last child of Florentius Camper (1675-1748) and Sara Geertruida Ketting (1689-1748). There had been Campers in Leiden for three generations. The great-grandfather of Petrus Camper was an immigrant from Düsseldorf. The family had originally belonged to the artisan class, but had soon joined the university-educated elite. Camper's grandfather was a physician, and his father was a clergyman. From 1702 to 1712 the latter was a minister in Batavia, where he married Sara Ketting, daughter of a prominent employee of the Dutch East India Company. After the death of his wife's parents Florentius Camper was a wealthy man. In 1713 he returned to Leiden, where he lived as a gentleman of independent means until his death.

Little is known about the youth of Petrus Camper. In 1731 he was enrolled as a pupil at the grammar school.[1] The education he received there was mainly intended to make him proficient in speaking and writing Latin. This limited curriculum did not really satisfy Camper's thirst for learning. Outside school hours he indulged in the study of architecture and perspective, and familiarized himself with the elements of mathematics. He practised his manual skills through carpentry and wood-turning. In addition he showed great interest in the plastic arts. He was able

to develop his artistic interests through lessons with the painter Karel de Moor.

Although Camper matriculated at Leiden University on 6 March, 1734,[2] there are no indications that he actually began his studies in that year and that he did not first complete the customary six-year course at the grammar school. Such early matriculation was not unusual. As a rule it allowed people to benefit from the taxation privileges which students enjoyed in those days. In Camper's case it also enabled him to attend the university lectures of W. Labordus, who was his mathematics teacher.

When he had intimated that he wished to study medicine, Camper's father consulted his friends Boerhaave and 's Gravesande.[3] They maintained that the best plan would be for his son first to make a thorough study of mathematics, physics, anatomy, and chemistry before applying himself to medical subjects proper. This advice clearly bears Boerhaave's signature and was quite modern for that time.

In the first half of the eighteenth century the medical faculty at Leiden was among the best in Europe. The high quality of the medical education was largely due to Boerhaave and was maintained for a considerable time by his successors B.S. Albinus, Gaubius, Oosterdijk Schacht, and van Royen. These four professors guaranteed a good training, and Camper benefited to the full from their teaching.

Unlike the majority of the medical students, Camper, apparently inspired by 's Gravesande's and Boerhaave's advice, was interested in receiving a scientific education that was as broad as possible. For this, too, Leiden University was specially suited. In Camper's day it was the leading centre on the continent for the rapidly developing experimental science. His teachers, Willem Jacob 's Gravesande and Petrus van Musschenbroek, were among its leaders. Under their guidance Camper gained a thorough knowledge of the contents and methods of the new experimental physics.

Among those who made a considerable contribution to Camper's scientific training were 's Gravesande and Van Musschenbroek, and Bernhard Siegfried Albinus, who was an anatomist of great repute. When Camper later

had made a name for himself as an anatomist, he still looked back in gratitude upon the lectures of Albinus, "anatomicorum princeps", which he had attended. For many years Albinus' textbook *De Ossibus corporis humani* (1726) was of great assistance to him in his dissections and his anatomy lectures.

Adriaan van Royen, professor of botany, found an attentive pupil in Camper. In his early days Camper had "un goût particulier" for botany. With some fellow-students he spent many pleasant hours on botanical excursions in the environs of Leiden.[4] Van Royen's influence is noticeable in Camper's medical dissertation, where he used a number of his "theses" to criticize certain parts of the botanical classification of Linnaeus.

Throughout his life Camper has occupied himself with the study of nature. He was prompted especially by a fundamental craving for knowledge. As he himself put it:

> "The craving for new discoveries or for the acquisition of new ideas ... is very much alive in me."[5]

Natural theology was another stimulus. Camper had a profound and sincere admiration for "the creator as he manifests himself in his works."[6] Like so many other eighteenth-century scientists Camper held the view that man can come to know God by studying natural phenomena and recognized the omnipotence and wisdom of the supreme being as a source of inspiration for his scientific work.[7]

Even as a young man Camper's "avid curiosity" produced, what his friend Hemsterhuis called a "rage de la recherche",[8] which has always been one of his characteristic qualities. In his student days animal anatomy was the main subject of his research. As far as can be ascertained, Camper first began to study this subject around 1744. He had already become acquainted with zootomy in connection with his medical studies. B.S. Albinus and his brother F.B. Albinus, who had become lecturer of anatomy in August 1745, gave lectures on zootomy from time to time. Unlike the work of his teachers, Camper's first zoological studies do not appear to have been a means for gaining

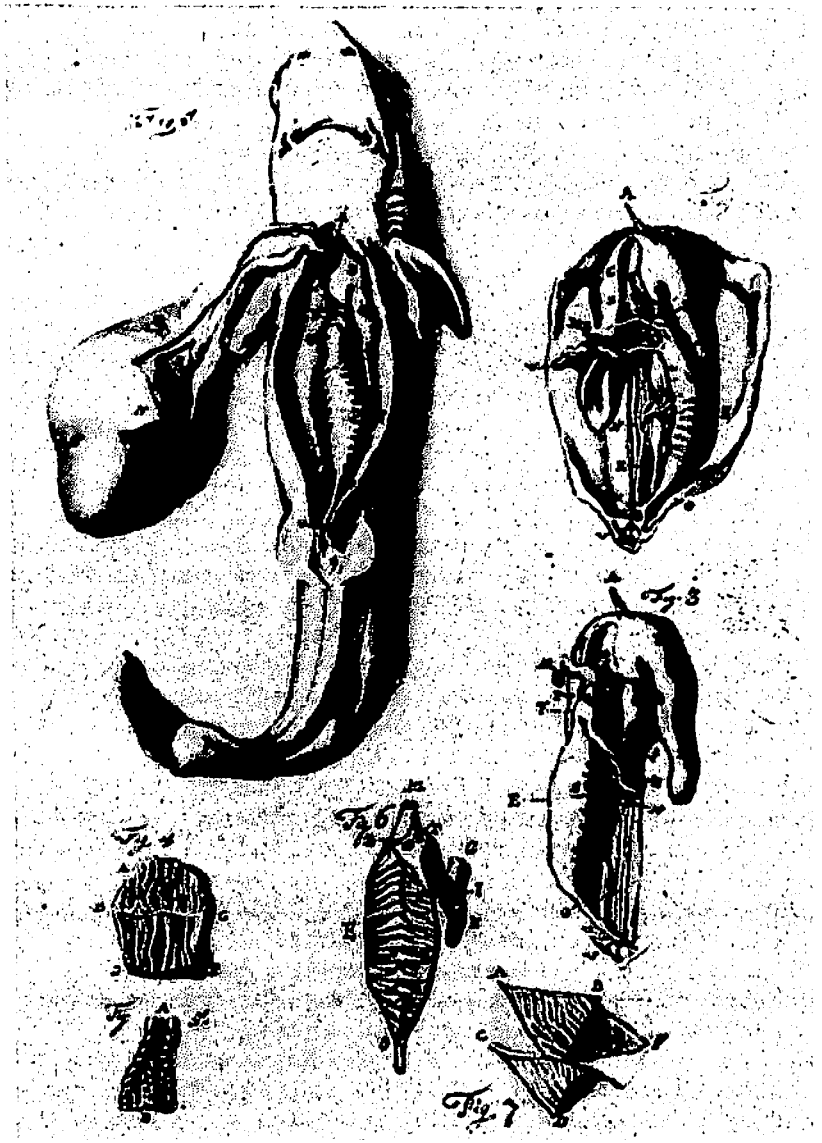

Fig. 1. Dissection drawing of a shark embryo

better understanding of the human organism. He was interested exclusively in the structure of animals:

> "in meinen ersten Jugendjahren fand ich ein vorzügliches Vergnügen an derjenigen Betrachtung der Natur, welche an den Thieren den Bau der innern Lagen ... vor Augen legt."[9]

As far as we know, an embryo of a shark was the first zoological object he dissected (see fig. 1).[10] In addition he made a special study of the structure of the auditory organ of birds, which he said he "knew perfectly" as early as 1745.[11]

Camper's interest in natural history was stimulated by his fellow-citizen Johannes Fredericus Gronovius, a renowned naturalist, to whose "extensive cabinet of botany and natural history he often had access."[12] Gronovius, an able ichthyologist, guided Camper in his first studies of fish.[13]

Camper concluded his university studies on 14 October, 1746 with a double promotion. First he graduated doctor of philosophy, under Van Musschenbroek, and next "doctor medicinae", under Van Royen. Like several other pupils from the school of Albinus, Camper had chosen to write his dissertations about the eye. In the physical dissertation he formulated a theory of vision. Giving evidence of wide reading, he discussed successively in a clear and critical way the eye as an optical instrument, ideas acquired by vision, and fallacies of vision. Camper had done very little independent research. His dissertation, as was common in those days, was based on a study of the literature. Camper's principal source was Robert Smith's *Compleat system of opticks* (1738).

In the medical dissertation he dealt with the eye-socket, of which he had made some excellent drawings on the basis of his own observations, and in particular with the lens. Camper had examined the lens microscopically, and like Leeuwenhoek he discovered that it had a fibrous structure. He further observed that towards the centre the fibres were thinner and more curved. He was the first to note the importance of these structures for the power of accomodation of the eye. The fact that both dissertations were included by Albrecht von Haller in his *Disputationum anato-*

micarum selectarum (1749) is an indication that they were considered of more than average quality.

When in 1748 his parents had died one shortly after the other, Camper was able to realise his plan to take a long journey abroad. Amply supplied with financial means, he left Leiden, reaching London by the end of 1748.[14] Here he made the acquaintance of many scientists and physicians, including Baker, Catesby, Collinson, Mead, Pringle, Sloane, and Watson. Within a short time Camper had become well established in the English scientific community, a fact which no doubt promoted his election as a fellow of the Royal Society, on 17 January, 1751. Six fellows, most of whom he knew personally, supported his candidature by describing him as a

> "Gentleman not only of great Learning in all the Branches of knowledge belonging to the Profession of Physick, but likewise well versed in all parts of Natural History."[15]

Camper stayed in England for nearly six months. On 15 June 1749 he left for Paris. Here too he availed himself of the numerous opportunities for extending his medical and scientific knowledge. He attended the lessons of the young surgeon Louis and had many conversations with the prominent obstetrician Levret. He also met Buffon. On account of a reorganization, he was unable to visit the Cabinet du Roi. In Paris, as in London, Camper did not occupy himself solely with the sciences. The large sums of money he spent on wigs, clothes, and theatre-going show that he participated fully in society life. On 30 September, 1749 he left Paris. He travelled back to Holland via Switzerland, and on 11 November he returned to Leiden "in good health and greatly satisfied".

This journey, which had lasted more than a year and had broadened his outlook and knowledge in many respects, marked the conclusion of Camper's training period. When he returned to his native town, a new phase in his career had already been foreshadowed. Just before he left Paris, he had received a letter from the board of governors of Franeker University, offering him the chair of philosophy. In practice this implied that he would have to teach mainly experimental

physics.[16] Camper accepted this offer, as well as the appointment to the chair of anatomy and surgery, which followed in the same year (1749).

Although his teaching brought him success and recognition, Camper was not enthusiastic about Franeker. Later he described his state of mind in the following terms:

> "The extreme silence of the town of Franeker, the profound quiet and indolence prevailing there, inspired me with an indefinable sadness."[17]

Notwithstanding these not very positive utterances, Camper had at least one pleasant recollection of his Franeker period, to wit his meeting with Johanna Bourboom (1722-1776). On 8 April, 1756 he married this lady, descendant of a Frisian family of "regents" and widow of one of the wealthiest men in the province. The young couple settled in Amsterdam, where Camper had been appointed professor of anatomy and surgery at the Athenaeum Illustre on 24 April, 1755.

In Amsterdam, thanks to the ample material available, he was able for the first time to display his considerable talents for human anatomy. The principal result was the *Demonstrationum anatomico-pathologicarum* (1760-1762), with which Camper established his reputation as an anatomist. The emphasis in this work was on descriptive anatomy. Despite the title, pathology played only a minor part in it. The *Demonstrationum* owes its importance especially to the excellent plates illustrating the nerves, muscles, tendons, and vessels of the arm and the pelvis in their normal condition and with their structural connections. A third volume, in which the brain and the cerebral nerves were to be described, was under preparation for many years, but never appeared.

In 1761 Camper left Amsterdam and settled on the estate of Klein Lankum, in Friesland near Franeker, which his wife had inherited from her first husband. Now he became involved in Frisian politics. In January 1761 - when still in Amsterdam - he had been elected a member of the "Diet" to represent the landowners from Franekeradeel. He does not seem to have been an active politician. During the three years (1761-1763) in which he held this function he

"sedulously attended the Meetings of the States, as a Spectator rather than in order to address them; born and fitted only to obey the Laws, not to make them."[18]

Owing to pressure of work, as a professor and a medical practitioner, Camper had to restrict his zoological studies at Franeker and in Amsterdam. Most of his research was inspired by didactic needs. He used the results of his animal dissections primarily to give his students a better understanding of human anatomy and physiology. It was not until 1761, when Camper retired to Klein Lankum, that he again began to occupy himself with pure zoology. His research now was especially concerned with the hearing of fish.

In the year 1762, in which he wrote his first article on this subject, Camper showed interest in a wide variety of other subjects. He wrote on agricultural problems, on liver-rot in cattle and sheep, completed a sequel to his treatise published in 1761 on infantile hernia, and prepared volume 2 of the *Demonstrationum anatomico-pathologicarum* (1762) for the press. In connection with a prize competition organized by the Hollandsche Maatschappij der Wetenschappen he wrote a treatise on education (1763), in which he advocated a simple and natural education, rather like Rousseau had done in his *Emile* (1762). Further he also started to publish in moral weeklies.[19]

After he had spent more than two years at Klein Lankum, the governors of Groningen University informed Camper on 27 August, 1763 that they wished to appoint him as professor of theoretical medicine, anatomy, surgery, and botany. Camper accepted the appointment by return of post. In Groningen he again took great pains to give his students the best possible training. Apart from his lectures on the four above-mentioned subjects, he also delivered highly successful policlinical lectures on his own initiative.

During his period in Groningen Camper's great zest for work covered a very broad field, which included of course in the first place medicine. In this connection mention should be made in particular of the active role he played in introducing variolation and the fundamental research he did on symphysiotomy. Further he

worked on such widely divergent subjects as cattle-plague, aesthetics,[20] the best method for making anatomical drawings, megalithic tombs,[21] fossil elephants, and human races. Camper devoted particular attention to zoology. He published various treatises on the results of his zootomical investigations. He also frequently gave lectures on them, usually with the aid of practical demonstrations. These lectures, which were unique in the Netherlands in form as well as substance, attracted a large audience and met with a considerable response. Three of his students wrote dissertations on comparative anatomy.[22]

In 1773 Camper left Groningen University, and his university career came to an end. For more than twenty years he had used his considerable capacities to further higher education. Especially in Groningen he exercised a considerable influence. During his professorship nearly three times as many students graduated there as in the preceding decade. Camper's lectures must have been rather attractive. He had the reputation of being a good speaker, who could explain things in a very vivid and penetrating way. The didactic effect of his teaching was enhanced by frequent practical demonstrations and the use of excellent drawings, which he made himself.

In the course of time Camper had become a prominent physician. His greatest merits lay in the field of surgery and obstetrics. Besides being an able practitioner, he helped in particular to place these specialisms on a sound anatomical basis.[23] He continued to have a medical practice as far as his numerous other activities would permit. A notable percentage of his patients came from the lower social classes, and he usually treated them free of charge.

When Camper left Groningen he was a private citizen. Although his wife's considerable fortune would have enabled him to live a life of ease and leisure, he had no intention of retiring. The thought that there was still a good deal to be discovered in nature did not let him rest. Medicine, both its theory and its practice, definitively receded into the background. From this time onwards comparative anatomy dominated his scientific research.

The peaceful life which Camper led for a few years was rudely upset when on 4 January, 1776 his wife died. He found the solitude of his widower's state hard to bear. In a letter to Reinier Vinkeles he complained, not without self-pity, about his misfortune:

> "I now work alone, my bedroom is a solitude and merely the witness of my sighs! When I wake up in the morning, nobody asks me if I have slept well. I leave my bed to breakfast in another solitude, nobody encourages me, everything is silent."[24]

After the death of his wife, Camper made a short trip to the Cleves region and Brabant. After his return to Klein Lankum he felt cheerful enough to resume his activities. The loss of his wife and the fact that his three sons were becoming more and more independent deepened his sense of social isolation. He found Friesland too silent and too quiet; he preferred to be in Holland, "centre de bon goût et des hommes illustres".[25]

Camper was particularly attracted to the residence of the stadtholder. He was a familiar figure in the distinguished circles there. It was not simply for social reasons that he went to The Hague. The famous natural history collection and menagerie of the stadtholder were additional attractions. At the well-stocked museum of William V he was able to enlarge considerably his anatomical knowledge of a variety of mammals. At the zoo of the stadtholder, on the outskirts of The Hague, he had an opportunity to observe living animals.

Initially Camper's scientific publications, particularly the zoological ones, did not have a very wide circulation. Notwithstanding his proficiency in English, French and Latin, he preferred to have most of his books and articles published in his native tongue. It was only when Johann Herbell, lawyer and friend of his son Adriaan, started in 1784 to publish German translations of his major works that his achievements as a zoologist became better known.

As a consequence of his frequent journeys to Germany, England and France and his voluminous correspondence, Camper was already a well-known scientist. He was a member of the principal European scientific

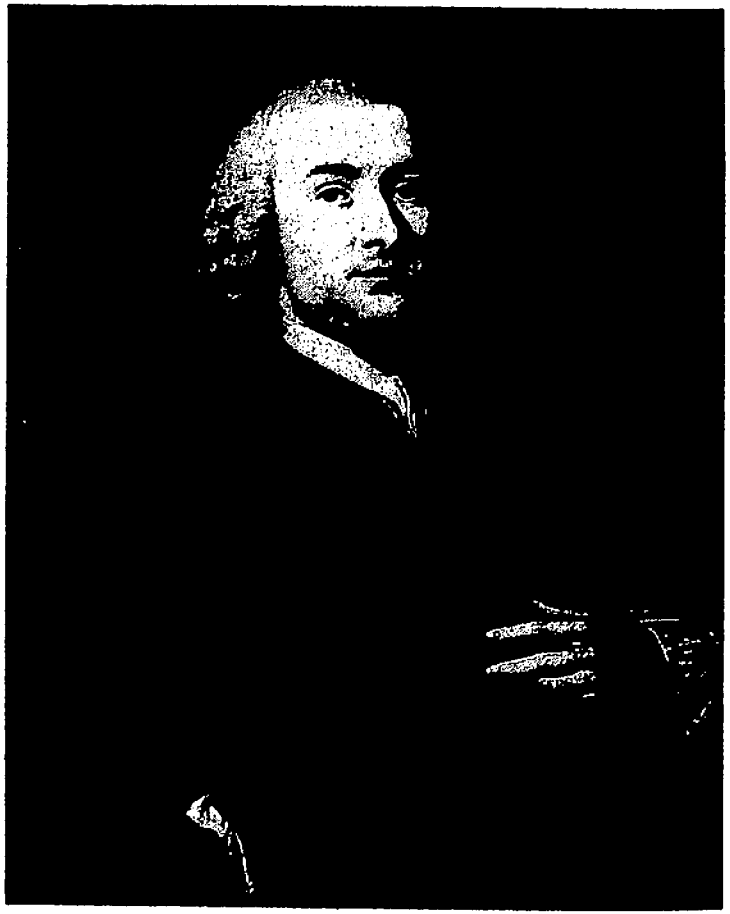

Fig. 2. Camper in 1760

societies and in 1785 was even elected an "associé étranger" of the Académie des Sciences. Until that time Boerhaave had been the only Dutchman who had belonged to that select group.

Prominent scientists such as Banks, Buffon, Collinson, Daubenton, J.A. Deluc, Haller, J. Hunter, Lacépède, Lichtenberg, Pallas, Portal, Vicq d'Azyr, and Wrisberg were among Camper's acquaintances. However, he maintained regular and intensive contacts only with a small group, which consisted mainly of promising

junior scientists, such as Blumenbach, Georg Forster, Merck, and Sömmering.

Early in 1777 Camper entered Frisian politics once more. In that year he was elected a delegate for the village of Idaarderadeel, a post which he held until 1781. After the outbreak of the Anglo-Dutch war in 1780, politics took up all his time. He had little leisure left for scientific work, and that was the reason why he resolved to retire from political life. However, his plans came to naught. Not only was he elected a delegate for Ferwerderadeel in 1782, but he also became "premier" (i.e. acting burgomaster) of the city of Workum. Through this latter office he became more involved in politics than ever before. In the following years he was, inter alia, also a delegate for the city of Ylst, a delegate to the States General, and chairman of the Council of State.

Camper's political career coincided with a period in which the patriot movement and the reaction to it created increasing turbulence in the Dutch Republic. Shortly after his appointment in Workum he revealed himself to be a fervent champion of the stadtholder's prerogatives. Like many other "regents", however, in due course he also made overtures to the patriots. Early in 1785 there were even rumours that he was seeking to make a treaty with C.L. van Beyma, Friesland's leading patriot, "in order to introduce a complete democracy".[26]

Like the majority of the "regents", Camper did not serve the cause of the patriots for long. He was essentially a conservative. In his view God had created a world that was perfect in every respect and he rejected fundamental changes in the existing order.[27] He heartily welcomed the restoration of the stadtholder's authority as a result of Prussian intervention. Upon the return of William V and his consort, he made two speeches as chairman of the Council of State, in which he expressed his joy at "this long-desired and blessed reversion of things". He hit out fiercely at the leaders of the patriots, "these abominable pests".

Politics gave Camper little satisfaction and caused him great worry. It always grieved him deeply that his efforts - which were not always very felicitous - to

restore peace and quiet were unsuccessful. He was greatly concerned about this because his exertions were at the expense of the many scientific projects which he still wanted to finish.

These projects included, inter alia, the publication - looked forward to by many - of the lectures he had delivered in the Amsterdam Art school, in particular those on the facial angle, further the writing of a monograph on the anatomy of the elephant, and in conjunction with Buffon a book-length study on the natural history of whales. Camper already had a great many data for these last two works, as well as for a sequel to the *Natuurkundige verhandelingen* (1782), in which several rare animals were to be dealt with. In addition he planned to publish papers on fossil vertebrates and on the comparative anatomy of the extremities, the brain, and the auditory and the speech organs. The fact that he did not achieve all his aims can be attributed only partly to the exigencies of politics. Another important obstacle was of a psychological character, and was already noted by Cuvier:

> "*Pierre Camper* qui porta sur les os de Maestricht cette même curiosité, ce même coup d'oeil rapide qui lui ont donné matière à tant d'apercus brillans, mais qui ne lui ont presque laissé approfondir aucun des sujets qu'il a si heureusement effleurés."[28]

Camper's "great craving for new discoveries" urged him all too frequently to move from one subject to another. He begrudged the time spent on working out the promising discoveries or on committing them to paper. Camper realized that his research had not always produced the expected results. Towards the end of his life, in a letter to Forster, he made the tragic confession: "J'ai travaillé beaucoup, mais peu en est devenu".[29]

Political disputes, solitude, anxiety about the future of his native country, and the feeling that he had not done, and was no longer able to do, what he had planned: all cast great shadows over the last years of his life. By the end of 1787 he carried out the plan which he had fostered for a long time, namely to leave Friesland for good. He removed to The Hague,

taking with him his museum, his library, and his other possessions. He spent his old age in quiet surroundings, close to his many friends and acquaintances.

After 1787 he hardly engaged in politics any more and at last he had sufficient leisure to take up scientific work again. However, this did not last long. By the end of March, 1789, Camper became seriously ill. He died on 7 April, and the Netherlands scientific community of the eighteenth century lost one of its best known and most widely honoured members.

Camper and the method of science

Camper's views on scientific method were dominated by the ideals of empiricism. During his studies at Leiden University he had gained first-hand knowledge of this influential philosophy of science through the lectures of 's Gravesande and Van Musschenbroek. It was these two professors, along with Boerhaave, who had elaborated Newton's method of scientific research, based on experience, and introduced it to the Netherlands and beyond, particularly to France. They firmly opposed Cartesian rationalism and emphasized the primacy of experience. In their orations and textbooks Boerhaave, 's Gravesande and Van Musschenbroek pointed out again and again that science should not be based on reason but on observation and experiment.[30]

Camper did not add anything basically new to this empiricist methodology. His ideas on scientific method can all be traced back to those of his teachers Van Musschenbroek and 's Gravesande. Camper expressed his views occasionally. Besides cursory remarks in several of his medical and zoological books and articles, the only publication in which he gave a coherent although brief, exposition of his views is the *Oratio de certo in medicina* (1758), pronounced on the occasion of the public inauguration of his professorship at the Amsterdam Athenaeum. A few years earlier he had given a more substantial exposition in the unpublished *Prolegomena in Philosophiam*,[31] an introduction to his Franeker philosophy course.

In Franeker Camper was welcomed as a "Newtonian". In the *Prolegomena* he lived up to his reputation and presented Newton as the shining example for natural scientists. He regarded the Englishman as the great renovator of science, thanks to whom man's knowledge of nature had been enlarged as never before. He repeatedly maintained that Newton's analytical-empirical method was the only correct one for the study of natural phenomena.[32]

Camper sharply criticized Descartes, just as 's Gravesande and especially Van Musschenbroek had done before. He rejected Descartes' method of deducing science from a small number of principles formulated a priori. According to him, Descartes had not made allowances for the limited capacities of the human mind. Camper thought that to believe that man could fathom the secrets of nature by means of reason was evidence of "inexcusable pride".[33]

Camper contrasted the investigator who, in accordance with Newton's directives, bases science on empirical data with Descartes, who worked on the basis of the "figments of the imagination" fabricated by his reason. According to Camper the true "philosopher" is someone who, unlike Descartes, shows a humble attitude towards the wonders of creation. This philosopher is aware of being ignorant of the "limits of God's wisdom and omnipotence" and is guided solely by what observation teaches.[34]

Just as in the case of a great many other eighteenth-century scientists, Camper's empiricism went hand in hand with a sensationalist epistemology. He, too, held that man has no innate ideas about the world outside him. For a knowledge of nature one is entirely dependent on the senses. Nothing can be stated with certainty about things that have not been observed. It is by means of the senses that we learn all that we know.[35] Camper rejected the view advanced, among others, by Descartes that one must fundamentally doubt the correctness of our empirical perceptions. He contended that this was absolutely contrary to divine providence. The senses can be trusted, since God has given them to us so that we can discover the truth.[36]

Camper admitted that the same phenomenon, when ob-

served by several scientists, could give rise to different ideas. However, to him this was no cause for scepticism about the senses. According to Camper, erroneous ideas do not originate in the senses but from a rash judgement of the mind. He pointed out that such errors could be prevented by repeated observations and by using, if possible, different senses which may confirm each other's observations. Furthermore he stressed the importance of a proper appreciation of the circumstances under which the observations were made; in this way errors due, for instance, to optical illusion could be avoided.[37]

Accurate observation and experiment were in Camper's view the scientist's basic tools. However, they were not the only tools. In addition to perception (sensus) Camper, following 's Gravesande, distinguished two other legitimate means for obtaining knowledge of the natural world, viz., the observations of others (testimonia) and reasoning by analogy (analogia).[38]

The justification of the use of testimonia is evident. If one accepts one's own observations, in principle one has also to accept those of others. Following 's Gravesande and Van Musschenbroek he based the analogia on the constancy of nature. In Camper's view of nature there was no room for "blind chance". The natural phenomena were governed by immutable laws. The "incredible constancy [with which] the divine spirit and providence rules the universe" implied for him that it was permissible to make predictions about things which had not yet been observed on the basis of earlier observations.[39]

Camper stated emphatically that the analogia and testimonia, although in principle reliable, "because God has seen fit that we should make use of them", should be handled with great caution.[40] In the *Prolegomena* he argued that the difficulty about reasoning by analogy is that nature does not always proceed in the same manner. This was particularly evident in natural history where the scientist was confronted with the fact that the same end could be achieved in different ways. Drawing on his own experience he referred by way of illustration to the sense organs, which although performing the same function, have different

structures in the various groups of vertebrate animals.[41] What he is inferring is clear: if one starts from a small number of observations it is highly probable that one does not get a proper understanding of the pluriformity of nature, and as a consequence reasoning by analogy might easily lead to incorrect conclusions.

As regards the testimonia, Camper warned against a belief in authorities. He impressed upon his students never to accept the statements of others, including himself, at once as true. These statements should be tested against the results of one's own investigations.[42]

Empirical examination and description of the phenomena were considered by Camper as the prime duties of natural science. But scientific knowledge ought to be more than a loose collection of observational data. The discovery of the laws "by which the Creator saw fit to rule the world" was in his opinion the ultimate goal of the scientist. Camper did not doubt that these laws existed, but what they were was not self-evident and could only be discovered by studying nature constantly and assiduously.[43]

In the *Prolegomena* and more comprehensively in the *Oratio* Camper dealt with the question of the nature of scientific knowledge. He refuted all sorts of sceptics who thought "that no conviction concerning the truth is to be found in man" and "that everything is based on surmise, doubt or uncertainty". He considered such a supposition as very foolish. In keeping with the ideas of 's Gravesande he declared that the immutability of natural events enables man to arrive at certain knowledge with the aid of the sensus, analogia and testimonia. Like his teacher he pointed out that this certainty has its foundation not in man himself, as is for instance the case with the certainty of mathematics, but that it is derived from the divine will and of a "moral" nature.[44]

Although science was able to give a true picture of the world, Camper was convinced that this picture would never be complete. He did not doubt that scientists would never find answers to such questions as "what if life?" or "what is the essence and substance

of living organisms?".[45] More than once he enunciated his firm belief that in our world there is a good deal which is beyond our comprehension and will always remain inaccessible to the human understanding.[46] For Camper, just as for 's Gravesande and Van Musschenbroek, the fundamental inscrutability of the universe was incontestable.[47]

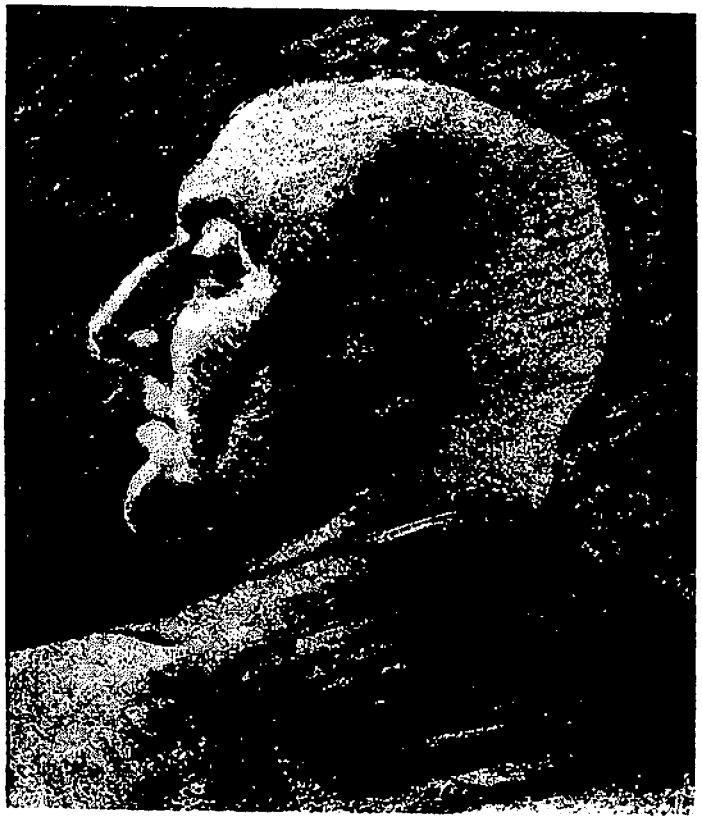

Fig. 3. Camper in 1774

Camper was a thoroughgoing empiricist, in theory but also in practice. Sensus functioned invariably as his primary and principal means of cognition. In accordance with his epistemology he worked in a strictly phenomenological way and studied only those "matters which are subject to our external senses".[48] About

phenomena which lay outside the scope of observation he kept silent or admitted his ignorance. Discussions about vital force, the relation between body and soul, the structure of (living) matter and other speculative subjects which occupied the minds of many eighteenth-century scientists are conspicuously absent from his writings.

Although the testimonia had the same epistemological status as the sensus, Camper did not value the observations of others in the same way as his own observations. His use of the testimonia was severely restricted by a principal distrust; a distrust which was strenghtened in the course of time by the many errors he discovered in the writings of predecessors and contemporaries.[49]

The analogia like the testimonia was for Camper of subordinate importance as a source of knowledge. He used it sporadically because he was well aware of the fact that particularly in natural history this method could easily lead to wrong conclusions. When he had recourse to the logic of natural history, as he aptly described reasoning by analogy,[50] it was mainly in order to supplement small lacunae in his anatomical descriptions. He never failed to emphasize the hypothetical nature of these statements.[51] If subsequent research proved them to be incorrect Camper hastened to redress his errors.[52] He always adhered to the primacy of (his own) experience.

Camper's activities as a practising scientist were for the greatest part addressed to collecting observational data. As we have seen he agreed that generalization of the individual facts was the ultimate aim of scientific inquiry. However, for the moment he considered this hardly feasible for zoology, his main field of research. Several times he had experienced that knowledge in this science was still too defective to come to meaningful generalizations. In seeking for the laws concerning the structure of animals he regarded it as essential "not to reach conclusions hastily"[53] thereby clearly indicating, as his teacher Van Musschenbroek had done before,[54] that what zoology needed primarily was an enlargement of its empirical basis. Camper has worked consequently in this way. A

cautious empiricism is characteristic of all his scientific work, his zoology in particular, and gave it a decidedly Baconian character.

Chapter II

ANATOMICAL AND PHYSIOLOGICAL RESEARCHES

Descriptive anatomy

Introduction

When Camper entered the field of zoology, it was generally regarded as the most neglected branch of natural history. For a convinced empiricist like Camper it was obvious that extension of observational knowledge was a prerequisite for the progress of zoology. The internal structure of the animals was the main object of Camper's fact-finding research.

Inspired by the practical success of the Linnaean reforms in botany, most zoologists in Camper's time were interested solely in classification and nomenclature, which they considered as the chief aims of their science. Although Linnaeus had accompanied the introduction of his *Systema naturae* with a research programme in which all aspects of the natural history of animals and plants were dealt with,[1] neither he nor his numerous disciples took great pains to get through this programme. Their investigations were generally confined to easily perceptible external characteristics, which were considered sufficient for classificatory purposes.

With, among others, Daubenton and John Hunter, Camper belonged to the small group of eighteenth-century zoologists who rejected this approach and upheld the primacy of anatomy for understanding the animal organism.[2] The use of the scalpel marked for Camper the difference between the philosopher, the true zoo-

logist, and the amateur who merely looked at the exterior of animals.[3]

The period of the Enlightenment did not show a great interest in animal anatomy. The *Encyclopédie* voiced a widespread opinion when De Jaucourt stated there "elle [zootomy] est quelquefois curieuse, & en même tems d'une utilité fort médiocre."[4] Camper did not share this view. He regarded the numerous factual errors which he discovered in the superficial descriptions of the systematists as a vindication for his conviction

> "that anatomy will always be and remain the sole and constant foundation of the real natural history of animals."[5]

Camper has always considered it as his principal task to broaden this foundation.[6] He was an anatomist not only from scientific conviction but also from a deep-rooted need. In the striking words of his son: "L'anatomie fut sa passion."[7] There were few things which gave him as great an intellectual satisfaction as "the discovery of the parts underneath". Camper's zoological activities centred on the vertebrates and in the first instance had no other purpose than "das geschaffne und gemachte ... offen und vor Augen zu legen."[8] In his publications we find this clearly expressed. For the greater part they were devoted to descriptive anatomy.

The auditory organ of the cetaceans

Camper's first publication in the field of descriptive anatomy was an article on the organ of hearing of the cachalot (1767). After a study on the way in which bony fishes perceive acoustic vibrations (1763), this was a new manifestation of his interest in the auditory organ; an interest which ever since his college days ran through his zoology like a continuous thread. Already in an early period Camper had conceived the plan to write a series of monographs on the auditory organ of the vertebrates.[9] For many years he worked at this project and collected a large number of data, of which he ultimately published only a small part. Apart from the above-mentioned articles, he published furthermore an article on the auditory organ of some cetaceans as an addition to the essay on the cachalot.

The zoologists before Camper had hardly paid any attention to the auditory organ of the cetaceans. Rondelet and Tyson were the only zoologists who had written about it. Their information, however, was brief and rather superficial. It was confined to some data on two auditory ossicles of a dolphin and the rough form of the auditory capsule of a porpoise.[10]

Camper's field of research was considerably more extensive than that of his predecessors. The object of his study, the isolated auditory organ of a cachalot which had run ashore, lacked the soft parts, but the osseous part was virtually intact. The treatise which he devoted to this object consists of a detailed and accurate description, both verbally and pictorially, of the separate parts and of their inter-relations.

Camper discovered great resemblance between this organ and that of the terrestrial mammals, but also found some notable differences. He had not been able to find any trace of either the fenestra rotunda or of the three semicircular canals in the cachalot. The latter in particular astonished him very much, since this part of the inner ear had so far been met with in all vertebrates. On the basis of this uniformity Camper also expected to find it in the cachalot. The discrepancy between a rational presumption based on the notion that the animals are constructed according to one and the same plan and the actual fact observed did not form any problem for him at all. The empirical data prevailed. It is illustrative of his consistent empirical approach that he at once accepted the absence of the fenestra rotunda and of the semicircular canals.

The last publication on the cetacean ear was a treatise "on the seat, the osseous auditory organ, and on an important part of the organ itself" (1776). Camper reported in this article on his research on a baleen whale, a porpoise, and a dolphin. It was intended in the first place to establish the relation of the auditory capsule to the rest of the skull. Camper at the same time availed himself of the opportunity to verify his observations on the cachalot with the evident intention of arriving at a general description of

the organ of hearing of the whales. The various auditory organs appeared to have a similar structure, as he had already suspected. The cachalot was an exception in one aspect. In this species he did not find the fenestra rotunda while it was present in all other cetaceans. Camper did not generalize the new observations. He maintained that the fenestra rotunda was lacking in the cachalot, and thus, here again, gave priority to empirical results over rational considerations.

Camper soon got followers. In 1785 and 1787 A. Monro Jr. and J. Hunter published the results of their investigations on the auditory organ of whales.[11] Their findings were largely identical with those of Camper. On one point, however, they differed. Whilst Camper had not been able to detect the extremely small semicircular canals, the two Britons had succeeded in finding them.

Monro was the first to report this discovery and he drew Camper's attention to the mistake in his descriptions. He did not succeed, however, in making him change his view. In general Camper was by no means impervious to such corrections, but in this case he did not see any reason for doubting his observations. Viewed against the background of the knowledge available to him, his negative reaction to Monro's criticism was quite plausible.

In his reply[12] Camper pointed to the carefulness and the wide scope of his research. In particular the latter was presented by him as a hardly assailable basis of his conclusion. In his opinion, at all events, it was not affected by Monro's criticism. It was not without any ground that Camper contended that Monro's observations were not very convincing. He rightly remarked that Monro's illustration of the semicircular canals did not depict these structures. For Camper this implied that the Scotch anatomist had not really seen what he described. If we add to this that when he was writing his reply, Monro's observations had not yet been confirmed by others, we have a situation in which, from an objective point of view, it was certainly not unreasonable that Camper refused to doubt that he was right.

Camper, never at a loss for words in order to publish his own merits, was rather satisfied with the results of his research on cetaceans. He considered that he had performed pioneer work although he was well aware that his description was incomplete because he had not been able to study the soft parts.[13] When we review his work and that of his predecessors, we may conclude that this qualification was justified. Camper indeed has to be given credit for having been the first to provide a clear insight into the internal and external structure and the seat of the auditory organ of the cetaceans.

Pneumaticity of the skeleton of birds

Among the "thousands of wonders of provident and wise Nature" there was none by which Camper

> "was struck so much because of its peculiarity as the contemplation of the empty cavities of the large bones of birds, and the way in which they are filled with the common air."[14]

The first time he came across this striking phenomenon was on February 10, 1771, when he prepared the femur of a recently killed white-tailed eagle as demonstration material for a lecture on human osteology. He found in it only the periosteum, and no trace of bone-marrow.

Camper was entirely unprepared for this observation. Fabricius and Marsili had already mentioned marrowless bird bones, but at that moment Camper was not yet aware of their work.[15] He began at once to explore this unexpected phenomenon more accurately. In another eagle the femur appeared also to be filled only with air. More or less accidentally he discovered on this object a natural opening in the underside of the trochanter. This was an entirely unknown structure, and Camper now focussed his research on this.

He found similar openings in the extremities, in particular the humeri, of various bird species. Moreover he established that they occur exclusively in hollow bones. On the basis of these observations Camper concluded that the air enters the bones through these openings. The question which of course he sub-

sequently asked himself was: where does that air come from? A simple experiment provided him with the answer. He pierced a hole into the distal part of the humerus of an owl, blew air into it, and

> "to my great delight I thus inflated the thorax and the abdomen, so that the air left the trachea again."[16]

Air transport by the opposite route was also possible

> "when I blew the air into the trachea, it left again through the hole made in the humerus."[17]

Experiments with a number of other bird species yielded the same results.

Camper not only examined the large bones of the extremities; he also did anatomical and experimental research on other parts of the skeleton. In an owl and an eagle he observed that the air blown in via vertebrae, ribs, ilium, sternum, and clavicles also inflated the thoracic and the abdominal cavity, and that in all cases the air sacs are the direct cause of this. Since it was known that the air sacs communicate with the lungs - his experiments had confirmed this once again - Camper had now proved irrefutably that the perforated, hollow bones are in communication with the respiratory system:

> "By the inspiration ... the air is introduced into the membranous cavities of the thorax and the abdomen; from these the air is transported into the bones mentioned above and is renewed constantly by the continuous respiration."[18]

In Camper's opinion this conclusion applied only to those objects the pneumaticity of which he had established empirically. Pneumaticized bones had not been found in other animals, and he supposed that they only occur in birds, but considered that further research was necessary in order to determine whether other species besides those studied by him also possessed them. He deliberately refrained from generalizations.[19]

Camper did not always find the pneumaticity in the same places. In some species both the femurs and the humeri were pneumaticized. Others were found to possess only hollow humeri. The first-mentioned situation was encountered by him exclusively in birds which fly for prolonged periods and at great heights

and which moreover are rather heavy. In species which fly infrequently, the pneumaticity was absent or limited to the humerus. These findings caused Camper to assume "that the bones are hollowed in proportion to the flight of the birds."[20]

Camper regarded the anatomical description of the pneumaticity as the chief result of his investigations. However, it did not completely account for the phenomenon. He also considered it necessary to determine its function. Camper's finalistic view of nature made this for him an indispensable part of the description of a hitherto unknown structure.

With the majority of the biologists from the pre-Darwinian period Camper shared the a priori conviction that nature is based on a plan according to which everything has been created for a certain purpose:

> "In forming the bodies of animals the great Creator of heaven and earth aimed at nothing but the usefulness of the parts."[21]

It was for Camper not only an established fact that the animal organism and its parts exist for the sake of the functions they perform, but also that the relation between form and function is a causal one:

> "the construction [of the] ... parts [is] the most necessary consequence ... of the *purpose* for which those particular animals are created."[22]

The eighteenth-century philosopher Hume pointed out that the teleological view of nature entails that

> "an anatomist, who had observed a new organ or canal would never be satisfied till he had also discovered its use and intention."[23]

Camper actually proceeded in this way. If he discovered new organs - which did not happen frequently - he did not consider it sufficient to describe their form. He would always ask himself as well what was their function. He regarded it as essential to anatomical cognition to explain structures in terms of final causes.

As we have seen, Camper derived his functional interpretation of the pneumaticity from the positive correlation with the capacity of flight. Supported by the ideas of Galilei and Borelli, according to which birds have a relatively light skeleton "in order that

... they ... might fly more easily",[24] he drew from this correlation the conclusion that the hollow bones serve to promote flight. This purpose was not only achieved by the fact that the absence of bone marrow made the body of the bird less heavy. The current physical knowledge suggested to him yet another way in which the pneumaticized bones carry out their function:

> "The heating to which the air is subjected in these internal parts is bound to inflate it, and thus make it lighter than the air of the atmosphere, as a result of which the bird, one more than the other, becomes *specifically* lighter and will fly with great ease."[25]

Realizing that he had studied only a limited number of species, Camper emphasized the hypothetical character of his functional interpretation.[26]

Since the structural relation between the hollow bones and the respiratory system had not yet been described before, Camper hastened to make public his discovery. He devoted a number of lectures to it, and early in March 1771, less than three weeks after the first observation, he sent an article to the secretary of the recently founded Bataafsch Genootschap der Proefondervindelijke Wijsbegeerte, for publication in their journal. It was not until 1774 that Camper's exertions were rewarded with publication.

Almost simultaneously with Camper's treatise an article on the same subject by John Hunter appeared.[27] It was evident that Hunter had also discovered a great many parts of the bird skeleton which communicate with the lungs via the air sacs. In the first instance he too thought that the hollow bones serve to promote flight. A relation between pneumaticity and flight, however, was resolutely rejected by Hunter after he had discovered a highly pneumaticized skeleton in the ostrich, which does not fly, whilst no trace of pneumaticity was to be found in a variety of species which were known as excellent flyers. On the analogy of the highly branched lungs of some amphibians and reptiles Hunter regarded the hollow bones as a functional part of the respiratory system.

