VITRUVIUS

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Ten Books on Architecture

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FIRST PRINCIPLES AND THE LAYOUT OF CITIES

PREFACE

1. So long as your divinely inspired intelligence and your godly presence, Imperator Caesar,* were engaged in taking possession of the world, your enemies leveled one and all by your invincible might, so long as citizens were glorying in your triumph and in your victory, with all the subject peoples awaiting your command, so long as the Roman People and Senate, freed from fear, were piloted by your far-ranging deliberations and plans, I dared not, in the midst of such concerns, publish my writings on architecture, even though these had been formulated according to extensive researches,* for fear that by intruding at an inappropriate moment I might incur the disdain of your keen spirit.

2. When, however, I perceived that you were solicitous not only for the establishment of community life and of the body politic, but also for the construction of suitable public buildings, so that by your agency not only had the state been rendered more august by the annexation of entire provinces, but indeed the majesty of the Empire had found conspicuous proof in its public works – then I thought that I should not miss the opportunity to publish on these matters for you as soon as possible, given that I was first recognized in this field by your Father [Julius Caesar]* and was a devoted admirer of his qualities. Thus when the council of the Olympians consecrated him among the abodes of immortality and passed his sovereignty into your own jurisdiction, this same devotion of mine, fixed upon his memory, naturally transferred allegiance to you. And so I was put in charge, along with Marcus Aurelius and Publius Minidius and Gnaeus Cornelius, of outfitting catapults as well as the repair of all the other sorts of war machines, and along with these men I received a stipend, first awarded by you, and continued at the recommendation of your sister.*

3. Therefore, because I had been put in your debt for the favor whereby I will never harbor the fear of want for the rest of my life, I began to record these matters for you. For I perceived that you had already built extensively (Figure 1),* were building now and would be doing so in the future: public as well as private constructions, all scaled to the amplitude of your own achievements so that these would be handed down to future generations. I have set down these instructions, complete with technical terms, so that by observing them you could teach yourself how to evaluate the works already brought into being and those yet to be. For in these pages I have laid out every set of principles for the discipline.

CHAPTER 1: THE EDUCATION OF THE ARCHITECT

1. The architect's expertise is enhanced by many disciplines and various sorts of specialized knowledge; all the works executed using these other skills are evaluated by his seasoned judgment. This expertise is born both of **practice** and of **reasoning.**[1] **Practice** is the constant, repeated exercise of the hands by which the work is brought to completion in whatever medium is required for the proposed design. **Reasoning,** however, is what can demonstrate and explain the proportions of completed works skillfully and systematically.

2. Thus architects who strove to obtain practical manual skills but lacked an education have never been able to achieve an influence equal to the quality of their exertions; on the other hand, those who placed their trust entirely in theory and in writings seem to have chased after a shadow, not something real. But those who have fully mastered both skills, armed, if you will, in full panoply, those architects have reached their goal more quickly and influentially.

1 The boldface labels duplicate the rubrics (headings) found in most manuscripts of Vitruvius.

3. In all things, but especially in architecture, there are two inherent categories: the **signified** and the **signifier.*** The **signified** is the proposed subject of discussion; it is signified by a reasoned demonstration carried out according to established principles of knowledge. Thus we see that whoever puts himself forward as an architect should be practiced in both. And furthermore he ought to have a native talent, and be amenable to learning the disciplines [of the profession]. For neither native talent without learning nor learning without native talent create the master craftsman. To be educated, he must be an experienced draftsman, well versed in geometry, familiar with history, a diligent student of philosophy, know music, have some acquaintance with medicine, understand the rulings of legal experts, and have a clear grasp of astronomy and the ways of Heaven.

4. Here are the reasons why this should be so. An architect should understand **letters** so that he may strengthen his own memory by reading what has been written in the field. Next, he should have knowledge of **draftsmanship** so that he can more easily use illustrated examples at will to represent the appearance of the work that he proposes. **Geometry,** in turn, offers many aids to architecture, and first among them, it hands down the technique of compass and rule, which enables the on-site layout of the plan as well as the placement of set-squares, levels, and lines. Likewise, through knowledge of **optics** windows are properly designed so as to face particular regions of heaven. Through **arithmetic** the expenses of buildings are totaled up, and the principles of measurement are developed; the difficult issues of symmetry are resolved by geometric principles and methods.

5. He should know a great deal of **history** because architects often include ornaments in their work, and ought to be able to supply anyone who asks with an explanation why they have introduced certain motifs. Consider, for example, if anyone has decided, in place of columns, to insert statues of women clad in *stolae* – the so-called Caryatids (Figure 2)* – into his work, and above them to set cornices and mutules. For those who inquire he will give the following rationale: the Peloponnesian city of Caryae had sided with the enemy, Persia, against Greece. Subsequently, the Greeks, gloriously delivered from war by their victory, by common agreement declared war on the Caryates. And so, when they had captured the town, slaughtered the men, and laid a curse on the inhabitants, they led its noble matrons off into captivity. Nor would they allow these women to put away their *stolae* and matronly dress; this was done so that they should not simply be exhibited in a single triumphal procession, but should instead be weighted down forever by a burden of shame, forced to pay the price for such grave disloyalty on behalf of their whole city. To this end, the architects active at the time incorporated images of these women in public buildings as weight-bearing structures; thus, in addition, the notorious punishment of the Caryate women would be recalled to future generations.

