A COMPANION TO THE ANCIENT GREEK LANGUAGE

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CHAPTER TWENTY-THREE

Technical Languages: Science and Medicine

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Definitions and Problems

A technical language can be defined as a subcategory of common language containing all the linguistic elements employed by a restricted group of speakers to name, define, and discuss the contents of a particular discipline. Since the ideas and the objects of any technical discipline need to be defined unambiguously, terminology is the landmark of any technical language. Technical terminology tends to be (cf. Willi 2003: 69):

a) Standardized, economic and concise, i.e., monosemy is preferred over polysemy;
b) Expressly neutral, i.e., the lexeme does not entail any judgment: e.g., gonorrhea vs the slang term "the clap";
c) Seldom used—though possibly understood—by the non-specialists. For this reason, technical terms often have lay synonyms in common language; this is particularly evident in medicine where technical and lay terminology coexist (e.g., *tinea pedis* vs "athlete's foot") and often physicians use the latter in order to be understood by their patients.

Studies of Greek technical languages need to take into account two basic features of Greek science. First, when speaking of "technical languages" we assume that there is a well-defined group of disciplines that uses them, but in ancient Greece this is far from being true. The term τέχνη was widely used by Greek writers to indicate a discipline founded on knowledge (ἐπιστήμη) and rationality (λόγος), but it was not clear which disciplines could be defined as τέχναι. We can reasonably speak of Greek science during the Hellenistic period, when mathematics (Euclid, Eratosthenes, Archimedes, Apollonius of Perge), astronomy (Aristarchus of Samos, Hipparchus), mechanics (Ctesibius, Philo of Byzantium), and medicine (Erophilus, Erasistratus) were highly developed and used what we can indeed call "technical languages." However, in earlier

periods the status of τέχναι is difficult to define. Medicine (with the Hippocratic school) and mathematics (with Hippocrates of Chios and Eudoxus) were flourishing, but their terminology was not yet fixed. For other fields things are even worse. For example, the Presocratics did have an interest in the physical aspect of the world, but it is difficult to consider them "scientists," because in the sixth and fifth centuries BCE philosophy takes the place of science. In addition, in antiquity the distinction between a technical text and a literary text is not as clear as in our societies. Didactic poetry consisted of "technical" topics not directed to specialists and primarily intended to "entertain" rather than to "inform;" in such works language follows poetic and metrical rules rather than clarity and monosemy.

Secondly, in many cases the Greeks were the first to discover even basic phenomena of the physical and biological world, or develop new disciplines. Even when they might have been influenced by other cultures (i.e., Egyptian or Middle Eastern lore), they did not adopt their technical vocabulary. As a consequence, the Greeks had no words readily available to describe their discoveries. Modern science can build on the experience of previous generations of scientists and on their vocabulary even when dealing with breakthrough new results. In addition, technical terms in modern scientific languages often derive from Greek or Latin roots and hence are "extraneous" to the common language. The Greeks could not draw on the work of predecessors, nor could they rely on other languages, because they were the first to give a name to something previously unknown. All Greek technical terms are thus Greek-based. As a consequence, on the one hand Greek technical language was more accessible to non-specialists than modern technical languages, but on the other hand it was a completely new (sub)language to develop from scratch.

In this overview of Greek technical language, the main goal is to outline the different strategies that the ancient Greeks adopted when they had to convey "scientific" content. The focus will be on two fields, medicine and mathematics, since these are the disciplines for which we have by far the most evidence: the Hippocratic Corpus, Hellenistic physicians and Galen for medicine, and the works of Euclid, Apollonius of Perge and Archimedes for mathematics. Medicine and mathematics are central also because many of the other technical languages in ancient Greece borrowed from mathematical or medical *Fachsprache*, due to their strong similarities to either or both these τέχναι. For example, harmonics, optics and astronomy, which were considered part of the μαθηματικὴ ἐπιστήμη, used mathematical language, while botany and zoology adopted medical linguistic expressions. Mechanics shares linguistic features of both disciplines.

Interestingly, medicine and mathematics employed quite different linguistic strategies to express their results. A comparison between them will thus highlight some important features of technical languages and the motivations behind certain linguistic choices.

Technical Terminology

Naming new objects, phenomena and concepts discovered in a scientific discipline is the main task of its technical vocabulary. There are three strategies to create a technical terminology: (i) use of existing terms; (ii) coinage of new terms through suffixation

or compounding; (iii) borrowing of existing terms from other semantic fields (metaphors). The medical language of anatomy and pathology is the best area in which to analyze these three strategies and to show how a new technical terminology was developed in ancient Greece.

Use of existing terms

This procedure consists of giving a more specific meaning to an existing word. This already happened in Presocratic philosophers, who endowed common Greek terms such as φύσις "nature" or ἀρχή "beginning" with new meanings to express their ideas about reality. Using common words with a technical meaning is attested also in medicine. Hippocratic and later physicians use Homeric words such as καρδίη, φρένες, φλέβες. Among diseases, σπασμός "convulsion" and φῦμα "what grows," hence "tumor," are words used by both Herodotus and Hippocrates. This practice, however, carries the risk of polysemy, since a term can have both a general and a technical meaning, which can be difficult to distinguish.

Coinage of new terms

To avoid ambiguity, neologisms are the most common solution for building up a technical vocabulary. The Greek language is especially versatile at creating new words. Its derivational morphology and its compounding capability are extraordinary resources to "name" something previously unknown. Medical neologisms created by the Hippocratic and Hellenistic schools are the best examples, also because many of these terms are still used by modern medicine. There are two strategies to create new terms: suffixation and compounding.

