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On the Greek Physician Praxagoras from Kos  
and  
the Development of Medical Thinking in Antiquity

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## Abstract

The Greek physician Praxagoras from Kos was active around year 300 BC. He represents the transition between the Hippocratic and the Hellenistic periods in medicine. Praxagoras was the teacher of several renowned physicians active during the 3rd century BC. Although he wrote many books nothing of his writing has survived to our time. To learn about his teachings we must rely on fragments and testimonies from the first centuries CE. The lack of preserved texts maybe explains why so little has been published about Praxagoras in modern literature. Only two comprehensive books containing Greek texts with translation and comments have been published (Steckerl 1958 and Lewis 2017).

The aim was to try to understand why Praxagoras made such an impact in Antiquity within four well defined areas: The role of humors in health and disease, the anatomy of blood vessels, the pulse, and the role of pneuma (πνεῦμα). To better understand how he came up with his ideas it was necessary to investigate what ideas had been put forward before him by the presocratic philosophers, by Hippokrates and by Aristoteles.

I have searched the Greek literature available in the database Thesaurus Linguae Graecae for texts wherein Praxagoras is mentioned. In total he was mentioned 197 times.

Praxagoras put much emphasis on the role of humors in health and disease. When the body is in balance, blood is produced from food and man is healthy. When the body is in imbalance humors, especially cold vitreous phlegm, are produced detrimental to health. Praxagoras was probably the first to make a clear distinction between arteries and veins, morphologically and physiologically. He thought that the role of arteries was to distribute pneuma, warm moist air, from the heart to the periphery of the body. This distribution was accomplished by an intrinsic activity in the arteries causing them to pulsate. Praxagoras used the pulse in his diagnostics. He thought that obstruction of the transport of pneuma by phlegm in the arteries caused disease. Praxagoras main legacy lies in his distinction between arteries and veins and the use of the pulse in diagnostics.

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Keywords: artery/ies - ἀρτηρία/ι, humor/s - χυμός/χυμοί, innate - ἔμφυτος, nerve - νεῦρον, pneuma - πνεῦμα, pulse - σφυγμός, vessel/s - φλέψ/φλέβες.

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תודה!

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#### Abbreviations:

CMG - Corpus Medicorum Graecorum, DK – Diels-Kranz, fr./frs. – fragment/s, LSJ – Lidell, Scott, Jones, A Greek English Lexicon, RQ – Research Question, TLG - Thesaurus Linguae Graecae.

#### Editorial symbols in Greek text:

Square brackets [ ]: Enclose words or parts of words which are consistently transmitted in manuscripts, but according to the editor not present in the original manuscript.

Crux/cruces † †: Put in front of the corrupt word or if more than one corrupt word on both sides of the corrupt words. A lacuna in the text which the editor could not fill is marked with ... or < ... >. A word not present in the manuscripts, but by the editor supposed to be present in the original manuscript is marked with < >.

## Chapter 1 Introduction

### 1.1 Field of study

This project concerns Praxagoras, an influential Greek physician, who flourished around year 300 BC and whose contribution was not only his discoveries, but also his role as a teacher of a new generation of innovative physicians. He represents the transition between Hippocratic and Hellenistic medicine.

Καὶ ταῦτα μὲν ὁ Πραξαγόρας, ἀνὴρ οὐχ ὁ τυχῶν οὔτε ἐν τοῖς κατὰ τὴν ἰατρικὴν θεωρήμασιν, οὔτε ἐν τῷ ἄλλῳ βίῳ·

Rufus from Ephesos *Synopsis de pulsibus* ch. 2, sect. 3, l. 1-3 (Daremborg & Ruelle) Fr. 27b.

And this was set forth by Praxagoras, not a man of little importance, neither in the theories about medicine, nor in other aspects of life.

Καὶ πόσοι οἱ συστησάμενοι τὴν λογικὴν; πέντε. τίνες οὗτοι; Ἴπποκράτης ὁ Κῶος, Πραξαγόρας, Φλότιμος, Ἐρασίστρατος καὶ Ἀσκληπιάδης

Erasistratos *Med. Testimonia et fragmenta*, fragment 15, l. 1. (Garofalo) Fr.1b.

And how many were those who put together the logical (school)? Five. Who were they? Hippokrates from Kos, Praxagoras, Phylotimos, Erasistratos and Asklepiades

### 1.2 Aim

The aim was to try to understand why Praxagoras' contributions made such an impact in his time, while he was then almost forgotten after the first centuries CE. Since he was active in the broad field of medicine a limitation had to be made to those areas in which his contributions were most innovative. I have limited my investigation to four fields:

The role of humors in health and disease,  
the anatomy of blood vessels,  
the pulse,  
the role of pneuma.

To better understand how Praxagoras came up with his ideas it was necessary to investigate what ideas had been put forward before him by the presocratic philosophers, by Hippokrates and by Aristoteles.

The information about Praxagoras in modern literature is scarce. Two books have been published, Steckerl 1958 and Lewis 2017. Steckerl's book received much criticism for being too speculative. Lewis' book is a thorough review of arteries, pulse and pneuma, but does not deal with the role of humors. Thus, it could be fruitful to reinvestigate Praxagoras and his teaching to obtain a better understanding of his role in the development of medicine in Antiquity.

## Chapter 2 Background

### 2.1 General background

The dominating school of medicine in Greece during the late 5<sup>th</sup> and 4<sup>th</sup> century BC was associated with Hippokrates from Kos, considered to be The Father of Medicine. From the Hippocratic physicians some 60-70 treatises have been preserved and gathered in *Corpus Hippocraticum* (Craik, 2015, pp. 465-466). However, Hippokrates was not the only one who made contributions to the development of the medical field. The basis was laid by the natural philosophers (usually named the presocratic philosophers) who were interested not only in the composition of the universe, but also of the human body. After Hippokrates the knowledge of anatomy was considerably increased by Aristoteles.

To facilitate for the reader not familiar with Ancient Medicine a short background of the four areas of investigation is given.

#### 2.1.1 Role of humors

A son-in-law of Hippokrates introduced the humoral theory, which says that the body for its function is dependent of four humors: Blood, phlegm, and yellow and black bile.

Τὸ δὲ σῶμα τοῦ ἀνθρώπου ἔχει ἐν ἑωυτῷ αἷμα καὶ φλέγμα καὶ χολὴν ξανθὴν καὶ μέλαιναν, καὶ ταῦτ' ἐστὶν\* αὐτῷ ἢ φύσις τοῦ σώματος, καὶ διὰ ταῦτα ἀλγεῖ καὶ ὑγιαίνει.

*Corpus Hippocraticum De natura hominis*, ch. 4, l. 1-2 (Littre)

\* CMG: ταῦτά ἐστιν

The body has in itself blood and phlegm and bile, yellow and black; these make up the nature of his body, and because of these he feels pain or enjoys health. (Translation: W.H.S. Jones.)

#### 2.1.2 Anatomy of blood vessels

In the Hippocratic treatises the word φλέβες (blood vessels) was used without distinction between arteries and veins (Fredrich, 1899, pp. 70, 78). Aristoteles who made important contributions to the knowledge of anatomy could not dissect the human body and did not make the distinction between arteries and veins, although he saw the different buildup of the aorta and the vena cava in animals (Aristoteles *Historia Animalium* 513b7-9).

#### 2.1.3 The pulse

The Hippocratic physicians were good diagnosticians and especially skilled in foretelling the outcome of diseases. The pulsation of the vessels in the temples had been noticed, but the Hippocratic physicians did not realize its importance for their clinical practice (Littre, 1839, p. 241). Aristoteles discussed how the pulse was generated by the heart (*De respiratione* 479a30ff), but he had nothing to say about the use of the pulse as a diagnostic instrument (Furley & Wilkie, 1984, p. 19).

#### 2.1.4 Pneuma

It was evident to Greeks that breathing air (πνεῦμα) was necessary for life. Of course, the reason for this was not understood. When animals were investigated after sacrifice by Alkmaion from Kroton he noted that some vessels contained less blood than others (Fredrich, 1899, p. 67). It was supposed that pneuma, so necessary for life, was



transported by these vessels in a similar way as in the trachea ή τραχειά ἀρτηρία (the rough windpipe).

## 2.2 Material

### 2.2.1 Praxagoras and his writings

Praxagoras was the son of Nikarchos, also he (maybe) a physician (Bardong, 1954, p. 1735) from the Ionian island of Kos.<sup>1</sup>

Also Hippokrates was born on Kos. The population of Kos spoke the Doric dialect, but in their writings the Hippocratic physicians and presumably also Praxagoras used the East Ionic dialect. It has been assumed that Hippokrates was born around 460 BC and that he died in Thessaly at high age (Craik, 2015, p. xx). Galenos tells that Praxagoras lived shortly after Hippokrates.

καὶ μὴν Διοκλῆς ὁ Καρύστιος καὶ Πραξαγόρας ὁ Κῶος ὁ Νικάρχου, μικρὸν ὕστερον Ἴπποκράτους γεγονότες.

Galenos *De uteri dissectione* vol. 2, p. 905, l. 9-11 (Kühn) Fr. 13a.

And Diokles from Karystos and Praxagoras from Kos, son of Nikarchos, lived a short period after Hippokrates.

It has been suggested that he was born around 340 and that his floruit was around 300 BC (Steckerl, 1958, p. 2). Many authors placed Praxagoras besides Hippokrates and Diokles.

τὴν λογικὴν (scil. συνεστήσαντο) οἶδε Ἴπποκράτης, Διοκλῆς, Πραξαγόρας, Φυλότιμος, Ἐρασίστρατος, Ἀσκληπιάδης.

Diokles *Med. Fragmenta*, Fragment 13g, l. 2-4 (van der Eijk) Fr. 1a.

These created "logical" medicine: Hippokrates, Diokles, Praxagoras, Phylotimos, Erasistratos, Asklepiades.

He was the teacher of many physicians: Phylotimos, Pleistonikos, Xenophon from Kos and Herophilos (Steckerl, 1958, p. 3). According to Galenos he belonged to the dogmatic school<sup>2</sup>, which is the same as the "logical" school.

δογματικὸν μὲν γὰρ οἶδα καὶ Διοκλέα καὶ Πλειστόνικον καὶ Διευχῆ καὶ Μνησίθειον, Πραξαγόραν τε καὶ Φιλότιμον καὶ Ἡρόφιλον καὶ Ἀσκληπιάδην φλεβοτομοῦντας.

Galenos *De venae sectione adversus Erasistratum* vol. 11, p. 163, l. 3-6 (Kühn) Fr. 98a.

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<sup>1</sup> A search in TLG on Praxagoras reveals two other physicians with the name Praxagoras. The first, Praxagoras senior, was a pupil of Hippokrates and cannot be Praxagoras, son of Nikarchos, who lived much later. Galenos often adds the father's name Nikarchos, most probably to avoid misunderstanding. Another physician with name Praxagoras lived in Napoli during the time of Pompeius (according to Plutarchos in his book on Pompeius, ch. 57).

<sup>2</sup> The dogmatic school based their practice on a theory of the basic structure of matter and of the human body. Health and disease depend on this structure. A detailed knowledge of the human anatomy was important. They accepted the idea of causation; all events have a cause or causes. On this theoretical foundation therapy can be based. Another school was empiricism. These doctors denied the need of having a foundational theory or knowledge of anatomy. Their practice was based solely on experience, observation, history, and inference from analogy. Galenos discusses the advantages and disadvantages of both these schools. (According to Ian Johnston in the General Introduction to Loeb Classical Library, LCL 523: Galenos, On the Constitution of Medicine, pp. xxiii-xxiv.)

As regards the dogmatists, I know that Diokles, Pleistonikos, Dieuches, Mnesitheos, Praxagoras, Phylotimos, Herophilos and Asklepiades practiced phlebotomy.

It is not known in what part of Greece Praxagoras practiced. If he left Kos for the mainland of Greece it was probably not for Athens where Aristoteles was active at Lykeion during the years 335-323 BC. In no fragment is it indicated that Praxagoras was aware of the work of Aristoteles. Since there was a close contact between Kos and Alexandria during the reign of Ptolemaios I, it has even been speculated that Herophilos, the pupil of Praxagoras, got some of his training under Praxagoras in Alexandria (von Staden, 1989, p. 43).

Praxagoras was an influential authority in medicine for many centuries. It is probable that a "Praxagorean" school existed in Galenos' time (Steckerl, 1958, p. 2). Galenos wrote two books on Praxagoras' ideas, the first on *Humors* (fr. 21, see section 4.2.3 on humors), the second on *Mixtures*. This book has been preserved in Arabic by the scholar Hunain ibn Isaq (Steckerl, 1958, p. 13).

From available fragments it can be inferred that Praxagoras wrote the following books:

- Θεραπείαι (Περὶ θεραπειῶν) Therapies (fr. 111, four books)
- Πάθη Αἰτίαι Θεραπείαι Disease, causes, therapy (fr. 109)
- Περὶ Νούσων On diseases (fr. 81, three books)
- Αἱ Διαφοραὶ τῶν Ὁξέων Different kinds of acute diseases (fr. 61)
- Ἀνατομή Anatomy (fr. 10)
- Φυσικά Physics (fr. 13b)
- Νόσοι Ἄλλοτριοι (Περὶ τῶν ἀλλοτρίων παθῶν) Other diseases (fr. 63, two books)
- Περὶ Ἐπιγινομένων (Τὰ ἐπιγινόμενα πάθη) On supervening symptoms (frs. 86, 92)
- Περὶ Συνεδρευόντων (Τὰ συνεδρευόντα) On associated symptoms (fr. 90, two books).

The number of books is uncertain. Titles within parenthesis are from Pauly's RE (Bardong, 1954, p. 1736). It is doubtful if Αἱ Διαφοραὶ τῶν Ὁξέων was written by Praxagoras (Bardong, 1954, p. 1737). A book on humors Περὶ χυμῶν, not mentioned by Steckerl, is mentioned in Pauly (Bardong, 1954, p. 1736). Steckerl also listed Κατὰ τὸ προγνωστικόν Prognostics. This seems to be a mistake. According to fr. 94 this was a book by Hippokrates.

None of these books have been preserved until today. There may be several reasons for this. Generally, ancient books were no longer copied when they were not considered important. When it comes to medicine the competition from Galenos apparently became too strong. His opinions became so dominating that the books written by Diokles, Praxagoras, Herophilos, Erasistratos, and many others were no longer read. How then can the survival of some 60-70 books written by Hippocratic physicians be explained? Here again Galenos may be responsible. He was an (uncritical) admirer of Hippokrates (Jouanna, 2012a, p. 313). Even treatises which at his time were considered written by others than Hippokrates were considered Hippocratic by Galenos. Thus, it is understandable that the Hippocratic corpus has been preserved until today.

### 2.2.2 Fragments vs. Testimonies

To learn about Praxagoras and his ideas we must search for fragments and testimonies in preserved Greek literature written a long time after Praxagoras. True fragments are verbatim quotations. It is not an easy task to distinguish fragments from testimonies, which are citations, the origin of which is uncertain. These texts were written during the first and second centuries CE, thus more than 400 years after the writing of the initial texts. Although the names of the original books are known, it is not certain that these texts were available to and read by the authors citing them. Compilations of medical texts, such as the *Anonymus Parisinus*, were circulating and might be the source rather than the original work. Both Steckerl and Lewis decided to abstain from making a difference between fragments and testimonies.

In fact, only three texts may be considered direct quotations and thus proper fragments:

Fr. 10 which is a quotation from *Ανατομή*:

Πραξαγόρας δὲ ἐν τῇ Ἀνατομῇ οὕτως φησί· Μετὰ δὲ τὴν τῆς γλώττης ...  
(Scholia in Homerum *Scholia in Iliadem (scholia vetera)* Book of Iliad 22, v. 325, l. 8-9 of Scholion) (Heyne)

Praxagoras in his *Anatomy* says this: Between the tongue ...

And fr. 13b from *Φυσικά*:

καὶ ὁ Πραξαγόρας ἐν τῷ πρώτῳ τῶν φυσικῶν, κοτυληδόνες δὲ εἰσι τὰ στόματα τῶν φλεβῶν καὶ τῶν ἀρτηριῶν τῶν εἰς τὴν μήτραν φερουσῶν.  
Galenos *In Hippocratis aphorismos commentarii vii*, vol. 17b, p. 838, l. 15-17 (Kühn)

And Praxagoras in his first book on *Physics*, cotyledones are the mouths of veins and arteries which lead into the womb.

and fr. 13a probably from the same source, although not clearly stated by Galenos:

ὁ γὰρ τοι Πραξαγόρας ᾧδὲ πῶς φησι αὐταῖς λέξεσι· Κοτυληδόνες δὲ εἰσι τὰ στόματα τῶν φλεβῶν τῶν εἰς τὴν μήτραν ἠκουσῶν.  
Galenos *De uteri dissectione*, vol. 2, p. 906, l. 3-5 (Kühn)

Praxagoras verbally says as follows: Cotyledons are the mouths of the veins which lead into the womb.

Even in these cases a certain doubt is at hand due to slight differences in the exact wording between fr. 13a and 13b. In fr. 13a the words καὶ τῶν ἀρτηριῶν are missing and φερουσῶν is exchanged for ἠκουσῶν.

The practice to call also all the other texts (i.e. those that are testimonies in the true sense of the word) fragments was criticized by Schubring in his review of Steckerl's book (Schubring, 1961, p. 259). Another view was held by Lewis (Lewis, 2017, pp. 18-19) who does not make a distinction. According to Lewis the use of fragment or testimony regarding texts concerning the same author gives an evaluation of credibility, which is not always possible to defend due to the uncertainty about the way a certain text has been handled. von Staden writes: "one should guard against an undue exaggeration of the

value of fragments" (von Staden, 1989, p. xviii) and further: "it is not always clear that the evidential value of a fragment, at least in medical history, is greater than that of a testimonium" (von Staden, 1989, p. xix).

In the following the word fragment (fr.) is used to cover testimonies as well as fragments in the strict sense.

### 2.2.3 Ancient sources

Galenos is our most important source (some 80 frs., according to the classification of Steckerl; almost 40 of these frs. cited in this essay). The name Praxagoras can appear more than once in a certain fragment and many fragments come from the same treatise of Galenos, who apparently had access to many of the texts written by Praxagoras, no longer available to us. In addition, more than 10 texts of Galenos not mentioned by Steckerl have been cited herein.

Galenos was born in Pergamon 129 CE and started his career as doctor to the gladiators. His experience from this period gave him detailed knowledge of the human anatomy. He also performed dissections of monkeys and pigs. When he lived in Rome, he became physician to the emperors Marcus Aurelius and Commodus. Galenos was an extremely productive author and his texts amount to more than 10 per cent of the literature in Greek preserved from antiquity to the end the second century CE (Jouanna, 2012a, p. 313). In the first volume of C.G. Kühn's edition of all Galenos' works he writes: "Claudius Galenus, medicorum omnium post Hippocratem princeps ..." (Claudius Galenos the foremost of all doctors after Hippokrates ...)(Kühn, 1821, p. XXI).

Another important source is Rufus from Ephesos who lived in the time of Trajanus during the late first and early second century CE (5 frs). In his work *περὶ σφυγμῶν* (On pulsations) he described how the heart causes the arteries to pulsate. He also gave a detailed description on the effect of several diseased states on the pulse and was the first to describe the optic chiasma (Daremborg & Ruelle, 1879, p. III). Galenos considered Rufus to be one of the νεώτεροι, the new ones, in contrast to the old ones, οἱ παλαιοί, i.e. Hippokrates, Diokles, Praxagoras and Erasistratos. Most of Rufus' writings has not survived in full but only in fragments or, to be correct, as testimonies. Some can be found in Arabic translations. Thus, the testimonies ascribed to Rufus are secondary information, the credibility of which is difficult to determine. His work has been compiled by Daremborg and Ruelle (Daremborg & Ruelle, 1879).

Fifteen fragments are found in *Anonymus Parisinus*, also named *De morbis acutis et chroniis* (Garofalo, 1997), in TLG called *Anonymus Medicus*. This is a doxographic compilation of fragments, probably from the first century CE. The author is unknown, and it is not known if he based his reports on the originals or on intermediate sources. The only physicians mentioned by *Anonymus* are the four "ancients", οἱ παλαιοί, Hippokrates, Diokles, Praxagoras and Erasistratos, often mentioned together without distinction. van der Eijk considers that the reliability of *Anonymus* "should be valued relatively high" (van der Eijk, 2001, p. xvii).

Another source is the Pseudo-Aristotelian treatise *De spiritu*, estimated to be from the time period between Praxagoras and Erasistratos, i.e. in the beginning of the 3<sup>rd</sup> century BC

(Lewis & Gregoric, 2015, pp. 125-126). Praxagoras is not mentioned in this treatise, but because of the close temporal relation to Praxagoras, *De spiritu* represents our earliest first-hand evidence of ideas otherwise only known to us through later sources. For instance, the concept of pneuma as an important physiological agent and the distinction between arteries and veins (Lewis & Gregoric, 2015, p. 126). It gives complementary, and in some respects probably better information than the fragments from the first two centuries CE about the development of ideas from Aristoteles to the Alexandrian physicians (Lewis & Gregoric, 2015, p. 127).

A papyrus from the second century CE discovered in British Museum in 1893 called *Anonymus Londinensis*, does not mention Praxagoras (and only briefly Hippokrates) but is still of interest in the study of medicine from Hippokrates and onwards. This papyrus is also called the *Menon papyrus* since its content appears to be taken from the *Menoneia*, a collection of medical texts mentioned by Galenos as Ἱατρικὴ συναγωγή (Medical Collection) and attributed by some to Aristoteles, but in reality written by Aristoteles' pupil Menon.<sup>3</sup> The Greek text, a translation into English and a commentary has been published by W.H.S. Jones (Jones, 1947).

## 2.3 Earlier studies

### 2.3.1 Editions

The Greek texts found in TLG are used and the source given in Appendix II. For all texts I have sought the latest printed critical editions, listed below, for comparison. If differences were found, they are indicated after the cited text.<sup>4</sup>

C.G. Kühn, *Claudii Galeni opera omnia*, 22 volumes, Leipzig, 1821-1833 used to be the standard edition of Galenos' writings. This edition does not have a critical apparatus and newer editions are today available for many of his texts. Thus, some of Galenos' texts in TLG have other editors and some have been examined as part of academic dissertations in the early 20<sup>th</sup> century. The following treatises can be found in critical editions in CMG and were all used by TLG:

*De uteri dissectione*, editor D. Nickel, CMG V 2,1

*De atra bile*, editor W. de Boer, CMG V 4,1,1

*De placitis Hippocratis et Platonis*, editor Ph. De Lacy, CMG V 4,1,2

*De bonis malisque sucis*, editor G. Helmreich, CMG V 4,2

*In Hippocratis Prorrheticum I commentaria II*, editor H. Diels, CMG V 9,2

*In Hippocratis De natura hominis commentaria III*, editor J. Mewaldt, CMG V 9,1.

A critical edition of *De utilitate respirationis* and *An in arteriis natura sanguis contineatur* has been published by Furley and Wilkie (Furley & Wilkie, 1984).

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<sup>3</sup> πάρεστί σοι τὰς τῆς Ἱατρικῆς συναγωγῆς ἀναγνῶναι βίβλους ἐπιγεγραμμένα μὲν Ἀριστοτέλους, ὁμολογουμένας δὲ ὑπὸ Μένωνος, ὃς ἦν μαθητὴς αὐτοῦ, γεγράφθαι, διὸ καὶ Μενώνεια προσαγορεύουσιν ἔνιοι ταυτὶ τὰ βιβλία.

Galenos *In Hippocratis de natura hominis librum commentarii iii* vol. 15, p. 26, l. 14-18 (Mewaldt)

You can read the books of the Collection on Medicine, attributed to Aristoteles, but agreed by everyone to have been written by Menon, who was his pupil and therefore some people call these the Menoneia.

<sup>4</sup> The only difference making a significant change of the meaning was found in fr. 85, section 4.3.3, p. 44-45.

A critical edition of *De plenitudine* has been published by Christoph Otte (Otte, 2001).

E. Littré, *Oeuvres complètes d'Hippocrate*, 10 volumes, Paris, 1839-1861 has been the standard edition of *Corpus Hippocraticum*. Littré studied all manuscripts available in his time. Newer editions are today available for some treatises. The following treatises can be found in CMG:

*De prisca medicina* (= *De vetere medicina*), editor J.L. Heiberg, CMG I, 1

*De alimento*, editor J.L. Heiberg, CMG I, 1

*De natura hominis*, editor J. Jouanna, CMG I, 3

A critical edition of *De prisca medicina* has been published by Jouanna (Jouanna, 1990).

The texts of *Anonymus medicus: De morbis acutis et chroniis* (= *Anonymus Parisinus*), are from a critical edition published in Italian by Garofalo, and now available with an English translation by Brian Fuchs (Garofalo, 1997).

The Aristotelian works have been published by several editors as indicated in Appendix II. They are ordered and paginated according to Immanuel Bekker 1831-1870.

All cited texts of Aristoteles can be found in Loeb Classical Library, i.e. *De generatione et corruptione*, *Historia animalium*, *De generatione animalium*, *De partibus animalium* and *De respiratione*. Although newer editions are today available for some texts those found in Loeb Classical Library must be considered sufficient for the present purpose.

The cited work of Platon, *Timaeus*, is paginated according to Stephanus 1578.

It can be found in Loeb Classical Library.

The fragments of the presocratic philosophers have been published by Diels and Kranz 1951, 1960 and by Diels 1965 and can also be found in Loeb Classical Library.

The fragments of Diokles have been published by P.J. van der Eijk 2000.

### 2.3.2 Studies on Praxagoras

There is a vast modern literature about medicine in Ancient Greece, starting from the 19<sup>th</sup> century up till now. Most concerns the Hippocratic physicians (Craik, 2015; Jouanna, 1999) and fairly little is about Praxagoras.

A biography of Praxagoras, his writings and his teaching can be found in Pauly's Realencyclopädie der classischen Altertumswissenschaft (RE) (Bardong, 1954). In RE it is stated that "Praxagoras der Große gehört somit einem Zweig des alten koischen Fürstengeschlechtes der Asklepiades" (Praxagoras the Great thus belonged to a branch of the aristocratic Asklepiades family) (Bardong, 1954, p. 1735). It is stated that it can be taken for granted that Galenos had access to Praxagoras' original writings, even if he "aus praktischen Gründen zu einer Exzerptsammlung gegriffen haben" (for practical reasons used a collection of excerpts) (Bardong, 1954, p. 1737). Short summaries are given about Praxagoras' teachings on physiology, anatomy, pathology, therapy, dietetics, and pharmacology.

E.D. Baumann published an article with the title "Praxagoras von Kos" (Baumann, 1937). Several pages concern cotyledones. The style is quite ranting. He comments the obvious mistakes made by Praxagoras, when compared with today's knowledge, with many

exclamation marks. Thus, he is in many respects critical of Praxagoras. When it comes to the pulse, just to take one example, he writes: “Praxagoras hat also die Lücke in der Symptomatologie angefüllt, freilich noch ein wenig dürftig” (Thus Praxagoras has filled a gap when it comes to symptomatology, admittedly still a little poor)(Baumann, 1937, p. 174).

Fritz Steckerl published a compilation of fragments with translation and comments in 1958 (Steckerl, 1958). Immediately after its publishing, his book received serious criticism by two authors, Schubring (Schubring, 1961, pp. 258-263) and Kühn (Kühn, 1962, pp. 132-137). Steckerl was criticized not only for poor philology, but also for poorly based speculations, e.g. regarding the role of pneuma in Praxagoras’ thinking. Steckerl had argued that the respired air, after mixing with moisture which was generated during digestion, constituted the soul (Steckerl, 1958, pp. 20-21). This view was criticized later also by Nickel (Nickel, 2005, p. 316), Lewis (Lewis, 2017, p. 253) and Furley (Furley & Wilkie, 1984, p. 22). The criticism to Steckerl’s book will be further discussed in sect. 5.1.