Hunter's publication did not escape Camper's notice.

In connection with the Dutch translation of it he came with a circumstantial reaction.[28] His primary concern was to show clearly that he had been the first to discover the pneumaticity, independently of Hunter. For this, Camper based himself solely on the dates of the two articles. He left out of consideration Hunter's statement - which could not be verified - that he had observed the pneumaticity already in 1758. Hunter's treatise had been read at a meeting of the Royal Society on February 27, 1774, and Camper assumed that the actual research had taken place shortly before that date. On the other hand, his own article was dated March 2, 1771. Camper supported his claims, inter alia, by references to his correspondence with respected scientists such as J.N.S. Allamand, professor of natural history at the university of Leiden, and A. Portal, a prominent French physician and anatomist, whom he had allegedly informed of his discovery already in 1771 and 1772.

The Hunter affair meanwhile appears to have been more than a question of priority for Camper. In a letter to William Hunter he wrote about it as follows:

> "It is possible that we [i.e. Camper and John Hunter] may have fallen upon the same object about the same time, but I suspect some of my pupils have given the hint, etc."[29]

It is certainly not quite impossible that Hunter may have become acquainted with Camper's results before their actual publication and that they inspired his own investigations. A possible source was the dissertation *De respiratione volucrum* (1773) of Camper's pupil L. Chernak in which the discovery of the pneumaticized bones was described at great length. Camper supposed that J. Kooistra, another of his pupils, who set up in London as a medical practitioner in the early 1770's, drew Hunter's attention to Chernak's book.[30] However, Camper's suspicions cannot be substantiated, so that our conclusion can only be that Hunter discovered the pneumaticity of the bird skeleton independently, but in all probability later than Camper.

Camper's public reaction to Hunter's work was not only prompted by the wish to stress his own merit. He

used the greater part of the article to supplement, verify, and correct, wherever necessary, his observations and those of Hunter. This did not yield any significant new points of view.

At the end of the article Camper took up Hunter's rejection of the functional interpretation such as he had given it. He concentrated on the example of the ostrich put forward by Hunter. Camper rightly considered the fact of a flightless bird with a pneumaticized skeleton as the most serious objection to his interpretation. He confirmed the correctness of the observations underlying the criticism, but did not share Hunter's conclusion. By viewing the pneumaticity not exclusively in connection with flight, but with locomotion in general, Camper could account without much difficulty for the hollow bones of the ostrich:

> "because the ostrich can run very fast, and as it were fly along the ground, which it would not be able to do if the Creator had not appreciably reduced its great weight by this artifice."[31]

The second point in Hunter's criticism, the absence of hollow bones in all sorts of good flyers, impressed Camper much less, convinced as he was that the same objective, in this case the increase of the capacity for flight, may be realized in different ways. He hardly paid attention to this objection and only recurred to it in greater detail in the supplement to the German translation of his first article.[32] In this supplement, Camper set forth that in the examples mentioned by Hunter, viz. the wood-cock and the bat, the lack of pneumaticized bones was compensated by other flight-promoting structures, such as hollow quills and a relatively highly developed musculature. He left the reader to draw his own conclusion. The drift of his argument, however, is clear: it is a mistake to consider the lack of hollow bones as evidence against the interpretation advocated by him, since experience shows that this is not the only means for facilitating flight.

In 1786 Hunter published a new version of his article on the pneumaticity.[33] He did not refer to Camper's work, although they had shortly before exchanged views on this subject.[34] It may be understood to some

extent that he was silent about Camper's priority claim; if he had gone into this, it could have produced little more than fruitless polemics. It is indeed striking that Hunter did not say a single word about Camper's objections to his view of the functional significance of the hollow bones of birds. Hunter maintained his own interpretation. Like Camper, he left it to posterity to arrive at a final conclusion on this point.[35]

The natural history of the orangutan, the double-horned rhinoceros and the reindeer

The studies on the cetacean ear and the pneumaticity of the skeleton of birds are not characteristic of Camper's zootomical activities. He was much more interested in organisms than in their isolated parts. His primary concern was to contribute on the basis of anatomy to the natural history of animal species. In this, Camper followed the monographic tradition which had begun to flourish in the seventeenth century owing to men such as Blasius, Duverney, Perrault, Steno, and Tyson, and which received new impulses from Buffon and Daubenton in the eighteenth century.

Zootomy was an ideal field of activity for a man like Camper, who preferred original empirical research. The anatomy of most of the animal species known in his day had hardly been studied, if at all. Buffon certainly did not exaggerate when he wrote

> "Nous avons des milliers de volumes sur la description du corps humain, & a peine a-t-on quelques mémoires commencés sur celle des animaux."[36]

Camper was intensively engaged in collecting as many of the little known species as possible.[37] He concentrated his research on those animals the information about which was most defective. His plan to combine the results of his research in a voluminous publication was not completely carried out. Camper published only the first of the planned two volumes of his zootomical magnum opus.[38] In this he described successively the orangutan, the black African rhinoceros, and the reindeer.

Camper's interest in the orangutan had first of all

been roused through his attempts to gain a better understanding of the anatomical writings of Galenus, which he greatly admired. Since Vesalius it had been very well known that they were not based on the dissection of human bodies, but on the anatomy of animals, and of monkeys in particular. In his spare time Camper tried to trace Galenus' sources. On the whole he does not seem to have found this very difficult. The only problem was Galenus' description of the larynx. Neither in monkeys nor in other animals did Camper find anything resembling what Galenus had seen. Starting from the idea that in ancient Rome Indian animals were available, Camper presumed that Galenus might have used the orangutan. In order to test this hypothesis he procured two of these animals via his connections at Batavia and in the East India Company. He concluded that the organ of speech of the orangutan conformed to Galenus' descriptions. Camper did not venture to assert that Galenus had really dissected these apes, since his other descriptions manifestly did not apply to this animal.[39]

Camper's interest in the orangutan was by no means exhausted after the exegesis of Galenus. He realized that his two specimens provided him with an ideal starting-point for a more thorough study of this animal from the East Indies than had hitherto been carried out. When Camper received his first orangutan there were no reliable observations on living animals; anatomical data were altogether lacking and those on the outward appearance were too scarce and too fragmentary to furnish a clear picture of the orangutan.

The Dutch physician N. Tulp introduced in 1641 the name orangutan and used it to designate an Angolese chimpanzee. His compatriot J. Bont was the first to associate the name with a living being from the East Indies which, however, did not much resemble any ape whatever. Until well into the eighteenth century Tulp and Bont were the main sources of information on the orangutan. The English artist G. Edwards was the first and only one who is known with certainty to have seen an orangutan prior to Camper.[40] According to Camper Edwards did not turn his possibilities to great account

> "being neither a dissector nor a naturalist, and a very poor draughtsman, he left nothing but a defective description and an even more imperfect drawing."[41]

Camper did not fail to make use of his possibilities for elucidating the natural history of the elusive orangutan. From 1770 to 1777 he examined eight animals in all; five of them were anatomized. Camper gave the definitive description of the orangutan in the *Natuurkundige verhandelingen* (1782). Before this he had published in 1779 an abbreviated English version of the chapter on the organ of speech and a summary, in Dutch, of the main results of his researches.[42]

As was customary in zootomical monographs, Camper started his description of the orangutan with a chapter on the outward appearance. In accordance with a technique introduced by Daubenton, he gave a tabular review of the principal dimensions of the two specimens in his museum. Further he described in the opening chapter those parts in which his orangutan differed from the chimpanzee dissected by Tyson, which was also called orangutan.[43]

The rest of the first chapter was mainly devoted to a criticism of his predecessors. Camper contended that in their illustrations they had made the orangutan resemble a human being too much. He admitted that his own drawings of a specimen preserved in alcohol differed considerably from the living orangutan which he had seen in 1776 in the zoological garden of Prince William V. But still he credited himself for having strictly followed nature and not having stretched the truth with a baseless fancy.[44]

In conformity with the standard approach of the eighteenth-century zootomists, the internal parts Camper dealt with were the organs of the thoracic and the abdominal cavity and the skeleton. To his regret he could not describe the brain; it had not been preserved in any of the specimens dissected by him.

Camper gave a brief, but adequate description of liver, stomach, intestinal canal, kidneys, spleen, lungs and sexual organs. In greater detail he described the larynx and the laryngeal sacs, which he regarded as the most remarkable aspect of the orang-

utan anatomy. He knew similar structures of other monkey species, but had never come across them in pairs, as in the orangutan. Camper gave a somewhat selective description of the skeleton. He devoted attention more emphatically than in the rest of the anatomy to those parts of the skull, the vertebral column, the pelvis, and the extremities in which, in his view, the orangutan showed characteristic differences with structurally related species. With the exception of the metacarpal bones, of which he counted eight instead of nine, Camper described the internal and external structure of the orangutan correctly.

The morphological description was not Camper's only objective. He also paid ample attention to the systematics of the orangutan. For the establishment of its place among the apes and monkeys, he compared the orangutan with a large number of these animals, the majority of which he had examined himself. In most cases he discovered such evident differences that he did not trouble to dwell on them. Camper realized that on the other hand it was of importance indeed to devote careful attention to the relation between the orangutan and those animals which were generally considered to be its closest relatives, viz. Buffon's group of the tail-less apes ("singes").

In this group Buffon had brought together those animals which most resemble man. Besides the orangutan, it included the gibbon and the pithecus (Barbary ape). Buffon considered it highly probable that the orangutan was a species, which occurred in two varieties, viz. the jocko or little orangutan, with as type varieties the animals described by Tulp and Tyson (i.e. the chimpanzee), and the pongo or big orangutan, an animal with an indistinct identity, which he only knew from travel stories.[45] In the early years of the second half of the eighteenth century this was the current view of orangutan systematics.

Whilst Buffon thought that the jocko and the pongo also inhabited the Dutch East Indies, Camper demonstrated in a convincing way that the animal known there by the name of orangutan differed essentially from the orangutan described by Buffon. He found a great number of resemblances between his orangutan and

the gibbon and jocko but "on the other hand it differs very much from them in its organ of speech and the bones of hands and other parts". When the difference with the pithecus appeared to be greater still, the conclusion could no longer be avoided that

> "the orangutan from Borneo ... [is] an animal which indeed belongs to the general genus of the apes or quadrumanous animals, but at the same time forms an entirely separate species thereof."[46]

A. Vosmaer, the director of the stadtholder's menagerie and natural history cabinet, had already suggested such a distinction. However, it is more than likely that he got this idea from Camper. Vosmaer possessed a copy of a lecture, delivered in 1772, in which Camper had described the orangutan and the chimpanzee as separate species.[47]

Camper's revision of ape systematics had of course nomenclative consequences. Without really exerting himself to make the necessary reforms, Camper did state clearly that the originally Malay name of orangutan ought to be used exclusively for the species described by him.

At first Camper had nothing but rather young animals at his disposal. Material of adult orangutans did not reach the Netherlands until after the appearance of his book. Towards the end of 1783 he received the skull of such an animal. Partly also on the basis of the complete skeleton present at the stadtholder's museum and of the observations published by Radermacher and Von Wurmb, he gave a brief preliminary description of the adult orangutan in the German translation of the *Natuurkundige verhandelingen*[48] (see fig. 4).

It is remarkable, but by no means incomprehensible that Camper did not recognize the adult orangutan as such. The internal and external structure was found to be similar on a great many points to those of the individuals which he had so far seen, but the skull was so completely different that he was convinced that the adult orangutan represented a separate species. Like Von Wurmb, he gave it the name of pongo and characterized it as "l'orang de la grande espèce", to distinguish it from "l'orang de la petite espèce", which he

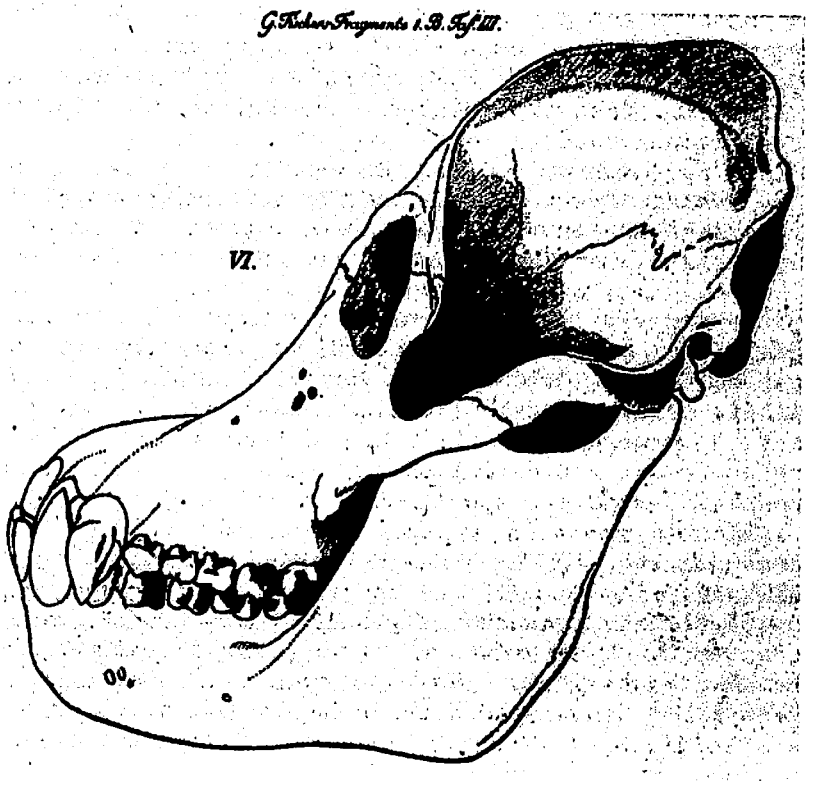

Fig. 4. Drawing of the skull of an adult orangutan sent by Camper to Sömmering

had described in the *Natuurkundige verhandelingen*. The dimorphism of the skull characteristic of the orangutan has led astray many naturalists after Camper in the same way. In 1826 the German zoologist K.A. Rudolphi introduced the hypothesis that the "little" orangutan is the immature form of Von Wurmb's pongo, and in 1835 his English colleague R. Owen furnished the definitive proof of this.[49]

Camper's spadework on the orangutan was warmly welcomed by his contemporaries. An illustrative reaction is that of Sömmering. About the *Kort berigt* (1779), Camper's preliminary description of the orangutan, he wrote as follows:

> "Bey dem so vielen völlig ungegründeten, sehr lächerlichen, und unausstehlich abgeschmackten das über diesen Affen, selbst von den besten Naturgeschichtsschreibern gesagt, und von unzählichen, zur Schande unsers Jahrhunderts, nachgebetet worden ist, müssen doch wohl die aus der Natur selbst hergenommenen Beobachtungen eines der grösten Philosophen und Zergliedern ... äusserst willkommen seyn ..."[50]

For a long time Camper was the indispensable source of information on the orangutan, partly also through his detailed and accurate drawings. His work lost this function only in the course of the nineteenth century, when it was gradually eclipsed by more comprehensive studies such as those of R. Owen and H. Schlegel.

Camper's monograph owes its importance not only to the fact that it was the first - and for many years the principal - contribution to the knowledge of the orangutan anatomy. It had moreover an unmistakable formative influence on the development of primate systematics. Camper drew attention to the confusion in the use of the name orangutan and was the first to offer arguments in favour of a distinction between the African "orangutan" (the chimpanzee) and the Asiatic or true orangutan. After 1782 there was no longer any expert zoologist who doubted that they were different species.[51]

The second species described by Camper in the *Natuurkundige verhandelingen* was the black African rhinoceros. When he started his research in 1772, the one-horned Indian rhinoceros was the only species the existence of which was tolerably well documented. Of the two-horned black rhinoceros little more was available besides Kolb's description and a more or less life-like illustration which Jan Wandelaar had added to the Dutch translation of Kolb's book on the Cape of Good Hope.[52] The anatomy of the rhinoceros was a completely unexplored field.

Camper's treatise on the black rhinoceros had

> "originated from a public lecture held by me at the Anatomical School at Groningen on the 6th of February of the year 1772, when the ice-bound water prevented teaching anatomy on dead human

bodies, which are sent from Amsterdam for that purpose."[53]

Instead of the usual lectures on human anatomy his audience was treated to the dissection of a desiccated rhinoceros head with which he had been presented a few months before by Joachim van Plettenberg, governor of the Cape Colony and one of his principal suppliers of exotic animals. Camper summarized the results of the dissection in the *Dissertatio de cranio rhinocerotis africani, cornu gemino* (1780), where they primarily served as an aid for identifying fossil rhinoceros skulls recently discovered in Siberia.[54] A further elaboration of the zootomical part of this article followed in the *Natuurkundige verhandelingen* (1782). The description of the skull formed the main part of Camper's rhinoceros monograph. In addition it contained a brief discussion of some other aspects which

"pertain to the further elucidation of the writings of the Ancients or to the more complete knowledge of the properties of this animal."[55]

Shortly after Camper had completed the manuscript of the *Dissertatio* in 1776, an article of the Africa traveller Anders Sparrman appeared, in which the skull of a Cape rhinoceros was described.[56] However, the *Natuurkundige verhandelingen* had by no means been superseded by this article. Camper provided considerably more information than Sparrman, who had confined himself to a single drawing with hardly any explanation.

Camper, like the excellent draughtsman he was, gave the most complete report of his observations in the illustrations. He published six figures, in which the head and the skull were shown full face as well as in profile.[57] Camper's drawings not only were more numerous, but they also contained considerably more details than those of Sparrman. The surplus value of his treatise was further determined by the detailed explanation which he added to his drawings. All the elements shown were exactly enumerated and named. In the text proper Camper once more described the main structures of the head and skull by reference to the drawings. He did not put forward in it any new morphological data.

As in his other descriptive anatomical studies, in that on the rhinoceros too Camper tested the work of

his predecessors by his own findings. In doing so, he concentrated on the two points on which recent writers chiefly differed, to wit the dentition and the meaning of the number of horns.

When in the first half of the eighteenth century it was becoming evident that in Africa a two-horned rhinoceros occurs, the existence of which had long been seriously doubted, zoologists were faced with the question as to the relation of this animal to the one-horned rhinoceros from Asia. At first it was presumed that they represented two separate species.[58] After Buffon had suggested that they were nothing but varieties of a single species, this became the prevalent opinion.[59] The difference in the number of the horns was attributed to external circumstances, sex or age.[60]

In the *Dissertatio* (1780) Camper mentioned the problem of the number of horns in passing. Although he did not take an explicit standpoint, it would appear that he endorsed the interpretation advocated by Buffon.[61] In the *Natuurkundige verhandelingen* (1782) this clearly was no longer the case. His new interpretation was partly due to the observations of Sparrman and R.J. Gordon published shortly before. Both these naturalists had studied various Cape rhinoceroses and had established that they always possess two horns, regardless of their age or sex.[62] Since Camper knew from his own experience and from the literature that the Asiatic rhinoceros has no more than one horn, he concluded that the difference in the number of the horns "is not a freak of nature, but a real *specific* property."[63]

The descriptions of Sparrman and Gordon put Camper on the track of a second constant difference between the two species. The African rhinoceros was found to have a comparatively smooth skin. The Asiatic rhinoceros, on the other hand, was amply provided with loose folds. Thus, Parsons' hypothesis that the rhinoceroses living in geographically different regions represent different species had been definitively confirmed for Camper. In the words of Cuvier it was Camper who put "le sceau à la détermination de ces deux espèces".[64] Summarizing, Camper concluded the treatise

on the Cape rhinoceros by stating

> "that there are two species of Rhinoceros.
> I. *One* indigenous to Asia, with a single round horn, and provided with considerable loose folds on the body ...
> II. *One* with two flattish horns, one behind the other, without folds, which is found only in Africa."[65]

The other controversial point on which Camper threw light - that with respect to the dentition - owed its origin to P.S. Pallas. In fossil rhinoceroses Pallas had come across specimens having nothing but molars. This induced him to impute an error to Parsons, Linnaeus, and Buffon, who had alleged that rhinoceroses possess incisors.[66] Camper had also observed the absence of incisors and canine teeth in the Cape rhinoceros, and in the *Dissertatio* (1780) he simply sided with Pallas' criticism. In the *Natuurkundige verhandelingen* (1782) he again concurred with the latter, but he added "that he now had a less clear insight into this point".[67] Camper's uncertainty had arisen because he had observed cavities in the lower as well as the upper jaw of a Javan rhinoceros which had unmistakably contained other teeth than molars. Owing to lack of sufficient material for comparison he did not yet venture to state whether this was an isolated case or "a constant ... difference between the two-horned and the one-horned [i.e. Javan] rhinoceros."[68]

After the publication of the *Natuurkundige verhandelingen* (1782) Camper tried to gain clarity on this point. He succeeded in this thanks to the cooperation of John Hunter, at whose museum he was allowed to make a detailed study of the skull of an Indian rhinoceros, and of Jacob van der Steege, a physician at Batavia, who sent him various skulls of Javan rhinoceroses. All the rhinoceroses from Asia were found to have incisors. Camper rightly concluded that these animals constantly differ in this from the African rhinoceros. Owing to this third differentiating feature, in addition to the difference in the number of the horns and in the structure of the skin, he considered the specific difference to be beyond doubt. In a letter in which he informed Merck of his discovery he wrote

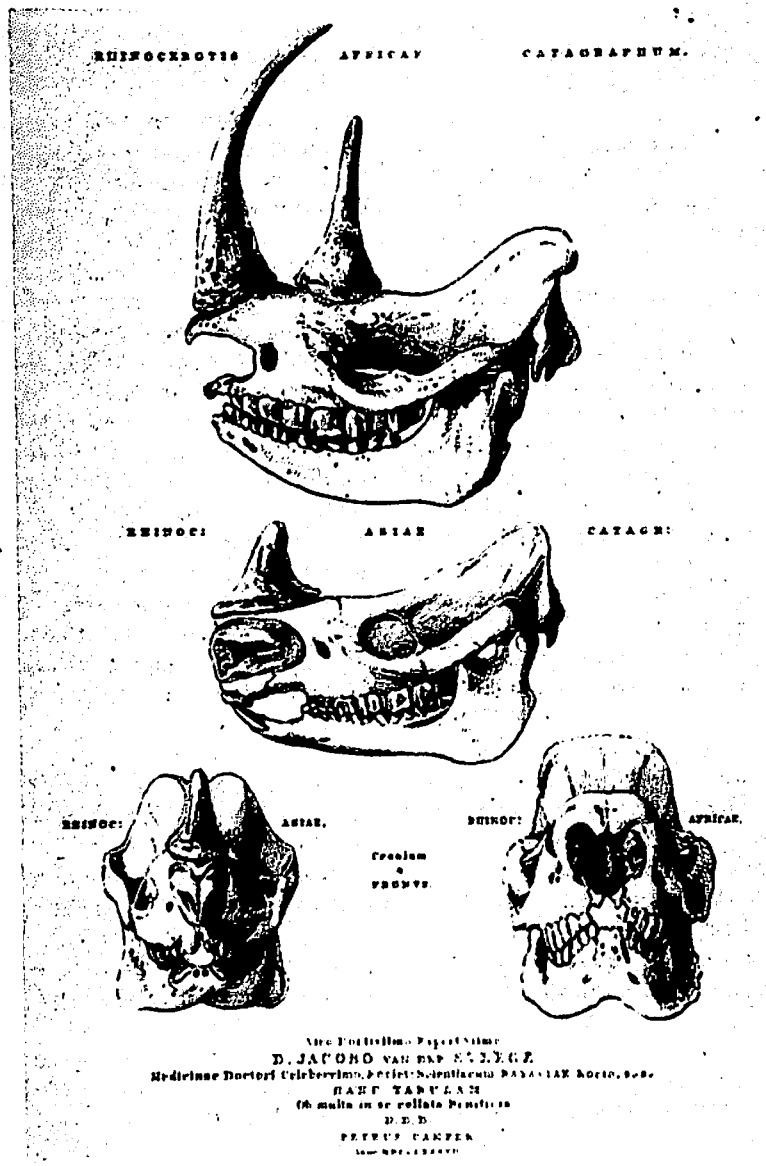

Fig. 5. Engraving of Camper's drawing demonstrating the osteological differences between the African and the Asian rhinoceros

triumphantly: "Voilà donc les deux espèces entièrement distinctes!"[69]

Camper has not been able to give much publicity to his later research on the rhinoceros. Shortly before he died, he described the presence of incisors in Asiatic rhinoceroses in a footnote to the German translation of the *Natuurkundige verhandelingen* (1782),[70] but without going into the difference with the African rhinoceros. For this latter aspect he referred his readers to an article to be published in the transactions of the Petersburg Academy, but it never appeared either there or anywhere else.[71] Among his contemporaries he informed only Merck and Joseph Banks in detail of the discovery concerning the differences in the teeth.[72] He further laid them down in a magnificent engraving (see fig. 5), which appeared in 1787 and was destined for private circulation. In this engraving the skulls of the African and Asiatic (Javan) rhinoceros are shown full face and in profile.[73]

With Sparrman and Gordon, Camper must be reckoned among the pioneers of research on the Cape rhinoceros. Unlike Sparrman and Gordon, he not only paid attention to this particular species. His need to pronounce on the controversial points in the natural history of the rhinoceros confronted him with the problem of the relation between the representatives of this group known in his day. His solution was a fundamental contribution to rhinoceros systematics. Camper demonstrated unambiguously the specific difference between the African and the Asiatic rhinoceroses. Later, probably after 1787, he made a further division, as appears from a letter to Pallas, in which he wrote:

> "Ich habe Gelegenheit gehabt die beiden Asiatische Gattungen von Rhinoceros aus einander zu setzen ..."[74]

This cannot but mean that Camper had arrived at the correct conclusion that the Javan and the Indian rhinoceros were different species. Unfortunately he has not stated anywhere on what arguments he based his distinction. It was therefore rather exaggerated when Sody asserted that through Camper "Das Erkennen des Javaners als neue Art ... vollzogen [war]."[75] Cuvier was the first to make a clear distinction between the

Indian and the Javan rhinoceros, for which he partly based himself on material from Camper's collection.[76]

The last years of Camper's professorship at Groningen were a particularly fruitful period for his zoological studies. It is from that time that date not only his first researches on the orangutan and the rhinoceros; in the same period the foundation was also laid for the third and last part of the *Natuurkundige verhandelingen* (1782), devoted to the reindeer.

Camper first became acquainted with this animal via a specimen which was shown at Groningen, probably as part of an itinerant menagerie. The animal died on February 13, 1770 and was drawn by Camper

> "the next day, as soon as possible, while I indulged the hope that I should be able to secure the dead animal for dissection at a moderate price ..."[77]

This hope proved idle. Camper's interest in the comparatively unknown reindeer, however, had been roused. He requested his acquaintances, the Ovens brothers, merchants at Frederikstad, to provide him with a living specimen. On June 21, 1771 it arrived at his home.

Camper's colleague Allamand was soon aware of his activities and invited him to make a contribution on the reindeer to his edition of Buffon's *Histoire naturelle*. Camper promptly agreed, and in that same year, 1771, his *Observations sur le renne faites à Groningue* appeared.[78] He certainly had not intended this publication to be his last word on the subject. As usual, Camper tried to base the definitive description on more than one individual. In this case he was not very successful in his attempts. He could lay hands only on parts of other reindeer, such as the head and the legs. In 1782 he finally published his treatise on the natural history of the reindeer.

It is an elaborated version of the *Observations*. The two publications have largely the same plan and content. New in the treatise is the last chapter, which contains some morphological data on the extremities. Another addition is the second chapter, the longest of all, in which Camper tried to prove that Julius Caesar had already mentioned the reindeer. Camper had a great

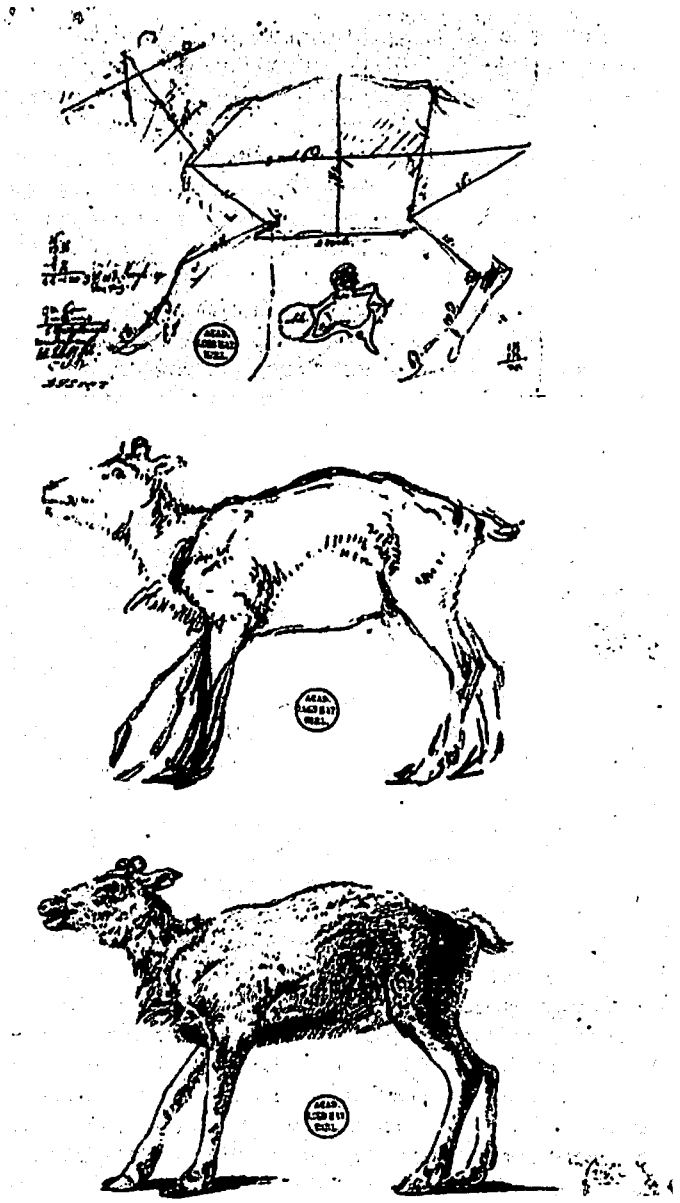

Fig. 6. Sketches of a young reindeer. They illustrate the careful way in which Camper made his drawings

liking for such philological exercises which enabled him to use his knowledge of natural history to clarify passages in classical authors. He had already done this with verse from Martialis in which a double-horned rhinoceros was described.

Camper opened the treatise on the reindeer by expressing his astonishment at the fact that a European animal of such great economic importance had been so deficiently studied.[79] The natural history of the reindeer had indeed hardly been explored. Bartholinus' article on some visceral organs and the description of its outward appearance by Linnaeus and Buffon were the main sources available around 1770.[80]

Of the animals described in the *Natuurkundige verhandelingen* the reindeer was the one to which Camper devoted least attention. He has not given a comprehensive account of its anatomy although he had examined it in detail. It may have been due to the fact that on many points the structure of the reindeer was practically identical with that of other deer species, which were already known, that Camper confined himself to

> "the main features which I found to be remarkable in the reindeer and which none of the other writers mention except in such an inadequate and deficient way ..."[81]

As regards the outward appearance, Camper concentrated on a description of the head and the hindlegs. He sharply criticized the Danish bishop Pontoppidan, who had asserted in his natural history of Norway (1752-1753) that during heavy snow-fall the reindeer shuts its eyes in order to prevent being blinded, and then can see only through a small opening in the eyelid. Camper did not find any trace of such an opening and confirmed Haller's suspicion that Pontoppidan's assertion was nothing but phantasy.

Like the outward appearance, Camper described the internal organization in a rather succinct way. He mentioned the number of teeth and molars, and established, as Buffon had done before, that the intestines are hardly different from those of deer and that the fibula is lacking, as in the other ruminants. The osteology, to which he used to pay a good deal of at-

tention, was not discussed further. Camper possessed a fine reindeer skeleton, but did not consider its quality good enough "to make a neat drawing of it".[82] The only thing he dealt with at length was the laryngeal sac, an organ which he had not observed so far in any animal except in a few monkey species.

The reindeer treatise is certainly not Camper's most remarkable zoological publication. In comparison with his studies on, for example, the orangutan and the rhinoceros he has enlarged the knowledge on the reindeer only in a modest way. The criticism of Pontoppidan and the description of the laryngeal sac and the glands on the hindleg constitute his main contributions to the natural history of this animal. The treatise decidedly did not fill all the gaps in the descriptions of Buffon and Daubenton for which Mulder wanted to pass it off.[83] Camper himself gave a more realistic assessment of his work when he concluded it by expressing the hope that his "few observations" might induce others to make greater discoveries.[84]

Contributions to the writings of Buffon, Pallas, and Vosmaer

Camper's relations with the scientific world were characterized by a striking tendency to confide the results of his research to others even before he had formally given publicity to them in publications of his own hand. His "grosse Bereitwilligkeit sich mitzutheilen"[85] had the consequence that some of his pioneering zootomical investigations were first of all published by colleagues, although with Camper's consent.

Buffon was the first to benefit substantially from Camper's generosity. In the preceding section we saw that through Allamand the *Observations sur le renne* were added to the *Histoire naturelle*. Further, Camper also made a direct contribution to this work. In 1778 Camper dissected a howler monkey, particularly in order to study its organ of speech. He did so not merely as to compare it with that of the orangutan, on which he was preparing an article. Camper's curiosity had also been stimulated by Buffon, who had pointed to

the exceptional form of this organ, but had not been able to give a clear description of it. Camper, on the other hand, had sufficient material to study this organ. In his own writings he only briefly mentioned the results.[86] The complete description of this "most peculiar organ of speech, hitherto unknown except through my dissection", was sent by him on November 15, 1778 to Buffon, who inserted it in his last volume of the *Histoire naturelle*.[87]

Buffon tried to get additional data about this subject from Camper. In a letter to the Prince de Gallitzin, Russian ambassador in the Netherlands, Buffon wondered whether Camper, "ce célèbre anatomiste", had continued the research on monkeys. Buffon was greatly interested in this, because he wanted to add to the *Histoire naturelle* a supplement on the quadrupeds, containing as complete as possible a rendering of Camper's observations on the organ of speech of monkeys and apes.[88] Camper thereupon sent his son Adriaan to Buffon with a large number of anatomical drawings of mammals. This collection, with a profusion of original data, contained considerably more than the requested information and was quite freely put at Buffon's disposal. There is no inventory of the drawings which Camper sent along with his son. Adriaan Camper wrote his father that Buffon had singled out 16 drawings which related to the orangutan, the mandril, the sloth, the aardvark, the giraffe, the porcupine and the reindeer.[89]

Camper's generosity would seem to have been prompted by the supposition that Buffon might use his drawings to enrich the supplement on other subjects besides monkey anatomy. Buffon, however, did not avail himself of Camper's offer. He was probably more interested in information on the outward appearance than in Camper's anatomical data. The supplement on the quadrupeds mainly contained additions and corrections to the descriptions of the exterior of the animals. The volume had only three anatomical plates, on a total of 82. One of these was Camper's drawing of the organ of speech of the howler monkey.[90]

Unlike in the case of his contacts with Buffon, in Camper's relations with P.S. Pallas the initiative was

on the side of the receiving party. After the Russian naturalist had received Camper's article on the Cape rhinoceros for the transactions of the Petersburg Academy, he started a correspondence with Camper. Pallas turned this to account to ask him for details on a variety of mammals for the benefit of his own work. In turn he aided Camper in collecting new specimens for his museum.

Of the zootomical information sent to him, Pallas published Camper's descriptions of the skull of an aardvark, and of the right hindleg and the skull of a giant kangaroo.[91] The simple recording of anatomical facts was not Pallas' main object. He used Camper's descriptions to support his refutation of Buffon's theory of faunistic difference between the old and the new world. Pallas thought, wrongly so, that Buffon considered the genera of ant-eaters and opossums as characteristic of America. His misunderstanding of Buffon's views arose partly from the vagueness of Buffon's concept of "genre". Pallas had read this as "genus". From the context it might also be inferred that it meant "species", a sense in which Buffon later used it explicitly for these animals.

In Pallas' opinion the incorrectness of Buffon's ideas was proved by the existence of the Cape ant-eater and the Asiatic opossum, the names commonly used at that time for the aardvark and the kangaroo. Camper did not take part in the controversy. He merely remarked that the Asiatic opossum is not identical with its American namesake.[92] He did not give an opinion on the classification of the aardvark. Pallas, nevertheless, considered Camper's anatomical findings as irrefutable proof of his previously published thesis[93] that aardvark and kangaroo belong to the same genera as the American ant-eaters and opossums.

The description of the giraffe skeleton was the last task of some magnitude which Camper performed for a colleague. It was Arnout Vosmaer, the director of the stadtholder's zoological garden and collection of natural curiosities, who benefited from it. As an author, Vosmaer became known in particular through a series of monographs on the rare animals from his employer's menagerie. In 1787 by way of exception a

treatise on a specimen from the museum appeared in this series. The animal in question was the giraffe, one of the more spectacular assets of the stadtholder's museum. Besides a dressed skin, it contained a complete skeleton, which was nowhere else in Europe to be found.

The anatomy of the giraffe had not been examined to any appreciable extent. Allamand had published a drawing of the skeleton,[94] but this was so bad that in this case Vosmaer, though usually not much interested in this subject, decided to involve also osteology in his work. Lack of expertise induced him to call in the assistance of others. At Vosmaer's request Camper's protégé, J.H. Merck, made a drawing of the skeleton. Camper supplemented Vosmaer's treatise with nine pages of "observations on the skeleton of the Camelopardalis."[95]

As the title already suggests, Camper did not make a complete description. The form and the arrangement of the parts of the skeleton had been pictured by Merck in an excellent way and were not discussed by Camper. In the "Observations" the emphasis is on quantitative data. Camper took great pains to determine the dimensions of a great many bony parts. In addition he made some stray remarks about anatomical particulars of the extremities and the skull. The widespread misconception that the forelegs are considerably longer than the hindlegs, among other things, was rectified by him.

Camper drew attention to the third horn, in the middle of the forehead, which is characteristic of the giraffe. It is curious that he did not draw any consequences from this for his criticism of Sparrman's suggestion that there exists a kind of unicorn in South Africa. According to Camper in such an animal the horn would have to be placed of necessity on the median suture of the skull bones. One of his reasons for rejecting Sparrman's assertion as an absurdity was that such a construction had not been observed in any horned animal.[96] The third horn of the giraffe refuted this argument, because it is actually situated on the median suture, as Camper himself had also clearly seen. The reason why he did not associate this ob-

servation with his criticism of Sparrman may have been due to the fact that he did not recognize the giraffe horn as such. In his specimen it was rather poorly developed and was no more than "a knotty excrescence".[97]

Posthumous publications

Camper left a voluminous scientific inheritance to his youngest son Adriaan Gilles. Apart from his museum, it comprised a great many manuscripts of a widely varied nature. With respect to both these elements Camper Jr. proved a worthy heir. He wrote an inventory of the museum and took great pains to publish as yet the writings drafted, but not published by his father.

In 1784 Merck asserted, during a stay at Camper's country seat, that

> "was öffentl. von ihm [i.e. P. Camper] erschienen ist, ist ohngefähr der 3te Theil dessen was noch vorhanden ist."

The suggestion that the rest "fertig in Mscripten und Figuren da liegt"[98] is unfounded as far as Camper's zoology is concerned. His inheritance, which has been preserved fairly intact, does not contain finished manuscripts of unpublished zoological books or articles. Camper had anatomized a great many more animals than he had published on. His portfolios contain a profusion of original data, but for the greater part in unedited form and not by a long way suitable for publication. The only material with which Adriaan Camper could do, and has done, something was that for monographs on the elephant and the cetaceans which were published in 1802 and 1820.

The foundation for the *Description anatomique d'un éléphant mâle* (1802) was laid by Petrus Camper himself in 1774. Early in that year a young Indian elephant died in the zoo of the stadtholder William V. As happened more frequently in such cases, he was allowed to dissect the dead body. Within three weeks he had completely anatomized the elephant, made a great many drawings and abstracted the principal literature. In the same year he published a brief account of the results in a journal in the Dutch language.[99]

Shortly afterwards he set to work to give publicity to his work outside the Netherlands. In July 1774 he sent, in two letters, the first part of a French article to the Parish anatomist Portal, for inclusion in the *Mémoires* of the Académie des Sciences. The committee assessing the letters, which consisted of Daubenton, Portal and Tenon, was of the opinion that they ought to be published together with the two letters which would form the second and last part of the article. Camper did not object to this suggestion but for unknown reasons sent only the third letter and never wrote the fourth.[100] The article therefore never appeared.

The Dutch article as well as that destined for the *Mémoires* of the Académie were intended as a preliminary description of the anatomy of the elephant. In the *Kort berigt* of 1774 Camper announced

> "that he would give a complete description of all the parts which it is necessary to know or which may be of influence in elucidating the anatomical descriptions of the Ancients and later writers."[101]

Camper evidently for a long time had no opportunity to work at the realization of this plan. He collected indeed data on other specimens, but it was not until the second half of 1786 that he resumed the preparatory work for his book on the elephant. The nucleus of it was to be formed by 20 folio plates with a total of 95 illustrations. Twelve plates had already been engraved. The completion of the remaining eight became a time-consuming affair, partly owing to pressure of work on the part of Reinier Vinkeles, the engraver. It was not until early in 1789 that the last engraving was finished. Meanwhile Camper had made the explication of the illustrations ready for the press. However, he was not able to do any more. A few months later he died.

Adriaan Camper looked upon it as his duty to complete the project on which his father had worked for such a long time. The illustrations were ready for use. However, there was not yet any text. Camper Sr. had not got beyond the stage of collecting abstracts from the literature and drawing up a division into

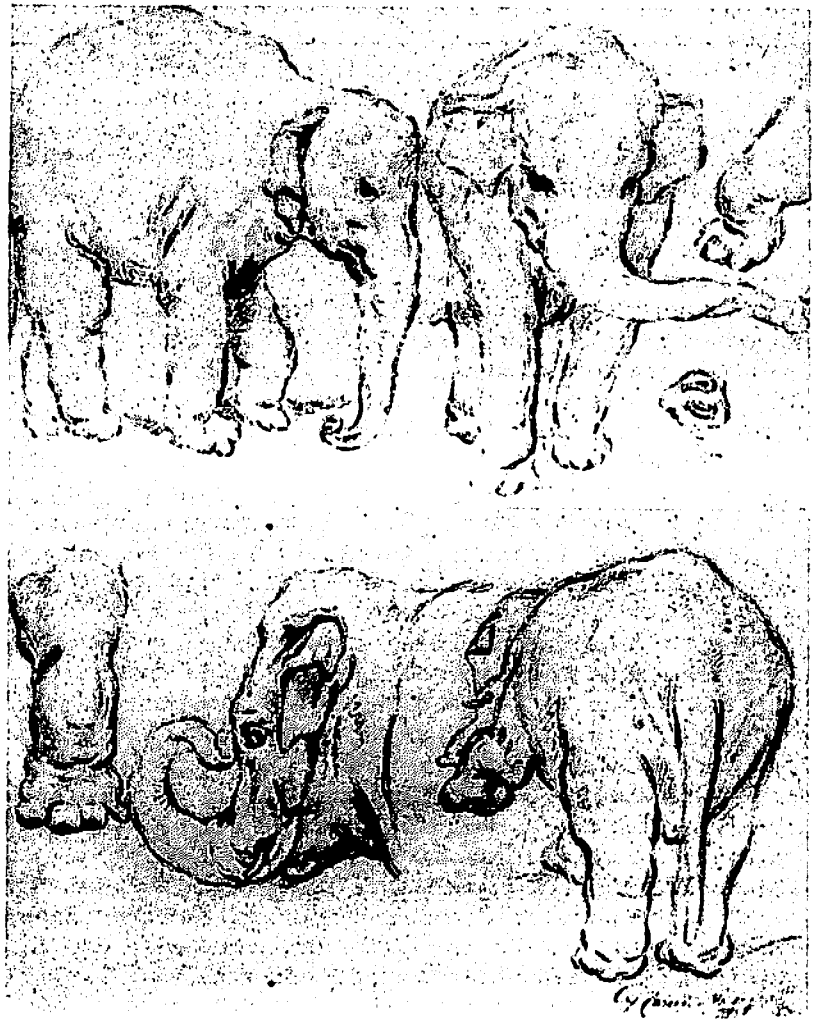

Fig. 7. Crayon-drawings of a young Indian elephant

chapters. Adriaan Camper, an amateur in the field of anatomy, did not find it easy to fill the gap. With the aid of the information obtained from the illustrations, the *Kort berigt* (1774), and the unfinished French article he ultimately succeeded reasonably well in rendering the results of his father's work. The sequence in which he treated the various parts is the same as that which Camper Sr. had used for the drawings. The anatomical description, where his contribution as to the substance was minimal, was enlarged by Adriaan Camper with two chapters, entirely by his own hand. In these he gave an exposition on the different species of elephants, both living and fossil, and on the geographical provenance of the fossil species.

The treatise on the elephant is Camper's most detailed anatomical species description. In the case of other animals he left certain aspects out of account, often from sheer necessity. With respect to the elephant Camper was able to complete almost the entire programme as it was handled everywhere in eighteenth-century zootomy. Successively he described the outward appearance, the organs of the abdominal, the thoracic, and the celebral cavity, the skull, the vertebrae, the ribs, and the legs.

