Streets and streams : health conditions and city planning in the Graeco-Roman world

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INTRODUCTION

Interaction between Anatomical and Civil Engineering Terminology

Introduction

Medicine[1] and city planning are disciplines which are, at first sight, far removed from each other. Medicine is a science thousands of years old – medical treatises were already written in the Graeco-Roman world – but city planning and traffic studies are modern sciences that constitute a common part of social and technical sciences. We have no information on the education of Greek or Roman city planners; we do not even know if there were traffic experts in Antiquity. On the one hand we know that knowledge of medicine was required for studying architecture, as stated by Vitruvius, the famous Roman architect and engineer, but on the other hand, the aspect of civil engineering or architecture did not play a role of any significance in medical education. In this volume I will set out to prove that there were, however, correlations between the sciences of medicine and civil engineering; their mutual terminologies were in use in both sciences just as they are today.

Medical concepts and words play an important role as 'gesunkenes Kulturgut' (the process whereby customs and words, in the first instance used by the upper classes, become more and more common amongst ordinary people) in social life and in literature.[2] In 1965, the Dutch traffic expert Henk Goudappel (1930-2007) described traffic problems in the following way:

> 'Many words describing traffic problems are derived from medical terminology: congestion, artery, circulation, sanitation, 'recovery'. On the one hand, all these terms acknowledge traffic as a vital urban function; on the other hand, they show that the city is not quite in a healthy state. Obstruction of the veins and arteries can

1 In this introduction, anatomy and physiology (I use their modern definitions, as used from the 16th century onwards; see Nutton 2012) are considered as parts of medicine.

2 See Elias 1980 *passim*, esp. part 1, 5-10, 43-50; part 2, 336-351 and 409-454.

> be lethal for a human being. This is also the case with cities: parts of a city can die, caused by interruptions or total blockages of traffic […]. As with a sick body, a sick city cannot be revived by a simple prescription. Traffic needs a more determined treatment. Observation, diagnosis, prognosis and therapy, the correct route towards recovery, all these are elements of traffic regulation'.[3]

Goudappel published these observations at a time when traffic congestion was still a relatively minor problem, in comparison to traffic congestion in the 21th century. Nevertheless he did state that a city with traffic congestion was 'sick'.

The problem is not a recent one; in the Graeco-Roman world[4] traffic congestion was also a problem and it is an interesting theme to research socio-economic values of traffic congestion at that time. Did people compare medicine (the human body) with traffic science, architecture and technology?

Metaphors, analogies and comparisons concerning the human body are used in almost all sciences and throughout history – and the Graeco-Roman world was no exception. The following famous statement is ascribed to the Greek sophist and philosopher Protagoras (490-420 BC): πάντων χρημάτων μέτρον ἐστὶν ἄνθρωπος, τῶν μὲν ὄντων ὡς ἔστιν, τῶν δὲ οὐκ ὄντων ὡς οὐκ ἔστιν, 'Man is the measure of all things; of what is, that it is; of what is not, that it is not', i.e. he explores the world, choosing his own body and parts of it as a point of departure.[5] By way of introduction to this volume, I will point out to what extent anatomic nomenclature and the description of physiological processes are used for traffic and architectural terminology – and the reverse. In other words, I will show which terms from the field of anatomy and physiology were used, with reference to landscape, city planning and traffic, and in reverse order; and in which field of science they were first used – as far as we are able to ascertain. An important question is how far these processes were known, comparing the terms of one-way, return and circulation, when describing the movements of both the human body and traffic.

To what extent did both sciences, civil engineering on the one hand and anatomy and medicine on the other, influence each other in the Graeco-Roman world? I will consider both sciences separately and in comparison and I will also discuss the historical development of each term. In seeking the answers, I have used lexicographic sources.[6]

3 Steÿn 2010, 17; translated by the author.

4 When I use the words 'Graeco-Roman world', I refer to the Greek-speaking area around the Mediterranean Sea and the Roman Empire, in the period between 800 BC and 700 AD.

5 DK 80 B 1 (DK II.263.9-10). Cf. Van Berkel 2013, 37-65, esp. 56-60. She refers to (p. 56-57): δάκτυλος (finger), πούς (foot), παλαμή (palm), πήχυς (elbow), κόνδυλος (knuckle) and ὄργυια (length of spread arms).

6 Behm, Hyrtl, Scarborough and Skoda; for the etymology see Beekes, Chantraine, Masson & Lejeune, LSJ and C.T. Lewis & C. Short, *A Latin Dictionary* (Oxford 1993).

1. Metaphor and analogy

First, let me give a short explanation of the term 'metaphor'. 'Metaphor' and 'analogy' are terms for related concepts. A metaphor is a figure of speech where a concept is replaced by an image (e.g. 'a ship of the desert' instead of 'a camel'). An analogy is a comparison: a camel crosses the desert like a ship crosses the sea. Throughout history, a vast amount of literature is published about the concepts 'metaphor' and 'analogy', including metaphors and analogies in Graeco-Roman literature. In his *Poetica* (*Poetics*), Aristotle gives a clear definition of these concepts.

A metaphor, on the one hand, contains two components: the word or concept itself, and on the other hand, the word that refers to something else, which is adapted.

An analogy,[7] on the other hand, contains four components: A, B, C and D. A and B have a distinct and usually functional relation to each other, like C and D. Then A is compared with C, and B with D. For example: Old age (A) is to life (B), as evening (C) is to day (D). This creates the following formula: A:B = C:D.[8] Of course the reader or listener to whom the metaphor or analogy is directed, has to know the meaning and connotations of the words involved; otherwise the message is not clear and the metaphor or analogy loses its function. Metaphors and analogies are thus subject to time, person and culture. E.g. the metaphor 'Time is money' can only be comprehended in a situation where the phenomenon 'money' is important, and 'time' is scarce, as in our modern Western society. For a text to be translated which is written in a particular period in a particular country or region, the translator has to be aware that not only the text, but also the context, has to be translated.[9] This culture-related aspect creates the possibility of using metaphors as comparisons for historical research.

7 Bartha (2013) describes an analogy as follows: 'An *analogy* is a comparison between two objects, or systems of objects, that highlights respects in which they are thought to be similar. *Analogical reasoning* is any type of thinking that relies upon an analogy. An *analogical argument* is an explicit representation of a form of analogical reasoning that cites accepted similarities between two systems to support the conclusion that some further similarity exists'.

8 Arist. *Po.* 1457b7-30; Stutterheim 1941, 65; 69-81; Taub 2012, 45-46; Fojt 2009, 112-113; Oosterhuis 1982, 40. Sometimes an analogy contains three components: Empedocles, DK 31 B 55 writes that 'the sea is the sweat of the earth', which is, according to Aristotle (*Mete.* 357a25-29), important in a poetical context, but not in a scientific context; Lloyd 2002, 116 n. 32; Lloyd 2012, 73-74. Cf. for other references and metaphors in the Graeco-Roman world Arist. *Rh.* 1406b, Arist. *Rh.* 1410b16-19 and Quint. *Inst.* 8.6.8-9. For Galen's use of metaphors see H. Von Staden, 'Science as text, science as history: Galen on metaphor', in Eijk, Ph.J. van der, Horstmanshoff, H.F.J. & Schrijvers, P.H. (eds), *Ancient Medicine in its Socio-Cultural Context*. Amsterdam/Atlanta 1995, 499-518.