6. The Spartans, too, led by Pausanias son of Agesilas [son of Polis], with only a handful of troops defeated an endless number of Persian infantry at the Battle of Plataea, and after they had won decisively, they set up the Portico of the Persians as a trophy of victory for posterity – after, of course, a triumphal celebration glorious for its spoils and booty. This portico was financed by the prizes of war in praise of the citizens' courage and as a monument of their victory for future generations. There they placed images of the Persian captives, decked out in their ornate barbarian dress, holding up the roof, their pride punished with well-deserved outrage. In addition, by this means enemies might shrink back, terror stricken at the results of Spartan courage. At the same time, the citizens, looking upon this example of battle courage, uplifted by pride, would be prepared to defend their own liberty. After this many architects employed statues of Persians to hold up epistyles and their ornaments, and by this means added notable variety to their works. There are other histories of the same type, with which the architect is obliged to have some acquaintance.

7. **Philosophy*** completes the architect's character by instilling loftiness of spirit, so that he will not be arrogant, but rather tolerant, fair, and trustworthy, and, most important of all, free from greed. For there is no work that can truly be done without honesty and disinterestedness; let him not be too grasping, nor fix his mind on receiving gifts or rewards, but let him pay serious attention to protecting his dignity by maintaining a good reputation – for these are the things that philosophy recommends.

Furthermore, philosophy serves to explain the science which in Greek is called **physiology.*** It is necessary to know this subject thoroughly, for it has many and varied natural applications, as, for example, in the matter of aqueducts. For natural water pressures differ, depending on whether one is dealing with swift downhill runs, curvatures, or ascents up onto a gradual slope, and no one can compensate for the impact of these pressures except someone who, thanks to philosophy, knows the basic facts of nature. In addition, anyone who reads the hand-

books of Ctesibius* and Archimedes,* or any of the other writers in this field, will not be able to absorb their reading without a grounding in these matters with the help of the philosophers.

8. The architect should know **music*** in order to have a grasp of **canonical** and **mathematical** relations, and besides that, to calibrate *ballistae,* catapults, and [the small catapults called] *scorpiones.* In the headpieces of war machines there are "hemitone" spring holes, right and left, through which the twisted sinew cords are pulled tight by windlass and handspikes; these cords should not be wedged in place or fastened down unless they give off a particular and identical sound to the ears of the catapult maker. For when the arms of the catapult have been cocked to these tensions, upon release they should deliver an identical and equivalent thrust; if they are not tuned identically, they will keep the catapult from launching a straight shot.

9. In theaters, likewise, the bronze vessels – the ones the Greeks call **echea*** – which are enclosed underneath the seats, are placed according to mathematical principle based on their pitch. The vessels are grouped in sections around the circle of the theater to create intervals of a fourth, a fifth, and so on, up to a double octave.* As a result, the voice, as it occurs onstage, should be so located in the theater's overall design that when it strikes the **echea** it will be amplified on impact, reaching the ears of the spectators as a clearer and more pleasant sound. As another example, no one could possibly create water organs and other such hydraulic devices without recourse to musical principles.

10. He should know the science of **medicine,*** as this depends on those inclinations of the heavens which the Greeks call **climates,*** and know about airs, and about which places are healthful and which disease ridden, and about the different applications of water, for without these studies no dwelling can possibly be healthful (Figures 3–5).

And he should know the **law,*** especially the law governing those things necessary to buildings that include party walls, that is, the courses of rain gutters and drains, and lighting, and also water supply. In addition, other subjects of this type should be known to architects, so that even before they begin their buildings they have taken care not to bequeath the patron a legacy of lawsuits along with their completed work. Indeed, they should exercise a legislator's care in their dealings both with contractor and with client. For if a law is expertly written, it will be such that each party may be released from the contract without undue dispute.

As for **astronomy,** he should know east, west, south, and north, and the principles of the heavens, the equinox, the solstice, and the course of the stars. Anyone who lacks this knowledge cannot understand the principle of a sundial.

11. Therefore, because so great a profession* must be adorned by and abundant in so many and such various types of expertise, I do not believe that architects can simply announce themselves as such, none but those who have climbed step by step, nurtured from an early age by education – in letters above all, and in the arts – to reach the loftiest sanctuary of Architecture.

12. But perhaps it will seem incredible to those unfamiliar with the profession that human nature could learn so great a number of disciplines thoroughly and still retain the memory of them. Yet if they notice how all these studies have interconnected subjects in which they participate in common, then they may easily believe it possible for such things to occur. For a well-rounded education,* just like a single body, is composed of quite different parts. And thus those who are educated from an early age in the various types of study recognize the same salient points in all types of writing, and the relationship of all the branches of knowledge, and because of this they come to know all manner of subjects with greater ease.

One of the architects of the past, Pytheos,* who gave the temple of Minerva at Priene its illustrious design, claims in his treatises that the architect ought to be more competent in every skill and discipline than those who have simply brought individual arts to a pinnacle of excellence through study and practice. But this is not what happens in fact.

13. For an architect should not and cannot be a philologist of Aristarchus's* quality, but neither should he be unlettered; if not a musician as gifted as Aristoxenus,* still he should know music, if not a painter equal to Apelles,* still not unskilled in draftsmanship; if not a sculptor on the order of Myron or Polycleitus,* still he should not be ignorant of sculptural technique. Again, although he may be no Hippocrates,* he should have working knowledge of medicine, nor may he be learned to an outstanding degree in the other individual disciplines – still, in all of them he should have some expertise. No one, after all, can possibly master the fine points of each individual subject, because it can scarcely be in his power to master and grasp their reasoning.

