

Anatomical Terms: towards Development of Terminologies (terminogenesis)

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SUMMARY

Anatomy is older than its name that means "cutting out" in Greek. The cut out parts must bear a name. This historical review is an attempt to investigate the evolution of the anatomical names from the prehistorical times when humans had no handwriting to record anatomy until the discovery of printing when anatomical names could become disseminated in printed books.

Throughout indeterminately long times, the people who spoke anatomical terms were the embalmers who touched human bodies, the priests who read the future in the entrails of animals and the magicians who prepared healing charms from various human, animal or plant components. But we have no traces of their words.

Having invented handwriting, early Egyptians and Mesopotamians were among those who began to give specific names to parts of the body. Yet it remains difficult to always understand them as they considered that each part of the body was inhabited by a specific god. Nevertheless, some of the names they used influenced the new language that unfolded in the South East corner of Europe, the unifying Greek language. Greek poets like Homer, philosophers like Aristotle and physicians like Hippocrates were using anatomical words that were later developed by anatomists like Herophilos, Erasistratos or Rufos to designate specific structures.

Greek became the language of Western medicine by the 4th century BCE, but Latin later superseded it in terms of political and linguistic influence. This meant that translators, such as Celsus, played a major role during the first years of the Christian era.

Nevertheless, it was still in Greek that Galen produced an immense medical literature in which anatomy was prominent. However, because Galen dissected animals, he unfortunately stamped in the minds of his successors errors that would last from his death (probably in 216 CE) until the Renaissance in the 15th century.

Even as the world of Latin imploded, the language maintained its influence. In the West, Christianity spread, preserving Greek and Latin manuscripts in its abbeys and cathedrals. In the East, numerous Greek manuscripts had survived. After the advent of Islam in 622 CE, a "House of Wisdom" was created in Baghdad at the beginning of the 9th century CE. Under Hunayn ibn Ishak, a team of experts undertook to translate into Syriac or Arabic all the manuscripts collected by the armies of the Caliph. Thanks to them, Greek science, medicine and literature were studied and Arabic translations could be found throughout the expanding Islamic world. Avicenna could thus write amongst many books his most famous medical opus, the "Canon of Medicine", which influenced medicine, and anatomy, until well beyond the 16th century.

On the Western side of the former Roman Empire, the organisation of medical practice had changed. It was linked to the abbeys and churches where healing monks and lay people (men and women) were instructed and entrusted with helping "the sick and the poor ones". In the 9th century, a medical school emerged in Salerno (Italy) and flourished there until the end of the 13th century, more or less independently from the Church.

During the 11th century, Arabic manuscripts had found their way to Salerno and other healing institutions. A network of Latin translators from Arabic

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permitted the Western World to re-access the ancient literatures, the School of Toledo (Spain) becoming in the 12th and 13th centuries the most important European centre of translation. Anatomy also re-emerged in Italy at the same time thanks to two types of institutions: the School of Salerno and the universities gradually founded since 1088 (Bologna). Whereas barber-surgeons, surgeons and master-surgeons often came from Salerno, medical doctors came from such Universities as Padua, Bologna and Siena, Oxford, Paris or Salamanca. Trained surgeons attended Universities to deepen their knowledge.

In 1315, Mondino de Liuzzi, Professor of Anatomy at the University of Bologna, inaugurated the teaching of human anatomy based upon the dissection of cadavers. The doors now opened to the re-discovery of anatomy, and especially of the internal organs. But Mondino still stuck to the doctrines of the "infallible" masters, although he had written (still in Latin) a book on dissection that remained a classic for two centuries.

Some surgeons who had benefited from both an apprenticeship and a Humanist education wrote books in which they finally dared to contradict the old masters. The time was ripe for the arrival of Vesalius.

INTRODUCTION

The International Federation of Associations of Anatomists (IFAA) has undertaken since 1989 to produce, and publish, official terminologies "after consultation with all the members of IFAA, thus ensuring a democratic input to the terminologies". This declaration of intent was part of the preface of the first edition of "Terminologia Anatomica" that appeared in 1998. Since then, several books have also been published listing histological and embryological terms, or translations of the original Latin and English lists into other languages. Now, terminologies are making their way across the Internet where they facilitate access to multidisciplinary medical approaches.

Official terminologies published today have their roots in a long medical tradition. It is important to understand their history in order to understand the complexity of the sometimes uneven and unstable development of anatomical terms. Anatomical, histological and embryological terms, but also their derivatives (clinical, pharmacological, pathological and biochemical terms), had to be coined by practitioners who needed them to operate and thus to communicate. Those terms and names that were chosen inevitably reflected the current state of knowledge and range of medical practices of their time, as well as cultural attitudes towards parts of the body.

For historical reasons, the official lists are written in Latin, an extinct, but "neutral", language. Of course their roots go even deeper, as proved by

archaeologists who have unearthed evidence of earlier explorations of the body in different parts of Africa (Egypt), America (Atacama) and Asia (Mesopotamia). This article is an attempt to track the development of anatomical terminology from these early beginnings up until and during the times when Latin was the "mother tongue" for many humans. No attempt will be made here to dig into the roots of the other main linguistic families of the world, whatever their importance and richness. Far Eastern, Pacific, Early American and Southern African cultures certainly developed ancient anatomical terminologies of their own but these are beyond the scope of this article because of my lack of the linguistic skills necessary to read original documents. The influence of some of these cultures on the formation of the Latin terminologies will however be evidenced in the following article.

Spoken Terminologies: The Cradle of Anatomical Names

Anatomical terms originated with language. Our first ancestors, *Homo habilis* or *Homo erectus* (Spoor, 2007) coined the first anatomical terms when they "talked" between themselves about themselves. We are left to speculate on these archaic terms and their derivatives, which grew during more than a thousand millennia when, on the occasion of many hunting accidents, struggles, wars or anthropophagous banquets, people could observe the insides of broken bodies. They obviously must have given names to what became visible and what should have remained hidden.

With the "oral" identification of body parts and organs came the need to structure the spoken names in order to facilitate the transmission of knowledge. We could speak now of the passing of identified single entities into structured composite concepts. The size of human anatomical heritage has probably grown for millennia because of this slow semantic accumulation.

It thus took many years, and many dialects, to identify more and more internal structures. Yet, all over the world, Neolithic people treated fractures, in Japan 4,000 to 3,000 years BCE for instance (Fujita, 2007). They practised trepanations around 10,000 years BCE in North Africa, Dnieper region, Ukraine, Portugal and Iraq (Crubézy, 2001), as in Mexico (Wilkinson, 1975). They only left us with scarce skeletal pieces, but enough of them to approximate the date of their burial. One can only speculate on the healing techniques that they used, although it is likely that these were more surgical than magical.

The appearance and evolution of funeral rituals must have determined the formulation of a more elaborate anatomical terminology. As technology improved, its transmission from generation to generation required the precise description of the contents of body parts. A good example of the evo-

lution is provided by the Chinchorro cultural complex discovered in 1917 by Max Uhle in the Atacama Desert and masterly analysed in 2012 by Marquet and his group. Chinchorro populations of coastal hunter-gatherers appeared about 10,000 years ago along the South Pacific coast and disappeared, for unknown reasons, some 5,600 years later. Probably because of the extremely arid climate of Atacama ("the driest place on Earth"), dead bodies were initially left on the ground or covered superficially with sand. However, around 6,000 years BCE, Chinchorro people began to use and to develop various conservation techniques that they adapted according to the social status of the dead person (Arriaza, 2005). To summarise, the corpses were either naturally preserved by desiccation, or artificially conserved.

Artificial conservation was obtained by replacing flesh by clay modelled on the rebuilt skeleton (the so-called "*black-style mummies*"), or by encasing the body in mud, or by evisceration (the "*red-style mummies*"). Replacement of flesh certainly was an opportunity to discover and name the body parts as they became exposed.

There is strong evidence that Egyptian mummification also originated in prehistoric times. Preserved bodies found in tombs dating from the Late Neolithic and Predynastic periods (4500-3350 BCE) were wrapped in linen clothes, in skin or in reed mattings. At El-Omari for example, Hassan (1988) describes "*the dead were buried in cemeteries...the body was wrapped in a mat of coarse fabric...the body was placed on its left side in a contracted position, with the head pointing south and facing west*". Textile samples taken from 16 mummies were investigated for microscopic structure, radiocarbon dating and chemical composition. All of them revealed that they had been impregnated with "*resins*" made of various organic components identified by chemical analysis and dissolved in plant oil or in animal fat. Aromatic plant extracts were always found, as well as pine resin and sugar or gum. Natural petroleum was present in 8 samples, sometimes in abundance. The same aromatic plants that could be recognised in extracts from prehistoric remains were still in use for mummification 3,000 years later.

At the beginning of a comprehensive review on body preservation, Brenner (2014) also lists many parts of the world, like Ethiopia, Spain, Canary Islands, Peru, Ecuador, Aleutian Islands, Tibet and Nigeria, where artificial body preservation was precociously performed. Bodies

were treated with different chemicals and additional means "*such as natron, herbs, cedar oils, natural, tree-derived resins, incense and gums, pitch, and tar*".

The art of mummifying must have been linked to oral tradition based upon exact recipes for embalming being transmitted from generation to generation. The heritage was obviously linked to anatomical knowledge necessarily based upon precise terminologies.

Unfortunately, no remnants of these early observations have been found up to now in the oldest drawings and sculptures that have survived archaic times. We can therefore only speculate about them and about the anatomical terms that were spoken, but not written, by our first ancestors, even though they were already practising their own well-established dissection techniques.

FROM CRADLE TO INFANCY: FROM THERAPY TO SCHOLASTIC ANATOMY

Egypt

The oldest medical papyrus from Egypt that is presently known is the "Kahun Gynaecological papyrus" (Haimov-Kochman, 2005). This appears to have been written in the 19th century BCE during the "Middle Kingdom". It is a small treatise of gynaecology containing 34 paragraphs dealing with such subjects as complications of vaginal delivery and reproductive disorders. It contains some anatomical knowledge but it deals mainly with symptoms and therapies.

Approximately 1,800 years BCE, a scribe, possibly two, wrote another remarkable clinical papyrus dealing mainly with traumatology but with some gynaecology (Fig.1). This papyrus was initially bought by an antiques dealer, Edwin Smith, whose



Fig. 1. Plates 6 & 7 of the Edwin-Smith Papyrus kept at the New York Academy of Medicine. © Licence: Public Domain.

name still identifies the papyrus. It contains systematic recordings and remarkable analyses of 48 cases of injuries (Stiefel, 2006). It is thought to be a copy of an older text, possibly written between 3'000 and 2,500 years BCE, as it is made use of older hieroglyphs from that epoch that were "not well known in 1700 B.C." Breasted (1930), who made the first translation of the Edwin Smith manuscript, attributed the original text to Imhotep, an unforgettable polymath, who lived in the 27th century BCE (thus 1200 years before the scribe of the papyrus). This "romantic" view has however recently been questioned with well-founded arguments (Blomstedt, 2014). In addition to this papyrus, Edwin Smith also bought another large papyrus, the "Ebers Papyrus" that is dated from about 1,550 BCE. This more recent medical papyrus deals not only with traumatology but also with many other non-traumatic emergencies.

The papyri bought by Edwin Smith are the first Egyptian medical documents not to be uniquely based upon magic. They rely on observations that "would be lost for 2,000 years until Hippocrates and the ancient Greeks reintroduced most of them" (Stiefel, 2006). They include a lot of common anatomical hieroglyphs such as the heart, skull, mandible, spine, nostril, brain ("seen for the first time in human history" according to Breasted). However, the least common terms lay dormant for more than 10 centuries. Meanwhile, Egyptian medicine had changed considerably. The early physicians of the epoch of "Kahun papyrus", and those influencing the Edwin Smith (3200 to 2400 BCE) and Ebers (1500 BCE) manuscripts, were already specialised: they were dentists, ophthalmologists and internists ("treating the anus, belly and inner liquids"). This was probably linked to the existence of discrete medical schools influenced by the belief that "man looked at each part of his body as a separate entity" (Ghalioungui, 1969).

The discovery of these papyri has given us the opportunity to investigate the origins of a true anatomical terminology. The concept of "body" remained amongst the Pharaonic Egyptians utterly different from ours. It was not found in the General Index of Breasted's translation of Edwin Smith Papyrus. According to Walker (1999), who scrutinised for his PhD thesis "medical papyri written in simple Middle Egyptian... [including]... 1700 or so prescription-remedies and case-studies", the "body was perceived as a corporation of quasi-independent semi-divine entities." [...] "Conceptual divisions of the body were predominantly regional (i.e. anatomical – head, arm, torso, liver) in preference to fabric divisions (i.e. physiological – bones, muscles, nerves, ligaments) or systemic divisions (i.e. functional – gastro-intestinal, musculo-skeletal, cardiovascular systems, etc.). Walker also noted that, in Egypt, the regions or bodily parts were three-dimensional in that they contained bones and muscles, and they were identified by the hieroglyph



Fig. 2. A \heartsuit , B $HAty$ and C ib . Hieroglyphs A copied from Walker's book, B and C downloaded from <www.hieroglyphs.net> Published by kind authorisation of Tito Sciotortino.

" \heartsuit " (Fig. 2A) *the most common anatomical term in the medical texts*". Generic terms existed for general structures such as bones, muscles, fat, vessels etc. but they were not given a specific name. A joint was not considered as a structure joining two regions but rather as a division separating them. As for the regions themselves, they usually were subdivided into an anterior (or ventral) and a posterior (or dorsal) part.

There was no clear partition between thorax and abdomen. Walker was posthumously awarded his PhD, which was published on the recommendation of his examiners. In a recension of Walker's text, Nunn (1999) indicated that Walker "concentrate[d] his attention on twenty basic words which, with their compound forms, gave a total of forty anatomical terms selected for analysis"... "New" terms such as thyroid gland, or anus different from rectum or pelvic intestine, were suggested by him to enable the interpretation of until then unclear hieroglyphs.

For the old Egyptians, the heart was so important that it was the only organ to be left in place during the mummification procedures. The archaic writings of the 4rd millennium BCE already represented it by a surprisingly accurate hieroglyph: a central hollow heart emitting 8 vessels (aorta, pulmonary artery, two venae cavae and four pulmonary veins). According to Ziskind and Halioua (2004), this central muscular heart (or $HAty$), Fig. 2B) was connected to the periphery by vessels (or " $metou$ ") which conveyed air, blood and the "wind of life" to and from the rest of the body (or ib), the "heart- ib " or "interior- ib ", Fig. 2C), and was associated with the trachea. These concepts remained nearly unchanged during the whole Pharaonic era. The term " $HAty$ " was also used in butchery, whereas "heart- ib " also meant "mind or centre of psychic life" and was used by both priests and physicians.

The Edwin Smith Papyrus also saw "the word <brain> occurring for the first time in the human speech" (Breasted 1930, page XV). The author of the papyrus compared the brain surface to the corrugations on metallic slag and recognised the presence in some cases of a sack of meningeal membranes containing a liquid (Breasted 1930, pp. 10, 14 and 65). He observed connections between brain and nerves (Breasted 1930, pp. 50 and 65) and even suggested that brain injuries

could induce distant effects like hemiplegia or ejaculation (Breasted 1930, page 66). However, the existence of such a structure as a nervous system, or of centrally controlled functions, were seemingly not suspected by the Pharaonic physicians.

More than a century after the end of the Late Period of Egyptian Pharaohs' reign (525 BCE), a Greek historian, Herodotus from Halicarnassus, made a trip to Egypt. He brought back from his visit many notices that would feed the second part of his Histories. Amongst these, he mentioned: *"The art of medicine among them is distributed thus:--each physician is a physician of one disease and of no more; and the whole country is full of physicians, for some profess themselves to be physicians of the eyes, others of the head, others of the teeth, others of the affections of the stomach, and others of the more obscure ailments."* It is obvious that Herodotus, had he only written this part of his "Histories", would be nowadays considered as an excellent writer of Travel Guides rather than as a historian. Yet he confirmed that the archaic specialisation of medical practice in Mesopotamia was still present about 1500 years after the times of the "Kahun papyrus".

Mesopotamia

The ancient people living in the region of the Tigris and Euphrates rivers spoke several languages of which two, the older Sumerian (5th and 4th millennia BCE) and the more recent Akkadian (4th to 1st millennia), have been thoroughly studied. This is due to the fact that they had developed a writing system, the cuneiform script, which remained in use from the 34th century BCE to the 2nd century CE. Cuneiform "characters" were imprinted on clay tablets that kept well over the ages when they had been dried or cooked.

