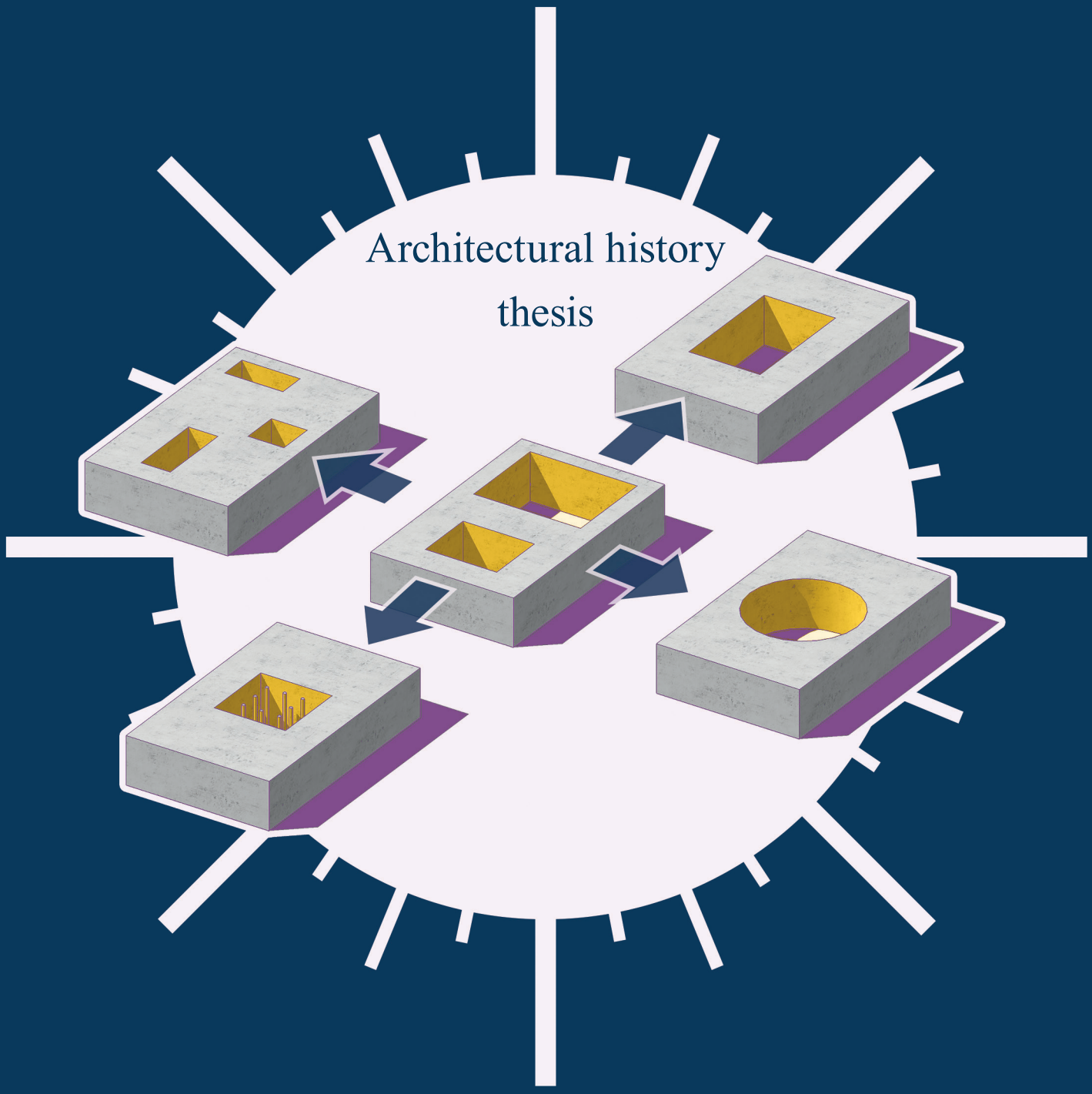
Europe's evolution of atrium houses



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MSc2 AR2A011 Architectural History Thesis

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Europe's evolution of atrium houses
An architectural history thesis

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Cover image by author

Acknowledgement

I would like to show my appreciation to Catja Edens for guiding me, helping me keep focus on the storyline and her constructive feedback.
Thank you.