Camper was not the first to examine the anatomy of the elephant. Moulin, Perrault, and Blair, amongst others, had preceded him.[102] Camper had thoroughly studied the literature, and in his own description placed the emphasis on those parts of the elephant anatomy on which his predecessors differed from each other and on those which they had overlooked.

The controversial issues Camper dealt with usually concerned minor details, such as the position of the nipples, the hairs on the eyelids, the structure of certain parts of the male reproductive organ and the number of toes. In retrospect we may establish that apart from a few exceptions[103] Camper was in the right on these and other controversial points.

The question as to the identity of the tusks was Camper's greatest problem. From of old they had been regarded as horns. Daubenton had suggested the incorrectness of this interpretation. He pointed out that the tusks are placed in the same bony part (the

os intermaxillare) as the incisors in other quadrupeds. He cautiously concluded from this that the tusks are also teeth. Camper made observations similar to those of Daubenton and reasoned along the same lines. He proclaimed with greater confidence than his French colleague that the tusks are not horns, "but teeth, because of the bone".[104]

Initially Camper had called them teeth and had not ventured a more precise identification. He did so only a few years after the *Kort berigt* (1774) had been published and then designated the tusks as canine teeth.[105] He changed his mind after he had examined the problem together with Merck in 1784. On the basis of their regular position in the upper jaw he now defined the incisors topographically. His final conclusion, which he also gave in the *Description* (1802), was that the tusks must be called incisors "quia in intermaxillaribus ossibus sedem habent".[106]

Camper's elephant research produced many new data, inter alia on the osteology of the extremities, on the structure of the skull and the brain, and on the musculature and the innervation of the trunk. The most important discovery dated from after the publication of the *Kort berigt* (1774) and concerned the structural differences between the molars of the Asiatic and the African elephant. Camper traced this phenomenon during his last stay in London (1785), when he first studied an African elephant, in the British Museum. Upon returning home he verified his findings and soon concluded that the molars of the African and the Asiatic elephant are composed of lamellae, of which the number and the shape of the crown differ. These differences appeared to be constant, which meant for Camper that the animals must be regarded as two different species.

Camper has never given much publicity to this discovery. He only informed some of his colleagues and friends, as for instance the French zoologist Vicq d'Azyr.[107] It was in particular Blumenbach who advertised Camper's discovery of the specific difference between the African and Asiatic elephant. He did so without mentioning Camper's name. Considering their regular contacts and the fact that Camper sent him drawings of the elephant it seems quite justified to

endorse Adriaan Camper's statement that Blumenbach got his arguments for the distinction of the two species from Camper Sr.[108]

The full scope of Camper's contribution to the natural history of the elephant was only realized by the scientific world through the *Description* (1802). The work had been superseded to some extent by Cuvier's osteological description of the elephant, which had appeared a few years earlier.[109] But owing to the fact that Camper had described more than the skeleton his book was by no means superfluous. Its specific value was to a large extent determined by the illustrations, which through their number and quality left all earlier attempts behind and which were referred to by E.O. Schmidt as "eine klassische Grundlage für die gröbere Anatomie der Proboscideen".[110]

The *Observations sur la structure intérieure et le squelette de plusieurs espèces de cétacés* (1820) was the other zoological work of his father which Adriaan Camper published posthumously. When in 1774 Camper Sr. began to study the auditory organ of the cetaceans, his attention soon extended to other parts of their anatomy. In Camper's time the cetaceans were among the least known vertebrates. The opportunities which this group presented for engaging in original research greatly stimulated Camper to concern himself with the cetaceans.[111] In particular owing to the absence of suitable material the work made only slow progress. After he had been able in 1775 and 1778 to enlarge his knowledge of more ordinary species, such as the porpoise and the dolphin, with observations on the skull of a young baleen whale and of a cachalot, it occurred to him to devote a publication to this group of animals.

At first this was intended to form part of the second volume of the *Natuurkundige verhandelingen*.[112] Camper changed his plans when through the intermediary of the Prince de Gallitzin he learned that Buffon wanted to write a book on the cetaceans together with him.[113] Without hesitation Camper agreed to this attractive proposal. In 1785 he sent his son with a great many drawings to Buffon in order to work out the plans in detail.

Buffon highly commended Camper's observations. It was no doubt very disappointing for Camper to learn at the same time that on account of his advanced age Buffon on second thoughts abandoned the plan of the publication.[114] Six months later, early in 1786, he was found to have changed his mind, and Adriaan Camper was able to inform his father that Buffon was prepared as yet to proceed with the work.[115] Camper at once set about correcting the illustrations, supplementing them, and adding an extensive explication, which his son translated into French. He assumed that Buffon would write the book and considered himself only as the person who was to supply the facts. Buffon would weld his data into a whole and "mettre au jour les rapports qui s'y trouvent". Since Camper did not have all the relevant literature at his disposal, he requested Buffon moreover for a critical survey of what had been written on the cetaceans.[116]

Buffon, who was approaching eighty, evidently no longer considered himself capable of undertaking such a share in the book on cetaceans. It was soon made clear to Camper that Buffon had in mind a different division of the work. It appeared that he was not at all prepared to concern himself with the content, but wished to take care exclusively of the style.[117] All these complications came to an end when shortly afterwards Buffon definitively withdrew from the project.[118] Daniels' suggestion that this was due to a downright conflict is unfounded. The explanation of Adriaan Camper that Buffon took his decision because his health was failing appears quite plausible.[119]

After Buffon had withdrawn, Camper continued the work alone. He completed the illustrations, the greater part of which had been engraved by De Sève at Buffon's expense. He did not live to write the text proper. Apart from a number of quotations from the literature and the articles on the auditory organ, he left no more to his son but a brief exposition in which he compared the skull of whales with that of man.[120] The text ultimately produced by Adriaan Camper was a summary of the findings which had been embodied in the illustrations. In separate chapters eight different cetaceans were thus described.[121] Adriaan Camper's own

contribution was confined to a short description of the orca and a few observations on the general features and the taxonomy of the cetaceans, for which he borrowed the data from his father's research and from recent literature. Camper Jr. also tried to give scientific names to the species studied by his father. He did not succeed in a satisfactory way in all cases. Cuvier, who at his request annotated the *Observations*, had to correct him on several points.[122]

The skull was the main object of Camper's research on cetaceans. Not only because plenty of skulls were available to him, but undoubtedly also because this was one of the more mysterious parts of cetacean anatomy. Various zoologists had paid attention to it, but in a rather superficial way.[123] No one yet had given a detailed analysis of its components. Considering the exceptional shape of the skull of the whale, this is not incomprehensible.

Camper, however, succeeded in unravelling the structure of the skull. His success was not only due to his considerable skills as an anatomist; he moreover had the advantage that in the majority of his preparations the sutures were still visible. With the openings for the sense organs and the occipital hole as fixed points of reference he was able to establish accurately the form and the position of the skull bones in seven species. For the common rorqual he had to confine himself to a rough sketch; the only complete skeleton he had found was suspended from the ceiling of the Bremen town hall and consequently could not be studied in detail.

Whilst up to that time it had appeared as if the cetacean skull defied any comparison, Camper was the first to show that it is composed of the same elements as the skulls of other mammals and does not essentially differ from them.[124] Merck's description of the cetacean skull[125] antedates Camper's publications but distracts nothing from the latter's merits. Merck started his investigations after Camper had finished his cetacean studies. Moreover, Merck's work was based on specimens in Camper's museum and executed under his guidance. It is safe to assume that Merck owed a lot of his knowledge of the cetacean skull to Camper.

Camper was of course at pains to study more than the skull. In this he succeeded only partly. Like other workers in this field, he was up against a great dearth of objects for his research. The description of the porpoise is the only one which can claim completeness. The anatomy of the other species, with the exception of the skulls, could be described by him only in a fragmentary way.[126]

When Camper completed his cetacean studies in 1786, he had managed to add an almost entirely new chapter to natural history. Of the species described by him the porpoise was the only one that was reasonably well known. Although the *Observations* (1820) appeared more than thirty years after the actual research had been finished, Camper's work had not lost much of its originality. John Hunter, Lacépède, and Cuvier had meanwhile enlarged the knowledge of cetacean anatomy, but they had not entered into large-scale competition with Camper.[127] Cuvier was the only one who studied the osteology intensively. His object, however, was comparative anatomy. He discussed the isolated bony parts and did not give a coherent description of the skeleton, as Camper had done in particular with the skull. The *Observations* was consequently the first work which gave a clear insight into the structure of the skull of a number of cetaceans.

Physiology

Introduction

Physiology, the study of the vital functions of the animal organism, has sprung from medical science and for a long time belonged to its exclusive working domain. Man was considered to be its ultimate objective. This aim found its expression in terms like "theoria medica" and "oeconomia hominis" which were used as synonyms for the science of animal physiology.

Physiological research on animals at first did not form an objective per se but was regarded as means for understanding the functions of the human body. In the course of the eighteenth century this view lost its sway and animal physiology formally attained independence. The French zoologist Daubenton was one of the first to put forward the opinion that the study of the "économie animale" ought to be part of natural history.[128]

Camper took a similar view. For him, too, animal physiology had a reason of existence beyond medicine. He recognized its usefulness for medical science when he wrote Forster that

> "Nous devons éclaircir, s'il y a moyen, l'usage des parties de notre corps par celle des autres animaux..."[129]

but considered it legitimate to study it for its own sake as well. In one of his spectatorial essays he propagated the idea that the zoologist should investigate not only the internal structure, but also the vital functions of the animals.[130] Camper did not confine himself to this plea. In a modest way he did physiological research.

Physiological investigations

Camper started his career as a zoological publicist with a treatise "on the reproduction of the American toads or pipae" (1761). This article owed its origin to two specimens with which he had been presented in 1758 and which confronted him with the phenomenon characteristic of these animals that the female carries the young on her back during their metamorphosis.

The literature taught Camper that it was unknown how the reproduction of these animals takes place. Maria Sibylla Merian, who had made the Surinam toads known in Europe, regarded the breeding cavities as uteri and thought that the eggs, after being fertilized in the abdominal cavity, get into the breeding sacs via the skin. Frederik Ruysch had called this interpretation in question because he had not discovered a single trace of a direct communication between the abdomen and the breeding cavities on the back. Ruysch offered no answer to the question of how reproduction takes place.[131] Camper was the first who made a serious attempt to solve this problem.

He started from the assumption that in the toads of South America reproduction does not proceed in an es-

sentially other way than in the related animals living in the Netherlands. In order to test his hypothesis, Camper dissected one of the female pipae and compared its internal structure with that of indigenous frogs and toads. The structure of their sexual organs was found to be identical. This proved to Camper that in toads and frogs "reproduction takes place in the same way". His conclusion was that in the pipae, as in the other species, fertilization takes place outside the body. He could thus reject a process such as sketched by Merian. However, Camper unravelled the reproductive process of the South American toads only partly. The intriguing question of how the eggs migrate to the back had to be left unanswered. The solution of this inscrutable mystery, as he called it, could not be deduced from the anatomy.[132]

An incidental effect of the above-mentioned work was a small piece of research on the croaking of frogs.[133] Camper had compared the anatomy of the pipae, with that of frogs as described by Swammerdam in his *Bijbel der Natuure* (1737-1738). It struck him that his compatriot had situated the vocal sacs of the male frog in another place than he himself had observed. This induced Camper to examine the external position of the vocal sacs more carefully. He seized the opportunity to study at the same time the mechanism of the sound production. On the ground of his anatomical findings he contended that the vocal sacs cause the croaking sound by forcing the air vigorously into the oral cavity. Camper's research was incidental work, to which he did not devote much time. He based his interpretation on a fairly superficial examination, a thing of which as a rule he was not guilty. It is therefore not surprising that we have to ascertain that his interpretation is wrong. Camper had studied only the oral cavity and, curiously enough, had omitted to ask himself whether frogs also have vocal chords, which he knew to be in general responsible for the production of sound.

The reproduction of South American toads and the croaking of frogs decidedly were not among the main physiological themes of Camper's time. They were subjects in which only few scientists were interested. As

regards the next subject of his physiological research, the hearing of fishes, the situation was quite different. Before Camper, a great many scientists had concerned themselves with this subject. They were prompted to do so by the question as to whether fishes can or cannot hear. This problem largely went back to Thomas Willis, who, against the prevailing opinion, had denied that fishes can hear, because in his view they had no auditory nerve.[134] G. Seger, P. Artedi, C. Linnaeus, and W. Arderon were among those who put forward the same standpoint as Willis, although on different grounds. Others, such as J. Ray, J.T. Klein, E.L. Geoffroy, and J. Baster, on the contrary, thought that fishes can indeed hear, although not all of them ventured to assert this with equal confidence.[135] In spite of the exertions of these and various other scientists there was as yet no satisfactory solution for the problem when around 1760 Camper became involved in it.

Camper's interest in the hearing of fishes was closely connected with the research which he had started in his student days and which had to result in a monograph on the auditory organ in all classes of vertebrates. In addition his interest had received a formative influence from an article by Nollet.[136] In this article it was proved experimentally that water may conduct acoustic vibrations. This led Nollet to suggest that fishes may be quite capable of perceiving sound. Nollet's request to verify this assumption was mentioned by Camper as the direct motive for his studies on the sense of hearing of fishes.[137]

Camper seems never to have doubted that fishes can hear. The aim of his work was to prove this unambigously. He shared Nollet's view that it was first of all necessary to establish the presence of the auditory organ, and that subsequently "the probable way in which the scaly fishes perceive sound in water" had to be indicated.[138]

As usual, Camper tried to base his conclusions on a broad empirical foundation. He did not confine himself to a single species, but examined several bony and cartilaginous fishes. His first step, in the anatomical analysis, was the description of the brain. This

did not have much to do with the real subject, but Camper did not wish to omit seizing the opportunity to publish a few details about this organ, since most zootomists had dealt only superficially with this part of the anatomy of fishes. He studied in particular the cranial nerves. The number, origin, and path of these nerves were found to resemble those of the other vertebrates to a striking degree.[139] It was naturally of direct importance to establish the presence and the path of the auditory nerve. In contrast with Willis' assertion, Camper discovered that it is an "extremely conspicious nerve". For a statement on whether fishes can or cannot hear this was an indispensable datum. In fact, an essential factor in the functioning of the sense organs was that the external stimuli are transferred via the nerves "to the soul, with which all animals without exception are endowed".[140]

The structure of the auditory organ was studied in great detail by Camper. He even used a magnifying glass - an instrument that was not very widely used in eighteenth-century zootomy - so as to follow the ramifications of the auditory nerve. His description comprised the position of the auditory organ, the innervation, and the form and position of the main parts, viz. the three semicircular canals, the endolymphatic canal, and the "cartilaginous bone" (i.e. utriculus and sacculus which Camper did not recognize as separate parts) with the otoliths.[141] Camper gave a clear insight into the structures with which fishes can perceive sound, and thus had satisfied Nollet's first requirement.

The current theories on hearing were not much use to Camper for an answer to the question of how the sound perception in fishes takes place. All these theories related to terrestrial animals and presupposed an auditory organ which is in direct communication with the outside world. In the fishes, however, this organ was completely enclosed by the cranial cavity, and consequently it was necessary to find first of all a route by which acoustic vibrations could reach it. Some naturalists thought that cartilaginous fishes did have an external auditory canal, but Camper rightly argued that what was taken for it (the spiraculum) had

nothing to do with the ear.[142] The fact that aerial vibrations can also be imparted to solid objects and are, for example, able to stimulate the human ear via the skull bones suggested to Camper a possible way in which sound may be perceived by fishes.

He wondered

> "whether the vibration of the water ... can be imparted to the head or skull of fishes, and whether the freely suspended bone or bones in the capsule will not be set moving thereby? whether, when these are set moving, the auditory nerve will not be affected in special ways and the vibration will be felt, that is to be heard by the scaly fishes?"[143]

Camper's choice of the otoliths as the proper instrument of hearing was obvious. The semicircular canals were his only alternative. Although, in view of their general occurrence, these were considered to be of essential importance for hearing, there was no clear notion of the way in which they functioned. As to the otoliths, however, it was fairly easy to see how they might react to acoustic vibrations. The fact that the space in which they are situated receives a great many fine ramifications from the auditory nerve reinforced Camper's surmise that the otoliths constitute the vital element of the auditory organ of fishes.

Camper verified his theory by examining whether solid bodies in a situation analogous to that of the otoliths, i.e. more or less freely suspended in a space filled with a fluid substance, can be stirred by vibrations of their surroundings. To this end he stepped on a frozen ditch, thumped with his fist on the ice, and noticed

> "that as far as I could see, the grass and other loose plants moved to and fro in proportion to the shock I produced."[144]

From this simple experiment Camper drew the conclusion that in all probability fishes perceive sound, in their case "the vibrating motion in the water", via the skull-cap, the fluid in the cranial cavity and the sacculus and the utriculus, which in turn set in motion the otoliths therein, which cannot "be affected

without the beautifully stretched auditory nerve being necessarily susceptible to it".[145] Thus Nollet's second question had been answered, and Camper thought, not unjustly, that he had rendered it plausible that fishes can indeed hear.

The work of Geoffroy (1755), Camper (1763, 1774), and Koelreuter (1773) put an end to the controversy concerning the sense of hearing of fishes.[146] They demonstrated unequivocally the presence of an auditory organ. This was considered convincing evidence that fishes can actually hear. Geoffroy and Koelreuter each had confined themselves to a single species and had not tried to generalize their findings. Camper, however, had dissected several species and clearly brought out that, but for variations in the number of otoliths, he regarded the results of his investigations as representative for the class as a whole. Further he may be credited with having been the first to propose a theory on the functioning of the auditory organ of fishes. The contemporaries of Geoffroy, Koelreuter and Camper were impressed most by the latter's work. The German anatomist Wrisberg considered Camper as the one who had conclusively shown that fishes can hear.[147]

The treatises on the reproduction of the pipae, the croaking of frogs, and the sense of hearing of fishes are Camper's main publications on animal physiology. His other activities in this field are not very voluminous and in general of a rather incidental nature. The results are scattered in different places in his zootomical writings. It was due to accident rather than purposive planning that Camper occasionally added a functional analysis to the anatomical description. He did so in particular when on the ground of his anatomical research he thought he was able to correct certain current functional notions on, e.g., the copulation of elephants and rhinoceroses and the way a newborn elephant is suckled.[148]

Camper's study of the functional aspects of the animal organism primarily arose from the direct question as to how certain organs perform their function. His finalistic view of nature was another incentive for physiological research. Camper occasionally discovered

new structures, and then he was inevitably faced with the traditional question as to the why and wherefore, the final cause of those structures, questions which could only be answered by the determination of their function. Although Camper said himself that he was obsessed by the tendency to assign a useful function to everything, in some cases he took little notice of the fact that he was unable to do so. As a rule this concerned details, such as the glands in the hind leg of the reindeer.[149] He took greater pains over functionally more striking phenomena, e.g. the hollow bones of birds.

Of the questions raised by teleology Camper devoted most attention to the functional explanation of the tail in the young South American toads. In other species of toads and frogs, where this organ, which disappears in the course of the metamorphosis, also occurs, it clearly served locomotion. The young pipae, on the other hand, are practically motionless in the breeding sacs and their tail appeared to be completely superfluous.

At first Camper thought that the tail was to be considered as fortuitous, as a freak of nature.[150] During a personal interview Blumenbach had little difficulty in convincing him that this was an error. Camper's own observations subsequently made him realize that the presence of the tail is indeed a natural phenomenon. The function of this rudimentary organ remained altogether unknown to him. He had no observations on living animals and did not like to indulge in guesswork. His confidence in the efficiency of nature, however, was so great that he did not doubt but the tail of the pipae did serve a useful purpose, although he did not know as yet what it was.

Limitations of Camper's physiology

Well into the nineteenth century anatomy was considered indispensable to physiology. It was a communis opinio that physiological knowledge can only be derived from anatomical facts. Camper was an out-and-out representative of this approach. In the preceding paragraph we have seen that dissection was always the

starting-point and the principal tool in his attempts to determine the function of certain organs.

In the eighteenth century the anatomical method was linked with a mechanistic view of life. The guiding principle of this view, which dominated physiology, was that the function of an organ could and should be accounted for by its mechanical construction. This construction was seen as analogous to a piece of machinery. Camper's physiological thinking was marked by this mechanical philosophy. In one of the theses added to his philosophical dissertation he stated that the circulation of the blood can only be understood and explained with the aid of hydraulics and hydrostatics.[151] Later he put forward similar ideas in particular in his lectures. He repeatedly pointed out to his students that knowledge of physics and mechanics is absolutely necessary to gain an insight into the functioning of organisms.[152]

It is to be noted that Camper's mechanicism did not imply the identification of animals with machines. Like the majority of the scientists and philosophers of the Enlightenment he dissented absolutely from the idea propagated in particular by Descartes that animals are "mere mechanical beings". Observation taught something quite different.

> "[Their] activities, ... their judgment, memory, hatred, love, thirst for revenge, and ... other passions"

according to Camper were evidence that animals also have "an active principle which can no more be material than our soul". He derived another argument for this thesis from the fact that animals possess sense-organs which obviously perform the same function as those of man, viz. the reception of notions of external objects. Since the soul was considered indispensable in this process, Camper concluded that animals have an immaterial soul, "though less perfect than ours".[153]

As a physiologist Camper worked not without results on, among other things, the reproduction of the South American toads and the hearing of fishes. He was less successful in the matter of nerve transmission.

In the first volume of the *Demonstrationum anatomico-pathologicarum* (1760) Camper made an attempt to explain this phenomenon. The Galenic spiritus-theory was rejected by him, as well as the conception that nerve action is analogous to the vibration of strings. Like Boerhaave, amongst others, Camper endorsed the atomistic-mechanistic version of Galenus' theory. He conceived the nerve as a hollow tube filled with very small globules of a substance like that of ivory. These globules conduct the impulse along the nerve by means of collisions. Camper regarded this as the most plausible explanation of nerve transmission because it accounted for the rapid rate at which this process is found to take place.[154]

He was aware of the defects attaching to this theory. At another occasion he had already pointed out its rather insufficient empirical foundation. The conception of the internal structure of the nerves was nothing but a conjecture.[155] Ultimately this proved to be decisive for his views. Three years after the *Demonstrationum* Camper gave as his final conclusion that the mechanism of nerve transmission is unknown.[156]

He took a similar position with respect to the problem of embryogenesis. Camper was greatly impressed by the arguments which Albrecht von Haller had advanced in support of the preformation theory. However, von Haller's arguments were unable to take away his persistent doubts. This would only be possible if the miniature organisms supposed to be present in the ovum or the spermatozoon could actually be observed. Only then "indeed, being completely convinced, could we be able to refute and solve all objections". Since this had not yet happened, he considered the theories on embryological development as a "maze from which one cannot escape".[157]

In both cases, the functioning of the nerves and embryogenesis, Camper rigorously subordinated the mechanistic interpretation to the ideals of empirical science. In a functional analysis he wanted to involve only those elements of which anatomical dissection had established their existence. In an era in which empiricism was the key-note this would seem to be an obvious procedure. However, by no means all physiologists who subscribed to the mechanistic view shared

Camper's approach.

The mechanical model used by eighteenth-century physiologists was to a large extent imaginary. It was effective with respect to e.g. the circulation of the blood and locomotion, but failed to explain the functioning of the brain, glandular secretion, or ontogenesis. With the mechanical model one could only account for these processes with the aid of all sorts of hypothetical structures, such as e.g. the minute globules in the hollow nerve tubes.

Numerous eighteenth-century physiologists appeared not to have had any difficulty at all in accepting such a speculative method. Camper at first did not wholly reject it, but he soon dissociated himself from it. From that time onwards he always adhered in his physiology to the strict limits set by observation. This cautious attitude explains why, despite the importance he attached to physiology, he did not deal with what in his time were considered the major problems in this field, which included the action of the muscles, respiration, digestion, and embryogenesis. A warranted mechanical analysis of these functions was impossible owing to the lack of the necessary anatomical knowledge of the finer structures of the organs involved in these processes. Since he had no alternative model, Camper preferred to leave these subjects alone rather than resort to speculative theories.

Chapter III

THE ORDER OF THE ANIMAL KINGDOM

Camper and systematics

In the preceding chapter, we have seen that Camper attached great importance to the analysis of the anatomical structure of little known animals. He regarded this as an absolutely indispensable activity. It was, however, not the only objective of his zoological research. Species were not isolated entities. They were related to each other and Camper considered it his task to elucidate this matter as well:

> "mon grand but étoit d'étudier constamment les rapports que les animaux ont entre eux."[1]

In Camper's day the view prevailed that systematics was the key for understanding the relations in the organic world. Linnaeus was the principal and most influential enunciator of this view. In his *Philosophia botanica* (1751) he had qualified the "dispositio" and the "denominatio" derived from it, as the basis of botany.[2] The successful way in which Linnaeus applied his ideas in botany raised the prestige of taxonomy and had a formative influence on the development of zoological systematics.

Botanists as well as zoologists practised systematics from the firm belief that living creatures are arranged in a knowable way. In general it was realized that the existing classifications did not yet give a true picture of the real arrangement. Although there was by no means a consensus as to the method to be followed, it was not doubted that the natural affinity between living organisms could be discovered and laid

down in a system of hierarchically arranged taxa. The natural system was the great ideal of the eighteenth-century systematists and the legitimization of their scientific activities.

Systematics did not meet with universal approval in the eighteenth century. Its aims and methods were severely and fundamentally criticized by Buffon. He contended that a classification based on a single characteristic which had been designated a priori as essential, does not reflect the natural order but one which exists only in the human mind. In his view a classification conceived in such a way could never result in true knowledge of nature:

> "vouloir juger de la différence des plantes uniquement par celle de leurs feuilles ou de leurs fleurs, c'est comme si on vouloit connoître la différence des animaux par la différence de leurs peaux ou par celle des parties de la génération; & qui ne voit que cette façon de connoître n'est pas une science, & que ce n'est tout au plus qu'une convention, une langue arbitraire, un moyen de s'entendre, mais dont il ne peut résulter aucun connoisance réelle."[3]

Buffon illustrated the inadequacy of the Linnaean method by reference to the sub-division of the quadrupeds. In the first editions of the *Systema naturae* this class was divided into five orders, which were characterized by the number of legs, teeth, and nipples. Buffon had little difficulty in showing that these were perfectly arbitrarily chosen characteristics, which did no justice at all to numerous other similarities and differences between the quadrupeds. If Linnaeus had used other criteria, quite a different classification would have resulted.[4]

Besides attacking the methodology of the systematists, Buffon also objected to their conception of the ontological status of the taxonomic categories. The systematists assumed, often tacitly, that genera, orders, etc. actually exist. As against this assumption, Buffon took a nominalistic position; he denied the reality of the taxonomic universals. He regarded individuals, and later species, as the only entity existing in nature. The other categories were mere

mental abstractions:

> "plus on augmentera le nombre des divisions des productions naturelles, plus on approchera du vrai, puisqu'il n'existe réellement dans la Nature que des individus, & que les genres, les ordres & les classes n'existent que dans notre imagination."[5]

Buffon's criticism implied that taxonomy could never give a blueprint of nature. He considered the classification of plants and animals useful as a means "dont on est convenu pour s'entendre"; it could never have any other reason for existence.

The eighteenth-century naturalists on the whole took little notice of Buffon's ideas. They ignored his criticism, ridiculed it or parried his views with the traditional justifications of systematics. Although Buffon did not incite a large-scale discussion on the fundamental principles of biological classification, we may ascertain, without suggesting a causal relation, that after him similar objections were raised by some other naturalists. Camper was one of them.

When in his student days Camper entered the field of natural history, he was interested not only in zootomy, but also in botanical taxonomy. It was in this same period that Linnaeus' ideas started to attract attention. Camper's teacher, Adriaan van Royen, and his mentor, Johannes Fredericus Gronovius, were among the first and more prominent followers of the Swedish naturalist.[6] It was no doubt partly through them that Camper concerned himself rather intensively with Linnaeus' botanical classification. He was apparently not interested in its theoretical aspects. It is remarkable that the thesis on the unknowability of the essence of living creatures[7], advanced in his philosophical dissertation, did not induce Camper to criticize Linnaeus who had emphatically asserted that the essence of plants and animals can be discovered and who had based his taxonomy on this conviction.[8]

Camper testified to his taxonomical interests in his medical dissertation. In the accompanying theses he revised Linnaeus' classification of a number of plant species. He also expressed his agreement with the principle of Linnaeus' sexual system. Camper observed

that the leaves of plants, like the reproductive parts, have immutable characteristic properties and consequently can also be considered as a classification criterion, but he held nevertheless that a classification on the basis of the reproductive parts is much to be preferred. He regarded this as the best criterion hitherto used.[9]

Camper did not confine himself to verbal expressions of his interest in Linnaean botany. The frequent botanizing trips undertaken by him in his youth indicate that he also applied himself to the practice of systematic botany. All taken together there is every reason to assume that Camper was fairly proficient in Linnaean systematics.

The assertion of Stöver that Camper introduced Linnaeus' botanical system in England and demonstrated there "wie man nach Linné's Idee Pflanzen examiniren müsse"[10], should not be left unrecorded in this context. It is by no means impossible that Camper made this contribution to the dissemination of Linnaean botany. During his stay in England, in 1748-1749 and 1752 respectively, when Linnaeus' work was hardly known there, he set out several times to collect and study plants in the fields accompanied by English friends and colleagues.[11] It is very likely he put his knowledge of Linnaeus' system and method into practice at these occasions. It cannot be established with certainty whether Camper really played the part which Stöver assigned to him. The origin of Stöver's statement is rather obscure and confirmation from other sources is lacking.

Camper's esteem of Linnaean systematics did not last long. After he had left London, he soon became a severe critic of Linnaean natural history. A first sign of his dissension from Linnaean systematics is to be found in a treatise on liver-rot dating from 1763, in which he observed incidentally that Linnaeus is too superficial and too variable in "all his works, which merely constitute a register of the names of created things".[12]

One year later Camper gave a more elaborate exposition of his opinion on the significance of botanical classification in the *Oratio de analogia inter animalia et stirpes*.

In this inaugural lecture he gave an outline of plant physiology by comparing the vital functions of plants with those of animals. It was his aim to make it clear that those who had engaged in research in this field, to wit the anatomists, ought to be regarded as the true botanists. Whereas Linnaeus had reckoned the anatomists among the group of the "botanophili", whom he considered to be of marginal importance for the progress of botanical science,[13] Camper held

> "that the nature and structure of the plants, ..., have been discovered not by the herbalists [i.e. the systematists], but by the anatomists, and that for this reason Malpighius, Grew, Hales, Leeuwenhoek, and Hook have to be counted among the first botanists."[14]

According to Camper, the other botanists had become known only by "making lists of names of plants and classifying them into species, genera, and orders".[15] In terms not to be misunderstood he intimated his opinion about this activity.

> "O ridiculous science, which confines plants to garden plots and beds and which titillates itself with high-faluting Greek words, which are to frighten one, ... What is one to think indeed of the conceit of the botanists of our age, who hide and disguise their ignorance in ... grand terms ... and ... learned jargon?"[16]

In the *Oratio* Camper left it at these attacks. In the course of his lectures he informed the students of one of the reasons, the most fundamental one for that matter, for his critical attitude towards systematics.

In his botanical teaching Camper deliberately emphasized the anatomy, the physiology and the medicinal virtues of plants. However, he also paid attention to plant classification, particularly to that of Linnaeus. Camper was enough of a realist to recognize that he could not leave the prospective physicians in the dark about the influential ideas of the Swedish botanist. Without a trace of the causticity that was typical of the passages on systematics in the *Oratio*, in his lectures he gave an excellent summary of Linnaean botany. Thereby not refraining from making it

quite clear what value he attached to it.

In the discussion of the taxonomical categories Camper admitted the reality of the species. Without mentioning his source, he quoted with approval, in a slightly changed form, Linnaeus' famous aphorism: "Species tot numeramus, quot diversae formae in principio sunt creatae."[17] With respect to the status of the genera Camper disagreed with Linnaeus.

Linnaeus assumed that the genera distinguished by him had been created as such.[18] The naturalness of the genera was the cornerstone of his nomenclature and classification. Camper conceded that some of Linnaeus' plant genera gave the impression of being natural. However, he also found a great number of genera in which species had been brought together which appeared to have little, if anything, in common. Camper suggested that the characteristic used by Linnaeus for the definition of the genera was not very suitable for expressing the natural relations.[19] The constant changes in the arrangement of plants and animals strenghtened his idea that the criteria for classification were not in conformity with nature.[20] Apparently Camper had no alternative criteria to offer. He pointed out to his students that in consequence of the pluriformity of nature the limits of the genera cannot be established.[21]

This conclusion implied that nomenclature, for which the generic name was of basic importance, did not have for Camper the objective value which Linnaeus attached to it. In Camper's view a name was no more than pure convention. Later he expressed this tersely when he concluded a discussion of the confusing nomenclature of apes and monkeys by professing his agreement with

> "the lesson of *Plato* ... rightly impressed upon us by *Galenus* ... of preferring to leave aside the names, and first and principally to apply ourselves to the knowledge of things themselves."[22]

The impossibility to determine the limits of the genera had another and more far-reaching consequence. If the natural genera could not be discovered, the same also held for the higher taxa which were all formed with the aid of the genera. Camper realized this consequence very well. When he asked himself the question what order had been established in the creation of the vegetable kingdom, he replied that it is impossible to ascertain the natural classification of the plants.[23]

Although he hardly emphasized the difference of opinion it becomes quite clear from Camper's botanical lectures that he did not share Linnaeus' appreciation of nomenclature and classification. In contrast with Linnaeus he did not consider systematics capable of really fathoming nature. Linnaeus' claim for its central position in natural history was for Camper without any foundation. He looked upon genera, orders and classes as artificial collections of species. He recognized their usefulness but did not regard them as indispensable. Classification and nomenclature were nothing but devices to facilitate the memorization of the names and the forms of the organisms.[24]

Camper's standpoint that the organic world consists of species and nothing else agrees with that of Buffon but seems to have had a different background. In the spirit of classic nominalism Buffon had denied the existence of entities above the species level. Camper's ideas did not have such a metaphysical foundation but originated from epistemological considerations. He did not reject a priori the reality of the genera, orders and classes. Camper only assumed that the arrangement of natural productions into a hierarchy of taxa is one of those matters which are beyond the scope of empirical science.[25]

Unlike Buffon, Camper did not bring to the forefront his nominalistic view of systematics. Apart from his lectures at Groningen University, he only gave expression to it, though in a very indirect way and before a small audience, as a member of the jury for a prize contest on the chain of being.[26]

Of the essays to be reviewed, Camper considered that of the Swiss-English polyhistor J.A. Deluc the best. He had read it "with great pleasure and acclaim ... and held the author to be worthy of being awarded the prize."[27] Camper's enthusiasm was no doubt inspired to a considerable degree by Deluc's nominalism which was one of the cornerstones of his refutation of the principle of continuity. Deluc argued that species are the

sole knowable entities in nature and that the other taxa are merely products of the human mind. Since the various species could be clearly distinguished from one another, Deluc did not see any reason for assuming the existence of a "gradation insensible" between the organisms.

Camper's criticism of systematics was twofold. Besides the epistemological objections, which he discussed mainly in his lectures on botany, he also criticized the methods used in systematic research. This latter aspect is a recurrent theme in his publications.

Camper raised his methodological objections first of all in a popular essay, in which he attacked the current practices in natural history, and particularly in zoology. He addressed specifically the rapidly growing number of amateurs and reproached them that they had lost sight of the illustrious examples of Swammerdam, Leeuwenhoek, Trembley, and Lyonet, and followed the lead of naturalists who were interested exclusively in the outward appearance of animals. In this respect Linnaeus was for him the greatest culprit. It was Linnaeus who had taught people "to look at the whole of nature ... in a superficial way". It was through him that the view had become prevalent that

> "one need only be able to count how many teeth, legs, wings, wing-covers, feathers, nails, mammae, or other things an animal has to be a great man in that science. One has nothing to do with the internal structure, nothing with the senses, nothing with the growth of the offspring. If only one knows a few Greek words and a few definitions, one is an excellent naturalist."[28]

Camper was too one-sided in indicating the cause of the neglect of anatomy, which he rightly considered as characteristic of the zoological systematics of his day. In view of Linnaeus' fame and influence, it is understandable that he mentioned his name in this context. However, Camper disregarded the fact that others too have contributed to this development. The Danzig zoologist J.T. Klein and the Frenchman Réaumur were among those who had elevated superficiality as a virtue for the systematist.[29]

Camper's description of Linnaeus' method, which for the rest is strongly reminiscent of that which Buffon had previously given,[30] is of course rather caricatural. The essence of the criticism implied in it, however, is by no means baseless.

Linnaeus recognized the importance of anatomy for systematics, but practised this insight only to a limited degree. He based the division of animals into classes partly also on the structure of the heart, but for the other taxa he used only external features. Daudin rightly observed

> "le recours à l'anatomie, bien que parfois déclaré nécessaire, n'en est pas moins très loin de devenir, chez Linné, un procédé obligatoire et constant de la recherche zoologique."[31]

A statement which applies even more so to the other eighteenth-century systematists.

Camper's methodological criticism of zoological systematics was inspired in particular by the frequent errors which in his opinion Linnaeus made when he occasionally referred to anatomical properties.

A first confrontation with Linnaeus' shortcomings took place when Camper discovered the auditory organ of fishes. Following P. Artedi, his mentor in the field of ichthyology, Linnaeus had categorically denied the existence of this organ. With reference to this, Camper argued that they, Artedi and Linnaeus,

> "n'ont jamais approfondi la structure des poissons; un examen superficiel des parties très-sensibles, leur sert de base & leur suffit pour former un système, qui fait peu d'honneur à ses auteurs, & encore moins à notre siècle, ..."[32]

Linnaeus' "unpardonnable ignorance" was for Camper the reason to reject J.E. Smith's request to be allowed to nominate him an honorary fellow of the Linnaean Society. Camper informed Smith that he did not wish to belong to a society named after "the most superficial Naturalist I ever knew".[33]

Camper had some renown as a discoverer of factual errors in Linnaeus' zoology. When the Frankfurt publishing firms of Varentrapp Jr. and Wenner were planning a new edition of the *Systema naturae*, they inquired via Merck whether Camper was willing to add his

"castigationes in Linnaeum". Merck supposed that they were very numerous and would form a welcome "antidote".[34] The plan was abandoned, but may have contributed to Camper's resolution to expose a number of Linnaeus' mistakes.

In two articles he revealed some of the "castigationes". Camper did so first of all for the *Siren lacertina*. Linnaeus had identified this neotene amphibian as the larval form of an animal that shows great resemblance to the salamanders. He placed it in the class of the *Amphibia* with the differentiating characteristics of having two legs, and gills as well as lungs.[35] Camper examined this curious animal when in October 1785 he visited the British Museum and Gray, the curator, allowed him to dissect one of their specimens.

His findings differed from those of Linnaeus. Camper discovered only gills, but no lungs. Moreover he thought that the exterior gills which Linnaeus had identified as such were nothing but fringes on the intermediate membranes of the gills proper. The third point of difference concerned the legs, which according to Camper resembled fins rather than the forelegs of a salamander. With these observations, he inevitably came to the conclusion that Linnaeus' identification was incorrect and that the *Siren lacertina* belonged to the fishes.[36]

Camper presented the *Siren lacertina* case as an illustration of Linnaeus' superficiality and lack of anatomical knowledge. The choice of this example was not very fortunate. Linnaeus' description was correct; it was Camper who was wrong. His mistakes were partly due to the condition of the material available to him, which, as he himself admitted, was badly damaged. In view of the fact that Camper generally based his descriptions on as many specimens as possible, it is all the more remarkable that he did not bother to verify his observations. One cannot entirely avoid the impression that the possibility of criticizing Linnaeus caused Camper to neglect the demands he usually made on the anatomical analysis of animal species.[37]

One year after the appearance of the article on the *Siren lacertina* Camper published a treatise on the so-

called *Amphibia Nantes* which Linnaeus had introduced in the tenth edition of the *Systema naturae* (1758) as an order of the class of the *Amphibia*. Besides the lamprey, this order comprised all the cartilaginous fishes known at that time. Linnaeus had come to this rather curious classification because he thought that these animals have lungs. He had mistaken the gill-cavities for them. After Alexander Garden had identified the swimming-bladder of a number of *Branchiostegi* as a lung, in the twelfth edition of the *Systema naturae* (1766) Linnaeus counted this order of fishes also among the *Amphibia Nantes*.

On various occasions Camper had criticized this classification.[38] In 1787 he published a detailed refutation of Linnaeus' arrangement after the German ichthyologist M.E. Bloch had asked him why Linnaeus had classed the lumpfish with the *Amphibia Nantes*. Camper had already dissected various specimens of this fish, but had never found any trace of lungs. He repeated his observations and at the same time studied other representatives of this order. He did not detect lungs in any species. He rightly concluded

> "dass die Branchiostegi und Chondropterygii vom Ritter Linnē unrichtig unter die Amphibien gebracht worden, weil sie keine mit Luft versehene Lungen, auch kein doppeltes oder dreyfaches Herz, sondern ein einfaches Herz, und Kiefen haben, deren Bau Niemanden ... unbekannt seyn wird."[39]

Linnaeus' *Amphibia Nantes* once again furnished Camper with evidence of his ignorance in anatomical matters. In Camper's view the information furnished by Linnaeus about the internal structure was "nichts als Worte, die ohne Sinn und Bedeutung, und überdies auch höchst unrichtig sind".[40]

Camper was not the only one who objected to the systematists' disregard of the internal structure. Such an attitude was widespread among those eighteenth-century zoologists who considered anatomy as the basis of their discipline and were convinced, with Buffon, that

> "les différences extérieures ne sont rien en comparaison des différences intérieures; celles-ci sont, pour ainsi dire, les causes des autres qui

> n'en sont que les effets. L'intérieur dans les êtres vivans est le fond du dessein de la Nature, c'est la forme constituante, c'est la vraie figure ..."[41]

Besides Buffon, his collaborator Daubenton, for instance, manifested himself as one of the pronounced opponents of the superficiality prevailing in systematic studies.[42]

Among the critics Camper took a special position. For his colleagues the neglect of anatomy was usually no more than a reason for discrediting systematics. For the rest, they showed little interest, if any, in this branch of natural history. Camper demonstrated greater involvement with the weal and woe of systematics. The fairly intensive training which, in contrast with most other critics, he had received in this field was no doubt responsible for this attitude. Camper denounced the superficiality of the "compilers of lists of names", as he usually called the taxonomists, but did not stop there. He sought to eliminate this shortcoming by stressing the importance of anatomy for systematic research.

He did this in an implicit way in the articles on the *Siren lacertina* and the *Amphibia Nantes*. Camper did more than pointing out Linnaeus' lack, or supposed lack, of anatomical knowledge. With the aid of the results of his own dissections he corrected Linnaeus, thus demonstrating the indispensability of anatomy for classifying animals.

Camper explicitly argued this indispensability in a letter to the French zoologist Lacépède, whom he wrote in reply to the latter's request for information concerning the classification of the amphibians, and of the lizards in particular. Camper expressed his dissatisfaction with Linnaeus' classification, in which, by means of no other criterion than the tail, 49 different lizards were distinguished, all of which were considered to belong to a single genus. He informed Lacépède that there are good reasons for dividing the group into several genera. Using the anatomical properties of these animals he made a number of suggestions for such a division. He observed in general: "Je pretends qu'on doit dissequer les objets pour se rendre scur de leur caractère".[43]

What results he expected from this approach became apparent at the end of the letter. There he urged Lacépède not to be too reserved in the matter of dissecting museum specimens. Such a procedure, which amounted to sacrilege for many eighteenth-century naturalists,[44] was deemed fully justified by Camper, because it made the classification "plus scur ... plus reelle, plus noble". At about the same time he stated elsewhere that with the aid of anatomy

> "man einmahl ein vernünftiges und beständiges Verzeichniss verfertigen können [wird], welches alle aufgeklärte Weltweisen annehmen, verbessern, und zur grösten Vollkommenheit bringen würden."[45]

The tenor of this statement as well as the qualifications "plus scur" and "plus reelle" used in the letter to Lacépède indicate that Camper saw only a gradual difference between the existing classifications of the animals and his ideal system. This means that also with regard to a system based on anatomy Camper took a nominalistic position. He deemed his method, just like the one practised by Linnaeus, incapable of an exact reconstruction of the hierarchical order of the animal kingdom. Camper propagated the consistent use of anatomical knowledge because he thought it would thus be possible to approach the natural order most closely. However, he did not doubt that the natural system was unattainable. A classification based on anatomical properties could therefore never be an end in itself. It was nothing but a means to arrive at a stable nomenclature.[46]

Camper's suggestions for a reform of systematics have remained paper proposals as far as he was concerned. His practical activities as to the classification of animals were slight in extent and intensity. The emphasis was on the distinction of species. The problems which he dealt with found their origin in his zootomical studies. If there was occasion for it, he ascertained to what extent the species dissected by him differed from or resembled related animals. His principal achievements in this field have been discussed in the previous chapter. They concerned the identification of the orangutan as a separate species

and the distinction of the Asiatic and African species of the rhinoceros and the elephant respectively.