The writing system evolved over the years from primitive pseudo-hieroglyphs to elaborate graphic symbols or characters. Rawlinson (1851) undertook its deciphering as early as 1835, a few years after that Champollion had read the first hieroglyphs of the trilingual Rosetta stone (1822). The discovery of bi- or trilingual cuneiform inscriptions (Fig. 3) by Burnouf in 1836 also permitted the investigation of several other languages. A first anatomical dictionary was published by Holma (1911.) This dictionary mostly contained terms dealing with the human body but words such as wing, claw,

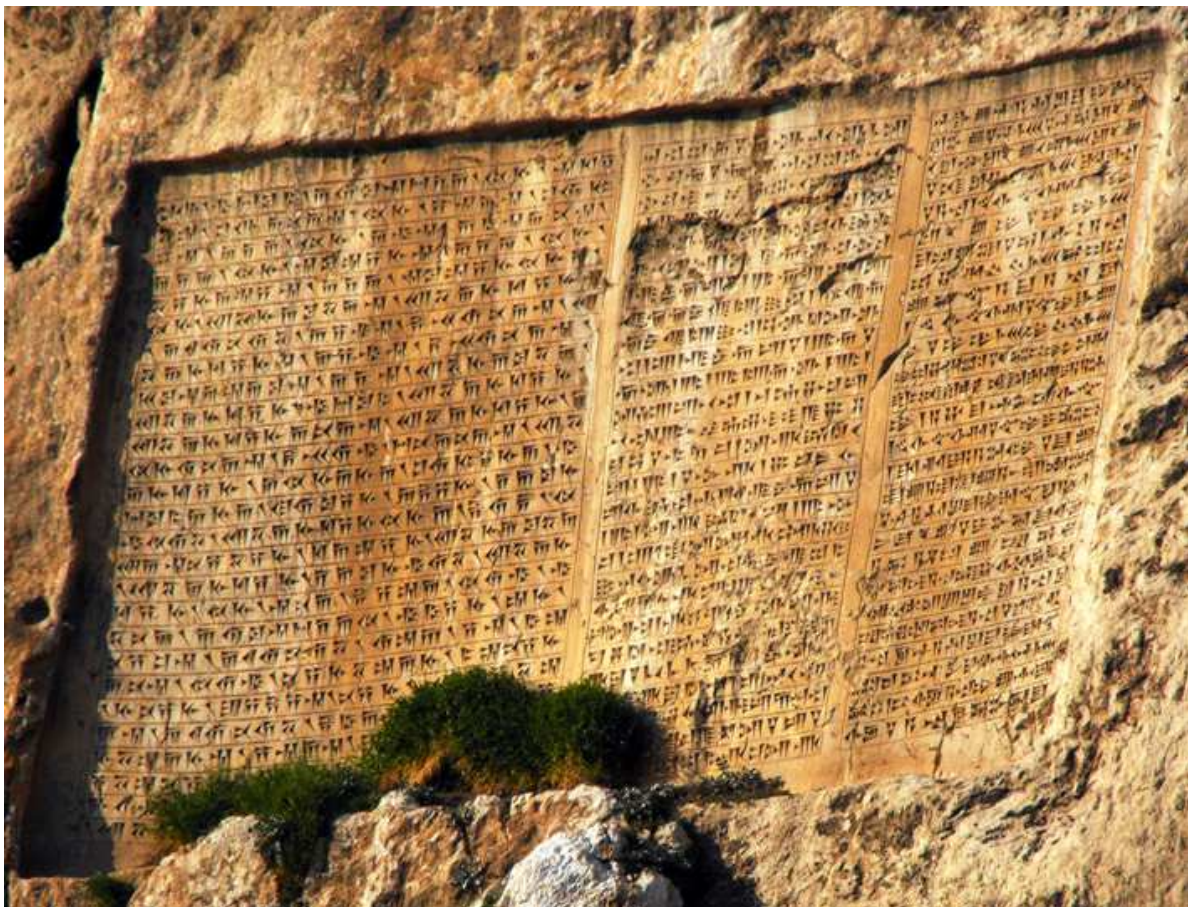


Fig. 3. Trilingual inscription of Xerxes the Great; from left to right: Old Persian, Babylonian and Elamite text praising Xerxes, son of Darius, the Achaemenid (5th century BCE). Credit: Andrez1; © Licence: Creative Commons Attribution-Share Alike 3.0.

mane, udder were also included, as well as a few pathological terms.

It is thought-provoking to look closely at Holma's German glossary. The book, a true lexicon, dealt with several Semitic languages relating to the Assyrio-Babylonian or the Akkadian languages that constitute its base. Of the 120 concepts of human anatomy listed in the German index, only 12 dealt with internal organs: *liver, lung, heart, gums, trachea, stomach, anal sphincter, bowels* and *intestine, kidney, uterus, nerve* and *medulla*. Concerning this last term, it is noteworthy that the same word is used to signify brain, medulla spinalis and medulla ossea, probably because of the gross similarity of these different organs. Furthermore, within the text, one finds different terms for blood (*dāmu*), "venous" blood (*adamatu* = dark blood) and "arterial" blood (*šarqu* = light red blood), although blood vessels (*ušultu*) were not specified in arteries and veins. There are also three words to name fat; probably because fat, as meat, was a butcher's rather than a physician's word according to Holma.

The other terms identified anatomical entities that are readily visible from the outside. In addition to the anatomical vocabulary (and to veterinary anatomy terms), several words must be considered as "physiological" (urine, faeces, sweat, saliva, sperm) or "pathological" (e.g. goitre). Finally, a few terms are generally descriptive, but may be considered as "general anatomical" terms: weight, height, figure and size for example. The term *spleen* was later identified by Adamson (1984) who published a series of new studies pertaining more to linguistics than to anatomy.

Another finding is significant. Such important organs as thyroid, ganglion, pancreas and colon were missing, although one may speculate about the difference between bowels and intestine. No dissections of human bodies were performed in those times, which would have allowed the recognition of these organs. As for the absence of a specific term for brain, it can be attributed to the fact that the old Babylonians thought that the liver was the centre of life, and the heart that of intelligence (Asher-Greve 2007, page XIV.): "A connection between the brain and thinking was not made." Even though late Mesopotamians (early 8th century BCE) were able to comprehensively describe many symptoms of epilepsy, their prognosis on the course of a seizure was founded on the nature of the 'demon' that caused it (Kinnier Wilson, 1990.) Also, nerves were identified but their function was certainly ignored or perhaps compared to that of tendons.



Fig. 4. Babylonian clay liver model used for divination. © Trustees of the British Museum.

The pivotal place of the liver in the Mesopotamian *Weltanschauung* is demonstrated by the numerous clay models of sheep's liver that have been discovered all over the Akkadian world (also in the Etruscan countries). These models (Fig. 4) were carved for scholars in divination and not for medical students (Jastrow, 1913). The inscriptions that they bore were typical of hepatoscopy, or divination by observation of an animal's liver (usually sheep) during sacrifice. They were naming anatomical details like left and right lobe, caudate lobe ("middle of the liver") with its processus caudatus ("finger of the liver") and papillaris ("fruit of the liver"), gallbladder ("bitter part"), hepatic duct ("output") whereas the main portal fissure already was called "gate of the liver" (Cavalcanti, 2013). These specific terms belonged more to magic than to anatomy or medicine. In spite of the accuracy of their anatomical and clinical observations, the Mesopotamian people were convinced of the ubiquity of 'demons' who caused most of their diseases.

Pre-Hippocratic Greece

What language was spoken in Greece before Greek?

Whereas early Mesopotamians spoke Sumerian, then later Akkadian and associated dialects, and wrote cuneiform scripts, Minoans living on Crete had developed their own language, the Aegean or "Pre-Greek", which had provided many roots for tongues or dialects spoken around the Aegean

See. At the end of the 3rd millennium, so-called "Cretan" hieroglyphs appeared that soon were replaced by a writing system called "Linear A". Unfortunately, this archaic script remains nearly indecipherable and archaic anatomical terms in Aegean are therefore unknown to us. The word "Asklepios" (Ἀσκληπιεῖος in archaic Greek) designating the future God of Medicine probably comes from the Pre-Greek period (Beekes, 2009).

The first form of Greek language to appear on the mainland of Greece was Mycenaean. It apparently came from Crete and was written in "Linear B". The first excavated traces date from about 1450 BCE (approximately 250 years after the copying of the Edwin-Smith papyrus). "Linear B" has been deciphered and it consisted of 87 characters, mainly syllabic, and kept a few signs from "Linear A" (Carpenter, 1957). We are however unable to find references to anatomical terms in the published literature concerning the numerous tablets discovered in Knossos and Mycenae. Regardless, "Linear B" spread and developed in Greece, probably because of the feasting habits of Mycenaean society (Wright, 2004). Dorian Greek, which appeared in Greece with the Dorian invasion during the 12th century BCE, also developed from "Linear B" and spoken languages began to stabilise in Greece.

Homer and Asklepios

Homeric works were written in "Homeric Greek", an archaic form of Ionian Greek, probably during the 8th century BCE and thus more than three centuries after the Trojan War. Homer (Kline, 2009) had already mentioned Asklepios in the Iliad (Books 2, 4, 11 and 14) but as a great healer only. However, it is possible that, by great healer, he understood some kind of early deity. Asklepios had two sons, Machaon and Podaleirios, who were physicians within the Greek army. During Homer's time, the influence of Asklepios had probably coincided with the move of Greek medical thinking from a mixture of clinical observations and religious beliefs to the beginning of a more rationalistic approach. Anatomical terms still meant concepts similar to those of the Akkadians. The word brain (ἔγκεφαλος) still signified "*no more than the stuff in the head*" (Doty, 2007). However, after more than 500 years, Asklepios had become a deity amongst the Greeks and was later promoted to the status of "god of medicine" by the Romans, who called him Aesculapius and invented for him a vivid biography.

Alcmaeon

Doty (2007) enthusiastically described the outcome of the Greek clinical rationalisation, exemplified by the life of Alcmaeon. Alcmaeon, who lived

in the Greek city of Kroton (now Crotona, in Calabria) at the end of the 5th century BCE during the Golden Age of Pericles at Athens wrote only one book, and it was written in Dorian Greek.

Nevertheless, he much impressed the physicians, scientists and philosophers of his time, though they rather spoke the Ionic dialect. He discovered before Aristotle that "*brain creates mind*". He was "*the first to raise a series of questions in human and animal physiology that later became stock problems every thinker tries to address.*" On the contrary, his views on the cardiovascular system, although coherent, were wrong but they badly influenced many later publications (Huffman, 2013).

Parallel to the Mesopotamians who spoke of arterial and venous blood (Holma, 1911), Alcmaeon wrote on arterial and venous vessels. According to Loukas, Tubbs et al. (2007), he found by experimentation that arteries also contained circulating blood, and not only air or "spirit" (πνεῦμα) as believed until then. Faller (1978) indicates that the word artery was later coined from ἀέρος/aeros (air) and τηρέειν/têrein (to keep).

Alcmaeon found, by dissecting the eye of animals, that sensory organs were connected to the brain and he gave hints about the nature of sensation. He also found that arteries and veins were "more or less" connected. Always on animals, he performed some dissection of the ear where he discovered cavities, which, according to Theophrastus and Aetius, prompted him to raise some theories about audition. He dealt with taste and olfaction, but not with touch. He was a physiologist more than an anatomist, and he later was quoted as such by Aristotle. Erhard (1941) considered him as "*the genial initiator of experimental biology*". He was the precursor of Hippocrates who followed him by a few years, although his contemporaries considered Alcmaeon as a philosopher rather than a scientist or a physician.

Empedocles

A few years younger than Alcmaeon, Empedocles (Parry, 2012) was a cosmographer from Agrigento (now Agrigento, Sicily). He left us with two main texts, one of which being "On Nature" in which he spoke of body and health. According to him, health is a matter of balance between different properties – like hot and cold and wet and dry – and everything is composed of four elements – air, earth, air and water – held together by "love" and dispersed by "hate". His views on vision as well as his ideas about life, strife and love have deeply impressed the physicians of the Hippocratic School who probably developed the Theory of Humours while he was still alive. He developed some innovative theories about specific perceptions being related to specific organs containing specific pores. For centuries, he influenced physicians like

Galen, and philosophers like Socrates and Aristotle.

Hippocrates

Often called "Father of Medicine", Hippocrates (Fig. 5) was born around 460 BCE on Cos, a small island of Dodecanese next to the coast of Turkey where a "temple-hospital" or asclepeion (Ἀσκληπιεῖον) existed. He was mentioned by Plato as "Hippocrates of Cos, of the Asklepiades" (Jones 1868), which means that this medical title most probably given to him by the Master-Physicians of Cos asclepeion.

Hippocrates is said to be the author of about 60 texts that were collected as "Corpus Hippocraticum" or Hippocratic Corpus. There is no proof that he wrote by himself any of these texts, which probably rather belonged sometimes to the library of the asclepeion where he professed medicine. Yet there is no doubt that the original manuscripts were inspired by the teaching of Hippocrates. These texts were the source of an ever growing literature.

The main theory proposed by the Hippocratic Corpus had a huge influence on medical practice until the 19th century. It is the "*Theory of Humours*" (Littre, 1849) exposed in "Περὶ Φύσιος Ἀνθρώπου", or "On the nature of man". According to the volume, *the human body is made of blood,*



Fig. 5. Hippocrates, "Atlas van de geschiedenis der geneeskunde" by JG de Lint, Amsterdam 1925. © Public Domain.

phlegm (mucus), yellow bile and black bile, which constitute the nature of the body, and through which come ailments and health. There is no doubt that "Hippocrates", whoever he was, was definitely impressed by the ideas of Empedocles (see above). Moreover, the concepts of black and yellow bile were commonly known before Hippocrates. Littre (1843), in the introduction of his monumental translation of the Corpus Hippocraticum, quoted several authors already mentioning them, like Empedocles (see above), Acron and Anaxagores.

In fact, the Corpus Hippocraticum dealt much more with physiology, pathology and clinical, and even veterinary practice (Lazaris, 1996) than with anatomy. It only included a single, very short chapter "On Anatomy" or "Peri Anatomes" in Eighth Book (Littre, 1853), and this chapter mainly concerned the inner organs of the trunk. From a terminological viewpoint, it appears that oesophagus, heart and stomach were already named but that their meaning was somewhat different from that of our current anatomical terminologies. While it was acceptable to say that oesophagus begins at tongue, its ending was less clear: it was bound to an aperture called στόμαχος or stomach (from στόμα: mouth or opening) in the belly (or "gaster") where it acquired "septic" properties enabling it to digest meat. This sense paralleled the actual meaning: our sepsis also corresponds to digestion, but made by germs and leading to rot.

The same chapter of the Corpus mentioned one lung only (πνεύμων), but with five lobes (λοβοί). The heart (καρδίη) was situated at its centre and more rounded than that of animals. It was connected to the liver by many tubes (βρογχίη for tube and not bronchus in this context) and one of these went to the kidneys. Interestingly, the diaphragm was identified by a plural term, "φρένες", probably referring to the crura of the muscle. A few years after Hippocrates, Plato used the singular word "φρήν" to name any serous membrane vesting the inner organs: pericardium, pleura or peritoneum.

In other volumes of the Corpus Hippocraticum, some anatomical descriptions were noteworthy, like that of the veins (Littre, 1849, Tome 6, §11). The author, who certainly quoted previous writings, imagined the existence in the human body of four pairs of main veins, having all their origin in head and "going down" along more or less parallel pathways before reaching the lower half of the body and, for two of them, the lower limbs. None was named apart from the jugulars, or "σφαγίτιδες"/sphagitides, a specific term, forming the second pair. The third pair would pass by the scapulae, named "ὠμοπλάτας" (from which the French "omoplate"), then by the lung to reach liver and kidney on the right and spleen and kidney on the left. This fanciful description exemplified the lack of direct anatomical observations at Hippocratic times, even in such glorious asclepiions as that of

Cos.

The Ninth Book of Corpus Hippocraticum (Littré, 1841) included a peculiar text: "On the Heart", whose origin remains obscure. Probably written in the middle or late 4th century BCE (Lonie, 1973), it expounds at large observations and theories on the cardiovascular system that would be soon developed by Aristotle. It clearly describes the pericardium without giving him a specific name, as "a smooth coat containing a small quantity of urine-like liquid surrounding the heart like a bladder" (Littré, 1841, §1). It also describes in the heart two separated cavities ("δύο γαστέρας"), of which the right one is the largest whereas the left one is located exactly under the mamma, where heart-beat can be felt (Littré, 1841, §4). This text will be later discussed and extended by Aristotle and by the Medical School of Alexandria.

It is obvious that Hippocrates and the authors of the Corpus Hippocraticum – his contemporaries and descendants globally called "Pseudo-Hippocrates" – remained universally famous because of the rational approach that they had introduced into clinical medicine. Their anatomical knowledge was nevertheless hindered by the fact that they did not dissect human bodies nor practised open surgery of the trunk.

Anatomy was still erratic and its vocabulary unstable. The most accurate and detailed descriptions were found in "On Joints", the Fourth Book of Hippocratic Corpus (Littré, 1844), and especially in its "Moklikos" or "Equipment" Section, where the anatomical details pertaining to the external reduction of fractures and luxations were summarised. Interestingly, only a few specific terms were used instead of circumlocutions expressing topographical locations, like "internal bone of the calf" for tibia (although the specific term *perone* already existed) or "*stethos*" meaning sternum and chest. The arrival of dissecting physicians from Alexandria would soon change the picture.

Post-Hippocratic times: from Aristotle to Galen

Aristotle

Aristotle was and remains one of the greatest and most influential philosophers of all times. He is said to have been born in 384 BCE, thus about a century later than Hippocrates. Both his father and mother came from a family of physicians, which probably influenced his career. As a youth, he entered Plato's academy in Athens and he stayed there for 20 years. After Plato's death, he founded his own school in Assos, on the Aegean Sea in front of the Island of Lesbos, to which he previously had to flee the Persians after two years spent in Assos. He then became preceptor of the Macedonian King's son, Alexander. He spent his most productive years with Alexander, who later became

"The Great". He went to Athens after Alexander's death and he founded there his famous "Lyceum" School, before fleeing again to Euboea Island near Greece mainland, where he died in 322 BCE (Zévort, 1847, §1-§6).

Aristotle defended against Plato the idea that reality was accessible to the senses. For him, and for his contemporaries, there was no difference between philosophy and science, but he accepted the importance of sensory experience. As a consequence, it is not surprising that he carefully read those writings of the Corpus Hippocraticum that were available to him, and that he undertook to dissect various animals by himself. So, he also taught and wrote about anatomy, especially human anatomy, although in the main he practised comparative anatomy. It does not seem likely that he ever practised human dissections.

According to Diogenes Laertius, who wrote some detailed biographies of Greek philosophers (in Greek) during the 3rd century CE, Aristotle was the author of 382 books (βιβλία) (Zévort, 1847, §21-§27) on such various subjects as poetry, philosophy, politics, ethics, mathematics or biology. Unfortunately, only one third of these works survived the Roman times. Nevertheless, Aristotle's writings were fundamental in philosophy and science for the Arabic, Persian and Christian cultures. Regarding medicine, they constituted one of the bases of anatomical knowledge after they were corrected and amended by the School of Alexandria. They remained a predominant influence on anatomy until the first publications of Vesalius in 1538.

