

VITRUVIUS

THE TEN BOOKS ON ARCHITECTURE

TRANSLATED BY

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WITH ILLUSTRATIONS AND ORIGINAL DESIGNS

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needed; for that quarter of the sky grows neither light nor dark with the course of the sun, but remains steady and unshifting all day long.

8. Economy denotes the proper management of materials and of site, as well as a thrifty balancing of cost and common sense in the construction of works. This will be observed if, in the first place, the architect does not demand things which cannot be found or made ready without great expense. For example: it is not everywhere that there is plenty of pitsand, rubble, fir, clear fir, and marble, since they are produced in different places and to assemble them is difficult and costly. Where there is no pitsand we must use the kinds washed up by rivers or by the sea; the lack of fir and clear fir may be evaded by using cypress, poplar, elm or pine; and other problems we must solve in similar ways.

9. A second stage in Economy is reached when we have to plan the different kinds of dwellings suitable for ordinary householders, for great wealth, or for the high position of the statesman. A house in town obviously calls for one form of construction; that into which stream the products of country estates requires another; this will not be the same in the case of money-lenders and still different for the opulent and luxurious; for the powers under whose deliberations the commonwealth is guided dwellings are to be provided according to their special needs: and, in a word, the proper form of economy must be observed in building houses for each and every class.

CHAPTER III

THE DEPARTMENTS OF ARCHITECTURE

1. THERE are three departments of architecture: the art of building, the making of time-pieces, and the construction of machinery. Building is, in its turn, divided into two parts, of which the first is the construction of fortified towns and of works for general use in public places, and the second is the putting up of structures for private individuals. There are three classes of public

buildings: the first for defensive, the second for religious, and the third for utilitarian purposes. Under defence comes the planning of walls, towers, and gates, permanent devices for resistance against hostile attacks; under religion, the erection of fanes and temples to the immortal gods; under utility, the provision of meeting places for public use, such as harbours, markets, colonnades, baths, theatres, promenades, and all other similar arrangements in public places.

2. All these must be built with due reference to durability, convenience, and beauty. Durability will be assured when foundations are carried down to the solid ground and materials wisely and liberally selected; convenience, when the arrangement of the departments is faultless and presents no hindrance to use, and when each class of building is assigned to its suitable and appropriate exposure; and beauty, when the appearance of the work is pleasing and in good taste, and when its members are in due proportion according to correct principles of symmetry.

CHAPTER IV

THE SITE OF A CITY

FOR fortified towns the following general principles are to be observed. First comes the choice of a very healthy site. Such a site will be high, neither misty nor frosty, and in a climate neither hot nor cold, but temperate; further, without marshes in the neighbourhood. For when the morning breezes blow toward the town at sunrise, if they bring with them mists from marshes and mixed with the mist, the poisonous breath of the creatures of the marshes to be wafted into the bodies of the inhabitants, they make the site unhealthy. Again, if the town is on the coast with a southern or western exposure, it will not be healthy, because in summer the southern sky grows hot at sunrise and is hottest at noon, while a western exposure grows warm after sunrise, hottest at noon, and at evening all aglow.

2. These variations in heat and the subsequent cooling off are harmful to the people living on such sites. The same conclusion may be reached in the case of inanimate things. For instance, no body draws the light for covered wine rooms from the south or west, but rather from the north, since that quarter is never subject to change but is always constant and unshifting. So it is with granaries: grain exposed to the sun's course soon loses its good quality, and provisions and fruit, unless stored in a place unexposed to the sun's course, do not keep long.

3. For heat is a universal solvent, melting out of things their power of resistance, and sucking away and removing their natural strength with its fiery exhalations so that they grow soft, and hence weak, under its glow. We see this in the case of iron which however hard it may naturally be, yet when heated thoroughly in a furnace fire can be easily worked into any kind of shape, and still, if cooled while it is soft and white hot, it hardens again with a mere dip into cold water and takes on its former quality.

4. We may also recognize the truth of this from the fact that in summer the heat makes everybody weak, not only in unhealthy but even in healthy places, and that in winter even the most unhealthy districts are much healthier because they are given a solidity by the cooling off. Similarly, persons removed from cold countries to hot cannot endure it but waste away; whereas those who pass from hot places to the cold regions of the north, not only do not suffer in health from the change of residence but even gain by it.