14. Neither is it the case that architects alone cannot achieve full mastery of all things, for even people who have separately mastered the individual details of par-

ticular arts do not all manage to reach the pinnacle of praise. Therefore, if for any individual skill, individual artisans – not all, but only a few – barely achieve distinction for all time, how can the architect, who ought to be skilled in so many arts, not simply to do some very great and wonderful thing, whatever it might be – how can he, without being deficient in any one of these arts, still do so well that he outshines all those artisans who have assiduously devoted themselves to individual skills?

15. Therefore Pytheos seems to be mistaken in this matter, because he fails to note that each individual art consists of two elements: the **work** itself and the **reasoning** behind it; one of these is the particular property of those who are trained in an individual skill, namely the execution of the work itself. The other [element, reasoning,] is shared in common with every learned person, just as doctors and musicians share knowledge of the rhythm of our veins' pulse* and the motion of our feet. However, if there is need to heal a wound or snatch a sick person from danger, the musician will not come forward, for this is the proper work of the doctor. Likewise, the musician, not the doctor, will play an instrument so that his ears will delight in song.

16. Similarly, astronomers and musicians discuss certain things in common: the harmony of the stars,* the intervals of squares and triangles, that is, the [musical] intervals of fourths and fifths, and with geometers they speak about vision, which in Greek is called *logos optikos*, the science of optics, and in the other disciplines many – or all – things are common property, so far as discussion is concerned (Figure 6). But as for embarking on the creation of works that are brought to elegant conclusion, whether through manual dexterity or skillful application, this is properly left to those who have been trained to practice a single skill. Whoever has a moderate grasp of the theory and the practical details of those individual disciplines necessary to architecture seems to have done enough, and more than enough; he will not fail, if need should arise, to judge and test decisions and evaluate these various areas and techniques.

17. But those to whom nature has granted such wits, acuity, and good memory that they are fully skilled in geometry, astronomy, music and related disciplines, pass beyond the business of architects and are turned into mathematicians. As a result they can easily hold their own in such fields of study, because they have a well-stocked scholarly arsenal with missiles from several disciplines. Nonetheless, such people are seldom to be found, such as once were Aristarchus of Samos, Philolaos and Archytas of Tarentum, Apollonius of Perge, Eratosthenes of Cyrene, Archimedes, and Scopinas of Syracuse,* who made all manner of discoveries on measurement through mathematics and natural philosophy, and left treatises on these subjects for subsequent generations.

18. Because by Nature's wisdom it has not been granted that all nations everywhere have such talents, but a few men only, and yet at the same time an architect's task must be carried out by means of many skills, and reason permits that, because of the immensity of the enterprise, he have not a supreme, but only a moderate knowledge of these disciplines, I request, Caesar, both of you and of those who will read these volumes, that they forgive anything that has not been composed according to the rules of literary style. For I have striven to write them not as a great philosopher or an eloquent orator, nor as a grammarian* trained in the finer points of his art, but as an architect who has dipped into literature. But on the power of my own art and the systems of reasoning included in it, I promise that, as I expect, in these pages I will without a doubt prove myself possessed of the greatest authority – not only for those who intend to build, but also for all learned men.

CHAPTER 2: THE TERMS OF ARCHITECTURE*

1. Architecture consists of **ordering**, which is called *taxis* in Greek, and of **design** – the Greeks call this *diathesis* – and **shapeliness** and **symmetry** and **correctness** and **allocation**, which is called *oikonomia* in Greek.

2. **Ordering*** is the proportion to scale of the work's individual components taken separately, as well as their correspondence to an overall proportional scheme of symmetry (Figure 7). It is achieved through **quantity**, which in Greek is called *posotês*. **Quantity**, in turn, is the establishment of modules taken from the elements of the work itself and the agreeable execution of the work as a whole on the basis of the elements' individual parts (Figure 8).

Next, **design*** is the apt placement of things, and the elegant effect obtained by their arrangement according to the nature of the work. The species of design, which are called *ideai* in Greek, are these: **ichnography** (plan), **orthography** (elevation), and **scenography**. **Ichnography** is the skillful use, to scale, of compass and rule, by means of which the on-site layout of the design is

achieved. Next, **orthography** is a frontal image, one drawn to scale, rendered according to the layout for the future work. As for **scenography**, it is the shaded rendering of the front and the receding sides as the latter converge on a point.

These species are produced by **analysis** and **invention. Analysis** is devoted concern and vigilant attention to the pleasing execution of a design. Next, **invention** is the unraveling of obscure problems, arriving, through energetic flexibility, at a new set of principles. These are the terms for design.

3. **Shapeliness (eurythmia)*** is an attractive appearance and a coherent aspect in the composition of the elements (Figure 9). It is achieved when the elements of the project are proportionate in height to width, length to breadth, and every element corresponds in its dimensions to the total measure of the whole.

4. **Symmetry*** is the proportioned correspondence of the elements of the work itself, a response, in any given part, of the separate parts to the appearance of the entire figure as a whole.

Just as in the human body there is a harmonious quality of shapeliness expressed in terms of the cubit, foot, palm, digit, and other small units, so it is in completing works of architecture (Figure 10). For instance, in temples, this symmetry derives from the diameter of the columns, or from the triglyph, or from the lower radius of the column; in a ballista, it derives from the hole that the Greeks call *peritrêton*, in boats from the [spacing of the] oarlock, which the Greeks call the *diapegma;** likewise for all the other types of work, the reckoning of symmetries is to be found among their component parts.