Then almost nothing was written on Praxagoras until Orly Lewis defended her PhD-thesis at the Humboldt-Universität zu Berlin in 2014 and subsequently expanded the thesis to a full book with the Greek texts, translations and comments (Lewis, 2017). Lewis concentrated on arteries, pulse, pneuma and Praxagoras’ ideas about the cause of some diseases. She did not discuss the humoral theory. Her book has been reviewed by four authors.

Jessica Wright in a review in *Bryn Mawr Classical Review* began her review with the following sentence: “Frustratingly little has been written on the medical author Praxagoras of Cos” (Wright, 2017).

Christopher Gill in his review wrote: “This book clearly marks an important advance in our understanding of this significant, but rather obscure, figure and his place in the history of Hellenistic medicine and anatomy”(Gill, 2018, p. 214).

Vivian Nutton, in his review of Lewis’ book, which he finds excellent, writes that Praxagoras “occupies a pivotal place in the history of ancient medicine” (Nutton, 2018, p. 378).

Finally, Daniela Manetti in her review, points out that after Steckerl’s book no thorough study of Praxagoras’ studies has been produced before Lewis’ book, which is “in a way surprising, because Praxagoras has always been considered a turning point in the history of medical and philosophical thought of the fourth century BC” (Manetti, 2019, p. 241).

### **2.3.3 Studies on medicine in Antiquity**

Of the vast literature concerning medicine during Antiquity only little concerns Praxagoras compared with other ancient physicians. Nevertheless, pieces of information can be found in many sources. The following books have been especially useful for me when writing this essay, and they will be referred to in the text when appropriate: Craik 2015, Daremberg & Ruelle 1879, Fredrich 1899, Jones 1923, Jones 1947, Kirk et al. 2013, Lewis 2017, Littré 1839, Longrigg 1993, Nutton 2004, von Staden 1989, Steckerl 1958.

## Chapter 3 Method and theory

From a philosophy of science perspective, this study will be inductive. It will be a study of meaningful phenomena in ancient literature needing interpretation. It will be idiographic and qualitative. It could also involve critical text analysis, but that is beyond the scope.

### 3.1 Classical philology

The definition of philological method has varied over time. The original definition was “studies committed to the historical knowledge of Antiquity” (Landfester, 2006).

A prerequisite for this type of study is to approach the text with an open mind without theoretical preconceptions (Schaps, 2011, p. 126). Concepts themselves are cultural products (Carlshamre, 2020, p. 83). There is an immanent risk of anachronistic interpretation, when the subject seems familiar to the reader (Lloyd, 1992). The study of medical or anatomical problems in antiquity were performed in an environment so different from ours that mistakes in interpretation are almost inevitable. However, the awareness of this possibility at least lessens the risk (Kovacs, 1993, p. 410). At the same time, this opens the possibility to reevaluate what has previously been written on the subject studied. This goes especially for Steckerl’s book.

#### 3.1.1 Textual criticism

Textual criticism concerns the trustworthiness of the manuscripts as witnesses of the original texts (Reynolds & Wilson, 1991, p. 207). The goal is to restore as closely as possible the text as it had been written in the original manuscript before its transmission from late Antiquity and the Middle Ages to modern times. The first step in this procedure is *recensio* during which the available manuscripts are evaluated to find the most primitive text (Reynolds & Wilson, 1991, p. 207). The second step is to decide if that text is authentic or not (*examinatio*) to be able to correct possible corruptions that have occurred during its transmission through the centuries from papyri through parchment codices to versions printed on paper (*emendatio*) (Reynolds & Wilson, 1991, p. 208).

We must be aware that “the data we have to work with have already been extensively processed: by the selectivity of the evidence, mostly literary, that has survived, by the vagaries of transmission, by the pressures of constant reinterpretation” (Lloyd, 1992, p. 567). Giovanni Lamola (ca. 1407-1449) wrote about the work of scribes: “*Multa non intellexerunt, multa abraserunt, multa mutarunt, multa addiderunt*” (There is much they have misunderstood, much they have deleted, much they have altered, and much they have added) (Landfester, 2006). However, some texts are more stable than others after a certain point, but it is beyond the scope of this essay to make that evaluation.

It may suffice to note that naturally many mistakes were made during the copying of texts. Occasionally, scribes even incorporated glosses into the original text (Clemens, 2007, p. 39).

The database TLG does not have a critical apparatus. However, many cited texts in TLG are from the critically evaluated texts in *Corpus Medicorum Graecorum* (<http://cmg.bbaw.de>). Other texts are available in later critical editions as reported above in section 2.3.1 and have been compared with those. A few minor differences have been noted and are reported after the texts.



To get a full understanding of Praxagoras' work is certainly not possible. We do not know how much of his writings has been lost. Not even during the first centuries CE is it certain that the majority, or even a large part was available to an interested public. Those teachings which had gained acceptance in the medical community were probably friendly reported, while controversial opinions might have either been totally dismissed or just improperly quoted. These circumstances must be considered when one tries to summarize what the fragments tell us (Lewis, 2017, p. 299).

The first lesson is to keep close to the wording of the fragments, while avoiding conjectures not based on the text. Steckerl's work (Steckerl, 1958), impressive as it is, was without a doubt damaged by his many unfounded guesses. His translations are not always accurate.

The second task is to try to understand to what extent our sources may give a skewed account of what the author tells us. An inherent problem is to distinguish what was the opinion of Praxagoras and what was the opinion of our dominating source, Galenos. Finally, it is essential to be aware of the fact that the millennia dividing us from Praxagoras' world open up for mistakes of linguistic and conceptual art.

### 3.1.2 Trustworthiness of authors

No texts from the hand of Praxagoras have been preserved until today. We therefore must rely on texts that have been written by authors who had in their time access to the writings of Praxagoras. Evidently there are pitfalls in the interpretation of such secondary information. It was customary for authors in the first centuries CE to cite ancient authors, especially when these corroborated their own views. Although a correct reproduction of the initial author's meaning could be anticipated this is by no means certain. If divergence in opinion existed between the authors a distortion of the original message is always a possibility. Some topics, e.g. the humors in man, were discussed by more than one author and their reports can therefore be compared, see below in section 4.2 on humors.

The dominating source is Galenos. His works have been preserved to a large extent because generations of physicians after him regarded them as very valuable. Galenos as a source is not unproblematic. It is often difficult to separate his own opinion from that of the author he refers to. "Galen is notorious for such misrepresentations and generalization of earlier opinions for the sake of neatness or in order to support his own doctrines" (Lewis, 2017, p. 257). Furthermore, his impartiality can be questioned. He "usually discusses his predecessors' views in a vigorously polemic context" (Nutton, 2018, p. 378). A similar judgement is made by Otte (Otte, 2001, p. 3).<sup>5</sup>

One obvious problem is that Galenos held Hippokrates in high esteem:

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<sup>5</sup> "In Anbetracht dieser Geisteshaltung Galens sieht man leichter darüber hinweg, daß er sich gelegentlich verhält, als wisse er alles besser, und daß man den Verdacht kaum verdrängen kann, daß den Thesen seiner Kontrahenten manches Mal keine gerechte Behandlung widerfährt, sei es durch zu knappes Zitieren, sei es durch seine eigenwillige, wenn nicht sogar mutwillig mißverstehende Interpretation." (In view of Galenos' attitude of mind, it is easier to overlook the fact that he occasionally behaves as if he knew everything better, and that one can hardly suppress the suspicion that the theses of his opponents are sometimes not treated fairly, be it by quoting too succinctly, be it through its idiosyncratic, if not willfully misinterpreted, interpretation.)

Ἱπποκράτης μὲν οὖν φαίνεται καλός τε καὶ ἀγαθός τις ἀνὴρ γεγονέναι, μὴ φιλοτιμίας ἢ φιλοδοξίας, ἀλλ' ἀληθείας ἐραστής.  
Galenos *De atra bile* vol. 5, p. 130, l. 14 - p. 131, l. 1 (De Boer)

Hippokrates was a noble man, a lover not of honors and concern for his reputation, but of truth.

One reason for this praise of Hippokrates was Galenos' fight with contemporary sects of physicians who did not accept the doctrine of the humors (Roselli, 2016, p. 331). "To his mind the sects were the root of the most serious evil affecting medical *tekhnē*", while Hippokrates represented the supreme of an ideal past (Roselli, 2016, p. 334).

Galenos was convinced that many of the treatises in *Corpus Hippocraticum* were in fact written by the historic Hippokrates. Some of his works are comments to Hippokrates in which he cites the original work line-by-line before he comments on them (ἐξηγήσεις καθ' ἑκάστην αὐτοῦ λέξιν) (Jouanna, 2012a, p. 316). However, Galenos often had a polemic attitude to some of his forerunners. This is especially evident when it comes to Erasistratos with whom he had considerable disagreements due to Erasistratos' supposed "rivalry with Hippokrates".

ἀλλ' Ἐρασίστρατος ὑπὸ τῆς πρὸς Ἱπποκράτη φιλονεικίας οὐδὲ τὰς κοινὰς ἀπάντων ἀνθρώπων ἐννοίας φαίνεται διασώζων.  
Galenos *De venae sectione adversus Erasistratum* vol. 11, p. 168, l. 9-10 (Kühn)

But Erasistratos because of his **rivalry with Hippokrates** seems not to have safeguarded even the opinions common to all men.

His attitude towards Praxagoras seems more tolerant, even if he sometimes says that Praxagoras "is blind", as in fr. 11 (see section 4.3.3 on blood vessels). Furthermore, he often groups the ancient doctors and attributes the same opinions to them all, without differentiation and this can make evaluation of a single persons view difficult (see e. g. frs. 6, 16, 20, 21, 35, 45, 49). It is also doubtful if he had in fact read all the authors he is referring to (Nutton, 2004, p. 123). Even if he was a wealthy man, book-rolls were expensive and above all not easy to get hold of, and impractical to read (in comparison with the codex format, where pages can be easily turned over) (Reynolds & Wilson, 1991, p. 2). This also means that quotations sometimes were made from memory giving room for mistakes (Reynolds & Wilson, 1991, p. 220). It is possible that some of Galenos' information came from compilations, doxographical summaries, such as *Anonymus Parisinus* (Garofalo, 1997; Nutton, 2004, p. 123). In that collection Praxagoras is cited 15 times. Bardong does not doubt that Galenos had the possibility to read the original texts of Praxagoras. However, it is probable that he in reality used an "Exzerptsammlung" (Bardong, 1954, p. 1737).<sup>6</sup>

### 3.1.3 Definition of terms

When we read fragments from the 2<sup>nd</sup> century CE referring to texts written in the 3<sup>rd</sup>

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<sup>6</sup> Galenos war daher in der Lage, die Originalstellen einzusehen. Bei seinen Zitaten und Verweisen wird er aber aus praktischen Gründen zu einer Exzerptsammlung gegriffen haben, die nach sachlichen Gesichtspunkten geordnet war. (Galenos was therefore able to see the original passages. For practical reasons, however, he must have resorted to a collection of excerpts for his quotations and references, which were arranged according to topics.)

century BC, we must be aware of the difficulty in interpreting these texts. It is easy to underestimate the difficulty to establish the intention of the initial writer. Conclusions we reach are always subjective in the sense that they reflect preconceptions, both those of the quoted author and our own (Lloyd, 1992, p. 565). Furthermore, there is always a risk of anachronisms. This is especially true if the Greek word has been transposed to our modern nomenclature, a problem not only for medicine, but generally. The Swedish philologist Jesper Svenbro wrote, with regard to the translation of the Swedish word "elementär": "Swedish is here mined with terms originating in latin ..... which risk to distort the linguistic repertory of the original" (Svenbro, 2022, p. 128).<sup>7</sup>

To find the lexical meaning of a certain word may be the most trivial undertaking. However, it is well known that many words, both common vocabulary and technical terms, or words that functioned (also) as technical terms, changed their meaning over the years. Good example is the word ἀρτηρία. The initial meaning of the word ἀρτηρία is windpipe (i.e. trachea), in plural ἀρτηρίαί bronchial tubes (LSJ) (Liddell & Scott, 1889). Homeros, Hippokrates, and Aristoteles all used the word in that sense. To complicate it further, the bronchi are sometimes named ἀρταί (= βρόγχια, LSJ). Before Praxagoras differentiation between arteries and veins was not common. All vessels were called φλέβες (LSJ: φλέψ = blood-vessel, whether vein or artery). Praxagoras used the word φάρυγξ for the trachea and ἀρτηρίαί for arteries.

Another word which can cause confusion is neuron (LSJ: νεῦρον = sinew, tendon, cord made of sinew). In Homeros νεῦρον simply means cord, string, or tendon. In *Corpus Hippocraticum* the words τόνος and τένων are also used for tendon (LSJ). The concept of nerves was still unknown to Hippokrates. Aristoteles also uses the word νεῦρον when he refers to tendon. When Praxagoras uses νεῦρον it most likely means tendon, although this is unclear. When Erasistratos uses the word, he means nerve (LSJ). Littré summarizes the confusion of terms:

On a là un nouvel exemple de ces confusions de la vieille anatomie: de même que, veine, artère, bronche, uretère même, tout cela a eu le nom commun *de veine*, sans exclusion d'un nom particulier, de même, nerfs, tendons, muscles, tout cela a été considéré comme de même nature (Littré, 1839, p. 235).

We have here a new example of these confusions of the old anatomy: just as vein, artery, bronchus, even ureter, all this had the common name of vein, without exclusion of a particular name, likewise, nerves, tendons, muscles, all of this was considered to be of the same nature.

When Praxagoras describes the pulsation of arteries he, according to those who quoted him, uses four words: σφυγμός, παλμός, σπασμός and τρόμος.

The meaning of these words according to LSJ:

σφυγμός throbbing of inflamed parts, beating of the heart, pulsation  
παλμός quivering motion, pulsation, throbbing, palpitation of the heart, twitching  
σπασμός convulsion, spasm  
τρόμος trembling, quaking, quivering

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<sup>7</sup> Svenskan är här minerad med latinrotade termer ..... vilka riskerar att förvanska originalets språkliga register.

The exact meaning of these different terms when used by Praxagoras is not evident and will be discussed in section 4.4 on the pulse below.

Other words that cause difficulties when translated to English are those concerning air. There are at least five main terms for air, breath/wind namely: ἀήρ (aer), αἰθήρ (aither), πνεῦμα (pneuma), φῦσα (phusa) and ἄνεμος (anemos), in addition several minor ones (Lloyd, 2007, p. S136). There was probably a certain difference between ἀήρ and αἰθήρ, the former representing the lower, hazy atmosphere, αἰθήρ representing the higher, clear sky. Empedokles used both terms in his theory about the four roots. The regular word for wind was ἄνεμος. Φῦσα comes from the word to blow, to puff and was the word for blast. Πνεῦμα means breeze and breath/respiration, but also spirit and inspiration (Lloyd, 2007, p. S137).

Since πνεῦμα is a central concept in Praxagoras' teaching a correct interpretation is essential. Πνεῦμα can undergo change in the body and become ἀτμῶδες (LSJ: = ἀτμιδῶδης vaporous). One cause of disease is development of bubbles, πομφόλυγες (LSJ: πομφόλυξ bubble), in the arteries. For further discussion of πνεῦμα, see section 4.5. An even more delicate problem is to ascertain what concepts are associated with words to which we normally give a simple meaning. A good example is given by the Greek words for hot, cold, moist, and dry (LSJ: θερμός, ψυχρός, ὑγρός and ξηρός). These adjectives are central in the Greek conception, not only for the composition of the world, but also for the composition of the body. To us they are just adjectives representing qualities, but evidently not so to the ancient Greeks. To them, these words sometimes must be interpreted as representing the elementary qualities of the four bodies fire, air, water, and earth. These bodies (σώματα) according to Aristoteles are composed of combinations of the elementary qualities: θερμόν and ξηρόν (fire), θερμόν and ὑγρόν (air), ψυχρόν and ὑγρόν (water), ψυχρόν and ξηρόν (earth). Nutton uses the word 'form' (p. 115) or element (p. 118) without a clear distinction (Nutton, 2004).

In his introduction to Aristoteles' *Historia Animalium*, A.L. Peck translates τὸ ὑγρὸν καὶ τὸ ξηρόν with "fluid substance and solid substance", rather than "moist" and "dry", which is commonly used:

"Actually, neither pair of English words fully expresses the Greek meanings. – The application of these terms as adjectives, e.g. "fluid" to flesh, blood, fat etc., "solid" to skin, sinew, bone etc., (see *Historia Animalium* 487 a 2 ff.), indicates that these things exhibit the qualities concerned and are largely composed of these substances" (Peck, 1965, p. lxx).

The (formidable) task at hand when one tries to interpret the ancient texts was formulated by Littré (who cites another author)(Littré, 1839, p. xiii):

La critique et l'interprétation, ne sont, à proprement parler, rien de plus qu'un moyen d'obtenir la correction et le vrai sens d'un texte. La critique s'arrête du moment que ce but a été atteint. Mais former l'esprit et le goût à l'aide des Anciens, en tirer, pour son profit, des connaissances précieuses, et faire servir, avec un juste sentiment de l'application, ces connaissances à l'utilité du temps présent, ce sont là des motifs et un attrait impérissable qui toujours nous exciteront à l'étude de l'antiquité.

(Criticism and interpretation are, strictly speaking, nothing more than a means of obtaining the correctness and true meaning of a text. Criticism stops when this goal has been achieved. But to find the spirit and the taste with the help of the Ancients, by drawing from them, for its own

profit, valuable knowledge, and to serve with a just sense, this knowledge for the usefulness at the present time, there are motives and an imperishable attraction which will always excite us to the study of antiquity.)

The problem of interpreting old texts is not a modern problem. Galenos, living more than 400 years after Praxagoras, sometimes expresses irritation of the complexity in Praxagoras' texts. In the following example he criticizes Praxagoras for his analysis of the pulse by palpation:

ἀλλ' οὐδαμῶς πάθος αἰσθήσεως ἐπεισάγει κοινόν. αἰνιγμα γὰρ ἂν οὕτως τὸν λόγον ποιήσειεν, ἵνα τις ἀναγινώσκων, εἶτα μὴ νοῶν, οἴηται τι βύθιον ἐγκεκρύφθαι τῷ λόγῳ καὶ θαυμαστόν, εἶτα κατατριβῆται δηλαδὴ, ζητῶν μὲν διὰ παντός, εὐρίσκων δ' οὐδέν.  
Galenos *De dignoscendis pulsibus libri iv*, vol. 8, p. 941, l. 19 – p. 942, l. 4 (Kühn) Fr. 84.

But he does not refer to any common sense-perception. He thus makes his statements such a riddle that one who reads his book without making out the sense believes that something deep and marvelous is hidden in his words. And so he clearly wastes his time, since he searches everywhere without finding anything.

The same can be said about Galenos himself, who tends to construct complex sentences.

One conclusion that could be made considering the difficulties to express "l'esprit et le goût" summarized above, would be that "it is often necessary to keep many important terms untranslated, allowing their significance to emerge from the examples of their use" (Lloyd, 1992, p. 566). That principle will be adhered to in the following regarding the words πνεῦμα and νεῦρον, for the reasons given above.

### 3.1.4 How can Praxagoras' opinions be differentiated from those of the quoting authors?

This is a crucial point in the evaluation of existing fragments. However, no general solution is at hand. Each fragment presents its own problems.

Galenos is the most problematic source, as already discussed above. Sometimes it can be understood from the text that there is a conflict of interest and then caution is needed when interpreting. Sometimes obvious enthusiasm and praise is also a reason to be cautious. When referring to Hippocrates, Galenos sometimes tries to interpret the Hippocratic texts to agree with his own views.<sup>8</sup> A good example of Galenos' method is his commentary on the Hippocratic treatise *The Nature of Man*. The authenticity of this treatise was discussed already in Galenos' time. In his commentary to this book, which has three parts, he argues that the first and the last parts are genuine and written by Hippocrates himself, while the middle part should have been written by his pupil Polybos. Galenos argues that the middle part is a forgery made up to increase the price of the whole book when it was sold to the library in Alexandria or Pergamon. He then disregards from the best witness of authorship, namely Aristoteles, who cites the description of blood vessels

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<sup>8</sup> Jones, W.H.S.: "Galenos' ideal of a commentator is beyond criticism. He prefers ancient readings, even when they are the more difficult, and corrects only when these give no possible sense. In commentating he is of opinion that he should first determine the sense of the text and then see whether it corresponds with the truth. Unfortunately he is not so successful when he attempts to put his ideal into practice. He is intolerably verbose, and what is worse, he is eager so to interpret Hippocrates as to gain support therefrom for his own theories". P. xli Jones, W. H. S. (1923). *Hippocrates with an English translation*. (Vol. I). William Heinemann Ltd and Harvard University Press.

in *Historia Animalium* (512b12 ff) and attributes it to Polybos. See Jouanna (Jouanna, 2012b, pp. 321-322) for a detailed discussion on this subject.

### 3.2 Implementation

The texts in which Praxagoras' name occurs in Greek were found by search in the data base *Thesaurus Linguae Graecae* (TLG) (<https://stephanus.tlg.uci.edu>). In total 197 of 249 quotations concerned Praxagoras from Kos (Appendix I). Only one fragment was found not mentioned by Steckerl. (The texts from Latin sources, in total 29, were not analyzed by me other than in translation due to my not deep enough knowledge of Latin. Almost all of them concern therapeutics (curatio) and do not fall within the four areas of this investigation.)

The names of Greek authors and places are given in their Greek form, not the latinized or English (e. g. Galenos, not Galenus or Galen), and for the sake of uniformity even in citations of modern authors when they used the latinized or English versions.

The numbering of fragments used by Steckerl (Steckerl, 1958) is used for identification, denoted fr. When Steckerl gave the same number to more than one fragment, they have in this essay been identified by number plus letter, as seen below.

The fragments cited herein were grouped into the four study groups (and are specified in the corresponding section below):

The role of humors: 29 frs.

The anatomy of blood vessels: 17 frs.

The pulse: 13 frs.

The role of pneuma: 8 frs.

(11 of these frs. concern more than one topic.)

Sources are given by their Latin names as they appear in TLG, and not by abbreviations otherwise used, to facilitate reading for those not familiar with those abbreviations. Book, section, page, and line(s) are presented as they are found in TLG. An index of cited ancient authors and their sources is shown in Appendix II.

#### 3.2.1 Translation

The English translations of Praxagoras' fragments made by Steckerl in his book have been used here if nothing else is stated. Sometimes his English is awkward and had to be corrected and if major changes have been made this is stated within parenthesis. When no printed translation could be found in Loeb Classical Library (e.g. regarding texts from *Corpus Hippocraticum*) the translations are mine. Most translations of Aristoteles' works are from Loeb Classical Library and the translator indicated. In some cases an existing translation has been adapted by me and indicated as such. In some cases translations made by Lewis (Lewis 2017) or by Brian Fuchs in the English translation of Garofalo's book on *Anonymus Parisinus* (Garofalo, 1997) have been used and indicated as such. The translations of texts from *Anonymus Londinensis* are from Jones 1947.

#### 3.2.2 Presentation of the material

All texts which are the basis of this investigation are presented with the Greek text, its origin, and the English translation. Focus to a certain wording is given by **fat font**.

Relevant information about the context, interpretation of the meaning of the text and my comments are given before and after each text.

### 3.3 Research questions

Two research questions were formulated:

**RQ 1:** How did medical thinking develop from the presocratic philosophers until the end of the fourth century BC, within these four areas: The role of humors (and the composition of man), the anatomy of blood vessels, the pulse, and the role of pneuma?

**RQ 2:** Which new knowledge and which theories were introduced by Praxagoras in these areas?

**RQ 2** is the **main question**, but Praxagoras' contribution cannot be evaluated without knowledge of the previous history.

## Chapter 4 Praxagoras' teachings

### 4.1 Motivation for the choice of areas for investigation

Praxagoras was active in the broad field of medicine<sup>9</sup>, and it would be impossible to cover all these areas in this essay. A selection had to be made. Which criteria could then be most appropriate for this selection? The most cited areas would be an easy, but trivial choice. His principles for treatment of different diseases could be interesting although the relevance is doubtful. It seemed most appropriate to investigate Praxagoras' most innovative teachings which also left a legacy to coming generations. Thus, the role of humors, the anatomy of blood vessels, the pulse, and the role of pneuma were chosen.

The last three topics, i.e. blood vessels, pulse and pneuma are closely interconnected, but are in the following treated separately to begin with and then finally discussed together.

### 4.2 On humors

#### 4.2.1 Earlier concepts

The Pythagorean philosophers in the 5th century BC were the first to take interest in medicine. Alkmaion from Kroton thought that health depends on balance (ισονομία) between certain opposites and that disease follows because of imbalance between these opposites.

Αλκμαίων τῆς μὲν ὑγείας εἶναι συνεκτικὴν τὴν ἰσονομίαν τῶν δυνάμεων, ὑγροῦ, ξηροῦ, ψυχροῦ, θερμοῦ, πικροῦ, γλυκέος καὶ τῶν λοιπῶν, τὴν δ' ἐν αὐτοῖς μοναρχίαν νόσου ποιητικὴν·

Ps-Plutarkos, *Placita philosophorum* 5.30 (Alkmaion Fragmenta 4, D. 442)

Alkmaion says that health is hold together by **the balance** between the forces, moist, dry, warm, bitter, sweet and the rest, but dominance among them causes disease.

Philolaos thought that bile, blood, and phlegm are the causes of disease.

Φιλόλαος δὲ ὁ Κροτωνιάτης συνεστάναι φ(ησίν) τὰ ἡμέτερα σώμ[ατα ἐκ] θερμοῦ. λέγει δὲ γί(νεσθαι) τὰς νόσους διὰ τε χολὴν καὶ αἷμα καὶ φλέγμα, ἀρχὴν δὲ γί(νεσθαι) τῶν νόσων ταῦτα·

Anonymus Londinensis *Iatrica* sect 18, l. 8-10, 30-32 (Diels)(Jones p. 70, 72)

Philolaos from Kroton says that our bodies are composed of heat. Diseases arise, he holds, through **bile, blood, and phlegm**, and these are the origin of diseases. (Translation: Jones, ad loc.)

Empedokles from Akragas (Agrigentum in Sicily), who was both a philosopher and a healer, was the first to describe more than one element as building components, not only

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<sup>9</sup> Among other fields: The anatomy of the human body, based on experience with dissection (not of humans, but animals). The role of humors. The role of different diets (e.g. water, wine, bread, peas, beans). The role of the pulse in diagnosis. The role of breathing. The role of the kidneys. The origin of semen. Symptoms and associated signs of diseases. Prognosis of disease. Gymnastics. Treatment of inflammation. Fasting. Enemas, clysters, and purgatives. Phlebotomy. White hellebore!



of the universe, but of all living organisms. He talked about the four roots and used four gods to symbolize air, water, fire, and earth.

τέσσαρα τῶν πάντων ῥιζώματα πρῶτον ἄκουε· Ζεὺς ἀργῆς Ἥρη τε φερέσβιος ἠδ' Αἰδωνεύς  
Νῆστις θ', ἣ δακρύοις τέγγει κρούνωμα βρότειον.  
Aëtios 1.3.20 DK 57 B6

Hear first the **four roots** of all things: Shining Zeus, life bringing Hera, Aidoneus and Nestis who with her tears waters mortal springs.