9 Examples of culture-subjected metaphors and types of metaphors are to be found in Lakoff & Johnson 1980, *passim.* Translations: Heeßel 2010, 175-177; Høyrup 2010, 398 (both referring to the translations of Babylonian texts). Cf. Craik 2009, 108; 111 (translation of φλέψ into 'channel').

2. City, body and metaphors

Metaphors referring to civil engineering and architecture on the one hand (macrocosm) and the human body on the other hand (microcosm),[10] as Goudappel describes, were also in use in the Graeco-Roman world.

In this introduction, I will discuss the following words: *dorsum*, ἔξοδος, κιών, κοιλία, κυκλοφορία, ὀχετός, πεδίον, πύλαι and πυλωρός and their Latin counterparts (*dorsum* and πεδίον have no counterpart, as far as we know, in Greek and Latin respectively). These words can be divided into two categories: words which in the first instance are mentioned in a medical context and later in a civil engineering context; and the reverse: words which in the first instance are mentioned in a civil engineering context and later in a medical context. Three of them are already cited in the works of Homer: κιών, πεδίον and πύλαι. The other Greek words (both civil engineering and medical) can be dated to the late 5th century BC, when Greek literature had reached a peak; the time when medical literature had made its entry. Their Latin counterparts date mainly from the 1st century BC when they are used by Vitruvius and Celsus.

Within the dichotomy of words in which the use in civil engineering is older than the medical use, and words where the medical use is older than that in civil engineering, there arises a second dichotomy: words having a 'static' and a 'dynamic' sense. The group of concepts with a 'static' sense is the largest: both groups refer to parts of the body and artefacts being at rest. Only after the rise of medicine did people observe the internal parts of the body and they not only observed, but also named, these parts, as is shown in the Hippocratic Corpus from the 5th century BC onwards. E.g. the name of the πυλωρός, pylorus, the circular muscle between the stomach and the duodenum, is derived from the fact that this muscle resembles a Graeco-Roman city gate at that period, which could be opened and closed. In this case, the civil engineering meaning is older than the medical meaning.

2.1. City planning, traffic and architectural terms, used in anatomy and physiology

The terms κιών, πεδίον and πύλαι are used by Homer; the civil engineering term is older than its medical counterpart.

Let us start with πεδίον, in the geographical sense 'plain', but in the medical sense 'metatarsus'.[11] This word refers to a 'plain' in the geographical sense, a phenomenon which we see in nature. This word has its roots in the Hittite language. Michler states that the word is used by many authors signifying 'ploughed field'. We find this meaning throughout the entire Greek literature.[12]

10 Macrocosm and microcosm: Holmes 2010, 99.

11 Hitt. peda- Beekes 2010, 1161; see Michler's article (1961) for an extended etymology; Poll. 2.179; 4.196. In Latin there is no equivalent; Celsus only describes the metatarsus in 8.1.27 (*Cetera pedis ossa ad eorum, quae in manu sunt, similitudinem structa sunt: planta palmae, digiti digitis, ungues unguibus respondent*).

12 Hom. *Il.* 5.222; Skoda 1988, 49-50, who refers in n. 181 to the female genitals, mentioned by Aristophanes: *Lys.* 88; *Av.* 507; LSJ.

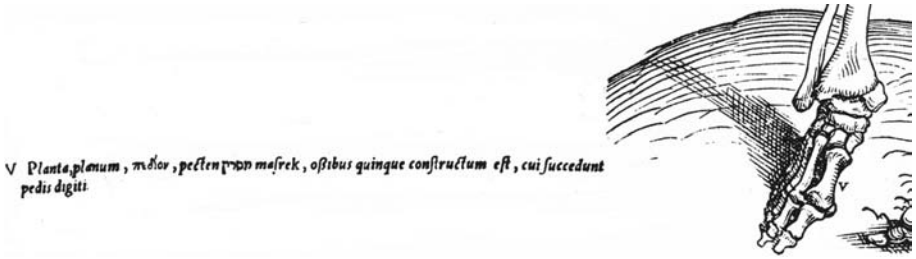

Fig. 1. *Πεδίον, still in use in Vesalius'* Tabulae anatomicae sex *(Saunders & O'Malley 1973, 243, plate 90; Vesalius' first edition 1538, plate IV; modified by C. van Tilburg).*[13]

In its medical sense we meet the word first in the works of Rufus of Ephesus (2nd century AD). Galen states in his work *De usu partium* (*The Function of the Parts of the Body*) that the word πεδίον (**fig. 1**) acquired its name because the metatarsus touches the earth, 'plain' or 'field' (according to Michler).[14] There are two other synonyms for the metatarsus: ὄρος (mountain) as stated by Pollux (2nd century AD)[15] and the more common ταρσός or ταρρός.[16]

The shape of the metatarsus can indeed evoke certain associations: plain, mountain and a ploughed field: the toes are very close to each other, evoking the image of furrows, ending at the metatarsus. Ταρσός or ταρρός evokes (in contrast to ὄρος) the association with a flat structure like the flat side of an oar or the palm of a hand.[17] Galen and Rufus indicate in their treatises on medical terminology that there were more names and terms for parts of the human body which were created by physicians who were trying to make a name for themselves.[18]

The other Homeric words of which the civil engineering meaning is older than the medical use, κιών and πύλαι, do not refer to a phenomenon found in nature but to artificial structures. Κιών (Lat. *columna*), civil engineering: 'column'[19] is cited, as already said, by Homer in an architectural context.[20] In the medical sense, κίων refers to four parts of the human body: uvula (**fig. 2**),[21] internasal septum,[22] wart[23] and penis.[24] In all senses, the word apparently refers to a vertical structure. Already in prehistory, vertical elements (poles) were used for tents and cabins to support their

13 Translation: The *planta, planum,* pedion, *pecten*, MASREQ, masrek is formed of five bones. After it come the digits of the foot (Singer & Rabin 1946, 28). The medieval Latin word *pecten*, the Hebrew MASREQ and Arabic masrek mean 'comb' (Singer & Rabin 1946, 26 nn. 155-156).

14 Rufus: Ruf. *Onom.* 125; Galen: Gal. *UP* 3.8 (3.201-203 K.); Michler 1961, 218-221.

15 Poll. 2.197.

16 From Homer onwards (*Il.* 11.377) up to now; Hyrtl 1880, 526-529.

17 Cf. Cels. 8.1.27; Beekes 2010, 1453-1454.

18 Galen: Gal. *Med. Nom.* 85r (translated from Arabic by Meyerhof & Schacht, see the bibliography) p. 9 r. 16-31; Rufus: *Onom.* 10; Haak 2013, 82 and 203; Lloyd 2002, 102-105.