5. Next, **correctness (decor)*** is the refined appearance of a project that has been composed of proven elements and with authority. It is achieved with respect to **function**, which is called *thematismos* in Greek, or **tradition**, or **nature.** Correctness of function occurs when temples dedicated to Jupiter the Thunderer and Heaven or the Sun and Moon are made open-air shrines, beneath their patron deity, because we see the appearance and effect of these divinities in the light of the outdoor world. Temples of Minerva, Mars, and Hercules will be Doric, because temples for these gods, on account of their courage in battle, should be set up without a trace of embellishment. Temples done in the Corinthian style for Venus, Proserpina, or the Fountain Spirits (nymphs) are those that will seem to possess the most fitting qualities, because, given the delicacy of these goddesses, the works executed in their honor seem best to augment a suitable quality of correctness when they are made more slender, ornamental, and are decorated with leaves and volutes. If temples are constructed in the Ionic style for Juno, Diana, Father Liber, and other gods of this type, the principle of the "mean" will apply, because their particular disposition will strike a balance between the stern lines of the Doric and the delicacy of the Corinthian.

6. Correctness of tradition will be expressed if, when buildings have magnificent interiors, their vestibules have been made equally harmonious and elegant, for if interiors were outfitted elegantly, but had entrances deficient in dignity and respectability they would lack correctness. Likewise, if Doric entablatures are sculpted with dentils in the cornices, or triglyphs show up atop cushion capitals and Ionic entablatures, so that characteristics from one set of principles have been carried over into another type of work, the appearance of the result will be jarring, because the work was established according to a different sequence of conventions.

7. Natural correctness occurs as follows: if, from the outset, temple sites are chosen in the most healthful regions, well supplied with suitable sources of water, but especially for the building of shrines to Asclepius, Health, and those gods by whose medicines the sick seem to be healed in the greatest numbers. When patients have been transferred from a pestilent to a healthful place and are afforded the use of waters from healthful springs, they will recover more quickly, and so it will be arranged that from the very nature of the place the divinity in question will receive a greater and greater reputation along with the dignity of divine rank. Likewise, natural correctness will obtain if the light source for bedrooms and libraries comes from the east, whereas the source for baths and winter quarters comes from the west in winter, while in the case of picture galleries and whatever areas need a constant level of illumination it should come from the north, because that region of the sky is neither made bright nor dark by the course of the sun, but remains dependable and unchanging throughout the day.

8. **Allocation*** is the efficient management of resources and site and the frugal, principled supervision of working expenses. This will be observed if from the outset the architect forbears to require things that cannot be found at all or only procured at great expense. After all, not every place has an abundant supply of pit sand or rubble or fir, or deal planks, or marble. Different resources occur in different places, and their transport elsewhere is difficult and expensive. Where there is no pit sand, river sand or washed seashore sand should be used instead; if there is a shortage of fir or of deal planks, use cypress, poplar, elm,

or pitch pine. Other problems should be resolved in a similar fashion.

9. The other level of **allocation** obtains when buildings are designed differently according to the habits of the heads of families, or the amount of money available, or to suit their prestige as public speakers. Urban dwellings ought to be set up in one way, and rustic holdings, where harvests must be gathered, in another; the homes of moneylenders, certainly otherwise, and still otherwise the homes of those who are fortunate and sophisticated. For those powerful men by whose counsel the republic is governed, dwellings should be designed to accommodate their activities, and in every case the allocation of buildings should be appropriate to every different type of person.

CHAPTER 3: THE DIVISIONS OF ARCHITECTURE

1. The divisions of architecture itself are three: **construction, gnomonics** (the making of sundials), and **mechanics.*** **Construction** in turn is divided into two parts, one of which is the placement of city walls and **public works** in public places; the other is the erection of **private buildings**. The allocations of **public works** are three, of which the first is **defense**, the second **religion**, and the third **service**. The architecture of **defense** is the set of principles devised so that walls, towers, and gates will be permanently effective in warding off enemy attacks. That of **religion** is the establishment of sanctuaries for the immortal gods and of temples; that of **service** is the design of public places for common use, such as ports, fora, porticoes, baths, theaters, promenades, and the other installations which are appointed in public places for the same purposes.

2. All these works should be executed so that they exhibit the principles of **soundness, utility,** and **attractiveness**. The principle of **soundness** will be observed if the foundations have been laid firmly, and if, whatever the building materials may be, they have been chosen with care but not with excessive frugality. The principle of **utility** will be observed if the design allows faultless, unimpeded use through the disposition of the spaces and the allocation of each type of space is properly oriented, appropriate, and comfortable. That of **attractiveness** will be upheld when the appearance of the work is pleasing and elegant, and the proportions of its elements have properly developed principles of symmetry.

CHAPTER 4: THE CHOICE OF A HEALTHFUL SITE

1. These should be the primary elements for constructing the walls themselves: first of all, the choice of a very healthful site (Figure 11).* It should be elevated, not cloudy, not liable to frost, facing those regions of the sky which are neither hot nor cold but temperate. In addition, if at all possible, proximity to swamps is to be avoided. For when the morning breezes enter the town with the rising sun, whatever mists have formed overnight are joined with them. Their gusts spew the poisonous exhalations of the swamp animals, which have been mixed in with the mist, at the bodies of the inhabitants, and these will make the place pestilent. Likewise, if the walls are built next to the sea, so as to face southward or westward, they will not be good for health, because in summer the southern sky warms at sunrise and by midday is burning hot; by the same principle whatever faces westward grows warm with the rising sun, heats up at noon, and boils by evening.