Camper's dealings with generic classification were confined to incidental attempts to rearrange existing genera.[47] He dissociated himself expressly from the current practice to use "teeth or similar features" as generic characteristics. Experience had taught him that this results in classifications which

> "will always be insecure, especially when the important point is to determine correctly the genera and their true and distinct species."[48]

As regards the genera, too, Camper clearly aimed at as natural a classification as possible. In a manner which resembles the natural method which was developing in systematic botany, but which was hardly practised as yet in zoology, he tried to achieve this object with the aid of a great many morphological, mainly anatomical features.[49]

The distribution of the animals over the higher taxa was a subject into which Camper hardly went at all. The only thing about which he fussed a good deal was the classification of the marine mammals, and of the cetaceans in particular.

After these animals had been classed with the fishes for many centuries, they were definitively incorporated into the class of the mammals by Linnaeus.[50] Camper seems to have had some difficulty in reconciling this classification with Linnaeus' definition of the mammalian class. Camper observed that the cetaceans did not have the four feet which Linnaeus considered one of the characteristics of this class. He remarked ironically that if Linnaeus' definition of mammals was applied to the cetaceans they would have to be described as "quadrupedal mammals but without feet".[51] When on a later occasion Camper confirmed that the cetaceans must be classed with the mammals, he had tacitly omitted the number of legs as a differentiating characteristic. In conformity with his own recommendations he defined the class predominantly in terms of their anatomical properties.[52]

Systematics was for Camper clearly not a substantial part of zoology. It was useful because of its nomenclature but was not of essential importance in unveiling the secrets of the animal world. While many eighteenth-century naturalists looked upon systematics as the principal means for gaining insight into the true relations between animals, it was for this purpose of no use to Camper.

Structural uniformity of the vertebrates

The first and only time that Camper expressed in a somewhat coherent way his positive views on the relations between animals was on 13 October 1778 at the Amsterdam Art school, on the occasion of the annual prize distribution to the winners of the model-drawing competition. He presented his ideas within the framework of a lecture on a method of depicting animals as true to nature as possible.[53]

As an experienced zoologist and artist, Camper had made the discovery that in most animal pictures reality was strained. He took it for granted that this was an undesirable situation. To achieve better results it was not sufficient to draw the animals accurately from life. Camper also considered it necessary that the artist had some insight "into the general scope of the animal creation".[54] In order to come up to this requirement he preceded the actual description of his method by a short and fragmentary exposition on the order and regularity in the animal kingdom. His point of departure was "that fishes and birds, as well as horses and elephants, are really quadrupeds".[55] Camper illustrated this thesis by comparing the skeletons of a human being, a dog, an eagle, and a penguin, and showing "how great is the analogy of the separate parts in these animals".[56]

Although he did not mention reptiles and amphibians they certainly were no exception to the uniformity rule. Camper always included these animals in his comparative descriptions.

From the remark that

> "the ponderous oyster, tied to its fixed position, [is] the basic principle of the fish, and the latter of the bird, of the dog, of the monkey, and finally of man!"[57]

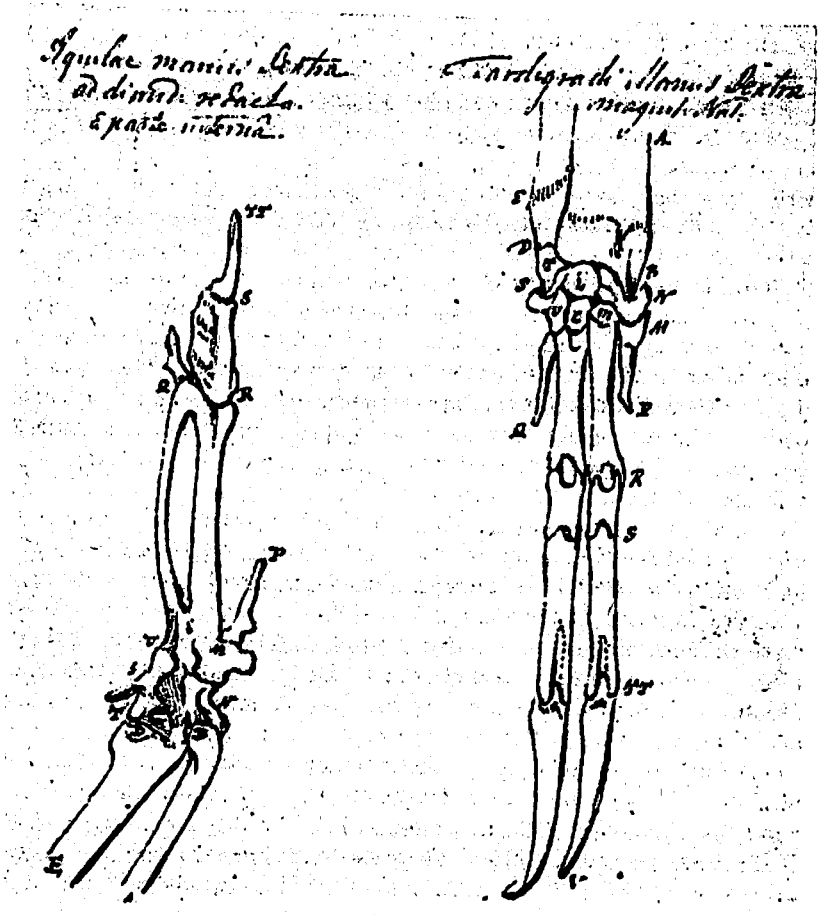

Fig. 8. Comparison of the distal part of the front limb of an eagle and a sloth. Note that Camper marked the homologous parts by the same letters

one might even conclude that Camper held that all animals, vertebrates as well as invertebrates, can be traced back to a single type. However, we have to observe that elsewhere not a trace of this idea is to be found. Whenever Camper brought up the structural uniformity of animals, he was always and exclusively referring to the vertebrates. In his comparative investigations, too, he confined himself to this group. It seems therefore justified to regard the passage quoted above as of no direct relevance where Camper's views of the unity of plan are concerned.

The basic anatomical similarity to which Camper drew attention in his lecture was considered as an undeniable fact in his time.[58] The confidence with which scientists and philosophers such as Bonnet, Buffon, Diderot, Herder, J. Hunter, Kant, Maupertuis, Réaumur, Robinet, and Vicq d'Azyr proclaimed that the animals, or groups of animals, are variations of one and the same basic plan was well-founded. In the course of time a good deal of evidence had been collected to support this idea. The consensus among his contemporaries as to the existence of a unity of plan was not conclusive for the formation of Camper's opinion. He admitted "That a resemblance is known between human and animal anatomy"[59] and did not evince any fundamental doubt concerning the idea of a uniform plan, but still he based his conclusion primarily on the results of his own investigations.

Camper has never published a comprehensive description of his observations. Only once did he give the scientific world some indication of the scope of his comparative studies. He did this in an essay for a prize competition organized by the Bataafsch Genootschap der Proefondervindelijke Wijsbegeerte. Starting from the observation that there are numerous structural similarities between man and animals, the society raised the problem whether there are natural reasons why man is more liable to diseases than the animals.

In the preface to his essay Camper dwelt for a moment on the comparative anatomical aspects of the problem.[60] In nine pages he gave a short and inevitably superficial survey of a number of similarities between man and animals. He did not omit to draw attention to his wide research in this field.[61] Camper dealt successively with the comparative anatomy of the brain and the cranial nerves, of the forelegs and some other parts of the skeleton, and of the principal organs of the thoracic and the abdominal cavity. While Camper had discovered that the sense-organs "show the greatest and most astonishing variety",[62] he found a

considerable degree of uniformity in the other structures.

More detailed information on Camper's comparative anatomy can be obtained from the writings of his pupil Gadso Coopmans. Coopmans, who studied from 1767 to 1770 at Groningen University under Camper and maintained regular contacts with him afterwards, referred to the latter's work in his translation of Bonnet's *Contemplation de la nature*.[63] Bonnet's remarks on the similarities between the skeleton of man and that of the quadrupeds were corroborated and supplemented by Coopmans with data borrowed from his teacher. He did so first of all with respect to Bonnet's observation that all mammals have seven cervical vertebrae. Coopmans stated that Camper

> "confirmed this observation about all the animals he has been able to examine, ... irrespective of whether the neck was very long, as in the case of the dromedary, ..., or very short, as in that of the elephant, the orangutan, etc."[64]

Coopmans separately mentioned Camper's analysis of the cervical vertebrae of the porpoise. These are deformed and reduced to such a degree that able anatomists, such as Edward Tyson, thought that the porpoise has only one cervical vertebra. Coopmans proclaimed Camper as the discoverer of the fact that the structure of the porpoise was in no way different from that of the other vertebrates and that in this species too seven cervical vertebrae could be detected.

In the field of comparative anatomy Coopmans had learned considerably more from Camper.

> "When a few years ago I had the pleasure to attend the instructive lessons of this able anatomist [i.e. Camper], I was not infrequently amazed about the similarities one observes in other parts of the skeleton as well between man and the animals: the rude and insignificant leg of a polar bear, the coarse skeleton [of the leg] of the camel, which undoubtedly do not show any similarity on the face of it, revealed to me the resemblance between the structure of the latter's and man's more perfectly formed hand quite clearly, while I also learned that this resemblance also extends in the same parts to other animals in which one would suspect it even much less, and is found even in the so-called amphibians, such as tortoises, seals, etc."[65]

Camper's comparative studies were not restricted to the skeleton. Coopmans was able to enlarge Bonnet's thesis on the structural uniformity by referring to observations of Camper which had demonstrated

> "that this similarity exists not only in the skeleton, but even in the structure of the more delicate parts; and, not to speak of the circulation of the blood and the organs serving for this purpose, of the heart, the arteries, the veins, the muscles, the liver, the stomach, the intestines, the brain, and what not, that the distribution of the cranial nerves of the third, the fourth, the fifth, and the sixth pair are perfectly the same in all animals, not only in the quadrupeds and in the birds, but even in all the fishes which he has made the objects of his investigations."[66]

From Camper's own statements and in particular from those of Coopmans it can be inferred that he had convinced himself with his own eyes that many animal species resemble one another in a great many parts. For him the anatomical similarities pointed to a law of nature. They derived their significance from the fact that they occur almost generally. Camper evidently considered the empirical foundation sufficiently broad to generalize his findings and to assert that the widely divergent vertebrate forms are all modifications of the same basic plan.

He has not made any unequivocal statement about the nature of this basic plan. In connection with the exceptional form of the skull of the whales he observed

> "qu'il est presque impossible, quelquefois, de se représenter l'original, l'homme, dont tous ces êtres ne sont que des variétés multipliées à l'infini."[67]

In conformity with the traditional conception, Camper here regarded man as the prototype of the animals, at any rate of a part of the animal kingdom. Another view emerges from the previously quoted statement about the

birds and the fishes, which "are really quadrupeds". In this case he did not regard the basic plan as being embodied in a specific organism. It would appear that a more abstract type concept, which did not fully develop until the nineteenth century, was predominant in Camper's mind. This impression is reinforced by the way in which he practised comparative anatomy; he used neither man nor another animal species as fixed reference material.

Convinced as he was of the purposiveness of creation, Camper had no difficulty in accounting for the origin of the modifications which the basic plan shows in the various species. After having stated in his lecture at the Art school that the vertebrates are essentially built in the same way, he argued that they

> "are made to differ in order that each might be able to perform most easily all the requisite movements in the fluid assigned and destined to them.
>
> Apart from that, every creature differs as to its head, body, legs, and tail according to the different purpose for which it is made: to wit, according to the main end for which it has been disposed on this globe by the Great and Wise Creator."[68]

Later on, Adriaan Camper tried to minimize his father's teleological interpretation of the pluriformity of the animals. In connection with the latter's description of the skull of the whale as a modification of the skull of man, Camper Jr. rightly stated that his father had accounted for the differences with the aid of the principle of the final causes. He did not deny that this was impossible, but added that

> "L'auteur [i.e. P. Camper] se plaisait à ces sortes de contemplations. Il y trouvait un grand motif de vénération pour la première cause de tout ce qui existe; et s'il faut les compter au nombre des illusions, au moins ces illusions livrèrent son âme à des impressions consolantes."[69]

In view of the fact that the uncomplicated teleological ideas as we find them in Camper were already out of date when in 1820 his son published the description of the skull of the whale, it is understandable that he tried to gloss over his father's views. In doing so, however, he did not do justiee to the place which teleology had in Camper's thinking. The final causes were a reality for him. The modification of the human skull to that of a cetacean was deemed by Camper to be based on a true principle.[70]

In the address before the Art school Camper illustrated the anatomical uniformity in a striking way by transforming with a few lines a picture of a cow into that of a bird and then doing the same with a horse which he transformed into a human being (see fig. 9). Afterwards Camper repeatedly made use of such "metamorphoses" or "re-creations", as he called them, to illustrate his discoveries. When in 1779 he was staying at the home of the German anatomist Wrisberg, he showed the latter and some guests, including Lichtenberg, Sömmering, and Blumenbach, how, allowing for the ways of living of the organisms concerned and the morphological properties required for this, one could transform any quadruped into a human being.[71] During a stay in London he showed some metamorphoses before, amongst others, Blagden, Burke, J. Hunter, Sheldon, and West.[72] Camper informed Herder by letter:

> "j'ai poussé mes idées sur l'analogie entre l'homme, les quadrupèdes, les oiseaux et les poissons plus loins, de sorte que je puisse metamorphoser avec l'addition de quelques lignes un poisson dans une quadrupède quelconque, et celuilà dans un homme..."[73]

The metamorphoses are remarkable not only as a graphic representation of Camper's ideas about the relations between the animals. They demonstrate that he saw regularity in the occurrence of the individual parts throughout the animal kingdom as well as in their interrelations within the various types of organisms. From the metamorphoses, just as from the comparative analysis of the skull of the whale, it becomes evident that Camper had arrived at the view that the spatial arrangement of the parts is so fixed and indissoluble that changes in one part of the organism inevitably entail changes in the other parts. Camper operated here with a principle which afterwards was to become, as the "Prinzip der Lage", one of the pillars

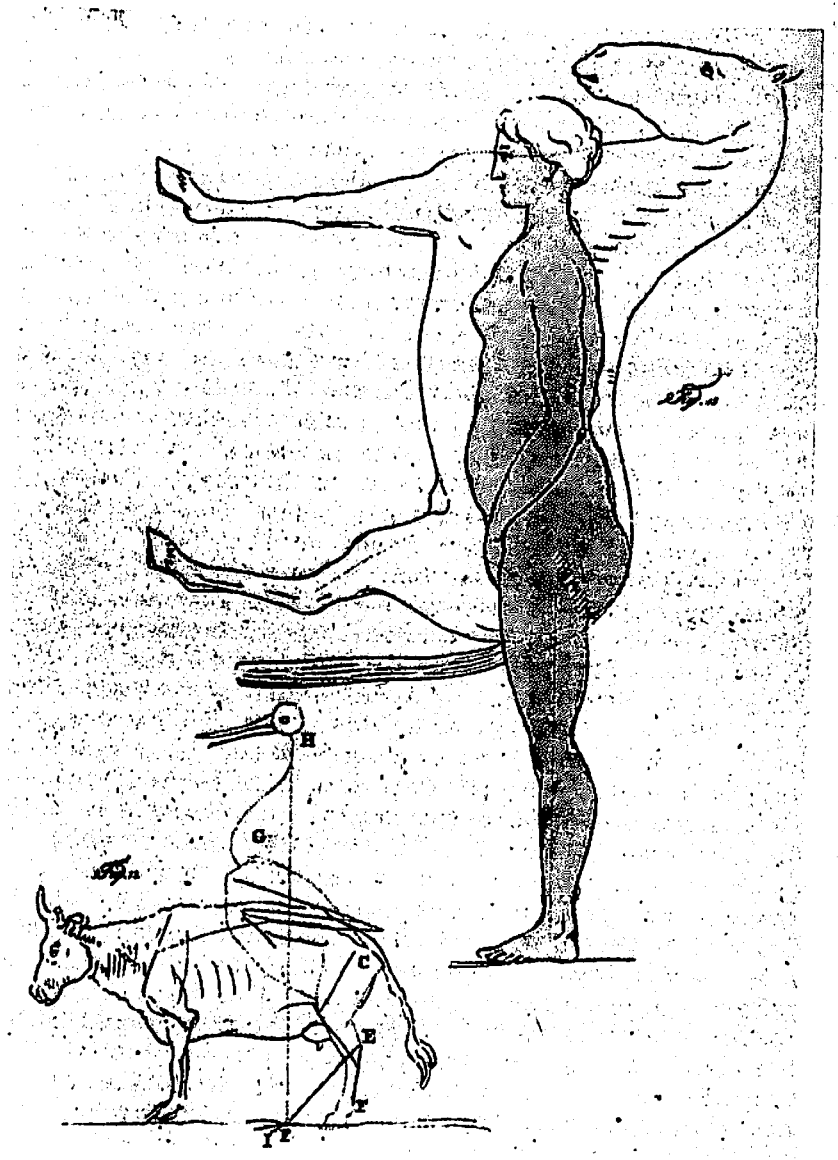

Fig. 9. "Metamorphoses" illustrating the unity of plan of the vertebrates

of comparative anatomy. This principle, no more than other conceptual aspects of the idea of uniformity, was put forward explicitly by him. This was by no means exceptional. The comparative anatomists of the pre-Goethe period were in general not much inclined to analyse the unity of plan theoretically.

Posterity has not paid much attention to Camper's ideas on the structural uniformity of the vertebrates. This was no doubt partly due to J.V. Carus. In his influential study on the history of zoology Carus mentioned the address before the Art school, but left its contents out of consideration, because the work was destined for artists and not for zoologists. Carus saw no further reason for including Camper in his survey of eighteenth-century comparative anatomy.[74] When Camper's ideas were dealt with occasionally by other historians, this was usually done with reference to the metamorphoses. These, however, did not earn him much appraisal for his comparative anatomy.

The sketches of the metamorphoses induced Julius Schuster to assert that Camper had no more than "eine groteske Vermutung von wunderlichen Analogien" and in consequence was unable to reach any "wissenschaftliche Einsicht in die Zusammenhänge und die Entwicklung [der Tiere]".[75] Schuster was alone in this sharp criticism. Other historians were more lenient in their opinion on Camper's comparative anatomy as expressed in the metamorphoses. They qualified his view of the relations between the animals as a fleeting aperçu[76] or at best as a brilliant intuition.[77]

Considering the superficial and not very detailed character of the metamorphoses, such interpretations are understandable, but this does not alter the fact that they are incorrect. Camper's conception of the unity of plan, a terminology moreover which he did not use, had nothing to do with some intuitive cognitive process, but was based on the results of patient empirical research.

Rádl's remark that Camper "nur gelegentlich und ohne bestimmte Absicht die Organe verglichen [hat]"[78] decidedly creates a wrong impression of the nature and scope of his comparative studies. It is true that Camper never explicitly formulated the objectives of his

comparative anatomy, but from the available sources it can be inferred that he certainly had them.

As we have seen, Camper compared the skeleton as well as the organs in the abdominal, the thoracic, and the cerebral cavity; this means that his comparative studies comprised all the structures which were considered of essential importance in his time for an understanding of the animal organism. In addition Camper took great pains to involve a large number of representatives of the various groups of vertebrates in his comparative research.[79] It would seem justifiable therefore to conclude that he deliberately sought to explore the structural uniformity as completely as possible.

The empirical element is the most striking part of Camper's view of the order of the animal kingdom. The idea of uniformity itself was not new. Before Camper revealed his views others had already contended, even more clearly than he ever did, that the animals have been created according to the same basic design. The eighteenth-century adherents of this idea, with the exception of Vicq d'Azyr, were contented with the available information in the field of comparative anatomy. Camper, however, realized that the anatomical similarities between the vertebrates were far from being investigated exhaustively.[80] He exerted himself to give a broader foundation to the conception of the unity of plan.

At the basis of Camper's comparative anatomy was the idea that the animals are interrelated through a uniform plan. His researches were aimed at giving concrete form to this relation. Camper tried to determine all the features which all vertebrates have in common. This objective was rather new for comparative anatomy. Around the middle of the eighteenth century an anonymous person rightly declared that "Comparative anatomy has hitherto been treated but by pieces".[81] In the same period clear signs of a changing attitude are to be found in the writings of Daubenton where the comparative method was propagated as the obvious means to arrive at "des connoissances générales de tous les animaux".[82] Daubenton left it at this. Camper practised what his French colleague preached. Although this did

not result in sensational discoveries, it gives him a place of his own in the development of comparative anatomy. Camper was a pioneer of the comprehensive approach in this discipline: an approach which was to reach its full growth only in the work of Georges Cuvier.

Chapter IV

MAN'S PLACE IN NATURE

Unity and variety of the human races

The origin of the negroes

As a zoologist, Camper was not merely interested in animals. Man was a recurrent object of his investigations. The relation between the white and black race was the aspect of human zoology to which Camper first applied himself. On November 14, 1764 he dealt with this subject in an address with which he started his yearly anatomical lessons at Groningen University. This *Oration on the origin and colour of the blacks*[1] was based on research dating from the period when Camper was professor at the Athenaeum Illustre at Amsterdam. In November 1758 he accidentally acquired there a recently expired "black Angolese boy".[2] Instead of utilizing the corpse in the usual way as demonstration material for his anatomical lectures, Camper dissected it before his students in order to refute notions about the inferiority of the negro.

Such notions were quite common in the second half of the eighteenth century.[3] The negroes were generally looked upon as an inferior race. They were thought to be wanting in any appreciable social and ethical culture and to be living the life of animals rather than of human beings. For many people they occupied a position halfway between whites and monkeys. The idea of the inferiority of the black race was reinforced by various physicians and naturalists, who seized upon rightly or wrongly established anatomical differences with European people to widen the gulf between the

races. This was done, for instance, by the German anatomist J.F. Meckel, who alleged he had seen that the brain and the blood of the negroes were black, and then suggested that they might very well belong to a species quite different from that of the white man.[4]

In the *Oration* Camper vigorously opposed the view that the negro is essentially different from the white man. In the historical introduction of the lecture he proclaimed his standpoint unambiguously. With reference to the extremely pronounced ideas of Herodotus concerning the animal-like behaviour of negroes he did not leave any room for misunderstanding as to the fact that he regarded them as his fellow human beings.[5]

Camper's idea of the unity of the human race had a theological as well as a scientific component. He justified his view in the first place with a reference to the story of the creation, according to which

> "in the beginning a single man had been created by God, to wit Adam, to whom all of us, whatever may be our figure or colour, owe our origin."[6]

For Camper the monogenetic origin of man was a truth not only revealed but also proved.[7] He observed that natural science had irrefutably demonstrated the correctness of the biblical doctrine. For this he referred first of all to the work of, among others, Maupertuis and in particular of Buffon.[8] Both these naturalists had argued on the basis of anatomical and physiological properties of the various races that they are varieties of one and the same species, and therefore have a common ancestor.

The *Oration* was intended to provide monogenism with further scientific support. By means of zoologico-anatomical arguments Camper attempted to instil other notions into the minds of those who doubted that the white and the black race belonged to the same species or frankly held "that the Blacks constituted a separate species, not originating from Adam".[9] It is doubtful whether the *Oration* has had the intended effect. To all appearance Camper's message escaped the notice of his countrymen. As far as I know, there are no references to his article in the literature from the period before 1800. The idea of the inferiority of the negro, on the other hand, was rather popular among

the Dutch intellectuals. An illustrative example is the clergyman-naturalist J.F. Martinet who suggested in his widely read *Katechismus der Natuur* that the Hottentot can be seen as the transition from man to the "lowest rational creature".[10]

Camper's argumentation followed two lines. First of all he asserted that there is a great difference between the Africans and those animals which were assumed to be most closely related to man. The popular idea

> "that the Negroes and the Blacks had originated from the hybridization of white men and big Apes or orangutans"[11]

was resolutely rejected by Camper. He could not take into his consideration the true orangutan because he did not know this species at that moment. In order to investigate the supposed animal origin of the negro, he compared the anatomy of the Angolese boy with the chimpanzee described by Tyson, which was the only ape that was reasonably well-known at that time. Camper concluded that nothing can be found in the negro "which resembled this animal more than a white man; on the contrary, everything was the same".[12] When a few years afterwards he was in a position to compare the negro with the true orangutan, Camper saw his conclusion confirmed.[13]

Camper did not confine himself to distinguish the negro from the ape. He realized quite well that, if he was to convince people of the correctness of his views, it was also necessary to make it clear that the African and the European belong to the same species.

With regard to this aspect, first of all he opposed the above-mentioned observations of Meckel. His own, wider, experience enabled Camper to correct these observations and to note that the blood and the brain of negroes do not have another colour than those of white men.[14] Without going over-much into detail, Camper asserted that negroes and whites have an identical anatomy.

The only point he went into further was the colour of the skin, the most conspicuous difference between the races. Like most other monogenists, Camper was fully aware that this distinctive could easily be interpreted as confuting the theory of common descent.

The greater part of the *Oration* was devoted to demonstrating the accidental nature of the colour of the skin.

Before giving his own views on the origin of the colour of the negroes, Camper criticized the views inspired by the Bible. He accepted the Bible as a source of information on the origin of man, but thought that no unequivocal data on the origin of the black colour of the skin are to be found there. The thesis, based on the fortunes of Cain and Ham, that it was the consequence of "a certain well-deserved curse or wrath of the Divine Being", according to Camper originated from scholars who beforehand assigned "a very odious meaning to black". In his opinion this thesis was not corroborated by what the Bible really says.[15]

Since he had not found any indication in the Bible that the negroes have been created as such, Camper sought elsewhere for an explanation of the colour of their skin. The geographical distribution of the races furnished him with the key to the origin of the negroes and of the colour of the skin of men in general.

It was partly on the authority of Maupertuis and Buffon that Camper stated that the negroes are found exclusively in the hottest regions of the earth and that, as one moves further away from the equator, the colour of men's skin becomes lighter and lighter, until the whitest skin is found in Denmark. This correlation was interpreted causally by Camper; he held "that the heat of the region in which we live is the cause of the colour".[16] The descendants of the first man

> "were bound to change as to their colour and form as soon as they were dispersed all over the wide earth, according as the country, the special food, and the diseases varied. An accidental variation was bound to be transmitted to many others by heredity; as we still see it happening. An intermingling of two very different types of people could not but produce a third type, which adopted something from each of the two and could only be changed in the course of some centuries."[17]

Like Maupertuis and Buffon, Camper assumed that the

black colour is not an immutable property. He considered it highly probable that negroes would become white after they had dwelt in more temperate zones for a long time. Conversely, it did not appear impossible to him that Europeans might become pitch black if they continued to live in the tropics for thousands of years.[18] These assumptions implied that it is impossible to answer the question as to the colour of the first man. Camper observed that Adam might have been white, brown, or black.[19]

Camper further stressed the non-specific character of the colour of the skin by pointing out, inter alia, that the part of the skin in which the black colour is located in negroes is always coloured more or less in other races; that the negroes are born with a relatively light skin and that the whites get a darker colour when they have been starving for a long time.[20] With these and other phenomena Camper supported his view that the difference of colour is only a gradual difference:

> "we are white Moors, or rather: we are human beings identical in every respect with the Blacks, except that our middle membrane [i.e. the Malpighian layer] is less tanned."[21]

The colour of the skin had been reduced by Camper to a characteristic of minor importance. It was not absolute and permanent but depended on fortuitous external circumstances. Consequently, it was not possible to derive from this attribute any arguments for drawing a real distinction between human races. Since Camper had not been able to discover any further significant physical differences, nothing prevented him from concluding that the European and the African should be considered to belong to the same species. He finished the *Oration* by summarizing his conclusion in the appeal

> "to object no longer to proffering ... the hand of fellowship to Negroes and Blacks, and to recognize them as the true descendants of the first Man, whom we all recognize as our father!"[22]

The brotherhood of all men was not merely a synonym for a scientific idea. Camper considered the white man and the negro as equals in social respects and condemned slavery. He regarded this as an unjustifiable institution[23] and was highly indignant about the Christians who forced the blacks, with the whip, to perform heavy labour as if they were animals.[24]

Camper's ideas about the origin of the races resemble those of Buffon. It is not quite imaginary that he was influenced to some extent by Buffon's environmentalist explanation of racial differences. Camper greatly commended the chapter entitled "Variétés dans l'espèce humaine", in which Buffon had exposed his theory.[25] There is a striking resemblance between Camper's description of the influence of external factors and that of Buffon as given in the final paragraph of that chapter.[26]

Camper shared with Buffon the monogenistic point of view. There is, however, a notable difference between their conceptions of the unity of mankind. The unity promulgated by Buffon had a limited validity. It related exclusively to the physique of man. In fact, Buffon saw a great dissimilarity between the mental and intellectual faculties of the various races. Measured by this criterion, he regarded the whites as absolutely superior and held that the other races were hardly more than animals.[27] Such a notion of white supremacy is entirely absent from Camper's writings, either published or unpublished. Although he did not express himself on the mental and intellectual faculties of the exotic peoples there is no reason to assume that he tacitly subscribed to Buffon's views. The biological unity, which he regarded as an irrefutable fact, clearly implied for Camper that on the spiritual level, too, no essential distinction could be made between the races. The appeal to proffer "the hand of fellowship" to the negroes and his rejection of slavery suggest that, in contrast with the majority of his contemporaries, Camper did not consider them in any respect as less human than the whites.

The facial angle

In the *Oration* Camper had remarked in passing that the shape of the African's skull is slightly different from that of the average European's. He saw this dif-

ference as determined by the protruding jaw of the negro.[28] Camper here drew attention to a phenomenon that was not altogether unknown. Albrecht Dürer, among others, had already had some notion of it.[29] Camper, however, was the first to analyse the phenomenon in detail.

The results of his analysis were made known by him when at the anatomical theatre of Groningen University he publicly dissected a negro.[30] Two years later, in 1770, he gave a more detailed account at the Amsterdam Art school, where he used his findings to lay down rules for faithfully depicting human heads. The latter address formed the basis of his exposition on "the curious difference of the features of the principal peoples of the earth", which constitutes the gist of the posthumously published *Verhandeling over het natuurlijk verschil der wezenstrekken in menschen van onderscheiden landaart en ouderdom* (1791).[31]

As far back as 1740 Camper had already become aware that the skulls of whites and blacks differ somewhat. When under the direction of Karel de Moor he was trained in the art of painting, one day he had to copy a work of Abraham van den Tempel in which a negro figured. He was not satisfied with the picture, because the negro was a "Black in colour, but a European in features". Attempts to achieve a better result were unsuccessful, because he was unable to ascertain the exact nature of the difference.[32] However, Camper kept the problem in mind and found the solution during a public dissection at the Athenaeum Illustre at Amsterdam when he discovered

> "from the comparison of bodies of different ages that the oval figure was not adequate for sketching the features with any certainty and promptness; I therefore sawed through several heads perpendicularly in the middle, both of Human Beings and of quadrupeds, and thought I saw clearly that the cranial cavity for the brain was indeed generally regular, but that the posture of the upper and the lower jaw constituted the natural difference of that amazing variety."[33]

A similar research was subsequently also carried out on skulls of other races. This led Camper to the view

that, besides by the broadness of the face and the angularity of the chin, the human skull could be characterized in particular by the extent to which the upper jaw protrudes.[34]

Camper started his treatise on the skulls of the various races by putting the question how the differences have arisen. Referring to his article on the origin and the colour of the negroes, he contended once more that the entire human race originated from a single couple, and that the differentiation took place in the course of the ages.[35]

Camper did not agree with the assertions of, among others, Buffon and Haller, that the shape of the skull of negroes is due to the fact that the nose of the new-born is flattened. Camper knew from his own experience that already at birth negroes possess their skull characteristics. Accordingly, they were not due to human intervention, but had to be attributed purely to natural causes.[36]

As in the case of the colour of the skin, Camper accounted for the shape of the skull by means of the environmentalist theory. In the oration on the origin and the colour of the negroes he had given the example of a man from Westphalia who, after he had come to live at Amsterdam, got a slightly different shaped skull. Camper ascribed this change to external influences.[37] He stated in general

> "that the Climate, including the Zone, the food, and the customs, was the only factor which imparts to the bones, and therefore necessarily also to the soft parts, a particular and characteristic form."[38]

While it was easily conceivable how the environment might influence the colour of the skin, this was considerably more difficult for the shape of the skull. Camper frankly admitted that he was unable to tell exactly in what way the outward circumstances might cause the protrusion of the jaw. He has not concerned himself any further with this problem. Obviously he did not care to engage in guesswork. In this case again Camper, as a convinced empiricist, had no difficulty in restricting himself to "what is all that we can do in Natural History", to wit "discover by ac-

curate observation".[39]

Camper tried to study the skulls of the four races distinguished in his time, viz. the European, Asian, African and American race. However, he could carry out this plan only partially, since he could not acquire the skull of an American Indian. He did not regard this as an insurmountable obstacle. He assumed that America had been populated from Asia, and therefore considered it justifiable, for want of anything better, to use the skull of an Asian Kalmuck as representative of the American aborigines.[40]

Camper determined the width of the skulls at several points, measured the angularity of the chin, but concentrated his analysis on the position of the facial skull in relation to the cranial skull. He thought it was from this that the most conspicuous distinguishing mark of the human races could be derived. In order to describe the difference accurately, he made use of the "linea facialis", a line extending along the forehead and the front teeth of the upper jaw. The angle which this line formed with a horizontal line along the lower part of the nose and the upper part of the external auditory meatus was a measure of the protrusion of the face.[41]

Camper did not possess any instrument for measuring this angle, later referred to as the facial angle, directly on the object. He determined the angle on a profile drawing of the skull, made according to the geometrical method which he always used for his anatomical drawings. In contrast with perspective drawing, the object is with this method viewed from a so-called wandering visual point. The eye moves in a plane parallel to the object, in such a way that the optical axis is always at right angles to the object. In this way Camper obtained drawings from which the dimensions of the original could be read exactly.[42]

With the aid of drawings made by the geometrical method Camper measured the facial angle of a tailed monkey, an orangutan, a Negro, a Kalmuck, a European, and finally also of the head of an antique statue. He had included the animals because he had observed that the facial angle decreases when it is pursued from man via the mammals to the birds. Although he was primarily interested in the differences between the human races, he also wanted to ascertain what angle marks the dividing line between man and animal. He recorded that the facial angle of man lies between 70° and 80°. Any figure exceeding the maximum value must be regarded as unnatural and attainable only by art, as in antique statues, where the facial angle is almost 100°. If a facial angle of less than 70° is measured, one can be certain that it belongs to an animal.[43]

Camper presented the results of his measurements in an ascending scale (see fig. 10). He began his description with the tailed monkey, which had a facial angle of 42°, and concluded - leaving apart the antique statue - with the European, with a facial angle of 80°. The Negro and the Kalmuck both had a facial angle of 70°, which lay between that of the European and that of the orangutan with a facial angle of 58°. On the basis of a more qualitative assessment Camper made a shift in this arrangement, when he wrote that

> "the lower as well as the upper jaw protrudes in the Blacks, in Negroes, Kaffirs, as well as in Kalmucks, for which reason they approach the Apes more closely than our faces or the antique faces."[44]

This certainly does not mean that Camper had gone back on his statement, quoted above, that there exists a fundamental difference between Negro and ape. At the beginning of the chapter in which he described the facial angle and other dimensions of the skull he emphasized once more the absurdity of the supposition that the Negroes have originated from a cross-breeding of whites and orangutans.[45] With respect to the resemblances in the form of their faces he observed:

> "The eyes standing close together, the small and as it were flattened nose, and the protruding upper lip constitute the greater part of the resemblance [of apes] to the Blacks, which our present-day Naturalists enhance even further with their beautifully arranged and ornate Plates, but which soon disappears when we fully consider all the parts of the body, and of the head in particular."[46]

It is clear from this quotation that Camper did not

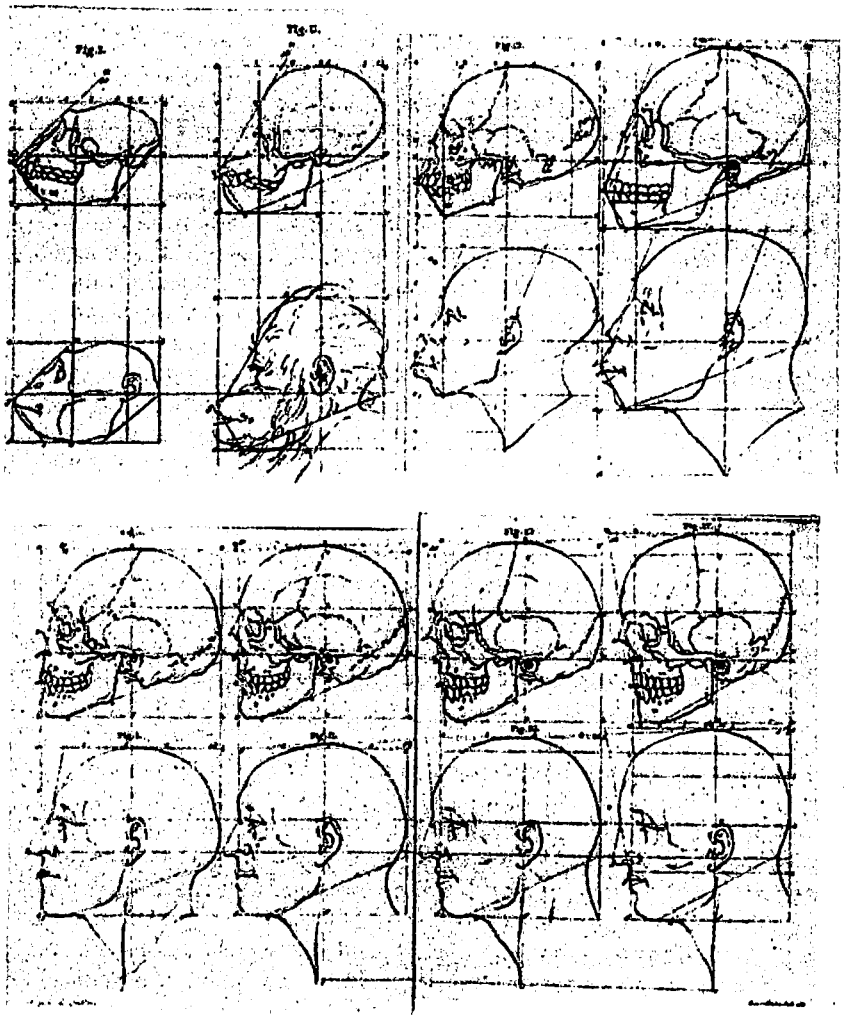

Fig. 10 The facial angle from monkey to Greek statue

regard the facial angle as a specific characteristic. This view is consistent with his assumption that the protrusion of the jaws is caused by external factors. The facial angle, like the colour of the skin, was not a permanent quality and therefore considered by Camper as unsuitable for taxonomic purposes.

The facial angle was for Camper a means, though not

the only one as Blumenbach supposed,[47] for the characterization of racial types. He had arranged the facial angles in an ascending scale, but he did not thus refer to the existence of a racial hierarchy. He did not attach any taxonomic significance to the quantifiable differences between the facial angles of Europeans on the one hand and those of Africans and Asians (and American Indians) on the other hand. For him the different values did not prejudice his view of the equality of the human races.

Camper's craniometrical analyses occupy a place of their own in the history of the scientific study of man. The principle of his method was not new. The pioneering attempts of the anatomist Adriaan van den Spiegel to characterize some European nations by means of the proportion between the breadth and the height of the skull date already from the early part of the seventeenth century.[48] Camper, however, was the first who applied the quantitative method in a systematic way and who discovered an exactly measurable characteristic for distinguishing the varieties of the human species.

Camper's work on the facial angle has met with considerable response. At first a critical attitude prevailed. Scientists such as Blumenbach, William Lawrence, and James Cowles Prichard maintained that the facial angle cannot be accurately measured and does not show any significant variation. Positive reactions came later, among others, from Broca and Topinard. It was mainly owing to these prominent French anthropologists that the facial angle, generally referred to as Camper's angle, became a standard parameter in the physical description of man.[49]

The influence of Camper's discovery was not restricted to anthropology. Geoffroy and Cuvier tried, without much success, to sub-divide the monkeys with the aid of the facial angle.[50]

Camper's facial angle has played a part in the development of nineteenth-century thinking about the inferiority of the negro. Although he had not associated the facial angle in any way with the mental capacities, for later generations this did not form an impediment to using this angle as an indication of man's

intelligence. The English physician Charles White was one of the first who interpreted Camper's findings in this sense and used them in support of his thesis that Africans are inferior to Europeans.[51] A great many writers followed in White's track.[52] It is rather tragic that Camper's writings, in which the equality of races was vigorously defended, became a source of inspiration for influential arguments upholding the hierarchical view of the human races.

The uniqueness of man

Camper held the view - which was rather modern for his day - that man must be regarded as a part of the animal kingdom. He did, however, assign a special place to man. Camper thought his fellowmen, notwithstanding their numerous defects, to be "the most excellent and most perfect creatures or animals of the whole earth". Man owed his exalted position to the sublime talents bestowed on him by "the goodness of the Creator", talents with which not a single other animal species was endowed. In conformity with traditional conceptions Camper held that the uniqueness of man was determined by three attributes, to wit his erect gait, his speech and his capacity for perfection.[53]

Camper took considerable pains to investigate the status of the first of these two attributes, which means that he tried to elucidate the uniqueness of man in so far as he was able, as a zoologist, to do so. He made his first attempt in a short, unpublished discourse, in which he combated the assumption he had come across in the writings of Rousseau and Buffon:

> "that human beings are really quadrupeds which would go on all fours if a certain refinement and good breeding had not taught them to walk on their feet and to keep their hands along their body. It is imagined that in this respect children imitate their parents and one man imitates the other, and that finally this constant habit not only has adapted our bodies to this posture, but that even the foetus when it is still in the mother's body is as it were reformed by it."[54]

The thesis that man was by nature a quadruped was an abominable absurdity for Camper. His indignation was all the greater because in his opinion it might easily lead to the notion that man has sprung from apes and monkeys. In Camper's view this supposition gave an "odious and absurd" picture of the origin of man and of "the perfection of Creation".[55]

It was for Camper not very difficult to show that the structure of the skeleton does not permit man to go on all fours and that he is only capable of walking upright. From this he inferred that man had been created as a biped and could never have been a quadruped as suggested by Rousseau and Buffon.

The orangutan was Camper's main motive for investigating man's relation with the rest of the animal kingdom. When in 1770 he embarked on the study of this exotic animal, it was looked upon, along with the so-called African orangutan [i.e. the chimpanzee] as the creature most closely resembling man. Although according to the prevalent opinion, man and orangutan were creatures of a different nature, some philosophers considered the likeness so great that they thought themselves justified in considering the orangutan as a variety of man. Camper attempted to refute this view.

His research on the orangutan was primarily concerned with giving an anatomical description of this species. From the very first, however, he also went into the question of the animal's relation to man. Camper compared man and the orangutan to ascertain "whether the Orang actually had a clear resemblance to Man"[56] in order thus to satisfy the curiosity of all those who, like himself,

> "craved to know the advantages and elevation of ourselves over all Creatures and the Orang, and on that account to glorify the Great and Divine Maker of the Universe with respectful gratitude."[57]

To ascertain the relation between man and orangutan, Camper needed an answer to two questions, viz.

> "whether it [i.e. the orangutan] walks erect and - which would decide everything - whether it has that excellent advantage which we indisputably

have over all other creatures, viz. speech?"[58]

The idea, introduced by Aristotle, that walking and standing erect are prerogatives of man, was no longer generally accepted in the eighteenth century. It had already been challenged in the first half of the previous century by Jacob de Bondt who claimed to have seen with his own eyes that orangutans walk erect.[59] Other travellers later made similar statements. They got scientific support from Edward Tyson, who was the first to dissect an ape. The English comparative anatomist had observed that the chimpanzee moved on all fours, but thought that this was not natural and was to be attributed to bodily weakness. The length of the heel, toes, and arms, the arrangement of the hairs on the lower arm, the attachment of the pericardium and of the diaphragm were among the structural attributes which caused him to decide that by nature the chimpanzee moves about in the same way as man.[60]

The fact that authorities such as Linnaeus and Buffon shared Tyson's conclusion[61] did not prevent Camper from examining the possibilities of an ape for bipedal movement once again.

In comparison with Tyson, Camper concentrated his attention much more on those structures which are directly involved in locomotion and the maintenance of the body's posture. The muscles of the legs, the structure of the knee-joint, the femur, the pelvis, and the vertebral column, the long dorsal spines of the vertebrae, the place of the occipital opening, and the location of the centre of gravity of the body furnished Camper with proofs to argue convincingly that the orangutan is not built to walk or stand erect, and that it is a quadruped in the true sense of the word.[62]

He got a confirmation of his functional interpretation some years afterwards in the zoological garden of stadtholder William V, where he observed that

> "the living Orang ... [walked] on all fours, and when it stood upright at all, which usually happened when it had just arrived here and was still strong, it stood like all Monkeys with knees bent."[63]

The need to oppose

> "the foolish delusion as though Animals were really to be found which greatly resembled human beings, if they were not really men!"[64]

was so strong that Camper also paid attention to the other candidate for a place beside man, viz. the chimpanzee, although he did not know this animal from his own experience. He was convinced that this animal is a quadruped, just like the orangutan, as appears from his criticism of Tyson and Buffon, whom he reproached with wrongly having depicted the chimpanzee with straight knees and standing on two legs.[65]

Camper did not substantiate his criticism. Perhaps one might think that, contrary to the cautious empirical approach professed by him, he generalized the results of the orangutan research rather too quickly. However, the apodictic presentation of his criticism of Tyson and Buffon is not necessarily an indication of the way in which he arrived at it. With the aid of Tyson's and Daubenton's[66] anatomical descriptions of the chimpanzee, Camper might have shown fairly easily in an analogous way as for the orangutan that the chimpanzee is also a quadruped.