Most of Aristotle's anatomical views were exposed in three books: "History of Animals", "About Parts of Animals" and "About Generation of Animals". According to Crivellato and Ribatti (2007), "in the heading of "Parts of Animals" and in the opening of "History of Animals", Aristotle introduced the term "part." This concept, completely different from the {*t*} of the ancient Egyptians, has a profound meaning in his anatomical reasoning. "Parts" are the constituents, the constitutive substances of the body. He classified these "Parts" in taxonomies that corresponded to structural -- uniform / non-uniform; soft / hard -- or to regional -- deep / superficial; left / right -- criteria. The crucial importance of these classifications of anatomical entities is exemplified by the contemporary "Foundational Model of Anatomy" (Rosse and Mejino, 2003), which nowadays opens the domain of anatomy to the biomedical informatics.

Aristotle re-arranged in topographical lists the terms that were already used in Corpus Hippocraticum; for example, he named four regions of the belly (two flanks, and ὑποχόνδριον / hypochondrion above and ὑπογάστριον / hypogastrion below the navel). He also called γαστροκνήμιον / gastrocnēmion, calf or "leg-belly". He named the οὐρητήρ/ureter and numbered the phalanges of hands and feet. However, he did not add newer

specific terms in his anatomical writings.

Apart from the fact that the book was illustrated, another important feature of "The History of Animals" and "About Parts of Animals" is the description by Aristotle of the cardiovascular system. His understanding of cardiac anatomy was remarkable, though inexact. For him, the heart possessed three (Barthélemy-Saint-Hilaire, 1883, Tome I, XIV: §1) cavities (he uses the word κοιλίας = bellies), on the right the largest one (probably the right ventricle), in the middle the medium one (perhaps the distorted faces of the septum) and on the left the smallest one (possibly the left ventricle, which was contracted and small in the suffocated animals that he observed) (ibidem, Tome I, XIV:§3 and Tome III, Chapters II, III, §5). No specific nomenclature was developed. Within the heart, Aristotle describes a "greasy and thick" membrane, which most probably corresponds to the atrioventricular plane of the modern anatomists. This description was in line with, yet more elaborate than, that of "On the Heart" in the Corpus Hippocraticum. It is highly probable that Aristotle had read the Corpus before his writing on cardiovascular anatomy (Lonie, 1973).

Finally, it must be recalled that Aristotle mentioned the existence of the cerebellum, which he called παρεγκεφαλις or "parencephalon". His description however remained rather vague and difficult to interpret. In the same book, he also described two membranes (ὑμένες) surrounding the brain. He probably meant the meninges, but he did not give them a specific name.

The Medical School of Alexandria

From Year 525 BCE to the accession of Alexander the Great to throne in 332 BCE, Greek culture found itself in a turmoil of several rulers, mainly from Persia and Mesopotamia. Yet it flourished in many cities everywhere in Southern Europe (Greece, Italy etc.), Anatolia and Mesopotamia, where the Greek language was spoken and Greek philosophers, physicians and scientists were able to exert their activities. The asclepiions of Cos and Cnidos, and the Pythagorean School of Kroton were famous all over the ancient Western world. Greece itself, under the leadership of Athens, lived its golden age and extended its influence well beyond its borders. Alcmaeon, Empedocles and Hippocrates, among others, were able to produce their masterpieces under the cultural umbrella of the first "democratic" leaders of Athens. However, Sparta gained more influence by the end of the 4th century BCE and Greek culture became less influential but remained buoyant. This intermediate period lasted about one century until the invasion by the Macedonians, whose second king, Alexander the Great, conquered the Hellenic world and extended his Empire in Asia and in North Africa.

Alexander founded the Egyptian city of Alexandria in 331 BCE. It quickly became the intellectual centre of the Mediterranean world thanks to the efforts of the Hellenistic Pharaohs of the Ptolemaic Dynasty who instituted a Library, which was said to be the largest in the world with more than half a million writings and documents (Sallam, 2002). At the end of the 4th and at the beginning of the 3rd century BCE, the Greek Pharaohs Ptolemy I and II invited numerous Greek physicians to come to Alexandria and to found a Medical School annexed to the Great Library. This School would last and fruitfully profess until 389 CE, when the Library was destroyed by fire.

Many Alexandrian professors were influential on medical science and clinical practice, and their influence lasted for several centuries. The most famous of them certainly was Galen, who lived in the 2nd century CE, and whose many writings were preserved along the years. Yet he was preceded by two remarkable physicians, Herophilos and Erasistratos, who are the real fathers of anatomy, thus of anatomical terminology.

Herophilos and Erasistratos

Although these two pioneers of anatomical science – and of anatomical terminologies – are always cited together, it is not clear whether they ever met. Herophilos was born around 325 BCE in Chalcedon, on the coast of the Sea of Marmara in front of Byzantium. He performed his medical apprenticeship under Praxagoras, probably in Cos. After a short stay in Athens, he went to Alexandria, after having been invited there by the Greek Pharaoh Ptolemy I Soter. He died around 255 BCE. Erasistratos was a few years younger than Herophilos, but the only reliable biographical detail that we have for him is that in 293 BCE he was the physician of the royal court of Seleucos I Nicator in Antioch, a Syrian rival city of Alexandria. He most probably spent a few years in Alexandria (Fig. 6). Herophilos was the author of at least six books, in which he himself quoted Erasistratos, whose only a few book titles survived (Von Staden, 1989, pp. 35-66). Fortunately, many fragments of Erasistratos' original writings were copied, quoted and/or translated, especially by Galen, which preserved them for us.

It may be said that both Herophilos and Erasistratos are the precursors of the current anatomical terminologies because of their ground-breaking investigations into internal human anatomy that mark the beginning of human dissection. Previously, anatomists had generally used periphrases to describe those "hidden" structures that they had observed by chance. Yet the number of "new" anatomical objects" (and of "new" functional concepts) that Herophilos and Erasistratos exposed after their opening of skin was so great that they had to re-define existing terms and/or to invent new

names to identify them.

Herophilos' life and works have been scholarly investigated by several authors of the 19th and 20th centuries. In his book, Von Staden (1989) has listed, quoted and commented numerous references to Herophilos' writings. They were published in the original, usually Greek or Latin, text with an English translation. According to him, "While reiterating a number of Aristotle's correct observations... .., Herophilo(u)s also went further: he seems to have been the first anatomist to distinguish and describe the main ventricles of the brain... ..He was also the first to describe and name the "calamus scriptorius", a cavity on the floor of the fourth ventricle of the brain, calling it κάλαμος (calamos) or "reed pen", because it resembles the groove of a writing pen" [page 158]. Herophilos also discovered the specific functions of many peripheral nerves and distinguished between sensory [νεύρον αίσθητικόν] and motor [νεύρον κινητικόν, pp. 200-201] nerves. He provided a detailed description of at least seven pairs of cranial nerves: optic, oculomotor, trigeminal, motor root of the trigeminal nerve, facial, auditory and hypoglossal [page 159]. These descriptions led him to name the styloid process (from στυλος, the word used by the Alexandrians to designate the stylets allowing to write on wax tablets) hanging from skull base. From his investigations on the encephalic vessels, he wrote the first description of the confluens sinuum, which he called ληνοῆς (wine press, in Latin "torcular") giving birth to the famous Latin eponym "Torcular Herophili" [page 158].

Another object of Herophilos' explorations was the Eye. He was first to reveal the existence of "at least four coats or membranes of the eye, bestowing upon subsequent anatomical terminology the terms "cornea" (a Latin translation of Herophilos' term κερατοειδής / keratoeides), "retina" (a Latin translation of Herophilos' term δικτυοειδής / dyktioides), and "choroid coat" (χοροειδής / choroides, a term probably forged by Herophilos for the similar aspect of its vessels to those of the χοριοειδής / chorioeides of the foetal membranes, [Von Staden, 1992, see also Darenberg, 1879]).

Together with Erasistratos, he discovered the heart valves and probably demonstrated their functions. The two anatomists distinguished the cardiac connections of the veins (φλέβες / phlebes, until then used in the sense of vessels) from those of



Fig. 6. Erasistratos discovering the cause of Antiochus' (son of Seleucos) disease: Antiochus' love for the king's wife. Painting by J-L David (1774). © Public Domain.

the arteries (ἀρτηριαί / arteriaī, wrongly considered as also carrying πνεῦμα or "life breath" since Alcmaeion). Similarly, they "gave a detailed account of the vascular system based on a systematic anatomical and functional distinction between veins and arteries" (Von Staden, 1992).

Herophilos also made an accurate description of the human uterus (which he recognised against Aristotle as having a single cavity). However, apart from the uterus itself that he named μήτρα (from which comes the Latin suffix *-metrium*), he called the annexes and the glands by their male names: ὄρχεις and δίδυμοι meaning both testicle and ovary, and σπερματικοῆς both spermatic duct and uterine tube (Von Staden, 1989, pp. 184-185). Nevertheless, he was most probably the first discoverer (according to Galen) of the ovary [ibidem, pp. 230-234]. In male genital tract, he recognised the accessory glands that he named προστάται or prostates, which later gave προστάτης for prostate only.

In the intestine, Herophilos identified the jejunum (νῆστιν / nestin), the Greek word for fasting) and the duodenum (δωδεκαδάκτυλον or twelve-finger long) parts. He also recognised several glands (ἀδένες / adenes) whose secretion, like saliva, took part in the digestion but he did not mention the pancreas as such, although he gave the general name πάγκρεας to all the glands secreting a clear fluid "next to the liver" (ibidem, pp. 161-165).

The few remainders of Erasistratos' writings dealt more with pathology and physiology than with anatomy, and they used a specific vocabulary. The anatomical terms epigastrium and mesenterium are attributed to Erasistratos (Fuchs, 1894); also

the heart valves: the tricuspid that he termed τριγλώχινες ὑμένες ("triple membranes") and the mitral valves named δυοῖν ὑμένων ἐπίφυσις (= two-membrane epiphysis). He was considered by Galen to be more advanced than Herophilos in his knowledge of heart (Von Staden, 1989, page 241) but his theories on circulation were later altered by his disciples to make them fit with those of Aristotle (Lonie, 1964).

Before leaving the two fathers of modern anatomy, it must be reminded that both of them attained a level of understanding of the living cardiovascular system that would not be reached again before the early 17th century and William Harvey. Their followers – the Herophileans and the Erasistrateans – formed two schools that survived them for more than three centuries. Unfortunately, most of disciples retreated from dissection.

Herophileans continued to work on (arterial) pulse and on bleeding. So did the Erasistrateans who correlated vascular and cardiac pulses, which led them to contradict their Herophileans

colleagues (Von Staden 1989, page 504). Both Schools had lost their influence at the beginning of the Christian era.

Rufus of Ephesus or Rufos

Rufus was a Greek physician who practised in Ephesus, his hometown now in the Izmir Province of Turkey, as well as in Rome and probably in Alexandria. He lived from 80 to 150 CE and produced around 100 books, of which only four were preserved in the Greek original, the others still existing as Latin or Arabic translations only. Bujalková (2011) analysed in her excellent paper Rufus' anatomical nomenclature from a linguistic and historical view-point.

Fortunately, one of the originals was "About the name of the parts of the human body" (Περὶ ὀνομασίας τῶν τοῦ ἀνθρώπου μορίων, usually abbreviated as "Onomastikon"). The book was first published with a Latin translation by Gulielmus Clinch in 1726 (Fig. 7) from several older manuscripts. The Greek text was later amended from newly discovered manuscripts, corrected and translated in French by Daremberg and Ruelle (1879).

I cannot resist quoting a few sentences from the beginning of this text: "Τί πρῶτον ἔμαθες ἐν κιθαρῳδῳν; Κρούειν ἐκάστην τῶν χορδῶν καὶ ὀνομάζειν... ..Βούλει οὐν καὶ τὰ ἰατρικὰ ἀπὸ τῶν ὀνμάτων ἀρξάμενος μαθάνειν... ..ἔπειτα τὰ ἄλλα ὅσα ἂν ἐπηται τῷ λογῳ, ἢ δοκεῖ σοι ἰκανὸν εἶναι δεικνύντα δηλοῦν ὡς περὶ κωφὸν ὃ τι χρῆζεις διδάξει. Ἐμοιῆ μὲν οὐ δοκεῖ ἐκεῖνο ἄμεινον: οὐκ εὐμαθὲς δεῖ καὶ ῥᾶστον οὕτω καὶ μαθάνειν αὐτόν, καὶ ἕτερον διδάσκειν", which means "What do you learn first before learning how to play cithern? To touch and name each of the strings.[...]. Thus do you want to learn medicine from its names?[...]. Or do you think that it would be better that I only show you what you should know, as if you were deaf? This last method does not seem to be the best: it does not teach you how to learn by yourself nor to teach to others". The actual teachers of anatomy would still not say anything else (English translation from Greek text by PS).

First part of Rufus' Onomastikon (Daremberg, 1879, pp. 135-149)

Following the introduction, Rufus wrote what can be considered as the first textbook of anatomy. It first dealt with surface anatomy, the visible part of the body, which is systematically described from head to feet.

1. Most of the employed terms are today still in use with the same meaning: for instance bregma, inion, metopon, tarso(u)s, iris, helix, ant-helix, concha, tragus, genion, pharynx, epigloss(tt)is, larynx, acromion, olecranon, carpo

ΡΟΥΦΟΥ ΕΦΕΣΙΟΥ

Περὶ τῶν ἐν κύσει καὶ νεφροῖς παθῶν.
Περὶ τῶν φαρμάκων καθαρτικῶν.
Περὶ θύσεως καὶ ὀνομασίας τῶν τοῦ ἀνθρώπου μορίων.

RUFII EPHESII

De vesicae renumque morbis.
De purgantibus medicamentis.
De partibus corporis humani.

Nunc iterum typis mandavit

GULIELMUS CLINCH, M. D.

Qui & DISSERTATIONEM de AUCTORE,
ejusque Scriptis, unâ cum COMMENTARIOLO
de usu idoneo vesicantium in morbis
curandis adjecit.



LONDINI,
Typis J. Bettenbam,

Impensis J. CLARKE Bibliop. apud Excambium Regium
in Cornhill. MDCCXXVI.

Fig. 7. Frontpage of the first English translation of Rufos into Latin by Clinch in 1726.

(u)s, metacarpo(u)s, phalanx, thenar, hypothenar, sternon(um), epigastriion(um), hyrogastriion(um), rachis, urethra, ureter, nympha, clitoris (about which Rufus noted that the verb "κλειτοριάζειν / cleitoriadzein" means to stimulate lasciviously [ἀκολάστως] the clitoris), go(e)nu, astragalo(u)s.

2. Some other terms used by Rufus have provided the etymological root of numerous Latin and/or modern anatomical words, like κανθοῆς (canthos = commissura palpebrarum), ρίς (rhis/rhinos = nose), γνάθος (gnathos = jaw), ὑπογλώσσις (hyroglossis = mouth floor), ἀγκών (ankōn = elbow), χεῖρ / χειρὸς (cheir/os = hand), κλείς/κλειῆδος (cleis/idos = clavicula or key), μαστοῆς or τιθήιον (mastos/titthion = breast), (θηλή = nipple), ὀμφαλὸς (omphalos = umbilicus), βουβῶν (boubōn = groin, hence bubo), ἐπίσειον (episeion = perineum femininum), βάλανος (balanos = glans), διδύμοι or ὄρχεις (didumoi / orchais = testes), κοτύλη (cotylē = acetabulum), γλουτὸς (gloutos = buttock), κνήμη (knēmē = leg or tibia) or ἰγνύα = fossa poplitea).
3. What is remarkable is that Rufus' surface anatomy also included detailed denominations for features currently considered as accessory, like type and location of hair, for example ἰούλος / ioulos = side-whiskers, μύστακες / mustakes = moustache, πάππος / rappos = beard on the chin and ὑπήνη / hypēnē = beard under the chin. Wrinkles (ρύτιδες / rutides) also deserved some specific terminology like ἐπισκύνιον / episkynion for the "attention wrinkle" above the eyebrows.

Second part of Rufus' Onomastikon (Daremborg, 1879, pp. 149-167)

Whereas the first part of the book was as sharp and precise as Rufus' gaze on the envelope of the human body, its second part was vaguer and more theoretical. We can trust Rufus when he invited the reader to follow him in dissecting a monkey but we notice that his description was influenced by several of his predecessors, especially Herophilos and Erasistratos, whom he seems to have highly appreciated. The chapter started with an Aristotelian foreword on comparative anatomy to introduce monkeys.

1. Then, as in the first part, some of the new names (not mentioned by his predecessors) that he employed are still in use: periost(eos), (sutura) lambdoidea, diploe, ethmoid, zygoma, masseter, sti(y)loid, pachymeninx, leptomeninx, hyalodēs hygron (= vitreous "liquor"), crystalloeidēs (= lens "cristallina"),

hyoid (bone), oesophago(u)s, cardia, pericardios(um), thymo(u)s, diaphragm(a) (instead of "phrenes", see above), pyloro(u)s (= gate warden), colon, epiploon, peritonai(e)on, pancreas (for the first time correctly located "laying before the origin of intestine"), cholēs angeion (= bile receptor, for biliary vesicle) with its auchēn (= neck) and its puthmēn (= fundus), kystis (= bladder), psoas, colpos (= vagina), dartos, cremaster, aorta (quoted from Aristotle), ten[d]on, angeion (= vessel), catamēnion (= menses), amnion(s), chorion, ourachos (= urachus), chondron (= cartilage).