2. Therefore, from the shifts of heat and cold, the matter that occurs in such places is weakened. This can even be observed in inanimate objects. Among covered wine cellars, not one admits light from the south or west, but only from the north, because that region of the heavens never alters with the season, but stays forever firm and changeless. For the same reason granaries which face the sun quickly ruin their stores, and dried fish or fruits that are not stored out of the sun's way are never preserved for long.

3. Invariably, whenever heat cooks down the strength of air, and its roiling vapors suck out and snatch away matter's natural properties, its fervor dissolves and softens matter to the point of limpness. We see the same thing with iron, which, however hard it is by nature, softens so completely when it is heated by the vapors of fire in furnaces that it is easily fashioned into every kind of shape; and by the same token, when, soft and glowing, it is chilled by dousing in cold, it hardens again and is restored to its former character.

4. We may also draw the conclusion that this is so from the fact that in the summer, everything, not just in pestilential places but even in healthful ones, grows flaccid in the heat, while all through the winter even the most plague-ridden regions are made healthful on account of the fact that they are solidified by the cold. Nor is there any doubt about this: that when objects are moved from cold areas to hot ones, they cannot endure but dissolve, while those that are taken from hot loca-

tions to the cold northern regions are not only none the worse for the change of place, but actually grow stronger.

5. For this reason, in laying out walls, it seems best to avoid regions that can taint human bodies with hot vapors.

According to the principles which the Greeks call *stoicheia*, just as all bodies are composed of elements, that is of heat and moisture, earth and air, so, too, a mixture of these elements in a given proportion produces all the particular qualities of each sort of living being to be found in the world.

6. Therefore in those bodies where heat dominates, it destroys and dissolves all the rest with its fervor. The air itself creates this defect in certain regions, when it settles into open veins more than the body allows at its natural temperament and mixture. Likewise, if moisture lodges in the veins of the body and puts it out of equilibrium, the other elements, as if corrupted by liquefaction, are diluted, and the natural virtues of the composition are dissolved out. These flaws can also be introduced into the body from the chilling effects of the moisture contained in the winds and breezes. On the same principle, the natural composition of air and earth in the body, by increasing or diminishing, weakens the other elements: the earth by an excess of food, the air by the heaviness of the atmosphere.

7. But whoever would like to study these facts more closely, take heed and note the nature of birds, fishes, and land animals, and in this light consider the differences in their makeup. The birds have one mixture, fishes another, and animals still another, far different from that of the first two. Birds have less earth, less moisture, a moderate amount of heat, and a great deal of air: therefore, composed as they are of lighter elements, they are more easily supported on moving air. The aquatic natures of fishes, on the other hand, because they are tempered by a bit of heat and largely made up of air and earth, but very little moisture, endure all the more easily in water to the extent that they lack the element of moisture in their bodies. And thus, when they are brought out on land they leave their lives behind with the water. Likewise, the land animals, because they have only a moderate complement of air and heat, less earth and a great deal of moisture – for the moist parts are abundant – cannot maintain life for long in water.

8. If these things truly seem to be as I have shown them, and with our own faculties we perceive that the bodies of animals are composed of these elements, and we judge that they suffer and dissolve when there are excesses or failures of one element or another, I have no doubt that if a healthful environment is to be sought after in constructing city walls, we should seek with all diligence to select temperate regions of the heavens.

9. Thus I assert emphatically my opinion that the old principles for selecting a site should be called back into service (Figure 12).* Our ancestors used to sacrifice some sheep pastured in the area where they wanted to establish towns or military camps, and examine their livers (Figure 13). If these were discolored and defective, first they would sacrifice more sheep, wondering whether the original victims might have been ravaged by disease or spoiled feed. Once they had scrutinized several victims and decided that the local water and fodder had produced perfect, solid livers, there they would lay their fortifications; if, on the other hand, they discovered the livers to be defective, they would decide that the supply of food and water produced in such a locale would prove just as pernicious to human bodies. Thus they moved onward, changing regions in the search for an environment healthful in every respect.

10. The validity of this conclusion, namely that the health-giving properties of the earth can be seen in fodder and food, can be noted and taken to heart in the Cretan countryside, along the river Pothereus, which flows between the two Cretan communities of Cnossus and Gortyna. Flocks graze on both the right and left bank of this river, but those that pasture hard by Knossos have a conspicuous spleen, whereas those by Gortyna do not. Hence doctors, inquiring after this phenomenon, discovered a herb growing in these regions; by grazing on it the flocks diminished their spleens. By collecting this herb they cure splenetics with a medicine made from it – the Cretans call it "no-spleen," *asplênon*. Thus, on the basis of food and water, it is possible to ascertain whether the properties of a place are naturally healthful or pestilent.

11. If walls are constructed in swamplands that are near the sea, and they face northward or northeast, and the swamplands themselves are higher than the seashore, these walls will prove to have been constructed on sound principles. For putting in drainage ditches will create an outlet for water along the seashore, and when the seas are swollen by storms, the surrounding swamp water, agitated by the seas' motion and by mixture with sea water, does not support normal swamp life. Thus whatever creatures swim up from the depths to the seaside are killed by the waters' unusual salinity. Indeed, the swamps of Cisalpine Gaul can serve as an example of the phenomenon – those around Altinum, Ravenna, Aquileia, and other towns in locations of this sort, situated near marshes – because, for

the reasons stated earlier, these places are marvelously salubrious.