Empedokles thought that blood is the seat of the innate heat and that this heat is intimately related to the soul. Philistion thought that man is composed of four 'forms', that is of four elements: fire, air, water, and earth.

Φιλιστίων δ' οἶεται ἐκ δ' ἰδεῶν συνεστάναι ἡμᾶς, τοῦτ' (ἔστιν) ἐκ δ' στοιχείων· πυρός, ἀέρος,  
ὔδατος, γῆς.  
Anonymus Londinensis *Iatrica* sect. 20, l. 25-27 (Diels)(Jones p. 80)

Philistion thought that we are composed of forms, this is from the elements: **fire, air, water, earth.** (Translation: Jones, ad loc.)

Some of the authors to the treatises in *Corpus Hippocraticum* had similar views. In *De semine, de natura pueri, de morbis iv* it is stated that:

Ἐχει δὲ καὶ ἡ γυνὴ καὶ ὁ ἀνὴρ τέσσαρας ἰδέας ὑγροῦ ἐν τῷ σώματι, ἀφ' ὧν αἱ νοῦσοι  
Γίνονται.  
Corpus Hippocraticum *De semine, de natura pueri, de morbis iv*, 3, l. 4-5 (Littre)

Women and men have **four kinds of moistness** in their bodies and from these diseases originate.

Εἰσὶ δὲ τέσσαρες ἰδέαι τοῦ ὑγροῦ, αἷμα, χολή, ὕδωρ καὶ φλέγμα.  
Corpus Hippocraticum *De semine, de natura pueri, de morbis iv*, 3, l. 3-4 (Littre)

There are four kinds of moistness, **blood, bile, water, and phlegm.**

However, this theory did not leave any legacy, but was forgotten (Jouanna, 2012b, p. 336).

The author of *De prisca medicina* (Περὶ ἀρχαίης ἰητρικῆς), possibly, although authorship is not at all evident, Hippocrates himself<sup>10</sup>, denounced the idea that medicine can be based on speculations, not founded in experience.

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<sup>10</sup> For a comprehensive critical review of the works in *Corpus Hippocraticum*, see Craik (2015).

Ὅκοσοι ἐπεχείρησαν περὶ ἰητρικῆς λέγειν ἢ γράφειν, ὑπόθεσιν σφίσις αὐτέοισιν\* ὑποθέμενοι τῷ λόγῳ, θερμὸν, ἢ ψυχρὸν, ἢ ὑγρὸν, ἢ ξηρὸν, ἢ ἄλλ' ὅ τι ἂν ἐθέλωσιν\*\*, ἐς βραχὺ ἄγοντες, τὴν ἀρχὴν τῆς αἰτίας τοῖσις ἀνθρώποισι τῶν νόσων τε καὶ τοῦ θανάτου, καὶ πᾶσι τὴν αὐτέην\*\*\*, ἐν ἣ δύο προθέμενοι, ἐν πολλοῖσι μὲν καὶ οἷσι λέγουσι καταφανέες εἰσὶν ἀμαρτάνοντες.

Corpus Hippocraticum *De veteri medicina* (= *De prisca medicina*) ch. 1, l. 1-6 (Littré)

\* CMG: αὐτοὶ αὐτοῖς; Jouanna 1990 (118 J. 1-7): αὐτοὶ ἐωυτοῖσις,

\*\* CMG and Jouanna 1990: θέλωσις,

\*\*\* CMG and Jouanna 1990: τὴν αὐτέην

All those who have undertaken to speak or write about medicine, having laid down as a hypothesis for their account hot or cold or wet or dry or anything else they want, narrowing down the primary cause of diseases and death for human beings and laying down the same one or two things as the cause in all cases, clearly go wrong in much that they say. (Translation: Schiefsky) (Schiefsky, 2005, p. 75).

Nevertheless, the author of this treatise had his own theory about powers which must be in balance in health, a standpoint similar to that of Alkmaion's *isonomia*:

Ἐνὶ γὰρ ἀνθρώπῳ καὶ πικρὸν καὶ ἀλμυρὸν, καὶ γλυκὺ καὶ ὄξυ, καὶ στρυφνὸν καὶ πλαδαρὸν καὶ ἄλλα μυρία, παντοίας δυνάμιας ἔχοντα, πληθὸς τε καὶ ἰσχύς.

Ταῦτα μὲν μεμιγμένα καὶ κεκορημένα ἀλλήλοισιν οὔτε φανερά ἐστίν, οὔτε λυπέει τὸν ἀνθρώπον· ὅταν δέ τι τουτέων ἀποκριθῆ, καὶ αὐτὸ ἐφ' ἐωυτοῦ γένηται, τότε καὶ φανερόν ἐστι καὶ λυπέει τὸν ἀνθρώπον.

Corpus Hippocraticum *De veteri medicina* (= *De prisca medicina*) ch. 14, l. 23-28 (Littré)

Jouanna 1990 (136 J. 10-14) has λυπεῖ instead of λυπέει. The order of πικρὸν καὶ ἀλμυρὸν in his text is also switched as can be seen in Scheifsky's translation below.

for there is in the human being salty and bitter and sweet and acid and astringent and insipid and a myriad other things having powers of all kinds in quantity and strength. These, when mixed and blended with one another, are neither manifest nor cause the human being pain; but when one of them separates off and comes to be on its own, then it is both manifest and causes the human being pain. (Translation: Schiefsky, p. 93.)

Platon had himself no direct personal medical experience. His medical knowledge was derived from other, contemporary, or earlier physicians or natural philosophers. His anatomical knowledge was also limited since he had no experience of dissection. He was influenced by the Pythagoreans as shown in the *Timaeus*. According to Platon the world is constructed in accordance with a divine plan and therefore he reduced the elements (fire, air, water, earth) to forms, using geometrical figures. A change in these elements causes disease. For a detailed discussion, see Longrigg (Longrigg, 1963, p. 146).

τὸ δὲ τῶν νόσων ὅθεν συνίσταται, δῆλόν που καὶ παντί. τεττάρων γὰρ ὄντων γενῶν ἐξ ὧν συμπέπηγεν τὸ σῶμα, γῆς πυρὸς ὕδατός τε καὶ ἀέρος, τούτων ἢ **παρὰ φύσιν** πλεονεξία καὶ ἔνδεια καὶ τῆς χώρας μετάστασις ἐξ οἰκείας ἐπ' ἀλλοτριάν γιγνομένη

Platon *Timaeus* 81e-82a (Stephanus)

The origin of disease is plain, of course, to everybody. For seeing that there are four elements of which the body is compacted,—earth, fire, water and air,—when, **contrary to nature**, there

occurs either an excess or a deficiency of these elements, or a transference thereof from their native region to an alien region (Translation: W.R.M. Lamb, [www.perseus.tufts.edu](http://www.perseus.tufts.edu))

Platon was confident that his view was accepted by everybody, δηλον παντί. He used the words παρὰ φύσιν, contrary to nature, central concepts also used by Praxagoras.

Aristoteles discussed the presocratic philosophers' concept of the construction of the world and criticized them all for not being consistent when they just take for granted how many opposites that make up the body without explaining why exactly these and why exactly that many.

οἱ μὲν γὰρ ἄλλοι ὑποθέμενοι χρῶνται, καὶ οὐδὲν λέγουσι διὰ τί αὐταὶ ἢ τοσαῦται.  
Aristoteles *De generatione et corruptione* 329b3-5 (Bekker)

For all other philosophers assume and make use of them without stating why they are these and why they are of a particular number. (Translation: E.S. Forster and D.J. Furley.)

He then presented his concept that the four elementary qualities, τέτταρα τὰ στοιχεῖα, are building blocks of the physical world. When these are combined, they form what he called the simple bodies, τὰ ἀπλᾶ σώματα: Fire, air, water, and earth.

Ἐπεὶ δὲ τέτταρα τὰ στοιχεῖα, τῶν δὲ τεττάρων ἕξ αἰ συζεύξεις, τὰ δ' ἐναντία οὐ πέφυκε συνδυάζεσθαι (θερμὸν γὰρ καὶ ψυχρὸν εἶναι τὸ αὐτὸ καὶ πάλιν ξηρὸν καὶ ὑγρὸν ἀδύνατον), φανερὸν ὅτι τέτταρες ἔσονται αἱ τῶν στοιχείων συζεύξεις, θερμοῦ καὶ ξηροῦ, καὶ θερμοῦ καὶ ὑγροῦ, καὶ πάλιν ψυχροῦ καὶ ὑγροῦ, καὶ ψυχροῦ καὶ ξηροῦ.  
Καὶ ἠκολούθηκε κατὰ λόγον τοῖς ἀπλοῖς φαινομένοις σώμασι, πυρὶ καὶ ἀέρι καὶ ὕδατι καὶ γῆ· τὸ μὲν γὰρ πῦρ θερμὸν καὶ ξηρόν, ὁ δ' ἀήρ θερμὸν καὶ ὑγρόν (οἷον ἀτμὶς γὰρ ὁ ἀήρ), τὸ δ' ὕδωρ ψυχρὸν καὶ ὑγρόν, ἡ δὲ γῆ ψυχρὸν καὶ ξηρόν  
Aristoteles *De generatione et corruptione* 330a30-b5 (Bekker)

Now since the elementary qualities are four in number and of these four six couples can be formed, but contraries are not of a nature which permits of their being coupled – for the same thing cannot be hot and cold, or again, moist, and dry – it is clear that the pairs of elementary qualities will be four in number, hot and dry, hot and moist, and, again, cold and moist, and cold and dry. And, according to theory, they have attached themselves to the apparently simple bodies, Fire, Air, Water and Earth; for Fire is hot and dry, Air is hot and moist (Air, for example, is vapor), Water is cold and moist, and Earth is cold and dry. (Translation: E.S. Forster and D.J. Furley.)

In his book on Hippokrates' view about the nature of man (*In Hippocratis de natura hominis*) Galenos mentions that Menon, a pupil of Aristoteles, had not found anything about the four humors in previous literature.

ὁ Μένων ἐκεῖνος, ἀναζητήσας ἐπιμελῶς τὰ διασφωζόμενα κατ' αὐτὸν ἔτι τῶν παλαιῶν ἰατρῶν βιβλία, τὰς δόξας αὐτῶν ἐκεῖθεν ἀνελέξατο· -  
κατὰ ταῦτ' οὖν τὰ βιβλία χολὴν ξανθὴν ἢ μέλαιναν ἢ φλέγμα στοιχεῖον ἀνθρώπου φύσεως οὐκ ἂν εὔροις οὐδ' ὑφ' ἑνὸς εἰρημένον  
Galenos *In Hippocratis de natura hominis librum commentarii iii* vol. 15, p. 26, l. 3-5, 7-8 (Mewaldt)

Menon carefully investigated the books of the ancient doctors still preserved in his time and excerpted their views from these – According to these books, then, you cannot find bile, yellow

or black, or phlegm said by even a single writer to be an element of human nature. (Translation: W.H.S. Jones.)

Apparently, Menon was not aware of the treatise *De natura hominis* (Περὶ φύσιος ἀνθρώπου). In this treatise, the theory about the four humors is presented, a theory that survived for more than 2000 years (Longrigg, 1998).

Τὸ δὲ σῶμα τοῦ ἔχει ἐν ἑωυτῷ αἷμα καὶ φλέγμα καὶ χολὴν ξανθὴν καὶ μέλαιναν, καὶ ταῦτ' ἐστίν\* αὐτῷ ἢ φύσις τοῦ σώματος, καὶ διὰ ταῦτα ἀλγεῖ καὶ ὑγιαίνει.

Corpus Hippocraticum *De natura hominis*, ch. 4, l. 1-3 (Littre)

\* CMG: ταῦτά ἐστίν

The body of man has in itself **blood, phlegm, bile, yellow and black**; these make up the nature of his body, and because of these he feels pain or enjoys health. (Translation: W.H.S. Jones.)

The properties of these four humors correspond to the four seasons, each predominating in the season which shares the same nature: blood (hot and wet) predominates in spring; yellow bile (hot and dry) in summer; black bile (cold and dry) in autumn; and phlegm (cold and wet) in winter.

This treatise is the only one in *Corpus Hippocraticum* of which we for certain know the author, namely Polybos (Aristoteles *Historia Animalium* 512b12ff). In this passage Aristoteles describes the anatomy of vessels in the same way as had been done in *De natura hominis* ch. 11. Polybos was the pupil and son-in-law of Hippocrates. This is corroborated by a passage in the papyrus *Anonymus Londinensis* from the second century CE:

ὁ δὲ Πόλυβος ἐξ ἑνὸς μὲν στοιχείου οὐ λέγει τὰ ἡμέτερα σώματα συνεστάναι, τὴν δὲ αὐτὴν φύσιν ὁμοίως πᾶσιν εἶναι, ἤπερ ἐκ ψυχροῦ τε καὶ θερμοῦ, οὐ χωρὶς ὄντων τούτων, ἀλλὰ κεκραμένων αὐτῶν, συνέστηκεν· μεταβαλὼν δὲ θάτερον θατέρω νόσον ἀποτελεῖν. δευτέραν δὲ ἀποτελεῖσθαι τῶν σωμάτων μεταβολὴν ἀπὸ αἵματός τε καὶ φλέγματος καὶ χολῆς ξανθῆς τε καὶ μελαίνης.

*Anonymus Londinensis Iatrica* sect. 19, l. 1-11 (Diels)(Jones p. 74, 76)

Polybos says that our bodies are not composed of one element, but that all alike have the same nature, which is composed out of the cold and the hot, not separated, but blended. A change of one produces another disease. A second change in bodies is brought about proceeding from blood, phlegm, yellow bile, and black bile. (Translation: W.H.S. Jones ad loc.)

#### 4.2.2 Number of fragments on humors and their authors

Twenty-nine fragments about the role of humors have been cited in this essay:

9, 16b, 17, 18, 20, 21, 22, 24, 25a, 25b, 25c, 38, 46, 50, 51a, 51b, 52, 55, 57, 59, 60, 64, 69, 70, 74, 75, 78, 84, 85.

The authors were: Galenos 22, *Anonymus medicus* 7.

#### 4.2.3 Cited authors and their opinions on Praxagoras' teaching on humors

The words χυμός (and other forms of χυμός) occur in 35 fragments: 9, 16a, 16b, 17, 18, 20, 21, 22, 23, 24, 25a, 38, 46, 50, 51a, 51b, 51c, 52, 53a, 53b, 54, 55, 56, 59, 60, 64, 68, 70, 79, 84, 95a, 95b, 95c, 96, 115.

χυμός can mean humor, flavor, taste as well as juice (Demont, 2005, p. 271).

Both Rufus and Galenos tell us that Praxagoras thought that many different humors can be found in man. These can be identified according to their color, taste, consistency, and corrosiveness.

Πραξαγόρας δὲ ἴδιον τρόπον τοὺς χυμοὺς ὠνόμαζε, γλυκὺν, καὶ ἰσόκρατον, καὶ ὑαλοειδῆ·  
τούτους μὲν κατὰ τὴν ἰδέαν τοῦ φλέγματος· ἄλλους δὲ ὀξὺν καὶ νιτροῶδη, καὶ ἄλυκόν,  
καὶ πικρόν· τούτους δὲ ὡς γευσασμένω φαίνονται· ἄλλους δὲ, πρασοειδῆ μὲν τῆ χροῶ,  
λεκιθῶδη δὲ τῆ παχύτητι· ἄλλους δὲ, ξυστικὸν μὲν, ὅτι ξύεσθαι παρασκευάζει·  
στάσιμον δὲ, ὅτι ἐν ταῖς φλεψὶν ἐνέστηκε, καὶ οὐ διαδίδωσιν εἰς τὴν σάρκα, διὰ τὸ λεπτοὺς  
καὶ φλεβῶδεις εἶναι τοὺς στασίμους χυμοὺς. Τὸ δὲ ὅλον, χυμὸν ὁ Πραξαγόρας  
πᾶν τὸ ὑγρὸν καλεῖ·

Rufus from Ephesos *De corporis humani appellationibus* sect. 226, l. 1-9 (Daremberg) Fr. 22.

Praxagoras named the humors in a peculiar way, calling them sweet, equally mixed, and vitreous. These belong to the genus of phlegm. The names of others are acid, sodic, salty, and bitter. These are differentiated according to taste. Others are called leek-green because of their color, others yolk-like because of their thick consistency. Another kind is given the name, corrosive humor, because they have the quality of corrosiveness. Further, there are stationary humors which remain in the veins and do not pass through into flesh, because they are thin and stay in the veins. As a role Praxagoras calls every liquid humor.

Three humors are categorized as phlegm (γλυκὺς sweet, ἰσόκρατος well mixed, and ὑαλοειδῆς vitreous). Three are identified due to their taste (ὀξύς acid, νιτροῶδης sodic, ἄλυκός salty, and πικρός bitter), one due to its color (πρασοειδῆς, leek-green), one due to its consistency (λεκιθῶδης, yolk-like) and one due to its corrosiveness (ξυστικός).

Thus, Rufus mentions ten different humors. The same number is given by Galenos, who then includes blood as the eleventh:

γέγραπται δὲ που καὶ δι' ἑτέρου λόγου περὶ τῶν κατὰ Πραξαγόραν τὸν Νικάρχου χυμῶν.  
εἰ γὰρ καὶ ὅτι μάλιστα δέκα ποιεῖ χωρὶς τοῦ αἵματος, ἐνδέκατος γὰρ ἂν εἴη χυμὸς αὐτὸ  
τὸ αἷμα, τῆς Ἰπποκράτους οὐκ ἀποχωρεῖ διδασκαλίας. ἀλλ' εἰς εἶδη τινὰ καὶ διαφορὰς  
τέμνει τοὺς ὑπ' ἐκείνου πρώτου πάντων ἅμα ταῖς οἰκείαις ἀποδείξεσιν εἰρημένους  
χυμοὺς.

Galenos *De naturalibus facultatibus* vol. 2, p. 141, l. 4-11 (Helmreich et al.) Fr. 21.

In another treatise I have written on the humors according to Praxagoras, son of Nikarchos; although he certainly makes as many as ten humors, not including the blood, the blood itself being an eleventh, this is not a departure from the teaching of Hippokrates; for he (Praxagoras) divides into species and varieties all the humors which Hippokrates first mentioned, while he at the same time demonstrates the properties of the mentioned humors. (Translation: Steckerl, modified.)

Galenos evidently, was not completely satisfied with Praxagoras' concept of as much as ten or even eleven different humors. However, he was eager to assure that this was not a departure from Hippokrates' teachings in *De natura hominis*. Thus, he interpreted the eleven as subdivisions only, of the original Hippocratic four. Praxagoras just made another grouping of the humors. This seems to be corroborated by Rufus who divided the humors into some five different groups.

In fact, Praxagoras' view is very similar to the view of the author of *De prisca medicina*, but maybe Galenos had not read that treatise? Anyway, he never refers to it.

It should be noted that it is nowhere stated that Praxagoras thought that the human body is **built** by humors as stated in *De natura hominis*. Humors are produced due to an imbalance, maybe in the innate heat, see below.

### How are humors produced?

Already Anaxagoras had been interested in the question how anything could come into being from the non-existent (Longrigg, 1963, p. 158). How is it possible that bread and water in the food can be transformed to hair, flesh, sinews, and bones? His solution to this problem was to assume that all parts needed were present in the nourishment.

τροφήν γοῦν προσφερόμεθα μονοειδή, ἄρτον καὶ ὕδωρ, καὶ ἐκ ταύτης  
τρέφεται φλέψ ἀρτηρία σὰρξ νεῦρα ὅσῃ καὶ τὰ λοιπὰ μέρη.  
τούτων οὖν γιγνομένων ὁμολογητέον, ὅτι ἐν τῇ τροφῇ τῇ προσφερομένη πάντα ἐστὶ  
τὰ ὄντα, καὶ ἐκ τῶν ὄντων πάντα αὐξεται  
Aëtios *De placitis reliquiae* p. 279, l. 4-11 (Stobaei excerpta)

Thus, we take in food of one kind, bread and water, and out of this there grows vein, artery (or maybe trachea?), flesh, sinews, bone and the other parts. Since this occurs it must be admitted that all exists in the nourishment taken in and out of this everything grows

λέγει γοῦν Ἀναξαγόρας ὅτι "ἐν παντὶ παντὸς μοῖρα ἔνεστι"  
Simplikios *In Aristotelis physicorum libros commentaria* vol. 9, p. 27, l. 9-11 (Diels)

Thus, Anaxagoras says that "all parts exist in everything"

It then was natural for the ancient physicians and for Galenos to assume that humors are produced from food, not that they were already present in the food.

καὶ μὴν οὐκ ἐνδέχεται ταῦτόν ἔδεσμα τοῖς μὲν χολὴν γεννᾶν, τοῖς δ' αἷμα μὴ οὐκ ἐν τῷ  
σώματι τῆς γενέσεως αὐτῶν ἐπιτελουμένης. εἰ γὰρ δὴ οἴκοθεν γε καὶ παρ' ἑαυτοῦ  
τῶν ἐδεσμάτων ἕκαστον ἔχον καὶ οὐκ ἐν τοῖς τῶν ζώων σώμασι μεταβαλλόμενον  
ἐγέννα τὴν χολήν, ἐν ἅπασιν ἂν ὁμοίως αὐτὴν τοῖς σώμασιν ἐγέννα ... εἴρηται δ' ἐπὶ  
πλείστον ὑπὲρ αὐτῶν Ἀριστοτέλει τε καὶ Πραξαγόρῃ τὴν Ἱπποκράτους καὶ Πλάτωνος  
γνώμην ὀρθῶς ἐξηγησάμενοις.  
Galenos *De naturalibus facultatibus* vol. 2, p. 124, l. 16 - p. 125, l. 2; p. 125, l. 11-13 (Kühn) Fr. 17.

But surely it is impossible that the same article of diet can produce in certain persons bile and in others blood, if it be not that the genesis of these humors is accomplished in the body. For if all

articles of food contained bile from the beginning and of themselves and did not produce it by undergoing change in the animal body, then they would produce it similarly in all bodies ... this subject has been treated at great length by Aristoteles and Praxagoras, who have correctly explained the view of Hippokrates and Platon.

The liver delivers blood to the veins. Blood is produced when the nutriment becomes altered in the veins by the innate heat, ὑπὸ τῆς ἐμφύτου θερμασίας. This only occurs when the heat is in moderation, συμμετρία, otherwise, when the innate heat is not in proper proportion, ἀμετρία, the other humors are produced.

περὶ δὲ τῆς τῶν χυμῶν γενέσεως οὐκ οἶδ', εἰ ἔχει τις ἕτερον προσθεῖναι σοφώτερον ὢν Ἱπποκράτης εἶπε καὶ Ἀριστοτέλης καὶ Πραξαγόρας καὶ Φιλότιμος καὶ ἄλλοι πολλοὶ τῶν παλαιῶν. ἀποδέδεικται γὰρ ἐκείνοις τοῖς ἀνδράσιν ἀλλοιουμένης τῆς τροφῆς ἐν ταῖς φλεψὶν ὑπὸ τῆς ἐμφύτου θερμασίας αἷμα μὲν ὑπὸ τῆς συμμετρίας τῆς κατ' αὐτήν, οἱ δ' ἄλλοι χυμοὶ διὰ τὰς ἀμετρίας γιγνόμενοι· καὶ τούτῳ τῷ λόγῳ πάνθ' ὁμολογεῖ τὰ φαινόμενα. καὶ γὰρ τῶν ἐδεσμάτων ὅσα μὲν ἐστί θερμότερα φύσει, χολωδέστερα, τὰ δὲ ψυχρότερα φλεγματικώτερα· καὶ τῶν ἡλικιῶν ὡσαύτως χολωδέστεραι μὲν αἱ θερμότεραι φύσει, φλεγματωδέστεραι δ' αἱ ψυχρότεραι· καὶ τῶν ἐπιτηδευμάτων δὲ καὶ τῶν χωρῶν καὶ τῶν ὥρῶν καὶ πολὺ δὴ πρότερον ἔτι τῶν φύσεων αὐτῶν αἱ μὲν ψυχρότεραι φλεγματωδέστεραι, χολωδέστεραι δ' αἱ θερμότεραι· Galenos *De naturalibus facultatibus* vol. 2, p. 117, l.8- p. 118, l. 6 (Kühn) Fr. 18.

Now in reference to the genesis of the humors, I do not know that one could add anything wiser than what has been said by Hippokrates, Aristoteles, Praxagoras, Phylotimos, and many others among the Ancients. These men have demonstrated that when the nutriment becomes altered in the veins **by the innate heating**, blood is produced when it is **in moderation** and the others when it is **not in proper proportion**. And all the observed facts agree with this argument. Thus, those articles of food which are by nature warmer are more bile-like, while those which are colder are more phlegmatic. Similarly of the periods of life, those which are naturally warmer are more bile-like, and the colder more phlegma-like. Of occupations also, localities and seasons, and above all, of natures themselves, the colder are more phlegmatic, and the warmer more bilious. (Translation: Steckerl, modified.)

There are at least two problems in the interpretation of this fragment. The first is the question whether Praxagoras recognized the existence of an innate heat. In this fragment Galenos refers to "the Ancient" physicians, including Hippokrates and Aristoteles, as being of the same opinion. It is questionable if Praxagoras really thought that an innate heat existed. Galenos says the opposite in fr. 19:

ἐγὼ μὲν γὰρ εἶπον τοῦ κατὰ φύσιν θερμοῦ πάθος εἶναι τὸ ῥίγος, ἵνα μὴ τις τοῦ ἕξωθεν<sup>11</sup> νομίσας εἰρησθαι, καταψεύδεσθαι με δόξειε Ἐρασιστράτου καὶ Πραξαγόρου καὶ Φιλοτίμου καὶ Ἀσκληπιάδου καὶ μυρίων ἄλλων, ὅσοι τὸ θερμὸν οὐκ ἔμφυτον, ἀλλ' ἐπίκτητον εἶναι νομίζουσι. πῶς γὰρ οὖν οὗτοι πάθος ἐμφύτου θερμοῦ λέγοιεν, οἱ μὴδὲ τὴν ἀρχὴν ἔμφυτον εἰδότες θερμὸν; ἀλλ' ἔμφυτον μὲν, ὡσπερ εἶπομεν, οὐ πάντες ὁμολογοῦσι τὸ θερμὸν ὑπάρχειν, γένεσιν δὲ ἐπίκτητον αὐτῷ τεχνώμενοι, διαφερόντως ἄλλος ἄλλην,

<sup>11</sup> Steckerl here has conjectured ἕσοθεν and translates: "so that nobody believing that that it is attributed to internal heat claims..." He does not give any explanation for his preference to ἕσοθεν. Although this sentence is complicated Steckerl probably found ἕσοθεν more appropriate.

ἐν τούτῳ πάντες ὁμολογοῦσιν, ὡς ἔσται τι **κατὰ φύσιν** ἐν ἐκάστῳ ζῳῷ **θεσμὸν**,  
ἐν τῷ προσήκοντι μέτρῳ θεωρούμενον.

Galenos *De tremore, palpitatione, convulsione et rigore liber* vol. 7, p. 614, l. 8- p. 615, l. 1. (Kühn) Fr.19.

In respect to shivering I said that it is an affection of **natural heat**, so that nobody, thinking that it is said of the external heat, believes that I tell lies against Erasistratos, Praxagoras, Phylotimos and Asklepiades and many others who are of the opinion that **heat is not innate but acquired**. How could these men speak of an affection of innate heat, since they do not recognize an innate heat at all? Not all physicians, indeed, agree as we said before that heat is innate, but if some devise for it an external origin, each a different one, all agree on this point, that there will be a **natural heat** in every living thing viewed in a fitting measure.