2. As in the first part, Rufus employed several terms from which are derived modern clinical and/or anatomical terms, like: κοιλία ἐγκεφάλου (coiliai enkephalou = bellies of encephalon = ventricles of brain), χιτών χοριοειδῆς (chitōn chorioeidēs = choroid layer; here, Rufus quotes Herophilos as calling this entity "choroid meninx"), keratoeidēs (= cornea, hence keratitis), ῥαγοειδῆς (rhagoidēs = grape-like), φακοειδῆς (phakoidēs = lens, or lenticular, another name for this entity, hence phacoemulsification), ὦτα καρδίας (= ears of heart, hence auricula), τυφλὸν (typhlon = caecum, hence typhlitis), ὕστερα (hystera = uterus), χόνδρος (chondros = cartilage), φλέγμα (phlegma = lymph, hence phlegm).
3. Although less interesting than the first one from an anatomist's viewpoint, the second part of Rufus' Onomastikon gives clear indications that its author was at the same time a practising physician and a scholar anatomist. As an anatomist, he is the first to speak of voluntary (προαιρετικὰ) nerves (Daremborg, 1879, page 163) originating from "brain" and spinal cord, and to classify both motor and sensory nerves. He uses some medical examples, like a good description of the symptoms of nephritis (ibidem, pp. 159-160) quoted from Cnidias. He exposes his own results about the pancreas and the abdominal cavity where he seems to have dissected by himself the peritoneal folds (ibidem, page 157). Yet he reports, sometimes critically, the writings of many anatomists. Amongst these, I have already cited Aristotle, Herophilos, Erasistratos and Cnidias; Hippocrates, Praxagoras, Eudemos and even Homer, the poet, also were referred to by Rufus.

As befits a good scientist, Rufus was able to remain neutral amongst the dissenting views of his colleagues, but also ready to explicitly contradict some of his predecessors and contemporaries, if necessary.

Celsus

Greek was to remain the professional medical

language for the first centuries of the Christian era. However, Aulus Cornelius Celsus facilitated the dissemination of medical writings within the public of the Roman Empire by publishing in Latin a large Section ("De Medicina") of his encyclopaedia ("Artes") at an undefined date between 14 and 39 CE (Langslow 2000). That he transposed numerous Greek words has been described by Wulff (2004) who said: "*He (Celsus) included, for instance, the Greek words pyloros (now pylorus) and eileos (now ileus), written with Greek letters in his Latin text. Secondly, he latinized Greek words, writing them with Latin letters and replacing Greek endings by Latin ones—e.g. stomachus and brachium. Thirdly, and most importantly, he retained the vivid imagery of the Greek anatomical terminology by translating Greek terms into Latin, such as dentes canini from Greek kynodontes (dog teeth) and typhlon from Greek to caecum (the blind [gut]). Thus, we can still enjoy the old Greek tradition of likening the shape of anatomical structures to, for instance, musical instruments (e.g. tuba = trumpet, tibia = flute), armour (thorax = breastplate, galea = helmet), tools (fibula = needle, falx = sickle), plants (uvea = grape, glans = acorn) and animals (helix = snail, concha = mussel, musculus = mouse, tragus = goat so named because that part of the external ear may be covered with hair, resembling the tuft on a goat's chin). Some of these words are the original Greek ones, while others are Latin equivalents introduced by Celsus and his successors.*"

Langslow has analysed the use of Greek and Latin terms in Anatomy, Pathology and Therapeutics by four Latin authors including Celsus (Langslow, 2000, page 77). Of the 917 items considered in "De Medicina", 244 (26.5%) were in Greek and 673 (73.5%) in Latin; 277 (30.2%) names concerned Anatomy, of which 26 (9.4%) were in Greek and 251 (90.6%) in Latin. A quick look at these figures indicates that Pathology (135 Greek for 260 [65.8%] Latin names) and Therapy (83 Greek and 162 [66.1%] Latin names) were significantly less "latinised" than Anatomy. Other Latin words introduced by Celsus are: anus (first used by Pliny to mean "ring"), vesica, basis cerebri, radius and scapula. The Latin word "tonsilla" also was apparently introduced by Celsus to identify the normal tonsil as an opposite to the Greek ἀντριάδες that meant "diseased tonsils".

Celsus also contributed to the generalising of the Greek term "splen" in Latin in replacement of the older Latin word "lien".

Celsus was not an anatomist nor a professional physician. As a literary polymath, he wrote numerous books, for which he was called "Cicero medicorum" because of the elegance of his style and the fact that many of those books dealt with medicine.

It may nevertheless be said that our current terminologies owe more to Celsus than to Galen. If

Celsus had not paved the way for the use of Latin terminology for Galenic Greek terms, it is likely that Galen's fame in the Roman world as a medical writer would have been less impressive. As a consequence, fewer manuscripts would have been copied and fewer opportunities for Persian and Arabic translations would have existed. It is worth noting that Celsus' "De Medicina" was the first medical book to be printed (1478 in Florence).

Galen

Galenus, or Γαληνός (Boudon-Millot, 2012) (no official forename [praenomen] nor surname [cognomen] actually known with certitude), was a Greek physician born in Pergamon (129 CE) where he trained in medicine at the local asclepion from the age of 16 years. He pursued his studies in several cities like Alexandria where he certainly stayed in 155 CE (Lang, 2013, page 194). In 157, he returned to Pergamon where he was called by the High Priest to become the physician of his official gladiators. The successful surgical practice that he established there for 4 to 5 years rendered him famous in the Roman Empire. He thus left to Rome but he soon had to move back to Pergamon mainly because of the opposition of his local "colleagues" and therapists who wanted to get rid of such a brilliant competitor. However, because of Galen's reputation, the Emperor Marcus Aurelius Antoninus called him to himself in 168 as a physician in the army. Marcus Aurelius soon made him his personal physician in 169. Galen came thus back to Rome at the onset of the great Antonine Plague, a devastating epidemic of smallpox. He was attached to Commodus, the heir of the Empire, to later become the Emperor's physician under Septimius Severus and Caracalla (ibidem, pp. 122-166). He later settled in Rome until his death in 200 or in 216. While that date remains the subject of a controversy (West, 2014), what is not in doubt is the fact that Galen's universal authority on medical knowledge remained intact for at least 14 centuries.

Galen was a prolific writer as much as a famous physician. Although bilingual, he wrote in Greek but, because he performed most of his writings in Rome, his books were immediately translated into Latin, which probably contributed to his fame. His celebrity helped him to make the acquaintance of many leading personalities of the Empire – philosophers, consuls, officers and public figures – to raise the steps leading to the Emperor himself. From his second arrival in Rome in 169 until his death 30 or 46 years later, Galen's main activity was devoted to practising medicine, writing his books, lecturing and demonstrating about anatomy (his anatomical demonstrations of 176 [Boudon-Millot, 2012, page 217] were recorded), also reading in the many libraries available in Rome. As he

aged, it seems that he became more self-critical, leaving his "posture of author" to "disappointedly frown at his writing activity" (ibidem, pp. 223- 224). Furthermore, the second Big Fire of Rome in 192 unfortunately consumed his personal library as well as those of his friends to whom he had given copies, and the depots where most of his books were kept. Galen spent his last years at trying to rewrite those writings that had been annihilated.

Before the Big Fire of 192, Galen had published a catalogue of his works: "Περί τῆς τάξεως τῶν ἰδίων βιβλίων πρὸς Εὐγενιανόν" or "About the order of my own books for Eugenianos" probably to distinguish himself from some of his contemporary authors (ibidem, pp. 214-215). After the fire, he wrote after 192 "Περί τῶν ἰδίων βιβλίων γραφή" or "About my own books", in an effort to transmit to his descendants as much as possible from his charred writings. The latest bibliography of Galen's works (Fichtner, 2015) lists 441 titles, of which 62 are attributed by Fichtner and Wittwer to Pseudo-Galen, an eponym covering several authors having lived in various times and sometimes included for unknown reasons into the Galenic Corpus.

Galen was a physician more than an anatomist. He never opened human bodies, but he performed many dissections on animals: monkeys, pigs and goats, which led him for instance to write about the human *rete mirabile*, a vascular network existing in the neck or head of various mammals, including cows and sheep, but not in the Humans. This obvious error was reflected in all the medical literature, and remained uncorrected until the 16th century.

However, as Goss (1965) noticed in his presidential address to the 68th Assembly of the American Association of Anatomists, Galen never hid the fact that most of his personal learning of human anatomy derived from his readings from such famous writers as Hippocrates, Aristotle, Herophilos and Erasistratos and also from his careful dissections of monkeys, which he specifically mentioned at least 77 times in his book "About anatomical procedures".

Regarding terminology, Galen coined or initiated few terms. His general descriptions made use of periphrases or of phrasal terms explaining to the reader what he was finding while performing a dissection. In this respect, it is interesting to read the translations performed by Goss directly from old published Greek documents. He hardly considered the Latin texts. These translations were published in the *Anatomical Record* and in the *American Journal of Anatomy*. This probably explains why, although readily accessible to medical professionals, they were hardly quoted in the abundant philological literature devoted to Galen and Galenism.

Galen nevertheless used some specific terms. Amongst his precise descriptions of vascular trunks and ramifications, we find for instance the

azygos vein (Goss 1961, page 357) but the vertebral artery, although clearly identifiable ("the artery running through the foramina in the 6 cervical vertebrae accompanies and is distributed with the vein to the meninges of the cord"), remains unnamed.

The case of uterus (Περί μήτρας ἀνατομῆς βιβλίον / Livre sur l'anatomie de l'utérus) is interesting (Goss, 1962). Here Galen discusses the form of the organ and writes about the existence of uterine horns (χέρατα, *cornua* in Latin), insisting that this corresponds to the reality in women but not in most of the animals, like sows, that were often used for dissections. He even enjoys the opportunity to contradict the terms used by Eudemos and Praxagoras, two famous previous anatomists. He also discovers that the tubae (still called διδυμοί since Herophilos, see above) are in communication with the uterus body over the horns.

Galen studied the muscles mainly in two books. The first to be written was "Περί μυῶν ἀνατομῆς", or *On the Anatomy of Muscles (for Beginners)*. In this book (Goss, 1963), Galen observes the most superficial subcutaneous muscles during his dissections of monkeys. He discovers and names the platysma (πλάτυσμα), and writes a very detailed description of the facial, masticatory, cervical, laryngeal, lingual, truncal and perineal and of limb muscles. Every muscle is identified by its attachments and its functions and sometimes bears the name of the body region to which it belongs (gastrocnemius for example).

The second book "Περί μυῶν κινήσεως βιβλία β", or "On Movement of Muscles Book 2" (Goss, 1968), dealt with the general anatomy of muscles and presented two parts, the one on the general form and connections (nerves and vessels) and the other on muscular kinesiology. From a terminological view-point, there is no significant addition to the already existing terms but Galen establishes a clear-cut distinction between arteries, veins, nerves and tendons. At the same time, he describes the relationship between these structures, explaining for example that tendons can include vessels and sensory nerves.

Galen also wrote a specialised treatise on nerves: "Περί νευρῶν ἀνατομῆς βιβλίον", or "On Anatomy of Nerves", also translated by Goss in 1966, that was excerpted by Galen himself from his bigger treatise "Περί ἀνατομικῶν ἐγχειρήσεων βιβλία ἐννέα" or "Nine books on anatomical procedures".

This relatively concise book was specifically concerned with the pairs of cranial and spinal nerves that Galen carefully dissected and minutely described. Once more, he did not use a specialised terminology. Yet he paid tribute to his master, Marinos, whose numbering sequence of seven pairs he followed for the cranial nerves. This reduced sequence was still employed by Vesalius, who

however did not attribute the same number to the same nerves (for example, 5th pair made of the facial and vestibulocochlear nerves together, according to Galen, and of the trigeminus to Vesalius (Shaw 1992, page 468).

It is necessary to give some details about the trip across the ages that allowed those pages to reach us. Galen lost the first manuscripts that he wrote in Rome around the year 165. He undertook from 177 to re-write a new and more detailed version. Only the first chapters of this version are still available in Greek. However, most of the other chapters could be reconstructed from an Arabic translation of later copies dating from 189 and 193 (Boudon-Millot, 2012, page 367). We shall come back later on this complicated story that concerned many Galen's writings and played an important role on the influence of Galen on the medical sciences of the following 14 centuries.

The importance of making use of an accurate terminology was however strongly defended by Galen in his book "Περὶ τῶν ἰατρικῶν ὀνομάτων", or "About the medical names", where he vehemently argued against the sophists on the accuracy of the terms demanded by clinical medicine. Unfortunately for the purpose of this article, the discussion related exclusively to names of diseases but not to the underlying structures. Yet, in "Περὶ χρείας τῶν ἐν ἀνθρώπου σώματι λόγοι" or "On the use of the parts of the human body", Galen went so far in terminology as to propose to replace in human anatomy the Greek term *encephalon* by the Latin word *cerebrum* (or by the Greek "syndapsus" which after him meant "nothing"), as the latter is more "neutral" than the further since it does not take into account the location of the organ (Daremborg, 1854). He mainly based his proposal on the fact that headless animals could not have an encephalon.

The Latin heritage of Galen

Most of the data included in this chapter are based upon Langslow's book (2000) on Medical Latin. It extensively deals with the linguistic and semantic aspects of the early replacement of Medical Greek with Latin.

From 1 to 300 CE, the Golden Empire

Very few medical writings, apart from those of

Celsus (see above), were published in Latin during the first 3 centuries of the Christian era.

Scribonius Largus authored the "*Compositiones*" with 271 short chapters about remedies for specific diseases or against poisons, and describing unguents and lenitives ("*malagmata*" and "*acopa*").

Plinius Secundus (Pliny the Elder) lived from 23 to 79 CE when he was killed at Pompei by the Vesuvius eruption. He was thus a predecessor of Galen. His few extant medical works survived him only through quotations by Gargilius Martialis who died in 260, 44 years after Galen. His influence on the history of medicine until the Renaissance was more extensive than what could be expected from the scarcity of his remaining medical manuscripts, thanks to the numerous quotations and translations (in Greek or Arabic, Syriac etc.) of his disappeared texts, which were later re-translated into Latin.

Celsus, more than Galen, remains the main figure of the Latin anatomical terminologists of the first 3 centuries.

From 300 to 600: from the late Empire to the Early Middle Age

During the first half of the 4th century, apart from "second-hand works" about previous literature, very few books were published in Latin and they all dealt with medical recipes only. Many of them presented vulgarised Latin translations of Greek writings with sometimes a "low level of aim, language, and medical contents."

At the end of the 4th and during the first half of the 5th century, a handful of medical practitioners of the Roman African province produced "*a number of relatively stylish, sophisticated, and authoritative compilations....in Latin.*" The concerned authors were Helvius Vindicianus (HV, end of the 4th century), Theodorus Priscianus (TP, early 5th century), Caelius Aurelianus (CA, first half of 5th century) and Cassius Felix (CF, second half of 5th century). With Celsus, they supplied a fundamental source to the medical literature of the later centuries. Regarding anatomical terminology, they latinised several Greek words: *bulbus* (βολβός) *oculi* [CF], *labium* / *lip* [CF] for *χειλή*, *fel* [CF] for *χολή* / *bile* that later regained predominance, *colpus* [CF] for *κόλπος* / *colpos*, *palatum* [CF] for *ὑπερώα* / *hyperoa*, *meninga* [TP] for *μῆνιγξ*, *viae urinales* [CF] for *πόρος οὐρητικός* / *urinary ducts*. They did not hesitate, however, to continue using Greek anatomical terms in their Latin texts. This is the case of Cassius Felix, who snobbishly preferred once every 5 times to write the Greek name instead of the Latin, whereas Celsus chose 12 over 13 times the Latin term [Langslow, 2000, pp. 124-125].

It is noteworthy that the use of proper-names had long before started to invade Greek terminologies, but of therapeutics only. The invasion extended to the Latin terms [ibidem, pp. 138-139] but did not

reach yet the anatomical nomenclature.

The last century of the period was devoid of original books about anatomy or medicine. A typical example of the medical literature of the time is given by Isidorus Hispanensis' work *Etymologiae* (or *Origines*), written at a time when authors published encyclopaedias of compilations and quotations from previous scientists. This 20-volume book encyclopaedia deals with liberal arts and medicine-related sciences of the 6th and 7th centuries (Bishop Isidorus lived from 562 to 636). The 4th book, "*De Medicina*", and the 11th "*De Homine and Portentis*" (about Man and Miracles), summarises and brings together excerpts from famous physicians. The following paragraphs are based upon Lindsay's (1911) edition.

Some interesting names appear in chapter 5 of "*De Medicina*", like *cholera* that seemed to identify not only the homonymic disease but bile as well ("*...unde et cholera, id est fellicula, nominata est...Graeci enim fel χολήν dicunt*"). In the chapters dealing with acute and chronic diseases, some references to anatomical – Latin or Greek – terms are clarified: for example, *cephalea* comes from *κεφαλή* that means *caput* / head. Some "vulgar" and nowadays extant Latin terms are translated into Greek in order to render the Greek derivatives understandable by lay readers: hepatic diseases pertained to "*iecur*" / liver, splenic diseases to "*lien*" / spleen (see Celsus). However, nearly all linguistic explanations concern names of diseases or of symptoms.

Nevertheless, in chapter 11 about Man and Miracles, Isidorus begins his text with a statement on the difference between *anima* / mind ("inside") and *corpus* / body ("outside") finishing with an explanation of the five senses. Logically, he then performs an elementary description of human surface anatomy, which reminds of Rufus. He again explains several common Latin terms like *pupilla* / pupil [§37] (small puppet, the "*middle point of eye where is the strength of seeing and where we can see small reflections of ourselves, therefore the name pupilla*"); then the bishop proceeded: "*most people call it pupula, yet they should say pupilla as it is pure and unpolluted, as the puella / young girl*", a peculiar allusion). At §64, Isidorus initiates a discussion, that has not been concluded yet in some countries, about the use of cubitus or ulna at the forearm. He seems to prefer cubitus but is not very sure! At §98, after having described the borders of "*dorsum*", Isidorus risks some hilarious (to contemporary eyes) sexual explanations: "*lumbi ob libidinis lasciviam dicti, quia in viris causa corporeae voluptatis in ipsis est, sicut in umbilico feminis*" / loins are named after the lustfulness of love because, in males, the cause of physical voluptuousness is in them, as it is in the navel of females.