12. But swamps that are stagnant and have no flowing outlets, whether by river or through ditches, like the Pomptine Marshes,* grow rotten from stagnation and send out grim, pestilent vapors into the surrounding areas. As another example, in Apulia there is a town, Old Salpia,* which Diomedes founded on his return from Troy, or, as several authors have stated, Elpias the Rhodian. This was sited in just such a region as I have described, for which reason the inhabitants, suffering every year from various diseases, came at last to the consul Marcus Hostilius with a public petition. They requested that he seek out and select for them a suitable place where they might relocate their walls, and he granted their request. He made no delay, but after an immediate, penetrating inquiry purchased a promising property along the seashore and asked the Senate and People of Rome for permission to relocate the town. He established the city wall, divided the city into lots, and gave each townsman full legal possession of his lot for the token payment of a one-sesterce coin. Once these works were complete, he made an outlet from a local lake into the sea, transforming this lake into a port for the town. And so now the Salpini, by moving four miles away from their old town, dwell in a healthy environment.

CHAPTER 5: CONSTRUCTION OF CITY WALLS

1. Once the scheme for siting the city walls* has been drawn up according to the principles of good health just stated, and its regions are choice and fertile in produce to nourish the population, and the construction of roads or access to rivers or marine ports will supply easy transport up to the city walls, then the foundation trenches* for the walls should be made according to the principle that they should be dug, insofar as this is possible, down to the solid ground and in solid ground, as far as seems reasonable, going by the width of the planned work. The width of the foundation should be greater than the projected width of the aboveground portion of the walls, and their construction should be as sound as possible.

2. Likewise, the towers should project toward the exterior,* so that if the enemy force wants to rush the wall, it may be wounded from the towers on either side, where its flanks are exposed. Special care should be taken to ensure that there be no easy approach to the wall for an attacker; rather the rampart should encircle precipitous heights* and be so planned that the approaches to the gates are not straight but on the left (Figures 14–17). For if the wall is made in this manner, then the right flank of those entering the gates, the side which will not be covered by a shield, will be closest to the wall. Furthermore, fortified towns should not be built in the form of a square, or with protruding corners, because the corner in this case protects the enemy more than it does the citizen within the walls.

3. I think that the thickness of the wall should be made in this manner: walking along its top, two armed men coming toward each other should be able to pass each other without difficulty; moreover, within its fabric, rods of scorched olive wood* should be installed at as frequent intervals as possible, so that each of the faces of the wall, linked together by these rods (which act as clamps), will maintain an everlasting fixity (Figure 18). For neither rot nor foul weather nor time can injure this material, and thus, when buried in dirt or sunk in water it remains undamaged, functional forever. These rods should be set not only in the curtain wall itself, but also in its substructure and in whatever partition walls are to be made to the thickness of the rampart; clamped by this principle they will not be weakened quickly.

4. The intervals between towers should be made so that the distance between them is never more than the length of a bow shot;* thus, if an attack is mounted at any particular point, the enemy will be thrown back by bolts from the catapults and the other missiles that have been launched from the towers on either side. And furthermore, the wall should be portioned off on the inner side of the towers at intervals as wide as the towers will be, so that there will be wooden catwalks set on the insides of the towers (Figure 19). Nor should these catwalks be nailed in place, for, if the enemy should occupy some part of the wall, the defenders may isolate that section, and, if they act quickly enough, they will not allow the enemy to penetrate to the other parts of the wall or the towers, unless they want to fall head over heels.

5. Towers should be made either round or polygonal,* as war machines break apart square towers more swiftly; the hammering of battering rams will smash apart the corners, but along curves a ram will simply act like a wedge; by pressing toward the center it will be unable to harm the structure (Figure 16). Likewise, the fortification of walls and towers is far more secure if these are joined to earthen ramparts, because neither rams, nor mining, nor any of the other war machines succeed in inflicting any damage on the latter (Figure 19).

6. But it is not reasonable to build ramparts everywhere, only in places where there is level access outside the fortifications from high ground to the walls under attack. In places of this sort first ditches should be made, as wide and as deep as possible, and then the foundations of the wall should be sunk within the hollow of the ditch, and these should be made so thick that they will easily sustain the earthworks.*

7. On the inward side of the substructure, there should be another foundation, this set far enough inside the exterior wall that whole cohorts of troops can be stationed for defense along the top of the completed earthwork, just as if they are in battle formation. Once foundations have been laid at this distance from one another, then cross walls, bonded into the exterior and interior foundations, should be laid out between them, comblike, as the teeth of a saw are arranged. With the weight of the earth partitioned and distributed into small units, never bringing its full burden to bear upon a single location, the sheer magnitude of the work will not be able to warp the wall's substructure for any reason.

8. As for the wall itself, and the materials of which it should be constructed and finished, there can be no hard and fast rules, because we cannot have exactly the resources we might desire in every locality. But where there is squared stone, or split stone, or rubble, or burnt brick, or mud brick, this is what should be used. Not every region can do as the Babylonians did, who with their wealth of liquid bitumen used this in place of lime and sand, and made their city walls of burnt brick. Every region may have peculiarities of the site or similar advantages of the same type, such that, using these materials, it, too, may have a faultless wall, perfect forever.