Suffixation

In Greek, new words, especially nouns, are created through particular suffixes conveying a particular meaning, such as the ending –της for *nomina agentis*, -μα for *nomina rei actae*, -σις for *nomina actionis* (see also ch. 8). The latter two suffixes are used also in medicine to distinguish the process from the result: ἕλκωσις "ulceration" and ἕλκωμα "ulcer"; οἴδησις "swelling" and οἴδημα "tumor." Greek medicine has the additional peculiarity of using specific suffixes, which, though also used in common Greek, eventually became particularly associated with medical terminology:

a) Suffix –ίη/-ία for many abstract nouns of diseases or symptoms: e.g., αἱμορραγία "hemorrhage"; λειεντερία "passage of undigested food into stools" → lientery; ὀφθαλμία "disease in the eyes" → ophthalmia; περιπνευμονία/περιπλευμονία "disease of the lungs" → pneumonia;

b) Suffix -ῖτις to indicate an inflammation in a particular part of the body (originally these are adjectival forms modifying νόσος, but eventually they came to be used substantively): e.g., ἀρθρῖτις "inflammation of the joints" → arthritis; ἡπατῖτις "inflammation of the liver" → hepatitis; φρενῖτις "inflammation of the brain" → phrenitis;

c) Suffix -αινα for diseases characterized by weeping/pus-filled sores: e.g., γάγγραινα "gangrene"; φαγέδαινα "cancerous sore"; φλύκταινα "blister made by a burn";
d) Suffix –ότης for feminine nouns, sometimes used to express a quality or durable attribute: e.g., ἐρυθρότης "redness"; ἐφθότης "languor"; καμπυλότης "crookedness"; χλωρότης "greenness";
e) Suffix –σμός for masculine nouns indicating a medical condition: e.g., μετεωρισμός "swelling"; κνησμός "itching"; λεπτυσμός "thinning";
f) Suffix -δών for feminine deverbal nouns: e.g., σηπεδών "putrefaction"; πρηδών "swelling"; σπαδών "cramp."

The following adjectives are particularly common in Greek medical language:

g) Adjectives in –ώδης (or -ιώδης) indicating any kind of similarity or quality: e.g., ἀλφώδης "leprous"; ἰκτερώδης/ἰκτεριώδης "jaundiced"; κνησμώδης "affected with itching"; σαρκώδης "fleshy"; ὑδεριώδης "suffering from dropsy";
h) Adjectives in –ειδής to indicate similarity (εἶδος): θρομβοειδής "full of clots or lumps"; πυοειδής "like purulent matter"; σποδοειδής "ashy";
i) Adjectives in -ικός often meaning "suffering from. . .": e.g., κεφαλαλγικός "suffering from headache," "of the headache"; σπληνικός "of the spleen" → splenetic; τετανικός "suffering from tetanus"; ὑστερικός "suffering in the womb" → hysterical.

Verbs are typically denominal: they are mostly derived from the names of the diseases and convey the idea of suffering from them. Hence the typical suffixes of denominal verbs are very much used:

j) Verbs in –ιάω: ἰκτεριάω "have jaundice"; ποδαγριάω "have gout"; ὑδεριάω "suffer from dropsy"; ψωριάω "have itch";
k) Verbs in -αίνω: e.g., προσγλισχραίνω "make more viscid"; πυρεταίνω "to be feverish"; παραχλιαίνω "warm slightly"; ὑδεραίνω "suffer from dropsy";
l) Verbs in –έω: e.g., αἱμορραγέω "have a hemorrhage"; κεφαλαλγέω "suffer from headache"; λευκοφλεγματέω "have dropsy."

In this process, derivational morphology comes also into play, so that from the one basic form, often a noun, verbs, and adjectives are also created. The result is a family of words, as for example, from νεφρός "kidney" we have: νεφροειδής and νεφρώδης "like a kidney," νεφριτικός and νεφριαῖος "of the kidneys," and the noun νεφρῖτις "inflammation of the kidneys."

Compounding

Compounds have the advantage of condensing in one word a complex concept, even an entire phrase. The Greek language allows extensive use of compounds in any field, starting from common and poetical language. Among medical compounds, Greek physicians used the typical prefixes privative ἀ-, δυσ- and εὐ- to compound nouns, adjectives and verbs:

a) Privative ἀ-: e.g., ἄκοπρος "with little excrement in the bowels"; ἄσαρκος "without flesh"; ἀσφυκτέω "to be without pulsation";
b) δυσ-: e.g., δυσέμβλητος "hard to set," of dislocations; δυσεντερία (→ dysentery); δυσεπίσχετος "hard to check," of bleeding; δυσθενέω "to be weak";
c) εὐ-: e.g., εὐέμετος or εὐήμετος "vomiting readily"; εὐεξανάλωτος "easy of digestion"; εὔσαρκος "fleshy," "in good condition"; εὐχροια "goodness of complexion."

In some cases the opposition between the prefixes δυσ- and εὐ- is used to create an antinomy with a technical meaning: εὐελκής "favorable for healing of sores" opposed to δυσελκής "unfavorable for healing of sores"; εὔπνοια "easiness of breathing" opposed to δύσπνοια "difficulty of breathing."

Some prefixes are used in medicine to give a more specific meaning to verbs, nouns, or adjectives. The prefix ὑπο- has a local meaning of "below," as in ὑπογλωσσίς "swelling under the tongue" and "the under side of the tongue," but it is also often used as a diminutive: ὑπαλγέω "have a slight pain," ὑπόγλισχρος "somewhat slippery," ὑπόλευκος "whitish," ὑπομέλας "blackish." The prefix περι- intensifies: περίψυχρος "very cold," περιωδυνάω and περιωδυνέω "suffer great pain."

Borrowing of existing terms from other semantic fields (metaphors)

A particularly interesting aspect of technical terminology is the use of metaphors. Metaphors can be linked with a typical scientific approach: analogy, by which new discoveries can be explained after something known that shares some features with them. Thus language can "visualize" a new phenomenon by naming it after a more common object that has some kind of resemblance. In this way, the name already contains some sort of explanation. The examples of metaphorical language in medicine and zoology are numerous, especially for anatomy and pathology. (See also the discussion of word meaning in ch. 9.)