19 IE (Indo-European) kʾīwōn, Beekes 2010, 707; Ruf. *Onom.* 60; Poll. 2.79; 2.99 (uvula).

20 Hom. *Od.* 8.66.

21 Hipp. *Epid.* 1.3.13 (196 Jones = 2.696 L.); Ruf. *Onom.* 60. For more synonyms of 'uvula' see *infra.*

22 Ruf. *Onom.* 37. For synonyms cited by Rufus see *infra.* In Latin: Isid. *Orig.* 11.1.48.

23 Hipp. *Nat. Mul.* 65 (290 Potter = 7.400 L.).

24 Only in Latin: Mart. 6.49.3. Cf. English 'pole'.

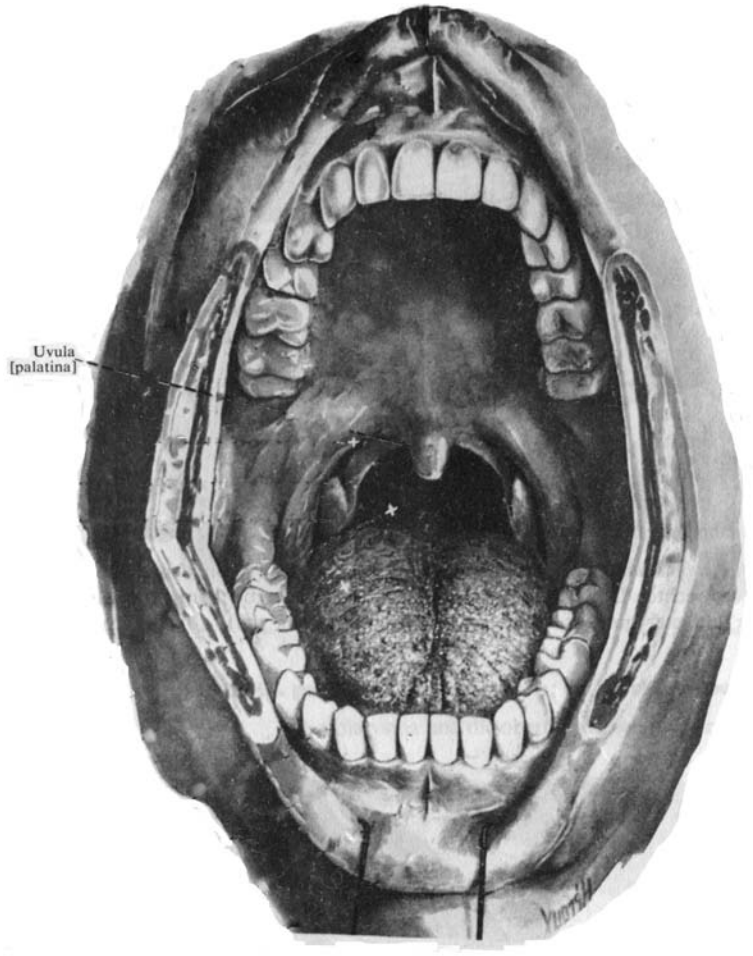

Fig. 2. *Uvula (Spalteholz & Spanner 1951-1961, 186, fig. 1049; modified by C. van Tilburg).*

roofs. Looking at the Indo-European origin of the word, it must indeed be very ancient. The parts of the human body to which the word refers are visible from the outside, but in (medical) literature we meet the word only from the 5th century BC onwards.

Roughly the same situation is found in the case of πύλαι (Lat. *iocineris*) *portae*, civil engineering: 'gate', medical: 'portal vein'.[25] Homer uses the plural form referring to the Skaiian Gate of Troy.[26] Like poles, gates can be considered as the basic elements of human dwellings; Beekes describes the word as 'pre-Greek'. The Minoans and Myceneans erected gates, such as the famous 'Lion's Gate' of Mycene. The image of the

25 Unknown etymology, probably pre-Greek, like many other words concerning architecture; Beekes 2010, 1257; Ruf. *Onom.* 179-180; Poll. 2.215.
26 Hom. *Il.* 3.145 (The Skaiian Gate of Troy).

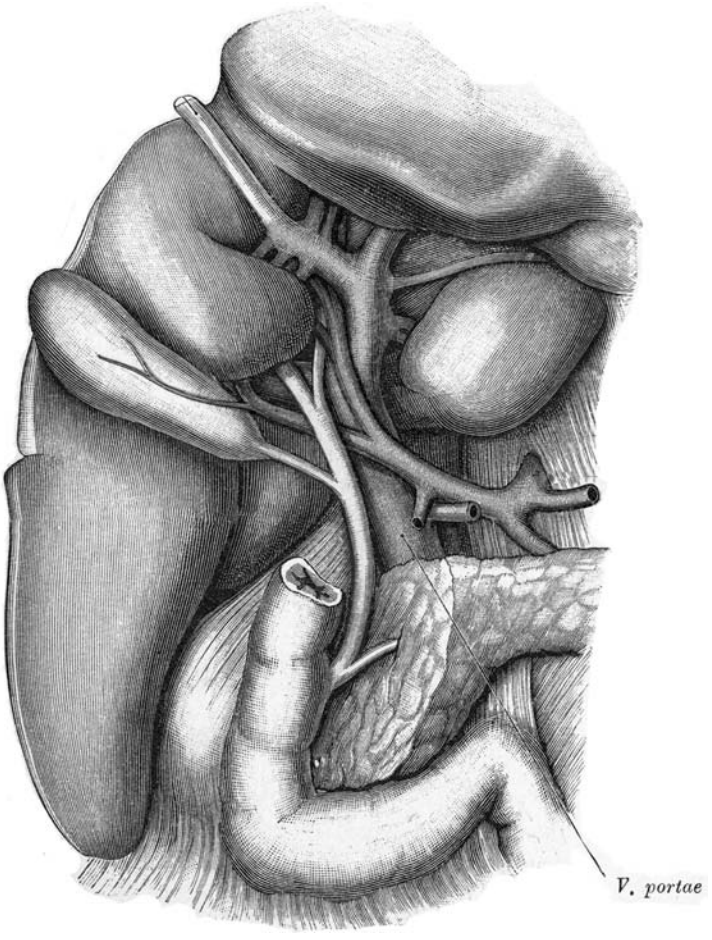

Fig. 3. *Portal vein (Heitzmann 1905, 359, fig. 429; modified by C. van Tilburg).*

portal vein, accompanied by the liver artery and bile ducts, corresponds with a busy forecourt of a city gate (**fig. 3**).

The portal vein is the only vein running from the digestive system to the liver, transporting blood. In a medical sense, too, this vein is called πύλαι (plural) because it splits up into several branches.[27] In this sense, we find the oldest reference (as far as we know) in Euripides' *Electra* (5th century BC). Here the portal vein of a calf is mentioned; the first reference to a human portal vein we find in the Hippocratic Corpus. Later references are found in Plato, Aristotle, Celsus and Galen.[28] The portal vein is the entrance to the liver. It is doubtful whether this vein was known before the first

27 Singular πύλη only cited by Ruf. *Onom.* 179; in *Onom.* 1.29 (Daremberg Ruelle 176), on the other hand, plural (πύλαι).

28 E. *El.* 828 (calf's liver); Hipp. *Epid.* 2.4.1 (64 Smith = 5.122 L.) (end 5th century-beginning 4th century BC; Jouanna 1992, 537; Craik 2015, 90-91); Pl. *Ti.* 71C; Arist. *HA* 496b32; Cels. 5.26.2 (also in Latin plural); Gal. *HNH* 2.6 (15.145 K.); Leven 2005, col. 560.