Sixty years after Galen's death, the mighty Roman Empire began to break apart. It was first divided into four parts, then re-unified, to be eventually

split into the Western and Eastern Roman Empires under Diocletian (245-311). His second successor, Constantine the Great (272-337), established his capital in Byzantium, which he renamed Constantinopolis (Constantinople). Meanwhile, the whole Roman world had turned itself to Christianity and its Western part had been raided by several waves of invaders. The Empire as such collapsed in 395, on the death of Theodosius, who was the last Emperor to rule over both its Western and Eastern parts.

The Western Empire quickly lost all its centralised power under Romulus Augustulus. Western Europe became the seedbed of various kingdoms (for instance, Isidorus Hispanensis was a subject of the Visigoth king of Hispania, whom he convinced to become a Christian). And in Italy, the first struggles for power started between invading Germanic chiefs who endlessly fought to designate between themselves the successor of the Western Roman Emperor. The Pope, being the bishop of Rome, also considered that his predecessors had been given their powers by Constantine.

From monastic to scholastic medicine

In the first half of the 6th century, an Italian monk, Benedict of Nursia (Saint Benedict), composed in Low Latin a monastic rule that still prevails in many convents and abbeys of the world. Chapters 36 "*De infirmis fratribus* / About sick brethren" and 37 "*De senibus vel infantibus* / About children and elders" of this rule (Figure 8) instituted that every convent was to ensure proper care to all sick monks by supplying them with special accommodation and by appointing to that care a "*servitor timens Deum et diligens ac sollicitus*". Except for God's fear, diligence and solicitude always are demanded from nurses.

Benedict died around 545 at the Monastery of Monte Cassino, which he had contributed to build



Fig. 8. Folio 3 of the Manuscript Royal 10 A XIII (around 1175) by Smaragdus of Mihiel (830) on the Benedictine Rule, from The Benedictine cathedral priory of Holy Trinity or Christ Church, Canterbury (UK). © Public Domain, downloaded from the British Library <www.bl.uk/catalogues/illuminatedmanuscripts>

and develop at the top of a steep hill approximately 180 km SE of Rome. Monte Cassino soon became the heart of Western monasticism, which meant that, following the still nowadays in power Benedictine Rule, a network of well-furnished infirmaries or dispensaries, and dedicated nursing brethren spread first in Italy, then over Europe.

This network could make use of many newly created libraries containing copies and translations of those medical books that were kept at Monte Cassino. The libraries were also used to train the nursing monks. It is likely that some Latin (or Greek) speaking monks were responsible for this teaching (Capparoni, 1923).

While these developments occurred, monasteries had to accept to treat prominent lay persons in their infirmary. Yet there was a difficulty with women. They could hardly be officially tolerated on the premises of a cloister. As a consequence, monastic infirmaries induced lay people, males and females, to acquire the capacity to practice medicine, surgery and gynaecology. Midwives, who already participated in the treatment of gynaecological diseases, also participated in this evolution that began in the mid-7th century to flourish during the 9th, when a Medical School was founded at Salerno by lay people. It became the seed and model for the "civilian" European "Universitates Studium" of which the oldest one was founded in 1088 in Bologna. Anyhow, the Salerno School proceeded with its teaching and writing activities – including female readers, professors and students – until at least the 13th century (see below: "*Constantine the African and the School of Salerno*".) For the first time in Europe, it made mandatory for persons who wished to practice medicine to "demonstrate competence and knowledge by passing appropriate examinations" (Moxham, 2014).

The Eastern heritage of Galen

When Galen was writing in Greek, he did not suspect that his language, though already widespread, would later become the official language of the Eastern Empire, which otherwise kept the traditions and laws of Rome. The Emperor would conserve the prerogative of ruling what was now the Byzantine Empire. With a short interruption due to the sack of Constantinople by the crusaders in 1204, it difficultly survived but finally succumbed to the Ottomans in 1453. Less than a century later, Andreas Vesalius would reshape anatomy.

In fact, Greek had always been the language of medicine. Apart from Celsus – but he was not a physician – every famous medical writer had written in Greek during the Antiquity. As a result, medical literature was still disseminated all over the former Roman Empire, from Southern Spain and North Africa to the East of the Asian province. In the 5th and 6th centuries, Greek was spoken in all cities, from the Mediterranean shores to the Western borders of Persia, and its influence was still

great beyond Persia. Galen's name probably was more famous in the 6th century than when he was alive. His works were translated in Syriac, as well as those of Hippocrates and Aristotle, by Sergius of Reshaina during the first half of the 6th century (Chabot, 1912.)

Even so, as Nutton (2013) has written: "*Seen from the perspective of the wordy, theoretical Galen, or even the writers of the massive compilations of extracts, Oribasius, Aëtius and Paul, Byzantine medicine is a disappointment.*" Nevertheless, medical texts from the Late Empire were living, "*bringing together remedies that were believed to work, some even centuries old, and adding new material to the stock either within the text or in the margins.*" Yet, as they dealt with therapeutics in a broad sense, no new terminological data could be found in them.

Then came the prophet Muhammad and Islam. The new religion inflamed the Arabian Peninsula starting from Mecca to Medina in 622. It spread to North Africa, South-Western Europe, Near East, Middle East, Central Asia and India. At the end of the 8th century, Islam was the heart of a brilliant civilisation illuminating the world from Córdoba (Al-Andalus, Spain) to Samarkand (now Uzbekistan). After the short period of Rashidun Caliphate in Medina (632-661), an Islamic Golden Age bloomed during the Caliphates of the Umayyads (661-750) in Damascus, then of the Abbasids (from 750) in Baghdad. The latter more or less survived until the 16th century. Meanwhile, the dynasty ruling the Umayyad province of Córdoba announced in 756 the creation of an Emirate that conquered the surrounding Islamic territories. Ultimately, the new Caliphate of Córdoba was founded in 1085. This Caliphate was successively ruled by two Berber dynasties, first the Almoravids (1085-1145), then the Almohads (1147-1238), which were contested by the Christian kingdoms of the Iberian peninsula. The last Islamic successors subsisted in the Emirate of Granada until their last defeat in 1492 (Summarised and retrieved from Wikiwand 1, 2015).

Hunayn (Ioannitius), his team and his family

The tremendously fast extension of the Islamic faith caused a parallel dissemination of the Arabic language. The Arabic alphabet was adopted even for other languages, such as Persian, for example. Arabic became the *lingua franca* of many intellectuals. Baghdad Caliph Al-Ma'mun (Abū Ja'far Abdullāh al-Ma'mūn ibn Harūn, 786-833 [Fig. 9]) undertook the development of the *House of Wisdom* (Bayt al-Hikma, founded in 762 by his father Harun al-Rachid) on the model of the Great Library of Alexandria (Hecketsweiler 2010, page 99). Many ancient Greek and Latin texts were actively sought for, and brought to, Baghdad, either as originals or as previous Syriac translations pro-



Fig. 9. Al-Ma'mun (on the right) sending an envoy to the Byzantine Emperor Theophilos, 13th-century Skylitzes Matritensis, manuscript, Biblioteca Nacional de España. © Public Domain.



Fig. 10. Schema of the eye in Cheshlm manuscript of Hunayn's "Ten treatises on the Eye" (1200 CE). © Public Domain

an Assyrian physician who wrote an important Textbook book of ophthalmology (Fig. 10). He was in charge of all the translations under Al-Ma'mun and his successors, notably Caliph Al-Mutawakkil.

Hunayn was a Christian. He and his team of translators did not perform their task word by word. They looked for the meaning of the subject and, for each new manuscript, they rewrote the "piece of knowledge" that they were processing. Usually, the *House of Wisdom* collected and compared between themselves similar Greek manuscripts before writing an Arabic translation – sometimes via Syriac or Pahlavi – of what Hunayn thought was the original text (Tschanz, 2003). As a physician, he understood quite well the medical words that he encountered and he was in a position to really translate anatomical terms rather than transliterating them, as many contemporary interpreters did (Fonahn, 1922, Preface). He processed himself 100 of the then available 129 Galen's writings, as well as those of Aristotle, Euclid, Plato, Hippocrates and Plotinus.

There is an event in Hunayn's personal history that reminds of Galen's biography. Both of them had to endure the destruction of their personal library, in the case of Hunayn, not by fire but by the Caliph's orders after what seems to have been a provocative attitude of the translator. Fortunately for him, and for us, Hunayn's disgrace did not last long. As physician and surgeon, he was able to later author, amongst other medical books, a treatise of ophthalmology which remained a classical book even after Vesalius. This book contained illustrations (Fig. 10) that were re-discovered by Mey-

duced in Damascus. Another source of documents was the newly conquered academy of Gundeshapur (Iran), where since the 6th century Greek and Roman refugees had translated into Pahlavi (old Persian) Greek and Syriac manuscripts (Wikiwand 2, 2015). All those texts were translated into Arabic by many resident scholars, Christians for the most part. The most famous of them was Hunayn ibn Ishaq (also Hunayn or Hunayn or, in Western Europe, Ioannitus, 809-873),

erhof in 1911 in an Arabic manuscript. They were probably copied from a Greek adaptation of Galen's original book "On the Utility of the Parts of the Human Body" (Sezgin, 2010).

Hunayn mastered the Arabic, Syriac, Greek and Latin languages. He was helped by his son, Ishāq ibn Hunayn (830-910), who was also a physician and who worked with his father at translating Greek scientific and clinical manuscripts into Arabic although his main personal interest was in mathematics and astronomy (Cooper, 2007, page 578).

Another member of Hunayn's dynasty, Hubaysh ibn al-Ḥasan al-A'sam al-Dimashqī, the son of his sister, was apparently his main collaborator for translating from Greek to Arabic and Syriac (Savage-Smith, 2014). Hubaysh even took over from Hunayn the writing of the last book that his uncle was composing when he died.

This book was known as the "*Isagoge Ioanniti*" along the Middle Ages, after it had been translated in Latin by Constantine the African during the 11th century (Jan Wilson, 2010). It continued to be read in the Medical Schools and Universities until the 15th century. The text is influenced by, and not merely translated from, Galen's *Ars Medica*. Its approach is to ask questions and give answers, as in Galen's "*Ars parva*".

The manuscript is particularly interesting since it is bilingual, being written in both Syriac and Arabic. It seems that Hunayn, and later Ishaq, made first a Syriac version before translating it in Arabic. It was this Arabic secondary version that was later used while attempting to reconstruct Galen's original Greek text (Wilkie, 1981). Nevertheless, although the two authors quoted Galen (Jan Wilson, page 314), the book was originally planned and initiated by Hunayn himself, thus before the early part of the 10th century. As to the bilingual manuscript, it probably dates from 1131 (Jan Wilson, page XV).

Hunayn & Ishaq's Syriac text, as translated in English by Jan Wilson and Dinkha in 2010, gives hints on some anatomical terms amongst a vast majority of clinical (mainly therapeutic) considerations. For instance, a distinction is made between "*organs with uniform components*" and "*compound organs*". The former denomination more or less defines tissues like "*bone, flesh, nerves, veins, arteries*". The latter term identified in fact both regions and organs made of various tissues and found in different locations of the body (ibidem, page 2 and 432-434). Hunayn & Ishaq were probably the first to mention the concept of "virtual space", named by the Greek word *peritonaion*, opening around the nerves in case of accumulation of fluid (ibidem, page 118). They make a minute description of tongue's innervation in relation to its sensitive, gustatory and motor functions (ibidem, page 214). They use a specific Syriac word (translated in English as "*circonvolutions*" of the brain by Jan Wilson and Dinkha, page 244). They also describe the anatomy of incorporating orally-

taken drugs by passing along mesenteric and portal circuits, crossing through the liver, returning to heart along vena cava inferior ("*deep vein*") and finally going to the lungs.

Hunayn's team played a central role in the development – not only the transmission – of Galen's heritage. Of course, they saved and copied many famous Greek medical manuscripts allowing their contents to survive the following centuries. Yet they also supplied their successors with many Arabic texts, either translated from Greek or written by themselves, especially by Hunayn himself (see above). These texts would impress the scholars of the whole Islamic World until the 16th century. And, by doing so, they allowed such great medical characters as Avicenna to emerge. Their influence on anatomical terminology was considerable, as they cleverly mixed words from various origins.

Rhazes (Abu Bakr Moḥammad ibn Zakariyā Rāzi)

Rhazes (864?-933?) was one of those great Arab polymaths who at the same time developed and criticised Galen's medical teaching. As a philosopher, he shattered the medieval religious beliefs. As an alchemist, a pharmacist and a physician, he wrote numerous books, including notes that were bound after his death in a 23-book Encyclopaedia, "The Comprehensive Book of Medicine" which was soon translated into Hebrew and Latin (Richter-Bernbuch, 2003). As a medical practitioner, he was a pioneer of neuroanatomy applied to neurology (Tubbs, 2007) and he re-assessed the description of cranial nerves made by his predecessors, Herophilos and Galen, recognising that chiasma opticum was a communication, and not a blending, between the two optic nerves (Souayah, 2005).

Ibn Hindū (Abū al-Faraḡ Ali ibn al-Husayn Ibn Hindū)

Ibn Hindū (954-1019?) was a contemporary of Avicenna. His pedagogical talents made him famous amongst philosophers and physicians, and his writings attracted many scholars and students from all over Persia (Nasser, 2007). He strongly defended the rationality of scientific medicine against the medieval bigots who preached that health was exclusively depending on God's decrees. As stated by Sanagustin (2014) at the end of the introduction of his French translation of Ibn Hindū's "*Miftah al-tibb wa-minhaj al-tullab*" (The key to the science of medicine and the student's guide), "*the interest of Ibn Hindū for the lexicon, with continuous references to Greek (that he seemed to know), to Persian and to Sanskrit, appears to show his wish to avoid that students be confused by the foreign terminology that is always showing in the Arabic medical treatises [personal translation]*".

Ibn Hindū has devoted the 10th chapter of his

book to "Terminologies and definitions in medical sciences". It was divided in three parts: logics, philosophy and medicine. The latter part begins with a rather short *terminology proper to the bases of medicine*, but it continues with *anatomy*. After having defined the human body and its limbs (homogeneous or *homeomeres*, and "instrumental" or *anhomomeres*), Ibn Hindū, as a true follower of Aristotle and Galen, comes to the detailed listing of the "members" of the body (which comprise the 4 humours): blood, sanies, sperm, phlegm, choler, atrabile, medulla, blood vessels, tendons/nerves, and flesh. He then distinguishes bones and cartilages, membranes around organs and limbs and membranes parts of, and on, organs, glands, fat (two types: flaccid under the skin and lighter around the kidneys or in the epiploons) and skin. The anhomeomeres are more or less similar to our body parts. Their enumeration varies depending on the fact that chest, abdomen and vertebral column are separated or unified under the term "tannūr al-badan", or trunk. Yet external genitals are a part by themselves.

Unfortunately, the anatomical chapter of Ibn Hindū's in Sanagustin's translation is significantly less precise than the other, philosophical or clinical, parts. The only specific words are listed only in French, which does not allow recognising the transliterated terms among the Arabic originals written in Latin types, as it is the case in the other chapters.

Avicenna (Ibn Sīnā)

Born around 980 near Bukhara (then Persia, now Uzbekistan) that was a world centre of Islamic civilisation, Abu 'Alī al-Husayn ibn Sīnā undertook his studies there until his 18th year when he officially became a medical doctor. He thus began his professional career at the age of 17 years when he was called to the local Court to treat the Emir. A few years later, he was made a political administrator in Gorgānj, taking over the Governorate of the Province though he continued to practise medicine. After 1012, when he was forced to leave his home town after an invasion, he led a peripatetic life that took him from Jorjān to Ray (1014), Qazvīn (1015), Hamadan (1015) where he was also thrown in prison for 4 months, then at last to Isfahan (1024) where he settled and worked for the local ruler, 'Alā'-al-dawla. He died in 1037 during a campaign where he had accompanied his master (Gutas, 2011). In spite of his hectic life, Avicenna was a most productive writer. "*Ibn Sina's wrote about 450 works, of which around 240 have survived. Of the surviving works, 150 are on philosophy while 40 are devoted to medicine, the two fields in which he contributed most. He also wrote on psychology, geology, mathematics, astronomy, and logic*" (O'Connor, 1999).

Although most of his actual celebrity came from

medical practice, Avicenna was above all a philosopher, and he is still nowadays considered to be the first Islamic philosopher. Nevertheless, the five books of his monumental "Canon of Medicine" (*al-Qānūn fī al-Teḏbb*) were already translated into Latin by Gerard of Sabloneta ("the Second Gerard of Cremona") during the 13th century, which indicates how extended his reputation was in the West during the Middle Ages.

The Canon comprises five books that, as usual in those times, were mainly clinical. Of these, Book One contains 263 chapters and is divided in 4 Parts. Part 1 is the only one that specifically deals with anatomy. Gruner (1930) translated it in English from a "Latin version published at Venice in 1608 and 1595, supported by an Arabic version printed at Rome in 1593 and (by) the Bulaq edition". Regrettably, Gruner states on page 103 (§118): "*The next four subsections of the text are omitted. They deal with the anatomy of the bones, muscles, nerves and blood-vessels, and are naturally inadequate in comparison with modern Anatomy*". Gruner, although a medical practitioner himself, seemingly considered his own translation more as a contribution to modern medical science than as an access to a historical masterpiece for his contemporaneous colleagues. Anyway, no original anatomical terms could be detected in the remaining non-anatomical Parts. As in Corpus Hippocraticum, lung was, according to Avicenna, a single organ made of two parts; heart, as described by Avicenna, was not different from that described by Galen, and uterus still was connected to breasts by veins.