Metaphors from common language

In metaphors, the link between the new object and the common object is usually a similarity in their aspect or, more rarely, in their function.

The first group includes some names for bones: for example, κερκίς "weaver's shuttle" is the name for the tibia or for the radius; περόνη "pin of a buckle" indicates a small bone in the leg (Lat. *fibula*); κοτύλη "cup" indicates the socket of a joint. Among body organs, τὸ ἔντερον τυφλόν or simply τὸ τυφλόν is the part of intestine without outlet (the "blind" gut); δακτύλιος "ring" becomes the anus. The name ἶρις "rainbow" indicates the colored part of the eye. The pupil is called (not only among physicians) κόρη "girl" (cf. Lat. *pupilla*), a metaphor which might have a more popular origin: people believed they saw a little image of a girl in the pupil (cf. Pl. *Alc.* I 133a).

Among the metaphors derived from similarity in function we can mention πυλωρός "gate-keeper" (→ pylorus), which is the lower orifice of the stomach that

serves as a "watcher" for what gets out from the stomach; moreover, πύλαι "gates" is the name of various orifices in the body such as in the liver. Similar is the case of πόρος, literally "ford" or "strait" in the sea; in medical terminology, it indicates a passage through the skin (→ pore) or many other ducts of the body (womb, ovaries, esophagus, arteries and veins). Many internal membranes (of the heart, of the eyes and of the testicles) are called χιτών "tunic," because they defend the organ by wrapping it up. The ζύγωμα "bolt" indicates the arcus zygomaticus, because it connects the cranial with the facial bones.

Herophilus employs various metaphors to name the new organs and bones he discovered through human dissection. He calls a pointed bone in the skull "pharoid process" (fragm. 92, ed. Von Staden 1989) in analogy with the Pharos of Alexandria, whose pointed shape was similar to the bone; he also (fragm. 88) calls the retina "spider's-web-like tunic" (χιτὼν ἀραχνοειδής) and describes (fragm. 89) it as similar to a net (ἀμφίβληστρον), from which the name χιτὼν ἀμφιβληστροειδής "net-like tunic" was derived (and the modern term "retina" is the Latin translation of this metaphor). The term "calamus scriptorius," designating a cavity in the fourth ventricle of the brain similar to the groove of a "reed pen" (κάλαμος), is also due to Herophilus (fragm. 79).

In pathology, χάλαζα "hail" indicates a small cyst on the eyelids or a pimple in the flesh of swine; ἄνθραξ "burning carbon" is a disease of the skin; φλεγμονή "heat" indicates an inflamed tumor. Also, verbs are used metaphorically to describe an anatomical process: "to digest" is συμπέσσειν, which means "to cook" (cf. the derivative noun: πέψις "cooking" and "digestion").

Metaphors from other technical languages

Metaphors can also be taken from other technical terminologies. The main semantic fields from which Greek physicians drew names were human and animal anatomy, plants' names and their parts, and architecture.

Human anatomy is particularly interesting: some internal parts of the human body are called with the same name given to external (hence known) ones similar to them. Κεφαλή "head" is probably the term most often "reused" to name other parts of the human body. It indicates the biggest part of an organ: so we have a κεφαλή of the humerus, of the femur, or of the heart. The femur has also an αὐχήν "neck," as does the uterus. Equally common is στόμα "mouth" for various orifices, such as in the uterus (where it indicates the same as the κεφαλή). The ball of the hand is the στῆθος χειρός "breast of the hand." The second (or sometimes the first) vertebra of the neck or its apophysis is called ὀδούς "tooth" because of its protruding shape. And the heart has "ears" (οὔατα or ὦτα).

The animal world also offers examples of metaphors. Muscle comes from μῦς "mouse" probably because of the rounded shape of a contracted muscle, similar to the body of a mouse. The cuckoo names the coccyx (κόκκυξ), as it resembles the beak of a cuckoo. The term χέλυς "tortoise" is used for the chest because of the similarity of shape with the tortoise's shell (and the chest also emits "sound" like the lyre, also called χέλυς, as Hermes made the first lyre from a tortoise's shell).

Pathology too uses names of animals. The καρκίνος "crab" indicates cancer because of the aspect of the ulcers and their resistance to cure. A πολύπους "octopus" designates

an anomalous excrescence on the skin similar to the shapeless body of the octopus. Βάτραχος "frog" is the name of swelling under the tongue in analogy with the frog's uneven body. Other diseases are named using the same stem of the animal's name: ἀλωπεκία, the disease "of the fox" (a disease in which hair falls off) is so called, because ancient physicians believed that it also affected foxes; or ἐλεφαντίασις (→ elephantiasis), because the swollen limbs resembled elephant legs. The κυνικὸς σπασμός, the "canine spasm," designates a facial paralysis with a tic, which makes the human face similar to that of a barking dog.

Plants and parts of plants too provide metaphors to physicians. In anatomy there is ῥίζα, the "root" of a tooth, of the eye, of the tongue; ἄκανθα "thorn" to designate the spinal column and also the apophysis of vertebras (→ spinous process). In pathology the names of plants are many, especially to describe skin disease. Ἄνθος "flower" together with the neologism ἐξάνθημα are used to indicate an "efflorescence" on the skin, an eruption, a pustule. Λειχήν "lichen" is a lesion on the skin, which resembles the vegetal organism; φακός "lentil" is the mole on the skin. Τέρμινθος is the terebinth tree and a disease of the olive; in human pathology, it indicates a swelling like the fruit of the terebinth tree. The name of the fig, σῦκον, indicates a fig-like excrescence, especially in the eye; in the eye too we can find a grain of "barley," κριθή. Σταφυλή is the "grape" of the vine and in pathology it means an inflammation of the uvula, swollen at the end and thus similar to a grape.