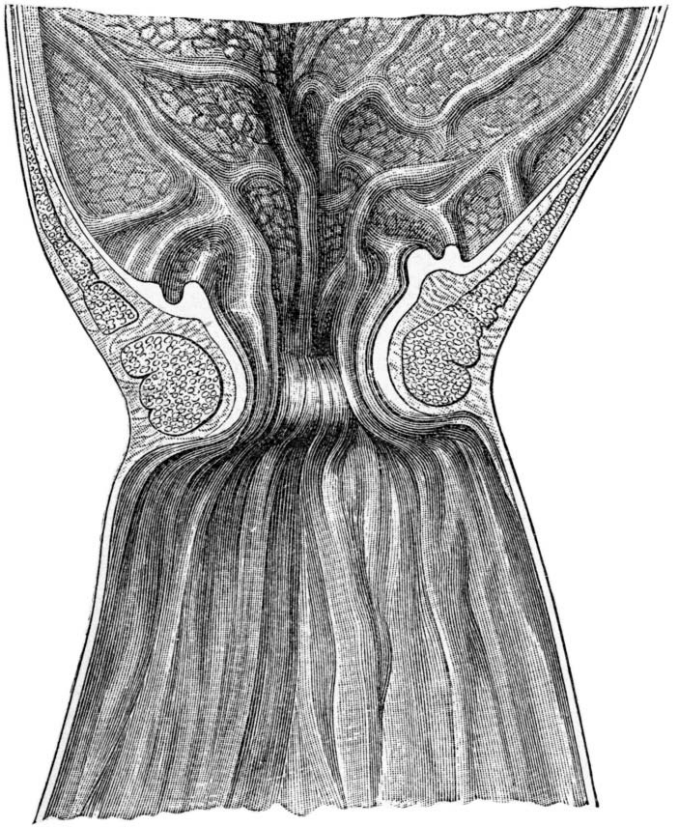

Fig. 4. *Pylorus (Heitzmann 1905, 333, fig. 397; modified by C. van Tilburg).*

medical treatises were written, imparting knowledge of anatomy and physiology; we have to assume that the medical sense of πύλαι is derived from the use in civil engineering.

Closely connected to the πύλαι is the πυλωρός (Lat. *pylorus*), civil engineering: 'gatekeeper', medical: 'pylorus'.[29] City gates must obviously be at least as old as gate keepers – there can be no gate keeper without a gate. The oldest reference as far as we know is found in Aeschylus (5th century BC).[30] In medical terminology, the pylorus is the circular muscle between the stomach and the duodenum (**fig. 4**). The function of the pylorus is to allow a fixed amount of the contents of the bowel to pass through it, on its way to the duodenum. Diocles of Carystus (4th century BC) is the first Greek medical author who mentions the pylorus,[31] followed several centuries later by Celsus, Rufus and Galen.[32] Both Celsus and Rufus make explicit why the cir-

29 Not cited by Beekes; Ruf. *Onom.* 169.3; Poll. 2.208; derived from πύλη, gate and οὖρος, keeper.

30 A. *Th.* 621.

31 Diocles (*Fr.* 109.55 Van der Eijk) mentions only the πυλωρός as 'end of the stomach', without any indication of the functioning of the πυλωρός.

32 Cels. 4.1.7; Ruf. *Onom.* 169; Haak 2013, 212; Ruf. *De partibus corporis humani* 1.42 (Daremberg

cular muscle is known as πυλωρός: it works like a gate, opening and closing, letting through a certain amount of the contents of the bowel. Probably the exact function was not yet known in Diocles' time, but he observed its physiognomy: before the πυλωρός, the bowel is already narrowed, and the πυλωρός itself is narrowed again. Some gates have a similar shape, for instance the Porta di Stabia in Pompeii,[33] in order to give access to a certain amount of traffic. Rufus used a monkey as an 'object of research';[34] maybe he had knowledge of the functioning of a monkey's pylorus.

So the civil engineering meaning of the πυλωρός is older than the medical one; in order to protect settlements or cities against invaders, gates had to be equipped with gate-keepers, but the anatomical πυλωρός was only known after the first use of dissection. Galen mentions two other internal organs that are θυροειδής (door- or shield-shaped): the vein passing the pubic bone and a hollow space, where later the thyroid was found. These names could only be used after the inventions of the door and shield.[35]

The πύλαι as well as the πυλωρός are – in contrast to the πεδίον and the κιών – internal parts of the human body, only visible upon (vivi)section. In Hellenistic and Roman Alexandria, dissection of human bodies took place; according to Von Staden, the Alexandrian scientist Herophilus was the first physician who described the liver elaborately.[36] Earlier, Euripides, Plato and Aristoteles mention the πύλαι in a medical context but only after animals were being researched.[37]

Other internal organs, bearing names as parts of the digestion system, where the civil engineering meaning is older than the medical, are ἔξοδος and ὀχετός.

Both in ancient civil engineering and ancient medicine, we find the word ἔξοδος (Lat. *exitus*), 'exit',[38] referring both to the exit itself and to the process of leaving. Used in the context of civil engineering, ἔξοδος means 'exit', 'street door' of a building or city, or part of a gate. The word is used throughout Greek literature; the oldest occurrence (as far as we know) is found in Aeschylus. Its Latin counterpart *exitus*

Ruelle 179); Gal. *UP* 4.7 (3.280 K.); *Nat. Fac.* 3.4 (2.156 K.). In the Hippocratic Corpus, the πυλωρός (now feminine) is only mentioned in the apocryphal *Epistulae* (*Letters*), described as the exit of the uterus, not, therefore, the pylorus: Hipp. *Epist.* 23 (104-105 Smith 1990 = 9.396 L.) (from the 1st century BC); Jouanna 1992, 543.

33 Van Tilburg 2012, 110-113.

34 Haak 2013, 82.

35 Respectively Gal. *AA* 3.13 (2.413-414 K.) and *Nerv. Diss.* 8 (2.839 K.). θυροειδής is derived from θύρα, 'door' (Hom. *Il.* 24.317) and θυρεός, 'stone put against a door' (Hom. *Od.* 9.240) and 'shield' (Plu. *Pyrrh.* 26). The θυροειδής gland, nowadays called the thyroid (Dutch 'schildklier', German 'Schilddrüse'), was discovered by Thomas Wharton in the 17th century. He called it *glandula thyreoidea*; Hyrtl 1880, 547-549.

36 Date *De anatomia*: Jouanna 1992, 530; cf. Craik 2015, 29 (late 5th-4th century BC). Section: Von Staden 1989 *passim*. Liver: Von Staden 1992, 224; Leven, 'Leber' 560.

37 Euripides: see paragraph πύλαι. It is not clear if Plato (*Ti.* 71C) is really referring to the portal vein. According to A. Rivaud (Budé-edition, Paris 1925, 198 n. 3) Plato considers the liver as tripartite, with three entrances. Aristotle refers to πύλαι, mentioning animals' livers. Cutting open animals for sacrifice provides knowledge of anatomy: Arist. *HA* 586b19; *HA* 496b24-25; Gladigow 1995, 346.

38 <ἐξ-όδός, 'out-way', not cited by Beekes; not in Rufus; Poll. cites only the use with reference to drama.