5. It appears, then, that in founding towns we must beware of districts from which hot winds can spread abroad over the inhabitants. For while all bodies are composed of the four elements (in Greek στοιχεῖα), that is, of heat, moisture, the earthy, and air, yet there are mixtures according to natural temperament which make up the natures of all the different animals of the world, each after its kind.

6. Therefore, if one of these elements, heat, becomes predominant in any body whatsoever, it destroys and dissolves all the

others with its violence. This defect may be due to violent heat in certain quarters of the sky, pouring into the open pores in great proportion to admit of a mixture suited to the natural temperament of the body in question. Again, if too much moisture enters the channels of a body, and thus introduces disproportion, the other elements, adulterated by the liquid, are impaired, and the virtues of the mixture dissolved. This defect, in turn, may arise from the cooling properties of moist winds and breezes blowing upon the body. In the same way, increase or diminution of the proportion of air or of the earthy which is natural to a body may enfeeble the other elements; the predominance of the earthy being due to overmuch food, that of air to a heavy atmosphere.

If one wishes a more accurate understanding of all this, he need only consider and observe the natures of birds, fishes, and land animals, and he will thus come to reflect upon distinctions of temperament. One form of mixture is proper to birds, another to fishes, and a far different form to land animals. Winged creatures have less of the earthy, less moisture, heat in moderation, air in greater amount. Being made up, therefore, of the lighter elements, they can more readily soar away into the air. Fish, with their aquatic nature, being moderately supplied with heat and made up of a great part of air and the earthy, with as little of moisture as is possible, can more easily exist in moisture for the very reason that they have less of it than of the other elements in their bodies; so, when they are drawn to land, they leave life and water at the same moment. Similarly, the land animals, being moderately supplied with the elements of air and heat, and having less of the earthy and a great deal of moisture, cannot long continue alive in water, because their portion of moisture is already abundant. Therefore, if all this is as we have explained, our reason convinces us that the bodies of animals are made up of the elements, and these bodies, as we believe, giving way and breaking up as a result of excess or deficiency in this or that element, we must not but believe that we must take great care to select a very

temperate climate for the site of our city, since healthfulness is, as we have said, the first requisite.

9. I cannot too strongly insist upon the need of a return to the method of old times. Our ancestors, when about to build a town or an army post, sacrificed some of the cattle that were wont to feed on the site proposed and examined their livers. If the livers of the first victims were dark-coloured or abnormal, they sacrificed others, to see whether the fault was due to disease or their food. They never began to build defensive works in a place until after they had made many such trials and satisfied themselves that good water and food had made the liver sound and firm. If they continued to find it abnormal, they argued from this that the food and water supply found in such a place would be just as unhealthy for man, and so they moved away and changed to another neighbourhood, healthfulness being their chief object.

10. That pasturage and food may indicate the healthful qualities of a site is a fact which can be observed and investigated in the case of certain pastures in Crete, on each side of the river Pothereus, which separates the two Cretan states of Gnosus and Gortyna. There are cattle at pasture on the right and left banks of that river, but while the cattle that feed near Gnosus have the usual spleen, those on the other side near Gortyna have no perceptible spleen. On investigating the subject, physicians discovered on this side a kind of herb which the cattle chew and thus make their spleen small. The herb is therefore gathered and used as a medicine for the cure of splenetic people. The Cretans call it *ασπληνον*. From food and water, then, we may learn whether sites are naturally unhealthy or healthy.

11. If the walled town is built among the marshes themselves provided they are by the sea, with a northern or north-eastern exposure, and are above the level of the seashore, the site will be reasonable enough. For ditches can be dug to let out the water to the shore, and also in times of storms the sea swells and comes backing up into the marshes, where its bitter blend prevents the reproductions of the usual marsh creatures, while any that swim

from the higher levels to the shore are killed at once by the stink to which they are unused. An instance of this may be found in the Gallic marshes surrounding Altino, Ravenna, Aquileia, and other towns in places of the kind, close by marshes. They are marvellously healthy, for the reasons which I have given.