Metaphors for parts of the body and for diseases are taken from other fields too; for example, γίγγλυμος, technically a "hinge" in architecture, is the "articulation." Γομφίος "molar tooth," is derived from γόμφος "bolt," because the molars are "fastened with bolts" in the mouth. Another name for the molar is μύλη "mill," as it grinds food. Ἦλος "stud," for the "callus," because of its shape and hardness, also comes from architecture.

Metaphors working on similarities between the new thing and a known one are thus one of the most powerful means to name new objects, concepts, and phenomena in disciplines where description of a new reality is paramount. Metaphors taken from daily life and human activities are the clearest and easiest to understand by laypeople, but medical language takes metaphors also from other technical vocabularies, such as those of zoology or botany. The phenomenon is not one-directional. There are cases of botany using terms of human medicine: ψωριάω means "to have the itch" (in the human body), but Theophrastus uses it also for a disease of trees in the sense of "to be scabby." In the same way, a leaf of a plant can be defined σαρκώδης "fleshy," as a human body would be. Mathematics takes from Greek anatomy words like πλευρά "rib," used to indicate the "side" of a triangle or another figure.

A particularly interesting cross-borrowing between two technical languages happens between mechanics and anatomy. Since the human body can be seen as a "machine," Erasistratus describes the heart as a pump with valves similar to the water pump invented by Ctesibius in the same period (fragm. 201, ed. Garofalo 1998). He also explains respiration in mechanical terms (fragm. 108). Physicians borrow from mechanics' names for their tools: πλινθίον, originally both "brick" and "frame" used in molding bricks, in medicine indicates the "bandage," which "molds" the limb, as well as a machine invented by Nileus to reduce dislocations. Conversely, machines can be described as human bodies.

Engines, especially the torsion-engine, can have legs (σκέλη), heels (πτέρναι), arms (ἀγκῶνες), eyebrows (ὀφρῦς, the woodwork enclosing the bore of a torsion-engine). Mechanics, like anatomy, borrows words from other disciplines: χελώνη "tortoise," to name a machinery used to transport heavy weights, comes from zoology. The torsion-engine has a χελώνιον "tortoise-shell" (the knob against which the butt-ends of the arms of a torsion-engine rest) and πτέρυγες "wings" (the front-frame).

Connotative metaphors: the battle against the diseases

Another metaphorical usage in Greek medicine concerns the way physicians see their τέχνη. Descriptions of symptoms and diseases often adopt expressions belonging to the language of war, aggression, and force. For example, a colic is a malignant "twist" (στρόφος). Diseases are an "attack" (ἐπίθεσις, ἔφοδος) on the patient; they are painful "like a bite" (δακνώδεις) and "take possession of him" (ἐπιλαμβάνειν), while the patient "toils" (κάμνειν) and is "tormented" (ἐπιτείνεσθαι). This metaphorical language describes how the ancient physicians used to see their profession: as a battle against the disease.

Limits and recognition of medical language

A technical language requires a certain degree of self-awareness by its speakers, since they are often its "creators" and almost its only users. In terms of self-awareness, medical terminology was the most advanced in antiquity.

The appearance of lexica of medical terms already in the Hellenistic period demonstrates that medical language was already perceived as a *Fachsprache*, not normally used (and understood) by laypeople. The development of medical lexicography in third-century BCE Alexandria parallels the development of literary lexicography (on Homer or lyric poets) and indicates that the language of Hippocrates needed interpretation like that of Homer.

However, Greek medical language was not "perfect." Polysemy often caused confusion, especially in the earlier period and for smaller organs like muscles, nerves, and the vascular system. The same term could be used for different organs: φάρυγξ meant "pharynx," "esophagus" but also "trachea" and "larynx." The δίδυμοι "twofold" were both the ovaries and the testicles; θαλάμη "lurking place" indicated the ventricle of the heart, the nostrils, the optic thalamus, the recesses in the cranial bones and the eye socket. In other cases, the same term indicated both the anatomical part and a disease affecting it: σταφυλή meant the uvula as well as its inflammation. The opposite problem was also present: one organ was called with different names. The retina was ἀμφιβληστροειδής "net-like," as we have seen, or ἀραχνοειδής "spider's-web-like," or ὑαλοειδής "glass-like"; the bronchi were called βρόγχια, σήραγγες, and ἀορταί.

This fluid situation in medical terminology is symptomatic of the status of the discipline that, from the very beginnings, had to invent its language but was divided in many different schools with different principles and terminology. Studying its technical language is thus a way to study the history of Greek medicine.

Syntax

The creation of a technical lexicon is an important feature of technical languages, but not the only one. There are many cases where technical texts manipulate syntactic tools in order to better convey their scientific content. For example, contrary to common language, technical languages tend to use nominal constructions (e.g., "energy flux") rather than verbal constructions (e.g., "energy flows"). As a consequence, a technical language tends to be richer in deverbal abstract nouns than common language. Specifically, scientific writings use language in a denotative rather than a connotative way, since their scope is to "communicate" a content rather than "comment" upon it. Thus, a scientific text needs to be clear and concise; in Greek terms, its characteristics are σαφήνεια "clarity" and συντομία "brevity," two fundamental principles of ancient rhetoric. The best example is Greek mathematics, because it uses syntactical devices rather than lexicon, the opposite strategy of medicine, which is instead based on a highly developed terminology and common syntactical features.

Greek Mathematics

The most striking feature of Greek mathematical texts is the homogeneity and repetitiveness of their language. There are only few neologisms and the vocabulary is standard and rather limited. However, the text is far from easy to understand. The reason lies in the syntactic constructions used by Greek mathematicians to express relationships between, and properties of, geometrical objects.