Camper dealt a severe blow to the myth of the bipedal ape. Fairly soon after the publication of his monograph on the orangutan, in 1782, this myth disappeared from zoological literature. His conclusion was warmly welcomed by Herder who used it to support a glowing discourse on the superiority of man, which according to Herder was primarily determined by his upright gait.[67]

The capacity of language was, unlike the erect posture of the body, considered in the eighteenth century a species-characteristic of man. It was generally held for the outward sign of the rational faculties[68] and was the main argument for setting man apart from the animals.[69]

Of all creatures it was the orangutan, or what passed as such at the time, which gave rise to the supposition that speech is not unique for man. Travellers repeated the stories of the natives that orangutans are able to speak, but refuse to do so from fear of having to work as slaves.[70] Around the middle of the eighteenth century the French philosopher La Mettrie

and the Scotch philologist Monboddo advanced serious hypotheses about the faculty of speech of the apes.

La Mettrie and Monboddo had been struck by the great anatomical resemblance between man and ape, particularly as regards the parts that were considered essential for speech, to wit the larynx and the brain. Tyson, who had discovered this resemblance, had asserted that the ape (the chimpanzee) cannot use its organ of speech in the same way as man because it lacks the mental equipment required for the proper functioning of the organ.[71]

La Mettrie and Monboddo were among the few who were not convinced by this metaphysical explanation of the muteness of the apes. From the structural resemblance they deduced a functional analogy. They were convinced of the ape's linguistic competence. The fact that the animal did not yet show any sign of it was no problem for them. They regarded this as a result of a lack of practice. La Mettrie and Monboddo did not doubt that with adequate training the apes could learn to speak just as well as man. They did not omit to point out that when the animals had learned it, the dividing line with man would have disappeared.[72]

Tyson's explanation of the fact that apes cannot talk, which was also endorsed, among others, by Buffon, was not entirely adequate to dispute the approach between man and ape suggested by La Mettrie and Monboddo. If one rejected Tyson's metaphysics, as La Mettrie did, and only took into account the anatomical data, there was every reason to assume that apes are able to speak. In fact, in eighteenth-century "anatomia animata" it was a legitimate procedure to postulate a functional similarity on the basis of an observed structural resemblance.

Camper, who was quite familiar with this procedure, will no doubt have realized that La Mettrie's and Monboddo's hypotheses could only be refuted effectively with the aid of anatomy, from which the two philosophers had primarily derived their arguments. It will therefore have been an important moment for him when he discovered that the organs of speech of the East-Indian orangutan and man do not have the same structure. This enabled Camper to formulate the question as to the faculty of speech of the orangutan as follows:

> "Since so many great Travellers and famous Authors regarded the highly extolled Orangs found in Africa as well as in Asia almost as human beings; and their silence or failure to speak was considered by many people as a political principle, in order that they should not be made slaves and be forced to work, rather than as a real defect of the organ of speech, it was a matter of great importance not only in Natural History but also in the Science of Man to know whether Apes, and in particular the Orang-Utans, kept silent, that is did not speak, in order to cheat the civilized Nations or from an imperfection in their structure and organic system?"[73]

The organ of speech of the orangutan differed from that of man by the paired lateral sacs of the larynx. Camper had observed these structures in all the specimens dissected by him. The laryngeal sacs were found to have considerable dimensions. They covered a large part of the thorax and mostly reached as far as the collar bone. In older animals they had grown together. Further Camper discovered that the sacs communicate with the larynx via openings situated just above the vocal chords.

It was quite obvious to Camper that such a construction makes it altogether impossible for the orangutan to produce articulate sounds,

> "for the air passing by the *rima glottidis* is immediately lost in the ventricles or ventricle of the neck ... and must consequently return from thence without any force and melody within the throat and the mouth."[74]

Camper corroborated this conclusion by recording his observation that the living orangutan produced no other sound but "a hoarse and ungainly screaming", and that only "if it was malcontent".[75]

It testifies to scant historical sense to qualify Camper's explanation of the muteness of the orangutan as a "wholly false proposition".[76] His theory indeed does not agree with present-day ideas about the process of speech formation, but measured by the stan-

dards of his day it was a perfectly plausible theory. Down into the nineteenth century the laryngeal sacs were considered as the cause of the muteness of the orangutan.[77]

Unlike in the case of the posture of the body and locomotion, as regards the faculty of speech Camper could not apply his argumentation about the speechlessness of the orangutan to the chimpanzee. According to Tyson the organ of speech of the latter was identical with that of man. By suggesting that Tyson might have overlooked the laryngeal sacs, Camper at first attempted to prove anatomically that the chimpanzee cannot speak.[78] He did not, however, persist in this attempt, and ultimately recognized the correctness of Tyson's observations.[79] Camper did not have any conclusive, i.e. anatomical, arguments for denying the faculty of speech to the chimpanzee. Although he will not have doubted that this animal too is unable to speak, he has not made any explicit statement on this point.

It had become a firmly established fact for Camper that the orangutan differs very greatly from man and does not form a menace to the latter's unique position in the animal kingdom. He had discovered differences in shape, size, and gait, and had also observed that the orangutan

> "can neither sit like human beings nor lie on its back, and even less so is able to seize something, since its thumb is much too short."[80]

However, all these differences were of secondary importance. It was of decisive importance that the orangutan is altogether unfit to speak. This enabled Camper to qualify it as an "irrational Creature".[81]

Camper's conclusion that the orangutan differs essentially from man was not surprising in itself. He confirmed what nearly all his contemporaries already suspected.[82] What is remarkable is the nature of his arguments.

Camper separated the orangutan from man on the basis of structural attributes. He argued man's uniqueness by demonstrating that the orangutan does not possess the structures deemed necessary for performing functions which of old were considered essential to man,

to wit walking and standing erect, and in particular speech.

This method for distinguishing ape and man differed from the one hitherto practised in the eighteenth century. Most of Camper's fellow-zoologists expected little result of the anatomical approach, because they assumed that man and ape show practically no structural diversity. Buffon stated that the difference between the two creatures is of a spiritual nature. Man can only be distinguished from the ape by his rational and immaterial soul.[83]

Buffon's differentiating characteristic, which had been used already by Tyson, did not play any part in Camper's argumentation. Apart from the fact that he did not share the underlying Cartesian dualism,[84] Buffon's metaphysical taxonomy did not agree with the positivist tendencies in his conception of science. As has been explained in the paragraph dealing with Camper's ideas on scientific method, he was of the opinion that the study of nature may only be aimed at empirical reality. The soul belonged to the domain of the philosophers and not to that of the naturalists.[85] Camper convinced his contemporaries that without having recourse to metaphysics man can be marked off from his nearest relations.

Camper and the intermaxillary bone

The intermaxillary bone of man is so small and so much grown together with the surrounding bones that for many centuries it formed a moot point whether it exists at all.[86] Camper was one of the eighteenth-century anatomists who thought that it is not present in man. He had examined countless skulls, both of adults and of new-born infants and foetuses, but had not found any trace of the intermaxillary bone. Since it was present in all the quadrupeds known to him, Camper looked upon it as a characteristic feature of this group.[87]

Camper's opinion about the absence of the intermaxillary bone in man met with little opposition on the part of his contemporaries. Goethe and the German

anatomists J.W. Josephi and J.C. Loder were the only ones who gave evidence that they did not agree with Camper. The objections of Josephi and Loder[88] were not noticed by Camper. He did, however, take note of Goethe's reaction.

Camper was confronted with Goethe's criticism when on 15 September 1785 he received one of the first drafts of the latter's comparative anatomical treatise on the intermaxillary bone.[89] This treatise, which was not published until 1820,[90] was sent to Camper at the author's request by their mutual friend J.H. Merck. Goethe, who greatly admired Camper, thus wished to inform him of the results of some osteological investigations with which he himself was rather pleased. In the treatise Goethe gave a description of the intermaxillary bone of man recently "discovered" by him, and stated that this bone occurs in all animals. He left no doubt as to the fact that he disagreed with Camper and Blumenbach, who had used the intermaxillary bone "als ein Unterscheidungszeichen zwischen dem Affen und Menschen" and had it "jenem Geschlechte zugeschrieben, diesem abgeleugnet".[91]

On the day after Camper had received Goethe's manuscript he sent Merck a first comment.[92] Camper praised the clarity of the illustrations and made some critical remarks on the Latin translation[93] of the original German text. With the contents of Goethe's treatise Camper dealt rather briefly. In his next letter to Merck he went into that in more detail. He welcomed Goethe's description of the intermaxillary bone of the walrus, the existence of which was unknown to him.[94] Further he highly commended Goethe's identification of the incisors of the dromedary. He considered this as an original contribution to zootomic knowledge.

However, Camper did not endorse the central thesis of Goethe's treatise. Against the latter's findings he maintained that man has no intermaxillary bone. In the first letter to Merck he simply denied its existence. In the second letter Camper argued his position. In order to verify Goethe's observations, he had studied

> "un nombre d'os maxil. des fétus, de nouveaux nés, de tout âge et principalement de 3 ou 4 ans, comme [c'] est l'os dans lequel l'auteur [i.e. Goethe] a si joliment représenté l'os intermaxill."[95]

Just as in his earlier investigations, Camper obtained again a negative result. He did not find the slightest indication of the presence of the intermaxillary bone and therefore claimed that man does not possess it.[96]

Merck presented Goethe only with concise information on Camper's comments. It was not until after Camper had sought direct contact with him by letter that Goethe got a clear idea of his objections. This letter as well as the ensuing correspondence between Camper and Goethe are unfortunately no (longer) available, so that we can only guess at the contents of their exchange of views about the intermaxillary bone.[97] Vis-à-vis the man whom he liked to regard as one of his principal teachers in the field of comparative anatomy Goethe will no doubt have done everything to defend himself. From later additions to his treatise on the intermaxillary bone it is evident that he did not succeed in making Camper change his mind.[98]

Camper's disagreement with Goethe is attributed in recent historiography to his views on man's place in nature. I think this interpretation needs some revision.

The current interpretation of Camper's share in the controversy over the intermaxillary bone originated from the Goethe-scholar Bräuning-Oktavio. According to Bräuning-Oktavio Goethe's discovery meant for Camper that the gap between man and animal had virtually been closed. He arrived at this conclusion because he presumed that Camper regarded the intermaxillary bone

> "als d a s [Bräuning-Oktavio's spacing] Unterscheidungsmerkmal zwischen Mensch und Tier, im besondern zwischen Affe und Mensch."[99]

Bräuning-Oktavio supposed that an approach between man and animal was unacceptable to Camper because it was not in conformity with the Christian doctrine. He tried to make Camper's orthodoxy plausible by wondering whether there was a connection between the latter's stay in London in 1785 and an essay competition on the truth of the Christian religion according to orthodox principles as initiated shortly afterwards by King George III.[100] Bräuning-Oktavio did not give an

answer to this question, but had nevertheless no doubts at all that Camper's opinion on Goethe was determined by the need to leave the Christian dogma of the demarcation between man and animal intact. The tenor of his argumentation is that Camper had taken an altogether unscientific attitude towards Goethe.

In recent years various historians have interpreted Camper's role in a similar way. Thus, Poliakov also took the view that for Camper the intermaxillary bone is indispensable for marking the dividing line between man and animal. In connection with Camper's negative opinion of Goethe's discovery of the intermaxillary bone he observed: "It looked as though, in this exchange, the Christian in Camper had got the better of the scientist."[101] A less reticent statement was given by Wells in his study on Goethe and the intermaxillary bone. For him it was

> "clear enough that Camper's attempt to help the theologians establish man's uniqueness led him to depart from his usual attitude that a bone is there if visibly delineated as a separate entity."[102]

The interpretation of Bräuning-Oktavio c.s. is considerably less plausible than they pretended. They wrongly assumed that Camper considered the intermaxillary bone as the chief feature for distinguishing man and animal from each other. This assumption is based on Camper's statement that the orangutan, on account of it having an intermaxillary bone "alone ... [is classified] among the quadrupeds".[103] It is true that Camper appears to attribute here great significance to the intermaxillary bone. Bräuning-Oktavio c.s., however, did not take into account that this remark stands quite alone, and moreover is greatly relativized by its context. Along with some other features of the orangutan skull Camper had characterized the presence of the intermaxillary bone a few lines higher up as "attributes ... for classifying this Animal even *more justly* [italics RV] among the quadrupeds.[104]

The possession of the intermaxillary bone supported a classification which was primarily determined by the inability of the orangutan to speak and to walk erect. In an earlier passage of the same article Camper had

designated the two latter characteristics as the principal criteria for separating man from the other animals.[105] The relatively small diagnostic value which Camper attributed to the intermaxillary bone is even more manifest from his final treatise on the orangutan.[106] In this work Camper made no use at all of the intermaxillary bone for indicating the difference between man and apes. He distinguished the orangutan from man on the ground of its being a quadruped and speechless.

Since Camper considered the intermaxillary bone as a differentiating feature of minor importance, there is no reason for assuming with Bräuning-Oktavio that he looked upon Goethe's discovery as a serious threat to his conception of man's place in nature. The possession of the intermaxillary bone would have approached man closer to the animals, but left the essential differences intact. Another point arguing against the interpretation of Bräuning-Oktavio is that Goethe's treatise has not been denounced by Camper as a menace of man's position. If in his opinion that position had been assailed, Camper would no doubt have drawn attention to it, as he had also done with the theories which assigned specifically human attributes to the orangutan.

As we have seen, Bräuning-Oktavio, Poliakov, and Wells accounted for Camper's reaction to Goethe's observations by stating that the uniqueness of man was for him a theological dogma and consequently incontestable. Apart from the facts that on Camper's part the difference of opinion did not concern the position of man, and man's uniqueness was for him primarily a scientific truth, it has to be observed that if there had actually been question of a conflict between theology and science, in all probability Camper would have opted for science. He was a convinced Christian, but decidedly not such an orthodox a type as Bräuning-Oktavio would make us believe. Bräuning-Oktavio's argument for Camper's orthodoxy is too speculative to take it seriously. There is not the slightest evidence for a relation between Camper's stay in London and the competition proposed by King George III.

Camper's standpoint was not a foregone conclusion

when the outcome of scientific research was not in agreement with theological dogmas. This is strikingly illustrated by his activities in the field of palaeontology. Around the same time when he rejected Goethe's description of the intermaxillary bone of man, his studies of fossils led him to the conclusion that the orthodox interpretation of Genesis does not give a correct picture on all points of the age and the development of life on earth.[107]

Camper's reaction to Goethe's work was not based on ideological considerations. It was determined by the fact that Goethe's discovery was not confirmed by his own observations. When Camper, who always showed himself prepared to rectify his errors, had read Goethe's work, he faced the possibility that man has an intermaxillary bone and made serious efforts to find it. When the material at his disposal did not yield positive results, the matter was settled for him. His fundamental distrust of the "testimonia",[108] prevented him from retracting his observations simply because they conflicted with those of another scientist. In such cases he consistently adhered to the primacy of his own experience, as appeared earlier from his controversy with Monro about the semicircular canals of the cetaceans. With respect to Goethe it was even easier for him to take such an attitude, because a number of contemporary anatomists also denied that man had an intermaxillary bone.

It seems quite clear that the current view of Camper's position in the conflict over the intermaxillary bone is incorrect. In the debate with Goethe he was not concerned with man's place in nature, nor did he bend under the yoke of theology. When it is seen against the background of the anatomical knowledge of his day and when his methodological principles are taken into account, we cannot but conclude that Camper defended a legitimate scientific point of view in the controversy with Goethe.

Chapter V

IDENTIFICATION AND INTERPRETATION OF FOSSILS

Identification of fossil vertebrates

Mainly in consequence of lack of other material, the study of fossils has long been concentrated on shells, corals, and other marine invertebrates. In the second half of the eighteenth century this situation gradually changed. From about 1770 onwards zoologists were increasingly confronted with fossil remains of vertebrates. Finds in several places all over the world revealed considerable numbers of petrified bones of mammals.

The new fossils exercised great attraction on the comparative anatomists. This was of course closely connected with the fact that they were best equipped to answer the burning question to what species of animal the bones had belonged. Like various other eighteenth-century comparative anatomists, Camper also contributed to the identification of vertebrate fossils.

His palaeontological interest manifested itself for the first time shortly after he had completed his university studies. During his stay in London in 1749 Camper bought a great many petrifactions. There is no reason for assuming that he did anything more with them beyond storing them in his museum.

The contact with palaeontology was renewed when, seventeen years later, the clergyman and amateur-naturalist J.C. Palier sent him a number of fossilized bones which had been unearthed during a damburst.[1] At about the same time his interest was also stimulated by J.L. Hoffmann, a physician at Maastricht, from whom

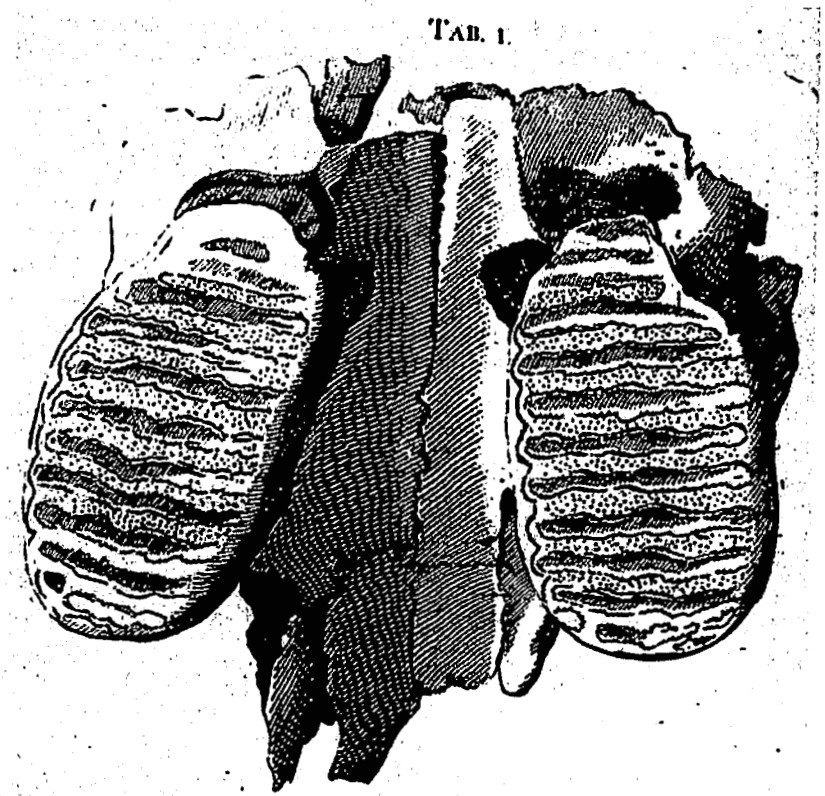

Fig. 11. One of Camper's illustrations for Verster's article on mammoth remains

he received Cretaceous fossils from the St. Pietersberg.[2] Soon afterwards Camper started to apply himself intensively to palaeontology, and continued to do so until his death. He grew to be a very active researcher in this field and was equalled by few of his contemporaries in the wide scope of his studies of fossil vertebrates.

Camper's concern with palaeontology was aimed in the first instance at obtaining a survey of the fossils from the main deposits in the Netherlands and other countries. With great energy he sought to accumulate a representative collection. His wide circle of acquaintances at home and abroad in combination with his ample financial means enabled Camper to pursue a very successful acquisition policy. He was assisted by his son Adriaan Gilles, who acquired a large number of fossils for his father during his travels in Germany, France, and Italy.

Camper received palaeontological material, usually as a present, from, inter alia, the British Museum, the Imperial Academy of Sciences in St. Petersburg, J. Banks, F.X. Burtin, G. Forster, W. Hunter, P.S. Pallas, and S.T. Sömmering.[3] He was willing to spend large sums of money on the acquisition of fossils. The American physician John Morgan received from him £ 105, a considerable amount for that time, for a collection of bones from the famous "Ohio incognitum" (i.e. the mastodon).[4] He spent an amount of the same order of magnitude for the purchase of the most important fossils from the inheritance of J.L. Hoffmann, which included many remains of the mosasaurus.

The result of Camper's activities was such that towards the end of his life he could assert without exaggeration that he was the owner of one of the largest and most varied palaeontological collections of Europe.[5] His collection, which contained many ammonites, shells, and similar animals, was especially remarkable on account of the vertebrates. At that time there was probably no other collection in which so many species were so plentifully represented. Camper's museum accommodated numerous fossil relics of proboscideans, carnivorous animals (including the cave-bear), rhinoceroses, ruminants (including the giant Irish 'elk'),

horse-like animals, rodents, reptiles, and fishes.[6]

The establishment of a palaeontological museum was by no means a goal in itself for Camper. It served scientific ends. He collected fossils in order to describe them and determine their origin. His collection provided him with an extensive field of research. He did not set any limits to it and was interested in all kinds of vertebrate fossils. However, he examined his possessions only partly. If he ever planned to produce a complete description, this could not come off because he did not have sufficient time for it. He obtained most of the fossils only in the last years of his life.

Camper started his palaeontological research in 1766. He was induced to do so by the request of the above-mentioned Palier to make an anatomical description of the two fossil bones with which the latter had presented him. Camper at once complied with this request.[7] One piece was almost intact and was recognized by him without difficulty as a thoracic vertebra. The other fossil was not complete. With a probability verging on certainty Camper identified it as the right femur of an elephant. He showed some reserve, because he had no accurate and reliable information on the characteristic attributes of the elephant femur.[8] When later he had thoroughly investigated the osteology of this animal, he asserted positively that the femur, like the vertebra, came from an elephant.[9]

Camper's first palaeontological study had a modest scope and did not yield any striking results. It makes it quite clear that he was convinced of the indispensability of comparison for the identification of fossils. The eighteenth-century vertebrate palaeontologists were the first to apply the comparative method systematically and consistently. Along with W. Hunter and Daubenton, Camper was one of the pioneers in this field.

Ten years after his contribution to Palier's article, Camper's second public appearance as a palaeontologist followed. This took place again in the publication of someone else, in this case of P.S. Pallas. The Russian zoologist had enlisted Camper's aid in order to get some clarification on the identity of fossil molars which had been dug up in Siberia. Pallas considered them to be identical with those which had been discovered in America and were later found to belong to the mastodon. According to Daubenton and Buffon the American material belonged to a hippopotamus. Pallas wished to learn from Camper whether this was also true of his fossils.

In a letter quoted extensively by Pallas, Camper argued on the basis of a comparative analysis that the Siberian fossils, and consequently also those from America, had nothing to do with a hippopotamus.[10] He also rejected the influential view of W. Hunter, according to which they had belonged to some carnivorous animal. In the molars described by Pallas, he could not discover any feature supporting this interpretation. His conclusion was that the molars greatly resembled those of an elephant. This conclusion also applied to the molars found in North America, since Camper regarded those to be analogous to those from Siberia. He pointed out that the fossil molars are not identical in all respects with those of the elephant. However, he considered the differences to be very small. They were "differentia specifica" and could not be regarded as "differentia generica". He thus confirmed the identification which Sloane and Breyne had given of the mammoth molars and which had become discredited through Hunter and Daubenton.[11]

Camper was convinced for only a few years that the mammoth and the mastodon were closely related to the elephants. He changed his mind after C.F. Michaelis had informed him about a fragment of the mastodon which was hardly known as yet in Europe. Michaelis, a medical practitioner with the Hessian forces in America, after his return to Germany learned that Camper was interested in the fossils found near the Ohio and sent him on 27 July 1784 a drawing of an upper jaw containing three molars. Michaelis looked upon this bone fragment, which he had come across in the Morgan collection, as the most important relic of the Ohio incognitum. In the covering letter he argued that this jaw is not suited to contain tusks. He assumed that the Ohio incognitum and the Siberian mammoth were one and the same species which belonged to a genus quite

different from the elephant.[12] He arrived at this incorrect conclusion because he had mistaken the front for the back of the jaw fragment and vice versa. As a result it was impossible for him to find a place where the tusks could have been planted.

Camper was greatly surprised by the identification of Michaelis.[13] However, the drawing and the description of the jaw fragment did not give him any reason to doubt its correctness. Thus he fell into the same error as Michaelis. He, too, was unable to determine the right position of the bone fragment. He took the processes of the pterygoid for the intermaxillary bone. Shortly after receipt of Michaelis' letter Camper informed him that he agreed with his identification.[14] He did not omit to give wider publicity to his change of mind. In his last palaeontological publication he accounted for it at length. Although Camper mentioned Michaelis as his source of inspiration, the latter's drawing was not the only basis of his identification. At the British Museum he had found a fossil jaw fragment which in his opinion was almost identical with that described by Michaelis.[15] In this case too, he mistook the front for the back.

The information of Michaelis combined with his own findings induced Camper to dispose of his earlier view as an idle guess. According to him the upper jaw of the mammoth and the mastodon did not have any room for tusks. Thus he was convinced that they were not elephant-like animals. He regarded them as a separate species, but did not offer an opinion on what type of animals they were. More fossils and further research were deemed necessary in order to obtain clarity on this point. Camper, who died shortly afterwards, has not been able to devote himself to this task. The jaw fragment described by Michaelis was the only part of the mastodon which he studied. At the end of 1788 he received it, along with the other fossils he had bought from Morgan, and upheld his opinion that the Ohio incognitum was not related to the elephants.[16]

Camper's identification of the mammoth and the mastodon, which was a leading identification for some time, was corrected later by his son. The latter did so after Cuvier had expressed doubts of his father's

views. Camper junior examined the crucial jaw fragment of the Ohio incognitum and was surprised to find that Cuvier's objections were justified. He discovered the error made by his father (as well as by Michaelis) and revised his identification. Adriaan Camper described the mammoth and the mastodon as close relatives of the elephants and moreover recognized them as two different species.[17]

In 1786 Camper first published independently a palaeontological treatise.[18] Its subject was the *Mosasaurus hoffmanni*, or the incognitum of the St. Pietersberg as it was generally called at that time. In 1774, eight years after the first remains had been discovered, he received a part of the lower jaw with teeth of this big marine reptile.[19] For several years this was the only mosasaurus fossil in his museum. For further data he had to rely on the drawings sent to him by J.L. Hoffmann, the most active collector of fossils from the St. Pietersberg. In 1782 Camper acquired numerous remains of the mosasaurus from Hoffmann's inheritance. He supposed that he now possessed sufficient material for a serious attempt to establish the identity of this animal. After he had completed the comparison with the crocodiles at the British Museum, one year later his article on the incognitum from the St. Pietersberg appeared.

Camper was not the first to try to identify it. Hoffmann had preceded him and had come to the conclusion that the incognitum had to be classed with the crocodiles. The arguments on which Hoffmann based himself unfortunately have not become known. Camper, who ascribed a different identity to the animal, kept Hoffmann from publishing his view of the mosasaurus.[20]

Already at first sight Camper had established that the big jaws that had been dug up in the St. Pietersberg did not belong to a crocodile. It became fairly soon clear to him from what kind of animal they did originate. On 28 March 1775 he sent a letter to A.A. van Iddekinge, curator of Groningen University, in which he wrote:

> "Je recevoi hier une lettre du Vieux Hoffmann, à qui j'avois envoyé des dents du cachalot, des marsouins, et des crocodiles pour luy convaincre

que son scelette petrifié [of the mosasaurus] est d'un marsouin, et non pas d'un crocodile, comme on avoit debité dans les gazettes il y a deux ans."[21]

The term "marsouin" evidently has a generic meaning here. Camper never was of the opinion that the incognitum was a porpoise. Perhaps he used this name to give Iddekinge, who was no expert in the field of zoology, some idea of the kind of animal that was concerned. On other occasions he called it a whale, or a "breathing fish", which he usually specified further by mentioning the great resemblance to the cachalot, the orca, and other toothed whales.

Camper started the mosasaurus research by comparing the lower jaw in his possession with the homologous parts of a crocodile and of a number of whales. From the letter to Van Iddekinge it appears that the teeth gave him an indication for the identity of the incognitum. In fact, he found that the teeth of the mosasaurus, like those of the toothed whales, have solid roots, whereas the roots of the teeth of the crocodiles are entirely hollow. This was an important foundation for his interpretation, but by no means the only one. The smoothness of the jaw-bone, the numerous nerve openings, and the position of the teeth provided him with further evidence to argue the whale-like nature of the mosasaurus and to oppose Hoffmann's view that it was a kind of crocodile.[22]

When in 1782, in Maastricht, Camper visited the fossil collection of canon T.J. Godding, he discovered in some mosasaurus fragments a part of the palate that was covered with teeth (see fig. 12). Such teeth were found not to be present in the crocodile. His son, on the other hand, had observed them in a stranded cachalot. Thus Camper thought he had got new evidence for the correctness of his conclusion.[23] In the printed version of the mosasaurus treatise he justified the use of this criterion by stating that fishes have teeth in the palate. This caused Cuvier to observe:

"*Camper* a été induit à employer ce motif [i.e. the teeth in the palate], parce qu'il confondoit alors les *cétacés* sous le nom et l'idée commune de *poissons* avec les *poissons à branchies*, dont

plusieurs ont en effect ce caractère."[24]

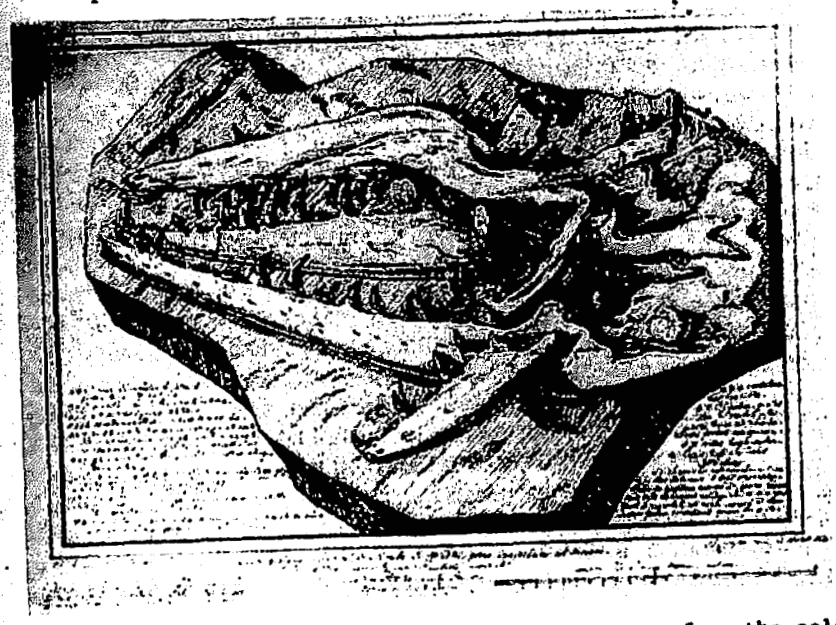

Fig. 12 Camper's drawing of mosasaurus fragments from the collection of canon Godding

Cuvier here gives an incorrect reconstruction of Camper's argumentation. He seems to have been misled by the careless use of the term fish, which Camper used for the real fishes as well as for the whales. By this common name he merely referred to a similarity of habitat, and by no means to a taxonomic relationship. He was very well aware of the great morphological differences between the two groups of animals. This appears, amongst other things, from the mosasaurus treatise, in which he emphasized once more that whales are mammals.[25] When the matter is viewed in this light, there is no reason to assume with Cuvier that Camper regarded the palatal teeth as a support for his identification because they are also present in the real fishes. Camper made use of the presence of such teeth in the mosasaurus because - wrongly, as was to appear later - he considered them as a characteristic attribute of the toothed whales. It is striking that

he had few empirical arguments for assigning this meaning to the palatal teeth. As far as is known, for this he only had at his disposal the previously mentioned, rather superficial observation of his son.

Further attributes in which the mosasaurus resembled the cetaceans and differed from the crocodiles were found by Camper in the structure of a number of vertebrae he had bought from the inheritance of Hoffmann.[26]

Camper's identification of the mosasaurus was very influential. For nearly twenty years the view that it was a whale prevailed. Renowned naturalists such as Merck, Schneider, and Van Marum repeated Camper's argumentation and expressed their agreement with his conclusions.[27] Hoffmann and some other collectors in Maastricht were among the few who did not subscribe to his identification. Camper's efforts to bring them round to his point of view were unsuccessful.[28] Hoffmann c.s. persisted in their opinion that the mosasaurus was a crocodile. Camper's authority, however, was so great that Hoffmann kept his justified doubts to himself and gave priority to Camper's interpretation rather than his own in front of other scientists.[29]

Blumenbach was the first to disagree openly with Camper. In the fifth edition of his *Handbuch der Naturgeschichte* (1797) he defined the mosasaurus as a crocodile-like amphibian.[30] A few years later he was followed by the French geologist Faujas de St. Fond, who advocated a similar view, though not on the basis of much expert knowledge of the matter.[31] Faujas de St. Fond's criticism of Camper induced Camper Jr. to go deeply into the mosasaurus problem.

A.G. Camper was convinced that his father was right and wanted to prove this with irrefutable evidence. To this end he subjected the mosasaurus remains collected by his father to a careful and scrupulous comparison with whales and reptiles. To Adrian Camper's astonishment the results did not come up to his expectations. The respect for his father's work did not prevent him from admitting this frankly and making it known that the former's identification of the mosasaurus had proved to be untenable. His findings did not admit of any conclusion but that the incognitum from the St. Pietersberg was a reptile, and not a whale. Camper Jr.

especially found a great many similarities to the lizards.[32] Cuvier, who was closely involved in his mosasaurus research, broadly confirmed Adriaan Camper's conclusions. The French zoologist rightly considered him as the only one "qui ait réellement saisi les caractères de cet animal."[33] Cuvier completed the work of Camper junior and definitively included the mosasaurus in the genus of the lizards.

Considering the fact that Camper had the same fossil material at his disposal as his son, his failure to ascertain the true nature of the mosasaurus must be attributed to the way in which he examined this material. His analysis is characterized by the total absence of any doubts about his identification. Being perhaps inspired by the size of the mosasaurus remains and by the fact that they were found amidst various marine fossils, from the very first moment he was firmly convinced that the mosasaurus was a whale. His comparative studies had no other aim than to demonstrate this and at the same time to refute the view of Hoffmann.

With a bias rather foreign to him, Camper never seriously contemplated that Hoffmann c.s. might be right after all. His partiality is illustrated by the slight attention he paid to the comparison with the crocodiles. For a long time he confined himself to the study of a single specimen. Later he also involved some material from the British Museum in his research. Other representatives of the genus among which the crocodiles used to be reckoned at that time, such as lizards and iguanas, were left out of account by him. If he had not done so, he would undoubtedly have realized the inadequacy of his argumentation. He would then have perceived that the attributes of the mosasaurus on which he based his identification, such as solid tooth roots and palatal teeth, are also found in various reptiles. If moreover he had studied all his mosasaurus relics, he would have found in two linked series of vertebrae the unequivocal evidence that the bones were those of a reptile and could not be ascribed to a whale. The bias with which he studied the mosasaurus resulted in excessive superficiality which gave this research an exceptional position in his zoo-

logical work.

A few months after the article on the mosasaurus Camper completed his second and at the same time last publication, which was entirely devoted to palaeontology. It appeared in 1788 under the rather meaningless title of *Complementa varia* and consisted of six separate sections in which he rendered an account of his observations and views with regard to the remains of several big mammals. The first two sections were used by him to comment on Pallas' identification of a fossil bison and buffalo. After having given a summary of his mammoth research for the benefit of Palier and having devoted a few lines to the molars of a fossil hippopotamus, Camper subsequently gave a short description of the giant 'elk', discovered in Ireland. He established that this animal, of which he possessed a few fragments, differed from the living deer. Camper concluded the article with an extensive exposition of his ideas about the mastodon already discussed above.

In order to complete the survey of Camper's contributions to the identification of fossil vertebrates, we must also mention that he did pioneering work as regards the specific difference between fossil and living rhinoceroses, and between the cave-bear, recently discovered in the cave of Gailenreuth, and the living bears.[34] Finally it has to be recorded that he also concerned himself with the famous *Homo diluvii testis*. In a letter to F.X. Burtin, director of the natural history museum of Prince Charles of Lorraine in Brussels, Camper expressed in passing his astonishment that "un lézard pétrifié a pu passer pour un anthropolithe."[35] He unmistakably referred here to the fossil salamander which J.J. Scheuchzer had taken for the remains of a poor sinner who had witnessed the Noachian deluge. Camper was the first to reject Scheuchzer's identification. He has not presented his further views on the *Homo diluvii testis*, so that we do not know on what considerations he based his criticism.[36]

The differences between fossil and living animals

Camper's palaeontological research confronted him with the fact that fossils as a rule are not identical with living animals. With the first object of his study the difference was not yet very striking. He did not doubt but the petrifactions sent to him by Palier originated from an elephant. He was astonished to find that the fossil femur was appreciably longer than that of an elephant, but apparently did not consider this a significant difference.

Probably the lack of similarity between fossil and living animals only became quite evident to him when in the early 1770's he compared Pallas' description of the skull of a fossil rhinoceros with that of an African rhinoceros. He detected clear anatomical differences and did not deem it impossible that they belonged to two separate species.[37] When he wrote down this assumption, the woolly rhinoceros was not the only fossil animal species for which he had not found an analogue in the recent fauna. The differences between the molars of fossil elephants and those of their living relatives were so great that Camper concluded that also "these animals [i.e. the fossil elephants] form a different species."[38]

The morphological dissimilarity between fossil and living animals was one of the main problems for the eighteenth-century palaeontologists. Camper, too, paid ample attention to it. He did not think it sufficient to determine the differences. In the publication in which he described his first observations about it he also went into the cause of the discrepancies. He rejected the explanation which was advocated, inter alia, by Buffon and William Hunter and which was based on the supposition that fossils represent extinct animals.[39] Like many contemporary naturalists, he had theological objections to this hypothesis. For Camper, extinction could not be reconciled with the Christian doctrine of the perfection of creation. The idea that entire animal species should have disappeared from the face of the earth was considered incredible by him because it was contrary to divine wisdom and provi-

dence.[40]

It was all the easier for him to put aside the extinction hypothesis because he thought he had a very plausible alternative. He explained the morphological differences with the aid of the notion introduced by John Ray, according to which petrifactions were the remains of existing but not yet discovered animals.[41] Camper thought it more than probable that the fossilized bones originated from species which were still living in hardly explored regions of the earth. For that time this was by no means an unfounded hypothesis. Camper rightly stated that the earth had not yet been explored exhaustively. He illustrated this by pointing out the new animals which were still being discovered especially in Africa and Asia. He had good hopes that the faunistic exploration of these areas would furnish the material for the identification of the unknown fossils.[42]

This theory, of course, confronted Camper with the question how the tropical animals such as elephant and rhinoceros had got into the colder regions where their petrified relics were found in large numbers. He sought the answer within the framework of the conventional views of the history of the earth. This provided room for events such as earthquakes, floods, and volcanic eruptions, but not for a sweeping and worldwide change of climate, by means of which a few years later Buffon was to give an explanation of the presence of fossil elephants and rhinoceroses in Siberia and North America.[43]

Camper was convinced that the fossils originated from unknown species of animals which had actually lived in the tropics. The popular notion that the Romans were responsible for their transport to northern regions was rejected by him. Most of the places where bones of elephants, rhinoceroses, buffaloes, and the like were found had at no time been visited by the Romans. As to the bones recently discovered in the Dutch soil, he submitted that they were much too large to be ascribed to the war elephants which the Romans were said to have used for subjecting the Batavians.[44]

According to Camper the transport of the fossils had been caused by geological catastrophes which had produced radical changes all over the earth. It appeared to him that the Mosaic flood was not one of these catastrophes. He regarded this event to have been too small and not intense enough. The fact that bones of elephants were never accompanied by ammonites, belemnites, and sharks' teeth, moreover, suggested to him that water had not been the chief instrument of the catastrophe. He conjectured that the wholesale movement of tropical animals to the moderate zones had to be attributed to big, regularly recurrent landslides, combined with volcanic eruptions. He remained rather vague about the nature and the mechanism of the earth's revolutions. He consciously refrained from a definitive opinion and thought that more and better evidence was required for this.[45]

These speculations published in the *Dissertatio de cranio rhinocerotis africani, cornu gemino* (1780) did not form Camper's last word on the morphological problem raised by many of the vertebrate fossils. He continued to concern himself with it, and ultimately arrived at quite a different solution. In his publications he showed relatively few signs of his change of mind. In letters and manuscripts the evolution of his new ideas is revealed much more clearly.

A few months after he had completed the *Dissertatio*, he informed the Princess De Gallitzin, the wife of the Russian ambassador in The Hague, about his palaeontological activities as follows:

> "L'histoire physique de notre globe m'occupe à cette heure plus serieusement que jamais car je suis infiniment curieux de scavoir de plus près s'il y a des races d'animaux éteintes, comme il me semble qu'on ne peut pas douter."[46]

This revealing passage is the first, but not the only indication of the change that had taken place in his views. At approximately the same time, in a letter to the Swiss physician Johannes Gessner, he also manifested himself as an advocate of the extinction theory.[47] This letter, which was meant to get Gessner's cooperation for the enlargement of his palaeontological collection, clearly showed how radical a change Camper's ideas had undergone. Whilst in the *Dissertatio* he had rejected extinction and had contended that

fossils originate from existing species, he proclaimed an almost opposite standpoint in the letter to Gessner. He did not exclude the possibility that living specimens of fossil animals could be found, but at the same time clearly evinced his great doubts about this. He now had gradually become convinced

> "qu'il y a grand nombre des grands animaux peris par les diverses catastrophes que notre globe semble avoir subi."

He considered this as "un chose inconcevable mais probable". He asked Gessner in particular for the relics of mammals because he thought that these would enable him to answer the important question "s'il y a des espèces éteintes".

Two years later already the conjectures had become a certainty. On 2 November 1779 Camper wrote to his former colleague Paulus Chevallier, professor of theology at Groningen University: "the extinction of many generations [is] beyond any doubt for me."[48] Extinction soon became a matter of course. In a letter to Forster, of 1781, Camper stated:

> "Il y a long-tems que j'ai été persuadé qu'un grand nombre d'animaux, et des plus grands, est éteint ..."[49]

Camper has not tried to make it clear why he changed his explanation of the morphological differences between fossil and living animals. The growth of his palaeontological knowledge, however, would seem to have been the cause of it.

When he wrote the *Dissertatio de cranio rhinocerotis africani* (1780), his fossil research had yielded only two new species, to wit the mammoth and the Siberian rhinoceros. In the letter to Gessner the number had tripled and been extended with some buffalo species found in Siberia, the incognitum from the cave of Gailenreuth (i.e. the cave-bear), and the mosasaurus. Shortly afterwards Camper discovered, inter alia in the fossil collection of the French physician Tenon, a great many more species which he did not know from the existing faunas.[50] He saw no reason to doubt these discoveries. He was quite sure that he had established the specific differences indisputably. In the letter to Gessner he justified his conclusions by observing

that he had studied a great number of animals and consequently was better qualified than anyone to judge the differences between the fossils and the living animals.

It is natural to assume that the explanation given in the *Dissertatio* lost its credibility for Camper as he detected among the fossils more and more unknown species. It may very well be conceived that when in 1779 he had found some twenty of them, he no longer considered it possible he would ever encounter them as living animals. The nature of the majority of these animals will undoubtedly have strenghtened this conviction. It is of course hardly conceivable that animals of a size like that of the mammoth, the woolly rhinoceros, the mosasaurus, the giant Irish 'elk', the cave-bear, and the buffalo should have been overlooked for centuries by all zoologists and explorers.

When his initial explanation of the morphological differences had proved untenable, the inevitable alternative was that the species not occurring in the existing fauna had become extinct. Camper seems to have accepted this without difficulty. From his unpublished writings it does not appear that the theological objections to the idea of extinction caused him serious problems. He presented his new explanation without relating it to the ideas about the perfection of creation. This is of course very remarkable in view of the fact that these ideas had previously, in the *Dissertatio*, induced him to call extinction incredible. When confronted with the new factual materials, his theologically inspired criticism had evidently lost its force. Camper clearly did not concede absolute primacy to Christian dogmas in scientific matters.

On a few occasions Camper also showed himself in his published works as an advocate of the extinction theory. In the monograph on the African rhinoceros (1782) he did so for the first time. In this case he did not omit to point out the changes which his standpoint had undergone since he wrote the *Dissertatio de cranio rhinocerotis*. With regard to the rhinoceros skull found in Siberia he observed:

> "perhaps this species has become quite extinct,

> just as a great many big quadrupeds seem to have become totally extinct owing to the great revolutions which the Earth has undergone from time to time; a fact which now I do not doubt, although in the year 1776, as I wrote to the Imperial Academy of St. Petersburg [i.e. in the *Dissertatio*], I thought I had reason to believe the contrary."[51]

The second and at the same time last occasion on which Camper made his conviction of the extinction of the animals public was in the *Complementa varia* (1788). The exposition he gave in that work is remarkable on account of the attention devoted to the theological implications of his opinion. He evidently considered extinction as a phenomenon which did not require any elucidation or evidence for the readers. It was presented by him in a few words as a firmly established fact. He only took pains to show that it did not contradict divine providence. Camper stressed the importance of his attempt at reconciliation by observing that it was only after very serious reflection that he had become convinced

> "that a law by which God commands those animals to cease [to exist] as soon as they have fully fulfilled their primary aim, which aim is unknown to us, is not contrary to divine providence."[52]

Except in the *Complementa varia*, Camper has never given any evidence, either in his published or in his unpublished writings, of concern about the incompatibility of his extinction theory with the prevailing Christian doctrine, let alone that he made attempts at reconciliation. One cannot therefore avoid the impression that the passage quoted above merely served tactical ends. In this way Camper undoubtedly tried to anticipate the theological criticism of the theory of extinction, a criticism which was widespread among the scientists of his own country,[53] and to facilitate the acceptance of his ideas.