Fortunately, a previous French translation (De Koning, 1903) of the Thesis V of the same Canon's Book One included its anatomical part, and was completed by some functional anatomy from Book Three. The translator worked from the earlier mentioned Bulaq edition published in 1897 in Cairo. He added to the translation many commenting notes about the original text language, and about the previous texts written by Galen on corresponding subjects. From there, it appears that, once more, Galen remained the absolute reference, Avicenna limiting himself to repeat in other words and in another language the anatomical descriptions made by his distinguished predecessor. The heart contained three chambers and was flanked by two accessory parts (atria), and comprised a bone, albeit only in large animals like bull or elephant. Avicenna sometimes quotes Herophilos, as in the chapter on liver where he insists that his definition specifically relates to human liver, whereas he strongly opposes the theory of his archaic predecessor about the digestive functions of the mesenteric veins (ibidem, pp. 708-714). In this respect, we now know that Herophilos was right.

Regarding genital organs, Avicenna's descriptions were more elaborate. As his predecessors, he uses more or less the same terms for males

and females: *testis* and *female testis*, male and *female spermatic vessels*, male and *female sperm*. Yet the penis contains three channels: for urine, sperm and *wadī* (prostatic humour?), and the (male) vessel (ductus deferens) is separated from testis by an *afīdhūmis* (page 749), a transliteration of epididymis. Nevertheless, the word *wadī* could also apply to prostate because Avicenna uses it to locate the tickling sensation felt by men immediately before ejaculation.

On the nervous system, Avicenna's descriptions are more precise than those of Galen, especially when he writes about the vermis (*dūda*) of the cerebellum and its macroscopic relations to mesencephalon (pp. 654-658).

In their article on the School of Toledo (see below), Arráez-Aybar et al. (2015) have analysed several anatomical mistakes made by Avicenna himself (*processus coracoideus* attributed to *acromion* for example) or by his translator(s) (*os femoris* for *os coxae*, or *cartilago epiglottale* [sic] for *processus xiphoideus*). The term *sutura sagittalis* often attributed to Avicenna was probably coined by his translator Gerard (the Second Gerard of Cremona, see above) with the following explanation: "because it stays as arrow in bow".

THE INFANCY OF SCHOLASTIC ANATOMY

The turn of the first millennium marked the apogee of the Arabic and Greek languages as the international vehicles for anatomical sciences from the Middle East to Western Europe. Galen in Greek

and Avicenna in Arabic had become the masters, whose ideas every early medico-scientific writer around the Mediterranean and Caspian Seas commented upon and analysed, yet never criticised. Those few exceptions who did criticise them, Rhazes for example, only did so from a philosophical view-point. From the 6th century on, several Christian establishments, following the example of the monastery at Monte Cassino, began to read, translate, analyse and teach the texts of Celsius and Galen and to establish infirmaries. These early institutions developed into real "Medical Schools" like that at Salerno during the 8th and 9th centuries. Nevertheless, these Schools, whatever their contemporary fame, did not seem to play an important role in anatomy nor in terminology.

Another important contribution occurred in Sicily, which, after having been under Muslim control from 876 to 1060, had become a Norman Kingdom. The Norman Kingdom of Sicily was administered in three languages [namely Greek, Arabic and Latin, Fig. 11], which made it an ideal place for translations. Consequently, numerous manuscripts were translated in Latin either from Greek or from Arabic. So were some writings of Galen and Hunayn that were translated by Accursius of Pitoja. It is also possible that Gerard of Sabloneta worked in Sicily before going to Toledo (see below).

The Toledo School of Translators

This remarkable institution was created around 1130 at the library of the Cathedral of Toledo. Then under Archbishop and Chancellor of Castile Ray-

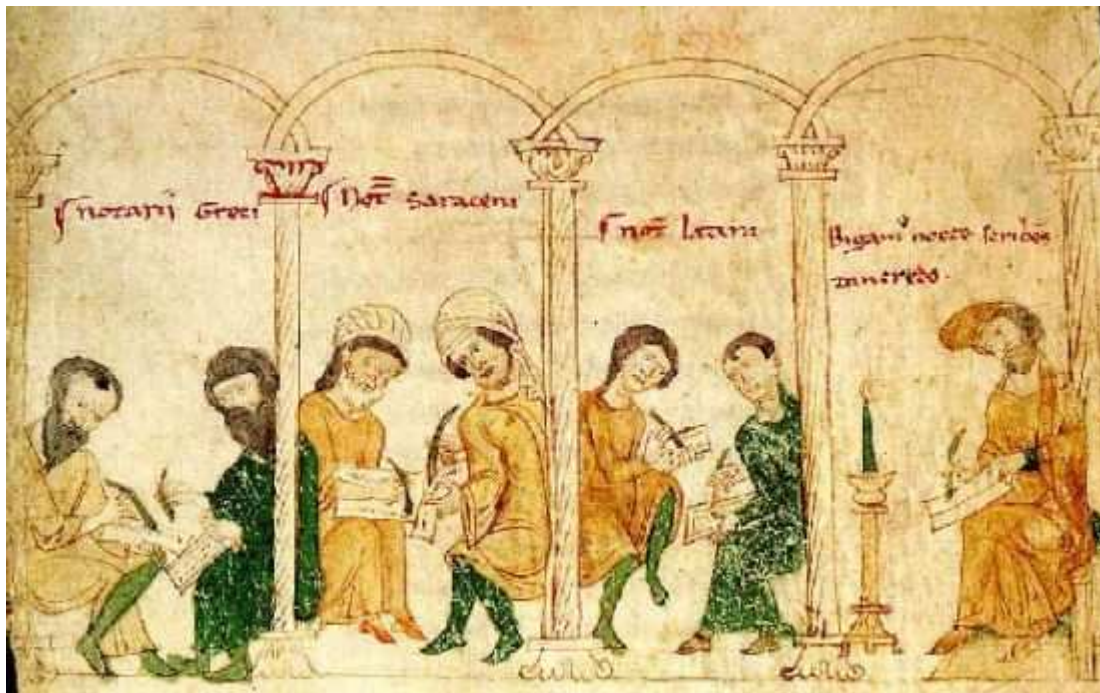


Fig. 11. Scribes (Notarii) at work in the various languages of Sicily (see captions from left to right: Greek, Arabic [Saraceni], Latin and accounting. Kingdom of Sicily from 1196. Liber ad honorem Augusti sive de rebus Siculis, Petrus de Ebulo. © Public Domain.



Fig. 12. Alfonso X the Wise elaborating his "Las Siete Partidas" or Law Code in Seven Parts. Miniature from the "Cantigas de Santa Maria", 13th century. © Public Domain.

mond de Sauvetât (a Benedictine monk following Benedict, the Saint of Monte Cassino), it gathered refugees from al-Andalus who had fled the absorption of Seville by dynasties of "fanatical Almoravids and Almohads". They included "Mozarabic" (Arabic-speaking Christians) "Toledans, Jewish scholars, Madrasah teachers and monks from the Order of Cluny" (Arráez-Aybar, 2015).

The School of Toledo succeeded a period of Jewish scholarship, which still flourished under Moslem rule, and during which (11th century) some translations were already undertaken. Since 1085, the scholars could pursue their activities under Christian rule. From 1130, these were considerably expanded. The methodology was depending on spoken translation. An Arabic-speaking reader read Arabic texts and loudly spoke them in Latin, whereas a cleric of the Cathedral wrote them down. The reader usually was a member of the Toledo Jewish community, wherein Arabic was commonly spoken but written with Hebrew characters. Under Alfonso X the Wise (Fig. 12) still, twelve translators were engaged in the programme, five of them being Jewish (Bernart, 2008).

Numerous translators of the Toledo School became famous. In the number of them, two were named Gerard. Though Gerard of Cremona (the first Gerard) was long considered to be the translator of Avicenna, it now appears that Gerard of Sabioneta (the second Gerard) performed the work (Ostler, 2009, p. 211). The importance of Toledo as a centre of translation during the 12th and 13th cen-

turies was sometimes questioned (D'Alverny, 1991) but it remains indisputable that the city remained a key node in the network of translation schools that had emerged at the time in Western Europe.

Early Medical Schools and Universities paving the way to anatomical Renaissance

Constantine the African and the Salerno School

Whereas the 11th-century Jewish scholars undertook their first translations in Toledo, the Medical School of Salerno (see above: "From monastic to scholastic medicine") had grown into such a famous healing place that remote bishops, i.e. Adalbero from Verdun, journeyed to it in order to be treated. Meanwhile, Constantine the African († before 1098), a converted Christian and Berber polymath who spent the first part of his life in North Africa, Ethiopia and India, had settled in Salerno in 1077 (Brachtel, 2005, pp 52-56). He brought with him from Tunis several medical manuscripts in Arabic, including a book on pulse and urine, and a medical guide for travellers (Fig. 13.)

He did not know of Avicenna, who would remain unknown in Tunis and in South Italy for another century. Nevertheless, he had the opportunity to read more Arabic medical texts, which had reached Salerno from Greek-speaking Sicily, then under Islamic rule. He was soon able to translate in Latin and to compile under his name various manuscripts. They formed the base for his two main opera: a book for wanderers, the "*Viaticum Peregri-*



Fig. 13. Constantine practising medicine at Salerno: a female patient showing a specimen of urine. © Public Domain.

nantis" and the "*Pantegni*" a large medical treatise in two parts, *Theorica* and *Practica* (Sudhoff, 1929). Altogether, Constantine's books give us an idea of the evolution of Greek and Byzantine medicines before Avicenna: Aristotle and Galen are the Masters, whose observations and descriptions remain hardly contested and piously preserved. Ironically, Constantine's fame remained considerable until the Renaissance, although he contented himself to transfer into Latin what he had read in an Arabic treatise written before 977 by Ibn al-Abbās al-Mağūsī, which gave the "*Pantegni Practica*". Moreover, a physician from Kairouan, Ibn Al-Jazzār's Zād Al-Musāfir, was the real author of "his" *Viaticum Peregrinantis*. Had he lived now, Constantine would be considered a plagiarist. Yet, he could also be considered as a re-discoverer of previous Greek tradition that eventually reached the Latin World through his adaptations from Arabic authors (Brachtel, 2005, pp. 64-69).

At least, he had the merit to transliterate into Latin some of the Arabic terms that had appeared in anatomical books for several centuries, like *siphac* or *syphac* for omentum, *mirac* or *myrach* for abdominal wall, or *zirbus* for network. He was responsible of the consolidation of *vena cephalica* and *vena basilica* in the Latin nomenclature. Con-

trary to what many people still believe, *basilica* comes from "wa-huwa *al-bāsiliq*", the Arabic translation for Galen's "great inner vein of the arm", and *cephalica* from "*al-kīfāl*", an Arabic transliteration of the Greek κεφαλή/head. Both terms were coined in Arabic by Hunayn who gave them the meaning that they still have (in early Middle Age Greek medicine, *Vena Basilica* could also apply to aorta, meaning "royal vessel", while *Vena Cephalica* was supposed to come from head [Oesterle, 1980].) Constantine endorsed Hunayn's expressions in Latin.

Similarly, if we follow the evolution of the term *meninx* (μήνινξ) introduced by Rufus (pachy- and leptomeninx, see above: *Rufus of Ephesus or Rufos*), we observe that it was used by Galen in a slightly different form: σκλῆρᾱ μήνινξ / sklêra mêninx and λεπτῆ μήνινξ / leptê mêninx. However, according to Strohmaier (1994), the pre-islamic poets used the Arabic term *umm ad-dimāg* (mother of brain) to designate the "visible" meninx, so Isa ibn Yahya al-Masihi, Galen's Persian translator, distinguished in Arabic between al-umm *al-ġāfiya* (*hard mother*) and al-umm *ar-raqīka* (*soft* for common people but *prudent* mother for literate ethicists). Hubaysh used *ġiṣā'an* / membranes as a general term to designate the meninges but he kept the Arabic *umm* / mother to characterise them, so did Avicenna. His translator, Gerard, used the Latin term *panniculus* to translate Avicenna's *membranes*. Meanwhile, Constantine had translated into Latin Isa ibn Yahya al-Masihi "*umm/mother*" and his fancy translations, *dura mater* and *pia mater* (he there followed the religious Liber Pantegni <pious> sense rather than the more ordinary <soft> meaning) became predominant.

An unintended contribution of Constantine to anatomical terminology is the term *nucha*. Still according to Strohmaier, Hunayn's school had correctly translated the Greek *nōtiaios myelos* (dorsal marrow) into the Arabic "*nuhā*". Constantine makes it clear in his manuscript that he writes a transcription from the Arabic: "lingua arabica vocatur *nucha*". He could not guess that his newly-coined Latin word *nucha* would become confused with the Arabic *nuqra* / neck four centuries later. Constantine also introduces in Latin the adjective "*sophena*" to qualify the main subcutaneous vein of the medial side of the leg, which Hunayn's school had called "*safin*". He attempts to explain that the word has a Greek origin, whereas it was an old Arabic name deriving itself from a Hebrew word meaning "hidden".

Amongst the numerous scholars who succeeded Constantine, two of the most famous were "Magistri" Maurus (about 1130-1214) and Urso di Salerno, also called Urso di Calabria, (about 1130-1225). Constantine had translated in Latin the book "*De urinis*" written in Arabic at the beginning of the 10th century by a Jewish physician Abu Ya'qub Ishaq ibn Suleiman (see above). Comment-

ing and adapting this translation, Maurus di Salerno wrote a new book named "*Regulae urinarum*" which became "classical" and quickly superseded Constantine's work. Numerous copies were disseminated around Europe but especially in France and Italy, where one may say that it was vulgarised among the medical practitioners (Moulinier-Brogi, 2010).

In his *Regulae Urinarum*, Maurus, who hardly understood Greek, follows Ishaq ibn Suleiman and Constantine, in using *siphac* – "*panniculus ausungiae qui dicitur siphac*" – for omentum majus but he adds that this equates with "*epigasunta hymenon*" or fatty membrane. He describes the passage of blood from the liver to the *vena concave*, then over the heart to the *adhortum* (aorta?). He also states "that the Arabic *meri* refers only to the *os stomachi* (gastric mouth) and not to the entire *ysophagus*", meaning that *meri* corresponds to the modern cardia. Similarly, "he [prefers] *ysmon* to *isthmus*, and *oscheon* to *oxeum* or scrotum." He "used "*ypochondria superiora*" to describe the cavities above the diaphragm" (Saffron, 1972, p. 14.) His Latin terminology thus mainly derived from approximate Greek words and he remained a faithful follower of Galen.

Urso succeeded Maurus in about 1200 as leader of the Salertinan medical community (ibidem, p. 13). His excellent teaching attracted many scholars to Salerno where he was the main author of the teaching aids "*Salertinan Questions*" (Maurus had contributed with only 2 of the 12 questions). He was more a practitioner than a scholar. Although his writings remained in favour until the 16th century in many European Universities, his contribution to anatomical terminologies was not noticeable.

Mondino de' Liuzzi

Mondino ("little Raimondo") was born around 1270 in Bologna, when the Medical School of Salerno had already begun to decline. Coming from a family of pharmacists, he studied medicine at the

University of his home-town (according to its website <www.unibo.it>, the oldest University of the Western World founded in 1088), from which he seems to have graduated in 1290 or 1291 (Giorgi, 2004). During his medical cursus, he was deeply impressed by one of his professors, Taddeo Alderotti, who taught him "the Aristotelian harmony between theory and practice" and introduced him "into the academic study of the Greek and Arabic authors that were translated during the 12th and 13th centuries". He died in 1326 (Fig. 14).

After a few years of further studies and medical practice, he was exiled for political reasons and he could only return in 1302 to Bologna after his family had paid a large financial compensation to the Commune. He rejoined with his uncle Liuzzo (Liucius) who was, like himself, a *medicus* and a *lector* at the University.

Yet the nephew, while studying under Alderotti, had become deeply interested in anatomy. He probably began by participating in some forensic autopsies, as these were performed by Arabian then by European physicians since the 10th century. However, after having been made a Professor "*ad legendum ordinarie et extraordinarie*" of Anatomy in 1306, Mondino performed the first "public" didactic dissection of a human cadaver in 1315. In 1316, he published what historians consider to be the first manual of dissection in the world: *Anothomia Corporis Humani*. Rufus of Ephesus had already written, 1100 years before, his "*Περὶ ὀνομασίας τῶν τοῦ ἀνθρώπου μορίων*" (see *Rufus of Ephesus or Rufos*) which also was devoted to dissection. Both books had to do exclusively with anatomy. It is true that Mondino also gave a few clinical examples but, like Rufos, his main purpose was to teach human anatomy by means of dissecting bodies. However, there was a great difference between the two writings: Rufus exposed the pieces of a freshly killed monkey while Mondino opened a cadaver, probably that of a convicted female criminal (Wilson, 1987, pp. 63-69). Whereas Rufos began his description with head, Mondino



Fig. 14. Mondino's original gravestone: the tomb of a teacher.

had to proceed first with abdomen in order to be able to remove as quickly as possible the quickly putrefying alimentary tract. Nevertheless, excepted for the sequence of chapters, both dissection manuals are comparable. In addition to his *Anothomia*, Mondino wrote several books on surgery and medicine, and comments on Hippocrates and Galen. None of these works were printed.