(< *ex-ire*) is also used in this way.[39] In the human body there are many exits: at all points where veins, bowels etc. enter or leave an organ, the word ἔξοδος can be used. The oldest references to a medical ἔξοδος are found in the Hippocratic treatises *Epidemiae* (*Epidemics*) and *De diaeta acutorum* (*Regimen in Acute Diseases*) (end 5th century BC). Some passages in Aristotle refer to an ἔξοδος in a medical context in the case of mammals: the anus and the penis.[40] These exits are visible, just as the exits of a building or a city. However, the oldest references in medical contexts are more recent than those in a civil engineering context, especially when referring to internal exits. Mouth, penis, anus and vagina have their own, specific name, in contrast to the exits of buildings and cities and later-discovered exits of the body, all of which had the general name of ἔξοδος.

The last word in this group that I will discuss is ὀχετός, 'duct'.[41] In a civil engineering context, we come across the following references: irrigation pipe (from Herodotus onwards),[42] aqueduct[43] and sewer.[44] All these cases refer to 'duct', or 'fluid transportation pipe'. The Latin word for 'sewer' is *cloaca*, but a *cloaca* does not usually contain clean water, but rather waste water.[45] The supply of clean water (for drinking) is facilitated by means of a *ductus* (*aquae* or *aquarum*, in Late Antiquity *aquaeductus*). In a medical context, the word ὀχετός is used for the discharge of urine and contents of the bowel (after the Hippocratic treatise *De articulis* (*Joints*) end 5th century BC),[46] sweat pore,[47] bronchial tube[48] and vein/artery.[49]

In its civil engineering context, the word refers to ducts or channels where fluids (clean or polluted) stream through. Herodotus must have observed such channels, travelling through Egypt, Palestine and Mesopotamia. In these areas, irrigation was already in use many centuries before medical authors used the word in their treatises; the origin of the word ὀχετός is Indo-European. All medical references involve internal ducts filled with fluids or air, only known after the first use of dissection.

Aretaeus (2nd century AD), in discussing diabetes, compares the disease with a tube system: 'Diabetes is a strange disease, it seldom occurs amongst human beings.

39 Passages: A. *Th.* 33; exits of a room: Hdt. 2.148; LSJ; exit of a house: Arist. *Pr.* 947a19; *Top.* 103a; (Ps.) Lucianus, *Am.* 42,2; exit of a city: Aen.Tact. 1.5.3. Latin: gate passage: Caes. *Gal.* 7.28.3; exit of a house: Liv. 39.51.5.

40 Hipp. *Epid.* 6.5.1 (240 Smith = 5.314 L.) (air); Jouanna 1992, 537; Craik 2015, 90-91. In physiological context ('outflow') Hipp. *Acut.* (*spur.*) 10.59 (254 Potter = 2.450 no 40 L.); Jouanna 1992, 559; Craik 2015, 6; 34. Animals: Arist. *PA* 675b9; *HA* 507a32; 511a27. Penis (ejaculation): Arist. *HA* 586a15. Latin: Plin. *Nat.* 11.116.

41 Derived from ὀχέω, 'to transport' and ὄχος, 'vehicle'; IE: uógho-; Beekes 2010, 1136; 1138; not cited by Rufus; Poll. 2.217. Ὀχετός has to be translated with *canalis* or *cloaca*, not with *ductus*, as some anatomists did in the early modern period; Hyrtl 1880, 188-192.

42 Hdt. 3.9.3.

43 Th. 6.100.1.

44 Artem. *Onirocriticus* 5.79.2.

45 Plautus refers to the stomach of a drunk woman: Pl. *Cur.* 123.

46 Hipp. *Art.* 48 (306 Withington = 4.216 L.); X. *Mem.* 1.4.6; LSJ.

47 Hipp. *Epid.* 6.3.1 (224 Smith = 5.292 L.).

48 Pl. *Ti.* 70D.

49 Poll. 2.217.

Flesh and bodily parts all flow into urine. As in the case of dropsy, it is caused by damp and cold. Discharge, however, takes place in the usual way via the kidneys and the bladder. The patient urinates continually; moreover, the urine flows away, as if through permanently opened pipes (ὀχετοί)';[50] just as water through an aqueduct.

2.2. Anatomical and physiological terms, used in city planning, traffic and architecture

Besides medical concepts derived from civil engineering and architecture, there are some civil engineering terms and diverse linear measurements in the Graeco-Roman world derived from medical concepts, or names of bodily parts: *dorsum*, κοιλία and δάκτυλος. The civil engineering terms refer to civil engineering phenomena, invented or discovered relatively recently.

The word κοιλία (Lat. *venter*), medical: 'belly', civil engineering: 'curve in a duct'[51] means primarily 'cavity', 'hollow space'; apart from 'belly' it refers to 'intestines' and even 'excrements' from those intestines. The word is used many times in a medical sense from Herodotus onwards, in a medical as well as in a non-medical context.[52] 'Hollow' implies that the cavity can be filled: with food, converted food and fluids.

The use in the context of civil engineering only became common after the development of aqueduct constructions, e.g. by Vitruvius in the eighth book of his work *De Architectura* (*On Architecture*). Here he uses the term *venter* ('belly'); a pipe of an aqueduct running from a slope reaches the bottom of a valley – water must always, inevitably, flow and therefore have a gradient – and the track of the pipe then becomes horizontal (inverted siphon) (**fig. 5**). Vitruvius also mentions the Greek version, *coelia* (κοιλία).[53] The fact that Vitruvius cites this Greek word shows that this concept has a Greek origin. So the use in medical context is older than the use in the context of civil engineering; it seems to be of Indo-European origin.[54] The curve is called 'belly' because it curves from diagonally upwards or downwards to a horizontal track, making a curve which can be filled. Vitruvius speaks of *geniculus*, 'small knee' (**fig. 5**) when the pipe, after crossing the valley, elevates too quickly against the corresponding slope.[55] In both cases, these constructions derive their names from their shape.

50 Aret. *SD* 2.2.1. Cf. διαβήτης, literally: 'through-walker'.

51 IE ḱeu-lo-, > Dutch 'hol', English 'hollow'; Beekes 2010, 730; Ruf. *Onom.* 95-97; Poll. 2.168.

52 From Herodotus onwards (2.87, where he discusses the embalming process in Egypt); LSJ. Excrements: Hipp. *Aer.* 10 (98 Jones = 2.44 L.). For more references – cavities filled with blood, cerebrum etc. – see Behm 1933-1978, 786; pneuma: Haak 2013, 93 (Gal. *AA* 7.7 [2.605 K.]).

53 Vitr. 8.6.5. For detailed information concerning the construction of an inverted siphon and the use of the word *venter* in relation to Vitruvius see Kessener's article (2001), esp. 148-150; Kessener 2011, 78-79. No Greek texts on aqueduct construction are known to us, so this is the only evidence that this Greek word is used in this context: LSJ does not cite this word in this sense. For the meaning of 'belly' cf. Zola's book *Le ventre de Paris* (1873) about the former market halls in Paris.