Camper's history of the earth

The fossil research led Camper to an explicit view

of what he called "l'histoire physique de la terre". Practically from the start of his activities in the palaeontological field he concerned himself with this subject and fairly soon began to plan publishing his "conjectures" on the history of the earth.[54] For reasons which are not quite clear this never came off. His plans stuck in the preparatory phase. The main thing left to us are manuscript notes in connection with an article of the German amateur-geologist J.C. Meinecke and the first version of an unfinished *Dissertatio physica de quadrupedibus in prima creatione soeculis aliquot ante Adamum natis*.[55]

Camper characterized fossils as "medals of former worlds".[56] Like his contemporaries, he considered them as the main source of information about the geological history of the earth. He deemed himself to be able "to demonstrate clearly the revolutions of our globe" with the aid of fossils.[57]

Condorcet and Vicq d'Azyr gave as their opinion that Camper regarded the petrifactions as "un indice du refroidissement du globe", an idea which he was thought to have borrowed from Buffon.[58] It is absolutely unclear on what grounds this interpretation is based. Camper's writings do not provide a single argument for it. The only occasion on which he spoke about the theory introduced by Buffon, he did it in a rather negative way.[59] Changes of the climate such as conceived by the French naturalist did not play a part in Camper's history of the earth. He was unmistakably no partisan of the theory of the cooling earth.

He deduced from the fossils geological events of a more actualistic nature. In his opinion subterranean fire, earthquakes, and floods had caused the extinction of the animals. Since a great many species and numerous individuals, scattered about a great part of the world, were involved, these catastrophes must have been of great intensity and magnitude. They had not merely brought about a revolution in life on earth. Camper believed that the catastrophes had at the same time given rise to the formations in which the fossils were found. In view of the wide dispersion and the different spots where the fossils were found, high up in the mountains and at great depths underground, no

other explanation was possible except that the catastrophes had had a considerable share in the formation of the crust of the earth. Camper did not regard them as the only forces that were responsible for this process. He assumed that the mountains which contained no fossils had been created in the beginning ex nihilo.[60]

A factor of fundamental importance for his reconstruction of the history of the earth was his conviction that human fossils did not exist. The fact that later discoveries put him in the wrong does not of course imply that he defended an ill-founded standpoint.

The petrifactions which in Camper's time were taken to be anthropoliths were rightly not recognized by him as such.[61] He took great pains to discover as yet human fossils, as their absence would have far-reaching consequences for the accepted views of the history of the earth. He searched in many of the palaeontological collections and books on fossils but came nowhere across an unequivocal trace of human remains. He did not mention Esper's report on a find of human fossils in the cave of Gailenreuth.[62] Camper shared, apparently, the opinion current among the more professional students of fossils that Esper's identifications should not be taken seriously.

All taken together, it was in Camper's situation by no means unreasonable to consider the absence of human fossils as a reliable fact. He did not think it possible to explain this by assuming that human bones are not suited for a prolonged sojourn in the earth. In the *Dissertatio physica* he gave an ample argumentation to make it clear that those bones might fossilize just as well as those of, for instance, the mammoth, the Siberian rhinoceros, or the cave-bear.[63]

The observation about the absence of anthropoliths combined with the discovery of the specific differences between fossil and living animals led Camper to conclude that the species we know through their petrified remains lived and became extinct before man and the other creatures described in Genesis appeared on the earth. Between the fossils and the still existing fauna there was evidently a chronological discontinuity. They had arisen at different points of time

and proved to Camper that creation was not unique, had not taken place all at once and simultaneously, but that there had been different epochs. The fossils and the living animals belonged to different creations.[64]

The periodization of the geological history was for Camper a logical consequence of his views about the successive creation of (animal) life. According to him the mountains and deposits with fossils had also been formed in the era preceding the appearance of man. The origin of the "montes primordiales", by which he understood mountains consisting, for instance, of granite and porphyry, which did not contain fossils, were situated by him, as we have already noted, in a past even farther back.[65]

Camper's geological chronology implied that the morphology of the surface of the earth, which was determined mainly by fossiliferous and non-fossiliferous rock, had come about in pre-adamitic times. The link between the biblical flood and the configuration of the crust of the earth, a link which for many eighteenth-century people was an unassailable reality, had thus been broken. Camper recognized this breach without reserve. In the *Dissertatio physica* he pointed out that fossils were already present in the mountains surrounding the garden of Eden and that the flood had not resulted in radical changes of the earth's surface.[66]

Unlike those who based their geological theory on a literal interpretation of Genesis, Camper was of the opinion that the history of the earth did not coincide with the history of man. His ideas about the evolution of life and of the earth implied that the earth was older than the approximately 6,000 years which had been calculated with the aid of the biblical chronology. He did not hesitate to draw this conclusion, although a number of years previously he had regarded "the accepted chronologies ... of Holy Writ" as infallible.[67] He had no criteria for determining even approximately the age of the earth. On this point he had to remain vague. His estimates as to the extent to which the conventional time-scale was to be extended varied from several centuries[68] to "some thousand years".[69]

Camper's attempts to reconstruct the physical history of the earth are characterized by a critical attitude towards the popular conception that the truth about this is to be found in the story of creation. He did not reject the Bible as a source of scientific information, but did not ascribe any special authority to it. He did not assume a priori that this information was correct. Where knowledge of nature was at issue, he used the Bible in the same way as other writings. He reserved to himself the right to test the biblical descriptions of natural phenomena by the results of his own empirical research, as he always did with other testimonia as well.

The orthodox version of the story of creation produced a geological theory in which the six days of creation and the flood figured as the main formative events in the evolution of the earth and of life on earth. Through his study of fossils Camper had conceived ideas which were not in conformity with these basic tenets of the literalists. In his history of the earth the Noachian flood was an event without geological importance. The creation in six days had to yield its unique position and was no longer considered as the beginning of everything.

One does not get the impression that Camper needed prolonged and profound considerations to allow his own theory to prevail over that derived from the story of creation. He wrote full of scorn about the "fanatik enthousiasts" who took offence at the geological ideas because they contradicted "the mosaical doctrine".[70] He did not show any traces of such fanaticism.

He saw no reason to doubt the reality of creation and the flood. In the light of his reconstruction of the history of the earth, however, he concluded straightaway that the book of Genesis as a whole did not give a true picture of that history. It was no objective and complete description of the origin and of the vicissitudes of the earth. According to Camper the story of creation could not be taken literally. It had to be judged exclusively by the "scopum moralem seu philosophicum", the only purpose for which it had been written.[71]

If Camper had been able to elaborate and publish the

ideas discussed above, they would undoubtedly have procured him a place in the histories of the earth sciences.[72] He would not have owed this place to the strictly geological aspects of his theory. His originality certainly did not consist either in the distinction he made between fossiliferous and non-fossiliferous mountain ranges or in his view of the forces which are responsible for the configuration of the crust of the earth. The historical importance of his work consists especially in his arguments for the extension of the time-scale.

Camper was not the first to state that the earth is much older than mankind. Those who had preceded him usually based their opinion on vague conjectures and speculative starting-points. With his observation about the absence of human fossils Camper first provided his contemporaries with a strong argument for the untenability of the traditional conception according to which the history of the earth coincides with the history of man. Kant gratefully took advantage of Camper's argumentation.[73] Camper's projected treatise on the physical history of the earth would have been a considerable support for the idea about the great age of the earth which was rapidly gaining ground, and more generally might have contributed to the secularization of geology.

CONCLUDING REMARKS

If we finally try, by way of summary, to characterize Camper's zoological work, then we have to observe first of all that he was one of the few eighteenth-century zoologists who set a high value on anatomical analysis. He spent most of his time and energy on investigations which aimed at collecting new data on the structural properties of animals and at verifying existing zootomical knowledge. It was a type of research that suited his tastes and perfectly answered his empirical ideals. Camper realized quite well that this did not yet create a zoological science. Apart from a few exceptions, such as the pneumaticity of the skeleton of birds, he did not study anatomy for its own sake. It was nothing less but also nothing more than the "sole and constant foundation of the real natural history of animals". Camper clearly did not regard zoology as identical with anatomy. Upon a survey of his work it appears that in the course of time he derived from anatomy three kinds of zoological knowledge.

At the outset of his career as a zoologist he mainly used anatomy to solve functional problems. Camper recognized the vital functions as a part of the zoologist's field of research. He, however, never grew to be a physiologist. After his studies on the reproduction of the South American toads, the croaking of frogs, and the hearing of fishes, he hardly showed any active interest in the functional aspects of the animal organism. The restrictions which were inherent for him in the anatomical method contributed to this in an important degree.

The focus of Camper's research shifted before long

from the organ and organ-systems to the organism. First of all he devoted himself to distinguishing the vertebrates by means of their anatomy. By comparing their internal structure he attempted to discover the essential differences and to mark off the species. Camper paid ample attention to this branch of zoology. He did not only do so in his descriptions of rare animals. In his anthropology and study of fossils he also tried to define vertebrate species in anatomical terms.

The taxonomic exercises on species level, which resulted in several useful discoveries, elucidated an aspect of what Camper held to be the main objective of zoology, viz. the relations between the animals. He did not suggest, however, that this was the principal aspect. Although Camper did not clearly express himself on this point, it is fully justified to conclude that he was ultimately not concerned with the differences, but with the resemblances between the animals. The eighteenth-century comparative anatomists, such as e.g. Daubenton, were of the opinion that especially there the "connoissances générales" could be found which Camper too saw as the highest form of scientific knowledge.

He tried to transcend the simple collecting of anatomical facts and to satisfy his need for meaningful generalizations by investigating the structural uniformity of the vertebrates. Camper was convinced that the variety in which the animal form manifests itself owed its origin to the different functions for which the animals had been destined by their creator and that the different forms must be seen as variations of a basic type. The purpose of his quest for the unity of plan was to substantiate this latter idea and to gain insight into what he thought to be one of the fundamental laws of the animal creation.

Comparative anatomy did not attain to full growth with Camper, no more indeed than with the other zoologists from the second part of the eighteenth century. While Daubenton enriched the nascent science with an uniform descriptive method to facilitate comparison and while his countryman Vicq d'Azyr made the first attempt to deal theoretically with comparative

anatomy, it is Camper's special merit to have collected an unparalleled amount of material supporting the idea of the structural uniformity of the vertebrates. His all-pervading empiricism prevented him from synthesizing these data and formulating general conclusions. The ideal of Camper and his colleagues, general knowledge, only became a reality with the next generation of zoologists, who, also thanks to their efforts, made comparative anatomy a mature science.

NOTES

ABBREVIATIONS

Camper's publications are given in short-title and identified by a number between brackets. This number refers to the Bibliography of Camper's writings (178-199) where further details are to be found.

D.D.	= Petri Camperi ... Dissertationes Decem (no. 124)
Hist. nat.	= G.L.L. de Buffon, Histoire naturelle, générale et particulière avec la description du cabinet du roi, 36 vols. (Paris, 1749-1788).
K.B.	= Royal Library, The Hague
Kl. S.	= Herrn Peter Campers ... sämmtliche Kleinere Schriften (no. 151).
Ms.	= Manuscript
O.C.	= Oeuvres de Pierre Camper (no. 168)
UBA	= Library of the Municipal University of Amsterdam
UBL	= Library of the University of Leiden
V.H.M.	= Verhandelingen uitgegeeven door de Hollandsche Maatschappye der Weetenschappen
V.S.	= Peter Camper's vermischte Schriften (no. 167)

INTRODUCTION

1. J.W. Goethe, "Zur Morphologie I. Theil", Goethes Werke [Weimarer Ausgabe], Abt. II, vol. 6 (Weimar, 1891) 18.
2. I. Kant, "Reflexionen zur physischen Geographie", Gesammelte Schriften, herausgegeben von der Preussischen Akademie der Wissenschaften, vol. 14 (Berlin, 1911) 620n.

Chapter I. BACKGROUND: CAMPER'S LIFE AND IDEAS ON SCIENTIFIC METHOD

1. Archief Latijnse School (Municipal Archives, Leiden), inv. no. 6.
2. Album Studiosorum Academiae Lugduno-Batavae (Den Haag, 1875), col. 949.
3. According to a short unpublished biography by A.G. Camper (Provincial Library Friesland, Ms. 1664). This biography is not identical with the one which he published under the title Levensschets van Petrus Camper (Leeuwarden, 1791).
4. Letter to A.A. van Iddekinge, 12 June, 1763 (K.B., 424 B 1), Itinera in Angliam (no. 136, 1939) 94.
5. Lessen gehouden over de Walvisschen 1772 (Ms., UBA, II F 78) 1.
6. See e.g. Verhandeling (no. 8, 1761) 266-267; Oratio (no. 17, 1764) 13-15; Redevoering (no. 56, 1772) 374; Oplossing (no. 98, 1783) xix.
7. Aanmerkingen (no. 61, 1774) 245.
8. L. Brummel, Frans Hemsterhuis, een philosophenleven (Haarlem, 1925) 31.
9. Bemerkungen (no. 108, 1787) 197.
10. Drawings and text in UBL, BPL 247^{II} and 247^{I} respectively.
11. Brief (no. 69, 1775) 57 and Vergleichung (no. 190, 1787) 168.
12. Quotation from the unpublished biography mentioned in note 3.
13. Bemerkungen (no. 108, 1787) 198.
14. The diaries of this journey and his two other journeys to England (in 1752 and 1785) have been published (no. 136, 1939).
15. Certificate of candidature (Records Royal Society, London).
16. S. Galama, Het wijsgerig onderwijs aan de hogeschool te Franeker 1585-1811 (Franeker, 1954) 225-226.
17. Oratio (no. 17, 1764) 2.
18. Idem 5.
19. As usual, in this literary genre, Camper published his essays under a pseudonym. On the basis of the preserved manuscripts (UBL, BPL 247/133) 22 essays (nos. 11, 1762; 16, 1764; 20-35, 1766; 38-39, 1767; 47-48, 1769) can definitely be attributed to him.
20. See e.g. the Oratio de pulchro (Ms., UBL, BPL 247/2), the addresses before the Amsterdam School of Art (no. 118, 1791; no. 119, 1792), an essay in De Philosooph (no. 39, 1767), and his work in connection with the prize competition for a new townhall in Groningen (cf. R. Meischke, "Achttiende-eeuws klassicisme: Twee bouwkundige prijsvragen", Nederlands Kunsthistorisch Jaarboek 10 (1959) 218 et seq.).

21. Drawings in UBA (II G 53); some of them were published later (no. 193, 1789).
22. M.J. Busch, De mechanismo organi vocis (Groningen, 1770); C.J. Keuchenius, De ossiculis e cordibus animalium (Groningen, 1772); L. Chernak, De respiratione volucrum (Groningen, 1773).
23. The principal studies on Camper as a medical man are: C.E. Daniels, Het leven en de verdiensten van Petrus Camper (Utrecht, 1880) 76-105; B.W.T. Nuyens, "Petrus Camper (1722-1789) als verloskundige", Nederlands Tijdschrift voor Geneeskunde 74 (1930) 38-60; various articles in the Camper issue of the Bijdragen tot de Geschiedenis der Geneeskunde 19 (1939) 73-151; C.J. Doets, De heelkunde van Petrus Camper, 1722-1789 (Leiden, 1948).
24. Letter, dated 2 September, 1780 (UBA, Eg 4).
25. Letter to François Fagel, 6 October, 1770 (State Archives, Den Haag, Fagel Coll., no. 2740).
26. F.J.L. Krämer, Gedenkschriften van Gijsbert Jan van Hardenbroek, vol. 5 (Utrecht, 1917) 651.
27. See Brief (no. 21, 1766) 141 and Oplossing (no. 98, 1783) 67-68.
28. G. Cuvier, "Sur le grand animal fossile des carrières de Maestricht", Annales du Muséum d'Histoire Naturelle 12 (1808) 148-149.
29. Th. H[uber], Johann Georg Forster's Briefwechsel, vol. 2 (Leipzig, 1829) 781.
30. For the ideas of these Dutch empiricists see P. Brunet, Les physiciens hollandais et la méthode expérimentale en France au xviiie siècle (Paris, 1926); E.G. Ruestow, Physics at seventeenth and eighteenth century Leiden: philosophy and the new science in the university (The Hague, 1973) ch. 7; C. de Pater, Petrus van Musschenbroek (1692-1761), een Newtoniaans natuuronderzoeker (Utrecht, 1979) esp. ch. 3.
31. Ms., UBL, BPL 247/12.
32. Prolegomena 34, 39, 42, 46.
33. Idem 37, 38, 39, 40, 41, 45-46. For 's Gravesande's and Van Musschenbroek's criticism of Descartes see De Pater, Petrus van Musschenbroek 76-79.
34. Oratio de mundo optimo (Ms., UBL, BPL 247/3) preface.
35. Oratio (no. 4, 1758) 10. Cf. thesis III of the Theses philosophicae (Ms., UBA, II G 55): "Mens corpore eorumque proprietate nullam ideam innatem habet".
36. Prolegomena 19, 20 and Oratio (no. 4, 1758) 10.

37. Prolegomena 21-23.
38. Prolegomena 23 et seq. and Oratio (no. 4, 1758) 9-10. Cf. thesis V of the Dissertatio (no. 1, 1746). For 's Gravesande see his Orationes tres ... De Evidentia (Leiden, 1734).
39. Prologomena 28 and Oratio (no. 4, 1758) 9. For 's Gravesande's and Van Musschenbroek's foundation of analogia, see Orationes tres and De Pater, Petrus van Musschenbroek 85.
40. Prolegomena 28.
41. Commentarius in Logicam 's Gravesandii (notes for his Franeker philosophy lectures, Ms., UBL, BPL 247/16) 58.
42. Lectiones physicae (notes for Camper's physics lectures at Franeker, Ms., UBL, BPL 247/13) prologus.
43. Prolegomena 6; Lectiones physicae prologus; Oratio (no. 4, 1758) 9, 11.
44. Prolegomena 23 et seq. and Oratio (no. 4, 1758) passim. For 's Gravesande, see his Orationes tres.
45. Dissertatio (no. 1, 1746) theses VIII and XII. Cf. also thesis VII of the Theses philosophicae (see note 35): "Natura corporis ignota est".
46. See e.g. Oratio de mundo optimo (see note 34) preface; Oratio (no. 4, 1758) 15, 20; Lessen (no. 45, 1769) 31.
47. For 's Gravesande and Van Musschenbroek, see Ruestow, Physics at ... Leiden 123, 125, 129-131.
48. Inleyding tot de lessen over de hersenen en zenuwen begonnen 1 December 1763 (Ms., UBA, II F 71) 15.
49. See Lessen (no. 45, 1769) 33. Camper's opinion on the value of the testimonia was based on an extensive knowledge of scientific literature. The numerous references in his writings testify to this knowledge, just as the catalogue of his well-stocked library: Pars Bibliotheca Camperiana sive Catalogus Librorum Maxima Parte Nitide Compactoru quos dum in Vivis erat Ad usus privatus sibi collegerat ... Petrus Camper ... (Leiden, 1790).
50. Bemerkungen, "Zusatz" (no. 108, 1787) 219.
51. E.g. in the Verhandeling (no. 36, 1767) 218; Mémoire (no. 59, 1774) 190; Verhandeling (no. 60, 1774) 238.
52. See i.a. Natuurkundige Verhandelingen (no. 95, 1782) 211-212.
53. Verhandeling (no. 71, 1776) 178.
54. For Van Musschenbroek's views see his Beginsels der Natuurkunde, ed. 2, vol. 1 (Leiden, 1739) 9.

Chapter II. ANATOMICAL AND PHYSIOLOGICAL RESEARCHES

1. This research programme, the Methodus, appeared as an appendix to the first edition of the Systema Naturae and was reprinted in the editions 2 to 9.
2. L.J.M. Daubenton, "De la description des animaux", in Hist. nat., vol. 4 (1753) 111-141, passim; J. Hunter, "On the study of natural history", Essays and observations on natural history, anatomy, physiology, psychology and geology (ed. R. Owen), vol. 1 (London, 1861) 25.
3. Natuurkundige verhandelingen (no. 95, 1782) 131.
4. Encyclopédie ou dictionnaire raisonnée des sciences et des arts, vol. 17 (Paris, 1765) 744, s.v. "Zootomie".
5. Brief (no. 99, 1783) 394. He also emphasized the importance of anatomy for zoology in the unpublished address De anatomes usu in omnibus scientiis (UBL, BPL 247/118); Over de dwaasheid der meeste liefhebberen van de natuurlyke historie (no. 27, 1766) 218-219; Redevoering (no. 56, 1772) 373-374; Bemerkungen (no. 108, 1787) passim.
6. Bemerkungen (no. 108, 1787) 219.
7. A.G. Camper, Description succincte (see note 37) v.
8. Kl. S., vol. 2 (2) 239.
9. Cf. Verhandeling over het gehoor van den cachelot (no. 36, 1767) 193 and a letter to Van der Aa, December 24, 1762, in which he stated his publication plans more precisely (Archives of the Hollandsche Maatschappij der Wetenschappen, Haarlem).
10. G. Rondelet, Libri de piscibus marinis, lib. III, ch. 3 (Lyon, 1554-1555); E. Tyson, Phocaena or the anatomy of a porpess (London, 1680).
11. A. Monro, The structure and physiology of fishes explained and compared with those of man and other animals (London, 1785) ch. 8, pt. 2, par. 1; J. Hunter, "Observations on the structure and oeconomy of whales", Philosophical Transactions 77 (1787) 430-437.
12. Camper's reply formed a part of his "Anmerkungen" to the German translation of Monro's book Vergleichung (no. 190, 1787) 158-161.
13. Verhandeling (no. 71, 1776) 188 and "Anmerkungen" (see note 12) 160.
14. Verhandeling (no. 60, 1774) 236.
15. H. Fabricius, De motu locali animalium secundum totum, [pt. 2] (Padua, 1618) 13; L.F. Marsili, Danubius Pannonico-Mysicus, observationibus geographicis, astronomicis, hydrographicis,

historicis, physicis, vol. 6 (Den Haag/Amsterdam, 1726) 10 et seq.

16. Verhandeling (no. 60, 1774) 238.
17. Ibid.
18. Idem 240.
19. Idem 241.
20. Ibid.
21. Redevoeringen (no. 119, 1792) 60.
22. Idem 30.
23. N.K. Smith, ed., Hume's Dialogues concerning natural religion, ed. 2 (London, 1947) 214.
24. Verhandeling (no. 60, 1774) 236.
25. Idem 241.
26. Ibid. and Brief (no. 69, 1775) 62.
27. J. Hunter, "An account of certain receptacles of air, in birds, which communicate with the lungs, and are lodged both among the fleshy parts and in the hollow bones of those animals", Philosophical Transactions 64 (1774) 205-213.
28. The translation appeared in the popular journal Hedendaagsche Vaderlandsche Letter-Oefeningen 3, pt. 2 (1774) 421-427. Camper reacted in a letter to the editors of this journal (no. 69, 1775).
29. Letter of November 8, 1774 (Wellcome Institute, London).
30. Camper ventilated these suspicions in an undated draft letter to Portal (UBA, X 36).
31. Brief (no. 69, 1775) 62.
32. In Kl. S., vol. 1 (1) 151-157.
33. J. Hunter, "An account of certain receptacles of air in birds, which communicate with the lungs and Eustachian tube", in his Observations on certain parts of the animal oeconomy (London, 1786) 77-86.
34. Idem 81n-82n. The exchange of views took place during Camper's visit to London in 1785.
35. A survey of later workers in this field is to be found in R.M. Strong, A bibliography of birds, vol. 2 (Chicago, 1946) 448-449. The function of the pneumaticity is still an unsolved problem.
36. Hist. nat., vol. 7 (1758) 24.
37. For Camper's natural history collections see A.G. Camper, Description succincte du musée de Pierre Camper (Amsterdam/La Haye, 1811). Besides numerous fossils, minerals and invertebrates, Camper's museum contained nearly 400 different vertebrates. With that of John Hunter, Camper's museum belonged to

the richest and most important private collections of the eighteenth century.

38. In the second volume hippopotamus, aardvark, kangaroo, dromedary, gavial, various cetaceans, and other rare animals were to be dealt with. Cf. Historiae literariae cultoribus S.P.D. Petrus Camper (no. 90, 1779) 6.
39. Natuurkundige verhandelingen (no. 95, 1782) 3, 49, 54; Account (no. 87, 1779) 154-155; Kort berigt (no. 88, 1779) 36.
40. N. Tulp, Observationes medicarum libri tres (Amsterdam, 1641) 274; J. Bont, Historiae naturalis et medicinae Indiae Orientalis (Amsterdam, 1658) 84-85. For a history of seventeenth- and early eighteenth-century orangutan research see C.D. O'Malley and H.W. Macoun, "Early concepts of the anthropomorpha", Physis. Rivista di Storia della Scienza A° IV (1962) 39-64.
41. Natuurkundige verhandelingen (no. 95, 1782) 26. Camper referred to G. Edwards, Gleanings of natural history, vol. 1 (London, 1758) 6-7, pl. 213.
42. Account (no. 87, 1779) and Kort berigt (no. 88, 1779).
43. E. Tyson, Orang-outang, sive Homo sylvestris, or the anatomy of a pygmie, compared with that of a monkey, an ape, and a man (London, 1699).
44. Natuurkundige verhandelingen (no. 95, 1782) 27.
45. Hist. nat., vol. 14 (1766) 2-4, 43-71.
46. Natuurkundige verhandelingen (no. 95, 1782) 89-90.
47. A. Vosmaer, Beschryving van de Aap-soort Orang-Outang (Amsterdam, 1778). Camper's lecture is in UBA (Ms., IV A 11[1]). Vosmaer mentioned it in Beschryving 7.
48. Naturgeschichte des Orang-Utang (no. 159, 1791) 146n-147n. The publications which Camper used were J.C.M. Radermacher, "Beschryving van het eiland Borneo", Verhandelingen van het Bataviaasch Genootschap van Kunsten en Wetenschappen 2 (1780) 140-143 and F. von Wurmb, "Beschrijving van de groote Borneoosche orang outang of de Oost-Indische pongo", Idem 245-261. Camper made two drawings of the skull and presented them to Sömmering. Fischer published the drawings and the accompanying text in his Naturhistorische Fragmente (no. 196, 1801). Sömmering's son later gave a facsimilé edition of the drawings and the text (no. 133, 1854).
49. K.A. Rudolphi, "Ueber den Orang-Utang, und Beweis dass derselbe ein junger Pongo sei", Abhandlungen der Königlichen Akademie der Wissenschaften zu Berlin. Aus dem Jahre 1825. Phys. Kl. (published in 1826) 131-135; R. Owen, "On the osteology of the chimpanzee and orang utan", Transactions of the Zoological

Society of London 1 (1835) 343-379.

50. S.T. Sömmering, Etwas vernünftiges vom Orang Utan (no. 144, 1780) 40-41. The monograph in the Natuurkundige verhandelingen was praised in reviews in, i.a., the Algemeene Vaderlandsche Letter-Oefeningen 4, pt. 1 (1782) 574-578 and the Göttingische Anzeigen von gelehrten Sachen pt. 7, January 11 (1783) 57-69.
51. In the Hist. nat. Suppléments, vol. 7 (1789) 1-29 Buffon rectified his original classification with a reference to Allamand, who based himself on Vosmaer, who in turn was indebted to Camper (see note 47). Moreover, Camper had already informed Buffon in 1779 that the orangutan differs from the gibbon as well as from Tyson's "pygmy" (letter, January 4, 1779, UBL, BPL 247/94). J.F. Gmelin reformed the Linnaean classification in the Camperian sense in his 13th edition of the Systema naturae, vol. 1 (Leipzig, 1788) 26-27. Blumenbach adopted the distinction in his Handbuch der Naturgeschichte, ed. 3. (Göttingen, 1788) 65.
52. P. Kolb, Caput Bonae Spei Hodiernum (Nuremberg, 1719) 159 et seq. The Dutch translation appeared in 1727 in Amsterdam under the title Naaukeurige en uitvoerige beschrijving van de Kaap de Goede Hoop. For Kolb's illustration, see L.C. Rookmaaker, "An early engraving of the black rhinoceros (Diceros bicornis (L)) made by Jan Wandelaar", Biological Journal of the Linnaean Society 8 (1976) 87-90.
53. Natuurkundige verhandelingen (no. 95, 1782) 127.
54. Idem 24; Dissertatio (no. 91, 1780) 193. Camper's palaeontology will be dealt with in chapter V.
55. Idem 171.
56. A. Sparrman, "Beskrifning om Rhinoceros bicornis", Konglika Vetenskaps Academiens Handlinger 39 (1778) 303-313. Camper knew its contents from a German translation which the Hamburg physician J.A.H. Reimarus had made specially for him (Natuurkundige verhandelingen (no. 95, 1782) 146n).
57. The drawings in the Natuurkundige verhandelingen had been taken over from the Dissertatio. The latter publication in addition contained illustrations of the base of the skull, of the lower jaw, and of a molar. These drawings were not included in the Natuurkundige verhandelingen to save expenses.
58. J. Parsons introduced this assumption in "A letter containing the natural history of the rhinoceros", Philosophical Transactions 42 (1743) 538. His suggestion was adopted, amongst others, by Linnaeus, Systema Naturae, ed. 10, vol. 1 (Stockholm, 1758) 56.

59. Hist. nat., vol. 11 (1754; read: 1764) 186-187. Linnaeus now also considered the rhinoceroses as belonging to one species, cf. Systema Naturae, ed. 12, vol. 1 (Stockholm, 1766) 104.
60. For a survey of the different interpretations, see L.C. Rookmaaker, "Early rhinoceros systematics", in A. Wheeler & J.H. Price, eds., History in the service of systematics (London, 1981) 115.
61. Dissertatio (no. 91, 1780) 195.
62. Sparrman, "Beskrifning". The observations of Gordon, a colonel in the Cape armed forces, were published by J.N.S. Allamand in his "Addition aux articles du rhinocéros", in Buffon Hist. nat., nouvelle édition, Suppl., vol. 5 (Amsterdam, 1781) 9-13.
63. Natuurkundige verhandelingen (no. 95, 1782) 157-158.
64. G. Cuvier, "Sur les ossemens fossiles de rhinocéros", Recherches sur les ossemens fossiles de quadrupèdes, vol. 2 (Paris, 1812) 11.
65. Natuurkundige verhandelingen (no. 95, 1782) 179-180.
66. P.S. Pallas, "De ossibus Sibiriae fossilibus craniis praesertim rhinocerotum atque buffalorum, observationes", Novi Commentarii Academiae Scientiarum Imperialis Petropolitanae 13 (1769) 453-454.
67. Dissertatio (no. 91, 1780) 200; Natuurkundige verhandelingen (no. 95, 1782) 165-166.
68. Natuurkundige verhandelingen (no. 95, 1782) 168.
69. Letter December 12, 1788. K. Wagner, ed., Briefe an Johann Heinrich Merck von Goethe, Herder, Wieland und andern bedeutenden Zeitgenossen (Darmstadt, 1835) 478.
70. Naturgeschichte des Orang-Utang (no. 159, 1791) 50n.
71. Idem 61n. The manuscript of this article dates from 1787 and is entitled Additamentum ad dissertationem de Cranio Rhinocerotis Africani Gemino cornu etc. (UBA, IV A 11²). It is not clear whether he ever sent it to the Petersburg Academy.
72. For Merck, see letter mentioned in note 69. Camper informed Joseph Banks in a letter of September/October, 1787 (letter in British Library, London, Add. Ms., 8096, fols. 413-414). Merck made Camper's discovery known in his Troisième lettre sur les os fossiles d'éléphans et de rhinocéros (Darmstadt, 1786) 9-10.
73. The drawings in profile were reprinted on a reduced scale by J.F. Blumenbach in his Abbildungen naturhistorischer Gegenstände, Hft. 1, no. 7 (Göttingen, 1796).
74. Aus einem Briefe (no. 120, 1793) 249. The suggested date of this letter is based on the fact that Camper mentioned this

difference neither in the letter to Banks (see note 72) nor in earlier expositions on rhinoceros systematics.

75. H.J.V. Sody, "Das Javanische Nasshorn ... historisch und biologisch", Zeitschrift für Säugetierkunde 24 (1959) 132. For a detailed analysis of Camper's contributions to the natural history of the Javan rhinoceros see L.C. Rookmaaker and R.P.W. Visser, "Petrus Camper's study of the Javan rhinoceros (Rhinoceros sondaicus) and its influence on Georges Cuvier", Bijdragen tot de Dierkunde 52 (1982) 121-136.
76. Cuvier, "Sur les ossemens fossiles" passim.
77. Natuurkundige verhandelingen (no. 95, 1782) 195.
78. Camper disowned the clumsy drawing which the printer had added on his own initiative and had wrongly attributed to him (Idem 194).
79. Natuurkundige verhandelingen (no. 95, 1782) 193.
80. T. Bartholinus, "Anatome rangiferi", Acta Medica et Philosophica Hafniensia 1, A. 1671 (published 1673) 274-278; C. Linnaeus, Cervus rheno, quem dissertatione zoologica descriptum ... sistit C.F. Hoffberg (Uppsala, 1754); Buffon, Hist. nat., vol. 12 (1764) 79-116.
81. Natuurkundige verhandelingen (no. 95, 1782) 228-229.
82. Idem 195-196.
83. J. Mulder, Oratio de meritis Petri Camperi in anatomiam comparatam (Groningen, 1808) 26-27.
84. Natuurkundige verhandelingen (no. 95, 1782) 229.
85. This characterization is from J.F. Blumenbach, "Petrus Camper", in his Medicinische Bibliothek, vol. 3, pt. 4 (Göttingen, 1795) 735.
86. Natuurkundige verhandelingen (no. 95, 1782) 46-47.
87. Kort berigt (no. 88, 1779) 22. For the publication in the Hist. nat., see no. 194, 1789.
88. A copy of Buffon's letter to De Gallitzin, dated September 27, 1784, in Camper's handwriting in UBA (IV A 10^{11}).
89. Letter of Adriaan Camper, August 4, 1785 (UBA, X 22).
90. Hist. nat. Suppléments, vol. 7 (1789).
91. In Pallas, Observationes (no. 183, 1780). The anatomy of these exotic animals had not yet been described before. Already in 1772 Camper had sent an article on the aardvark to the Académie des Sciences. However, they never published it. Camper thought this was due to Daubenton's machinations, cf. Historiae literariae (no. 90, 1779) 3; H[uber], Forster's Briefwechsel, vol. 2, 766 and letters to Buffon, November 15, 1778 and June 9, 1779 (UBL, BPL 247/94). A summary of Camper's kangaroo research appeared in the same year in E.A.W. Zimmermann, Geographische Geschichte des Menschen, vol. 2 (Leipzig, 1780) 430.

92. Later Camper correctly assumed that his Asiatic "opossum" was identical with the kangaroo observed by Banks in Australia. Cf. Naturgeschichte des Orang-Utang (no. 159, 1791) 18n.
93. P.S. Pallas, Miscellanea zoologica (Den Haag, 1766) 59-65.
94. J.N.S. Allamand, Buffon Hist. nat., nouvelle édition, Suppl., vol. 5 (Amsterdam, 1781) 20. The engraving had been made after a drawing which Allamand had received from Gordon (cf. note 62).
95. Beschrijving (no. 191, 1787).
96. His criticism of Sparrman was the subject of the "Zusatz" to the Bemerkungen (no. 108, 1787) 219-226.
97. Waarneemingen (no. 191, 1787) 42. Vosmaer emphatically did not regard it as a horn (Beschrijving (no. 191, 1787) 37).
98. In a letter to Anna Amalia, Duchess of Sachsen-Weimar-Eisenach, June 3, 1784, H. Kraft, ed., Johann Heinrich Merck Briefe (Frankfurt a. M., 1968) 452.
99. Kort berigt van de ontleding eens jongen elephants (no. 68, 1774).
100. Portal informed Camper of the decision of the committee (letter of August 15, 1774, UBL, BPL 885). In 1786 Tenon returned the letters to Adriaan Camper (cf. Description (no. 131, 1802) viiin & 13n). The letters are in UBL, BPL 247/101 & BPL 885.
101. Kort berigt (no. 68, 1774) 312.
102. A. Moulin, An anatomical account of the elephant accidentally burnt in Dublin (London, 1682); C. Perrault, "Description anatomique d'un éléphant", in Mémoires pour servir à l'histoire naturelle des animaux, vol. 3, part 3 (Paris, 1734) 91-156; P. Blair, "Osteographia elephantina", Philosophical Transactions 27 (1710) 51-168.
103. E.g. the Vaterian ampulla which Camper mistook for the gall bladder.
104. Kort berigt (no. 68, 1774) 302. For Daubenton, see Hist. nat., vol. 11 (1754, read: 1764) 117-120.
105. Dissertatio (no. 91, 1780) 196.
106. Camper in a letter to Sömmering, June 12, 1784, R. Wagner, Samuel Thomas von Sömmerings Leben und Verkehr mit seinen Zeitgenossen. Erste Abtheilung. Briefe berühmter Zeitgenossen an Sömmering (Leipzig, 1844) 323.
107. F. Vicq d'Azyr referred to Camper's discovery in his Traité

d'anatomie et de physiologie, vol. 1 (Paris, 1786) 28.

108. Description (no. 131, 1802) 18. For the drawings Camper sent to Blumenbach, cf. Blumenbach's letter, July 27, 1799, to A.G. Camper (UBA, X 11). Blumenbach made use of Camper's discovery in De generis humani varietate nativa, ed. 3 (Göttingen, 1795) section 2, par. 23 and in Handbuch der Naturgeschichte, ed. 6 (Göttingen, 1799) 121-122.
109. G. Cuvier, "Mémoire sur les espèces d'éléphans vivantes et fossiles", Mémoires de l'institut national des sciences et arts 2 (1798/9) 1-22.
110. E.O. Schmidt, Die Entwicklung der vergleichenden Anatomie. Ein Beitrag zur Geschichte der Wissenschaften (Jena, 1855) 64.
111. See the introduction to his Lessen gehouden over de Walvisschen 1772 (Ms., UBA, II F 78).
112. Historiae literariae (no. 90, 1779) 6.
113. See letter of A.G. Camper to P. Camper, August 28, 1785 (UBA, X 23). On the role played by De Gallitzin no further details are known. It is quite possible that he acted as an intermediary. From 1763 to 1773 De Gallitzin was Russian ambassador in Paris and will no doubt have met Buffon there. When later, at The Hague, he held the same function, Camper belonged to his circle of acquaintances. Buffon's proposal might have been inspired by Camper's offer to send him drawings of whales (cf. copy of a letter of Camper to Buffon, June 9, 1779, UBL, BPL 247/94).
114. Letter of A.G. Camper to P. Camper, August 29, 1785 (UBA, X 23). A survey of the drawings sent to Buffon was given by Camper in Kl. S., vol. 2 (2) "Vorrede".
115. Letter of A.G. Camper to P. Camper, January, 1786 (UBA, X 23).
116. Copy of a letter of Camper to Buffon, August 29, 1786 (UBL, BPL 885).
117. Letter of A.G. Camper to P. Camper, October 2, 1786 (UBA, X 24).
118. Cf. Adriaan Camper's preface to the Observations (no. 132, 1820) 4.
119. Idem 5. For Daniels' suggestion, see his Het leven en de verdiensten van Petrus Camper 67-68.
120. Published in J.G. Schneider, Vergleichung des Baues und der Physiologie der Fische (no. 190, 1787) 168-169 + plate 34.
121. Viz. Greenland whale, common rorqual, bottle-nosed whale, cachalot, narwhal, pilot whale, dolphin, and porpoise.
122. For Adriaan Camper's contributions see Observations (no. 132, 1820) 9-41, 86-94, 111-118, 124-126. For Cuvier's corrections

Idem 78n, 92n, 121n.

123. Tyson gave a fairly good illustration of the skull of the porpoise, but omitted to name its parts (Tyson, Phocaena). Daubenton did not get beyond the description of the base of the skull of a dolphin and a small cachalot in his "Observations sur un grand os qui a été trouvé dans Paris et sur la conformation des os de la tête des cétacés", Histoire et Mémoires de l'Académie Royale des Sciences A. 1782, 211-219.
124. Camper summarized the results in Vergleichung (no. 190, 1787). A detailed description was published in the Observations anatomiques (no. 132, 1820) 157-163 + plate 53.
125. Merck published his observations in "Von den Cetaceen", Hessische Beiträge zur Gelehrsamkeit und Kunst 2 (1786) 297-312 and "Mémoire sur les cétacés", Histoire et Mémoires de la Société des Sciences Physiques de Lausanne 2 (1789) 339-344.
126. Apart from the skulls Camper described the following items. Greenland whale: organs of the thoracic and the abdominal cavity, ribs, sternum, and umbilical cord, all of a very young embryo. Common rorqual: shoulderblade and some vertebrae. Cachalot: vertebrae and front extremity. Dolphin: bony capsule of the ear, vertebral column, ribs, and the bones and muscles of the front extremities.
127. J. Hunter, "Observations on the structure and oeconomy of whales", Philosophical Transactions 77 (1787) 371-450; B. de Lacépède, Histoire naturelle des cétacées (Paris, 1804); G. Cuvier's observations are here and there in the Leçons d'anatomie comparée, 5 vols. (Paris, 1800-1805).
128. Daubenton, "De la description des animaux" 135.
129. Camper to Forster, January 28, 1781, H[uber], Forster's Briefwechsel, vol. 2, 767.
130. Over de dwaasheid der meeste liefhebberen van de natuurlyke historie (no. 27, 1766) 219-220.
131. M.S. Merian, Dissertatio de generatione et metamorphosibus insectorum Surinamensium (Amsterdam, 1719) Fig. 59; F. Ruysch, Thesaurus animalium primus (Amsterdam, 1725) 9-10.
132. In spite of a German translation (no. 138, 1767) the article was hardly known. Charles Bonnet in his article "Observations sur le pipa ou crapaud de Surinam", Journal de physique 14, pt. 2 (1779) 425-436 did not mention it and repeated Camper's observations on the reproductive organs. He reached the same conclusion as Camper and got saddled with the same questions as he.
133. Like that on the pipae, the research dated from 1760, but was

not published until 1774, Aanmerkingen over het gezang der mannetjes kikvorschen (no. 61, 1774).

134. T. Willis, Cerebri anatome; cui accessit nervorum descriptio et usus (London, 1664) 76.

135. G. Seger, "De piscium auditu", Miscellanea curiosa medico-physica Academiae Naturae Curiosorum Dec. 1, Ann. 4 & 5 (1673/-1674) 142-143; P. Artedi, Ichthyologia sive opera omnia de piscibus, part 5 (Leiden, 1738) 19-20; C. Linnaeus, Systema Naturae, ed. 10, vol. 1 (Stockholm, 1758) 239; W. Arderon, "Extract of a letter ... concerning the hearing of fish", Philosophical Transactions 45 (1748) 149-155; J. Ray, Historia piscium (ed. Willughby) (Oxford, 1686) 6-8; J.T. Klein, Historiae naturalis piscium ... missus I ... (Dantzig, 1749) 9-11, and Mantissa ichthyologica sive de sono et auditu piscium ... (Leipzig, 1746); E.L. Geoffroy, "Premier mémoire sur l'organe de l'ouie des reptiles, et de quelques poissons que l'on doit rapporter aux reptiles", Mémoires de mathématique et de physique, présentés à l'Académie Royale des Sciences 2 (1755) 164-196; J. Baster, "Van het gehoor der vissen", in his Natuurkundige uitspanningen, vol. 1 (Haarlem, 1762) 98-105.

136. J.A. Nollet, "Mémoire sur l'ouie des poissons et sur la transmission des sons dans l'eau", Mémoires de mathématique et de physique, présentés à l'Académie Royale des Sciences A. 1743 (published in 1746) 199-224.

137. Verhandeling (no. 13, 1763) 87; Mémoire (no. 59, 1774) 178.

138. Verhandeling (no. 13, 1763) 88-89.

139. Mémoire (no. 59, 1774) 79.

140. Verhandeling (no. 13, 1763) 83.

141. Camper first published his observations on the bony fishes (Verhandeling (no. 13, 1763)) and subsequently those on the cartilaginous fishes (Mémoire (no. 59, 1774)). The latter work moreover contains a description of the auditory organ of the pike.

142. Verhandeling (no. 13, 1763) 116; Mémoire (no. 59, 1774) 194.

143. Verhandeling (no. 13, 1763) 106.

144. Idem 113-114. In the Mémoire (no. 59, 1774) 196 he based himself on an experiment with a glass filled with a gelatinous liquid, in which there was a solid body. A tap on the glass set this body moving.

145. Idem 114-115; Mémoire (no. 59, 1774) 187.

146. For Geoffroy, see note 135. J.T. Koelreuter, "Observationum splanchnologicarum, ad acipenseris russici et husonis anatomen, speciatim vero ad ipsorum auditus organum spectantium,

continuatio", Novi Commentarii Academiae Scientiarum Imperialis Petropolitanae 17 (1773) 521-539.