Naming geometrical objects

The Greek geometrical lexicon is not as rich and diversified as the medical one. Still, it has interesting features, especially when compared with medical terminology. First, mathematical words are not normally created *ex novo*, but rather they are taken from everyday language: σημεῖον "sign," hence "point"; γωνία "corner," hence "angle"; κύκλος "ring," "circular object," hence "circle"; στερεός "firm," "solid," hence geometrical "solid" figure; σφαῖρα "ball," hence "sphere"; or verbs like δείκνυμι "demonstrate"; δίδωμι "give," as in ἡ δοθεῖσα γραμμή/γωνία "the given line/angle"; τέμνω "cut," hence "divide" a line. All these are common Greek words used with a more specific meaning. Other words seem more "geometrically oriented," such as γραμμή "line," τετράγωνος "square," and κύλινδρος "cylinder," but they are still used in common Greek. Some words are used by mathematicians with a technical meaning derived from but not identical to the original one: μέρος changes meaning from singular to plural, as the μέρος of a number is one of its divisors, whereas its μέρη are all the numbers less than the given one that are not divisors of it (cf. Euc. *El.* 7, def. 3–4).

Metaphors, unlike in medicine, are rare. For example, κέντρον, the "center" of a circle, at first sight might seem metaphorical. Literally, κέντρον is the "horse-goad," a spike used to spur on the animals. From this, κέντρον then indicated many pointed

objects: the point of a spear, the sting of bees and wasps, and the pin or rivet in mechanics, and also the point of a pair of compasses. Since compasses draw circles and the point is the "center" of the circle, κέντρον was then used by mathematicians in the latter sense. This use, however, is not metaphorical but metonymic.

In terms of lexicon, mathematics is easier than medicine. However, this does not mean that mathematical texts are simple, but that they use a different strategy to convey their content. Words like σημεῖον, γραμμή, γωνία, κύκλος, and τετράγωνος are the "technical" terms to name a point, line, angle, circle, and square in the definitions. However, in the demonstrations, which are the real core of the mathematical deductive reasoning, the way of expressing these geometrical objects is different. In fact, particular points are here identified by a letter, as in τὸ A σημεῖον or, in the most abbreviated form, τὸ A. Just to give some examples, we can mention:

ἡ AB (γραμμή)→ the (line joining the points) A (and) B.
ἡ ὑπὸ τῶν AB, BΓ (γωνία) → the (angle contained) by (the straight lines) AB (and) BC.
ἡ πρὸς τῷ B (γωνία) → the (angle originating) at (the point) B
ὁ ABΓ (κύκλος) → the (circle passing through the points) A B C
τὸ ABΓ (τρίγωνον) → the (triangle whose vertexes are the points) A B C
τὸ ABΓΔE (πολύγωνον) → the (polygon whose vertexes are the points) A B C D E
τὸ ἀπὸ τῆς AB (τετράγωνον) → the (square described) on (the segment) AB
τὸ ὑπὸ τῶν AB, BΓ (ὀρθογώνιον) → the (rectangle contained) by (the straight lines) AB (and) BC

These syntagms are familiar to us because they are also used in modern geometry based on Euclid's systematization. However, they reveal many interesting details about Greek mathematical reasoning and its expression. The complete phrase behind the cryptic τὸ ὑπὸ τῶν AB, BΓ is to be understood as τὸ ὑπὸ τῶν AB, BΓ εὐθειῶν περιεχόμενον ὀρθογώνιον "the rectangle contained by the straight lines AB, BC." None of the elements expressing these geometrical objects are "technical terms." There are definite articles, letters (A, B, Γ), and prepositions (ἀπό, πρός, ὑπό), and they all have a specific function. The article "points to" real geometrical objects, a very important function, since Greek mathematics deals with geometrical objects drawn in diagrams accompanying the texts, rather than with the abstract idea of a geometric figure. Letters indicate the most important points of a line, plane, or solid figure, so they "identify" these objects. Finally, prepositions "place" each object in the space and help defining their relative position, thus avoiding ambiguity.

This vocabulary is extremely flexible and fit for what Greek mathematics is: the study of geometrical objects and their relations. It is not, as Netz (1999: 134) claims, uneconomical. An angle can be called ἡ ὑπὸ τῶν AB, BΓ and ἡ πρὸς τῷ B, because the two expressions are just two different ways to look at the same geometrical object, according to whether we decide to focus on the lines enclosing it or on the vertex. The use of articles, letters, and prepositions comes almost naturally from the use of diagrams in the text. Thus, when a Greek mathematician is writing ἡ ὑπὸ τῶν AB, BΓ, he is doing nothing more than "describing" what he sees on the diagram. Hence, in this perspective, there is no need of "lexical economy," as long as the name is clear, unambiguous, and meaningful.

This language is immediately recognizable as belonging to mathematics. The technical element has been reached not through suffixation, compounding, or neologisms, but rather through the interplay of simple words (articles, prepositions, and letters) in peculiar syntactic constructions (especially the attributive positions and the substantivation of any part of speech through the article) that privilege the visual side of the discipline.

The reason for this linguistic choice is that, unlike modern mathematics, Greek mathematics did not have any symbols. Language using mathematical symbols is more concise, but Greek mathematics could only use Greek common language. To express what we would write as: ∠ A = ∠ D (i.e., the angle in A is equal to the angle in D) Euclid had to write a much longer sentence: ἔστι δὲ καὶ ἡ πρὸς τῷ A ἴση τῇ πρὸς τῷ Δ (Euc. *El.* 6, prop. 7, 36). Moreover, the written text was not easy to read: in antiquity, Greek words were written in *scriptio continua* and without marks for accents and breathing, making the text even more complex to divide into elements.