Also, this time he refers to “the Ancients”, but this time omitting Hippokrates and Aristoteles. It also seems as if Galenos here equals innate and natural heat.

The second question is regarding the interpretation of the words *συμμετρία* and *ἀμετρία* in fr. 18. Steckerl translates “in moderation” and “not in proper proportion”, respectively. Alternative translations could be “in due proportion” and “in disproportion” or maybe even “in excess”. The ideal seems to be Alkmaion’s *ἰσονομία*. The lexical meaning of *ἰσονομία* is “equal rights”, a term otherwise used in politics (equality of political rights), but in Alkmaion’s meaning the balance between “the powers”, moist and dry, cold, and hot etc. The “monarchy” of one of them is destructive and the cause of disease (Kirk et al., 2013, p. 260).

Different kinds of food produce different humors. Warm food produces bile, while cold produces phlegm (fr. 18, above). Hard food causes salty humor and so does extensive cooking:

Οὐ μόνον ἐπὶ τῶν ἰχθύων τῶν σκληροσάρκων, ἀλλὰ καὶ τῶν ἄλλων ἀπάντων ἔδεσμάτων, ὅσα σκληρά, Πραξαγόρας καὶ Φυλότιμος οἴονται **τὸν ἀλυκὸν** γεννᾶσθαι **χυμὸν** ἐν ταῖς ἐπὶ πλέον ἐψήσεσιν, ὀνομάζουσι δ’ αὐτὸν οὐχ ἀλυκὸν μόνον ἢ ἀλμυρὸν, ἀλλὰ καὶ νιτρώδη.

Galenos *De alimentorum facultatibus libri iii* vol. 6, p. 730, l. 15- p. 731, l. 2 (Helmreich) Fr. 25a.

Praxagoras and Phylotimos believe that not only hard flesh of fish, but all other hard food also, when cooked excessively, produces **the salty humor**. They call this humor not only salty or briny but also sodic. (Translation: Steckerl, modified.)

τοὺς χυλοὺς δ’ αὐτοὺς μόνους ἐὰν ἐψης, **ἀλυκώτεροι** μὲν τὸ πρῶτον, ὕστερον δὲ καὶ πικροὶ γίνονται. διὸ καὶ περὶ μὲν τῶν χυλῶν συγχωρητέον ἐστὶ τῷ τε Πραξαγόρα καὶ τῷ Φυλοτίμῳ γινώσκουσιν, ὡς εἴρηται, περὶ δὲ τῶν στερεῶν σωμάτων ἔμπαλιν ἔχειν ἡγητέον.

Galenos *De alimentorum facultatibus libri iii* vol. 6, p. 732, l. 11-14 (Helmreich) Fr. 25b.

When one boils the juices alone, they become **saltier** first and then even bitter. Therefore regarding the humors one must be agree with the theory of Praxagoras and Phylotimos, as we have said. But of solid substances one must think the opposite way. (Translation: Steckerl, modified.)



μάλιστα δ' ὁ ζωμὸς ἐξηπατηκέναι μοι δοκεῖ τοὺς περὶ τὸν Πραξαγόρα **άλυκώτερος**  
ἐν τῷ τῆς ἐψησεως χρόνῳ γιγνόμενος.  
Galenos *De alimentorum facultatibus libri iii* vol. 6, p. 733, l. 4-6 (Helmreich) Fr. 25c.

Especially the soup, which when cooked for a longer time gets **saltier**, seems to have misled the physicians associated with Praxagoras.

and everything that causes excessive heat:

εἰ δὲ καὶ **άλυκοὺς** ἢ σκληροτέρα τροφή τοὺς χυμοὺς ἐργάζεται, σκεπτέον ἐφεξῆς. ὁ μὲν γὰρ  
Φυλότιμος, ὥσπερ γε καὶ ὁ διδάσκαλος αὐτοῦ Πραξαγόρας, τὸν ἀλυκὸν χυμὸν  
ἐκ τῶν ἐπὶ **πλέον θερμαινόντων** γεννᾶσθαι φησιν.  
Galenos *De alimentorum facultatibus libri iii* vol. 6, p. 730, l. 7-10 (Helmreich) Fr. 24.

When harder food produces **salty** humors also, we shall examine afterwards. For Phylotimos, like his teacher Praxagoras, says that the salty humor is generated by everything that causes **excessive heat**.

It is unclear if this salty humor is a part of the food or if it is generated in the body.

ὅσοι τοίνυν τούτων (scil. ἄρτων) οὔτε ζύμης οὔθ' ἁλῶν ἱκανῶς ἔσχον οὔτ' ἐπὶ πλεῖστον  
ἐφυράθησαν οὔτ' ἐν κριβάνῳ καλῶς ὠπτήθησαν, οὗτοι **παχύχυμοι** πάντες  
εἰσὶ μετὰ τοῦ καὶ γλισχρότητος οὐκ ὀλίγης μετέχειν, ὄντινα χυμὸν οἱ περὶ  
Πραξαγόρα τε καὶ Φυλότιμον ὀνομάζειν εἰώθασι κολλώδη.  
Galenos *De rebus boni malique suci* vol. 6, p. 764, l. 14 – p. 765, l. 2 (Helmreich) Fr. 38.

All bread that did not contain enough leaven nor salt and has not been very much kneaded nor baked well in the oven, all these are **thick humored** and with a share of no small stickiness. This type of humor the physicians associated with Praxagoras and Phylotimos used to call glutinous. (Translation: Steckerl, modified.)

Thus, there seems to be some ambiguity, whether humors are not only generated in the body, but also present already in the food.

### What are the roles of humors?

The central role of humors (μόνοις τοῖς χυμοῖς, to the humors alone) in health and disease is evident from the following fragment:

οἱ μὲν **μόνοις τοῖς χυμοῖς** τῶν τε **κατὰ φύσιν** τὴν σύστασιν καὶ τῶν **παρὰ φύσιν** τὴν αἰτίαν ἀνέθεσαν, ὡς Πραξαγόρας καὶ Ἡρόφιλος.  
Ps-Galenos *Introductio seu medicus* vol. 14, p. 698 l. 18 – p. 699, l. 1-3 (Kühn) Fr. 46.

Some, as, for instance, Praxagoras and Herophilos, attributed **to the humors alone** the establishment of what is **according to nature** and the cause of what is **contrary to nature**.

Here we see the expressions *κατὰ φύσιν* and *παρὰ φύσιν*, which are so often occurring in the fragments, indicating health and disease, respectively.

Disease could be caused by a humor as such or by putrefaction of a humor. Praxagoras thought that fevers were all caused by a putrefaction (σῆψις) of the humors in the hollow vein:

λοιπὸν δὲ τὸ τῶν συνόχων γένος, ὧν ὁ σύμπας χρόνος εἰς παροξυσμὸς ἐστὶν ἤτοι διὰ παντὸς ὁμότονος, ἢ μειούμενος, ἢ αὐξανόμενος ἄχρι κρίσεως, ὑπὸ τοιαύτης αἰτίας γενέσθαι πέφυκεν, οἷαν ἀπάντων πυρετῶν ὁ Πραξαγόρας ὑπέθετο, **σῆψιν** οἰόμενος **τῶν χυμῶν ἐν τῇ κοίλῃ φλεβί** συνίστασθαι.

Galenos *De differentiis febrium libri ii* vol. 7, p.404, l. 8-13 (Kühn) Fr. 60.

Finally, the type of continuous fevers which are characterized by one exacerbation, whether equal all the time, or decreasing or increasing until the time of the crisis, originate from such a cause, as Praxagoras assumed for all the fevers. He thought that they are all caused by a **putrefaction of the humors in the hollow vein**.

A disturbance of the balance between humors is deleterious for health. Excess of either bile or phlegm is bad, and cause among other things shivering. The cold phlegm is called vitreous, *ύαλώδης*, a quality that is frequently reported.

οὐ μόνον δ' ἐπὶ τῆς ξανθῆς ἢ μελαίνης χολῆς ῥίγος, ἀλλὰ καὶ ἐπὶ **τῷ ψυχρῷ πάνυ φλέγματι** φιλεῖ γίνεσθαι· καλεῖ δὲ **ύαλώδη** τὸν χυμὸν τοῦτον ὁ Πραξαγόρας.

Galenos *De tremore, palpitatione, convulsione et rigore liber*, vol.7, p. 634, l. 16-18 (Kühn) Fr. 51a.

Shivering is readily caused not only by the yellow or black bile, but also by **very cold phlegm**. Praxagoras calls this humor **vitreous**.

When the phlegmatic cold humor and the warm humor of the bitter bile are abundant at the same time, the patient shudders and has fever.

οὔτε γὰρ τῶν τοιούτων διαθέσεων οὐδὲν θαυμαστὸν, οὐδὲ πῶς ἅμα ῥιγούσι καὶ πυρέττουσιν ἔνιοι τῶν νοσοῦντων. καὶ γὰρ εἰ **φλεγματοῦδος χυμὸς ψυχρὸς**, ὃν ὁ Πραξαγόρας **ύαλοειδῆ** καλεῖ, καὶ πικρόχολος καὶ θερμὸς ἅμα πλεονάζοιεν τε καὶ κινοῖντο διὰ τῶν αἰσθητικῶν σωμάτων, οὐδὲν θαυμαστὸν ἀμφοτέρων ὁμοίως αἰσθάνεσθαι τὸν ἄρρώστον.

Galenos *De inaequali intemperie liber* vol. 7, p. 749, l. 5-10 (Kühn) Fr. 51b.

There is nothing in such states at which one must be astonished, not even that some of the patients shudder and have fever at the same time. For when the **phlegmatic cold humor**, which Praxagoras calls **vitreous**, and the warm humor of the bitter bile are abundant at the same time and move through the sensitive body it is not to be astonished that both of them are experienced alike by the sick person.

The humor most often mentioned in the fragments is φλέγμα, phlegm. According to LSJ φλέγμα is flame, fire, heat, in medicine inflammation, heat or phlegm. A possible translation to modern nomenclature could maybe be mucus. Phlegm and black bile apparently were deleterious for health. It is not easy to understand how the domination of any of these humors was determined. It must be remembered that the knowledge about the interior of the human body was imperfect, since no dissection of the human body (dead or alive) was made before the Hellenistic period (Lloyd, 1973, p. 75). In some

fragments it is stated where phlegm or bile can be found, most commonly in the secretion from nose, mouth, and intestines. In fr. 50 it is described how intake of cold water, bath, or cold fruits at the wrong time, all which causes constriction of the arteries also generates cold phlegm:

πηξίς δ' ἐκ ψύξεως ἐπί τε τοῦ ψυχροῦ πόσεσιν ἀκαίροις ἢ ἀμέτροις, ἢ λουτροῖς ὁμοίοις, ἐπί τε ταῖς ψυχούσαις ὀπώραις ἀκαίροις ἢ ἀμέτροις, ἢ ὅλως ὅσα τὸ ψυχρὸν φλέγμα γεννᾶν πέφυκεν ἱκανῶς, ὃν περὶ ὑαλώδη χυμὸν ὁ Πραξαγόρας ὀνομάζειν εἴωθεν  
Galenos *De praesagitione ex pulsibus libri iv.* vol. 9, p. 248, l. 2-6 (Kühn) Fr. 50.

Constriction through cold comes about by taking cold water at the wrong time or excessively, or by taking a bath in the same way, or by taking cold fruits at the wrong time or by taking too many, or in general by whatever is readily able to engender **the cold phlegm** which Praxagoras usually calls **vitreous** humor.

Could this be a common cold with secretion from the nose? As was stated in fr. 51a (see above) shivering is caused not only by the yellow or black bile, but also by the very cold phlegm. This is of course compatible with common cold as is the case which is described in fr. 52, and similarly in frs. 53a, 53b and 54 (not shown).

ψύξις τε γὰρ ἰσχυρὰ ποτὲ μὲν αὐτὴ καθ' αὐτήν, ἔστι δ' ὅτε ἐπὶ φλέγματι πάνυ ψυχρῶ, (τοιούτων δὲ ἔστι παραπλήσιον ὑάλω κεχυμένη κατὰ τε τὴν χροῶν καὶ τὴν σύστασιν, ὃν περὶ δὴ καὶ ὑαλώδη χυμὸν οἱ περὶ τὸν Πραξαγόραν τε καὶ Φιλότιμον ὀνομάζουσιν)  
Galenos *De symptomatum causis libri iii.* vol. 7, p. 137, l. 17 – p.138, l. 3 (Kühn) Fr. 52

For violent chilling sometimes comes about itself, at other times in connection with **very cold phlegm**. (This phlegm is very similar to melted glass in respect to its color and consistency and is called **vitreous** humor by the physicians associated with Praxagoras and Phylotimos.)

The common quality of phlegm in these three fragments is that it is ὑαλώδες, i.e. vitreous.

According to frs. 56, 95a, 95b, 95c (not shown) vitreous humor can be found in the urine. In fr. 55 the vitreous phlegm is apparently in the intestines.

ὁ γε μὴν ὑπὸ Πραξαγόρου καλούμενος ὑαλώδης χυμὸς ὁμοῖος ὧν ὑάλω κεχυμένη τοιούτος ἔστιν, ὡς ὀδύνας μεγίστας τονώδεις παρέχειν, ὅταν διεξέρχεται τοὺς χιτῶνας τῶν ἐντέρων. ἔστι δὲ τῇ κράσει ψυχρότατος ἀπάντων τῶν κατὰ τὸ σῶμα γεννωμένων χυμῶν.  
Galenos *In Hippocratis prorrheticum i commentaria iii* vol. 16, p. 585, l. 9-12 (Kühn) Fr. 55.

This humor, which has been called vitreous by Praxagoras, resembles melted glass, and has the quality of causing very strong spasmodic pains when it breaks through the walls of the intestines. Regarding its mixture, it is the coldest of all the humors produced in the body.

This is also the case in fr. 59 in which Galenos describes his own experience with oil of rue, probably used as some kind of enema. When it was emitted, it created awful pain together with vitreous humor:

ὅτι δὲ ψυχρότατος ὁ χυμὸς οὗτός ἐστιν, εἴρηται μὲν δήπου καὶ Πραξαγόρα τῷ καὶ τοῦνομα κατ' αὐτοῦ θεμένῳ τὸ ὑαλώδες· φαίνεται δὲ σαφῶς καὶ κατὰ τὴν τῆς ἀφῆς αἴσθησιν αὐτῶν τε τῶν ἀποκρινάντων αὐτὸν καὶ εἴ τις ἄψασθαι βουληθείη παραχρῆμα· καὶ θαυμάσαι γ' ἐστὶ, πῶς ψυχρὸς ὑποπίπτει, μηδὲν ὑπὸ τῆς κατὰ τὴν ἐκπτώσιν βίας θερμαινόμενος.

Galenos *De locis affectis libri vi*. vol. 8, p. 82, l. 2-8 (Kühn) Fr. 59.

That this humor is **very cold** has also been stated by Praxagoras who gave the name **vitreous** to it. It is manifestly noticeable by the touch perception both to those who themselves secrete it, and to anyone else who wants to touch it immediately. This, indeed, is astonishing that it comes through so cold without being warmed by the force of the emission.

This passage illustrates the problem of interpreting the terms 'warm' and 'cold' as used during a period when no possibility to measure temperature was available. It is of course improbable that discharge from the rectum (or maybe from the mouth, it is not clear which) could be considerably lower than 37 degrees Celsius if measured immediately. Some other characteristics of the phlegm, or maybe some preconception must have influenced Galenos. Phlegmatic humor was also supposed to explain the occurrence of ileus, like hard excrement or twisted intestines or inflammation. In the following fragment Praxagoras is included in the Ancients:

εἰλεοῦ αἰτία. ὁμοίως καὶ εἰλεόν συμφώνως εἶπον οἱ ἀρχαῖοι γίνεσθαι. ἔμφραξιν γὰρ εἶναι τῶν ἐντέρων ἥτοι ὑπὸ σκληρῶν σκυβάλων ἢ φλεγματικῶν καὶ πεπηγῶτων ὑγρῶν ἢ ὑπὸ ἐλίκων συστραφειῶν ἢ διὰ φλεγμονῆν.

Anonymus medicus *De morbis acutis et chroniis* disease 14, sect. 1, p. 94. (Garofalo) Fr. 57.

Cause of ileus. Likewise the Ancients agreed on the genesis of ileus; it is, according to them, an obstruction of the intestines due either to hard feces or **frozen phlegmatic humors** or to twisted intestines or inflammation. (Translation: Garofalo/Fuchs, ad loc.)

A search in TLG using the lemma ὑαλώδης in Galenos gives 10 hits out of 19 connected to Praxagoras. Apparently this description of phlegm was characteristic for Praxagoras.

Finally, bubbles in phlegmatic humors were also considered responsible for epilepsy and apoplexy. This will be discussed below, section 4.5.2 What is the role of pneuma in disease?

Although bile was considered bad for health, little can be found regarding its role. Dominance of bile was of course evident if the patient had jaundice. Whether black or yellow cannot be judged. In fr. 64 *Anonymus Parisinus* tells that in jaundice there is a cooling of the innate heat, κατάψυξιν τοῦ ἐμφύτου θερμοῦ.

ικτέρου αἰτία. Πραξαγόρας δὲ κατάψυξιν τοῦ ἐμφύτου θερμοῦ καὶ τῶν ἐν τῷ σώματι χυμῶν γενέσθαι φησί. ὃ καὶ ὥσπερ ὄδον εἶναι εἰς ὕδρον· ἀνξηθεὶς γὰρ εἰς ὕδρωπα μεταβαίνει. πιστοῦται δὲ τοῦτο, ὅτι χειμῶνος γίνεται καὶ ὅτι πρεσβύταις μᾶλλον, καὶ ὅτι δοιμέσι προσαρτύμασι χρῶνται καὶ οὐκ εἰσι καυσώδεις οὐδὲ διψώδεις.

Anonymus medicus *De morbis acutis et chroniis* disease 33 sect. 3, p. 178. (Garofalo) Fr. 64.

Cause of jaundice. Praxagoras says that it arises from **chilling of the inborn warmth** and of the humours in the body, which is a path to dropsy; as it increases it passes to dropsy; a proof of this is that it occurs in winter, and especially to old people, and that they use acrid seasoning and are not stricken with ardent fever nor thirsty. (Translation: Garofalo/Brian Fuchs, ad loc.)

There are at least two things worth noting in fr. 64. The first is the mentioning of inborn warmth (innate heat). According to Galenos Praxagoras did not believe in the existence of an innate heat. It is impossible for us to judge what was the true opinion of Praxagoras in this case. See further discussion in section 4.5 on pneuma.

The second fact worth noting is that the text of fr. 64 as printed by Steckerl deviates from that printed by Garofalo and found in TLG:

πιστοῦται δὲ τοῦτο, ὅτι χειμῶνος γίνεται καὶ ὅτι πρεσβύταις μᾶλλον, καὶ ὅτι  
**νοθεύσης τῆς χολῆς ὄξον πiónτες** δοιμέσι προσαρτύμασι χρῶνται καὶ οὐκ εἰσι  
καυσώδεις οὐδὲ διψώδεις.

Steckerl translates the added words νοθεύσης τῆς χολῆς ὄξον πiónτες as "the patients drink wine ... as the bile is in abnormal state". This addition is Steckerl's conjecture of νοθείσης τῆς χολῆς ὄξον πιούσης present in one of the manuscripts of this fragment (ms. P 2324 in the edition of Robert Fuchs 1894).<sup>12</sup>

Garofalo omits the words in question; van der Eijk in his edition of the fragments of Diokles from Karystos prints the text of ms. P2 (= P 2324 in Fuchs 1894 and Garofalo 1997) in square brackets (van der Eijk, 2000, p. 206).

To summarize, it is difficult to make a safe conclusion about Praxagoras' standpoint on the cause of jaundice. (The remark on jaundice, dropsy and, possibly, wine-drinking of course may indicate liver cirrhosis.)

In fr. 69 it is said that melancholy is caused by black bile gathering around the heart:

μελαγχολίας αἰτία. Πραξαγόρας καὶ Διοκλῆς μελαίνης χολῆς περὶ τὴν καρδίαν  
συστάσης καὶ τὴν ψυχικὴν δύναμιν τρεπούσης φασι γίνεσθαι τὸ πάθος.  
Anonymus medicus *De morbis acutis et chroniis* disease 19, sect. 1, p. 116. (Garofalo) Fr. 69.

Cause of melancholy. Praxagoras and Diokles say that this disease is caused by black bile gathering around the heart, a disturbance which upsets the psychic power.

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<sup>12</sup> Steckerl changed πιούσης to πiónτες and νοθείσης to νοθεύσης, which, however is as problematic as the manuscript reading (is it intended as a form of νοθεύω "to corrupt"?). Fuchs (1894, p. 554), the first editor of the manuscript in question, prints νοσούσης τῆς χολῆς ὄξον πιούσης. That is, νοσούσης for νοθείσης of the ms., which makes better sense, and adds (καὶ ὅτι) after πιούσης; in the apparatus he also suggests that πιούσης should perhaps be πιούσι.

### Galenos' opinion on humors

Since Galenos is our main witness about the role of humors in Praxagoras' teachings, it seems necessary to comment on his own view, which of course must have influenced his citation of his forerunners. Although Galenos appreciated the concept of four humors as the building blocks of the human body, his own practice was governed by the allopathic principle that opposites cure opposites:

Ἴπποκράτης μὲν οὖν μοι δοκεῖ τὸ χρήσιμον εἰς τὰ τῆς τέχνης ἔργα πρῶτος εἰπεῖν, ὥσπερ αὖ πάλιν Ἐρασιστράτος ὅλον παραλιπεῖν. οἱ δὲ περὶ Πλειστονικόν τε καὶ Πραξαγόραν καὶ Φιλότημον ἐπὶ πλείστον ἐξεργασάμενοι τὸν περὶ τῶν χυμῶν λόγον ἔνια μὲν μοι δοκοῦσι χρησίμως διορίσθαι τῶν ἀδιορίστως Ἴπποκράτει γεγραμμένων, ἔνια δὲ καὶ ψευδῶς ἀποφήνασθαι.

Galenos *De atra bile* vol. 5, p. 104, l. 6 - p. 105 l. 3 (Kühn) Fr. 16b.

Hippokrates has, I think, first put forth the items useful for the practice of medicine, while on the other side, Erasistratos neglected the whole problem completely. The physicians associated with Pleistonikos, Praxagoras and Phylotimos, who worked out very extensively the theory of the humors, seems to me to have made in some points useful distinctions which Hippokrates failed to make, but to have been mistaken in some other points.

The allopathic principle is based on the concept that the four elementary qualities (hot, cold, moist, and dry) build the body and that health is maintained when these qualities are in balance, in εὐκρασία (i.e. well mixed or blended).

Ὑγεία ἐστὶ τῶν πρῶτων κατὰ φύσιν ἢ εὐκρασία τῶν ἐν ἡμῖν χυμῶν ἢ τῶν φυσικῶν δυνάμεων ἀπαραπόδιτος ἐνέργεια. ἢ ὑγεία ἐστὶν εὐκρασία τῶν τεσσάρων πρῶτων στοιχείων ἐξ ὧν τὸ σῶμα συνέστηκε, **θερμοῦ, ψυχροῦ, ὑγροῦ, ξηροῦ**  
Ps-Galenos *Definitiones medicae* vol. 19, p. 382, l. 6-10 (Kühn)

Health is well mixed in accord with the nature of the primary humors in us, or an unhindered function of the physical capacities. Health is a good mixture **of the four primary elements** from which the body is composed, **hot, cold, moist, dry.** (Translation: mine.)

This was one of the reasons why he was so critical to Erasistratos, who “overlooks and despises” (ὑπεριδὼν καὶ καταφρονήσας) what the best philosophers, including Praxagoras had said.

ἀλλ' Ἐρασιστράτος ὁ σοφὸς ὑπεριδὼν καὶ καταφρονήσας, ὧν οὐθ' Ἴπποκράτης οὔτε Διοκλῆς οὔτε Πραξαγόρας οὔτε Φιλιστίων ἀλλ' οὐδὲ τῶν ἀρίστων φιλοσόφων οὐδεὶς κατεφρόνησεν οὔτε Πλάτων οὔτ' Ἀριστοτέλης οὔτε Θεόφραστος, ὅλας ἐνεργείας ὑπερβαίνει καθάπερ τι σμικρὸν καὶ τὸ τυχὸν τῆς τέχνης παραλιπῶν μέρος οὐδ' ἀντειπεῖν ἀξιώσας, εἴτ' ὀρθῶς εἴτε καὶ μὴ σύμπαντες οὗτοι θερμοῦ καὶ ψυχροῦ καὶ ξηροῦ καὶ ὑγροῦ, τοῖς μὲν ὡς δρῶσι, τοῖς δ' ὡς πάσχουσι, τὰ κατὰ τὸ σῶμα τῶν ζώων ἀπάντων διοικεῖσθαι φασὶ καὶ ὡς τὸ θερμὸν ἐν αὐτοῖς εἰς τε τὰς ἄλλας ἐνεργείας καὶ μάλιστ' εἰς τὴν τῶν χυμῶν γένεσιν τὸ πλείστον δύναται.

Galenos *De naturalibus facultatibus* vol. 2, p. 110, l. 12 - p. 111. l. 6 (Helmreich et al.) Fr. 20.

The learned Erasistratos, however, **overlooks and despises** – what neither Hippokrates, Diokles, Praxagoras, nor Philistion despised, nor indeed any of the best philosophers, whether Platon, Aristoteles or Theophrastos; he passes by whole functions as though it were but a

trifling and casual department of medicine which he was neglecting, without deigning to argue whether or not these authorities are right in saying that the bodily parts of animals are governed by the warm, the cold, the dry and the moist, the one pair being active and the other passive, and that among these the warm has most power in connection with all functions, but especially with the genesis of the humors.

Galenos thought that the hot/warm was the most important power to create humors. One important reason for the persistence of the humoral theory in medicine over time was doubtless its endorsement by Galenos, who found it “useful for the practice of medicine.” He considered *De natura hominis* as a foundation, κρηπίς, of the Hippocratic works.

Ἱπποκράτης μὲν οὖν μοι δοκεῖ τὸ χρήσιμον εἰς τὰ τῆς τέχνης ἔργα πρῶτος εἰπεῖν  
Galenos *De atra bile* vol. 5, p. 105, l. 6-7 (de Boer)

Hippokrates was, I think, the first to put forth what is useful for the practice of medicine.

#### 4.2.4 Summary

##### Earlier concepts

Alkmaion from Kroton taught that balance (ἰσονομία) between “the forces, moist, dry, warm, bitter, sweet and the rest” is necessary for health. Dominance among them causes disease. Philolaos said that disease is caused by bile, blood, and phlegm.

The idea that a quartet of substances (fire, air, water, and earth) build the universe and man was first put forward by Empedokles and Philistion. Platon adhered to the same idea and said that disease is caused when there is, contrary to nature, an excess or deficiency of one of these elements. Aristoteles said that fire, air, water, and earth are formed from a combination of the “elementary qualities” hot, cold, moist, and dry.

The role of humors in health and disease was apparent to the Hippocratic physicians. In *De semine, de natura pueri, de morbis iv* the author mentions four kinds of moistness, blood, bile, water, and phlegm. In *De prisca medicina* several humors are mentioned. When these are well mixed and blended, they do not cause pain, but when one is dominant it causes pain. In the same treatise the author takes a stand against what he calls unfounded hypotheses about hot, cold, moist, and dry.

*De natura hominis* restricted the number of humors to four (blood, phlegm, yellow and black bile) and considered these four to be the elements building the body. Because of these four humors man feels pain or enjoys health.