147. Cf. Wrisberg's edition of A. von Haller's Primae lineae physiologiae, ed. 4 (Göttingen, 1780) 266n.

148. For the elephant, see Kort berigt (no. 68, 1774) 303-304, 298, and for the rhinoceros Natuurkundige verhandelingen (no. 95, 1782) 173.

149. Natuurkundige verhandelingen (no. 95, 1782) 227.

150. Celeberrimo ac nobilissimo D.D. Blumenbachio S.P.D. Petrus Camper (no. 116, 1789) 130. This article was entirely devoted to the problem of the tailed pipae. Blumenbach mentioned Camper's problems in the Beiträge zur Naturgeschichte, ed. 2, vol. 1 (Göttingen, 1806) 126-127, where he described him as someone who believed so strongly in the purposiveness of nature that he denied the existence of things which are not in conformity therewith.

151. Dissertatio (no. 1, 1746) thesis VII.

152. Inter alia in Prolegomena in Philosophiam (Ms., UBL, BPL 247/-12) 9; Lectiones physicae (Ms., UBL, BPL 247/13) prologus; introduction to his lectures on anatomy, dated November 26, 1767 (Ms., UBA, II F 71).

153. Vervolg ... over de zedelyke opvoeding (no. 35, 1766) 371. The discussion on the soul of animals, summarized here, was given by Camper as part of a pedagogic exposition in which he advocated teaching children to feel more compassion for animals.

154. Demonstrationum anatomico-pathologicarum (no. 6, 1760) 7-8. Apart from Boerhaave, Borelli too had explained nerve transmission in a similar way. Baldinger therefore was wrong in asserting that this theory is due to Camper. Cf. E.G. Baldinger, "Herr Peter Camper ...", in his Biographien jetztlebender Aerzte und Naturfoscher, vol. 1, pt. 2 (Jena, 1770) 254-255.

155. Introduction to the anatomical lectures on the brain, dated January 29, 1756 (Ms., UBA, II F 72).

156. Lessen over de zenuwen, about 1763 (Ms., UBA, II F 72). He asserted the same in ms. notes, probably dating from 1768, to Boerhaave's Institutiones medicae (Ms., UBA, II E 40).

157. Redevoering (no. 137, 1764) 28, 26. Criticism of the animalculistic version of the preformation theory and of the notion of emboîtement had previously been uttered by him in the Dissertatio (no. 1, 1746) theses II and III.

Chapter III. THE ORDER OF THE ANIMAL KINGDOM

1. Letter to Buffon, 29 August, 1786 (UBL, BPL 885).
2. C. Linnaeus, Philosophia botanica (Stockholm, 1751) 97.
3. Buffon, "De la manière d'étudier et de traiter l'histoire naturelle", Hist. nat., vol. 1 (1749) 15-16.
4. Idem 38-40.
5. Idem 38.
6. See Frans A. Stafleu, Linnaeus and the Linnaeans. The spreading of their ideas in systematic botany, 1735-1780 (Utrecht, 1971) 159-165.
7. Dissertatio (no. 1, 1746) thesis XII.
8. For Linnaeus' essentialism, see A.J. Cain, "Logic and memory in Linnaeus' system of taxonomy", Proceedings of the Linnaean Society of London 169 (1958) 144-163.
9. Dissertatio (no. 2, 1746) thesis XVII. Camper was so impressed by the advantages of this criterion that he suggested to classify the animals, too, according to their reproductive organs (Dissertatio (no. 1, 1746) thesis I). Later he withdrew this proposal because the anatomical examination of these organs took too much time and might not be very attractive for many people, cf. Elementa botanica pars IIa (Ms., UBL, BPL 247/71).
10. D.H. Stöver, Leben des Ritters Carl von Linné, vol. 2 (Hamburg, 1792) 337-338. Stöver's statement was adopted without comment by J.N.F.X. Gistel in his Carolus Linnaeus. Ein Lebensbild (Frankfurt a.M., 1873) 232. In the relevant literature no further mention is made of Camper's role in the dissemination of Linnaean botany.
11. See Itinera in Angliam (no. 136, 1939) 94-95, 152-153. For the fact that Linnaeus was so little known in England in those days, see Stafleu, Linnaeus and the Linnaeans 199.
12. Verhandeling over de botten, of platte lever-wormen der schaapen en runderen (no. 15, 1763) 308.
13. Linnaeus, Philosophia botanica 54, 15.
14. Redevoering (no. 137, 1764) 6-7.
15. Idem 7.
16. Ibid.
17. Elementa botanica (see note 9) 106.
18. Linnaeus, Philosophia botanica 100.
19. Elementa botanica (see note 9) 108.
20. Cf. Redevoering (no. 137, 1764) 40.
21. Elementa botanica (see note 9) 98.

22. Natuurkundige verhandelingen (no. 95, 1782) 11.
23. Elementa botanica (see note 9) 98.
24. Idem 96.
25. Idem 98.
26. For this contest see J.G. de Bruijn, Inventaris van de prijsvragen uitgeschreven door de Hollandsche Maatschappij der Wetenschappen 1753-1917 (Haarlem, 1977) 57.
27. Letter to the secretary of the Hollandsche Maatschappij, 23 March, 1783 (Archives of the Hollandsche Maatschappij der Wetenschappen, Haarlem). The essay of Deluc did not win a prize, but was nevertheless published in the journal of the Maatschappij: "Mémoire sur la gradation des êtres naturels", V.H.M. 25 (1788) 457-498.
28. Over de dwaasheid der meeste liefhebberen van de natuurlyke historie (no. 27, 1766) 219.
29. H. Daudin, De Linné à Jussieu. Méthodes de la classification et idée de série en botanique et en zoologie (1740-1790) (Paris, n.d.) 64-65.
30. Cf. Buffon, "De la manière d'étudier" 22: "on a voulu prononcer sur la ressemblance & la différence des animaux, en n'employant que le nombre des doigts ou ergots, des dents & des mammelles...".
31. Daudin, De Linné à Jussieu 74-75.
32. Mémoire sur l'organe de l'ouïe des poissons (no. 59, 1774) 178.
33. Camper to J.E. Smith, 22 June, 1788. This letter and Smith's request were published by B.D. Jackson in the Proceedings of the Linnaean Society of London (1897-1898) 55-58.
34. Merck to Camper, 17 January, 1785, cf. H. Kraft, ed., Merck Briefe 474.
35. A. Osterdam, "Siren lacertina dissertatione academica ... quam ... praeside ... Carolo a Linné ... publice ventilandam sistit Abrahamus Osterdam", Amoenitates Academicae, vol. 7 (Stockholm, 1769) 311-325. The dissertation, defended on 21 June, 1766, had as usual been written by Linnaeus himself.
36. Kort berigt (no. 103, 1786) 282-283. Camper raised the subject of the Siren lacertina once again in Auszug (no. 109, 1787) 479-482, where he repeated his conclusions and further tried in particular to refute Linnaeus' supposition that the animal is the larval form of a kind of salamander.
37. Camper was one of the few who took the Siren to be a fish. Among others, John Ellis, supported by John Hunter, and Blumenbach also considered it to be an amphibian. It was probably due

to Camper's authority rather than to the force of his arguments that J.F. Gmelin exchanged Linnaeus' identification for that of Camper, see Systema naturae, ed. 13, vol. 1, 1136.

38. Over de dwaasheid (no. 27, 1766) 222-223; Verhandeling over het gehoor van den cachelot, of pot-walvisch (no. 36, 1767) 198-199. J.V. Carus, in his Geschichte der Zoologie bis auf Joh.Müller und Charl. Darwin (München, 1872) 520, wrongly assumed that P.S. Pallas was the first to reject Linnaeus' classification of the Amphibia Nantes. Pallas raised his objections for the first time in the Spicilegia zoologica, fasc. 8 (Berlin, 1770) 36-37. The priority therefore lies clearly with Camper.
39. Bemerkungen (no. 108, 1787) 210. Partly also under Camper's influence, Gmelin cancelled the order of the swimming amphibians in the thirteenth edition of the Systema naturae (1788).
40. Idem 199.
41. Buffon, Hist. nat., vol. 13 (1765) 37.
42. For Buffon, see his publication mentioned in note 3. For Daubenton, see "De la description des animaux" 113-141.
43. Letter dated 29 August, 1786 (Bibliothèque du Muséum d'Histoire Naturelle, Paris, Ms. 346). Lacépède did nothing with Camper's suggestions. In his Histoire naturelle des quadrupèdes ovipares et des serpens, vol. 1 (Paris, 1788) 14 & n, he only referred to Camper's letter in order to confirm his observations on the number of vertebrae in various reptiles.
44. Camper pressed his museum without reservation into the service of zoology. He did not hesitate to dissect even extremely rare specimens if this was necessary for the advancement of science. Cf. Kort berigt (no. 88, 1779) 21.
45. Bemerkungen (no. 108, 1787) 218.
46. Idem 211, 218.
47. The first attempt concerned the African chevrotain. Both Linnaeus and Buffon thought that this animal formed one species with its Asian relative. Camper, however, discovered sufficient anatomical differences to suggest that it be classed in a separate genus (Natuurkundige verhandelingen (no. 95, 1782) 226). Another suggestion concerned the genus Lacerta. In a letter to Lacépède (see note 43) he advocated splitting up this genus into genera of the crocodiles, the iguanae (true lizards), and the salamanders. Finally, mention must be made of his criticism of Linnaeus' classification of the sea-cows (dugong and manatee) in the same genus with the seals and the walruses. Camper argued that the sea-cows should form a separate genus (Kort berigt (no. 193, 1786) 275-281).

48. Natuurkundige verhandelingen (no. 95, 1782) 228.
49. Idem 225-226.
50. C. Linnaeus, Systema naturae, ed. 10, vol. 1, 75-77.
51. Lessen gehouden over de Walvisschen 1772 (Ms., UBA, II F 78) 8.
52. See, inter alia, Aus einem Schreiben (no. 96, 1782) 397; Conjectures (no. 104, 1786) 454 and Bemerkungen (no. 108, 1787) 215.
53. Redenvoering over de verbaazende overeenkomst tusschen de viervoetige dieren, de vogelen, de visschen en den mensch. Camper did not carry out the plan to elaborate and publish this address. A.G. Camper published the literal text of his father's lecture posthumously in the Redenvoeringen (no. 119, 1792) 19-54 + pl. III-VII. At the Art school Camper had previously given lectures on methods for drawing pictures of people of different races and ages (in 1770) and of man's facial expressions (1774). In 1782 he delivered his last speech there, on beauty. These speeches too were published posthumously (cf. nos. 118 and 119).
54. Redenvoeringen (no. 119, 1792) 54.
55. Idem 28.
56. Idem 29. For lack of time he omitted a comparison with the fishes.
57. Idem 28.
58. See e.g. J.G. Herder, Ideen zur Philosophie der Geschichte der Menschheit (ed. G. Schmidt) (Darmstadt, 1966) 75.
59. Oplossing der vraage (no. 98, 1783) xix.
60. The Society regarded this as a needless digression and decided, partly also on that account, not to consider Camper's essay for a prize. Camper published his essay at his own expense: Oplossing der vraage (no. 98, 1783).
61. Idem xviii, 4.
62. Idem 6.
63. G. Coopmans, Beschouwing der Natuur van den Heere C. Bonnet, 3 vols. (Franeker, 1774-1777). Coopmans' description of Camper's comparative anatomy was printed again, via the Wittenbergisches Wochenblatt zum Aufnehmen der Naturkunde und des Oekonomischen Gewerbes, in the Nieuwe Genees- Natuur- en Huishoud-Kundige Jaarboeken 5, pt. 1 (1784) 243-246.
64. Idem, vol. 2 (1775) 277.
65. Idem 277-278. The comparison of the foreleg, here referred to, was later extended to birds. There again Camper discovered

great uniformity and not unjustly qualified his findings as a novelty which was not to be found in any other publication, cf. Oplossing der vraage (no. 98, 1783) xviii, 10.

66. Idem 278.
67. Camper made this remark in a letter to J.H. Merck, 18 August, 1785, see Wagner, ed., Briefe an Johann Heinrich Merck 456.
68. Redenvoeringen (no. 119, 1792) 28.
69. Observations anatomiques (no. 132, 1820) 158.
70. See Vergleichung (no. 190, 1787) 168 and Observations anatomiques (no. 132, 1820) 163.
71. See his diary Reyze naar Hamburg, Zelle, Hannover, Pirmont ... (Ms., UBA, II F 37), about 15 October, 1779 and Celeberrimo ac nobilissimo D.D. Blumenbachio S.P.D. Petrus Camper (no. 116, 1789) 129-130.
72. Itinera in Angliam (no. 135, 1939) 180, 202, 204, 218.
73. Letter dated 31 August, 1785, H. Düntzer & F.G. von Herder, Von und an Herder. Ungedruckte Briefe aus Herders Nachlass, vol. 3 (Leipzig, 1872) 295. Camper's metamorphoses received further publicity through his son Adriaan. When in 1787 Camper Jr. met Goethe in Rome, he demonstrated some examples for him, cf. K.L. Wolf et al., eds., Goethe. Die Schriften zur Naturwissenschaft. Pt II, vol. 9, pt A. Zur Morphologie. Von den Anfängen bis 1795. Ergänzungen und Erläuterungen (Weimar, 1977) 374-375.
74. Carus, Geschichte der Zoologie 566-567.
75. J. Schuster, "Die Anfänge der wissenschaftlichen Erforschung der Geschichte des Lebens, durch Cuvier und Geoffroy Saint Hilaire ...", Archiv für Geschichte der Mathematik, der Naturwissenschaften und der Technik 13 (1930/1932) 2.
76. Cf. E. Rádl, Geschichte der biologischen Theorien in der Neuzeit, ed. 2, vol. 1 (Leipzig/Berlin, 1913) 310 and H. Spemann, "Zur Geschichte und Kritik des Begriffs der Homologie", in Die Kultur der Gegenwart, vol. 1, pt. 3 (Leipzig/Berlin, 1915) 64.
77. Cf. Th.H. Huxley, "Owen's position in the history of anatomical science", in R. Owen, The Life of Richard Owen, vol. 2 (London, 1894) 288 and H. Friedrich, "Kritische Studien zur Geschichte und zum Wesen des Begriffes der Homologie", in Ergebnisse der Anatomie und Entwicklungsgeschichte 29 (1939) 30-31.
78. Rádl, Geschichte der biologischen Theorien 309.
79. Camper has not specified the mammals, birds, amphibians and fishes he compared. The catalogue of his museum gives an indication of the material available to him. It contained large-

ly self-made preparations of about 130 mammals, 70 birds, 60 amphibians and reptiles, and 80 fishes. The museum reflected his comparative anatomical interests in a number of series in which the skull, the gastro-enteric canal, the auditory organ, the extremities, and the vertebral column of different vertebrates were placed side by side, cf. A.G. Camper, Description succincte du musée de Pierre Camper.

80. Cf. Oplossing der vraage (no. 98, 1783) xix.
81. A. Monro, "An essay on comparative anatomy" [1744] in The Works of Alexander Monro ... (Edinburgh, 1781) 728. The quotation has been taken from the preface, written by an anonymous person.
82. Daubenton, "De la description des animaux" 130.

Chapter IV. MAN'S PLACE IN NATURE

1. The oration was published eight years later in the rather obscure periodical De Rhapsodist (no. 56, 1772).
2. Idem 380.
3. Cf. i.a. W.D. Jordan, White over black. American attitudes toward the negro 1550-1812 (Baltimore, 1969) and H.E. Pagliaro, Racism in the eighteenth century (Cleveland/London, 1973).
4. J.F. Meckel, "Nouvelles observations sur l'epiderme et le cerveau des nègres", Histoire de l'Académie Royale des Sciences et Belles Lettres de Berlin (1757) 61-71.
5. Redevoering (no. 56, 1772) 377.
6. Idem 375.
7. Ibid.
8. Idem 375, 394. The sources are Maupertuis' Vénus physique (S.l., 1745) and Buffon's "Variétés dans l'espèce humaine", Hist. nat., vol. 3 (1749) 371-530.
9. Idem 375.
10. J.F. Martinet, Katechismus der Natuur, ed. 2, vol. 2 (Amsterdam, 1778) 8.
11. Redevoering (no. 56, 1772) 381.
12. Ibid.
13. Cf. Idem 381n.
14. Idem 379. Meckel had dissected two negroes in all. Camper dissected four negroes before he had his Oration printed, cf. Idem 380n.
15. Idem 382.
16. Idem 384-385.

17. Idem 393.
18. Idem 383.
19. Idem 393.
20. Idem 389-392.
21. Idem 391.
22. Idem 394.
23. Redevoering (no. 119. 1792) 75.
24. Oplossing der vraage (no. 98, 1783) 76.
25. Redevoering (no. 56, 1772) 384, 394.
26. For Camper's description, see p. 99, sub note 17. Buffon expressed his ideas as follows: "il n'y a eu originairement qu'une seule espèce d'hommes, qui, s'étant multipliée & repandue sur toute la surface de la terre, a subi différens changemens par l'influence du climat, par la différence de la nourriture, par celle de la manière de vivre, par les maladies épidémiques, & aussi par le mélange varié à l'infini des individus plus ou moins ressemblans que d'abord ces altérations n'étoient pas si marquées ... qu'elles sont ensuite devenues variétés de l'espèce ... qu'elles se sont perpétuées & qu'elles se perpétuent de génération en génération ..." (Buffon, "Variétés dans l'espèce humaine" 530).
27. Cf. Buffon, "De la dégéneration des animaux", Hist. nat., vol. 14 (1766) 311-374, passim.
28. Redevoering (no. 56, 1772) 387.
29. A. Dürer, Hierinn sind begriffen vier Bücher von menschlicher Proportion, Bk. 3 (Nürnberg, 1528).
30. The ms. text of this lecture in UBA (II F 71).
31. Camper had prepared the text of this work for the press, cf. Verhandeling (no. 118, 1791), "Voorrede van den uitgeever" (i.e. A.G. Camper), v. Before the treatise appeared in print, its substance was already reasonably well-known. A summary of the lecture before the Art school appeared in the Nieuwe Vaderlandsche Letter-Oefeningen 4, pt. 2 (1770) 386-393 (translation in Kl. S., vol. 1(1) 11-23). Camper himself widely advertised his discovery. He lectured about it in the Académie des Sciences (1778) and the Royal Society (1785). He mentioned it in the monograph on the orang-utan (cf. Natuurkundige Verhandelingen (no. 95, 1782) 74) and in his correspondence and personal contacts with e.g. G. Forster, S.Th. Sömmering, J. Reynolds, J. Banks, J. and W. Hunter, J.H. Merck, C.F. Nicolai, and D. Diderot. Via these as well as other channels reports on the facial angle appeared already before 1791 in print. Lavater published a summary, derived from a letter of

Camper, in his Physiognomische Fragmente (cf. no. 180). Sömmering referred to Camper's discovery in his Uebet.die körperliche Verschiedenheit des Mohren vom Europäer (Mainz, 1784) 78. The Göttingen anatomist J.W. Josephi gave a short description in his Anatomie der Säugetiere, vol. 1 (Göttingen, 1787) 115-116. In his own country Camper's work was announced by e.g. J.F. Martinet (Katechismus der Natuur, vol. 1, 244-246) and J.D. Pasteur ("Verhandeling over de Physiognomiekunde", Genees-, Natuur- en Huishoud-Kundig Kabinet 3 (1782) 459).
32. Verhandeling (no. 118, 1791), "Voorreden van de schrijver", ii.
33. Idem vi-vii.
34. Idem vii.
35. Idem 15-16.
36. Idem 22-27.
37. Redevoering (no. 56, 1772) 387.
38. Verhandeling (no. 118, 1791) 53.
39. Idem 29.
40. Idem 21.
41. Idem 33-35.
42. Idem 33-34. In the preface to vol. 1 of the Demonstrationum anatomico-pathologicarum (no. 6, 1760) Camper had drawn attention to the distortions which are the inevitable consequence of the perspective method and advocated the geometrical or architectonic method as the most adequate one for making anatomical drawings. In the Epistola ad anatomicorum principem magnum Albinum (no. 37, 1767) he returned to the subject in greater detail. Here Camper demonstrated the defects of perspective drawing by means of examples, for instance, from the works of Albinus, and argued once again that the architectonic method is the only one that can give representations which are true to nature.
43. Idem 40.
44. Idem 43.
45. Idem 32.
46. Idem 33.
47. Blumenbach, De generis humani varietate nativa, ed. 3, 200-203.
48. A. van den Spiegel, Opera quae extant, lib. 1, c. 8 (Amsterdam, 1645).
49. See, i.a., K. Saller, Lehrbuch der Anthropologie, ed. 3, vol. 3 (Stuttgart, 1957) 373.

50. E. Geoffroy and G. Cuvier: "Mémoire sur les orangs-outangs", Journal de Physique 46 (1798) 185-191.
51. C. White, An account of the regular gradation in man, and in different animals and vegetables; and from the former to the latter (London, 1799) 50-51.
52. Cf. J.S. Haller, Outcasts from evolution. Scientific attitudes of racial inferiority 1859-1900 (Urbana, 1971) ch. 1, passim.
53. Redenvoering over de voortreffelykheid der Menschen boven alle Dieren (Ms., UBA IV A 11[1]) 2. For the historical context see F. Tinland, L'homme sauvage, Homo ferus et Homo sylvestris, de l'animal à l'homme (Paris, 1968) 173-211.
54. Unpublished lecture of March 15, 1768 (UBA, II F 71) 1. It was especially Rousseau who showed himself a champion of this idea, cf. Discours sur l'origine et les fondemens de l'inégalité parmi les hommes in Oeuvres complètes, vol. 3 (ed. B. Gagnebin et al.) (Paris, 1964) 196-198.
55. Redenvoering (see note 53) 2.
56. Kort berigt (no. 88, 1779) 20.
57. Ibid.
58. Ibid.
59. Bont, Historiae naturalis 84-85.
60. Tyson, Orang-outang 81-82.
61. For Linnaeus, see C.E. Hoppius, Dissertatio (de) Anthropomorpha (Uppsala, 1760). For Buffon, "Nomenclature des singes", Hist. nat., vol. 14 (1766) 1.
62. Natuurkundige verhandelingen (no. 95, 1782) 70-72, 78-79.
63. Idem 35.
64. Idem 36.
65. Ibid.
66. Daubenton, "Description du jocko", Hist. nat., vol. 14 (1766) 72-83. On account of the position of the occipital opening, Daubenton had doubted in a very covert way that the chimpanzee walks erect.
67. Herder, Ideen zur Philosophie der Geschichte der Menschheit 104.
68. Cf. e.g. Buffon, "Nomenclature des singes" 32.
69. Cf. Tinland, L'homme sauvage 186-200.
70. J. de Bont, Historiae naturalis, started this story.
71. Tyson, Orang-outang iii, 55.
72. J.O. de La Mettrie, L'homme machine (ed. A. Vartanian) (Princeton U.P., 1960) 160-163; J. Burnett (Lord Monboddo), Of the origin and progress of language, vol. 1 (London, 1773).
73. Natuurkundige verhandelingen (no. 95, 1782) 53.

74. Account of the organs of speech of the orang outang (no. 87, 1779) 155-156.
75. Natuurkundige verhandelingen (no. 95, 1782) 53.
76. R. Wokler, "The ape debates in Enlightenment anthropology", Studies on Voltaire and the Enlightenment 192 (1980) 1173.
77. E.g. by Cuvier, see his Leçons d'anatomie comparée, vol. 5, 499-500.
78. Account of the organs of speech of the orang outang (no. 87, 1779) 155.
79. Natuurkundige verhandelingen (no. 95, 1782) 89.
80. Ibid.
81. Kort berigt (no. 88, 1779) 35.
82. Cf. Sömmering's reaction in Etwas vernünftiges vom Orang Utan (no. 144, 1780) 40-41.
83. Buffon, "Nomenclature des singes" passim.
84. See p. 68.
85. Redevoering (no. 56, 1772) 374.
86. A short survey of the various opinions since Galenus is given by M.F. Ashley Montagu, "The premaxilla in man", Journal American Dental Association 23 (1936) 2046-2048.
87. Kort berigt (no. 88, 1779) 35.
88. J.W. Josephi, Anatomie der Säugetiere 198-199; J.C. Loder, Anatomisches Handbuch, vol. 1 (Jena, 1788) 87. Josephi based himself on his own observations and directed his criticism explicitly at Camper. Loder made use of the results of Goethe's research and criticized without mentioning any names.
89. It was entitled Versuch aus der vergleichenden Knochenlehre dass der Zwischenknochen der obern Kinnlade dem Menschen mit den übrigen Thieren gemein sey. The manuscript was for many years part of Camper's manuscript legacy. It is now in the Goethe-Schiller Archiv at Weimar.
90. "Dem Menschen wie den Thieren ist ein Zwischenknochen der obern Kinnlade zuzuschreiben", Zur Naturwissenschaft überhaupt besonders zur Morphologie, vol. 2, pt. 2 (Stuttgart/Tübingen, 1820) 199-251.
91. Versuch (see note 89) 1.
92. In a letter of September 16, 1785, Wagner, ed., Briefe an Johann Heinrich Merck 466-468.
93. Goethe had had the Latin translation made specially for Camper. He assumed, wrongly so, that Camper could not read German.
94. In the Kort berigt (no. 103, 1786) 276, Goethe was mentioned by Camper as the person who had first drawn his attention to

the intermaxillary bone of the walrus.

95. Letter to Merck of September 19, 1785; Wagner, ed., Briefe an Johann Heinrich Merck 469.
96. Idem 470.
97. The exact extent of their correspondence is unknown. Goethe destroyed Camper's letters, along with many others. Goethe's share of the correspondence is in the possession of Camper's descendants and in all probability is somewhere in the U.S.A.
98. Cf. Goethe, Die Schriften zur Naturwissenschaft, vol. 9, pt. 1, Morphologische Hefte (ed. D. Kuhn) (Weimar, 1954) 171.
99. H. Bräuning-Oktavio, "Vom Zwischenkieferknochen zur Idee des Typus. Goethe als Naturforscher in den Jahren 1780-1786", Nova Acta Leopoldina 18, N.F. no. 126 (1956) 71.
100. Idem 72.
101. L. Poliakov, The Aryan myth. A history of racist and nationalist ideas in Europe (transl. E. Howard) (London, 1974) 162.
102. G.A. Wells, "Goethe and the intermaxillary bone", The British Journal for the History of Science 3 (1967) 352.
103. Kort berigt (no. 88, 1779) 35.
104. Ibid.
105. Idem 20.
106. In Natuurkundige verhandelingen (no. 95, 1782) 1-120.
107. This matter will be dealt with in chapter V.
108. Cf. p. 21.

Chapter V. IDENTIFICATION AND INTERPRETATION OF FOSSILS

1. Cf. Palier, Verhandeling (no. 177, 1770). For this as well as another mammoth find in the Netherlands, also studied by Camper (cf. note 9) see R.P.W. Visser, "Dutch palaeontologists of the 18th century", Janus 62 (1975) 133-135.
2. See C.O. van Regteren Altena, "Achttiende-eeuwse verzamelaars van fossielen te Maastricht en het lot hunner collecties", Publicaties van het Natuurhistorisch Genootschap in Limburg 9 (1956) 89.
3. Complementa varia (no. 112, 1788) 252.
4. See W.J. Bell, "A box of old bones: a note on the identification of the mastodon, 1766-1806", Proceedings of the American Philosophical Society 93 (1949) 169-177, passim, esp. 174-177.
5. Cf. letter to Forster October 10, 1788 (H[uber], Forster's Briefwechsel, vol. 2, 786) and a letter to Joseph Banks, November 1, 1788 (British Library, Add. Ms. 8097.22).
6. A survey of the palaeontological material of Camper's museum is given by A.G. Camper in Description succincte du musée de Pierre Camper 42-54.
7. Camper's description dated June 22, 1766, was printed by Palier in his Verhandeling (no. 177, 1770) 379-381.
8. Idem 380-381.
9. Cf. Verster, Bericht (no. 189, 1786) 62. At Verster's request Camper studied some of his fossils. He identified them as the right hip-bone and as a part of the upper maxilla of an elephant, i.e. the Indian elephant, the only one he knew at that time (1776-1778).
10. Camper's analysis in Pallas, Observatio (no. 182, 1780) 219-222.
11. See H. Sloane, "An account of elephants teeth and bones found under ground", Philosophical Transactions 35 (1729) 457-471, 497-514; J.P. Breyne, "A letter ... to Sir Hans Sloane ... with observations and a description of some mammoth's bones dug up in Siberia proving them to have belonged to elephants", Idem 40 (1741) 124-138; W. Hunter, "Observations on the bones, commonly supposed to be elephants bones, which have been found near the river Ohio in America", Idem 58 (1769) 34-45; Daubenton, "Mémoire sur des os et des dents remarquables par leur grandeur", Mémoires de l'Académie des Sciences A. 1762, 206-229.
12. Letter in UBA (X 98).
13. Complementa varia (no. 112, 1788) 260.
14. Camper to Michaelis, September 3, 1784 (UBA, X 33).
15. Complementa varia (no. 112, 1788) 259-264. Camper illustrated his essay with Michaelis' drawing and with a drawing he had made of the fossil in the British Museum.
16. Cf. his letter to Forster, October 10, 1788 (H[uber], Forster's Briefwechsel, vol. 2, 785).
17. Description anatomique d'un éléphant mâle (no. 132, 1802) ch. 2.
18. Conjectures relative to the petrifactions found in St. Peters Mountain, near Maestricht (no. 104, 1786).
19. See A.G. Camper's letter to M. van Marum, September 11, 1800 (Archief van de Hollandsche Maatschappij der Wetenschappen, Haarlem).
20. Conjectures (no. 104, 1786) 443. Fourteen water-colours of the principal mosasaurus bones are the only remainders of Hoffmann's publication plans, see van Regteren Altena, "Achttien-

de-eeuwse verzamelaars van fossielen" 89-90.

21. Letter in Municipal Archives Groningen (Inv. no. 171 r.n.r.). The letter to Hoffmann, mentioned here, could not be traced.
22. Conjectures (no. 104, 1786) 446-450.
23. See the unpublished Conjectures touchant les grandes pétrifactions trouvées dans la montagne de St. Pierre à Maestricht (Ms. in KB, 72 D 34/5 and UBA, A V).
24. G. Cuvier, "Sur le grand animal fossile" 152.
25. Conjectures (no. 104, 1786) 454.
26. Idem 446-448.
27. J.H. Merck, "Von dem Krokodil mit dem langen Schnabel", Hessische Beiträge zur Gelehrsamkeit und Kunst 2 (1785) 80-81; for J.G. Schneider see the comments in his translation of Camper's treatise on the mosasaurus: "Ueber die versteinerten Knochen" (no. 157, 1787); M. van Marum, "Beschryving der beenderen van den kop van eenen visch, gevonden in den St. Pietersberg by Maastricht, en geplaatst in Teyler's museum", Verhandelingen uitgegeeven door Teyler's Tweede Genootschap 8 (1790) 383-389.
28. See Conjectures (no. 104, 1786) 444.
29. See van Regteren Altena, "Achttiende-eeuwse verzamelaars van fossielen" 88-89.
30. J.F. Blumenbach, Handbuch der Naturgeschichte, ed. 5 (Göttingen, 1797) 705. In the two previous editions Blumenbach still agreed with Camper's interpretation. It is not clear why he changed his mind.
31. B. Faujas de St. Fond, Histoire naturelle de la montagne de Saint-Pierre de Maestricht (Paris, 1799-?) 62-67, 222-242.
32. A.G. Camper announced his discovery in the Bulletin des sciences, par la société philomatique fructidor an 8 (1800) 142. A detailed description appeared a month later as "Lettre ... à G. Cuvier, sur les ossemens fossiles de la montagne de St. Pierre, à Maëstricht", Journal de Physique 51 (1800) 278-291. Camper published a Dutch translation as a letter to van Marum: "Over den oorsprong der uitgedolven beenderen van den St. Pietersberg, ...", Natuurkundige verhandelingen van de Bataafsche Maatschappij der Wetenschappen 1, pt. 1 (1801) 169-198.
33. Cuvier, "Sur le grand animal fossile" 150.
34. For the rhinoceroses see Dissertatio de cranio rhinocerotis (no. 91, 1780) passim. For the cave-bear see Camper's letter to Forster, April 7, 1781, cf. H[uber], Forster's Briefwechsel, vol. 2, 772-773. Camper was ahead of his contemporaries with his identification of this animal. The first publication

that mentioned the cave-bear as a separate species appeared in 1795.

35. F.X. Burtin, "Sur les révolutions générales, qu'a subies la surface de la terre, et sur l'ancienneté de notre globe", Verhandelingen uitgegeeven door Teyler's Tweede Genootschap 8 (1790) 35-36. As Burtin finished his manuscript in 1784, Camper's letter must have been written in that year or earlier.
36. Camper did not study the famous fossil in Scheuchzer's museum, as Jahn asserted, because he never visited this museum, cf. Melvin E. Jahn, "Some notes on Dr Scheuchzer and the Homo diluvii testis", in C.J. Schneer, ed., Toward a history of geology (Cambridge, Mass., 1969) 203. Camper probably only knew it from drawings.
37. Dissertatio de cranio rhinocerotis (no. 91, 1780) 202.
38. Ibid.
39. Buffon, "Théorie de la terre", Hist. nat., vol. 1 (1749) 290. Later he modified his view and claimed that the American mastodon was the only extinct land animal (cf. Hist. nat. Suppléments, vol. 5 (1778) 300); W. Hunter, "Observations on the bones".
40. Dissertatio de cranio rhinocerotis (no. 91, 1780) 202.
41. J. Ray, Observations topographical, moral and physiological, made in a journey through part of the Low Countries, Germany, Italy and France (London, 1673) 113-131.
42. Dissertatio de cranio rhinocerotis (no. 91, 1780) 202-203.
43. Buffon, "Epoques de la nature", Hist. nat. Suppléments, vol. 5 (1778) 165-190.
44. Dissertatio de cranio rhinocerotis (no. 91, 1780) 204.
45. Idem 205.
46. Letter to Princess de Gallitzin, written shortly after March 9, 1777 (UBA, X 30).
47. Letter March 30, 1777 (Zürich Zentralbibliothek, Manuscript Dept.).
48. Camper's letter is in the Chevallier-collection of the Utrecht University Library, Manuscript Dept.
49. Letter January 28, 1781, see H[uber], Forster's Briefwechsel, vol. 2, 764.
50. Camper referred to this discovery in a draft letter to P.S. Pallas, November 23, 1778 (UBA, IV A 11²). He visited Tenon in the summer of 1777.
51. Natuurkundige verhandelingen (no. 95, 1782) 148-149. Camper was the first supporter of the theory of extinction in the Netherlands.

52. Complementa varia (no. 112, 1788) 251.
53. See e.g. P. van Musschenbroek, Introductio ad philosophiam naturalem (Leiden, 1762) 22; G. Coopmans, Beschouwing der natuur van den heere C. Bonnet, vol. 3, 389-390; D.H. Gallandat, "Beschryving van een zonderling stuk yvoor; ...", Verhandelingen uitgegeeven door het Zeeuwsch genootschap der wetenschappen 9 (1782) 374-377; P. Boddaert, "Verhandeling over de groote uitgestrektheid van het ryk der dieren", Nieuwe Genees- Natuur- en Huishoud-Kundige Jaarboeken 3 (1783) 124n.
54. He mentioned this plan in the letter to Gessner (see note 47).
55. The notes refer to Meinecke's article "Ueber die hypothetische Vermuthung, dass viele Petrefacte Ueberbleibsel einer präadamitischen Vorwelt sind", Der Naturforscher 18tes St. (1782) 252-268. To these notes Camper added the outline of an article which corresponds to the Dissertatio physica. The notes and the manuscript of the six page Dissertatio are in UBA (A V).
56. Letter to Paulus Chevallier, March 25, 1786 (Chevallier-collection, see note 48).
57. Idem
58. See Condorcet, "Eloge de Pierre Camper" in O.C., vol. 1, xcviii and Vicq d'Azyr, "Eloge de Pierre Camper" in Idem lxxviii.
59. Cf. Natuurkundige verhandelingen (no. 95, 1782) 205.
60. Dissertatio physica (see note 55) 1-2.
61. Idem 5.
62. J.F. Esper, Ausführliche Nachricht von neuentdeckte Zoolithen unbekannter vierfüsiger Thiere ... (Nürnberg, 1774) 25-26.
63. Dissertatio physica 3-4.
64. Idem 1.
65. Ibid.
66. Idem 2.
67. Unpublished lecture on bipedality as a natural property of man, dated March 15, 1768 (UBA, II F 71) 2.
68. Complementa varia (no. 112, 1788) 251.
69. Letter to C.F. Michaelis, September 3, 1784 (UBA, X 33).
70. Idem
71. Note to Meinecke's article (see note 55) 4. Camper saw in this interpretation the possibility to defend himself against the by no means imaginary reproach that he had subverted the biblical story of creation.
72. Camper has not kept the world altogether ignorant of his views about the history of the earth. In passing he referred to the great age of the earth several times. In Verhandeling (no. 118, 1791) 15-16 he stated that the human species had arisen "after the earth had existed for centuries, and thousands of revolutions had taken place". In the Complementa varia (no. 112, 1788) 251 he justified this view with the absence of human fossils.
73. Cf. Kant, Gesammelte Schriften, "Kritik der Urtheilskraft", vol. 5 (1908) 428; "Der Streit der Facultäten", vol. 7 (1907) 88-89; "Opus postumum", vol. 21 (1936) 213, 215. Burtin used the observation on the absence of human remains to argue that the origin of the fossiliferous strata cannot be attributed to the deluge ("Sur les revolutions" (see note 35) 170). He did not mention Camper as a source. Burtin might have come across this observation entirely by himself. It is equally possible that Camper communicated him his findings in his correspondence or during one of his visits to Burtin.

BIBLIOGRAPHY OF CAMPER'S WRITINGS

Contents:

Publications marked with an * could not be traced in any of the major Dutch libraries.
For the abbreviations see p. 147.

ORIGINAL BOOKS AND ARTICLES

1746 1. Dissertatio optica de visu (Leiden, 1746).
++ Also published in A. von Haller's Disputationum anatomicarum selectarum, vol. 4 (Göttingen, 1749) 225-260. For a facsimilé edition see no. 173.

2. Dissertatio physiologica de quibusdam oculi partibus (Leiden, 1746).
++ Also published in Haller's Disputationum, vol. 4, 261-308.

1754 3. Dissertatio de patellae fractura (Franeker, 1754).
++ This dissertation appeared with the name of J. Koole on the title-page. According to the preface of nr. 117 it was written by Camper.

1758 4. Oratio inauguralis de certo in medicina (Amsterdam, 1758).
++ Translation: no. 172.

1759 5. Tractaat van de siektens der swangere vrouwen ... door François Mauriceau ... Uit het Frans vertaelt. Tweede druk. Vermeerdert met eenige verhandelingen ...en opgeheldert met drie bygevoegde plaaten door Petrus Camper ... (Amsterdam, 1759).
++ Mauriceau's text was preceded by six treatises by Camper. A second edition was published in 1783. For a translation of Camper's contributions see no. 142 and V.S. 73-212, where the translation was enlarged with hitherto unpublished "Zusätze zu den Betrachtungen über die Geburtshülfe" (337-396).

1760 6. Demonstrationum anatomico-pathologicarum liber primus, continens brachii humani fabricam et morbos (Amsterdam, 1760).
++ For book 2 see no. 10.

1761 7. "Verhandeling over de oorzaaken der meenigvuldige breuken in de eerstgeboorene kinderen", V.H.M. 6, pt.1 (1761) 235-265.
++ Translation: Kl. S., vol. 2 (1) 41-63. "Zusätze" in Kl. S., vol. 3 (2) 180-182. Cf. also no. 14.

8. "Verhandeling over de voortteeling der Americaansche padden, of pipae", V.H.M. 6, pt. 1 (1761) 266-284.
++ Translations: no. 138; Kl. S., vol. 1 (1) 126-140; O.C., vol. 3, 423-442.

9. Catalogus van chirurgicale instrumenten ... verzamelt door Petrus Camper (Amsterdam, 1761).
++ From the preface it appears that Camper was the author of this auction catalogue.

1762 10. Demonstrationum anatomico-pathologicarum liber secundus. Continens pelvis humanae fabricam et morbos (Amsterdam, 1762).

11. "Brief aan den Philantrope over de weelde der natuur in de voortbrenging van menschen, dieren en planten", De Philantrope 6, no. 317 (1762) 337-344.

1763 12. "Verhandeling over het bestier van kinderen", V.H.M. 7, pt. 2 (1763) 357-464.
++ Latin original with Dutch translation both by Camper. Published in book-form as Verhandeling over het bestuur van kinderen. Translations: no. 142; D.D., vol. 1, 1-64; O.C., vol. 3, 215-296.

13. "Verhandeling over het gehoor der geschubde visschen", V.H.M. 7, pt. 1 (1763) 79-117.

14. "Vervolg over de oorzaaken der meenigvuldige breuken in eerstgeboorene kinderen", V.H.M. 7, pt. 1 (1763) 58-78.
++ Together with no. 7 republished as a book: Verhande-

ling over de oorzaaken der meenigvuldige breuken in de eerstgeborene kinderen (Amsterdam, 1800). Translation: Kl. S., vol. 2 (1) 64-78.

15. "Verhandeling over de botten, of platte lever-wormen der schaapen en runderen", "Verhandeling over de kwaade droes", "Waarneming omtrent een kalf, geheel vergaan in de lyfmoeder van eene koe", De nieuwe wyze van landbouwen, opgehelderd door proeven en waarnemingen ..., vol. 2 (Amsterdam, 1763) 303-320, 321-330, 331-334.

1764 16. "Brief van een koopman aan den DENKER, over de onnuttigheid der studie; en de verkeerde geleerdheid zijner drie broeders", De Denker 1, no. 6 (1764) 41-48.

17. Oratio de analogia inter animalia et stirpes (Groningen, 1764).
++ Translation: no. 137.

18. "Proeve over de beste middelen om de landeryen in de Vereenigde Nederlanden, zoo hooge, als laage, elk naar zynen aart, ten meesten voordeele, aan te leggen", De nieuwe wyze van landbouwen ..., vol. 3 (Amsterdam, 1764) 295-355.

1765 19. "Verhandeling over den oorsprong der leverwormen, in schaapen en runderen", Idem, vol. 4 (1765) 320-325.

1766 20. "Brief over de in-enting der kinderpokjes, aan den kant van de besmetting zyner nabuuren en eener geheele stad beschouwd", De Denker 3, no. 122 (1766) 129-136.

21. "Brief over de zedelyke opvoeding der kinderen", Idem 3, no. 123 (1766) 137-144.
++ For a continuation see nos. 23, 25, 26, 28-29, 31-35.

22. "Tweede brief over de in-enting der kinderziekte, aan den kant der voordeelen en gevaaren beschouwd", Idem 3, no. 125 (1766) 153-160.

23. "Brief over de zedelyke opvoeding der kinderen", Idem 3, no. 127 (1766) 169-176.

24. "Brief van den heer C. waarom elk een buitenplaats begeert; hoe men die trapsgewijze bekoomt, en uit enkele zuinigheid een koets met vier paarden aanlegt", Idem 3, no. 129 (1766) 185-192.

25. "Brief over de zedelyke opvoeding der kinderen", Idem 3, no. 130 (1766) 193-200.

26. "Idem", Idem 3, no. 132 (1766) 209-216.

27. "Over de dwaasheid der meeste liefhebberen van de natuurlyke historie, om zig enkel te vergenoegen met het verdeelen van hunne zeldzaamheden in "Classes" en "Genera"

en de ongerijmdheden welke zich in het systhema van Linnaeus opdoen", Idem 3, no. 133 (1766) 217-224.

28. "Brief over de zedelyke opvoeding der kinderen", Idem 3, no. 134 (1766) 225-232.

29. "Idem", Idem 3, no. 136 (1766) 241-248.

30. "Drie brieven van drie Friessche vrouwen, behelzende klagten wegens de liefhebbery haarer mannen in het hartdraaven, jaagen en de comedie, met den raad van den DENKER", Idem 3, no. 139 (1766) 265-272.

31. "Brief over de zedelyke opvoeding der kinderen", Idem 3, no. 140 (1766) 273-280.

32. "Over de voor- en nadeelen der publyke schoolen, en de gebreken, welke in onze Latynsche scholen verbeterd konden worden", Idem 3, no. 149 (1766) 345-352.

33. "Aanmerkingen over de Fransche kostschoolen", De Philosooph 1, no. 7 (1766) 49-56.

34. "Vervolg van no. 7 over de zedelyke opvoeding", Idem 1, no. 26 (1766) 201-208.

35. "Vervolg van no. 26 ...", Idem 1, no. 47 (1766) 369-376.

1767 36. "Verhandeling over het gehoor van den cachelot, of potwalvisch", V.H.M. 9, pt. 3 (1767) 193-229.
++ Translation: Kl. S., vol. 1 (2) 32-64.

37. Epistola ad anatomicorum principem magnum Albinum (Groningen, 1767).
++ Translation: V.S. 605-640.

38. "Brief van den heer C. over het vermeerderen der armen in ons land", De Philosooph 2, no. 76 (1767) 185-192.

39. "Brief van den heer C. over het gebrek van smaak in de Nederlanders", Idem 2, no. 93 (1767) 321-328.

40. Brief ... aan ... Jan de Reus ... waarin met authentique stukken aangetoond wordt, dat de wateraftapping aan de zwangere huisvrouw van Mr. Evert Rinsma ... tegens alle waarheid den schrijver is aangewreeven (Leeuwarden, 1767).