But marshes that are stagnant and have no outlets either by rivers or ditches, like the Pomptine marshes, merely putrefy and they stand, emitting heavy, unhealthy vapours. A case of a town built in such a spot was Old Salpia in Apulia, founded by Laocoon on his way back from Troy, or, according to some writers, by Elpias of Rhodes. Year after year there was sickness, until finally the suffering inhabitants came with a public petition to Marcus Hostilius and got him to agree to seek and find them a better place to which to remove their city. Without delay he made the most skilful investigations, and at once purchased an estate near the sea in a healthy place, and asked the Senate and the people for permission to remove the town. He constructed walls and laid out the house lots, granting one to each citizen for a mere trifle. This done, he cut an opening from a lake into the sea, and thus made of the lake a harbour for the town. The result was that now the people of Salpia live on a healthy site and at a distance of only four miles from the old town.

CHAPTER V

THE CITY WALLS

AFTER insuring on these principles the healthfulness of the site of a city, and selecting a neighbourhood that can supply plenty of food and stuffs to maintain the community, with good roads or else convenient rivers or seaports affording easy means of transport to and from the city, the next thing to do is to lay the foundations for the city walls. Dig down to solid bottom, if it can be found, and lay them therein, going as deep as the magnitude of the proposed work seems to require. They should be much thicker than

CHAPTER I

THE ORIGIN OF THE DWELLING HOUSE

1. THE men of old were born like the wild beasts, in woods, caves, and groves, and lived on savage fare. As time went on, the thickly crowded trees in a certain place, tossed by storms and winds, and rubbing their branches against one another, caught fire, and so the inhabitants of the place were put to flight, being terrified by the furious flame. After it subsided, they drew near, and observing that they were very comfortable standing before the warm fire, they put on logs and, while thus keeping it alive, brought up other people to it, showing them by signs how much comfort they got from it. In that gathering of men, at a time when utterance of sound was purely individual, from daily habits they fixed upon articulate words just as these had happened to come; then, from indicating by name things in common use, the result was that in this chance way they began to talk, and thus originated conversation with one another.

2. Therefore it was the discovery of fire that originally gave rise to the coming together of men, to the deliberative assembly, and to social intercourse. And so, as they kept coming together in greater numbers into one place, finding themselves naturally gifted beyond the other animals in not being obliged to walk with faces to the ground, but upright and gazing upon the splendour of the starry firmament, and also in being able to do with ease whatever they chose with their hands and fingers, they began in that first assembly to construct shelters. Some made them of green boughs, others dug caves on mountain sides, and some, in imitation of the nests of swallows and the way they built, made places of refuge out of mud and twigs. Next, by observing the shelters of others and adding new details to their own incep-

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they constructed better and better kinds of huts as time went on.

And since they were of an imitative and teachable nature, they would daily point out to each other the results of their building, boasting of the novelties in it; and thus, with their natural faculties sharpened by emulation, their standards improved daily. First they set up forked stakes connected by twigs and covered the walls with mud. Others made walls of lumps of dried mud, covering them with reeds and leaves to keep out the rain and the heat. Finding that such roofs could not stand the rain and the storms of winter, they built them with peaks daubed with mud, the roofs sloping and projecting so as to carry off the water.

That houses originated as I have written above, we can see from ourselves from the buildings that are to this day constructed of like materials by foreign tribes: for instance, in Gaul, Spain, Portugal, and Aquitaine, roofed with oak shingles or thatched. Among the Colchians in Pontus, where there are forests in plenty, they lay down entire trees flat on the ground to the right and the left, leaving between them a space to suit the length of the trees, and then place above these another pair of trees, resting on the ends of the former and at right angles with them. These four trees enclose the space for the dwelling. Then upon these they lay sticks of timber, one after the other on the four sides, crosswise each other at the angles, and so, proceeding with their walls of trees laid perpendicularly above the lowest, they build up high towers. The interstices, which are left on account of the thickness of the building material, are stopped up with chips and mud. For the roofs, by cutting away the ends of the crossbeams and making them converge gradually as they lay them across, they bring them up to the top from the four sides in the shape of a pyramid. They cover it with leaves and mud, and thus construct the roofs of their towers in a rude form of the "tortoise" shell.