##### Praxagoras' teachings

Both Rufus from Ephesos and Galenos say that Praxagoras reckoned eleven different humors (including blood), which can be identified according to their color, taste, consistency, and corrosiveness. Praxagoras did not consider these as building elements, but responsible for the balance between health and disease. Only a few of the eleven seem to be crucial (at least only a few have been considered important enough by the citing authors to comment upon). The most important humor for the development of disease is **cold phlegm**, especially **vitreous phlegm**. **Black bile** is also negative.

Humors are formed in the body from food. Different kinds of food produce different humors. Warm food produces bile, while cold food produces phlegm. Salty humor is produced by hard food and extensive cooking. Blood is formed under normal conditions, while humors are formed under conditions which are not normal. It is unclear what this means. According to Galenos this occurs when the innate heat is in ἀμετρία, not in proper proportion. However, Praxagoras seems not to have accepted the idea of an innate heat. It is difficult to distinguish Praxagoras' ideas from those of Galenos regarding this question.

According to Praxagoras humors are the only causes for what is παρὰ φύσιν, contrary to nature. A disturbance of the balance between humors is deleterious for health. Excess of bile or phlegm causes chilling and fever.

Praxagoras' main contribution is his ambition to couple imbalance in specific humors with specific diseases. However, it is not possible to understand how he determined the presence and location of each humor in the body. For example, he attributed all fevers to putrefaction of the humors in the hollow vein and neurological diseases were considered to depend on impeded transport of pneuma in the arteries due to phlegm.

### Legacy

Praxagoras' teaching in this field did not leave any legacy, mainly because of Galenos' support of the four-humor theory and the emphasis on the allopathic principle for therapy.

## 4.3 On the anatomy of blood vessels

### 4.3.1 Earlier concepts

The Hippocratic doctors had detailed knowledge of bones and joints and could use this in their treatment. They got their training when treating combat wounds and dislocated joints. A good example is the so called 'Hippocratic maneuver' for treatment of a dislocated shoulder, which has been used up till modern times, even by me myself as a young emergency surgeon. (Shoulder dislocation was probably not uncommon among wrestlers and other athletes in Greece.)

In contrast to this expertise, the knowledge of the interior of the human body was imperfect. The reason for this was the taboo against dissection of the human body, which was done first in Alexandria during the Hellenistic era (Lloyd, 1973, p. 76; Longrigg, 1998, p. 177; Nutton, 2004, p. 129). Due to the lack of precise information about the organs in the thorax and the abdomen, analogy with other species had to be the basis for medical practice.

Ἄγνωστα γὰρ ἐστὶ μάλιστα τὰ (scil. τὰ ἐντὸς) τῶν ἀνθρώπων, ὥστε δεῖ πρὸς τὰ τῶν ἄλλων μόρια ζώων ἀνάγοντας σκοπεῖν, οἷς ἔχει παραπλησίαν τὴν φύσιν.

Aristoteles *Historia animalium* 494b22-24 (Bekker)

The inner parts of man are for the most part unknown, and so we must refer to the parts of other animals which those of man resemble, and examine them. (Translation: A.L. Peck, ad loc.)



Concerning the blood vessels there was great uncertainty and many guesses. Instructive overviews are given by Littré in the chapter “De quelques points de chronologie medicale” (Littré, 1839, pp. 200-241) and by Fredrich in the chapter “Adern und Arterien” (Fredrich, 1899, pp. 57-80). It was known that blood vessels pass the heart, originating either in the brain or in the abdomen, but the heart itself was not given a central role. On the other hand, the heart was considered the seat of the soul and of thinking:

... ἀλλὰ καὶ διὰ τὸ νομίζειν ἐν τῇ καρδίᾳ τὴν ψυχὴν καθιδρῦσθαι, ὡς Πραξαγόρας καὶ Φυλότιμος οἱ ἰατροὶ παραδεδώκασιν.

Athenaios *Deipnosophistae* book 15, Kaibel paragraph 36, l. 20-22 Fr. 30.

... but also because they believed the soul to be seated in the heart, as the physicians Praxagoras and Phylotimos have taught.

Φρενίτιδος αἰτία. Πραξαγόρας δὲ φλεγμονὴν τῆς καρδίας εἶναί φησι τὴν φρενίτιν, ἧς καὶ τὸ κατὰ φύσιν ἔργον φρόνησιν οἶεται εἶναι· ὑπὸ δὲ τῆς φλεγμονῆς ταρασσομένην τὴν καρδίαν τοῦδε τοῦ πάθους συστατικὴν γίνεσθαι.

Anonymus medicus *De morbis acutis et chroniis* disease 1, sect. 2, p. 2. (Garofalo) Fr. 62.

Praxagoras says that phrenitis is an inflammation of the heart, the natural function of which, he believes is thinking. The heart harassed by inflammation, is overcome by this disease.

The author of *De semine, de natura pueri, de morbis* suggests that “the heart is the source of blood”:

τῷ μὲν δὴ αἵματι ἡ καρδίη πηγὴ ἐστὶ

Corpus Hippocraticum *De semine, de natura pueri, de morbis* in sect. 33, l. 9 (Littré)

The heart is the source of blood

Aristotle was certain that the heart was the origin of the vessels (Littré, 1839, p. 220).

Ἀρχὴν δὲ τούτων (τῶν φλεβῶν) ἀναγκαῖον εἶναι μίαν· ὅπου γὰρ ἐνδέχεται, μίαν βέλτιον ἢ πολλάς. Ἡ δὲ καρδία τῶν φλεβῶν ἀρχή· φαίνονται γὰρ ἐκ ταύτης οὔσαι καὶ οὐ διὰ ταύτης  
Aristoteles *De partibus animalium* 665b-14-17 (Bekker)

There must be one origin for the vessels, since wherever it is possible, one is better than many. The heart is the origin of the vessels, since they appear to come **from the heart and not thorough** it. (Translation: A.L. Peck, ad loc.)

The blood vessels transport not only blood but also pneuma. In the treatise *De ossium natura* the author seems to forebode the circle which Harvey would demonstrate almost two millennia later (Littré, 1839, p. 223).

Αἱ φλέβες διὰ τοῦ σώματος κεχυμένα πνεῦμα καὶ ῥεῦμα καὶ κίνησιν παρέχονται ἀπὸ μῆς πολλὰ διαβλαστάνουσαι, καὶ αὕτη μὲν ἢ μία ὅθεν ἦρκεται καὶ ἡ τετελεύτηκεν οὐκ οἶδα· **κύκλου** γὰρ γεγενημένου ἀρχὴ οὐχ εὐρέθη.

Corpus Hippocraticum *De ossium natura* sect. 11, l. 3-6 (Littré)

The vessels transport pneuma and blood (i.e. that which flows) through the body and exhibit movement. From one they divide into many, and where from this one comes and ends, I do not know. For the beginning of the **circle**, once it has become one, is not found.

Two different names for blood vessels can be found already in *Corpus Hippocraticum*. In the treatise *De articulis*, which displays an impressive knowledge of anatomy of bones and joints (Craik, 2015, p. 110), the names ἀρτηρία and φλέβες are used. It is not clear why the author made the distinction.

Αἱ δὲ φλεβῶν καὶ ἀρτηριῶν κοινωνία ἐν ἑτέρῳ λόγῳ δεδηλώσονται, ὅσαι τε καὶ οἶαι,  
καὶ ὅθεν ὠρμημέναι

Corpus Hippocraticum *De articulis* 45, l. 7-8 (Littre)

How much and what arteries and veins have in common and wherefrom they come will be described elsewhere. (N.B. The treatise which is announced here is unfortunately lost.)

ἀποθανεῖν τὰ νεῦρα καὶ τὰς σάρκας καὶ τὰς ἀρτηρίας καὶ τὰς φλέβας

Corpus Hippocraticum *De articulis* 69, l. 30-31 (Littre)

(when damaged) sinews, flesh, arteries and veins die

Littre was of the opinion that the author really understood the difference between arteries and veins and therefore he also questions the idea that Praxagoras was the first to make the distinction (Littre, 1839, pp. 201, 207). In the treatise *De carnibus* two hollow vessels going from the heart are described, one called artery and the other κοίλη φλέψ.

Δύο γὰρ εἰσι κοῖλαι φλέβες ἀπὸ τῆς καρδίας· τῇ μὲν οὖνομα ἀρτηρίη· τῇ δὲ κοίλη φλέψ,  
πρὸς ἧ ἡ καρδίη ἐστίν·

Corpus Hippocraticum *De carnibus* 5, l. 6-7 (Littre)

There are two hollow vessels from the heart, one is called artery, the other the hollow vein, which is at the heart.

However, it should be noted that this work was considered post-Aristotelian by Littre (Fredrich, 1899, p. 65).

To understand the naming of blood vessels, one must go back to Alkmaion from Kroton (Fredrich, 1899, p. 67). When he made dissection of dead animals, he noted that some vessels (which we now call arteries) contained less blood than others (today veins). The former he called φλέβες (vessels), the other αἰμόρροιοι φλέβες (vessels flowing with blood). All vessels were supposed to transport both blood and pneuma, but due to the lesser amount of blood in the arteries it was supposed that their main function was to transport pneuma, just like the trachea ἡ τραχεῖα ἀρτηρία (the rough windpipe).

Aristoteles made dissections of many species as described in his *Historia animalium*. Most of these descriptions are correct in detail and his naming of anatomical structures are still used. A few times he made mistakes though, the most often mentioned is his

misconception of the anatomy of the heart which he thought had three chambers. According to Longrigg “a celebrated error” (Longrigg, 1993, p. 173).

Ἡ δὲ καρδία ἔχει μὲν τρεῖς κοιλίας, κεῖται δ' ἀνωτέρω τοῦ πλεύμονος κατὰ τὴν σχίσιν τῆς ἀρτηρίας, ἔχει δ' ὑμένα πιμελώδη καὶ παχύν, ἣ προσπέφυκε τῇ φλεβί τῇ μεγάλῃ καὶ τῇ ἀορτῇ.

Aristoteles *Historia animalium* 496a4-7 (Bekker)

Now the heart has three cavities, and it lies above the lung at the point where the windpipe divides into two, and has a fat, thick membrane at the place where it is attached to the great blood-vessel and the aorta. (Translation: A.L. Peck, ad loc.)

ἀρτερία is here used for windpipe. Although Aristoteles gave different names to the vena cava and the aorta (φλέψς μεγάλη and ἀόρτη, respectively) he did not differentiate between smaller arteries and veins as can be seen e.g. from his description of the blood vessels in the mesentery.

Ἐξήρτηται δ' ἐκ τῆς μεγάλης φλεβὸς καὶ τῆς ἀορτῆς, καὶ δι' αὐτοῦ φλέβες πολλαὶ καὶ πυκναί, κατατείνουσαι πρὸς τὴν τῶν ἐντέρων θέσιν, ἄνωθεν ἀρξάμεναι μέχρι κάτω.

Aristoteles *Historia animalium* 495b33-496a2 (Bekker)

It (the mesentery) is attached to the great blood-vessel and the aorta, and through it there run numerous blood vessels packed close together, which extend to the region of the guts, starting from above and continuing to down below. (Translation: A.L. Peck, ad loc.)

Here all blood vessels are called φλέβες. Sometimes he describes vessels as πόροι (openings, passages), without distinction between arteries and veins.

Φέρουσι δ' εἰς αὐτοὺς πόροι ἐκ τε τῆς μεγάλης φλεβὸς καὶ τῆς ἀορτῆς

Aristoteles *Historia animalium* 497a4-5 (Bekker)

Passages lead to them (the kidneys) both from the great blood-vessel and from the aorta. (Translation: A.L. Peck, ad loc.)

However, he noticed the morphological difference between the two vessels to the kidneys, one of which he described as more sinewy.

Ἐκ μέσου δὲ τῶν νεφρῶν ἑκατέρου φλεψὶ κοίλῃ καὶ νευρώδῃ ἐξήρτηται

Aristoteles *Historia animalium* 497a13-14 (Bekker)

To the middle of each kidney is attached a hollow and a sinewy blood-vessel. (Translation: A.L. Peck, ad loc.)

*Historia animalium* was probably written sometime between 335 BC and Aristoteles' death in 322. The floruit of Praxagoras has been estimated to around the year 300. Thus, the concept of two different types of blood vessels must have evolved during this period. The names of arteries became ἀρτερίαι, while the veins dropped αἰμόρροι and became just φλέβες (Fredrich, 1899, p. 68).

### 4.3.2 Number of fragments and their authors

Seventeen fragments about the anatomy of blood vessels have been cited in this essay: 7, 8, 9, 11, 13a, 13b, 28a, 28b, 31, 60, 70, 74, 75, 78, 84, 85, 98a.

The authors were: Galenos 11, Anonymus Medicus 4, Rufus from Ephesos 2 frs.

### 4.3.3 Cited authors and their opinions on Praxagoras' teaching

It is likely that Praxagoras was the first one to make a clear distinction between arteries and veins, although it is not explicitly stated in any fragment. Rufus from Ephesos writes that in the old times they wanted to call φλέβες which pulsate for arteries:

Τὰς δὲ ἀρτηρίας τὸ ἀρχαιότατον φλέβας ὠνόμαζον· καὶ σφύζειν ὅποτε λέγοιεν τὰς φλέβας, ἀρτηρίας ἐβούλοντο καλεῖν ἀρτηριῶν γὰρ τὸ σφύζειν ἔργον·  
Rufus from Ephesos *De corporis humani appellationibus* sect. 208, l. 1-3 (Daremberg & Ruelle)

In the oldest times they called arteries φλέβες, and when they said that φλέβες pulsate, they wanted to call them arteries, because to pulsate is the work of arteries

He then most probably refers to Praxagoras, who is mentioned a few sentences later:

Αορτὴν δὲ Ἀριστοτέλης ἐξαιρέτως τὴν διὰ τῆς ῥάχεως ἀρτηρίαν ὀνομάζει, ἢ τις μεγίστη παρατέταται τῇ ῥάχει· ταύτην δὲ παχεῖαν Πραξαγόρας εἶθισται καλεῖν.  
Rufus from Ephesos *De corporis humani appellationibus* sect. 209, l. 1-3 (Daremberg & Ruelle) Fr. 8.

The artery running along the spine is specifically called the aorta by Aristoteles, the largest artery extending the length of the spine. Praxagoras customarily called it the thick (artery).

His father Nikarchos could very well have contributed to the discovery of the difference between arteries and veins, although he is fairly seldom mentioned in the fragments (Longrigg, 1998, p. 121). The following fragment is a possible exception, which apparently states that Nikarchos and Praxagoras made a distinction between arteries and veins:

ἐν μὲν δὴ ταῖς τοιαύταις διαθέσεσιν οὐδὲν ἐναργὲς γνῶρισμα τοῦ κατὰ τὰς φλέβας ἠθροισμένου πλήθους ἐκ τῆς τῶν ἀρτηριῶν κινήσεως ἔνεστι λαβεῖν, εἰ καὶ ὅτι μάλιστα τῷ Νικάρχῳ καὶ Πραξαγόρᾳ δοκεῖ, καίτοι μὴ μεταδιδόντι ταῖς ἀρτηρίαις αἵματος·  
Galenos *De plenitudine liber* vol. 7, p. 573, l. 16 - p.574, l. 1 (Kühn) Fr. 85.

It is not possible to get a clear knowledge about the amount (of the humors) which is collected in the veins in such morbid states by way of inference from the movements of the arteries, even though this seems entirely possible to Nikarchos and Praxagoras, although they do not assign blood to the arteries. (Translation: Steckerl, modified.)

The text as printed in Kühn is contested. Christoph Otte published his PhD-thesis on Galenos' *De plenitudine* in 2001 (Otte, 2001). According to Otte the text should read:

ἐν μὲν δὴ ταῖς τοιαύταις διαθέσεσιν οὐδὲν ἐναργὲς γνῶρισμα τοῦ κατὰ τὰς φλέβας ἠθροισμένου πλήθους ἐκ τῆς τῶν ἀρτηριῶν κινήσεως ἔνεστι λαβεῖν, εἰ καὶ ὅτι μάλιστα τῷ Νικάρχῳ Πραξαγόρᾳ δοκεῖ, καίτοι μὴ μεταδιδόντι ταῖς ἀρτηρίαις αἵματος

Thus, in this work Otte (Otte, 2001, pp. 97-98) has τῷ Νικάρχου Πραξαγόρα instead of τῷ Νικάρχῳ καὶ Πραξαγόρα which was published by Kühn and found in TLG. This changes the meaning from "Nikarchos and Praxagoras" to "Praxagoras, son of Nikarchos".

Otte's examination of four different manuscripts (A, E, M, and P1) shows that an unsuccessful correction in P1 is the background for the version of Kühn. In the apparatus Otte writes: Νικάρχου scripsi: Νικάρχῳ AEMP1, post Νικάρχῳ suppl. καὶ P1<sub>ms</sub>; vide explic. μεταδιδόντι AMP1: μεταδόντι E, in μεταδιδούσι mut. P1<sub>ms</sub>.\*

\* In his introduction and in sigla Otte explains that manuscript P1 has been corrected by two different hands. P1<sub>ms</sub> has many false conjectures. One of these is the addition of καὶ after Νικάρχῳ. Another is the change of the participle to μεταδιδούσι.

The reading of Otte attributes to Praxagoras alone the opinion that arteries do not contain blood, contrary to Kühn and Steckerl who attribute this opinion to both father Nikarchos and son Praxagoras. Otte concludes that all secondary literature must be revised.<sup>13</sup> This goes e.g. for Longrigg 1998, p. 121 and Nutton 2004, p. 126.

In favour of Otte's version is the fact that in the seven other instances when Nikarchos is mentioned together with Praxagoras it is as the father of Praxagoras, i. e. in genitive Νικάρχου (In: *De naturalibus facultatibus, De uteri dissectione, De utilitate respirationis liber, De tremore palpitatione, convulsione et rigore liber, Diocles Fragmenta* (twice), *Erasistratos Testimonia et Fragmenta*). The participle μεταδιδόντι (alt. μεταδόντι) in singular, agreeing with one head word, also speaks in favour of Praxagoras as being the only one holding this opinion.

That Praxagoras did not think that the arteries contain blood is also said in fr. 9, see section 4.5.5, on the role of pneuma in the arteries.

That he made a distinction between veins and arteries can also be concluded from Galenos' comment to the Hippocratic *Aphorisms*:

ἐν τε γὰρ τῷ πρώτῳ τῶν γυναικείων αὐτός (scil. Ἴπποκράτης) φησιν, ἣν δὲ αἱ κοτυληδόνες φλέγματος περίπλεες ἔωσι, τὰ καταμήνια γίνεται ἐλάσσονα, καὶ ὁ Πραξαγόρας ἐν τῷ πρώτῳ τῶν φυσικῶν, κοτυληδόνες δὲ εἰσι τὰ στόματα τῶν φλεβῶν καὶ τῶν ἀρτηριῶν τῶν εἰς τὴν μήτραν φερούσῶν.

Galenos *In Hippocratis aphorismos commentarii vii* vol 17b, p. 838, l. 13-17 (Kühn) Fr. 13b.

He (Hippokrates) says in his first book of his Gynecology that the menstrual flow is reduced when the cotyledons are quite full of phlegm; and Praxagoras says in his first book of his *Physica*: Cotyledons are the apertures of the veins and arteries which lead into the womb.

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<sup>13</sup> Sämtliche Stellen in der Sekundärliteratur, die auf Grund von *De plen.* 11,11 ihm die dort genannte Lehrmeinung zusprechen, müssen also revidiert werden: Sie können sich nicht auf die handschriftliche Überlieferung berufen, den der bisher verbreitete griechische Text geht auf einen mißlungenen Heilungsversuch des Korrektors von P1 zurück. (All the passages in the secondary literature, which based on *De plen.* 11,11 ascribe to him the opinion described therein, thus must be revised. You can not refer to the manuscript tradition because the previously widespread Greek text goes back to an unsuccessful attempt at healing by the corrector of P1.)

A good indication for Praxagoras' primacy is given by Rufus, who says that the reason for the differentiation between the two types of vessels was the finding that only the arteries pulsate, see section 4.4.4 on the pulse below.

Praxagoras called the aorta the thick, *παχεῖαν* (artery), see fr.8 above. He called a vein below the diaphragm for *κοίλη*, the hollow (fr. 7). This vein sends branches from the liver to the kidneys. Other physicians gave the same name to the vein which goes through the diaphragm to the heart, apparently the vena cava. Thus, Praxagoras by *κοίλην* most probably meant the inferior vena cava.

Ὑστερον δὲ διὰ ἔθους ἔσχον οἱ ἰατροὶ κοίλην ὀνομάζειν, τὴν τε ἀπὸ τοῦ ἥπατος ἐπὶ [τοῦς] νεφροῦς πέμπουσιν τὰς ἀποφύσεις, ἔνθα φησὶν ὁ Πραξαγόρας τὴν πρώτην ἀρχὴν εἶναι τῶν πυρετῶν· καὶ οὗτος κοίλην μόνην ταύτην καλεῖ· ἄλλοι δὲ καὶ τὴν ἄνω διὰ τῶν φρενῶν ἐπὶ καρδίαν τείνουσαν·  
Rufus from Ephesos *De corporis humani appellationibus* sect. 199, l. 1 – sect. 200, l. 1 (Daremberg & Ruelle) Fr. 7.

Later on the physicians got the habit of calling this vein “the hollow one” which sends branches from the liver to the kidneys. There originates, as Praxagoras says, the first beginning of the fevers. He calls only this vein hollow vein. Other physicians call by this name also that vein which stretches through the diaphragm toward the heart.

The most detailed discussion about Praxagoras' conception of the blood vessels is found in fr. 11: Galenos *De placitis Hippocratis et Platonis* (On the doctrines of Hippocrates and Platon) book 1, ch. 6, sect. 13 – ch. 8, sect. 1. Here Galenos, in almost two chapters writes about Praxagoras and criticizes his views on vessels and nerves.

Praxagoras had maintained that the heart is the origin of the nerves, which was also the standpoint of Aristoteles.

Ἀριστοτέλει δὲ γε καὶ Πραξαγόρα παρὰ τὸ φαινόμενον ἀποφαινομένοις ἀρχὴν τῶν νεύρων εἶναι τὴν καρδίαν ἐγκαλέσειεν ἂν τις δικαίως. ὅτι μὲν γὰρ ἄλλα πολλὰ τῶν κατὰ τὰς ἀνατομὰς ἀκριβῶς ἐωράκασιν, ἐξ ὧν ὑπελείποντο συνταγμάτων ἔνεστι καταμαθεῖν· ὅτι δὲ ἦτοι παντάπασι αὐτοὶ τυφλώττοντες ἢ τυφλοῖς διαλεγόμενοι περὶ τῆς τῶν νεύρων ἀρχῆς ἔγραψαν, οὐ λόγοις χρὴ μακροῖς κατασκευάζειν, ἀλλ' ἐπὶ τὴν αἴσθησιν ἰέναι.

But Aristoteles and Praxagoras, asserting contrary to evidence that the heart is the origin of the nerves, would rightly be blamed. That many of their other anatomic observations are correct, you can learn from the works they have left behind; but that they were either themselves completely blind or conversed with blind men when they wrote on the origin of the nerves, I need not establish by giving a long talk, but rather by turning to sense-perception.

Steckerl translated *κατὰ τὰς ἀνατομὰς* with “anatomic observations”. A better translation, which is pointed out by Lewis (Lewis, 2017, p. 105), would be “during dissections” since Galenos was aware of, and otherwise praised Praxagoras' experience with anatomic dissections. (*ἀνατομή* from the verb *ἀνατέμνω*, LSJ: to cut up, cut open.)

Praxagoras further believed that arteries, when they divide and successively get smaller, are transformed *εἰς νεῦρα*, into “nerves”.

οὐ μικρὸν ἀπετόλμησε ψεύσασθαι τὰς ἀρτηρίας φάμενος ἐν τῷ προῖέναι καὶ κατασχίζεσθαι στενὰς γιγνομένας εἰς νεῦρα μεταβάλλειν· τοῦ γὰρ δὴ σώματος αὐτῶν ὑπάρχοντος νευρώδους μὲν ἀλλὰ κοίλου, ἡκαίε κατὰ τὴν ἐπὶ πλέον ἐν τῷ ζῶνι σχίσιν οὕτως γιγνομένων μικρῶν τῶν κοιλοτήτων ὡς ἐπιπίπτειν ἀλλήλοις τοὺς χιτῶνας, ὁπότεν τοῦτο πρῶτον γένηται, νεῦρον ἤδη φαίνεσθαι τὸ ἀγγεῖον.

(Praxagoras) did not show even the slightest hesitation in boldly making a false claim: he said that the arteries, becoming narrow in the course of their advance and branching, change into *neura*. Their body [he argued] is manifestly *neura-like*, but hollow, and in the course of their branching further and further in the animal their hollows become so small that their walls collapse on one another; and as soon as this happens [he argued], the vessel already looks as a *neuron*. (Translation: Lewis, p. 41.)

Galenos apparently was upset and therefore used the strong word ψεύσασθαι, to lie, about Praxagoras' view. In this passage Lewis has translated νεῦρα with *neura*. Considering what we know and do not know about Praxagoras' intention it might be wise here to leave the word untranslated to indicate the uncertainty. For some reason Galenos in the last sentence uses the word ἀγγεῖον for vessel. This word was often used by Aristoteles, e.g. when mentioning blood in φλέψ (*Historia Animalium* 521b6). Nowhere else is this word attributed to Praxagoras. Since Galenos was well aware of the difference between arteries and veins this is maybe another sign of Galenos' frustration with Praxagoras.

ἀλλ' ἐν ταύταις μὲν ἴσως οὐ χρή πικρῶς διελέγχειν τὸν Πραξαγόραν ἀλλὰ τι καὶ συγγνώμης νέμειν, εἰ μικρὰς ἀρτηρίας οὐκ ἐθεάσατο.  
(καίτοι γε ὅταν εἰς νεῦρα μεταβάλλειν αὐτὰς φάσκη τὰς μικροτέρας, οὐκ ἀμβλυωπίαν ὑποτιμᾶται δῆπουθεν, ἀλλ' ὅξυ βλέπειν ἐπαγγέλλεται.)

In the case of these arteries, however, it is perhaps unnecessary to refute Praxagoras harshly, but rather we should even grant him some measure of leniency, if he did not see small arteries. And yet, when he says that the smaller [arteries] themselves change into *neura*, he is surely not claiming dim-sightedness, but professes to see sharply. (Translation: Lewis, p. 43.)

It seems like Galenos is disappointed that Praxagoras so openly disregards what he must have seen.

τὰ μὲν δὴ τοῦ Πραξαγόρου ψεύσματα πεφώραται σαφῶς ἤδη καὶ οὐδὲν ἔτι Πραξαγόρου γ' ἔνεκεν ἐπὶ τὰς ἀρτηρίας ἰέναι χρή τῷ λόγῳ.

The lies of Praxagoras are thus now clearly revealed and it is not necessary any more to return to the arteries as far as regards Praxagoras.

Praxagoras' view is so impossible that Galenos is not willing comment further.

This passage, so critical to Praxagoras, also includes the following sentence which again exemplifies the difficulty in translating anatomical terms:



οὐκ οὐκ ἀρτηρίας χρὴ ζητεῖν ἐξ ὧν νεῦρα τῷ λόγῳ γεννήσαντες  
ἢ τοὺς δακτύλους κινήσομεν ἢ τι τῶν κατὰ τὰς χεῖρας ἕτερον (ch 7, sect. 23-24).

It is therefore unnecessary to look for arteries from which, after theoretically producing *neura* from them, we will move our fingers or some other part of our arm. (Translation: Lewis, p. 45.)