54 See *supra*.

55 Vitr. 8.6.6. For a more detailed and technical explanation of the *venter* and *geniculus* see Kessener

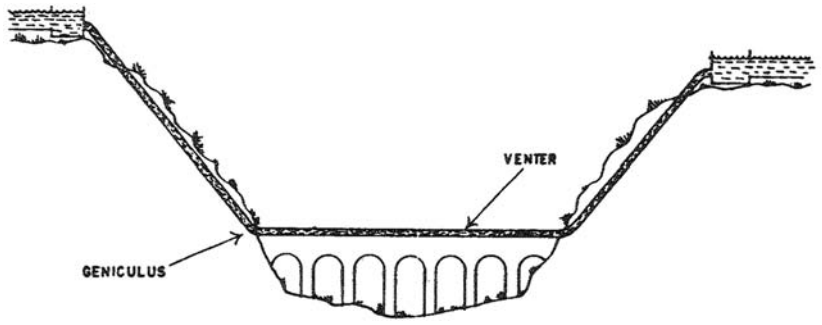

Fig. 5. Venter *and* geniculus *(Hodge 1992, 148; modified by C. van Tilburg).*

In classical Latin prose, the word *dorsum*, 'back, ridge'[56] is only used for the back of an animal; in poetry (and later also in prose), also for the back of a human being; the first occurrence is found in the *Trinummus* (*Three-Dollar Day*) of Plautus. Another meaning of *dorsum* is 'ridge'; in civil engineering 'road pavement'. Of course, this meaning came in use only when roads were equipped with pavements (from the planning and construction of the Via Appia, 312 BC). The first use of *dorsum* in this context is found in Statius, describing the construction of the Via Domitiana under emperor Domitian (81-96 AD).[57] *Dorsum* always refers to a structure in the shape of a flat half cylinder, such as a man's or an animal's back, a road surface or a mountain ridge.

Protagoras' statement 'Man is the measure of all things' is also reflected in several measures of length, derived from parts of the human body:[58]

δάκτυλος	*digitus*	'finger'	
παλαιστή	*palmus*	'palm'	= 4 *digiti*
πούς	*pes*	'foot'	= 4 *palmi*
πῆχυς	*cubitus*	'elbow'	= 1,5 *pedes*

Vitruvius used such linear measures and their proportions in building design. A great disadvantage of using these measures is, of course, their inaccuracy; not everyone's limbs are of the same length. At a later stage they were fixed and calibrated. It was only in the 19th century when many countries chose the metric system (based on the metre) that the former way of measuring, based on the human body, lost its importance.[59]

In short, we may conclude that there are more medical concepts derived from civ-

2001, 148-150 and Nikolic 2008, 15-16, 22-24, 48-50, 63-64 and 72.

56 *Dorsum* is related to the Greek δειρή or δέρη (neck, throat). The first occurrence in Homer: Hom. *Il.* 11.26.

57 Plaut. *Trin.* 719; OLD s.v. 'dorsum'. Ridge: Caes. *Gal.* 7.44. Road surface: Stat. *Silv.* 4.3.44; Van Tilburg 2012, 13-15.

58 Vitr. 3.1.5. Cf. δωδεκαδάκτυλος, *duodenum*; Hyrtl 1880, 192-194; Horstmanshoff 1989, 86; 91.

59 For detailed information concerning measuring, based on the human body see the article of

il engineering concepts than the reverse. The civil engineering terms refer to natural phenomena or human artefacts; they gave their names to the parts of the human body only at a relatively late stage. Of the six words under discussion ἔξοδος, κιών, ὀχετός, πεδίον, πύλαι and πυλωρός, three have a civil engineering name which was already cited by Homer (κιών, πεδίον and πύλαι); two other terms (ἔξοδος and πυλωρός) are in use from Aeschylus onwards (5th century BC) and ὀχετός after Herodotus (5th century BC). However, this word was perhaps already in use before Herodotus.

The corresponding medical terms all date from the end of the 5th century BC when the first Hippocratic treatises were written, except for πεδίον. This word is quite different in the sense that it is the only part of the body featuring on the above mentioned word-list which is not part of the digestive system; πεδίον and κιών are the only parts of the body visible from the exterior. The other parts of the body received their names after the use of dissection, which enabled them to be discovered. Sometimes these internal parts of the body were already known in the case of animals (πύλαι and ἔξοδος) before they were discovered in human bodies, but here again their names were originally derived from civil engineering.

With regard to the group of words where the civil engineering meaning is derived from the medical meaning, we can state that their names are relatively recent: *dorsum* and κοιλία are concepts discovered and invented in civil engineering, in which linear measures play an important role. The parts of the human body which gave their names to these are clearly visible and their medical names go back to ancient history.

2.3. Movements

Finally, I shall now discuss bodily movements and movements in the city (traffic). The concepts discussed above refer to things that move when something passes through it. In the human body as well as in the city, movement is crucial. In the case of blockage because of lack of movement, the bodily and city functions are endangered, as quoted by Goudappel at the beginning of the introduction. How did people regard movement in body and city in the Graeco-Roman world? In my opinion, there are three movements which are easily distinguished: one-way traffic, two-way traffic, and circulation.

In the Graeco-Roman world, one-way and two-way, or return, journeys were well-known. According to ancient perceptions, the digestive tract is a one-way system. As discussed above, many terms referring both to the body and to civil engineering are related to organs which are part of the digestive tract. Evidently, the digestive tract was considered as resembling a traffic highway; food or contents of the bowel travel from mouth to anus.[60] Beyond the stomach, in the intestines, the term is διαχώρημα,[61] meaning literally 'material passing through' in the various stages of

F. Zöllner, 2004, 'Anthropomorphismus in der Architektur von Vitruv bis Le Corbusier', in Neumaier, O. (ed.), *Ist der Mensch das Mass aller Dinge?* Paderborn, 307-344, esp. 313-314 and 331-333.

60 Digestion process: Hipp. *Anat.* 1 (4-6 Potter = 8.538-540 L.); Oser-Grote 2004, 216.

61 Διαχώρημα is derived from διαχωρέω, 'going through'; Hipp. *Vict.* 3.74 (396 Jones = 6.616 L.) (διαχωρέεται). So it is material 'on the road', like traffic. Cf. διαρρέω, 'flowing through', with the cor-

digestion. It is a one-way journey: material does not usually travel in the opposite direction.[62] For the excretional tract roughly the same story applies.[63]

Some ducts or channels allow return material (e.g. the oesophagus and vagina), but their contents differ. Galen correctly compares the system of blood vessels (supplying foodstuffs) to the irrigation of a garden: channels run from a main source, ending at the most distant parts of the garden where water is absorbed by the surrounding earth and plants, just like an aqueduct system in a Greek or Roman city, which is actually also a type of irrigation.[64] The vessels supply blood to the entire body, with the exception of the outer skin. Inevitably blood also has to return, but the ancient authors are not clear on this topic.[65] Before Galen it was already known that the function of the blood was to supply nutrients. This is shown in the parable of Menenius Agrippa, cited by Livy: after the separation of the plebeians in Rome, the envoy Menenius Agrippa explains that both patricians and plebeians have their own duties and are forced to cooperate with each other like body parts: the stomach feeds the body by means of the blood (*Inde apparuisse ventris quoque haud segne ministerium esse, nec magis ali quam alere eum, reddentem in omnes corporis partes hunc* […] *sanguinem*).[66]

Finally, the circulation. Κυκλοφορία (Lat. *circulatio*), 'circular motion', derived from κύκλος and φέρεσθαι, 'to move in a circle', is used in classical Greek by only two authors: Aristotle and Theophrastus.[67] They refer to circular motions concerning dizziness and heavenly movement. In classical Latin, *circulatio* is a hapax: it is only mentioned by Vitruvius referring to the orbit of Mercury before it returns to its starting point.[68] According to our evidence, then, this concept is only used in the context of perception and cosmic movement.