Thus the problem for Greek mathematicians was not to "create" new terms to name new geometrical objects, because all geometrical objects can be described using their basic components: points, lines, angles, and circles. It was to reduce common language to the "bare bones" to be as clear and concise as possible. Streamlining the syntax and fully exploiting the possibilities of Greek language was their solution. The problem in reading a Greek mathematical text is that reduced forms, though syntactically intelligible, are very difficult from the mathematical point of view, unless the reader is trained in mathematics and in its language. As happens now with modern mathematical symbolism, one needs to know exactly the mathematical concept behind each reduced form in order to understand phrases like τὸ ὑπὸ τῶν AB, BΓ.

Discussing geometrical objects

Because Greek mathematics is deductive, conjunctions play an important role. With conjunctions and connective particles the strategy is the same: reduction to the minimum in favor of conciseness and clarity. For example, the same conjunctions always introduce the same kind of clause: καί for coordinate clauses, δέ or ἀλλά for coassumptions, ἤτοι for disjunctive clauses (see Acerbi 2008). The conclusion of an inference is usually introduced by ἄρα or sometimes by ὥστε. A postpositive explicative assertion is marked by γάρ or διά. Anteposed explications are introduced by ἐπεί (or ἐπεὶ γάρ, καὶ ἐπεί, ἐπεὶ οὖν).

Syntax is shaped by content. In the case of mathematics, most theorems are inferential; hence the most common syntactic construction is the conditional clause of the type "If A, then B" (Acerbi forthcoming). The typical form is always ἐάν with aorist or present subjunctive in the protasis, and present or future indicative in the apodosis, to express the idea that whenever something happens, something else will follow, i.e., a general truth (e.g., Euc. *El.* 1, Prop. 6 **Ἐὰν** τριγώνου αἱ δύο γωνίαι ἴσαι ἀλλήλαις **ὦσιν**, καὶ αἱ ὑπὸ τὰς ἴσας γωνίαις ὑποτείνουσαι πλευραὶ ἴσαι ἀλλήλαις **ἔσονται** "If two angles of a triangle are equal to one another, also the sides subtended by the equal angles will be equal to one another"). Instead, the conditional clause with εἰ and present indicative in the protasis and present or future indicative or imperative in the

apodosis is a simple condition: if something happens, something else will follow but without implying that what is stated in the protasis may possibly apply. The latter form is therefore often used for *reductio ad absurdum* proofs: εἰ γὰρ δυνατόν ἐστι, . . . ἔστω . . . 'For if it is possible, let (some property) be true . . .'.

Geometrical constructions in Euclid are characterized by particular tenses and moods in the verbs. Normally, we find the perfect imperative in the middle passive such as ἐπεζεύχθω "let [a straight line] be joined . . .," κύκλος γεγράφθω "let a circle be drawn." The impersonal form and the passive voice help the reader to focus on the geometrical object rather than on who must draw the geometric figure. The perfect is a resultative form, which helps to visualize the result of the construction. The same use of the imperative (but not necessarily in the perfect tense) is found also in mechanics when the construction of a machine is described, for example in the mechanical works by Hero of Alexandria.

Essential and concise language was a necessary choice in mathematics. Since the basic principles were few, and the rest was deductive and inferential, the required lexicon was small and easy to learn. Therefore, unlike medical language, Greek mathematical language in the Hellenistic and early Roman period was standardized.

Technical Language and Formulae

Mathematical language tends to be repetitive. It uses set phrases, easy to recognize after reading a few texts. This has led scholars to apply the concept of "formula," known from Homeric studies, to Greek mathematical language. Formulae are used to name geometrical objects (e.g., τὸ A, ἡ AB); in the enunciation of a problem (e.g., περὶ τὸ[ν] δοθέν[τα] + name of a figure (e.g., κύκλον) + name of a figure (e.g., τετράγωνον) περιγράψαι "Let (a square) be drawn around a given (circle)"); to open proofs (e.g., ἔστω γὰρ . . . followed by the name of the geometrical object discussed in the proof). The imperatives of the constructions are also formulaic, e.g., ἤχθω "let be drawn," ἐπεζεύχθω "let be joined."

Other very common formulae are found in demonstrations, such as . . . ἄρα . . . ὅπερ ἔδει δεῖξαι ". . . therefore . . . QED" at the end of the demonstration, which can also be considered a sort of "ring composition" within the demonstration. Another example is found in the *reductio ad absurdum*: Εἰ γὰρ δυνατόν, . . . ἔστω. . . ὅπερ ἐστὶν ἀδύνατον. Οὐκ ἄρα . . . "For if possible, let [some property] be true. [Then, consequence of the assumed property,] which is impossible. Therefore, negation [of the property]."

There are formulae typical of the theory of proportions: the relationship of proportionality is introduced by: ὡς . . . οὕτως . . . "as . . . so . . .," while the different possible modifications of the terms of a proportion are expressed by the adverbs ἐναλλάξ "alternatively" and ἀνάπαλιν "inversely," and by forms of a so-called *dativus iudicantis*, e.g., συνθέντι "in composition" (literally "for one who puts things together)," διέλοντι "separately," and ἀναστρέψαντι "by conversion."

Another formula, used mainly in *Elements* Book Five (dedicated to the theory of proportion), is used when applying the definition of proportional magnitudes: καὶ εἰ

ἴσον, ἴσον, καὶ εἰ ἔλαττον, ἔλαττον "if it is equal, equal, and if less, less" (with the variant καὶ εἰ ἴσον ἐστίν, ἴσον, καὶ εἰ ἐλλείπει, ἐλλείπει).