CHAPTER 6: ORIENTATION

1. Once the walls have been raised, the division into lots of the area contained within the walls should follow, and the orientation of streets and lanes according to the regions of the heavens.* This process will be properly accomplished if, with foresight, the lanes are kept from facing into the path of the prevailing winds.* For if the winds are cold, they injure; if hot, they corrupt; if moist, they are noxious. For which reason this defect should be avoided, nor should what happens in so many communities be allowed to occur, as, for instance, on the island of Lesbos, where the town of Mytilene is magnificently, elegantly constructed, but poorly sited. For in that community, when the south wind blows, people grow sick; when Corus blows, they cough; with the north wind, their health returns, but they cannot gather in the streets or side streets because it is so chilly.

2. Wind is a flowing wave of air with an excess of irregular movements (Figure 20). It is produced when heat collides with moisture and the shock of the crash expels its force in a gust of air. We can observe that this is true from bronze statues of Aeolus, and by means of such clever inventions we may wring divine truth from the hidden principles of heaven. Make hollow bronze Aeolus spheres; these have a pinhole opening. They are filled with water and placed over a fire, and before they heat up they have no breath at all, but as soon as they reach the boiling point they emit a powerful gust at the fire. Thus, on the basis of a small, very brief spectacle, it is possible to understand and evaluate the great and extensive principles underlying the nature of the heavens and the winds.

3. If they are kept out, not only will they create a healthful place for healthy bodies, but also, if by chance some epidemic should spring up from other infections, which might have antidotes or cures in different, more healthful climes, even in these cases, because the winds have been shut out, the epidemic will the more readily be cured by the mildness of the air. For there are distempers that are difficult to cure in such regions as have been described here. These are heaviness of the arteries, coughs, pleuritis, phthisis, consumption, and other maladies that are cured, not by purges, but by additive diets. These are healed with difficulty for the following reasons: first of all, because they are caught from chills, and furthermore because for those whose strength has been sapped by disease the air is agitated, thinned by the agitation of the winds, and together with them it drains out the sap from afflicted bodies and makes them still weaker. On the other hand, mild, dense air, which has neither drafts nor frequent circulation, on account of its motionless stability, by adding to the physique of those who are afflicted with these diseases, nourishes the patients and restores them to health.

4. It pleases some to say that there are four winds: from equinoctial east Solanus, from the south Auster, from the equinoctial west Favonius, and from the north Septentrio (Figures 21, 22). But those who have studied the matter more thoroughly insist that there are eight, above all Andronicus Cyrrestes, who even went so far as to demonstrate this by means of an octagonal marble tower in Athens. On each side of the octagon he designed sculpted images of the winds, each facing its

own blast, and atop this tower he put a conical column and above this he placed a bronze Triton holding a wand in its right hand, so contrived as to revolve with the wind, so that it will always face into the prevailing wind and hold its wand over the image of the wind that is blowing at the moment.

5. And so between Solanus and Auster in the southeast we find Eurus, in the southwest between Auster and Favonius we find Africus, between Favonius and Septentrio we find Caurus, which so many people call Corus, between Septentrio and Solanus, Aquilo. This seems to be a way to understand the number of winds, their names, and the direction from which the fixed blasts of the winds blow.

Now that the subject has been thus examined in depth, this is how to set up your reasoning in order to discover their regions and their places of origin (Figure 23):* 6. Let a marble benchmark be set in the middle of the space enclosed by the city walls, or let a surface be dressed with a rule and level so that a benchmark will not be necessary, and above the very center of this surface place a bronze gnomon, that type of sundial which is called "shadow-tracker" in Greek (*skiothêrês*). An hour before midday, and about the fifth hour of morning, the end of the shadow of the gnomon should be noted and marked by a point, and, opening compasses to the point that signals the length of the gnomon's shadow, a line of circumference should be drawn circling around from the center. Likewise, the lengthening afternoon shadow of this gnomon should be observed, and when it touches the line of the circle and the afternoon shadow comes to equal the length of the morning shadow, then this, too, should be marked with a point.

7. Around these points the compass should draw two arcs intersecting in an "X", and a line should then be drawn from the point of intersection, through the midpoint of the circle, to the circle's outer circumference, in order to obtain the southern and northern regions. Then the sixteenth part of the entire circumference should be obtained, and the point of the compass placed on the southern line where it intersects the circle, and a mark made to right and left along the circumference, both in the southern and the northern part. Then lines should be drawn forming an "X" between these four marks, from one side of the circle to the other. By this means Auster and Septentrio will have their designated eighth of the circle. The remaining three parts to right and left should be assigned around the circle so that the eight equal sections are designated to the winds, as in the drawing. Then it will be evident that the alignment of the streets and side streets ought to follow the angles between the regions of two different winds.

8. By means of these principles and these divisions, the detrimental force of the winds will be shut out of dwellings and side streets, for when the broad streets are designed to face the winds head on, the force and the dense gusts coming from the open expanse of the heavens, trapped in the heads of alleyways, wanders about with more violent energy. For these reasons the orientation of streets should be rotated obliquely to the regions of the winds; then, when the gusts approach the corners of apartment blocks they break apart, and, repulsed, are dissipated.

9. Perhaps those who know many names of winds will marvel at the fact that we have given the number of the winds as eight. But if they will have noted that the circumference of the terrestrial globe was discovered by Eratosthenes of Cyrene (Figure 24),* using the course of the sun, the shadows cast by the gnomon at the equinox, and the heavens' inclination, on the basis of mathematical principles and geometric methods, to measure 252,000 stades, which made 31,500,000 paces, then the eighth part of that total, which is what a wind can be seen to occupy, measures 3,937,500 paces. Then they should hardly wonder that in so large an expanse a single wind's wandering, twisting, and receding should create varieties by shifting its breath.