41. Tweede brief ... aan ... Jan de Reus ... waar in de authenticiteit van het relaas, aangaande de ziekte en behandeling van de huisvrouwe van Mr. Evert Rinsma ... onwederspreekelyk beweezen wordt (Leeuwarden, 1767).

1768 *42. Ontwerp voor eene teken-academie te Groningen (Groningen, 1768).
++ According to the Algemeen huishoudelijk-, natuur-, zedekundig- en konst-woordenboek, vol. 6 (Leeuwarden, 1778) 3267, it was published anonymously.

1769 43. Voorstel tot oprichting eener societeit om het jong hoornvee door inentinge tegens de sterfte van de thans grasserende veeziekte te beveiligen (Groningen, 1769).
++ G. van Doeveren was co-author.

44. Ontwerp van eene maatschappye in Friesland, om onder het bestier van Petrus Camper, en het opzicht van Wynold Munniks ... te beproeven, in hoe verre men het jonge hoornvee door inentinge tegen de thans omgaande veeziekte zoude konnen beveiligen (Leeuwarden, 1769).

45. Lessen over de thans zweevende veesterfte (Groningen, 1769).
++ Translations: no. 139; Kl. S., vol. 3 (1) 35-163, where it was supplemented with "Neuen Zusätzen ..." and "Nachtrag ..." (164-172); O.C., vol. 3, 5-157.

46. Voorloper van waarneemingen omtrent den uitslag van de inëntinge der besmettelyke veeziekte op een honderd en twaalf hokkelingen ... (Leeuwarden, 1769).
++ Written together with W. Munniks. It was re-issued with no. 50.

47. "Onderzoek of de konst om der menschen geaardheid, uit hun uitwendig voorkoomen op te maaken, niet tot grooter volmaaktheid zou te brengen zyn", De Philosooph 4, no. 189 (1769) 257-264.

48. "Brief over eene nieuwe machine, om de kapsels der vrouwen naar te schikken", Idem 4, no. 193 (1769) 289-296.

1770 49. "Lettre à l'auteur de la Gazette Salutaire", Gazette Salutaire XI (March 15, 1770).
++ A report on cattle plague inoculation.

50. Missive van Professor Petrus Camper en Doctor W. Munniks ... (S.l., 1770).
++ For a translation of this letter on cattle plague inoculation see Kl.S., vol. 3 (1) 173-189 and O.C., vol. 3, 158-177.

51. Aanmerkingen over de inëntinge der kinderziekte met waarneemingen bevestigd (Leeuwarden, 1770).
++ Translations: no. 140 and Kl.S., vol. 3 (2) 1-128.

1771 52. Naauwkeurige afbeelding en beschrijving van eene geheel en al verloorene, maar door konst herstelde neus en verhemelte (Amsterdam, 1771).
++ Translation: V.S. 599-604.

53. Naamlyst der intekenaars in de societeit tot inentinge van het hoornvee ... korte staat van de uytkoomste der proeven... (Groningen, 1771).

++ Co-authors G. van Doeveren and W. Wichers.

54. "Observationes circa callium ossium fractorum", Essays and observations, physical and literary. Read before the Philosophical Society in Edinburgh 3 (1771) 537-545.
++ Translation: V.S. 589-598.

55. "Brief ... aan ... David van Gesscher ... over het voordeel der doorsneede van de schaambeenderen, om, met behoud van het leven beide van moeder en kind, moeijelyk geklemde hoofden te redden: en de keizerlyke sneede, of den haak, te vermyden", Nieuwe Vaderlandsche Letter-Oefeningen 5, pt. 2 (1771) 386-411.
++ Reprinted in Opuscula selecta Neerlandicorum de arte medica, vol. 12 (Amsterdam, 1933) 1-23, 25-32. For translations see no. 65 and V.S. 213-260.

1772 56. "Redevoering over den oorsprong en de kleur der zwarten. Voorgeleezen in den Ontleedkonstigen Schouwburg te Groningen, den 14 van slachtmaand 1764", De Rhapsodist 2 (1772) 373-394.
++ Translations: Kl.S., vol. 1 (1) 24-49 and O.C., vol. 2, 449-476.

1773 57. Verklaaring van Petrus Camper gedaan in de Commissie der Edelmog: Heeren Curatoren van de Acad: van Stad en Lande, den 22 May 1773 (S.l., s.a.).

1774 58. "Remarques sur les accouchemens laborieux par l'enclavement de la tête, & sur l'usage du levier de Roonhuysen dans ce cas", Mémoires de l'Académie Royale de Chirurgie 5 (1774) 729-746.
++ Translation: V.S. 261-286.

59. "Mémoire sur l'organe de l'ouïe des poissons", Mémoires de mathématique et de physique, présentés à l'Académie Royale des Sciences 6 (1774) 177-197.
++ Translation: Kl.S., vol. 2 (2) 1-34 "Zusätze ..." on 35-39.

60. "Verhandeling over het zaamenstel der groote beenderen in vogelen, derzelver verscheidenheid in byzondere soorten", Verhandelingen van het Bataafsch Genootschap der Proefondervindelyke Wysbegeerte 1 (1774) 235-244.
++ Translations: nos. 70 and 170; Kl.S., vol. 1 (1) 94-107, "Anhang ...", 151-157; O.C., vol. 3, 457-473 and on 489-496 a translation of the "Anhang" from Kl.S.

61. "Aanmerkingen over het gezang der mannetjes kikvorschen", Idem 1 (1774) 245-252.
++ Translations: Kl.S., vol. 1 (1) 141-150 and O.C., vol.

3, 443-456.

62. "Verhandeling over het toestellen van breukbanden", Idem 1 (1774) 253-276.
++ Translations: no. 63 and Kl.S., vol. 2 (1) 79-110.

63. "Mémoire sur la construction des bandages pour les hernies", Mémoires de l'Académie Royale de Chirurgie 5 (1774) 626-642.
++ Camper's translation of no. 62.

64. Les avantages de l'inoculation, et la meilleure méthode de l'administrer. Ouvrage traduit de la dissertation latine couronnée par l'Académie Royale des Sciences ... de Toulouse (Toulouse, 1774).
++ Latin and French text. The Latin original was also published in no. 65.

65. Dissertatio de emolumentis, et optima methodo insitionis variolarum ... accedunt ... epistola ad D. van Gesscher, de emolumentis sectionis synchondroseos ossium pubis in partu difficile cet. nunc primum latine reddita. Nec non animadversiones criticae in illustrissimi G.L.B. van Swieten Commentaria de Variolis (Groningen, 1774).
++ A second edition in 1789 (Leiden). The Dissertatio was re-issued in D.D., vol. 1, 65-128. For a translation of the last part see Kl.S., vol. 3 (2) 129-155.

66. Gerechtelyke en ontleedkundige verhandeling over de tekenen van leven, en dood in nieuwgeborenen kinderen (Leeuwarden, 1774).
++ For a translation cf. no. 67.

67. Gedagten ... over de misdaad van kindermoord; over de gemakkelyke wyze om vondelinghuizen in te voeren; over de oorzaaken van kindermoord: en over zelfmoord. Dienende tot antwoord op de ongegronde aanmerking van ... S.M.V.D. (Leeuwarden, 1774).
++ It was translated together with no. 66 as no. 141. This translation was also published in V.S. 397-540.

68. "Kort berigt van de ontleding eens jongen elephants", Hedendaagsche Vaderlandsche Letter-Oefeningen 3, pt. 2 (1774) 293-314.
++ Translation: Kl. S., vol. 1 (1) 50-93.

1775 69. "Brief van ... Petrus Camper ...", Idem 4, pt. 2 (1775) 54-62.
++ Camper argued in this letter that he had discovered the pneumaticity of the bird skeleton prior to J. Hunter. For translations see: no. 170; Kl.S., vol. 1 (1) 108-122;

O.C., vol. 3, 474-488. The letter had an appendix on the tempering of steel (63-64) which was translated in Kl.S., vol. 1 (1) 123-125.

1776 70. "Mémoire sur la structure des os dans les oiseaux, et de leurs diversités dans les différentes espèces", Mémoires de mathématique et de physique, présentés à l'Académie Royale des Sciences 7 (1776) 328-335.
++ A slightly modified version of no. 60.

71. "Verhandeling over de zitplaats van het beenig gehoortuig, en over een voornaam gedeelte van het zintuig zelve in de walvisschen", V.H.M. 17, pt. 2 (1777) 157-200.
++ Translation: Kl. S., vol. 2 (2) 1-40.

*72. Over den aanleg en 't onderhouden der zeeweringen (1777).
++ Mentioned in M.P. v. Buytenen and H.T. Obreen, Westergo's IJselmeerdijken ... (Bolsward, 1956) 108.

73. Brief ... aan Karel George, Graave van Wassenaar Twickel. Behelzende een betoog van de onbestaanbaarheid, en te groote kostbaarheid der vak- en steenwerken aan de Vyfdeels-Dyken in Friesland ... (Amsterdam, 1777).

74. "Bericht ... weegens eene onheusche beschuldiging, hem door den heere A. Cyrus aangeweeven, in zekere verdediging, onder zyne handtekening onlangs uitgegeeven", Hedendaagsche Vaderlandsche Letter-Oefeningen 6, pt. 2 (1777) 118-120.

75. "Brief ... aan de heeren Martens, van Gesscher, Zwagerman en van Hussem, ... over het steensnyden in twee reizen", Idem 6, pt. 2 (1777) 451-457.
++ Re-issued in no. 97, 83-104 and vol. 17 of the Opuscula selecta Neerlandicorum de arte medica (Amsterdam, 1943) 346-359. For translations see nos. 152, 158 and Kl. S., vol. 2 (2) 95-107.

1778 76. "De incommodis ab unguentorum & emplastrorum abusu necnon de praxeos trivialis, pro curandis ulceribus, hâc in materiâ, emendatione", Mémoires sur les sujets proposés pour les prix de l'Académie Royale de Chirurgie 4, pt. 2 (1778) 727-883.
++ Latin and French text. The Latin text was re-issued in D.D., vol. 1, 129-232.

77. De verhandelingen van Hippocrates, C. Celsus, en Paulus Aegineta, over de pypzweeren, en uitzakkingen van den aars; vertaald, en met aanmerkingen en waarneemingen, opgehelderd (Amsterdam, 1778).
++ Translations: no. 147 and Kl. S., vol. 2 (1) 111-180,

with a "Zusatz", 181-183.

78. Noodige aanmerkingen ... op de verhandeling van ... Karel, George, Graave van Wassenaar Twickel ... over de Vyfdeels Dyken van Vriesland ... (Harlingen, 1778).
79. Antwoord van Petrus Camper aan zynen vriend N.C.R. ... C.F. behelzenden eene sentimentaale apologie, en tastbaar bewys van niet te zyn de edelmoedige eigenerfde in een der V Deelen (Harlingen, 1778).
80. Memorie ... aan de Edele Mog. Heeren Staaten van Friesland, waarin de verandering van het profil van de V Deels Dyken van 1:5 voorglooijing, en 1:3 agterglooijing, als onvoldoende en te kostbaar wordt aangetoond (S.l., 1778).
81. Verdeediging ... wegens zyn gedrag omtrent het advis om de resolutie tot het herscheppen van den V.D. Dyk van 1:5, en 1:3, tot nader onderzoek op te schorten ... (S.l., [1778]).
82. Zaakelyke wederlegging van het antwoord door ... Carel George, Graave van Wassenaar Twickel uitgegeeven tot staaving van de bestaanbaarheid en onkostbaarheid der vak- en steenwerken aan den V deelen dyken aangelegd ... (Harlingen, 1778).
83. "Waarneeming over eene zeer byzondere, en nieuwe longziekte, of hoest welke thans onder de kalveren heerscht", Leeuwarder Courant September 9, 1778.

1779

84. "Peter Camper über die wahre und eigentliche Ursache der Krankheiten, die unter dem grossen und kleinen Viehe, als ansteckende Seuchen, wüthen, eine von der Gesellschaft N.F.F. gekrönte Preisschrift", Beschäftigungen der Berlinischen Gesellschaft Naturforschender Freunde 4 (1779) 95-166.
++ Republished in 1823 together with the prize essay of C.G. Weisz. "Zusätze" in Schriften der Berlinischen Gesellschaft ... 1 (1780) 112-118. New additions in Kl. S., vol. 3 (1) 200, 207-209. Translations: nos. 143 and 166; Ch. 6 in Kl. S., vol. 3 (1) 190-197 and O.C., vol. 3, 178-186; "Zusätze" in O.C., vol. 3, 167-189, 190-197 and no. 166.
85. "Mémoire sur l'épizootie de la Hollande", Mémoires de la Société Royale de Médecine A. 1776 [published 1779] 321-323.
86. Recueil van stukken tot der V. Deelen Dyken van Friesland betrekkelyk (Franeker, 1779).
87. "Account of the organs of speech of the orang outang ...", Philosophical Transactions 69, pt. 1 (1779) 139-159.
++ Translation: Kl. S., vol. 2 (2) 49-72.
88. "Kort berigt wegens de ontleding van verscheidene ORANG OUTANGS ... ", Algemeene Vaderlandsche Letter-Oefeningen 1, pt. 2 (1779) 18-36.
++ Translations: no. 144 and Kl. S., vol. 1 (1) 65-94.
89. "Verhandeling over den waaren aart der kankerwording, en over een zeer zaakelyk en onfeilbaar teken van onherstelbaaren borstkanker ...", Genees- Natuur- en Huishoud-Kundig Kabinet 1 (1779) 193-209.
++ Translations: no. 155 and Kl. S., vol. 3 (2) 156-179.
90. Historiae literariae cultoribus S.P.D. Petrus Camper ... (Harlingen, 1779).
++ Another edition in 1781.

1780

91. "Dissertatio de cranio rhinocerotis africani, cornu gemino", Acta Academiae Scientiarum Imperialis Petropolitanae, pro Anno 1777 pt. 2 [published in 1780] 193-209.
92. "Verhandeling over den besten schoen", Genees- Natuur- en Huishoud-Kundig Kabinet 2 (1781) 275-309.
++ Translations: nos. 145, 146, 148, 149, 156, 161, 169, 171 and Kl. S., vol. 1 (2) 119-184.

1782

93. "Brief ... aan ... B^{S} Hussem ... Over het mankgaan der kinderen", Algemeene Vaderlandsche Letter-Oefeningen 4, pt. 2 (1782) 96-102.
++ Translation: Kl.S., vol. 1 (2) 108-118.
94. "Aanmerkingen ... over het schynbaar groot getal gestorvenen binnen Harlingen, in den jaare 1779 ...", Idem 222-234.
++ Translation: V.S. 555-576.
95. Natuurkundige verhandelingen over den orang-outang; en eenige andere aap-soorten. Over den rhinoceros met den dubbelen horen; en over het rendier (Amsterdam, 1782).
++ Translations: nr. 159 and O.C., vol. 1, 1-353. The part on the orangutan was also translated separately in French. As far as I know there are only two printed copies of this translation, in UBL (BPL 247/96), with the last 5 pages lacking, and in the Bibl. Nationale, Paris (S. 2818). Both copies are incomplete: title page and illustrations are lacking.
96. "Aus einem Schreiben des Herrn Professor Camper an die Gesellschaft", Schriften der Berlinischen Gesellschaft Naturforschender Freunde 3 (1782) 394-398.

97. Aanmerkingen over de veranderingen, welke de steenen in de pisblaas der menschen ondergaan. Brief over het steensnyden in twee reizen, volgens P. Franco. Verhandeling van den heere Maret, over de voordeelen van het steensnyden in twee tyden. Als mede de stelregels, van Celsus, Albucasis en Le Dran, over deeze konstbewerking. Gestaafd door waarneemingen van de heeren Ten Haaf en van Wy ... [half-title] Mengelstoffen over de steengroejing en derzelver heelwyze (Amsterdam, 1782).
++ Translations: no. 150 and Kl. S., vol. 2 (2) 73-182.

1783 98. Oplossing der vraage, door het Bataafsch Genootschap ... voorgesteld ... Door*** Med. Doct. ... (Amsterdam, 1783).
++ Translations: no. 154 and O.C., vol. 2, 283-448. Cf. also no. 153.

99. "Brief ... [over eene artificieële hand eens orang-outangs]", Algemeene Vaderlandsche Letter-Oefeningen 5, pt. 2 (1783) 392-394.
++ Translation: in no. 159, 208-210. Cf. also no. 186.

100. "Brief over de thans regeerende ziekte onder het rundvee, het fenyn genaamd", Leeuwarder Courant, September 6 and 10, 1783.
++ Also published in the Magazijn van vaderlandschen landbouw 4 (1808) 413-429.

1784 101. "An account of a contagious disorder, called the venom, which has prevailed lately among the horned cattle in Friesland. Communicated in a letter to Samuel Foart Simmons ...", London Medical Journal 4 (1784) 386-392.

102. "Verhaal van de konstbewerking, en gelukkigen uitslag, der doorsnede van de schaambeenderen; gedaan ... door ... J.C. Damen ... Medegedeeld ... door Petrus Camper", Algemeene Vaderlandsche Letter-Oefeningen 6, pt. 2 (1784) 468-489.
++ Also published in Opuscula selecta Neerlandicorum de arte medica 12 (Amsterdam, 1933) 149-171. Translation: V.S. 287-323.

1786 103. "Kort berigt, wegens den dugon van den graave de Buffon, en de siren lacertina van den ridder Linneus", Nieuwe Algemeene Vaderlandsche Letter-Oefeningen 1, pt. 2 (1786) 275-283.
++ Translations: Kl. S., vol. 3 (1) 20-34 and O.C., vol. 2, 477-495.

104. "Conjectures relative to the petrifactions found in St. Peter's Mountain, near Maestricht", Philosophical Transactions 76, pt. 1 (1786) 443-456.
++ Translations: no. 157; Kl. S., vol. 3 (1) 1-19; O.C., vol. 1, 335-391.

105. "Verhaal van den gelukkigen uitslag der doorsnede van de schaambeenderen, voor de tweede reize op dezelfde vrouwe gedaan ... door ... J.C. Damen ... Meegedeeld ... door Petrus Camper", Nieuwe Algemeene Vaderlandsche Letter-Oefeningen 1, pt. 2 (1786) 366-374.
++ Translation: V.S. 324-336.

106. Rapport nopens de nieuwe dijks instructie voor de Vijf Deelen (Leeuwarden, 1786).
++ Co-authors: J. van Idsinga and C.L. van Beyma.

107. Concept instructie van de regeeringe der dijkzaaken van de Vijf Deelen Binnen- en Buiten-dijks (Leeuwarden, 1786).
++ Co-authors: J. van Idsinga and C.L. van Beyma.

1787 108. "Bemerkungen über die Klasse derjenigen Fische, die vom Ritter Linné schwimmende Amphibien genannt werden", Schriften der Gesellschaft Naturforschender Freunde zu Berlin 7 [= Beobachtungen ..., vol. 1] (1787) 197-218.
++ Followed by a "Zusatz ...", 219-226, in which he argued that a unicorn cannot exist.

109. "Auszug aus einem Brief des Herrn Professor Camper an den Herrn D. Bloch", Idem, 479-483.

110. Aanspraak aan Haare Koninglijke Hoogheid, Mevrouwe de Prinsesse van Orange en Nassau ... den 24. van Herfstmaand des Jaars 1787 ... (S.l., 1787).
++ Also published in the Nieuwe Nederlandsche Jaarboeken 22, pt. 6 (1787) 5125-5127; Gedenkboek van Nederlands wonderjaar 1787 ... (Middelburg, 1788); Vaderlandsche Historie ... ten vervolge van Wagenaar's Vaderlandsche Historie, vol. 15 (Amsterdam, 1795) 226-228.

111. Aanspraak aan Zyne Doorluchtigste Hoogheid den Heere Prins van Orange, en Nassau ... (S.l., 1787).
++ Also published in the Nieuwe Nederlandsche Jaarboeken 22, pt. 6 (1787) 5113-5123; Verzameling van placaaten ... enz. betrekking hebbende tot de gewigtige gebeurtenissen, in de maand September MDCCLXXXVII ... voorgevallen, vol. 1 (Kampen, 1788) 190-200; Gedenkboek ...; Vaderlandsche Historie ..., vol. 15, 230-243.

1788 112. "Complementa varia Acad. Imper. Scient. Petropolitanae communicanda, ad Clar. ac Celeb. Pallas", Nova Acta Academiae Scientiarum Imperialis Petropolitanae 2 (1788)

250-264.

113. "Dissertatio medica. De hydropum variorum indole, causis & medicinâ ...", Mémoires de la Société Royale de Médecine, Années 1784 et 1785 [published in 1788] 46-156.
++ Re-issued in D.D., vol. 2, 387-559.

114. "Ueber die Bellensucht (Bilzucht) der Kälber", Kl. S., vol. 3 (1) 210-211.
++ Translation: O.C., vol. 3, 199-201.

115. "Ueber die Giftseuche ('t Fenyn)", Idem 212-221.

1789 116. "Celeberrimo ac nobilissimo D.D. Blumenbachio S.P.D. Petrus Camper", Commentationes Societatis Regiae Scientiarum 9 (1789) 129-133.

117. Dissertatio de fractura patellae et olecrani (Den Haag, 1789).
++ Translation: V.S. 1-72.

1791 118. Verhandeling van Petrus Camper, over het natuurlijk verschil der wezenstrekken in menschen van onderscheiden landaart en ouderdom; over het schoon in antyke beelden en gesneedene steenen. Gevolgd door een voorstel van eene nieuwe manier om hoofden van allerleye menschen met zekerheid te teekenen ... uitgegeeven door ... Adriaan Gilles Camper (Utrecht, 1791).
++ Translations: nos. 160, 161, 162 and 165.

1792 119. Redenvoeringen van wylen Petrus Camper, over de wyze, om de onderscheidene hartstogten op onze wezens te verbeelden; over de verbaazende overeenkomst tusschen de viervoetige dieren, de vogelen, de visschen en den mensch en over het gedaante schoon ... Uitgegeeven door ... Adriaan Gilles Camper (Utrecht, 1792).
++ Translations: nos. 163, 164, 165 (the lecture on physical beauty is lacking from this translation) and O.C., vol. 3, 297-421.

1793 120. "Aus einem Briefe des nun verstorbnen H. Professors Camper ...", Neue Nordische Beyträge 6 (1793) 249-250.

1797 121. "Essai sur les influences que l'air, par ses diverses qualités, peut avoir dans les maladies chirurgicales, et sur les moyens de le rendre salutaire dans leur traitement", Mémoires sur les sujets proposés pour les prix de l'Académie de Chirurgie 5, pt. 2 (1797) 915-976.
++ Also published in D.D., vol. 1, 403-504.

122. "Dissertatio chirurgica de somni et vigiliae indole, atque usu, in morbis, qui manu curantur", Idem 709-768.
++ Also published in D.D., vol. 2, 127-224.

123. "Solution de la question ... [Comment le vice de différentes excrétions peut influer dans les maladies chirurgicales, et quelles sont les règles de pratique's rélatives à cet objet?]", Idem 769-864.
++ Also in D.D., vol. 2, 225-385.

1798 124. J.F.M. Herbell, ed., Petri Camper ... Dissertationes decem, quibus ab inlustribus Europae, praecipue Galliae, academiis palma adjudicata 2 vols. (Lingen, 1789-1800).

125. "Dissertatio de theoria et curatione morborum chronicorum pulmonum", D.D., vol. 1, 233-402.

1800. 126. "Dissertatio de remediorum specialium requisitis, genuina historia, actione, et optima administrandi methodo; nec non de morbis, quorum speciales curationes desiderantur", D.D., vol. 2, 1-126.

127. "De optima agendi vel exspectandi in medicina ratione", D.D., vol. 2, 561-798.

128. "Dissertatio de forficum indole et actione", D.D., vol. 2, 799-830.

1801 129. "Ueber die Behandlung neugeborner Kinder", V.S. 541-554.

130. Petri Camperi Icones Herniarum editae a Sam. Thom. Soemmering (Frankfurt a.M., 1801).

1802 131. Description anatomique d'un éléphant mâle ... publiée par ... A.G. Camper (Paris, 1802).
++ Also in O.C., vol. 2, 5-282.

1820 132. Observations anatomiques sur la structure intérieure et le squelette de plusieurs espèces de cétacés ... publiées par... Adrien-Gilles Camper ... avec des notes par M.G. Cuvier 2 vols. (Paris, 1820).

1854 133. Viro celeberrimo ... Friederico Tiedemann impetrati in medicina summi honoris solemnia quinquagesima die X Martis MDCCCLIV. Celebranda gratulatur tabulasque duas simiae pongo cranii icones primum exhibentes Petri Camperi calamo exaratas ab ipso autore Samueli Thomae Soemmeringio dono datas autographicis utriusque notis ornatas ... offert filius D.W. Soemmering (Frankfurt a.M., 1854).
++ Cf. no. 196.

1913 134. "De oculorum fabrica et morbis", Opuscula selecta Neerlandicorum de arte medica 2 (Amsterdam, 1913).

1935 135. "Consilium de comitissa de Randwyck", Idem 13 (1935) 259-263.

1939 136. B.W.T. Nuyens, ed., "Petri Camperi Itinera in Angliam, 1748-1784", Idem 15 (1939).

TRANSLATIONS

1764 137. Redevoering ... over de overeenkomst tusschen de dieren en gewassen ... vertaald door Cornelius van Engelen (Amsterdam, 1764).
++ Translation of no. 17.

1767 138. "Fortpflanzung der Amerikanischen Kröten", Allgemeines Magazin der Natur, Kunst und Wissenschaften 12 (1767) 243-252.
++ Translation of no. 8.

1771 139. Vorlesungen über das heutige herumgehende Viesterben (Kopenhagen, 1771).
++ Translation of no. 45.

1772. 140. Anmerkungen über die Einimpfung der Blattern durch Beobachtungen erläutert (Leipzig, 1772).
++ Translation of no. 51.

1777 141. Abhandlung von den Kennzeichen des Lebens und des Todes bey neugeborenen Kindern. Nebst einigen Gedanken über die Strafen des Kindermords ... übersetzt und mit neuen Zusätzen des Verfassers, wie auch einigen Anmerkungen vermehret von J.F.M. Herbell (Frankfurt/Leipzig, 1777).
++ Translations of nos. 66 and 67.

142. Betrachtungen über einige Gegenstände aus der Geburtshülfe und über die Erziehung der Kinder ... (Leipzig, 1777).
++ Translations of nos. 5 and 12.

1779 143. "Antwoord ... op de vraage naar de oorzaaken der veeziekte", Genees- Natuur- en Huishoud-Kundige Jaarboeken 2, pt. 1 (1779) 339-366.
++ Summary and translation of no. 84.

1780 144. "Etwas vernünftiges vom Orang Utan", Göttingische Taschenkalender (1780) 40-64.
++ S.T. Sömmering's translation of the greatest part of no. 88.

1781 145. Dissertation sur la meilleure forme des souliers (S. l. [1781]).
++ Translation of no. 92.

146. Abhandlung von der besten Form der Schuhe (Hamburg, 1781).
++ Translation of no. 145.

1782 147. Abhandlungen des Hippokrates C. Celsus und Paulus von Aegina über die Fisteln und Vorfälle des Afters ... Vermehrte Ausgabe (Leipzig, 1782).

++ Translation of no. 77. On p. 107-110 a "Zusatz" from Camper.

148. Abhandlung über den besten Schuh ... übersetzt von Joseph Franz Edlen von Jacquin (Wien, 1782).
++ Translation of no. 92.

1783 149. Abhandlung über die beste Form der Schuhe (Berlin/Stettin, 1783).
++ A translation of no. 145.

1784 150. Observationes circa mutationes quas subeunt calculi in vesica ... in latinum translata a Josepho Cseh-Szombathy (Budapest, 1784).
++ Translation of a part of no. 97.

151. Herrn Peter Campers sämmtliche Kleinere Schriften die Arzney- Wundarzneykunst und Naturgeschichte betreffend. Im Teutschen mit vielen neuen Zusätzen und Vermehrungen des Verfassers bereichert von J.F.M. Herbell 6 pts. in 3 vols. (Leipzig, 1784-1790).
++ Vol. 1 (1) appeared in another issue with identical contents but a different title-page: Peter Campers Kleinere Schriften die Arzneykunst und fürnemlich die Naturgeschichte betreffend. Erstes Bändchen ... (Leipzig, 1782).

152. "Peter Camper über den Blasensteinschnitt in zween verschiedenen Zeiträumen", Sammlung auserlesener, zur Geschichte und Ausübung des Blasensteinschnitts gehöriger Abhandlungen (Leipzig, 1784) 163-180.
++ Translation of no. 75.

1785 153. "Auszüge aus einer wenig bekannten Camperischen Schrift", Der Teutsche Merkur vom Jahre 1785 24-41, 193-210.
++ Summary of no. 98.

1786 154. Beantwortung einer von der Batavischen Gesellschaft ... aufgegebenen Preisfrage ... Durchaus mit Zusätzen und Vermehrungen des Verfassers bereichert, und mit einigen Anmerkungen teutsch herausgegeben von J.F.M. Herbell (Kleef/ Amsterdam, 1786).
++ Translation of no. 98.

155. "Von der wahren Natur der Entstehung des Krebses und einem sehr wesentlichen und sichern Zeichen der Unheilbarkeit der Krebsgeschwülste in der Brust", Sammlung auserlesener Abhandlungen zum Gebrauche praktischer Aerzte 11, pt. 3 (1786) 509-528.
++ Translation of no. 89.

1787 156. Delle scarpe de' mali da esse cagionati e loro ripari

trattato del sig. d. Pietro Camper ... tradotto ... in Italiano da G.V. ... (Milaan, 1787).
++ Translation of no. 148.

157. J.G. Schneider, "Ueber die versteinerten Knochen in St. Petersberge bey Maestricht, von einer unbekannten Wallfischart, welche man für Krokotill-knochen ausgab", Leipziger Magazin zur Naturkunde und Oekonomie pt. 3 (1787) 447-463.
++ Mainly a summary of no. 104.

1789 158. "An account of a method of performing the operation of lithotomy at two different times", London Medical Journal 10, pt. 2 (1789) 162-177.
++ Translation of no. 75.

1791 159. Naturgeschichte des Orang-Utang und einiger andern Affenarten, des Africanischen Nashorns, und des Rennthiers. Ins Deutsche übersetzt, und mit den neuesten Beobachtungen des Verfassers herausgegeben von J.F.M. Herbell (Düsseldorf, 1791).
++ Translation of no. 95.

160. Dissertation physique de Mr. Pierre Camper, sur les différences réelles que présentent les traits du visage chez les hommes de différents pays et de différents âges; sur le beau qui caractèrise les statues antiques et les pierres gravées. Suivie de la proposition d'une nouvelle méthode pour dessiner toutes sortes de têtes humaines avec la plus grande sûreté ... Traduite ... par Denis Quatremere D'Isjonval (Utrecht, 1791).
++ Translation of no. 118.

161. Dissertation sur les variétés naturelles qui caractérisent la physionomie des hommes des divers climats et des différens ages. Suivie de réflexions sur la beauté; particulièrement sur celle de la tête; avec une manière nouvelle de dessiner toute sorte de têtes avec la plus grande exactitude ... Traduit ... par H.J. Jansen. On y a joint une dissertation ... sur la meilleure forme des souliers (Paris/Den Haag, 1791).
++ Translation of nos. 92 and 118. Re-issued in 1792 (Paris).

1792 162. Über den natürlichen Unterschied der Gesichtszüge in Menschen verschiedener Gegenden und verschiedenen Alters; über das schöne antiker Bildsäulen und geschnittener Steine; nebst Darstellung einer neuen Art, allerlei Menschenköpfe mit Sicherheit zu zeichnen ... übersetzt von S.Th. Sömmering (Berlin, 1792).
++ Translation of no. 118.

163. Discours ... sur le moyen de répresenter d'une manière sûre les diverses passions qui se manifestent sur le visage; sur l'étonnante conformité qui existe entre les quadrupèdes, les oiseaux, les poissons et l'homme; et enfin sur le beau physique ... traduits ... par Denis Bernard Quatremere D'Isjonval (Utrecht, 1792).
++ Translation of no. 119.

1793 164. Vorlesungen ... über den Ausdruck der verschiedenen Leidenschaften durch die Gesichtszüge; über die bewundernswürdige Ähnlichkeit im Bau des Menschen, der vierfüssigen Thiere, der Vögel und Fische; und über die Schönheit der Formen ... übersetzt von G. Schaz mit ... einer kurzen Nachricht von dem Leben und den Schriften des Verfassers (Berlin, 1793).
++ Translation of no. 119.

1794 165. The works of the late Professor Camper on the connexion between the science of anatomy and the arts of drawing, painting, statuary ... translated ... by T. Cogan (London, 1794).
++ Translation of nos. 118 and 119 (the part on physical beauty was not translated). A second edition in 1821 (London).

1798 166. "Dissertatio de vera et praecipua causa morborum, inter pecora et armenta epidemice seu epizootice grassantium", D.D., vol. 1, 505-562.
++ Translation of no. 84, the "Zusätze" are lacking.

1801 167. Peter Campers vermischte Schriften, die Arzney- Wundarzney- und Entbindungskunst betreffend. Uebersezt [sic] und aus der Handschrift vermehrt (Lingen, 1801).

1803 168. Oeuvres de Pierre Camper, qui ont pour objet l'histoire naturelle, la physiologie et l'anatomie comparée 4 vols. (Paris, 1803).

1861 169. J. Dowie, The foot and its covering; comprising a full translation of Dr. Camper's work on "The best form of shoe" (London, 1861).
++ Translation of no. 92. A second edition was published in 1871 (London).

1878 170. "On the structure of the bones in birds, and of their differences in their various species ... Translated by R. Morrow", Proceedings and Transactions of the Nova Scotian Institute of Natural Science 4 (1878) 403-423.

++ A translation of the French version of no. 60, as published in O.C..

1939 171. Petrus Camper's Abhandlung über die beste Form der Schuhe (Leipzig, 1939).
++ A facsimilé edition of the translation of no. 92 in Kl. S., vol. 1 (2) 119 seq., edited by W. Thomsen. A second edition in 1949 (Leipzig).

172. "De zekerheid der geneeskunde ... Vertaling van Dr. R.A.B. Oosterhuis", Bijdragen tot de Geschiedenis der Geneeskunde 19 (1939) 86-103.
++ Translation of no. 4.

1962 173. Optical dissertation on vision (Nieuwkoop, 1962).
++ Facsimilé and translation of no. 1.

PUBLICATIONS EDITED BY OR WITH CONTRIBUTIONS FROM CAMPER

1749 174. Caroli Linnaei ... Amoenitates Academicae, seu Dissertationes variae physicae, medicae, botanicae ... Volumen primum (Leiden, 1749).
++ Edited by Petrus Camper.

1754 175. G. Coopmans, Celebris Anatomici Alexandri Monro ... Nervorum anatome contracta. Latine reddita ... (Franeker, 1754).
++ On p. 16n-18n and 57n-62n notes by Camper on lip cancer and lead colic. Translation: V.S. 577-588.

176. W. Smellie, A sett of anatomical tables, with explanations, and an abridgement, of the practice of midwifery, with a view to illustrate a treatise on that subject, and collection of cases (London, 1754).
++ Tables 12, 16-19, 24, 26-28, 34, 36 were after drawings by Camper.

1770 177. J.C. Palier, "Verhandeling over twee ongemeene groote beenderen, welke in den Bommeler-Waard gevonden zijn", V.H.M. 12 (1770) 373-390.
++ On p. 379-381 a letter from Camper, June 22, 1766, in which he identified the fossil bones described by Palier.

1771 178. J. de Reus, Naauwkeurig onderwys in de vroedkunde ... met eene voorreden van ... Petrus Camper (Amsterdam/Harlingen, 1771).

179. "Observations sur le renne faites à Groningue", J.N.S. Allamand, ed., Histoire naturelle ... par ... Buffon, vol. 15 (Amsterdam, 1771) 53-56.

++ Republished by Buffon in Hist. nat. Suppléments, vol. 3 (Paris, 1776) 138-144. Translation: Kl. S., vol. 2 (2) 40-48.

1778 180. J.C. Lavater, Physiognomische Fragmente ... Vierter Versuch (Leipzig/Winterthur, 1778).
++ On p. 281-283 a fragment of a letter by Camper to Lavater, September 1776.

181. J.A. de Chalmot, Algemeen Huishoudelyk-, Natuur-, Zedekundig en Konstwoordenboek, ed. 2, 7 vols. (Amsterdam, 1778).
++ According to J.A. de Chalmot, Biographisch Woordenboek, vol. 5 (Amsterdam, 1799) 321-322, Camper was the author of all the medical entries in this encyclopaedia. As appears from the Vervolg, vol. 11 (Campen, 1789) 2580 Camper also wrote the articles "gouverneur", "gouvernante" and "opvoeding" (I owe this information to Dr. P. Buijnsters, Nijmegen).

1780 182. P.S. Pallas, "Observatio de dentibus molaribus fossilibus ignoti animalis, canadensibus analogis, etiam ad uralense iugum repertis", Acta Academiae Scientiarum Imperialis Petropolitanae, pro Anno 1777, pt. 2 [published in 1780] 213-222.
++ With an extract from a letter by Camper on the mammoth (219-222) and a drawing of a hippopotamus molar (tab. 8, fig. 3) also by Camper.

183. P.S. Pallas, "Observationes circa myrmecophagam africanam et didelphidis novam speciem orientalem; e litteris celeberr. Petri Camper excerptae et illustratae", Idem 223-231.
++ Camper's contributions: 225-228, 229-230 + pl. IX.

184. D.A. de Gallitzin, "Lettre de M. Le Prince de Gallitzin [Sur la forme des conducteurs électriques]", Mémoires de l'Académie Impériale et Royale des Sciences et Belles Lettres de Bruxelles 3 (1780) 1-12.
++ On p. 11-12 Camper's verbal and pictorial description of a hen killed by an electric discharge.

1781 185. Een drietal gekroonde prijsverhandelingen over de vraage of het voor de Provintie van Friesland voordeeliger zij, den uitvoer van hooi ééns voor al te verbieden; of wel voor altoos onbepaald open te stellen? ... Door eene MAATSCHAPPY van TIEN LEDEN ... voorgesteld (Harlingen, 1781).
++ Camper wrote the preface, iii-xvi.

1783 186. J.F.M. Herbell, "Herr D. Herbell an Hrn. Professor Forster in Cassel, eine Aufklärung in der Naturgeschichte betreffend", Göttingisches Magazin der Wissenschaften und Litteratur 3, pt. 5 (1783) 768-773.
++ Contains on p. 769-773 a quotation from Camper's article on the counterfeited hand of an orangutan (no. 99).

1784 187. J.H. Merck, Seconde lettre ... sur les os fossiles (Darmstadt, 1784).
++ Camper contributed 3 drawings of a molar of a rhinoceros (pl. II).

1786 188. J.F. Blumenbach, Geschichte und Beschreibung der Knochen des menschlichen Körpers (Göttingen, 1786).
++ The two illustrations in this book were after drawings by Camper.

189. F. Verster, "Bericht wegens twee elephantsbeenderen, naaby 's Bosch gevonden, met eenige aanmerkingen over dezelve", V.H.M. 23 (1786) 55-84.
++ Camper provided this article with 5 illustrations plus explanation (58-62).

1787 190. J.G. Schneider, Vergleichung des Baues und der Physiologie der Fische mit dem Bau des Menschen und der übrigen Thiere durch Kupfer erläutert von Alexander Monro. Aus dem Englischen übersetzt und mit einigen Zusätzen und Anmerkungen von P. Campern vermehrt (Leipzig, 1787).
++ Contains "Peter Camper's Anmerkungen ... Aus der Lateinischen Handschrift übersetzt" 152-169. Tab. XXXIV, fig. 1 was also by Camper.

191. A. Vosmaer, Beschrijving van het ... Kameel-paard ... (Amsterdam, 1787).
++ On p. 38-44 Camper's "Waarneemingen over het geraamte van de Camelopardalis, 't welk in het kabinet van Z.D.H. den Heere Prinse van Orange gevonden wordt".

1789 192. G. Coopmans, Neurologia et observatio de calculo, ex urethra excreto (Franeker, 1789).
++ Tab. 1 was after a drawing by Camper.

193. [D.A. de Gallitzin], Lettres sur quelques objets de minéralogie à Mr. le Professeur Petrus Camper (Den Haag, 1789).
++ With Camper's drawings of megalithic tombs.

194. Buffon, Histoire naturelle ... Suppléments, vol. 7 (Paris, 1789).
++ On p. 93-99 extract from a letter by Camper on "l'organe de la voix des sapajous heurleurs", pl. XXVII representing the "Poche osseuse de l'alouatte", was made after a drawing by Camper.

1793 195. D. van Gesscher, "Ontleed- en heel-kundige aanmerkingen over de afzetting der ledemaaten", Verhandelingen van het Genootschap ter Bevordering der Heelkunde 2 (1793) 17-42.
++ With quotations from Camper's unpublished manuscripts (23, 26-27, 28-29, 34-35, 37-38, 39) and 2 engravings after drawings by Camper.

1801 196. J.G. Fischer von Waldheim, Naturhistorische Fragmente (Frankfurt a.M., 1801).
++ Contains the drawings of the skull of an adult orangutan together with an explanation, which Camper sent to Sömmering (Tab. III, IV, p. 207-208). A facsimilé of Camper's manuscript was published by Sömmering's son (see no. 133).

1804 197. J. van Munster, Een zestal verloskundige operatien en waarneemingen ... Met een aanprijzenden brief van wijlen Professor Petrus Camper (Amsterdam, 1804).

SAMENVATTING

Dit proefschrift behandelt het werk van een van de meer opmerkelijke zoölogen uit de achttiende eeuw, te weten Petrus Camper (1722-1789). Met de Fransman Daubenton stond hij aan het begin van de renaissance welke de vergelijkende anatomie in de tweede helft van de achttiende eeuw beleefde. In het begin van de negentiende eeuw zou deze wetenschap de hoeksteen van de zoölogie worden.

Camper was een van de weinige achttiende-eeuwse zoölogen die zich niet conformeerde aan de overheersende idealen van de systematiek. Voor hem stond het vast dat echte vooruitgang in de zoölogie alleen mogelijk was indien men uitging van de anatomie. Zijn eigen research was in de eerste plaats gericht op de uitbreiding van de anatomische kennis der vertebraten. Camper realiseerde zich echter zeer wel dat dit slechts een eerste stap was op de weg naar een zoölogische wetenschap. Anatomie was niets minder maar ook niets meer dan de "eenige en standvaste grondslag ... van de wezenlyke Natuurlyke Historie der Dieren." In de loop der tijd heeft Camper de anatomie benut als basis voor drie soorten zoölogische kennis, te weten de fysiologie, systematiek op soortsniveau en vergelijkende anatomie in engere zin.

Het eerste hoofdstuk begint met een korte biografische schets. Vervolgens worden Camper's opvattingen over de wetenschappelijke methode geanalyseerd en leren we hem kennen als een overtuigd aanhanger van het door zijn leermeesters 's Gravesande en Petrus van Musschenbroek verkondigde empirisme.

Hoofdstuk 2 is voor het grootste deel gewijd aan zijn zoötomische onderzoekingen. Daarin lag het accent op de beschrijving van exotische en weinig bekende dieren als orang oetan, olifant, rhinoceros, giraffe, rendier en diverse walvisachtigen. Verder komt in dit hoofdstuk zijn fysiologie aan de orde. Als gevolg van de beperkingen die er voor hem kleefden aan de bij de functionele analyse gehanteerde anatomische methode waren Camper's aktiviteiten op dit gebied van betrekkelijk geringe omvang.

Hoofdstuk 3 behandelt Camper's kritiek op de systematiek en zijn speurtocht naar de structurele uniformiteit der vertebraten. Dit laatste was voor hem hèt middel om te komen tot de algemene inzichten die hij beschouwde als de hoogste vorm van wetenschappelijke kennis. Camper verzamelde een ongeëvenaarde hoeveelheid materiaal die de gedachte van de eenheid van bouwplan ondersteunde. Zijn allesoverheersend empirisme verhinderde hem deze gegevens te synthetiseren en generaliserende uitspraken te doen.

In hoofdstuk 4 wordt Camper's fysische anthropologie besproken. In dit hoofdstuk wordt uiteengezet hoe hij met behulp van de structurele eigenschappen der rassen de eenheid van de menselijke soort demonstreerde en hoe hij, eveneens op puur zoölogische gronden, een onderscheid maakte tussen de mens en zijn naaste verwanten, namelijk de mensapen en de orang oetan in het bijzonder.

Hoofdstuk 5 tenslotte is gewijd aan zijn fossielenonderzoek. Allereerst wordt hierin een analyse gegeven van zijn pogingen de versteende resten van vertebraten te identificeren. Daarna wordt ingegaan op Camper's denkbeelden over de geschiedenis van de aarde en van het leven op aarde. Het fossielenonderzoek blijkt Camper te hebben gebracht tot een afwijzing van de orthodoxe lezing van het scheppingsverhaal. Uiteindelijk raakte hij ervan overtuigd dat er talloze diersoorten zijn uitgestorven en dat de aarde een aanzienlijk hogere ouderdom heeft dan doorgaans op grond van de bijbelse chronologie werd aangenomen.

LIST OF ILLUSTRATIONS

Cover: Nineteenth-century fancy-portrait of Camper. Lithograph after a painting by J. de Groot.

INDEX