It must be pointed out that this is Galenos' view, not a direct citation of Praxagoras. Steckerl has concluded that νεῦρα here should be translated as tendons (Steckerl, 1958, p. 18): "Apparently nerves are tendons which lead to the extremities." Steckerl may be right, but that seems unlikely. Galenos did not use the word νεῦρα when meaning tendons. Other interpretations are possible. One explanation would be that Praxagoras with the word νεῦρα just meant fibrous cords, not exactly tendons. Or maybe even more plausible: Praxagoras' intention could have been to explain voluntary motion, since he thought that the role of arteries was to transmit pneuma around the body and he conceived pneuma to be essential for execution of voluntary motion (Lewis, 2017, p. 110). Lewis in her book on Praxagoras refrains from taking stand on this issue and leaves the word νεῦρα untranslated (Lewis, 2017, p. 104).

In his harsh criticism of Praxagoras, Galenos writes about πανουργίας τινὸς ἐπιβεβουλευμένος (some deliberate deception). "According to Galenos this is not a mere innocent mistake on Praxagoras' behalf, but an intentional attempt to support a false physiological hypothesis by falsifying the anatomical facts. Hence, it is, for Galenos, a deception rather than an ignorant mistake" (Lewis, 2017, p. 106).

Galenos finishes by calling Praxagoras the insolent sophist, τὸν Πραξαγόραν ἀναίσχυντα σοφιζόμενον.

It is apparent that Galenos had many reasons to criticize Praxagoras. The first was of course the facts. Galenos had extensive experience with dissection and Praxagoras obviously was wrong. Another reason was that Praxagoras' views differed from that of Hippokrates when it came to the origin of nerves. Earlier in this treatise (l. 18) he writes: ἐφιλοτιμεῖτο δὲ πρὸς Ἴπποκράτην, "he rivals with Hippokrates". Galenos took every opportunity to defend Hippokrates.

#### 4.3.4 Summary

##### Earlier concepts

Before Hippokrates all blood vessels were called φλέβες. They were supposed to transport both blood and pneuma. In the Hippocratic treatises for the first time the word ἀρτηρία was used together with φλέψ. It is not clear why the Hippocratic authors used two different words for blood vessels. Littré claims that they in fact had understood the difference. Aristoteles saw the structural difference between the vessels connecting the kidneys with the aorta and the vena cava, but did not make a difference between smaller vessels, e. g. in the mesentery where all vessels were called φλέβες.

##### Praxagoras' teachings

It is probable that Praxagoras was the first to make a clear distinction between arteries and veins, but his primacy is not explicitly stated in any fragment. Maybe, although



uncertain, this work was made in cooperation with his father Nikarchos. What is clear is that he made a difference between the thick artery (aorta) and the hollow vein (vena cava) and used the words artery and vein for vessels in the womb. He noted that arteries, but not veins do pulsate. According to Galenos, Praxagoras during dissection noticed that arteries when they become thin seem to lose their lumen and become solid, like νεῦρα. Galenos was very critical to this and argued that Praxagoras was either blind or intentionally tried to mislead his readers. A more benevolent interpretation would be that Praxagoras' intention in fact was to explain how movement of the extremities was accomplished. He was convinced that the role of arteries was to distribute pneuma which is essential for voluntary movement.

### **Legacy**

Even if his primacy cannot be conclusively demonstrated, it seems clear that the demonstration of pulsating vessels called arteries was during antiquity attributed to Praxagoras.

## **4.4 On the pulse**

### **4.4.1 General considerations regarding nomenclature**

The topic on the pulsation of blood vessels is complicated, mainly for two reasons. The first is the risk of anachronisms. All the words used by the ancient authors are nowadays in use, but not always with the same meaning as in antiquity. The second, even more difficult reason is that our main source Galenos is so eager to establish his own view that the original opinion of Praxagoras becomes blurred.

It must be remembered that the only way to evaluate the pulse was by the senses, mainly digital palpation, but also to some degree visual observation. The measurement of blood pressure was not possible.

It may facilitate our understanding if we make clear what we today can judge, without the use of advanced technical equipment. The first is rhythm. Is the pulse regular or irregular? The second is rate (frequency). Is the pulse rapid (tachycardia) or slow (bradycardia)? The third is amplitude (volume). Is the pulse bounding (hyperkinetic) or weak (hypokinetic)? In addition, compressibility of the pulse can be regarded as a rough measure of blood pressure. Let us keep this in mind when we try to understand Praxagoras and the physicians after him.

When writing about the fairly complicated topic of the pulse, I have had great help from Orly Lewis' book (Lewis, 2017). The English translations of texts about the pulse made by Steckerl in many cases do not follow the original closely enough, but also include his interpretations, not based on the original. The more precise translations made by Lewis are presented in the following.

#### 4.4.2 Earlier concepts

In the *Iliad* an increase of heart rate is described, but not an effect on the pulse.

ἐν δ' ἐμοὶ αὐτῇ στήθεσι πάλλεται ἦτορ ἀνὰ στόμα, νέρθε δὲ γούνα πῆγνυται

Homeros *Iliad* 22.452

and in mine own breast my heart leapeth to my mouth, and beneath me my knees are numbed

The Hippocratic physicians did not use the pulse in their diagnosis.

Περὶ μὲν οὖν σφυγμῶν οὐδεὶς τῶν ἀρχαίων σοφῶν ἰατρῶν ἀριδῆλως συνέγραψεν, ἀλλ' οὐδ' αὐτὸς ὁ Ἱπποκράτης

Theophilus Protospatharios *De Pulsibus* p. 7, l. 6-8 (Ermerins)

Of the old wise physicians no one clearly described the pulse, not even Hippokrates himself

However, description of batting vessels can be found in many treatises. In the *Epidemics* the word πηδάω (LSJ: leap, spring, throb) is used to describe the pulsation of arteries in the temple during fever:

αὶ ἐν κροτάφοισι φλέβες ἐπήδων

Corpus Hippocraticum *De morbis popularibus* (=Epidemiae) book 7, ch. 1, sect. 84, l. 17 (Littre)

the vessels throbbed in the temple

The word σφυγμός (LSJ: throbbing, beating) is also used:

ἐν κροτάφοισι δὲ σφυγμὸς διετέλει

Corpus Hippocraticum *De morbis popularibus* (=Epidemiae) book 7, ch. 1, sect. 5, l. 23 (Littre)

and there was beating in the temples

In these two examples from *Epidemiae* the pulsation of vessels in the temples was probably seen, not palpated. Galenos writes that Hippokrates used the word σφυγμός, but without developing the concept and without attributing it to a function of the arteries.

Πρῶτος μὲν οὖν ἀπάντων ὧν ἴσμεν Ἱπποκράτης τό τε ὄνομα τοῦ σφυγμοῦ γράφει καὶ τὴν ἐν αὐτῷ τέχνην οὐκ ἀγνοεῖν ἔοικεν, οὐ μὴν οὐτ' ἐπὶ πλεον ἐξεργάσατο τοῦτο τὸ μέρος τῆς τέχνης οὐτ' ἐπὶ πάσης ἀρτηριῶν κινήσεως τοῦνομα φέρει.

Galenos *De differentia pulsuum libri iv* vol. 8, p. 497, l. 13-17 (Kühn)

Hippokrates, then, was the first among all those of whom we know, who not only used the term 'sphygmōs' [*scil.* pulse] in his writings but also seems not to have been ignorant of the art (concerning the pulse). He did not, however, work out this part of the art any further nor did he extend this term [*scil.* sphygmōs] to refer to all arterial movements. (Translation: Lewis, p. 47)

A detailed compilation is given by Littre (Littre, 1839, p. 227). Regarding the Hippocratic era, he concludes: "L'application de la sphygmologie est tout à fait ignorée" (the application of sphygmology is completely ignored) (Littre, 1839, p. 241).

Aristoteles realized that the beating of the heart and the pulse were connected to each other.

καὶ σφύζουσιν αἱ φλέβες πᾶσαι, καὶ ἅμα ἀλλήλαις, διὰ τὸ ἠρτηῆσθαι ἐκ τῆς καρδίας. κινεῖ δ' αἰεὶ ὥστε κἀκεῖναι αἰεὶ, καὶ ἅμα ἀλλήλαις, ὅτε κινεῖ.  
Aristoteles *De respiratione* 480a12-14 (Ross)

All the vessels throb, and throb simultaneously with each other, because they are connected with the heart. The heart beats always, and therefore so do the vessels; and they beat simultaneously with each other when the heart beats. (Translation: W.S. Hett, ad loc.)

Loeb here has veins as translation of φλέβες. Since we today (after Praxagoras) make a difference between arteries and veins which Aristoteles did not make, it seems better to use vessels.

#### 4.4.3 Number of fragments and their authors

Fourteen fragments about the pulse have been cited in this essay: 9, 26a, 26b, 27a, 27b, 27c, 27d, 27e, 27f, 28a, 28b, 84, 85 + Marcellinus (not mentioned by Steckerl).

The authors were: Galenos 12, Rufus from Ephesos 1, Marcellinus 1 frs.

#### 4.4.4 Cited authors and their opinions on Praxagoras' teaching on the pulse

The beating of arteries was called σφυγμός by Praxagoras in contrast to Aigimios who used the word παλμός (LSJ: quivering motion):

ἅπασαν ἀρτηριῶν κίνησιν παλμὸν ὀνομάζει. ἡ δὲ Πραξαγόρου τε καὶ Ἡροφίλου χρῆσις ἔτι καὶ εἰς τὰδε κρατεῖ. σφυγμὸν γὰρ οὗτοι πᾶσαν ἀρτηριῶν κίνησιν τὴν αἰσθητὴν καλοῦσιν.  
Galenos *De differentia pulsuum libri iv* vol. 8, p. 498, l. 5 – 11 (Kühn) Fr. 26a.

He (Aigimios) called every movement of the arteries 'palmos'. The usage of Praxagoras and Herophilos, however, still prevails today. For they call every perceptible motion of the arteries 'sphugmos'. (Translation: Lewis, p. 47.)

This is a bit difficult to understand. Praxagoras did use not only σφυγμός to describe the pulsation of arteries, but also παλμός, τρόμος and σπασμός. However, this fragment indicates that in Galenos' time all motions of arteries were called σφυγμός. The other words were used for other movements in tissues around arteries, see below.

#### Cause of arterial pulsation

Praxagoras thought that the arteries pulsate by themselves due to a natural, innate capacity, like that of the heart:

ἔτι δὲ μείζων ἄλλη διαφορὰ τοῖς ἰατροῖς ἐκ παλαιοῦ περὶ τῶν ἀρτηριῶν ἐγένετο, τινῶν μὲν ἡγουμένων αὐτὰς ἐξ ἑαυτῶν σφύζειν, σύμφυτον ἐχούσας ὁμοίως τῇ καρδίᾳ τὴν τοιαύτην δύναμιν, ὧν ἔστι καὶ ὁ Πραξαγόρας  
Galenos *De differentia pulsuum libri iv* vol. 8, p. 702, l. 14 – 18 (Kühn) Fr. 28a.

Yet another and bigger difference regarding the arteries existed among the ancient physicians: while some of them believed that the arteries pulsate **by themselves**, since they possess such an ability innately, as the heart does – Praxagoras, too, was one of these.

νομίζουσι (Πραξαγόρας καὶ Φυλότιμος) τὸ πάμπαν ἐξ ἑαυτῶν σφύζειν τὰς ἀρτηρίας  
Galenos *De placitis Hippocratis et Platonis* book 6, ch. 7, sect. 3, l. 3-4 (Kühn) Fr. 28b.

They (Praxagoras and Phylotimos) think that the arteries beat completely **by themselves**

Praxagoras misjudgment of the relation between the beating of the heart and the pulse was soon corrected by his pupil Herophilos (von Staden, 1989, p. 270). However it is possible that Praxagoras saw *some* connection between the heartbeat and the pulse. At least this is indicated by Galenos:

ὡς Ἡροφίλω τε καὶ πρὸ τούτου Πραξαγόρα καὶ Φυλοτίμω καὶ Διοκλεῖ καὶ Πλειστονίκω καὶ Ἱπποκράτει καὶ μυρίοις ἑτέροις ἀρέσκει. ὅτι μέντοι τῆς διαστελλούσης τὰς ἀρτηρίας δυνάμεως οἷον πηγὴ τίς ἐστὶν ἢ καρδία. καὶ τοῦθ' ἐτέρωθί τε πρὸς ἡμῶν ἐπιδέδεικται καὶ τοῖς προειρημένοις ἅπασιν ἀνδράσιν ὠμολόγηται,  
Galenos *An in arteriis natura sanguis contineatur* vol. 4, p. 732, l. 1-6 (Albrecht)

as Herophilos thought, and before him Praxagoras, Phylotimos, Diocles, Pleistonicos, Hippokrates, and countless others. All the aforementioned men agree, however – and it has been demonstrated elsewhere by me - that the heart is something like a source of the faculty which dilates the arteries. (Translation: v. Staden, p. 323.)

The above text is part of an attack on Erasistratos regarding the distribution of pneuma in the arteries. As often all the *παλαιοί* are mentioned together, which considerably weakens the proof. Actually, this is another indication that Galenos' writings must be judged with skepticism.

Different aspects of the pulse are presented together in the same fragments (fr. 27a, 27b, 27c, 27d), but are discussed separately for the sake of clarity in the following.

### Quantity vs. quality of the pulse

According to Rufus, Praxagoras described the pulse using four words: σφυγμός, παλμός, σπασμός and τρόμος (pulse, palpitation, spasm, and tremor; for English synonyms see 3.1.3). He considered the difference between these to be in quantity, but not in quality (ποσότητι vs. ποιότητι):

Ὁμοίωται δὲ τῷ σφυγμῷ ὃ τε παλμός καὶ ὁ σπασμός καὶ ὁ τρόμος· καὶ γὰρ καὶ ταῦτα δοκεῖ τισὶν οὕτω γίνεσθαι, ὥσπερ καὶ ὁ σφυγμός, ἕκ τε διαστολῆς καὶ συστολῆς. διαφορὰ δὲ ἐν αὐτοῖς ὑπάρχει πλείστη· Πραξαγόρας μὲν οὖν ὑπέλαβε ταῦτα (scil. σφυγμὸν, παλμὸν, σπασμὸν, τρόμον) ἀλλήλων διαφέρειν **ποσότητι**, οὐκέτι δὲ καὶ **ποιότητι**· γίνεσθαι γὰρ ἕκ μὲν τοῦ σφυγμοῦ, μᾶλλον αὐτοῦ περὶ τὴν κίνησιν ἐπιταθέντος, τὸν παλμὸν, ἕκ δὲ τοῦ παλμοῦ τὸν τρόμον. Καὶ ταῦτα μὲν ὁ Πραξαγόρας, ἀνὴρ οὐχ ὁ τυχῶν οὐτε ἐν τοῖς κατὰ τὴν ἰατρικὴν θεωρήμασιν, οὔτε ἐν τῷ ἄλλω βίῳ· ὁ δὲ Ἡρόφιλος ἀκριβέστερον ἐπιστήσας τῷ τόπῳ ἐν ποιότητι μᾶλλον αὐτῶν τὰς διαφορὰς εὔρεν·  
Rufus from Ephesos *Synopsis de pulsibus* ch. 2, sect. 1 - sect. 3, l. 4 (Daremberg & Ruelle) Fr. 27b.

Palpitation, spasm, and tremor are similar to the pulse, for they too appear, to some people, to be generated from an expansion and contraction, just like the pulse; the difference between them, however, is great. Praxagoras, for one, understood these to differ from one another **in quantity, but not in quality**; for [he believed that] palpitation is generated from the pulse, when the latter's motion increases to a greater extent, and that from palpitation tremor is generated. And these things were [said] by Praxagoras, no ordinary man in the medical science or in other aspects of life. Herophilos, however, who understood the matter more accurately, found the differences between these phenomena to lie rather in their quality. (Translation: Lewis, p. 51.)

The sentence γίγνεσθαι γὰρ ἐκ μὲν τοῦ σφυγμοῦ, μᾶλλον αὐτοῦ περὶ τὴν κίνησιν ἐπιταθέντος was translated “palpitation is generated from the pulse, when the latter's motion increases to a greater extent” by Lewis, while Steckerl had “grow faster”. Lewis points out that ἐπιταθέντος is derived from the verb ἐπιτείνω which means “to increase intensity” and does not necessarily refer to speed. It may instead refer to the dimension or the force of the observed motion (Lewis, 2017, p. 126).

The next meaning which follows fr. 27b says:

γίγνεσθαι γὰρ τὸν σφυγμὸν περὶ μόνας ἀρτηρίας καὶ καρδίαν, τὸν δὲ παλμὸν καὶ τὸν σπασμὸν καὶ τὸν τρόμον **περὶ μύας τε καὶ νεῦρα**.

Rufus from Ephesos *Synopsis de pulsibus* ch. 2, sect. 3, l. 4-6 (Daremborg & Ruelle)

For pulse occurs only in the arteries and the heart, whereas palpitation and spasm and tremor occur **in muscles as well as nerves**.

The lexical meaning of ποσότης is quantity. Galenos reports the same opinion as Rufus from Ephesos in fr. 27a, οὐ γένει ... ἀλλὰ μεγέθει, “not in kind, but in magnitude”:

οὐ σμικρὰ δ' ἀντιλογία περὶ τῶν παθῶν τούτων γέγονεν Ἡροφίλω πρὸς τὸν διδάσκαλον Πραξαγόραν, οὐκ ὀρθῶς ἀποφηνάμενον ἀρτηριῶν πάθος εἶναι καὶ παλμὸν καὶ τρόμον καὶ σπασμὸν, **οὐ γένει διαφέροντα** τῆς σφυγμῶδους ἐν αὐτοῖς κινήσεως, **ἀλλὰ μεγέθει**. κατὰ φύσιν μὲν γὰρ ἐχόντων ἄνευ πάσης περιστάσεως γίνεσθαι τοὺς σφυγμοὺς, ἀξηθείσης δὲ τῆς κινήσεως αὐτῶν εἰς τὸ παρὰ φύσιν πρῶτον μὲν σπασμὸν ἀποτελεῖσθαι, δεύτερον δ' ἐπ' αὐτῷ τρόμον, καὶ τρίτον τὸν παλμὸν, **ἀλλήλων διαφέροντα μεγέθει** πάντα ταῦτα τὰ πάθη. διὰ τοῦτ' οὖν Ἡρόφιλος εὐθέως ἐν ἀρχῇ τῆς περὶ σφυγμῶν πραγματείας ἀνατρέπειν πειρᾶται τὴν τοῦ διδασκάλου δόξαν, ἀλλ' ὡς ἔθος Ἡροφίλω, δι' ἑρμηνείας ἀσαφοῦς, ἦν ἐπὶ τὸ σαφές οἱ ἀπ' αὐτοῦ μεταλαμβάνοντες ἔγραψαν ἐν αἷς ἐποίησαντο πραγματείας περὶ τῆς Ἡροφίλου αἰρέσεως. Galenos *De differentia pulsuum libri iv* vol. 8, p. 723, l. 9- p. 724, l. 5 (Kühn) Fr. 27a.

And no short disputation regarding these affections [scil. palpitation, tremor, and spasm] did Herophilos make against his teacher Praxagoras, for wrongly claiming that palpitation, tremor and spasm are affections of the arteries, which differ from the pulse-motion in them **not in kind but [only] in magnitude**. For, [Praxagoras claimed that], when the arteries are in natural condition, without any difficulties, the pulse occurs, but that when their motion increases to an unnatural extent it turns first into spasm, then, after that, into tremor and then into palpitation – all these affections **differing from one another in magnitude**. This, then, is why Herophilos, right at the beginning of his work *On the pulse*, attempts to refute his teacher's view. But, as was

the custom of Herophilos, he does so by means of an obscure explanation, which those who succeeded him substituted with a clear explanation, which they put down in the works that they wrote about Herophilos' school. (Translation: Lewis, p. 49.)

Galenos here apparently refers to Praxagoras when he writes that magnitude is what characterizes different pulses. (However, he gives another order of events, see 4.4.7 below.)

Marcellinus in a treatise probably written during the first centuries CE, says that Praxagoras thought that the pulse of feverish patients was large, rapid, and strong, thus confirming the role of intensity/quantity besides rapidity:

Πραξαγόρας δὲ μέγαν, ταχύν, σφοδρὸν τὸν σφυγμὸν εἶναι ἐπὶ τῶν πυρεσσόντων μετὰ τοιούτων συμπτωμάτων εύρισκόμενον, δίψους τε καὶ θέρμης καὶ κεφαλαλγίας  
Marcellinus *De pulsibus* l. 281-283 (Schöne)

Praxagoras (assumed) that the pulse of those suffering from fever is **large, rapid and strong** and is found together with symptoms such as thirst, (feverish) heat and headache. (Translation: Lewis, p. 61.)

In fr. 27d Galenos again states that Praxagoras' view was that pulses differ from each other in magnitude.

Πραξαγόρας δὲ καὶ ταῖς ἀρτηρίαις ἀνατίθησι σφυγμὸν, ὡσπερ ἀμέλει καὶ παλμὸν καὶ τρόμον καὶ σπασμὸν ἀρτηριῶν πάθη· καὶ σφυγμὸν μὲν ἐν τῷ κατὰ φύσιν ἔχειν· παλμὸν δὲ καὶ τρόμον καὶ σπασμὸν ἀλλήλων μὲν διαφέρειν **μεγέθει**, κινήσει δὲ εἶναι παρὰ φύσιν.  
Galenos *De tremore, palpitatione, convulsion et rigore liber* vol. 7, p. 599, l. 11-15 (Kühn) Fr. 27d.

Praxagoras, however ascribed also pulsation to the arteries, just as he [considered] palpitation, tremor and spasm as *affections* of the arteries; that is, [he thinks] that pulsation occurs when [the condition] is according to nature, and that palpitation, tremor and spasm, while they differ from one another by magnitude, are [all] unnatural movements. (Translation: Lewis, p. 53.)

In fr. 27c, which is from the same book as fr. 27a (above), Galenos again confirms Praxagoras' view about magnitude, when he criticizes him for not being right when he thinks that the different motions of the arteries "differ from one another by magnitude".

Ἐπειδὴ Πραξαγόρας ὁ Νικάρχου, τὰ τε ἄλλα τῆς ἰατρικῆς ἐν τοῖς ἀρίστοις γενόμενος ἐν τε τοῖς περὶ φύσιν λογισμοῖς δεινότατος, **οὐκ ὀρθῶς** μοι δοκεῖ περὶ τε σφυγμοῦ καὶ παλμοῦ καὶ σπασμοῦ καὶ τρόμου γινώσκειν, ἀρτηριῶν μὲν ἅπαντα νομίζων εἶναι πάθη, **διαφέρειν δὲ ἀλλήλων μεγέθει**· διὰ τοῦτο ἔδοξέ μοι κοινῇ περὶ πάντων αὐτῶν ἐν τῷδε τῷ γράμματι διελεῖν, οὐχ ἵνα ἐλέγξαιμι Πραξαγόραν ἐν οἷς σφάλλεται, τοῦτο μὲν γὰρ αὐτάρκως Ἡρόφιλος ἔπραξε, μαθητῆς αὐτοῦ γενόμενος  
Galenos *De tremore, palpitatione, convulsion et rigore liber* vol. 7, p. 584, l. 1- p. 585, l. 1 (Kühn) Fr. 27c

Seeing that Praxagoras, son of Nikarchos, who was among the best in the other aspects of medicine and particularly skillful in theories on nature, seems to me not to possess the correct understanding of pulsation, palpitation, spasm and tremor – for he believes that they are all

affections of the arteries and that **they differ from one another by magnitude** [alone] – I decided therefore, to deal with all these [affections] together in this work. Not in order to refute Praxagoras on the points on which he was wrong – for Herophilos, who was his student, has done this sufficiently. (Translation: Lewis, p. 51.)

It is obvious that there was a rapid development of thinking and practice in the period after Praxagoras. Herophilos not only made a difference between systole and diastole of the pulse, but noticed the difference between a regular and an irregular pulse:

ὁ δὲ Ἡρόφιλος κατὰ γένος τὰς ἄλλας διαφορὰς τῶν σφυγμῶν ἐκθέμενος οὕτως· μέγεθος, τάχος, σφοδρότης, ῥυθμός. ἀσυζύγως κατ' εἶδος τάξεως ἐμνήσθη καὶ ἀταξίας ὁμαλότητός τε καὶ ἀνωμαλίας.

Galenos *De differentia pulsuum libri iv*, vol. 8, p. 592, l. 12-16 (Kühn)

Although Herophilos expounded the other differences between pulses by genus as follows, namely by “size, speed, vehemence, and rhythm”, he also mentioned regularity (*taxis*) and irregularity (*ataxia*) and evenness (*homalotes*) and unevenness (*anomalía*). (Translation: von Staden, p. 341.)

### Order of events

According to Rufus from Ephesos, Praxagoras taught that when the motion of the pulse grows faster it turns into palpitation and then tremor develops (fr. 27b, p. 52). Galenos reports the same order in fr. 27d (p. 54). In fr. 27a (p. 53) the order of events given is: Pulse -> spasm -> tremor -> palpitation. Was this misunderstood by Galenos or was it intentional? We will never know.

Even if nothing can be taken for granted, it seems probable that in Praxagoras' thinking palpitation was a first step, maybe like what we today speak about when we say that anxiety or other excitement causes palpitation of the heart. If so, it corresponds to what Aristoteles writes in *De respiratione* where he uses two words for palpitation, πῆδησις and παλμός:

Πῆδησις ... οἷον ἐν τῇ νόσῳ τῇ καλουμένῃ παλμῶ, καὶ ἐν ἄλλαις δὲ νόσοις, καὶ ἐν τοῖς φόβοις δέ·

Aristoteles *De respiratione* 479b20-23

Palpitation ... as occurs in the disease called heart palpitation among others, and also in fear;

In Galenos teaching palpitation (παλμός) is a disease, a πάθος, not according to nature, οὐ κατὰ φύσιν:

ἡ τῆς καρδίας κίνησις ἢ μὲν κατὰ τοὺς σφυγμοὺς ἐνέργειά ἐστιν, ἢ δὲ κατὰ τοὺς παλμοὺς πάθος. ἐξ ἑαυτῆς μὲν γὰρ ἐστὶ καὶ ἡ κατὰ τοὺς παλμοὺς, ἀλλ' οὐ κατὰ φύσιν, ἐξ ἑαυτῆς δὲ καὶ ἡ τῶν σφυγμῶν, ἀλλὰ κατὰ φύσιν. δεῖ δὲ τοῦ σφυγμοῦ ὀνόματος ἀκούειν οὕτως νῦν ὡς Πραξαγόρας καὶ Ἡρόφιλος ἅπαντες τε σχεδὸν οἱ μετ' αὐτοὺς ἐχρήσαντο μέχρι καὶ ἡμῶν, ὡς ἢ γε παλαιότερα χρῆσις, ἢ κὰν τοῖς Ἐρασιστράτου τε καὶ Ἰπποκράτους εὐρίσκειται γράμμασιν, ἑτέρα τίς ἐστὶ ...

Galenos *De placitis Hippocratis et Platonis* book 6, ch. 1, sect. 10, l. 3- sect. 11, l. 8 (De Lacy) Fr. 26b.

The motion of the heart during pulsation [*scil. sphugmos*] is an activity but during palpitation [*scil. palmos*] it is **an affection**. For even the motion during palpitation originates in the heart itself, but it is **not in accordance with nature**, whereas the motion during pulsation also originates in the heart itself, but it is in accordance with nature. It is necessary here to understand the term 'pulsation' [*scil. sphugmos*] as Praxagoras and Herophilos and almost all those after them, down to our time, used it, since the more ancient use of the term, which is found even in the writings of Erasistratos and Hippokrates is a different one ... (Translation: Lewis, p. 47.)