Regarding terminology, the *Anothomia* and the other extant texts of Mondino were in line with Constantine. The Latin texts included the same Arabic words as those used by Constantinus: *siphac*, *zirbus* and *mirac*. Nevertheless, the first printed edition of the *Anothomia* (Mondino, 1478) also used Latin specific terms, as *mediastinum*, *mesenterium* and *monoculus* (caecum). The old term *stomachus* of Celsus predominated over the more general *ventriculus*, which remained as a synonym. The lung still was unique and accommodated the heart. Like the second Gerardus (see above "The Toledo School of Translators"), Mondino used *paniculus*, or *panniculus*, for membranes, speaking for instance of *paniculus pectoris*, *paniculus mediastini* and *paniculus "dyafragmaticus"* to designate pleurae, a term that he also employed. He named (*h*)*ostiola* (small doors) the valvulae semilunares. He called *furcula pectoris* (chest fork "because it is bifurcated") the sternum, *fauces* (narrow passage) the throat, and *pomus granatus* (pomegranate) the grainy relief of the processus xiphoideus that is palpable under the skin and that "guards the mouth of the stomach". Contrary to Maurus (see above "Constantine the African and the Salerno School"), Mondino called "*meri*" the whole oesophagus, the heading of the 35th chapter of *Anothomia* being "*De anothomia meri et trachee arterie*" and dealing with topography and consistency of the two neck "*tubae/tubes*" in relation with their different contents. He named and described the "*epiglotis*" as indirectly connected to the brain over heart and responsible for voice-emitting, so correcting one of the errors made by Avicenna or his translators (Arráez-Aybar, 2015), whereas he still ignored the *larynx* of Rufus. Anyway, he wrote that the "*epiglotis*" contained three cartilages: first the *clipeus* or shield outside, second a "nameless cartilage" that "performs anything that the first one cannot do: refracting and reverberating sounds, and closing the passage from the *meri* during swallowing", and thirdly the *cartilago "ci(y) mbalaris"* – in form of navelwort, a plant whose split leaves resemble a navel – that could correspond to the glottis. He also rightly described the cervix uteri as having the form of a "tench's snout", which remained in French as the old eponym "museau de tanche" for uterine neck (Crivellato, 2006).

Mondino was unable to discard the anatomical errors and fallacies that his predecessors, especially Galen, had seeded in the mind of physicians. His description of the heart fitted with that of Aristo-

tle: a three-ventricle organ, the middle one – "*ventriculus medius*" – corresponding to the septum. He had excuses for that, as contradicting the Great Masters of his time would have given rise to a public scandal committed by a respected University Professor who had already dared to inaugurate regular anatomy lectures based upon practical dissections of cadavers. He could not guess that the small dissection manual, *Anothomia*, that he had written for his students would become an anatomical best-seller for the next two centuries.

Apart from its anatomical accuracy, or inaccuracy (see above), what strikes us most while reading the *Anothomia* is the direct and practical language spoken by Mondino to address his readers. He used the 2nd person singular as if really speaking to a student. And as Rufus before, he took his readers' hand to lead them inside the human body, although not starting from the same structure. Yet, Mondino's handwritten dissection manual was originally devoid of illustrations (Gurunluoglu, 2013).

Illustrated anatomy textbooks: towards Vesalius

Whereas Mondino was a respected Professor of the University of Bologna, new medical, or better said surgical, non-academic experts in human

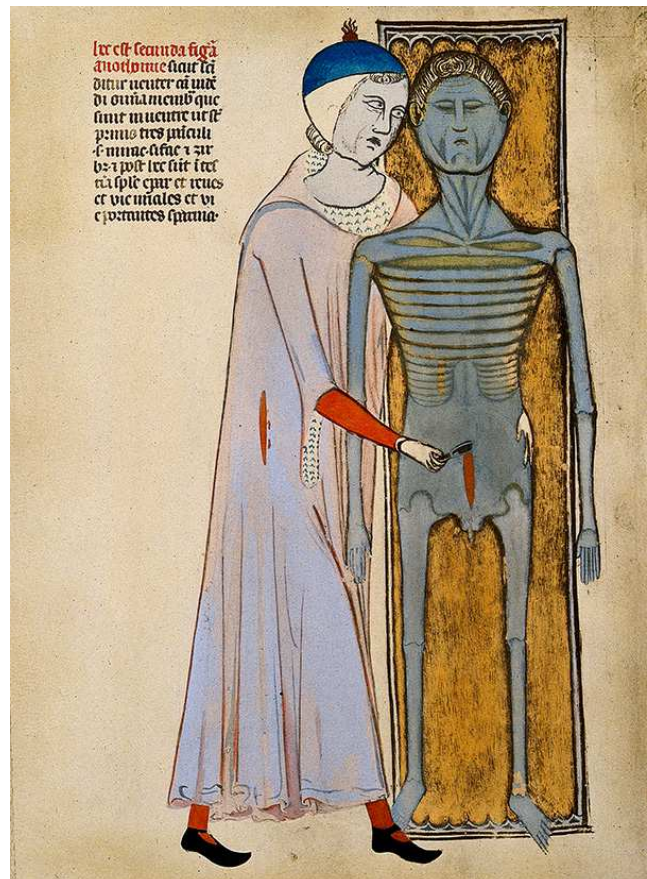


Fig. 15. Opening of abdomen, Ms 334/569 fig. 2 from Liber notabilium Philippi Septimi, francorum regis, a libris Galieni extractus von Guido da Vigevano, 1345. © Wellcome Library, London.

anatomy gained in importance. One of them was *Guido da Vigevano* (1280-1350, also called Guido da Papia), a former student of Mondino, who left Bologna to make a very successful career of surgical practitioner (and engineer) at the Courts first of the Emperor, then of the French King Philippe VI, and especially of his wife the Queen Jeanne of Burgundy. Without contact with the contemporary Universities of Paris and Montpellier, he wrote several books, including an "*Anothomia Designata*" that is based on Mondino's *Anothomia*. The manuscript initially comprised 24 figures but the last 6 of them have disappeared (Fig. 15). The remaining ones illustrated for the first time the anatomy following Mondino's (1478) method. Some of them exemplified real dissections, although the 10th figure, while attempting to prove that uterus does not reach the diaphragm, presents a non-realistic 7-cell organ which is in agreement with that described by Galen and Mondino. As Mondino, clinical anatomists of the 14th century were not yet ready to confront the ancient Masters.

Henri de Mondeville (1260-1320) also was a Frenchman who studied in Bologna under Theodoric Borgognoni, a precursor of Mondino. He became there a Master Surgeon. He was one of the early members of the group of *modernisti*, those active practitioners whose excellence was widely recognised. He later taught anatomy and surgery to apprentices in Paris and Montpellier and he was Surgeon of two Kings of France: Philip IV the Fair (1268-1314) and his eldest son Louis X the Stubborn (1289-1316).

Mondeville wrote in Latin a book, *Cyurgia* (Surgery), whose first part treats of Anatomy ("*de anathomia...*") in 12 chapters and was completed in 1312. He had the courage to openly contradict Aristotle on the anatomy of skull, which is said by the Master to be different in Women and Men but which, in reality, is similar "*ut patet in atrio Sancti Innocentis Parisiis ubi sunt centum milia craneorum*" [as appears in churchyard of the Saint Innocents in Paris where there are hundred thousands of skulls] (Pagel, 1892, p. 29). Writing about eye, he uses the terms *sclerotica* for sclera, *tunica aranea* for choroidea, *uvea*, *humor crystallinus*, *humor vitreus*, *humor albugineus*, *cornea*, already used in Salerno, and *retina*, which he probably found in Avicenna's

translations (*ibidem*, pp. 33-34). He states that there are 4 mandibles, two superior and two inferior ones, each of these *mandibulae* having a fleshy and an osseous part (*ibidem*, p. 36). He uses *spatula* instead of scapula and he names *humerus* the whole shoulder (*ibidem*, pp. 38-39), which is the original meaning of the word. He also describes heart as having a right and a left ventricles separated by a wall whose inferior part shows a "concovitas" named *ventriculus tertius*, vena "*mesarayca*" being a synonym for vena *mesenterica*. He uses the Germanic term *hancha* or *hanca* giving it the meaning of *coxa* (*ibidem*, p. 55), indicating that mediaeval Latin was strongly influenced by Northern languages.

Anyhow, the term has survived in Latin-derived languages like Italian and Portuguese (*anca*), or French (*hanche*). He names *pecten* or *os pectinis* the pelvis and *coxa* or *os coxae* the femur. He uses the term *cavilla* to name the region from which foot begins (*Regio talaris*).

However, what is important about *Cyurgia* is that it was illustrated. Mondeville inserted a few handmade vignettes in his manuscript. Originals are missing but 13 illustrations could be found in a French handwritten translation dating from 1314, thus before Henri's death (Vrebos, 2011). Moreover, 17 small vignettes (Fig. 16) were found in a Latin manuscript described by Sudhoff in 1908. However, Mondeville's anatomical miniatures were never printed but they were copied from the life-sized figures that he used for his teaching. They most probably are the first anatomical illustrations of human dissections in the Western world.



Fig. 16. Two vignettes from a French manuscript (1314) of the translation of Mondeville's original; they illustrate, rather than precisely describing, some anatomical preparations: on the left, isolated superficial veins, on the right, an écorché holding his dissected skin on a stick. Bibliothèque Nationale de France, Manuscrit 2030 Folio 9v and 10v, downloaded from <www.biusante.parisdescartes.fr/pare/06-02.htm>.

There is another interesting feature in *Cirurgia*. In his introduction, Henri de Mondeville writes a special chapter about "*Doctrina et ars sciendi computare per figuras algorismi / Science and art of calculating by means of digits*" because he has to teach his readers how to read the Arabic digits that he uses "*for the sake of briefness*" in the figures that he draws. In fact, he was "*so famous that a French and a Provençal translation were produced before his death*" (Clarke, 1931).

Jacopo Berengario da Carpi (1460-1530) was the last of the great "pre-Vesalian" anatomists (Merlini, 2003). He studied medicine in Bologna and taught anatomy and surgery in Padua. He seemed to have had a violent character that led him to several condemnations in Court but which also enabled him to severely criticise Mondino for his blind following of Herophilus and Galen about the *rete mirabile*. He so paved the way to Vesalius. Yet his main contribution to anatomy was the publication in 1530 (Vesalius still was a 16-year old art student at the University of Leuven) of an illustrated book of anatomy, the "*Isagogae*" (Carpi, 1530), which includes 24 woodcuts that depict various parts of the human body (a series of 6 on the muscles of ventral wall of trunk, 2 on uterus, 3 on heart, 2 on brain, 1 on spinal nerves, 1 on vertebrae and pelvis, 2 on veins of upper and 1 on the veins of lower limbs, 3 écorchés of a male, 2 complete skeletons and 1 figure on hand and foot skeleton). These figures were obviously carved from knowledge acquired through dissection, which is confirmed several times in the text by Carpi himself. And it is highly probable that he also carved them himself.

These were the developments that created the right conditions for the appearance of someone as original as Andreas Vesalius. That his contemporaries were not all that aware of how unique he was can be seen in the way that he had to struggle to persuade them that it was he, and not Galen nor even Avicenna nor Mondino, who had really explored and described the details of the human body. Needless to say, he was successful and became the instigator of the anatomical Renaissance, not to say Revolution. Yet this will be a different story.

FROM ANATOMICAL NOTHINGNESS TO TEXT-BOOKS

Anatomical terminologies have followed closely the development of languages. They diverged early from the vernacular of the butchers and soldiers, but remained attached for centuries to the dialects of the embalmers and soothsayers. As a consequence to the emergence of main languages (mainly Egyptian, Greek and Latin in the Western World), physicians had to use jargon to understand each other. Poets helped them to coin, then to write, their vocabulary, and philosophers to classify

it. By doing so, they enabled the first medical "scientists" – who were learning the human body without knowing that they were inventing anatomy – to establish growing lists of anatomical terms. Using phrases to describe anatomical entities, they progressively established first small catalogues of specific words, which later became longer and more elaborate.

The human body thus became an "objectivised" reality, which made it thinkable to "anatomise", or more openly said, to dissect it. The first dissectors within the Western World spoke Greek. Their influence on medical practice was immense, in spite of the fact that they were defamed and demonised during centuries (perhaps rightly if it is true that they performed vivisection on prisoners). Meanwhile, anatomical knowledge also progressed through the investigation of animal organisms. However, surgeons had greatly contributed, and the acme of "classical" anatomy also corresponded to the improvements of "classical" medicine and surgery marking the last two centuries.

Nil sub sole novum (Nothing new under the sun). Anatomy still enjoys the benefits of collaboration between physicians and surgeons, to whom physicists should be added because, without them, no progress could have been made beyond the range of our sense organs. Furthermore, biochemists, immunologists and molecular biologists are constantly opening new possibilities to further "objectivise" the human body. Will the mind also become an object?

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REFERENCES

- ADAMSON PB (1984) Anatomical and Pathological Terms in Akkadian – Part IV. *J R Asiatic Soc Gr Brit Irel*, 1: 3-18.
- ARRÁEZ-AYBAR LA, BUENO-LÓPEZ JL, RAIÓ N (2015) Toledo School of Translators and their influence on anatomical terminology. *Ann Anat*, 198: 21-33.
- ARRIAZA BT, DOUBRAVA M, STANDEN VG, HAAS H (2005) Differential mortuary treatment among the Andean Chinchorro Fishers: social inequalities or in situ regional cultural evolution? *Curr Anthropol*, 46(4): 662-671.
- ASHER-GREVE JM (1997) The Essential Body: Mesopotamian conceptions of the gendered body. *Gender &*

- History*, 9(3): 432-461.
- BARTHÉLÉMY-SAINT HILAIRE J (1883) Histoire des Animaux d'Aristote, traduction en français. Tome premier, Book III, Chapter III, §1-§8 and Book III, Chapters II, III and IV, consulted at <<http://remacle.org/bloodwolf/philosophes/Aristote/animaux3.htm#III>>
- BEEKES R (2009) Etymological dictionary of Greek. Vol 1, Leiden, Brill.
- BERNART H (2008) Toledo. In: "Jewish Virtual Library". Downloaded from: <www.jewishvirtuallibrary.org/jsource/judaica/ejud_0002_0020_0_19924.html>
- BLOMSTEDT P (2014) Imhotep and the discovery of cerebrospinal fluid. *Anat Res Int*, ID 256105, 2 pages, <http://dx.doi.org/10.1155/2014/256105>.
- BOUDON-MILLOT V (2012) Galien de Pergame: un médecin grec à Rome. 404 pages, Les Belles Lettres, Paris.
- BRACHTEL MM (2005) Ibn Al-Jazzār's Zād Al-Musāfir and Constantinus Africanus' Latin version *Viaticum Peregrinantis*: a comparative study. *Master Thesis, Kulliyah of Human Sciences*, Int Islam Univ Malaysia.
- BREASTED JH (1930) The Edwin Smith Surgical Papyrus, published in facsimile and hieroglyphic transliteration with translation and commentary in two volumes. *University of Chicago Oriental Institute publications*, 3-4, University of Chicago Press.
- BRENNER E (2014) Human body preservation – old and new techniques. *J Anat*, 224: 316-344.
- BUJALKOVÁ MÁRIA (2011) Rufus of Ephesus and his contribution to the development of anatomical nomenclature. *Acta med-hist Adriat*, 9(1): 89-100.
- CAPPARONI P (1923) "Magistri Salertani Nondum Cogniti", A Contribution to the History of the Medical School of Salerno. *Res Stud in Med Hist No. 2*, John Bales, Sons & Danielson Ltd, London.
- CARPENTER R (1957) Linear B. *Phoenix*, 11(2): 47-62.
- CARPI IACOBUS [BERENGARIO DA] (1530) *Isagogae breves et exactissimae in Anatomiam Humani Corporis*. Henricus Sybold, Strasburg (Argentorati).
- CAVALCANTI DE A MARTINS A, MARTINS C (2013) History of liver anatomy: Mesopotamian liver clay models. *HPB*, 15 : 322 - 323 ; <DOI: 10.1111/j.1477-2574.2012.00555.x>.
- CHABOT JB (1912) Syriac Language and Literature. In: *The Catholic Encyclopedia*. Robert Appleton Company, New York. Downloaded from: <www.newadvent.org/cathen/14408a.htm>.
- CLARKE CC (1931) Henri de Mondeville. *Yale J Biol Med*, 3(6): 459-481.
- COOPER GM (2007) Ishāq ibn Ḥunayn: Abū Ya'qūb Ishāq ibn Ḥunayn ibn Ishāq al-'Ibādī. In: HOCKEY T et al. (eds.) "The Biographical Encyclopedia of Astronomers, Springer Reference". Springer, New York. Downloaded from: <http://islamsci.mcgill.ca/RASI/BEA/Ishaq_ibn_Hunain_BEA.pdf>
- CRIVELLATO E, RIBATTI D (2006) Mondino de' Liuzzi and His *Anothomia*: A milestone in the development of modern anatomy. *Clin Anat*, 19: 581-587.
- CRIVELLATO E, RIBATTI D (2007) A Portrait of Aristotle as an Anatomist. *Clin Anat*, 20: 477-485.
- CRUBÉZY E, BRUZEK J, GUILAINE J, CUNHA E, ROUGÉ D, JELINEK J (2001) The antiquity of cranial surgery in Europe and in the Mediterranean basin. *C R Acad Sci Paris, Sciences de la Terre et des planètes*, 332: 417-423.
- D'ALVERNY MT (1991) Translations and Translators. In: Benson RL, Constable G (ed.). "Renaissance and Renewal in the Twelfth Century". Medieval Academy Reprints for Teaching 26, pages 421-462. University of Toronto Press.
- DAREMBERG C, RUELLE C (1879) Œuvres de Rufus d'Ephèse: texte collationné sur les manuscrits. *Imprimerie Nationale, Paris*, 677 pages. Downloaded from: <<http://gallica.bnf.fr/ark:/12148/bpt6k28924s/f5.item>>.
- DAREMBERG CV (1854) Œuvres anatomiques, physiologiques et médicales de Galien traduites sur les textes imprimés et manuscrits, accompagnées de sommaires, de notes, de planches et d'une table des matières, précédées d'une introduction ou étude biographique, littéraire et scientifique sur Galien. *Tome Premier*: pages 536-539, J.B. Baillière, Paris. Downloaded from <www.bium.univ-paris5.fr/histmed/medica/cote?34857x01>
- DE KONING P (1903) Trois traités d'anatomie arabes par Muhammed ibn Zakariā Al-Razī, 'Ali ibn Al-'Abbās et 'Ali ibn Sīnā. Librairie et Imprimerie ci-devant E.J. Brill, Leide. Downloaded from: <<https://archive.org/details/troistraitsdan00rzabuoft>>.
- DOTY RW (2007) Alkmaion's discovery that brain creates mind: a revolution in human knowledge comparable to that of Copernicus and of Darwin. *Neuroscience*, 147: 561-568.
- ERHARD H (1941) Alkmaion, der erste Experimentalbiologe. *Sudhoffs Arch für Geschichte Medizin und Naturwissenschaften*, 34(1): 77-89. Downloaded from: www.jstor.org/stable/20774097.
- FALLER A (1976) Die Fachwörter der Anatomie, Histologie und Embryologie. 29. Auflage, *JF Bergmann Verlag*, München.
- FICHTNER G (2015) Corpus Galenicum, Bibliographie der galenischen und pseudogalenischen Werke. *Berlin-Brandenburgische Akademie der Wissenschaften*, Ausgabe 2015/02. Downloaded from: <<http://cmg.bbaw.de/online-publications/hippokrates-und-galenbibliographie-fichtner/>>.
- FONAHN A (1922) Arabic and Latin Anatomical Terminologies, chiefly from the Middle Ages. 174 pages, In Commission by Jakob Dybwad, Kristiana.
- FUCHS R (1894) De Erasistrato Capita Selecta. *Hermes Zeitschr Class Philolog*, 29(2): 171-203.
- FUJITA H, ASAKURA K (2007) Care for bone fractures during the Jomon period: evidence from the pathological condition of fractures. *Jpn J Health Behav Sci*, 22: 96-105.
- GHALIOUNGUI P (1969) Early specialization in ancient Egyptian Medicine and its possible relation to an archetypal image of the human organism. *Medical History*, 13(04): 383-386.
- GIORGI P (2004) Biografia di Mondino de' Liuzzi da Bologna. *CIS, Department of Philosophy*, University of