William Harvey, the discoverer of the circulatory system in the 17th century,[69]

responding substantive διάρροια, 'diarrhea'. The substantive διαχώρημα is found for the first time in Hipp. *Aph.* 2.14 (110-112 Jones = 4.474 L.), possibly later than *De victu* (according to Jouanna 1992, 531 and 559; according to Craik 2015, 34 and 275 respectively ± 400 BC and late 5th-early 4th century BC) and further only in medical authors. In a similar context the word διαχώρησις is found; Hipp. *Aph.* 2.18 (112 Jones = 4.474 L.), referring to the process, 'excretion'. This word is also used by non-medical authors, e.g. Aristotle: Arist. *PA* 675a22 (animals).

62 Hipp. *Vict.* 3.80 (406-408 Jones = 6.626 L.); Stamatu 2005b, col. 893.

63 Gal. *Nat. Fac.* 1.6 (2.36-37 K.); Stamatu 2005a, col. 379. See 'Opinions concerning Faeces and Urine in the Graeco-Roman World', pp. 107-133.

64 Gal. *Nat. Fac.* 3.15 (2.210-211 K.). Cf. Hipp. *Cord.* 7 (62 Potter = 9.84 L.); Pl. *Ti.* 77C. For blood as fluid supplying foodstuffs see Gal. *Med. Nom.* 102v (Meyerhof & Schacht 1931, 30 ll. 29-30).

65 Van den Berg 1959, 34-35; Leven 2005, col. 169. Scholars have tried to prove that the circulatory system was already known in Antiquity, e.g. with reference to Hippocrates: Hipp. *Loc. Hom.* 1 (18-20 Potter = 6.276 L.), but this view has been refuted; Leven 2005, col. 169.

66 Liv. 2.32.8-12; Demandt 1993, 354; Demandt 1978, 22. The story is also referred to in Shakespeare's *Coriolanus*: Hale 1971, 11-15; 26-28; Brock 2006, 353.

67 E.g. Arist. *Ph.* 223b19 (earth rotation, according to the Loeb edition of Wicksteed and Cornford 1929, 423); Thphr. *Vert.* 8.9-10 (dizziness); *Metaph.* 5b28 (movement of the cosmos; Van Raalte 1993, 237-238).

68 Vitr. 9.1.8.

69 Plato writes in *Ti.* 70B: περιφερομένου κατὰ πάντα τὰ μέλη σφοδρῶς αἵματος, 'the blood flows firmly around through all members'. It is tempting to consider Plato as the discoverer of the circulatory system. Galen cites this four times (*Foet. Form.* 3 [4.672.1 and 4 K.] *PHP* 3.1.31 [5.292 K.] and 6.8

did not then use the term *circulatio*; in chapter IX of his work *Exercitatio anatomica de motu cordis et sanguinis in animalibus* (or, in short, *De motu cordis*)[70] he uses the word *circuitus*, 'circuit' (*Esse sanguinis circuitum*). In 1630 however, Primerose uses the words *circulatio sanguinis* in an apology to Harvey (in the title), and we find this word again in later writings concerning the circulatory system.[71] C*irculatio* (*sanguinis*) is therefore a Neo-Latin word;[72] and although already used in Antiquity, it was never used in a blood circulatory context. According to Pulkkinen, Harvey considers the heart as a pump and the circulatory system as a hydraulic system; blood vessels are compared (through a metaphor) to 'transportation' roads.[73] Civil engineering items such as pumps and hydraulics, then, were well-known amongst Early Modern physicians.

In ancient physiology therefore, the phenomenon of 'circular movement' was unknown, in contrast to one-way and return journeys. But did these terms apply to Graeco-Roman traffic? Neither the Greek nor the Latin language used the words κυκλοφορία and *circulatio* to indicate traffic circulation.[74] Nowadays we use the word 'traffic circulation' as a metaphor in city planning, like the words 'traffic congestion'[75] and 'artery', derived from the circulatory system. In a city, traffic makes a circular movement.[76]

Nevertheless, in the Graeco-Roman world the phenomena 'one-way traffic', 'return' and 'circulation' must have been known in city planning, although we do not

[5.575 K.]. According to Taylor (1928, 502-503), the functioning of veins and arteries was not yet known and Galen's notion that the liver was the source of blood instead of the heart (Van den Berg 1959, 34-35), was wishful thinking ('He [sc. Galen, CvT] assumes that Plato shared his view', cites Taylor at p. 503). In the early modern period, Spinoza, *Ethica* 4.39 (1677) and A.G. Baumgarten, *Aesthetica* I.23.338 (1750-1758) refer to this passage of Plato and the *circulatio sanguinis*. Cf. Hipp. *Loc. Hom.* 1 (18-20 Potter; 6.276 L.), where the author states that the human body is cyclic by nature. In his article (p. 45), Asper translates αἱμάτωσις in Galen's treatise *In Hippocratis de Natura Hominis* (*Commentary on Hippocrates' 'Nature of Man'*) 3.10 (15.191 K.) wrongly with 'blood circulation'. The correct translation is 'changing into blood' (LSJ s.v. αἱμάτωσις). See also for the refutation Leven 2005, col. 169.

70 Published in 1628; Scarborough 1992, 213-216; 228.

71 Primerose*: Exercitationes et animadversiones in librum de motu cordis et circulatione sanguinis adversus Guilielmum Harveum*. London 1630. Harvey, to Jean Riolan: *Exercitatio anatomica de circulatione sanquinis* (sic)*: ad Joannem Riolanum filium Parisiensem, medicum peritissimum anatomicorũ coryphæum, in Academia Parisiensi Anatomes & Herbariæ Professorem Regium & egregium atque decanum, Reginæ matris Lodovici XIII medicum primarium*, Cambridge 1649; Wear 2004, 835.

72 WNT. The Dutch word 'circulatie' is derived from the French 'circulation'. In the sense of 'blood circulation' it is found – as far as we know – for the first time in 1699 ('Anders zou de stremmende kou der hooge jaren de circulatie van haar bloed al eer gestolt hebben'). http://gtb.inl.nl/iWDB/search?actie=article&wdb=WNT&id=M012715&lemmodern=circulatie.

73 According to Horstmanshoff, Erasistratus already considered the heart as a pump; Horstmanshoff 1989, 92. Blood as hydraulic system: Pulkkinen 2008, 278-282. Transport system: Kalff 2012, 178.

74 The Latin term *commeatus* refers to separate movements, not to traffic as a whole; OLD.

75 See *infra*.

76 'Circulation' refers to a 'circular movement', a 'point to which one returns to'. The origin of the English 'traffic' and French 'trafic' (for the English forms of 'traffic' see from ± 1500 onwards *Oxford English Dictionary* 1989^2 s.v. 'traffic') is – according to many etymological dictionaries – unknown, but in my opinion it is possible that it is related to the Latin verb *transvehere*, 'to convey over', 'to transport'. It suggests here a 'one-way' direction, traffic goes in one direction only, so there is no circulation movement.

find the words in this context. In many cities, streets were narrow and in Pompeii for example, one-way traffic was common. Cities which were founded later, for example Xanten, had wider streets where two-way traffic was normal. Governments had to control traffic circulation by means of legislation, even if the streets were too narrow.