Praxagoras' view (fr. 27a, above p. 53) was that if these movements take place according to nature, κατὰ φύσιν, and without any difficulties, ἄνευ πάσης περιστάσεως, they were called pulse.

### **Galenos' opinion on which organ is pulsating?**

It seems that Galenos does not support Praxagoras' view, that all these changes occur in the arteries. Apparently, we are now leaving Praxagoras' views and only deal with the views of Galenos. However, for the sake of completeness Galenos' opinions are presented here.

πεπονθῶς δὲ τόπος εἷς οὐδεὶς ἐστὶν ἐξ ἀνάγκης ἐν τρόμοις, καὶ μέμφομαί γε ἐνταῦθα Πραξαγόρα καὶ Ἡροφίλω, τῷ μὲν ἀρτηριῶν πάθος εἰπόντι τὸν τρόμον, Ἡροφίλω δὲ φιλοτιμουμένῳ δεῖξαι περὶ τὸ νευρῶδες αὐτὸ γένος ἀεὶ συνιστάμενον. ὁ μὲν οὖν Πραξαγόρας πόρῳ τοῦ ἀληθοῦς ἤκει·

Galenos *De tremore, palpitatione, convulsion et rigore liber* vol. 7, p. 605, l. 1-5 (Kühn) Fr. 27f.

In tremor the suffering does not necessarily occur in a single place. And I rebuke, therefore, Praxagoras and Herophilos, the first one for saying that the tremor is an affection of the arteries, Herophilos for being anxious to show that this disease is always and exclusively connected with the nerves. Praxagoras, indeed, goes far from the truth.

Galenos seems to be uncertain about the role of muscle and skin in palpitation, while he is sure that spasm and tremor occur only in the νεῦρα:

εἰ δὲ ὀρθῶς ἔνιοι τοῖς μυώδεσι σώμασι μόνοις ἀνατιθέασιν τὸν παλμόν, τοῦτό μοι δοκεῖ μᾶλλον ἄξιον ἐπισκέψεως εἶναι.

Galenos *De tremore, palpitatione, convulsione et rigore liber* vol. 7, p. 599, l. 4-5 (Kühn)

But if some, who ascribe palpitation to muscular bodies alone, are correct, seems me more worthy of consideration.

ἀλλ' εἴτε μυῶν ἐστὶ πάθος μόνον ὁ παλμός, ὡς Ἡρόφιλος ἐνόμιζεν, ἢ καὶ τοῦ δέρματος, ἢ ἀρτηριῶν, ὡς ὑπελάμβανε Πραξαγόρας, αὐθις τοῦτο σκεψόμεθα.

Galenos *De tremore, palpitatione, convulsione et rigore liber* vol. 7, p. 595, l. 10-13 (Kühn) Fr. 27e.

But whether the palpitation is a condition of the muscles, as Herophilos thought, or also of the skin, or of the arteries, as Praxagoras held, we shall consider later.



ἀλλ' ὅτι μὲν ὁ τε σπασμὸς καὶ ὁ τρόμος ἐν νέρυοις μόνον γίνονται, καὶ γὰρ σύμφημι· παλμὸς δὲ προφανῶς ὀρθᾶται καὶ περὶ τὸ δέρμα συνιστάμενος, ἐναργῶς δὲ καὶ τοῖς σαρκώδεσι μοριοῖς, ἅπερ ἐστὶ μυῶν μέρη, καὶ κατὰ γε τοὺς φόβους καὶ τὰς ἀγωνίας ἐναργῶς ἢ καρδία φαίνεται παλλομένη.

Galenos *De differentia pulsuum libri iv* vol. 8, p. 723, l. 4-9 (Kühn)

Now, that spasm and tremor occur only in neura, I too agree; but palpitation is plainly seen to occur also around the skin, and clearly also in the fleshy parts, which are parts of muscles, and during fear and agitation it is clearly seen in the heart.

On the other hand, in the treatise *De tremore, palpitatione, convulsione et rigore* he ascribes both palpitation, spasm and paralysis to an affection of τῶν ὀργάνων, the organs (the instruments), most probably Galenos with this term means the nerves.

Καὶ τὸ μὴ κινεῖσθαι τοιγαροῦν καὶ τὸ κακῶς κινεῖσθαι γένοιτ' ἂν ἢ διὰ τῶν ὀργάνων τὸ πάθος, ἢ διὰ τὴν χρωμένην τοῖς ὀργάνοις δύναμιν. παλμοὶ μὲν οὖν καὶ σπασμοὶ καὶ παραλύσεις ὀργάνων βλάβαι, τρόμοι δὲ δυνάμεως ἀρρωστούσης πάθη.

Galenos *De tremore, palpitatione, convulsione et rigore liber* vol. 7, p. 606, l. 10-14 (Kühn)

Inability to move or defective motion come about, therefore, either because of an affection of the instruments, or because of the faculty using the instruments [being impaired]. Hence, palpitations, spasms and paralysees are injuries of [the] instruments, while tremors are affections of a weak faculty. (Translation: Lewis, p. 55.)

Tremor is caused by a weak δύναμις, faculty (capacity). This is explained earlier in the same treatise. The nerves are “the instruments”, while the faculty (capacity) “pervading through the nerves” cause the motion.

ὁ δὲ Ἡρόφιλος ἠπατήθη τὸ τῆς δυνάμεως πάθος ἀναφέρων τοῖς ὀργάνοις. ὅτι μὲν γὰρ τὸ νευρῶδες γένος, οὐ τὸ ἀρτηριῶδες, ὑπηρετεῖ ταῖς κατὰ προαίρεσιν κινήσεσιν, ὀρθῶς ἐγίνωσκεν· ὅτι δὲ οὐκ αὐτὸ τὸ σῶμα τῶν νέρυων αἴτιον κινήσεως, ἀλλὰ τοῦτο μὲν ὄργανον, ἢ κινούσα δ' αἰτία ἢ διήκουσα δύναμις διὰ τῶν νέρυων ἐστίν, ἐνταῦθα μέμφομαι αὐτῷ μὴ διορίσαντι δύναμίν τε καὶ ὄργανον.

Galenos *De tremore, palpitatione, convulsione et rigore liber* vol. 7, p. 605, l. 5-12 (Kühn)

But Herophilos was mistaken because he attributed an affection of the faculty to the instruments. Indeed, he knew correctly that it is the nerve-like class, and not the arteries, which serves the voluntary motions; but since the body of nerves itself is not the cause of motion, but [only its] instrument, whereas the moving cause is the faculty pervading through the nerves, I find fault with him [scil. Herophilos] here, for he did not distinguish between faculty and instrument. (Translation: Lewis, p. 53.)

If we now disregard Galenos' own views, the above fragments confirm Praxagoras' teaching that palpitation and tremor both occur in the arteries.

The relation between arterial pulsation and πνεῦμα in the arteries will be discussed in the next section 4.5.5 on pneuma.

#### 4.4.5 Summary

##### Earlier concepts

Physicians before Praxagoras had noticed (i.e. seen) blood vessels throbbing but did not use this in their diagnosis. They called all vessels φλέβες. Aristoteles realized that the pulsation of blood-vessels was connected to heartbeat.

##### Praxagoras' teachings

Praxagoras made a distinction between arteries and veins because he saw that only arteries pulsate. He thought that this pulsation is due to an innate capacity of the arteries to do this. He did not see the connection between heartbeat and pulse. The effect of pulsation according Praxagoras is to draw pneuma into the arteries. He characterized the pulsation using the words: σφυγμός, παλμός, τρόμος and σπασμός. The difference between these is only in ποσότης (quantity)/μέγεθος (magnitude), but not in ποιότης/γένος (quality). Praxagoras regarded σφυγμός as natural, κατὰ φύσιν. The other motions were considered παρὰ φύσιν, i. e. unnatural. Consequently, he realized that the pulse could be used in the diagnosis, e.g. in patients with fever.

Although the lexical meaning of ποσότης/μέγεθος is clear it is still not certain if this refers to the amplitude of the pulse or to its frequency. Steckerl translates these words with "intensity", which opens for both interpretations, while it at the same time therefore may be misleading. It is possible, although not at all certain, that the word παλμός, palpitation, was used for a condition with increased pulse frequency caused by e.g. excitation or fever. The interpretation of τρόμος and σπασμός is uncertain. Galenos thought that those motions were not due to motions of arteries but of muscle, skin, or nerves.

##### Legacy

After Praxagoras there was a rapid development of the understanding of the pulse and Praxagoras' opinions were abandoned. His pupil Herophilos regarded the difference in pulsation as different in ποιότης and also realized the important difference between a regular and an irregular pulse.

#### 4.5 On pneuma

##### 4.5.1 Earlier concepts

If the previous sections on humors, vascular anatomy and pulse were fairly straightforward to handle, the area on pneuma is more complex. This is a topic in which philosophy, medicine and religion meet and in which the interpretation of terminology, in this case the word pneuma, is not evident (Lloyd, 2007). In ancient Greece there was a close relation between psyche, pneuma and soul. Homeros had many words for soul (thymos, nous, menos, phrenes, psyche) (Katona, 2002). According to LSJ θυμός is soul, spirit, the principle of life, but also breath. Νοῦς is mind, as employed in perceiving and thinking. Μένος is spirit, passion. Φρήν, φρένες is mind as a seat of the mental faculties, perception, thought. Ψυχή is the conscious self or personality.

Lloyd writes that the concept of pneuma "lies at the heart of several Greek attempts to bridge the gap that they themselves opened up between mind and body" (Lloyd, 2007, p. S135). Lloyd also admits some difficulties in defining the word. "If I am asked for the

meaning of some of the main terms used in this area, such as *pneuma* or *aer*, I am unable to answer for the Greeks as a whole, but have to relativize my reply to particular authors” (Lloyd, 2007, p. 5136). Thus, we must scrutinize the existing fragments to understand what Praxagoras’ opinion was.

It was obvious to the Greeks that life is dependent on breathing. Breathing air, i. e. *pneuma*, keeps man alive. When man takes his last breath *psyche*, ψυχή, leaves the body and goes to Hades. However, the role of the lungs in respiration was not clear to Homeros and the Hippocratic physicians (Thivel, 2005). The lungs were perceived as wet and spongy (σπογγοειδής) organs (Thivel, 2005, p. 249). This is illustrated by the following poem which is an adaptation of Hesiodos’ *Works and Days* 582:

τέγγε πλεύμονας οἴνωι, τὸ γὰρ ἄστρον περιτέλλεται  
Plutarchos *Biogr. et Phil. Quaestiones convivales* Stephanus p. 698, sect. A, l. 1  
Fr. 347 Voigt (put together from multiple quotations): greater Asclepiad (Colvin, 2007, p. 225; Voigt, 1971).

Soak your lungs with wine, because the dog-star is up. (Translation: Colvin, ad loc.)

Empedokles thought that, besides the nostrils, air came into the body through pores in the skin.

Γίνεσθαι δέ φησι τὴν ἀναπνοὴν καὶ ἐκπνοὴν διὰ τὸ φλέβας εἶναί τινας, ἐν αἷς ἔνεστι μὲν αἶμα, οὐ μόντοι πλήρεις εἰσὶν αἵματος, ἔχουσι δὲ πόρους εἰς τὸν ἔξω ἀέρα  
Aristoteles *De respiratione* 473b2-4 (Ross)

But Empedokles says that inhalation and exhalation occur because there are certain vessels, which contain some blood but are not full of blood, but have **openings** to the air outside. (Translation: W.S. Hett.)

ὧδε δ’ ἀναπνεῖ πάντα καὶ ἐκπνεῖ πᾶσι λίφαιμοι σαρκῶν **σύριγγες** πύματον κατὰ σῶμα τέτανται, καὶ σφιν ἐπὶ στομίοις πυκναῖς τέτρηνται ἄλοξιν **ῥινῶν** ἔσχατα τέρθρα διαμπερές ὥστε φόνον μὲν κεύθειν, αἰθέρι δ’ εὐπορίην διόδοισι τετμηῆσθαι.  
Aristoteles *De respiratione* 473b10-14 (Ross)

Thus all things breathe in and out: all have in their flesh bloodless **pipes** reaching to the verge of the body, and these are pierced at their mouths with many passages right through the surface of the **skin** so that they keep in the blood, but an easy passage is cleft for the air. (Translation: W.S. Hett.)

There is some uncertainty about the word ῥινῶν because of its ambiguity. It could be genitive plural of the words for nose/nostrils ῥίς, ῥή, pl. ῥῖνες or skin ῥινός, ὄ. It was suggested by Furley that Empedokles by his formulation wanted to point out that the skin functions like the nose, alternatively it was meant just as a wordplay (Furley & Wilkie, 1984, p. 5). Anyway, it seems obvious that Empedokles’ idea was that there exist tubes/pipes/vessels which can contain blood as well as air.

Anaximenes thought that the soul is air:

οἷον ἢ ψυχὴν, φησὶν, ἢ ἡμετέρα ἀήρ οὐσα συγκρατεῖ ἡμᾶς, καὶ ὅλον τὸν κόσμον πνεῦμα καὶ ἀήρ περιέχει.  
Aëtios 1.3.4. DK 13 B2

He says: Just as our soul, which is air, dominates us, so too breath and air surround the whole world.

(The correctness of this quotation of Anaximenes by Aëtios, doxographer from the second century CE, has been disputed.) (Kirk et al., 2013, p. 159).

According to Aristoteles the faculties for movement and sensibility are located in the heart (Jaeger, 1913, p. 43).

ἀρχὴ γὰρ τῆς φύσεως ἡ καρδία  
Aristoteles *De generatione animalium* 738b16 (Bekker)

The heart is the ruler of the body

Aristoteles thought that the beating of the heart was due to the expansion of pneuma produced by the heating of blood in the heart.

σφύξις δ' ἢ τοῦ ὑγροῦ θερμαινομένου πνευμάτωσις  
Aristoteles *De respiratione* 480a16 (Ross)

but pulsation is the aeration of the fluid by the agency of heat (Translation: W.S. Hett.)

So, what is the nature of pneuma? Pneuma is one of the synonyms to air, but evidently pneuma has in some circumstances additional characteristics compared with the air we breathe. According to Aristoteles innate pneuma, σύμφυτον πνεῦμα, is present already in the embryo before the first breath has been taken (ἔμβρυον ἄπνουν "the foetus who does not breathe"). In this case pneuma apparently is not synonymous with air.

Two Greek words are used for innate, σύμφυτος and ἔμφυτος, with no clear distinction. One characteristic property of living organisms is innate heat, ἔμφυτος θερμότης. The difference between innate pneuma and innate heat is not clear. Parmenides talked of the vital heat as the factor which distinguishes the warm living and the cold dead (Solmsen, 1957, p. 119). Sometimes these entities are treated almost as synonyms, see below on the role of pneuma in disease.

Innate pneuma must be distinguished from the pneuma that comes from outside and is inhaled when breathing, θύραθεν ἐπείσακτον πνεῦμα (Jaeger, 1913, pp. 44-45).

#### 4.5.2 Number of fragments and their authors

Eight fragments were about pneuma: 9, 28b, 31, 32a, 33, 70, 74, 78.

The authors were: Galenos 5, Anonymus Parisinus 3 frs.

### 4.5.3 Cited authors and their opinions on Praxagoras' teaching

#### What is the role of pneuma and breathing?

Praxagoras thought that breathing gives nourishment to the psychic pneuma.

δήλη μὲν ἤδη καὶ ἡ Ἀσκληπιάδου ἐξεληλεγμένη δόξα μετὰ τῆς Ἐρασιστράτου, δήλη δὲ καὶ ἡ Πραξαγόρου καὶ Φιλοτίμου καὶ εἰ τις ἕτερος ἔνεκα **θρέψεως μόνης** τοῦ ψυχικοῦ πνεύματος ἀναπνεῖν ἡμᾶς φησιν.

Galenos *De utilitate respirationis liber* vol. 4, p. 483, l. 7-10 (Noll) Fr. 32 a.

Obviously the opinion of Asklepiades has been refuted along with that of Erasistratos, and clearly also that of Praxagoras and Phylotimos and of anyone else who says we breathe **only to nourish** the psychic pneuma. (Translation: Furley/Wilkie, p. 97)

Galenos then argues that those who say that nourishment of the soul is the usefulness of respiration focus on the substance, τὴν οὐσίαν, of the inhaled air, while those talking about fanning/cooling focus on the quality, τὴν ποιότητα. In a clever argumentation he then explains why the substance cannot be important since the suffocated animal dies with the lungs full of air.

ἀλλ' ὡς τὸ πνίγεσθαι τοῖς ζώοις ἐπεχομένης τῆς ἀναπνοῆς **οὐ διὰ τὴν ἀτροφίαν** τοῦ ψυχικοῦ πνεύματος γίνεται. πάρεστι γὰρ αὐτοῖς δαψιλῆς ἐν τῷ πνεύμονι τὸ πνεῦμα  
Galenos *De utilitate respirationis liber* vol. 4, p. 483, l. 12-15 (Noll)

But that when the breath is held, suffocation happens to the animals **not because of lack of nourishment** to the psychic pneuma. For they have in the lung pneuma in abundance (Translation: Lewis, p. 63.)

Thus, he concludes, nourishment of the soul cannot be the effect of breathing, see fr. 32a above. (Galenos evidently could not know that the “nourishing” part of air, i. e. oxygen, is about 20% of the volume, and is substituted for carbon dioxide in the lungs before the animal dies.)

In his book *De usu partium* (“The usefulness of the parts”) Galenos describes the teleological wisdom of Nature in the buildup of the body. It is unclear what he means, when he says that Praxagoras thought that the abdominal muscles were good not only for the expelling of excrement, but also for the “retention of the breath”:

καὶ γὰρ αὖ καὶ αὐτοὺς τοὺς κατὰ τὸ ἐπιγάστριον ἅμα μὲν πρόβλημά τι καὶ σκέπασμα τῶν ὑποβεβλημένων, ἅμα δ' ἐκκρίσεως περιττωμάτων ὄργανα δημιουργήσασα συγχρηται καὶ τούτοις πρὸς τε τὴν τῆς μεγάλης ἐκφυσῆσεως καὶ φωνῆς γένεσιν, ἤδη δὲ καὶ πρὸς τὴν τῶν ἐμβρύων ἀποκύησιν καὶ τὴν ὑπὸ Πραξαγόρου συνήθως ὀνομαζομένην **κατάληψιν πνεύματος**.

Galenos *De usu partium* vol. 3, p. 403, l. 6-13 (Helmreich) Fr. 33.

Conversely, [Nature] has made the [muscles] of the abdomen to be some kind of barrier and a covering of the parts lying beneath them and she has made them at the same time instruments of the expulsion of residues. Besides these [functions], she also uses them for generating a great emission of breath and for generating the voice, as well as for delivering children and for that which is usually called '**retention of pneuma**' by Praxagoras. (Translation: Lewis, p. 65.)

A possible meaning could be “holding ones breath” (Lewis, 2017, p. 170). If so, this indicates that Praxagoras used the word pneuma also for the air which enters and exits during breathing, i. e. Aristoteles’ θύραθεν ἐπεΐσακτον πνεῦμα.

To summarize, the position of Praxagoras regarding the role of respiration was that it gives nourishment to the psychic pneuma. Since he did not believe in innate heat, he did not consider cooling to be the effect of breathing. (In view of today’s knowledge, Praxagoras must be considered more foreseeing than Galenos.)

### **On the role of pneuma in the arteries**

As discussed above in section 4.4.4 on the pulse, Praxagoras thought that the arteries have an innate capacity to draw pneuma by pulsating. This was probably not a completely new idea. In *De morbo sacro sect. 4, l. 2-4* it is stated: [φλέβες] τὸν ἠέρα ἐς σφᾶς ἔλκουσαι, [the vessels] pull the ἀήρ into themselves.

Praxagoras thought that arteries contain pneuma, not blood:

οὐδὲ ... διὰ τῆς ἀφῆς οὐδὲν ἔχω συμβαλεῖν, οὐτ’ εἰ πνεῦμα μόνον ἐν ταῖς ἀρτηρίαις οὐτ’ εἰ καὶ χυμοὶ περιέχονται τινες. ἀλλ’ οὐδὲ δύνασθε, ὡς καὶ πρόσθεν ἔφην, ἐπειδὴν πρὸς Ἐρασίστρατον, ἢ Πραξαγόραν ἀντιλέγητε περὶ τοῦ τὰς ἀρτηρίας αἷμα περιέχειν, τὴν αἴσθησιν ἐπικαλεῖσθαι μάρτυρα, πάντως ἂν αὐτὸ ποιήσοντες, εἴπερ ἑναργὲς ἦν. ἀλλ’ οὐδ’ αὐτῶν ἐκείνων οὐδεὶς ἐπὶ τὴν αἴσθησιν μάρτυρα κατέφυγεν, ὡς εἶεν **αἱ ἀρτηρίαι χυμῶν μὲν καθαραὶ, πνεύματος δ’ ὄργανα μόνου** δεόντως.

Galenos *De diagnoscendis pulsibus libri iv* vol. 8, p. 950, l. 9-17 (Kühn) Fr. 9.

Nor can I decide at all by touch whether pneuma alone or some humors too are contained in the arteries. But you cannot, as I said above, call the sense-perception as witness when you wish to polemize against Erasistratos or Praxagoras about the question whether arteries contain blood. You would not fail to do so if it were manifest. Neither had anyone of them recourse to the sense-perception as evidence that **the arteries are clean of humors** and necessarily instruments of the **pneuma only**.

ἀλλ’ εἰ τοῦτο λέγουσιν, ὡς ἔστιν ἐκτῶν κατὰ τὴν ἀφήν παθῶν συλλογίσασθαί τι περὶ τῶν κατὰ τὰς ἀρτηρίας διαθέσεων, οὐκ ἀντιλέγω. καὶ γὰρ Πραξαγόρας αὐτὸ ποιεῖ καὶ Ἡρόφιλος καὶ πάντες ὀλίγου δεῖν, οἱ μὲν μᾶλλον, οἱ δὲ ἥττον, καὶ οἱ μὲν χεῖρον, οἱ δὲ βέλτιον. τὸ μὲν γε τοῦ Πραξαγόρου καὶ θαυμαστὸν ἴσως σοι φανεῖται. **μηδὲ γὰρ περιέχεσθαι λέγων ἐν ἀρτηρίαις τοὺς χυμούς**, ὅμως ἐκ τῶν σφυγμῶν ιδέας τινὰς αὐτῶν ἀναλογίζεσθαι πειρᾶται.

Galenos *De diagnoscendis pulsibus libri iv* vol. 8, p. 941, l. 11-19 (Kühn) Fr. 84.

But if they mean that it is possible to infer from the alterations [of the pulse] which are perceived by touch something about the arteries, I do not dispute this. For also Praxagoras does this as well as Herophilos and almost all [the physicians], some more and some less, some worse and some better. Indeed, Praxagoras’ doctrine will probably seem astounding to you: although he says that **the arteries contain no humors**, he attempts, nonetheless, to determine certain kinds of humors based on the pulse. (Translation: Lewis, p. 59.)

Galenos discusses this claim by Praxagoras (and Erasistratos) in his treatise *An in arteriis*

*natura sanguis contineatur* (Whether the arteries naturally contain blood). How can it be, that arteries when they are cut only are seen to emit blood and not pneuma? This fact had by Erasistratos been explained as dependent on the thinness of pneuma compared to air. When arteries are cut the thin pneuma escapes and the artery is then filled with blood from surrounding veins and is seen when the artery is cut. Galenos then argues that air when it comes into the body and gets in contact with warm fluids will necessarily become denser and more vaporous:

λεπτομερέστερον μὲν οὖν οὐκ ἂν εἴη τὸ κατὰ τὰς ἀρτηρίας πνεῦμα τοῦ περιέχοντος ἡμᾶς ἀέρος, ὡς ἡ γένεσις αὐτοῦ διδάσκει. γίνεται γὰρ κατὰ τὸν Ἐρασίστρατον ἐκ τοῦ περιέχοντος ἡμᾶς ἀέρος εἴσω τοῦ σώματος εἰς μὲν τὰς κατὰ πνεύμονα πρώτας ἀρτηρίας ἐλθόντος, ἔπειτα δὲ εἰς τε τὴν καρδίαν καὶ τὰς ἄλλας. εἰς ὅσον οὖν ὑγροτέροις ὀμίλει σώμασιν, εἰς τοσοῦτον εἰκὸς αὐτὸ **παχυμερέστερόν τε καὶ ἀτμωδέστερον** γίνεσθαι. θερμότερον δὲ γίνεται, ἀλλ' ὡς ἀτμὸς ἄνω φερόμενον οὔτε ἀφανῆ τὴν κένωσιν οὔτε οὕτως ὠκεῖαν ἔξει. Πραξαγόρας μὲν οὖν καὶ **παχυμερέστερον** αὐτὸ καὶ **ἱκανῶς ἀτμῶδες** εἶναι φησιν.

Galenos *An in arteriis natura sanguis contineatur* vol. 4, p. 706, l. 9 – vol. 707, l. 3 (Albrecht) Fr. 31.

Now, the pneuma in the arteries could not be composed of finer parts than the air around us, as its origin teaches us. For according to Erasistratos it comes into being inside the body from the air around us, having entered first into the arteries in the lungs, then into the heart and the other arteries. Now, to the extent that it is associated with moist bodies, we may assume it becomes that much **more coarse-grained and more vaporous**. It does indeed become warmer, but, ascending as vapor, it will be neither imperceptible when emerging, nor so swift. Praxagoras, indeed, says it is both **somewhat coarse-grained and fairly vaporous**. (Translation: Furley/Wilkies, p. 147, 149)

Thus, according to Galenos Praxagoras had said that pneuma is *παχυμερέστερον* and *ἱκανῶς ἀτμῶδες*. Literally this should be translated 'denser' and 'rather vaporous'. Furley and Wilkies here has "somewhat coarse-grained and fairly vaporous". Lewis argues that *παχυμερέστερον* is not a regular comparative and that the comparison with surrounding air is a conjecture (Lewis, 2017, pp. 67, 173). She suggests that the comparative form has a softening role and could be translated 'somewhat dense'.

The idea about pneuma in the arteries without doubt negatively influences the judgement of Praxagoras' contributions. von Staden concludes that "Praxagoras' influential insistence that the arteries are bloodless, containing only pneuma, for centuries wreaked havoc with Greek physiology" (von Staden, 1989, p. 270).

In the treatise *De pulsibus*, written by Theophilos during the 6th century CE, the author starts by describing the heart and says that the left chamber contains much pneuma and little blood.

Ὅτι μὲν δύο κοιλίαι τῆς καρδίας εἰσὶν, ἀριστερά τε καὶ δεξιὰ, καὶ ὅτι ἡ μὲν ἀριστερὰ περιέχει τὸ πνεῦμα πολὺ, αἷμα δ' ὀλίγον, ἡ δεξιὰ δὲ τοῦναντίον αἷμα μὲν πολὺ, πνεῦμα δ' ὀλίγον, ἔλκουσα τὸν εἰσπνεόμενον ἀέρα ὑπὸ τοῦ πνεύμονος διὰ τῆς τραχείας ἀρτηρίας

Theophilos Protospatharios *De Pulsibus*, p. 1-4 (Ermerins)

The heart has two chambers, a left and a right, and the left contains much pneuma and little blood, the right on the other hand much blood, but little pneuma, the heart takes the inhaled air by the lungs via the trachea.