On the other hand, the Phrygians, who live in an open coun-

try, have no forests and consequently lack timber. They therefore select a natural hillock, run a trench through the middle of it, dig passages, and extend the interior space as widely as the site admits. Over it they build a pyramidal roof of logs fastened together, and this they cover with reeds and brushwood, heaping up very high mounds of earth above their dwellings. Thus their fashion in houses makes their winters very warm and their summers very cool. Some construct hovels with roofs of rushes from the swamps. Among other nations, also, in some places there are huts of the same or a similar method of construction. Likewise at Marseilles we can see roofs without tiles, made of earth mixed with straw. In Athens on the Areopagus there is to this day a relic of antiquity with a mud roof. The hut of Romulus on the Capitol is a significant reminder of the fashions of old times, and likewise the thatched roofs of temples on the Citadel.

6. From such specimens we can draw our inferences with regard to the devices used in the buildings of antiquity, and conclude that they were similar.

Furthermore, as men made progress by becoming daily more expert in building, and as their ingenuity was increased by their dexterity so that from habit they attained to considerable skill, their intelligence was enlarged by their industry until the more proficient adopted the trade of carpenters. From these early beginnings, and from the fact that nature had not only endowed the human race with senses like the rest of the animals, but had also equipped their minds with the powers of thought and understanding, thus putting all other animals under their sway, they next gradually advanced from the construction of buildings to the other arts and sciences, and so passed from a rude and barbarous mode of life to civilization and refinement.

7. Then, taking courage and looking forward from the standpoint of higher ideas born of the multiplication of the arts, they gave up huts and began to build houses with foundations, having

or stone walls, and roofs of timber and tiles; next, observation and application led them from fluctuating and indefinite notions to definite rules of symmetry. Perceiving that nature was so lavish in the bestowal of timber and bountiful in stores of building material, they treated this like careful nurses, and in developing the refinements of life, embellished them with ornaments. Therefore I shall now treat, to the best of my ability, of the things which are suitable to be used in buildings, showing their qualities and their excellencies.

Some persons, however, may find fault with the position of this book, thinking that it should have been placed first. I will therefore explain the matter, lest it be thought that I have made a mistake. Being engaged in writing a complete treatise on architecture, I resolved to set forth in the first book the branches of learning and studies of which it consists, to define its departments, and to show of what it is composed. Hence I have there indicated what the qualities of an architect should be. In the first book, therefore, I have spoken of the function of the art, but in this book I shall discuss the use of the building materials which nature has provided. For this book does not show of what architecture is composed, but treats of the origin of the building art, how it was improved, and how it made progress, step by step, until it reached its present perfection.

This book is, therefore, in its proper order and place.

I will now return to my subject, and with regard to the materials suited to the construction of buildings will consider their natural formation and in what proportions their elementary contents were combined, making it all clear and not obscure to readers. For there is no kind of material, no body, and no form that can be produced or conceived of, which is not made up of elementary particles; and nature does not admit of a truthfulness in accordance with the doctrines of the physicists without an accurate demonstration of the primary causes of things, showing how and why they are as they are.

CHAPTER I

ON CLIMATE AS DETERMINING THE STYLE OF THE HOUSE

1. If our designs for private houses are to be correct, we must at the outset take note of the countries and climates in which they are built. One style of house seems appropriate to build in Egypt, another in Spain, a different kind in Pontus, one still different in Rome, and so on with lands and countries of other characteristics. This is because one part of the earth is directly under the sun's course, another is far away from it, while another lies midway between these two. Hence, as the position of the heaven with regard to a given tract on the earth leads naturally to different characteristics, owing to the inclination of the circle of the zodiac and the course of the sun, it is obvious that designs for houses ought similarly to conform to the nature of the country and diversities of climate.