At no point should traffic flow be blocked or even hampered. If it happens, the existence of body and city comes into danger. Nowadays, if the city centre (in Dutch: 'stadshart', 'city heart') or the artery is unable to cope with traffic flow, we call it 'traffic congestion'[77] and 'traffic infarct',[78] threatening the existence of the city. In the Graeco-Roman world these phenomena were recognised, as shown by the measures taken to control traffic. [79]

Conclusion

It may be assumed that visible objects in nature or those built or installed by man, such as plains, gates and gate-keepers, already had a name before these were written down. In this introduction I have discussed six Greek words: ἔξοδος, κιών, ὀχετός, πεδίον, πύλαι and πυλωρός. Except for πεδίον, they also refer to civil engineering and architectural matters; in the case of πυλωρός, it is obvious that without the gate, there cannot be a gatekeeper at all.

From the 5th century BC onwards, new (internal) parts of the human body were continually being discovered and these needed a name. These names were derived from concepts already known, from macrocosm, on the basis of their appearance, and applied to microcosm. A portal vein evokes the image of an approaching road. This medical terminology is found from the end of the 5th century and the beginning

77 'Congestion' is derived from *congestio*, 'heaping up': *terrae congestio* (Vitr. 6.8.5). In the *Gesta Collationis Carthaginiensis* (411 AD) there is talk of *congestio populorum*. In medicine, in French it is mentioned ± 1370; in English ('congestion') ± 1634; in Dutch in 1624 in Dodonaeus' *Ars Medica* ('Abnormale opeenhooping van bloed') in a certain organ or tissue. As far as we know, in a traffic context, it is mentioned in English for the first time in 1883 ('congestion of traffic'; *Oxford English Dictionary* 1989[2]); in Dutch after 1970 (*Maritieme Encyclopedie* 2, 70 *b*); WNT. Also here it is compared with blood circulation; cf. Goudappel's observation at the beginning of this introduction.

78 'Infarct' is derived from *infarcire* or *infercire*, 'to stuff into' (Cic. *Or.* 69.231). In modern Latin we find the word *infarctus*, from which derive the French 'infarctus', English 'infarct' and 'infarction', German 'Infarkt' and Dutch 'infarct' (all 19th century), meaning 'obstructions in the lower part of the body, hardening of faeces'; nowadays the term is used for 'partial or total blockage of blood supply, causing degeneration of texture'. In traffic terminology, the word 'traffic infarct' is used only in the last decades – in the Dutch dictionary of Van Dale (1970[9]) it is not yet mentioned, but Goudappel uses the word 'congestie' (congestion). For the first time in a Dutch dictionary, it is mentioned in the Van Dale 1999[13] edition; according to an article in the Dutch newspaper NRC 11 January 2010, the first citation of 'verkeersinfarct' ('traffic infarct') is dated 3 August 1990, stressed by quotation marks; in the *Handelingen van de Tweede Kamer der Staten-Generaal* (*Proceedings of the Dutch Lower House of the States-General*), dated 19 December 1990, the word is used again, between quotation marks too. In German, 'Verkehrsinfarkt' was used earlier: http://weblogs.nrc.nl/woordhoek/2010/01/11/een-verkeersinfarct-tussen-guillemets. The term is strictly incorrect; a (medical) infarct is not the blockage itself, but the dying of an organ caused by the blockage. Sometimes infrastructure is too wide because traffic has decreased. Goudappel states that public transport was the victim of anaemia caused by the increased use of cars: Steÿn 2010, 42.

79 Especially the *Lex Julia Municipalis*, and other laws; Van Tilburg 2012, 128-136.

of the 4th century BC onwards, at the time that these concepts were written down; in other words, later than the civil engineering concepts. Some organs were already known by means of dissections on animals (which was reported in literature), such as the portal vein (monkeys were used as objects of research). Five of the six above-mentioned words refer to organs which are part of the digestive tract and four of these are internal, so invisible from the exterior (the fifth, the κιών, is almost visible). From macrocosm to microcosm.

From the 6th century BC onwards, new civil engineering constructions were being invented and utilised. Here the reverse took place: they obviously needed names and these names were derived from the names of parts of the human body. The linear measures, the κοιλία of the aqueduct and the *dorsum* of the road, came into existence. They are static, except for κοιλία; this concept refers again to the digestive tract and is dynamic. From microcosm to macrocosm.

It was relatively easy to acquire knowledge of anatomy by means of dissections on animals throughout history, and in Hellenistic Alexandria dissection on humans took place. During physiological research, the idea arose that movements in the body followed one-way routes (digestion and excretion tracts) or return-routes (the blood vessel system).

Unfortunately, there is little information on traffic in the Graeco-Roman period. There are no Greek or Latin words for 'one-way' or 'return', or 'traffic' in a general sense. Excavations, some statements in literature and in legislation prove that busy traffic was a problem in certain places and traffic control measures were needed. If the French and English words 'trafic' and 'traffic' are indeed derived from the Latin *transvehere* or *transvehi*, 'to convey over' or 'to transport', they refer to a 'one-way system'. The Dutch and German words 'verkeer' and 'Verkehr' refer to a 'return'. Neither in medicine, nor in civil engineering, ancient terms for 'circulation' or 'circuit' were in use, although the words κυκλοφορία and *circulatio* were used for different purposes.

Blood as the supplier of nutrients was already known in Antiquity, as is shown by the parable of Menenius Agrippa, but the *circulation* of blood was unknown at that time. It was only in the 17th century that this was discovered by William Harvey. From that time onwards, the idea arose that traffic flow in a city can be better compared with the circulatory system than with the digestive and excretion tracts, where 'one-way traffic' prevails. Terms concerning traffic which arose from the 19th century onwards and are still in use today, refer rather to the circulatory system: traffic circulation, traffic congestion, traffic infarct, artery, and bypass. Blood flow is crucial for the functioning of the human body, even more important than the flow of the contents of the bowel, or urinary flow.

Modern city planning and modern medicine are based on modern ideas and theories (from the 19th century onwards) – where medicine and city planning influenced each other; they are not based on ancient ideas and theories, but developed over a recent period. Nowadays, too, medical and civil engineering terms intermingle: the 'eye of the camera', 'he has a screw loose'. There is also the awareness that a city as well as a body always is in motion and should always remain in motion. I will end this introduction by citing Goudappel again:

'We should be aware that what has been said above concerning traffic is only part of the entire field of what we call communication and its most evident sonsequence: mobility. This *mobilitas*, mobility and variability, is the characteristic and even the condition for the existence of everything, in nature as well as in human culture. In all movements, there is a fusion of space and time. This mobility is expressed in what has been recognised as the human condition ever since Heraclitus: *Panta Rhei*: everything is in motion and has to be in motion. It is the basis of what we call development.'[80]

80 Goudappel, cited by Steÿn 2010, 7-8; translated by the author.

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