10. Thus at the right and left of Auster, Leuconotus and Altanus are wont to blow; to either side of Africus, Libonotus and Subvesperus; around Favonius, Argestes and at certain times of year the Etesian breezes; at the sides of Caurus, Circias and Chorus; around Septentrio, Thracius and Gallicus, to the right and left of Aquilo, Supernas and Caecias; around Solanus, Carbas and at a certain time of the year the Ornithiae; and with Eurus occupying the middle range, Euricircias and Volturnus take up the extremes (Figure 21). There are many other names for other breaths of wind, derived from places, or rivers, or mountain tempests.

11. Then there are the morning breezes, when the sun, emerging on its rounds from the subterranean region, strikes the moisture of the air, and spilling forth in the onslaught of its rising, it thrusts out the breaths that precede the coming of the daylight. When these persist once the sun has risen, then they occupy the regions around Eurus, and for this reason, because it is created from morning breezes (*aurae*), it is evidently called *euros* by the Greeks. And "tomorrow" is said to be called *aurion* [in Greek] because of these same morning *aurae*.

There are some who deny that Eratosthenes could have derived the true measure of the terrestrial globe. Whether the measurement is true or false, however, our own treatise cannot have false definitions of the regions from which the currents of the winds arise.

12. With the nature of the winds such as it is, suffice it to say that the forces of individual winds do not have a fixed proportion relative to one another, but only greater or lesser degrees of force.

Because these things have already been set out by us briefly so that they be more easily understood, it seemed best to me that at the end of this book, I supply two figures or, as the Greeks say, *schêmata*, one so drawn that it displays the directions from which the various winds originate, and another showing how their harmful breaths may be avoided by the oblique orientation of streets and avenues.

13. On a plane surface there will be a center point at the letter A, and the morning shadow of the gnomon at the point B, and with the compass spread from the center A to the mark made by the shadow at B, make a circle. Setting the gnomon back in the place where it had been before, one must expect that after it has receded it will lengthen a second time to an extent equal to the length of the morning shadow and touch the afternoon line of the circle at C. Then, from the mark at B and the mark at C, mark an "X" with the compass where there will be a point D, and then through the "X" where there is the letter D and the center, a line should be drawn to the outer edge, and along this line there will be the letters E and F. This line will serve as the index to the northern and southern regions.

Then by means of the compass derive the sixteenth part of the whole circumference, putting the point of the compass on the southern line where it intersects the circle at letter E, and mark the intersections at left and right with G and H. Likewise in the northern section put the point of the compass at the intersection of the circumference and the northern line F, and mark I and K to the left and right. Then draw lines from G to K and H to I through the center point A. The space from G to H will be the space of Auster and the part belonging to due south. Likewise, the space from I to K will be that of Septentrio. The remaining sections should be equally divided: three on the right and three on the left, to the east where you see letters L and M and to the west where there are the letters N and O. From M to O and from L to N intersecting lines should be drawn. And in this way there will be eight equal spaces for the winds as you go around the circle. If they have been so drawn, and we begin going angle by angle from due south: in the angle between Eurus and Auster there will be the letter G; between Auster and Africus, H; between Africus and Favonius, N; between Favonius and Caurus, O; between Caurus and Septentrio, K; between Septentrio and Aquilo, I; between Aquilo and Solanus, L; between Solanus and Eurus, M. When these have been established, put the gnomon between the corners of the octagon, and this is how the division of side streets will be guided.

CHAPTER 7: ALLOCATION OF PUBLIC SPACES

1. Once the lanes have been laid out and the broad streets have been established,* it is time to explain the way in which sites should be selected for access, convenience, and the city's public use, for temples, the forum, and other public places (Figure 11). If there are city walls next to the sea, then the site for the forum should be chosen right next to the port; if, on the other hand, the city site is inland, the forum should be placed in the very center of town (Figures 25–27). But for temples whose gods are regarded as particularly involved in protecting the city: to Jupiter, Juno, and Minerva, for example, sites should be allocated in the very highest place, the vantage from which to see the greatest possible extent of the city walls. Temples to Mercury should be located in the forum, or, as with Isis and Serapis, in the marketplace. Temples to Apollo and Father Liber belong next to the theater, those to Hercules, in cities which lack gymnasia and amphitheaters, should be situated by the circus, those to Mars outside the city but near the drill grounds, and similarly, those to Venus should be situated by the harbor.

Furthermore, this same point is enshrined by the Etruscan seers in the priestly writings of their discipline, namely that shrines of Venus, Vulcan, and Mars should be located outside the city walls so that venereal lust will not become a commonplace for the city's adolescents and matriarchs. By summoning Volcanic energy out of the city by means of rites and sacrifices, the city's buildings are thought to have been delivered from the danger of fire. And if the divinity of Mars is honored outside the city walls, there will not be armed conflict among citizens; rather, he will ensure that the walls serve only to defend the city from its enemies and the danger of war.

2. Likewise the shrine of Ceres should be sited in a place outside the city where no one need go except to offer sacrifice; the place ought to be maintained religiously, chastely, and purely. The sites for other temples should be assigned to the other gods as befits the requirements of their sacrifices.

As for the construction of temples themselves and their proportional systems, I will account for their principles in the third and fourth volumes, because in the second volume I thought it better to begin with the supplies of material that should be assembled for buildings, the qualities they possess and the way they should be employed, and only then to move on to the dimensions of temples, their design sequences, and the individual types of proportional systems, and to explain them in subsequent volumes.