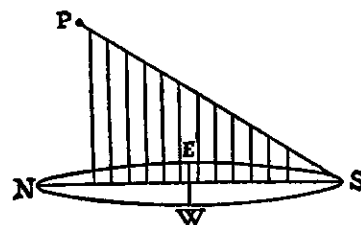
2. In the north, houses should be entirely roofed over and sheltered as much as possible, not in the open, though having a warm exposure. But on the other hand, where the force of the sun is great in the southern countries that suffer from heat, houses must be built more in the open and with a northern or north-eastern exposure. Thus we may amend by art what nature, if left to herself, would mar. In other situations, also, we must make modifications to correspond to the position of the heaven and its effects on climate.

3. These effects are noticeable and discernible not only in things in nature, but they also are observable in the limbs and bodies of entire races. In places on which the sun throws out its heat in moderation, it keeps human bodies in their proper condition, and where its path is very close at hand, it parches them up and burns out and takes away the proportion of moisture which they ought to possess. But, on the other hand, in the cold re-

gions that are far away from the south, the moisture is not drawn out by hot weather, but the atmosphere is full of dampness which diffuses moisture into the system, and makes the frame larger and the pitch of the voice deeper. This is also the reason why the races that are bred in the north are of vast height, and have fair complexions, straight red hair, grey eyes, and a great deal of blood, owing to the abundance of moisture and the coolness of the atmosphere.

4. On the contrary, those that are nearest to the southern half of the axis, and that lie directly under the sun's course, are of lower stature, with a swarthy complexion, hair curling, black eyes, strong legs, and but little blood on account of the force of the sun. Hence, too, this poverty of blood makes them over-timid to stand up against the sword, but great heat and fevers they can endure without timidity, because their frames are bred up in the raging heat. Hence, men that are born in the north are rendered over-timid and weak by fever, but their wealth of blood enables them to stand up against the sword without timidity.

5. The pitch of the voice is likewise different and varying in quality with different nations, for the following reasons. The terminating points east and west on the level of the earth, where the upper and lower parts of the heaven are divided, seem to lie in a naturally balanced circle which mathematicians call the Horizon. Keeping this idea definitely in mind, if we imagine a line drawn from the northern side of the circumference (N) to the side which lies above the southern half of the axis (S), and from here another line obliquely up to the pivot at the summit, beyond the stars composing the Great Bear (the pole star P), we shall doubtless see that we have in the heaven a triangular figure like that of the musical instrument which the Greeks call the "sambuca."



6. And so, under the space which is nearest to the pivot at bottom, off the southern portions of the line of the axis, are four nations that on account of the slight altitude of the heaven above them, have shrill and very high-pitched voices, like the strings nearest to the angle in the musical instrument. Next in order come other nations as far as the middle of Greece, with lower elevations of the voice; and from this middle point they go on in regular order up to the extreme north, where, under high altitude, the vocal utterance of the inhabitants is, under natural laws, produced in heavier tones. Thus it is obvious that the system of the universe as a whole is, on account of the inclination of the heaven, composed in a most perfect harmony through the temporary power of the sun.

7. The nations, therefore, that lie midway between the pivot at the southern and the northern extremities of the axis, converse in a voice of middle pitch, like the notes in the middle of a musical scale; but, as we proceed towards the north, the distances to the heaven become greater, and so the nations there, whose vocal utterance is reduced by the moisture to the "hypatès" and the "proslambanomenon," are naturally obliged to speak in heavier tones. In the same way, as we proceed from the middle point to the south, the voices of the nations there correspond in extreme height of pitch and in shrillness to the "paranètès" and "netès."

8. That it is a fact that things are made heavier from being in places naturally moist, and higher pitched from places that are hot, may be proved from the following experiment. Take two cups which have been baked in the same oven for an equal time, which are of equal weight, and which give the same note when struck. Dip one of them into water and, after taking it out of water, strike them both. This done, there will be a great difference in their notes, and the cups can no longer be equal in weight. Thus it is with men: though born in the same general form and under the same all-embracing heaven, yet in some of them, on account of the heat in their country, the voice strikes

the air on a high note, while in others, on account of abundance of moisture, the quality of tones produced is very heavy.