The application of the concept of Homeric formulae to Greek mathematical language explains the same sense of "repetitiveness" found in Greek mathematical texts and epic poetry. However, Homer composed poetry and mathematicians wrote prose. Also, Greek mathematicians were literate and wrote their texts, while literacy and writing are considered the antithesis of orality and hence of formulae. According to Aujac 1984, the origin of Greek mathematical formulae might be didactic: Greek mathematical education was oral and hence worked like Homeric poetry. More simply, in mathematics, the repetitiveness of set phrases helped logical necessity, a function that now is fulfilled by mathematical symbolism. Indeed, formulae can be found also in other Greek technical texts, where it serves the purpose of articulating logical reasoning. In medicine, we find recurrent linguistic patterns, especially introductory and concluding formulae, such as νῦν δὲ ἐρέω "and now I shall say"; μέλλω ἐρεῖν "I will say"; ταῦτα δέ μοι ἐς τοῦτο εἴρηται "this has been said by me up to this point."

Style and Rhetoric

Greek "scientific style" has been described as "a continuous, systematic, and discursive, though non-rhetorical and non-emotional prose" (Thesleff 1966: 89). However, scientific discourse in ancient Greece sometimes uses language in a connotative way when it needs to convey some emotion to convince the audience/reader about its contents.

One of the most striking uses of rhetoric aimed at persuading can be found in the Hippocratic Corpus, especially *The Art of Medicine* and *On Breaths* (Jouanna 1984). These texts are characterized by long introductions and conclusions, antitheses, anaphoras, and sound effects typical of Gorgianic style (see also ch. 30). Rhetorical elements are also found in other works, not primarily composed for laypeople, such as *The Sacred Disease*, *Air, Waters and Places*, *Fractures*, *Prognostics*, just to quote the most famous examples. The reason why medicine, unlike other technical disciplines, uses rhetoric can be explained by looking at the historical context. Medicine, especially in the fifth and fourth centuries BCE, had to establish itself against other common healing practices performed by magicians, priests, and other types of healers. The first physicians not only did "medical research," but also had to fight against these practices to prove that "real" medicine was better and more effective than magic. This meant convincing a general audience who would go to magicians rather than to physicians. Thus, according to a common practice of Greek society, rhetoric was necessary to "persuade" both colleagues and prospective clients.

Mathematics, by contrast, makes a much more sparing use of rhetorical devices, because it did not need to fight against any similar but unscientific discipline, as medicine had to do against magic. As a consequence, mathematical language does not so much "persuade" as "demonstrate," and it achieves this not so much by rhetorical means as by using logical connective particles, which are part of dialectic, as developed by Aristotle and then by the Stoics.

Technical language sometimes admits personal elements in scientific texts. Both the Hippocratic Corpus and Euclid use verbs of "saying" in the first person singular (φημί or λέγω and, in medicine only, ἐρέω) when stating something or clarifying a key passage. This use of the *Ich-Stil* (Regenbogen 1961: 171) is a feature of the Ionic tradition of the ἱστορίη, and Greek "scientists" use it to underline their own results or to explain important concepts. In medicine, this sense of individual scientific achievement and of the ἱστορίη through first-person statements is particularly evident. In mathematics, instead, the first person is much less used, with the exception of prefatory letters that mathematicians like Archimedes or Apollonius of Perge address to a colleague. In these prefaces, first and second persons are much used, as the incipit of Archimedes' letter to Eratosthenes (the dedicatee of the *Method*) shows:

> Ἀρχιμήδης Ἐρατοσθένει εὖ πράττειν. Ἀπέστειλά σοι πρότερον τῶν εὑρημένων θεωρημάτων ἀναγράψας αὐτῶν τὰς προτάσεις φάμενος εὑρίσκειν ταύτας τὰς ἀποδείξεις, ἃς οὐκ εἶπον ἐπὶ τοῦ παρόντος·
>
> Archimedes greets Eratosthenes. Before, I sent you some theorems I found, limiting myself to their propositions and asking you to find out these demonstrations which I did not indicate at that time. (*Method* 426.3)

Apart from these letters, which are not, strictly speaking, "mathematical writings" but belong to the genre of the "preface," mathematical texts tend to be characterized by highly impersonal style and passive forms. However, there are some interesting cases of *Ich-Stil* in Archimedes, who is more personal than Euclid. Archimedes intrudes in his own persona in the discussion by frequently using verbs in the first person singular: for example in the *De sphaera et cylindro* he uses καλῶ many times in the axioms (eg., Archim. *Sph. Cyl.* 6.25 ῥόμβον δὲ **καλῶ** στερεόν, ἐπειδὰν . . . "I call it a solid rhombus when . . .") or λαμβάνω in the sense of "I take it/assume (that . . .)" to introduce postulates (which he calls λαμβανόμενα "things taken"). By contrast, Euclid's first-person forms λέγω "I say" and ὁμοίως δὴ δείξομεν "similarly we will prove" sound more like formulae than real "personal statements."

Non-Normative Syntax

Technical prose is sometimes characterized by what, at first sight, can be defined as an elliptic and anacoluthic syntax. This is certainly evident in the Hippocratic writings, in particular the *Epidemics*, for example:

> Ἐρασινὸν, ὃς ᾤκει παρὰ Βοώτου χαράδρην, πῦρ ἔλαβε μετὰ δεῖπνον· **νύκτα ταραχώδης.**
> **Ἡμέρην τὴν πρώτην δι' ἡσυχίης, νύκτα ἐπιπόνως.**
> **Δευτέρῃ πάντα παρωξύνθη· ἐς νύκτα παρέκρουσεν.**
> Τρίτῃ ἐπιπόνως· παρέκρουσε πολλά.
> Τετάρτῃ δυσφορώτατα· ἐς δὲ τὴν νύκτα οὐδὲν ἐκοιμήθη· ἐνύπνια καὶ λογισμοί· ἔπειτα χείρω, μεγάλα καὶ ἐπίκαιρα, **φόβος, δυσφορίη.**
> Πέμπτῃ πρωῒ κατήρτητο, καὶ κατενόει πάντα· πουλὺ δὲ πρὸ μέσου ἡμέρης ἐξεμάνη· κατέχειν οὐκ ἠδύνατο· **ἄκρεα ψυχρά, ὑποπέλια· οὖρα ὑπέστη**· ἀπέθανε περὶ ἡλίου δυσμάς.