- Bologna, 12'350 words. Downloaded from: <<http://cis.alma.unibo.it/Mondino/biographia.html#fnB31>>.
- Goss CM (1961) On anatomy of veins and arteries by Galen of Pergamos. *Anat Rec*, 141(4): 355-366.
- Goss CM (1962) On the anatomy of the uterus. *Anat Rec*, 144: 77-83.
- Goss CM (1965) The precision of Galen's anatomical descriptions compared with Galenism. *Anat Rec*, 152: 376-380.
- Goss CM (1966) On anatomy of nerves by Galen of Pergamon. *Am J Anat*, 118(2): 327-335.
- Goss CM (1968) On movement of muscles by Galen of Pergamon. *Am J Anat*, 123(1): 1-26.
- GRUNER OC (1930) "A treatise of the Canon of Medicine of Avicenna", incorporating a translation of the first book. Luzac & Co., London.
- GURUNLUOGLU R, GURUNLUOGLU A, WILLIAMS SA, CAVDAR S (2013) The history and illustration of anatomy in the Middle Ages. *J Med Biography*, 21(4): 219-229.
- GUTAS D (2011) Avicenna ii. Biography. In: "Encyclopaedia Iranica", Columbia University. Consulted in May/June 2015 at: <www.iranicaonline.org/articles/avicenna-ii>.
- HAIMOV-KOCHMAN R, SCIAKY-TAMIR Y, HURWITZ A (2005) Reproduction concepts and practices in ancient Egypt mirrored by modern medicine. *J Obstetr Gynecol*, 123: 3-8.
- HASSAN FA (1988) The Predynastic of Egypt. *J World Prehistory*, 2(2): 135-185.
- HECKETSWEILER P (2010) Histoire de la Médecine. Ellipses, Paris
- HERODOTUS' Histories. Translation in English by MACAULEY GC (1890), Volume I, Book II Euterpes: #84, McMillan and Co Publishers, London & New York. Downloaded from <http://wps.pearsoncustom.com/wps/media/objects/2427/2486120/chap_assets/bookshelf/herodotus.pdf>
- HOLMA H (1911) *Die Namen der Körperteile im Assyrisch-Babylonischen - Eine lexikalisch-etymologische Studie*. Druck von August Pries im Leipzig.
- HUFMANN C (2013) Alcmaeon. In: Zalta EN (ed). *The Stanford Encyclopedia of Philosophy*. Downloaded from <<http://plato.stanford.edu/encyclopedia/entries/alcmaeon/>>.
- JAN WILSON E, DINKHA S (2010) Hunain ibn Ishaq's "Questions on Medicine for Students", Transcriptions and translation of the oldest extant Syriac version (Vat. Syr. 192). Studi e Testi 459. *Biblioteca Apostolica Vaticana*, Città del Vaticano.
- JASTROW M (1913) The Medicine of the Babylonians and Assyrians. *Proc Roy Soc (Sect Hist Med)*, 7: 109-176.
- JONES J, HIGHAM TFG, OLDFIELD R, O'CONNOR TP, BUCKLEY SA (2014) Evidence for Prehistoric origins of Egyptian mummification in late Neolithic burials. *PLOS ONE*, 9(8): e103608, doi:10.1371/journal.pone.0103608.
- JONES WHS (1868) Plato's references to Hippocrates, in "Hippocrates Collected Works I": Cambridge Harvard University Press. Downloaded from: <<http://daedalus.umkc.edu/hippocrates/HippocratesLoeb1/page.27.a.php>>.
- KINNIER WILSON JV, REYNOLDS EH (1990) Translation and analysis of a cuneiform text forming part of a Babylonian treatise on epilepsy. *Med History*, 34: 185-198.
- KLINE AS (2009) Homer: The Iliad (English poetry translation). Downloaded from: <www.poetryintranslation.com/klineasiliad.htm>.
- LANG P (2013) Medicine and Society in Ptolemaic Egypt. 318 pages, Brill, Leiden-Boston.
- LANGSLOW DR (2000) Medical Latin in the Roman Empire. Oxford University Press.
- LAZARIS S (1999) Deux textes grecs hippocratiques pseudo-hippocratiques: remarques et considérations, "IXe Colloque International Hippocratique, Pisa". In: *Asp Terapia Corpus Hippocrat*, pp 479-484.
- LINDSAY WM (1911) Isidore of Seville: The Etymologies (or Origins). Oxford University Press. Downloaded from: <<http://penelope.uchicago.edu/Thayer/E/Roman/Texts/Isidore/home.html>>
- LITTRÉ E (1841) Œuvres complètes d'Hippocrate, traduction nouvelle avec le texte grec en regard. Tome 9, §4-§12_Chez J.B. Baillièrè, Libraire de l'Académie royale de Médecine. Consulted at <<http://remacle.org/bloodwolf/erudits/Hippocrate/coeur.htm>>.
- LITTRÉ E (1843) Introduction et commentaires médicaux sur tous les livres hippocratiques. Introduction, page vii. Société Encyclopédique des Sciences Médicales, Bruxelles. Consulted at <<http://remacle.org/bloodwolf/pseudohippocrates/f/erudits/Hippocrate/intro.htm#INT>>.
- LITTRÉ E (1849) Œuvres complètes d'Hippocrate, traduction nouvelle avec le texte grec en regard. Tome 6, §4. Chez J.B. Baillièrè, Libraire de l'Académie royale de Médecine. Consulted at <<http://remacle.org/bloodwolf/erudits/Hippocrate/nature.htm>>.
- LITTRÉ E (1853) Œuvres complètes d'Hippocrate, traduction nouvelle avec le texte grec en regard. Tome 8, page 538. Chez J.B. Baillièrè, Libraire de l'Académie royale de Médecine. Consulted at <<http://remacle.org/bloodwolf/erudits/Hippocrate/anatomie.htm#I>>
- LONIE IM (1964) Erasistratus, the Eristrateans, and Aristotle. *Bull Hist Med*, 38(1): 426-443.
- LONIE IM (1973) The paradoxical text on the heart, Part I. *Med Hist* 17(1): 1-15.
- LOUKAS M, TUBBS RS, LOUIS RG JR, PINYARD J, VAID S, CURRY B (2007) The cardiovascular system in the pre-Hippocratic era. *Int J Cardiol*, 120: 145-149.
- MARQUET PA, SANTORO CM, LATORRE C, STANDEN VG, ABADES S, RIVADENEIRA MM, ARRIAZA B, HOCHBERG ME (2012) Emergence of Social complexity among coastal hunter-gatherers in the Acatama Desert of northern Chile. *PNAS*, 109 (vol 37): 14754-14760.
- MERLINI L, TOMBA P, VIGANO A (2003) Berengario da Carpi, a pioneer in anatomy, rediscovered by Vittorio Putti. *Neuromuscul Disord*, 13: 421-425.
- MEYERHOF M, SCHACHT J (1931) Galen über die medizinischen Namen, Arabisch und Deutsch herausgegeben. Abhandl Preuss Akad Wissensch Phil-Histor Klasse, 3: 1-41.

- MONDINO DE' LUZZI (1478) Anothomia Mundini. In: Wick-ersthaimer E (1926) "*Anatomies de Mundino dei Luzzi et de Guido de Vigevano*". Slatkine Reprints, Genève 1977.
- MOXHAM BJ, PLAISANT O (2014) The History of Teaching Gross Anatomy – How we got to where we are. *Eur J Anat*, 18(3): 219-244.
- MOULINIER-BROGI L (2010) La fortune du *De Vrinis* de Maurus de Salerne et ses *volgarizzamenti* inédits. *Mélang Ecole Franç Rome*, 122(2): 261-278.
- NASSER M, TIBI A (2007) Ibn Hindu and the Science of Medicine. *J R Soc Med*, 100(1): 55-56.
- NUNN J (1999) Studies in Ancient Egyptian Anatomical Terminology by James H. Walker. *J Egypt Archaeol*, 85: 257-259.
- NUTTON V (2013) Byzantine medicine, genres, and the ravages of time. In: Zipster B "*Medical books in the Byzantine world*". Eikasmos Quaderni Bolognesi di Filologia Classica, Studi Online, 2: 7-18.
- O'CONNOR JJ, ROBERTSON EF (1999) Abu Ali al-Husain ibn Abdallah ibn Sina (Avicenna). In: "*Biographies, MacTutor History of Mathematics Archive*". University of St Andrews. Downloaded from: <<http://www-history.mcs.st-and.ac.uk/Biographies/Avicenna.html>>.
- OESTERLE HJ (1980) Vena basilica – Vena cephalica: Die Genese einer unverstandenen Terminologie. *Sudhoffs Arch*, 64(4): 385-390. Downloaded from JSTOR at: <www.jstor.org/stable/20776682>.
- OSTLER N (2009) *Ad Infinitum - A biography of Latin*. Walker & Co., New York.
- PAGEL JL (1892) *Die Chirurgie des Heinrich von Mondeville (Hermondaville) nach Berliner, Erfurter und Pariser Codices zum ersten Mal herausgegeben*. Verlag von August Hirschwald, Berlin.
- PARRY R (2002) Empedocles. In: Zalta EN (ed). *The Stanford Encyclopedia of Philosophy*. Downloaded from <<http://plato.stanford.edu/archives/fall2012/entries/empedocles/>>
- RAWLINSON HC (1851) Memoir on the Babylonian and Assyrian inscriptions. *J Roy Asiatic Soc Gr Brit Irel*: 14 (Part 1): 1-16.
- RICHTER-BERNBURG L (2003) Hāwī, Al (i.e., *al-Ketābal-hāwīfī'l-ṭebb* "Comprehensive book on medicine"). In: "*Encyclopaedia Iranica*", Columbia University, consulted in May/June 2015 at: <www.iranicaonline.org/articles/hawi-medical-book>
- Rosse C, Mejino Jr JLV (2003) A reference ontology for biomedical informatics: the foundational model of anatomy. *J Med Informatics*, 36: 478-500.
- SAFFRON MH (1972) Maurus of Salerno: Twelfth-century "Optimus Physicus", with his commentary on the prognostics of Hippocrates. *Trans Amer Philosoph Soc*, 62 (1): 1-104. Downloaded from JSTOR at: <www.jstor.org/stable/1006058>.
- SALLAM HN (2002) L'ancienne école de médecine d'Alexandrie. *Gynécol Obstét Fertil*, 30: 3-10.
- SANAGUSTIN F (2014) Traduction annotée de "*Le livre des clés pour la médecine ou la méthode à l'usage des étudiants*", par Abū al-Faraġ Ali ibn al Husayn Ibn Hindū. 5-172, Librairie Orientaliste Paul Geuthner, 75006 Paris.
- SAVAGE-SMITH E (2014) Hunayn ibn Ishāq, al-'Ibādī. In: *Bio-Bibliographies, Islamic Medical Manuscripts at the National Library of Medicine*. Downloaded from: <www.nlm.nih.gov/hmd/arabic/bioH.html#hubaysh>.
- SEZGIN F (2010) Collection of the Institute for the History of Arabo-Islamic Sciences. Frankfurt: Vol 4, Chapter 7: 1-34. Downloaded from: <<http://ibttm.org/ENG/museum/collection/4-1.pdf>>.
- SHAW JP (1992) A history of the enumeration of the cranial nerves by European and British Anatomists from Time of Galen to 1895, with comments on nomenclature. *Clin Anat*, 5: 466-484.
- SOUAYAH N, GREENSTEIN JI (2005) Insights into neurologic localization by Rhazes, a medieval Islamic physician. *Neurology*, 65: 125-128.
- SPOOR F, LEAKEY MG, GATHOGO PN, BROWN FH, ANTÓN SC, MCDUGALL I, KIARIE C, MANTHI FK, LEAKEY LN (2007) Implications of new early *Homo* fossils from Ileret, east of Lake Turkana, Kenya. *Nature*, 448: 688-691.
- STIEFEL M, SHANER A, SCHAEFER SD (2006) The Edwin Smith Papyrus: The birth of analytical thinking in Medicine and Otorhinolaryngology. *Laryngoscope*, 116: 182-188.
- STROHMAIER G (1994) Constantine's pseudo-classical terminology and its survival. In: Burnett C, Jacquart D (ed.). "*Constantine The African and Ali Ibn al-Abbās al-Maġūsī – The Pantegni and Related Texts*", pp. 90-98, E.J. Brill, Leiden-New York-Köln.
- SUDHOFF K (1908) Ein Beitrag zur Geschichte der Anatomie im Mittelalter. Tafel XXIV, Verlag J. A. Barth, Leipzig. Nachdruck durch Georg Olms Verlagsbuchhandlung, Hildesheim (Germany) 1964.
- SUDHOFF K (1929) Salerno, ein mittelalterliche Heil- und Lehrstelle am Tyrrhenischen Meere (1921). *Arch Geschichte Medizin*, 21, H 1: 43-62. Downloaded from JSTOR at: <www.jstor.org/stable/20773506>.
- TSCHANZ DW (2003) Hunain bin Ishaq: The Great Translator. *J Int Soc Hist Islam Med*, 1(1): 39-40.
- TUBBS RS, SHOJA MM, LOUKAS M, OAKES WJ (2007) Abubakr Muhammad Ibn Zakaria Razi, Rhazes (865-925 AD). *Childs Nerv Sys*, 23: 1225-1226.
- VON STADEN H (1989) *Herophilus – The Art of Medicine in Early Alexandria*. 666 pages, Cambridge University Press.
- VON STADEN H (1992) The discovery of the body: Human dissection and its cultural contexts in ancient Greece. *Yale J Biol Med*, 65: 223-241.
- VREBOS J (2011) Thoughts of a neglected French medieval surgeon: Henri de Mondeville (ca. 1260-1320). *Eur J Plast Surg*, 34(1): 1-11.
- WALKER JH (1996) Studies in ancient Egyptian anatomical terminologies. *Australian Centre for Egyptology, Studies 4*, Arish and Philips Publishers, Warminster UK.
- WEST JB (2014) Galen and the beginnings of Western physiology. *Am J Physiol Lung Cell Mol Physiol*, 307: L121-L128.

- WIKIPEDIA 1 (2015) Summarised from <www.wikiwand.com/en/Caliphate>, <www.wikiwand.com/en/Rashidun_Caliphate>, <www.wikiwand.com/en/Umayyad_Caliphate>, <www.wikiwand.com/en/Abbasid_Caliphate> and <[www.wikiwand.com/en/Caliphate_of_C%C3%B3rdoba](http://www.wikiwand.com/en/Caliphate_of_C%3%B3rdoba)>.
- WIKIPEDIA 2 (2015) Gundeshapur. Consulted at <www.wikiwand.com/en/Gundeshapur>.
- WILKIE JS, LLOYD GER (1981) The arabic version of Galen's *Ars Parva*. *J Hellen Stud*, 101: 145-148. Downloaded from: <www.jstor.org/stable/629858>
- WILKINSON RG (1975) Trephination by drilling in ancient Mexico. *Bull NY Acad Sci*, 51(7): 838-850.
- WILSON L (1987) William Harvey's Prelectiones: The performance of the body in the renaissance theater or anatomy. *Representation*, 17 (Special Issue): 62-95. Downloaded from JSTOR at: <www.jstor.org/stable/3043793>.
- WRIGHT JC (2004) A survey of evidence for feasting in Mycenaean society. *Hesperia*, 73: 133-178.
- WULFF H (2004) The language of medicine. *J Roy Soc Med*, 97: 187-188.
- ZÉVORT MC (1847) Aristote. In: "*Diogène de Laerte – Vies et Doctrines des Philosophes de l'Antiquité*", *traduction nouvelle*. Livre V, chapitre 1. Charpentier, Libraire-Éditeur, Paris. Consulted at <<http://remacle.org/bloodwolf/philosophes/laerce/5aristote1.htm>>
- ZISKIND B, HALIOUA B (2004) La conception du cœur dans l'Égypte ancienne. *Médecine/Sciences*, 20(3): 367-373.