### **What is the role of pneuma in disease?**

*Anonymus Parisinus* (in TLG found as *Anonymus medicus*) describes neurological diseases which are caused by obstruction of arteries by cold, thick phlegm: Apoplexy (fr. 74), paralysis (fr. 75) and epilepsy (fr. 70):

ἀποπληξίας αἰτία. Πραξαγόρας καὶ Διοκλῆς περὶ τὴν παχεῖαν ἀρτηρίαν γίνεσθαί φασι τὸ πάθος ὑπὸ φλέγματος [δὲ] ψυχροῦ καὶ παχέος ὡς μὴδ' ἐν αὐτῇ οὐχ ὅτι πνεῦμα παραπνεῖσθαι δύνασθαι· καὶ οὕτω κινδυνεύειν τὸ πᾶν ἐγκαταπνιγῆναι.  
*Anonymus medicus De morbis acutis et chroniis* disease 4, sect. 1, l. 1-5 (Garofalo p. 24 l. 20 - p.26, l. 3) Fr. 74.

The cause of apoplexy. Praxagoras and Diokles say that this disease originates in the region around the aorta and is caused by cold and thick phlegm. Consequently, not the slightest amount of pneuma can enter into the aorta, and thus there is danger of complete suffocation.

παραλύσεως αἰτία. Πραξαγόρας δὲ καὶ Διοκλῆς ὑπὸ παχέος καὶ ψυχροῦ φλέγματος περὶ τὰς ἀποφύσεις τὰς ἀπὸ καρδίας καὶ τῆς παχείας ἀρτηρίας γινομένην, δι' ὧν περὶ ἢ κατὰ προαίρεσιν κίνησις ἐπιπέμπεται τῷ σώματι.  
*Anonymus medicus De morbis acutis et chroniis* disease 21, sect. 1, l. 7-10 (Garofalo p. 122, l. 24- p. 124, l. 2) Fr. 75.

The cause of paralysis. Praxagoras and Diokles [say that it occurs] because of thick, cold phlegm gathering around offshoots of the heart and the thick artery, through which voluntary motion is sent to the body. (Translation: Garofalo/Fuchs.)

The supposed mechanism in the first case is said to be blockade of pneuma which leads to danger of suffocation. In the second case, it is not explicitly stated that it is pneuma that is blocked, but it can be assumed that the effect is due to blockade of pneuma, since pneuma is the faculty causing voluntary movement mediated by the arteries. This is confirmed in fr. 70 where it is stated that epilepsy is caused by blockade of “the passage of the psychic pneuma from the heart”.

ἐπιληψίας αἰτία. Πραξαγόρας περὶ τὴν παχεῖαν ἀρτηρίαν φησὶ γίνεσθαι φλεγματικῶν χυμῶν συστάτων ἐν αὐτῇ· οὐδὲν δὲ πομφολυγούμενους ἀποκλείειν τὴν δίοδον τοῦ ἀπὸ καρδίας ψυχικοῦ πνεύματος καὶ οὕτω τοῦτο κραδαίνειν καὶ σπᾶν τὸ σῶμα· πάλιν δὲ κατασταθειῶν τῶν πομφολύγων παύεσθαι τὸ πάθος.



Διοκλῆς δὲ καὶ αὐτὸς ἔμφραξιν περὶ τὸν αὐτὸν τόπον οἶεται· συμβαίνειν καὶ τὰ ἄλλα κατὰ τὰ αὐτὰ ἡ Πραξαγόρας [δὲ] φησὶ γίνεσθαι· τὸ μὲν εἶδος τῆς αἰτίας παραλέλοιπεν, ἐπαναφέρεσθαι δὲ φησὶ ἐν τῇ καταλέξει τοῦ πάθους ἀπορώτερον ἦν ἢ τὰ κωλύματα τῷ πνεύματι.

Anonymus medicus *De morbis acutis et chroniis* disease 3, sect. 1 (Garofalo p. 18, l. 10-20) Fr. 70.<sup>14</sup>

The cause of epilepsy. Praxagoras says that [epilepsy] arises around the thick artery from phlegmatic humors that gather in it; by producing bubbles, they stop passage of the psychic pneuma out of the heart and so this vibrates and induces spasm in the body. When afterwards the bubbles subside again the affection ceases.

Diokles also thinks that there is an obstruction in the same place. He thinks that also the other (process) happens in the same way as Praxagoras says it happens; however, he has omitted to specify the cause, but in describing the affection says rather doubtfully that (the cause) should be referred to the hindrances encountered by the pneuma. (Translation: Brian Fuchs/Garofalo, modified.)

One could wonder how Praxagoras determined that there was phlegm in the arteries? Galenos says in fr. 84 that he did so by examination of the pulse. Galenos ridicules the obscure method and the contradictory thinking. If the arteries transport pneuma, why do they also contain phlegm?

τὸ μὲν γε τοῦ Πραξαγόρου καὶ θαυμαστὸν ἴσως σοι φανεῖται. μηδὲ γὰρ περιέχεσθαι λέγων ἐν ἀρτηρίαις τοὺς χυμούς, ὅμως ἐκ τῶν σφυγμῶν ἰδέας τινὰς αὐτῶν ἀναλογίζεσθαι πειράται. ἀλλ' οὐδαμῶς πάθος αἰσθήσεως ἐπεισάγει κοινόν. αἰνιγμα γὰρ ἂν οὕτως τὸν λόγον ποιήσῃεν, ἵνα τις ἀναγινώσκων, εἶτα μὴ νοῶν, οἴηται τι βύθιον ἐγκεκρῦφθαι τῷ λόγῳ καὶ θαυμαστὸν, εἶτα κατατρίβηται δηλαδὴ, ζητῶν μὲν διὰ παντός, εὐρίσκων δ' οὐδέν. Galenos *De diagnoscendis pulsibus libri iv* vol. 8, p. 941, l. 16-19 – p. 942, l. 4 (Kühn) Fr. 84

Indeed, Praxagoras' doctrine will probably seem astounding to you: although he says that the arteries contain no humours, he attempts, nonetheless, to determine certain kinds of humours based on the pulses. But he does not refer to any common sense-perception. He thus makes his statements such a riddle that one who reads his book without making out the sense believes that something deep and marvelous is hidden in his words. And so he clearly wastes his time since he searches everywhere without finding anything.

However, the idea that paralysis and epilepsy is caused by blockade of arteries transporting pneuma is in line with Aristoteles' view that the faculties for movement and sensibility are located to the heart (Jaeger, 1913, p. 43). ἀρχὴ γὰρ τῆς φύσεως ἡ καρδία "The heart is the ruler of the body" (*De generatione animalium* 738b16).

These three descriptions by *Anonymus Parisinus* help to clarify the otherwise difficult to interpret passage in fr. 11 about Praxagoras' observation that arteries in their extremities are changed into νεῦρα (section 4.3.3 on blood vessels).

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<sup>14</sup> The manuscripts have: συμβαίνει καὶ τὰ ἄλλα κατὰ τὰ αὐτά. Πραξαγόρας δὲ φησὶ ...

Fuchs comments: συμβαίνει usque ad γίνεσθαι fortasse sic refingenda sunt συμβαίνειν καὶ τὰ ἄλλα κατὰ τὰ αὐτά Πραξαγόρα φησὶ γίνεσθαι, sed ambigimus. Fuchs also thinks that ἀπορώτερον ἦν is corrupt. See Fuchs (1894, p. 542) Wellman edited: συμβαίνειν ... Πραξαγόρα. See Wellmann (1901, p. 29, 140)

None of these uncertainties do considerably change the meaning of the text regarding the understanding of Praxagoras.

Some additional support may be found in another three reports by *Anonymus* (diseases 7, 22 and 24) quoted by Lewis (Lewis, 2017, pp. 79-81). These are not proper fragments since Praxagoras is not mentioned by name, but they all refer to opinions of “the four” or “the ancients”, usually synonymous with Hippokrates, Diokles, Praxagoras and Erasistratos. All three texts regard nerves which are blocked by phlegm preventing the faculty, τὴν δύναμιν (disease 24) or the psychic pneuma, τὸ ψυχικὸν πνεῦμα (disease 7) to reach the proper organ.

An interesting piece of information is given by *Anonymus* in fr. 78, where he says that ravenous appetite is caused by cooling of the innate pneuma. This indicates that the distinction between innate heat and innate pneuma was not so clear in his time (around the year 100 CE). Whether Praxagoras was of the same opinion is difficult to know. The fact that *Anonymus* here explicitly mentions the book *περὶ νοῦσων* increases the credibility. Otherwise, a mistake with confusion of heat and pneuma could be suspected. In all other fragments Praxagoras is said to regard breathing as nourishment to the innate pneuma.

Βουλίμου αἰτία. ὀνομαστὶ μὲν τοῦ πάθους οἱ ἀρχαῖοι οὐκ ἐμνήσθησαν, κατὰ δὲ τὴν τούτων ἀκολουθίαν φαμὲν αὐτὸν γίνεσθαι κατὰ ψῦξιν μὲν τοῦ ἐμφύτου πνεύματος, κατὰ πῆξιν δὲ τοῦ ἐν μεσεντερίῳ φλεβῶν αἵματος· ταῦτα γὰρ αἰτία καὶ τῆς ὀρέξεως.  
ὁ δὲ Ἱπποκράτης ἐν τῇ διαιτητικῇ, ὁ δὲ Πραξαγόρας ἐν τῇ περὶ νοῦσων,  
ὁ δὲ Διοκλῆς ἐν τῇ περὶ πέψεως· εἰ περὶ οὖν ἡ ἀνειμένη ὀρεξις μικρὸς ἐστὶ λιμός,  
ἢ ἐπιτεταμένη βούλιμος ἂν εἴη. ὅτι δὲ ψῦξις ἐστὶ τοῦ θερμοῦ καὶ πῆξις τοῦ αἵματος,  
πιστοῦται τὸ ἐπιπολάζειν ἐπὶ γέροντας τὸ πάθος μάλιστα, πολλάκις καὶ ἐν χειμῶνι,  
καὶ ἡ θεραπεία δὲ δηλοῖ· πυρία γὰρ καὶ οἰνοποσία καὶ δριμύων προσφορὰ  
ἰῶνται τὸ νόσημα.

*Anonymus medicus De morbis acutis et chroniis* disease 11, sect. 1, l. 1-12 Fr. 78.

The cause of ravenous appetite. The old physicians did not mention this disease, but following their opinions we say that it has its origin in the **cooling of the innate pneuma** and in concretion of the blood in the veins of the mesentery; for these factors also cause appetite. Thus think Hippokrates in his “Dietetics”, Praxagoras in his book “On diseases”, Diokles in his book “On concoction”. If the arising appetite is small, it is called hunger; its intense state would be ravenous appetite. That it is a **cooling of heat** and coagulation of the blood is proven by the fact that mostly old men are taken by this disease, often also in winter. Moreover, it is clear from the therapy, for vapor-bath, wine and highly seasoned food heal the disease.

#### 4.5.3 Summary

##### Earlier concepts

It was evident to Greeks already from Homeric times that breathing air was necessary for life. Anaximenes regarded the soul as air. Empedokles thought that air could enter the body not only through the nose but also through small openings in the skin which were connected to vessels containing blood.

The role of the lungs in respiration was not clear. They were regarded as wet spongy organs. According to Aristoteles the faculty for movement was localized in the heart. He also thought that the beating of the heart was caused by the expansion of pneuma due to heating of blood in the heart. Aristoteles made a distinction between σύμφυτον πνεῦμα

and θύραθεν ἐπεΐσακτον πνεῦμα, the former present in the body since embryonic life, the latter inhaled with the air we breath.

### **Praxagoras' teachings**

Praxagoras thought that the inhaled air is nourishment to the psychic pneuma. The inhaled air is transformed in the body, becoming slightly dense and moist. This transformed πνεῦμα is then distributed in the body by the pulsation of the arteries which draws πνεῦμα into them. πνεῦμα is the "faculty" making movement possible. If the flow in the arteries is blocked by φλέγμα disease is the result. Neurological diseases like paralysis, apoplexy and epilepsy are explained in this way.

### **Legacy**

Galenos opposed the view that breathing is nourishment to the πνεῦμα. He argued that breathing is necessary to cool the innate heat (σύμφυτος θερμός).

The concept of pneuma in the arteries persisted for many hundred years. Because of this some scholars blame Praxagoras for the long delay before blood circulation was finally detected by Harvey.

## Chapter 5 General summary and conclusion

### 5.1 Earlier studies

#### 5.1.1 Aspects on Steckerl's book

The collection of Praxagoras' fragments published by Steckerl in 1958 was the most comprehensive so far.<sup>15</sup> Already in his introduction (p. 7-8) Steckerl tries to make Praxagoras' views to fit, not only with Aristoteles, but also with Hippokrates. He then cites *Anonymus Londinensis* who writes that "Hippokrates says that τὰς φύσας, wind-air-breath, is the cause of disease" and that these φῦσαι come from περισσώματα, residues.

Ἱπποκράτης δὲ φ(ησιν) αἰ(τίας) (εἶναι) τῆς νόσου τὰς φύσας  
*Anonymus Londinensis Iatrica* sect. 5, l. 35-36 (Diels)(Jones p.34)

Hippokrates says that τὰς φύσας, wind-air-breath, is the cause of disease. (Translation: W.H.S. Jones, ad loc.)

τούτ(ων) ἐκκειμέν(ων), ὅταν γέν(ηται) περισσώμα<τα>, ἀπὸ τούτων γί(νονται) φῦσαι, αἶ δὴ  
ἴναθυμ(ιαθεῖσαι), τὰς νόσους ἀποτελοῦσι  
*Anonymus Londinensis Iatrica* sect. 6, l. 31-33 (Diels)(Jones p. 38)

On this theory, when residues occur, they give rise to breaths, which rising as vapour cause diseases. (Translation: W.H.S. Jones, ad loc.)

Steckerl then compares this opinion of *Anonymus Londinensis* with what is found in the two fragments in *Anonymus Parisinus* on epilepsy (fr. 70) and neurosis (fr. 71). Both these diseases are according to Praxagoras caused by πομφόλυγες, bubbles.

Steckerl continues:

"Beyond any doubt, there is complete agreement between the account of Anonymus about the doctrine of Hippokrates and these two fragments of Praxagoras. – On the basis of these two passages one could imagine the way and manner in which the theory of humors generally ascribed to Hippokrates and his School and the theory of the φῦσαι mentioned by the Menon-Papyrus might have been linked together one with the other" (Steckerl, 1958, p. 8).

There are many reasons why this over-confident analysis ("one could imagine"! ) seems questionable, also to a less experienced reader. The most important are the following.

First, the theory of humors, even if sometimes ascribed to Hippokrates, was in fact introduced by Polybos, son-in-law to Hippokrates. Second, the treatise *De flatibus* considered to be a sophistic work was almost certainly not written by a Hippocratic physician. Not surprisingly, Steckerl's book was after its publishing, met by severe

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<sup>15</sup> The work of Steckerl is impressive, considering that it was completed before computers and the digitalization of ancient texts. However, more attention to detail from the editor could have improved this work. The numbering of fragments is inconsistent. He gave a number to 120 fragments, when in fact many more have been presented. For example, fr. 27 comprises 6 different fragments which could have given unique numbers and in a logical order. One important fragment between 10 and 12, thus no 11, lacks an identifying number. Spelling errors not only in the English, but also in the Greek text are numerous and could have been corrected. The philological deficiencies have been pointed out by Schubring, 1961.

criticism. Schubring admitted that the task to make a compilation of Praxagoras' works was "eine sehr dringende Aufgabe" (a very compelling undertaking)(Schubring, 1961, p. 258). At the same time, he stated that Steckerl's book is "vor allem durch mangelnde Genauigkeit und Konsequenz unbefriedigend" (above all because of the lack of accuracy and consequence unsatisfactory). He criticized the abundant spelling errors, not only in the English text, but also in the Greek. His most severe criticism was the lack of adequate references, lack of consequent numbering of the fragments and above all the lack of a critical apparatus. Thus, this criticism was mainly from a classic philological standpoint.

Kühn agreed to the "Unzulänglichkeiten der textkritischen Behandlung" (the insufficiency of the text critical treatment) and then attacked the highly speculative comments to the fragments made by Steckerl (Kühn, 1962, p. 133). In those comments Steckerl had made conclusions that could not be based on the fragments alone but needed indirect support from other sources. The first was the controversial Hippocratic treatise *De flatibus*. The second was the text of *Anonymus Londinensis*. The conjectures made by Steckerl were vigorously refuted by Kühn.

Also Furley was critical: "The collection is useful, but the interpretation is frequently unconvincing"(Furley & Wilkie, 1984, p. 22). So was Longrigg: "in several respects stand in need of correction"(Longrigg, 1985).

Many years later, Nickel (Nickel, 2005, p. 317) did also criticize Steckerl for writing that Praxagoras should have been influenced by and in "complete agreement" with Hippocratic thinking as presented in *Anonymus Londinensis* and *De flatibus* regarding the cause of illnesses. He points out that the word *phusa* (φῦσα) which is used in *De flatibus* cannot be found in fragments of Praxagoras. Also, the word *perissomata* (περισσώματα) which is used in *Anonymus Londinensis* is never used by Praxagoras. On the other hand, the word *pompholuges* (πομφόλυγες) is not found in *Anonymus Londinensis* (Nickel, 2005, p. 319).

Lewis in her book states: "Steckerl's reconstruction, however, is often misleading. It presents conclusions in a decisive form but these are not always supported by the sources and at times even contradict them ... "(Lewis, 2017, p. 7).

Taking all this criticism into consideration I have tried to adhere as closely as possible to the fragments as they can be understood, without making conjectures. When Steckerl's translations seemed to far from the original wording they have been replaced by others, mainly from Lewis' monography. Her book has been of great help, also because she has set the short fragments which were published by Steckerl in perspective.

### 5.1.2 Aspects on Lewis's book

It would be unfair to put Orly Lewis's book in the same category as Steckerl's book. Her book is a masterpiece in every respect. Vivian Nutton finds it excellent (Nutton, 2018, p. 378). It gives a thorough overview of all that can be known about Praxagoras' work in the fields of arteries, pulse and pneuma. All fragments are put in perspective and not just the short sequences published by Steckerl. "By insisting on the specific context of much of Praxagoras' work, Lewis has successfully avoided both the static recital of opinions

adopted by later doxographers such as *Anonymus Parisinus* and any simplistic notion of him as worth considering only as transitional figure between others more famous” (Nutton, 2018, p. 379). This has greatly facilitated the work with this essay. Adequate references are given, including the most recent published critical versions, mainly in CMG. Admittedly, she has not made an own text critical analysis, a task that would be overwhelming.

Lewis does not discuss the role of humors in Praxagoras’ teaching, neither the role of factors affecting the humors, such as food or environment.

## **5.2 What do the available fragments tell us about Praxagoras’ teaching?**

### **5.2.1 On his role**

Praxagoras was an authority of his time and a teacher of a generation of younger physicians, among others Phylotimos, Herophilos, Pleistonikos and Xenophon from Kos. He wrote more than ten books on anatomy, diagnosis and treatment of many diseases. Some of these books were available to readers hundreds of years later.

### **5.2.2 On humors**

The author of *De natura hominis* taught that the human body is **composed** of the four humors: Blood, phlegm, yellow and black bile. Aristoteles taught that the body is composed of the four elementary qualities: Warm, cold, moist and dry, which in turn make up the four simple bodies air, fire, water and earth.

There is no clear indication in available fragments that Praxagoras was adhering to any of these opinions. It is not even certain that he was aware of the theory of the four humors as put forward by Polybos. Regarding the four elementary qualities there is some uncertainty. In fr. 20 Galenos criticizes Erasistratos for despising the theory that “the bodily parts of all animals are governed by the warm, the cold, the dry and the moist”, a theory he claims was not despised by Hippokrates, Diokles, Praxagoras, Philiston, Platon, Aristoteles or Theophrastos. Thus, all seven should have accepted the theory he himself held so high. Nevertheless, this is not consistent with the view expressed in *De prisca medicina*, a treatise never referred to by Galenos.

However, humors had been of interest to physicians a long time before Praxagoras and it is certain that humors played a central role in his teaching. He recognized ten different humors (according to their smell, taste, color, consistency etc.), eleven if blood is included. According to him humors determined the difference between health and disease. Under normal conditions blood is produced from food, most probably in the liver from which blood flows into the veins. It is not easy to understand what was considered normal conditions. Probably there was an idea of some kind of balance. Some food produces more humors. There is contradictory information regarding Praxagoras’ opinion about innate heat. Galenos says that Praxagoras did not believe that an innate heat existed. Nevertheless, Galenos says that blood is formed when the innate heat is in moderation, while humors are produced when this is not the case. Again, this may be Galenos’ own opinion.

The most negative impact was attributed to phlegm (φλέγμα), usually described as cold, thick and vitreous (ψυχρόν, παχύ, and νιτροῶδες)(in total ten fragments). The presence of phlegm in the aorta and arteries had dire consequences because it obstructed the passage of pneuma, where upon apoplexy, paralysis or epilepsy could follow.

### **5.2.3 On blood vessel anatomy, pulse and pneuma**

Praxagoras was not the first to note that different vessels have different morphological characteristics. Neither was he the first to note that some vessels throb. However, he was the first to combine these observations. He realized that it was just one type of vessels that was pulsating, and he called these vessels arteries and gave them a role to transport pneuma to the periphery of the body.

How did he come to this conclusion? Galenos says that he was experienced in dissection. Then the anatomical difference in vessel wall is evident to the dissector. In his role as physician, he must have noted the pulsation of some vessels and the absence of pulsation in others. He also noted that these pulsations differed depending on the condition of the patient. He did not see the connection between heartbeat and pulsation but thought that the arteries had an intrinsic activity causing pulsation.

He thought that this activity had the function to draw pneuma into the arteries. The concept that some vessels are devoid of blood was not new. It was based on findings postmortem in animals. He hypothesized that pneuma was produced from air which was inhaled during respiration and subsequently transformed by moistening and warming in the lungs and heart and then distributed via arteries to the periphery. The role of the the air we breathe was to nourish the σύμφυτον πνεῦμα, the innate pneuma. The πνεῦμα distributed by the arteries was the effector of motor activity.

There is no evidence that he considered pneuma to be the soul. The central role of cognitive functions was assigned to the heart.

### **5.3 What was Praxagoras' impact on medicine during Antiquity?**

To discuss Praxagoras impact on the development of medicine in the period up till Galenos would require a separate study. However, the main legacy is without doubt the classification of arteries as a distinct type of vessels which are pulsating. Equally important is his observation that the quality of the pulse could be used in the evaluation of the patient. However, his opinion that the difference in pulses is only a question of quantity was abandoned already by his pupil Herophilos, who realized that it is a question of quality. Herophilos was aware of the important difference between a regular and an irregular pulse.

Praxagoras' ideas about the role of humors were forgotten mainly because of Galenos' strong support for the four-humor theory ascribed by him to Hippokrates.

The acceptance of his thoughts about the role of pneuma among the Stoics and Erasistratos is more uncertain. "It is tempting to assume that Praxagoras was the source of Erasistratos' doctrine on the contents of the arteries, but we must bear in mind that there is no evidence for this and there is nothing to have prevented Erasistratos from reaching the same conclusion (rather than just confirming it) independently" (Lewis, 2017, p. 307).

Four hundred years later Galenos distinguished “the vital pneuma in the arteries from the psychic pneuma responsible for the activities of the brain and the nervous system. – In both types of pneuma production Galenos gives a complex account, and indeed does so in some of the most convoluted prose in his corpus” (Lloyd, 2007, p. S143).

Another four hundred years later Theophilus was writing about pneuma in the arteries. Thus, the idea persisted. It is uncertain how much responsibility can be given to Praxagoras for this fact. Some scholars have implied that Praxagoras’ clear distinction between arteries and veins as having different roles was the reason for the long delay before Harvey finally during the 17th century detected the blood circulation (Lewis, 2017, p. 307). This implication seems unfair to a physician who undoubtedly made a great contribution to the medical field during Antiquity.

## **6 Ethics**

There is no ethical problem associated with this study of ancient literature.



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(Overview of used editions. Full references are given in Appendix II.)

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## 8 Appendix I, Results of text search in TLG

using the lemma Πραξαγόρας. Number of hits within parenthesis.

(Last visited February 2023.)

1. ΠΡΑΞΑΓΟΡΑ (1)
  2. Πραξαγόρα (11)
  3. Πραξαγόρα (14)
  4. Πραξαγόραι (2)
  5. Πραξαγόραν (34)
  6. Πραξαγόραο (5)
  7. Πραξαγόρας (148)
  8. Πραξαγόρου (34)
- Σ 249

Authors mentioning Πραξαγόρας, but **not Praxagoras from Kos** (number within parenthesis)

Anacreon (1), Anthologia Graeca (2), Anthologiae Graecae Appendix (3), Aristophanes (4), Chrysippos (1), Democritos (1), Erasistratos (8), Eustathios (1), Plutarchos (1), Flavius Philostratos (2), Lascaris (1), Tzetzes (1), Myrepsos (2), Photios (4), Porphyrios (1), Praxagoras (3), Scholia in Aristophanem (9), Scholia in Theocritum (4), Suda (1), Theocritos (2).

Authors mentioning Πραξαγόρας, **Praxagoras from Kos** (number within parenthesis)

Anonymus medicus (16), Athenaios (6), Diokles (56), Erotianos (1), Galenos (99), Marcellinus (1), Oribasios (3), Ps-Galenos (3), Rufus (7), Scholia in Homerum (2), Scholia in Nicandrum (3).

## 9 Appendix II, Index of cited Ancient authors and their sources

	Fr. number according to Steckerl (1958)	Page
<b>Anonymus Londinensis</b>		
<i>Iatrica</i> sect 18, l. 8-10, 30-32		24
<i>Iatrica</i> sect. 20, l. 25-27		25
<i>Iatrica</i> sect. 19, l. 1-11		28
<i>Iatrica</i> sect. 5, l. 35-36		68
<i>Iatrica</i> sect. 6, l. 31-33		68
H. Diels, <i>Anonymi Londinensis ex Aristotelis iatricis Menoniis et aliis medicis eclogae</i> [ <i>Commentaria in Aristotelem Graeca</i> suppl. 3.1. Berlin: Reimer, 1893]		
<b>Anonymus medicus (=Anonymus parisinus)</b>		
<i>De morbis acutis et chroniis</i> disease 14, sect. 1, p. 94.	Fr. 57	36
<i>De morbis acutis et chroniis</i> disease 33 sect. 3, p. 17.	Fr. 64	36
<i>De morbis acutis et chroniis</i> disease 19, sect. 1, p. 116.	Fr. 69	37
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(H = humors, BV = blood vessels, P = pulse, Pn = pneuma)

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70	BV,H,Pn <i>De morbis acutis et chroniis</i> disease 3, sect. 1.	64
74	BV,H,Pn <i>De morbis acutis et chroniis</i> disease 4, l. 1-5	64
75	BV,H <i>De morbis acutis et chroniis</i> disease 21, sect. 1, l. 7-10	64
78	BV,H,Pn <i>De morbis acutis et chroniis</i> disease 11, sect. 1, l. 1-12	66
84	BV,H,P <i>De diagnoscendis pulsibus libri iv</i> , vol. 8, p. 941, l. 19 – p. 942, l. 4	65
84	BV,H,P <i>De diagnoscendis pulsibus libri iv</i> vol. 8, p. 941, l. 16-19 – p. 942, l. 4	65
85	BV,H,P <i>De plenitudine liber</i> vol. 7, p. 573, l. 16 - p.574, l. 1	44
98a	BV <i>De venae sectione adversus Erasistratum</i> vol. 11, p. 163, l. 3-6	9