9. Further, it is owing to the rarity of the atmosphere that southern nations, with their keen intelligence due to the heat, are very free and swift in the devising of schemes, while northern nations, being enveloped in a dense atmosphere, and chilled by moisture from the obstructing air, have but a sluggish intelligence. That this is so, we may see from the case of snakes. Their movements are most active in hot weather, when they have got rid of the chill due to moisture, whereas at the winter solstice, and in winter weather, they are chilled by the change of temperature, and rendered torpid and motionless. It is therefore no wonder that man's intelligence is made keener by warm air and duller by cold.

10. But although southern nations have the keenest wits, and are infinitely clever in forming schemes, yet the moment it comes to displaying valour, they succumb because all manliness of spirit is sucked out of them by the sun. On the other hand, men born in cold countries are indeed readier to meet the shock of arms with great courage and without timidity, but their wits are so slow that they will rush to the charge inconsiderately and inexpertly, thus defeating their own devices. Such being nature's arrangement of the universe, and all these nations being allotted temperaments which are lacking in due moderation, the truly perfect territory, situated under the middle of the heaven, and having on each side the entire extent of the world and its countries, is that which is occupied by the Roman people.

11. In fact, the races of Italy are the most perfectly constituted in both respects — in bodily form and in mental activity to correspond to their valour. Exactly as the planet Jupiter is itself temperate, its course lying midway between Mars, which is very hot, and Saturn, which is very cold, so Italy, lying between the north and the south, is a combination of what is found on each side, and her preëminence is well regulated and indisputable. And so by her wisdom she breaks the courageous onsets of the

barbarians, and by her strength of hand thwarts the device of the southerners. Hence, it was the divine intelligence that directed the city of the Roman people in a peerless and temperate country, in order that it might acquire the right to command the whole world.

12. Now if it is a fact that countries differ from one another and are of various classes according to climate, so that the nations born therein naturally differ in mental and physical formation and qualities, we cannot hesitate to make our houses suitable in plan to the peculiarities of nations and races, and we have the expert guidance of nature herself ready to our hand.

I have now set forth the peculiar characteristics of localities as far as I could note them, in the most summary way, and have stated how we ought to make our houses conform to the physical qualities of nations, with due regard to the course of the sun and to climate. Next I shall treat the symmetrical proportions of different styles of houses, both as wholes and in their separate parts.

CHAPTER II

SYMMETRY, AND MODIFICATIONS IN IT TO SUIT THE SITE

1. THERE is nothing to which an architect should devote more thought than to the exact proportions of his building with reference to a certain part selected as the standard. After the standard of symmetry has been determined, and the proportionate dimensions adjusted by calculations, it is next the part of wisdom to consider the nature of the site, or questions of use or beauty, and modify the plan by diminutions or additions in such a manner that these diminutions or additions in the symmetrical relations may be seen to be made on correct principles, and without detracting at all from the effect.

2. The look of a building when seen close at hand is one thing; on a height it is another, not the same in an enclosed place, still

different in the open, and in all these cases it takes much judgment to decide what is to be done. The fact is that the eye does not always give a true impression, but very often leads the mind to form a false judgment. In painted scenery, for example, columns may appear to jut out, mutules to project, and statues to be standing in the foreground, although the picture is of course perfectly flat. Similarly with ships, the oars when under the water are straight, though to the eye they appear to be broken. To the point where they touch the surface of the sea they look straight, as indeed they are, but when dipped under the water they emit from their bodies undulating images which come swimming up through the naturally transparent medium to the surface of the water, and, being there thrown into commotion, make the oars look broken.

3. Now whether this appearance is due to the impact of the images, or to the effusion of the rays from the eye, as the physicists hold, in either case it is obvious that the vision may lead us to false impressions.

4. Since, therefore, the reality may have a false appearance, and since things are sometimes represented by the eyes as other than they are, I think it certain that diminutions or additions should be made to suit the nature or needs of the site, but in such fashion that the buildings lose nothing thereby. These results, however, are also attainable by flashes of genius, and not only by mere science.

5. Hence, the first thing to settle is the standard of symmetry, from which we need not hesitate to vary. Then, lay out the ground lines of the length and breadth of the work proposed, and when once we have determined its size, let the construction follow this with due regard to beauty of proportion, so that the beholder may feel no doubt of the eurythmy of its effect. I must now tell how this may be brought about, and first I will speak of the proper construction of a cavaedium.