A fever seized Erasinus, who lived near the Canal of Bootes, after supper. [He was] agitated during the night.
During the first day [he was] quiet, during the night [he was] in pain;
On the second day, everything exacerbated, at night he became delirious.
On the third day, [he was] in pain; he was in great delirium.
On the fourth day, [he was] in a most uncomfortable state; he did not sleep at night; dreams and talking; then (every symptom became) worse, strong and serious; [he had] fear, discomfort
On the fifth day, in the morning he recovered and was in full possession of his senses; but long before midday he fell in great delirium; he could not restrain himself; [his] extremities [were] cold, livid; urines stopped. He died around sunset. (Hippoc. *Epid.* 1, Case 8)

The syntax, rich in non-consequential constructions, is typical of notes, rather than of elaborated prose text. Many predicates are suppressed in nominal clauses with a simple nominative (φόβος, δυσφορίη) or with an adjective referring to the sick person (νύκτα ταραχώδης) or with a prepositional phrase or an adverb (ἡμέρην τὴν πρώτην δι' ἡσυχίης, νύκτα ἐπιπόνως). There are harsh changes of subjects (δευτέρῃ πάντα παρωξύνθη· ἐς νύκτα παρέκρουσεν). Sometimes, nominal phrases are followed by a clause with predicate, creating an odd *variatio* (ἄκρεα ψυχρὰ, ὑποπέλια· οὖρα ὑπέστη).

Sometimes the syntax is not only brachylogic as here, but even grammatically incorrect, as when necessary articles are missing as in *Epid.* 1.3.1–3: . . . πυρετοὶ . . . **μακρὰ δὲ νοσέουσιν, οὐδὲ περὶ τὰ ἄλλα δυσφόρως διάγουσιν** ἐγένοντο ". . . fevers . . . attacked persons who had been sick for a long period, but who were otherwise not in an uncomfortable state," where a definite article τοῖσι before μακρὰ δὲ νοσέουσιν, οὐδὲ περὶ τὰ ἄλλα δυσφόρως διάγουσιν is necessary in order to substantivize the participle. Another typical trait is the *nominativus pendens*, a nominative that is not followed by any predicate and seems thus disconnected from the rest of the clause, but which can serve as a topic marking, as in *Epid.* 3.14.4–6: Τὸ μελαγχολικόν τε καὶ ὕφαιμον· οἱ καῦσοι καὶ τὰ φρενιτικὰ, καὶ τὰ δυσεντεριώδεα τούτων ἥπτετο "And the melancholic and the sanguine (complexions); bilious remittent fevers, the symptoms of phrenitis and those of dysentery attacked them." This loose syntax is typical of notes, whose purpose is to keep track of important events without any interest in style and elegance. The result is a "brachylogic" prose, that must be considered not a mistake but a personal choice of the scientific writer. This "minimalist" style suits didactic texts and reference works well, since it contains only the relevant data and highlights the most important logical steps through the process of topicalization, as the *nominativus pendens* or other absolute word-usages.

In this survey, brief and limited for obvious reasons, I have tried to show how Greek technical writers were able to exploit the lexical, morphological, and syntactic possibilities of their language in order to express new scientific ideas and reasoning. They adopted various strategies. Technical terminology was created by reusing old generic terms, by creating new ones with suffixes and compounding, as well as by adopting "visual" metaphors. Syntax too was used to communicate scientific content (especially

by using argumentative particles to articulate proofs) as well as to "persuade" a larger audience of the soundness of the "scientific" approach to a discipline. Beyond doubt, medicine and mathematics are the best examples of technical languages in ancient Greece. However, behind them and their linguistic achievements there is Aristotle. Not only did he use the technical languages of both medicine (in his biological works) and mathematics, he also made a crucial contribution to scientific language and its syntax and style by setting out the principles of both dialectic and rhetoric, which, as we have seen, are at the core of ancient scientific discourse.

FURTHER READING

On technical languages in general, see Fluck 1985 and Hoffmann 1985. On modern terminology for diseases, see Goltz 1969. Snell 1953: 227–45 and Barnes 1987: 18–22 discuss the language of the Presocratics. On Ancient Greek scientific style in general, see Thesleff 1966, Eijk 1997, and Willi 2003: 51–95. Langslow 2000 and Fögen 2003 are more focused on Latin, but still very useful.

On Greek medical terminology, see Lanza 1983, Lloyd 1983: 149–67, and López Férez 2000. Metaphorical language in Greek medicine is discussed in Vegetti 1983 and Skoda 1988. On Greek medical style and rhetoric, see Langholf 1977, Lloyd 1979: 86–98, Wenskus 1982, Hellweg 1985, Jouanna 1984, Nutton 1992: 16–27, Von Staden 1997, and Eijk 1997. Von Staden 1996 and 1998 deal with the interactions of medicine and mechanics.

A general approach to Greek mathematical language is Acerbi 2007: 213–18, 259–313, 532–4. On the other hand, Netz 1999: 89–126 must be approached with caution due to several inaccuracies in terms both of collection of data and linguistic analysis. A good reference work is the dictionary by Mugler 1958. Aujac 1984 covers formulae in Greek mathematics. For Aristotle's influence on mathematical language, see Einarson 1936. On language and logic in Greek mathematical language, see Acerbi forthcoming. Various and specific aspects of Greek mathematical language are covered by Federspiel 1992, 1995, 2003, 2005, and 2006, by Vitrac 2008, and by Acerbi 2008.