14/04/21

Abstract

This thesis investigates the historical evolution of the atrium house in Europe. The origin and the climatic benefits of the atrium house were found by conducting literature review. Typological variants on the atrium house are determined by testing them to a set of criteria. The traditional atrium house developed in the Roman empire from Greek and Etruscan influences. The research shows four residential variants on the atrium typology in Europe, which are: the courtyard, cortile, patio and court. These typologies with enclosed outdoor spaces have impact by offering climatic benefits and a secluded outside space which stimulates social interaction. From an architectural perspective, this research emphasizes the benefits and history of the atrium typologies.

Keywords: Atrium, Benefits, Courtyard, Cortile, Court, Patio, Typologies.

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Introduction

The place: Italy; The year: around the birth of Christ; The stories about the Roman empire, its vastness, structure in how it was ruled and especially how advanced this ancient civilization was in the way they built, has intrigued many. Some advances in the building technologies are: the invention of the arch which allowed the Roman to build grander structures in comparison to the ancient Greeks with their building methods of columns and beams, the heated public bathhouses (which can be seen as the predecessor of central heating) and large houses for the wealthy with atria to give protection to the hot and humid Mediterranean climate. The last one, the atrium house, is fascinating because of two reasons. The first reason is the relation between public and private spaces: the public shops in the front of the house, a complete enclosed private outdoor area in the middle and the transition or barrier between them. The second point lies in dwellings: the most basic form of shelter and the place where humans live almost all of their lives. This research has the goal to extend on the knowledge about atrium houses: the subject is the historical research about the evolution of the atrium house in Europe.

The definition of the atrium is a large central space open to the sky, first used in the Roman house[1]. The classification of the atria is based upon the number of sides the atrium shares with the building mass[2]. Sharples & Lash categorised four groups: centralized, semi-enclosed, attached and linear, see figure 1. Jaberansari and Elkadi defined five atrium types[3]. These two theories combined make the following classification of the

1 Kent, "Inside the livable city: The atrium", 36-43.
2 Ho, "Climatic responsive atrium design in Europe.", 67.& Sharples & Lash, Daylight in Atrium Buildings, 301.
3 Jaberansari and Elkadi, Influence of different atria types on energy efficiency and thermal comfort, 3.

atrium:

- Single-sided atrium (*Attached*)
- Two-sided atrium
- Three-sided atrium (*Semi-enclosed*)
- Four-sided atrium (*Centralized*)
- Linear atrium (*Linear*)

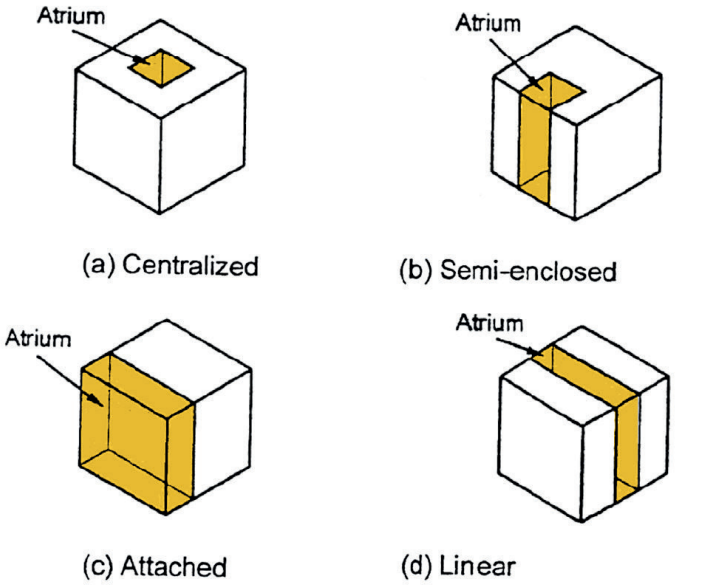


Figure 1: The four atrium categories, image from Sharples & Lash, Daylight in Atrium Buildings, 302. Edited by author.

This research focuses on the centralized atrium, the internal atrium and not the external atrium.

The main question, which will be researched and answered with this paper, is: What is the evolution of the atrium house in Europe? This question will be answered with three sub-questions. First, When did the atrium become a common part of architecture? Second, Which kind of dwelling typologies resulted out of the atrium house? Third, What role does climate play in where atrium houses are built?

Giving my hypothesis on the questions starts with when the atrium became a common part of architecture. In my view the atrium was first widely used in Roman villa's as a way to enclose rooms, keep out the warm Mediterranean sun and to collect rainwater in the centre. In the time periods after the Roman era I mainly know of the Dutch dwelling typology the 'hofjes': small dwellings surround a semi-private courtyard, often combined with a religious way of living (beguinages). In contemporary buildings a glass-covered atrium is used as a tool to benefit from solar radiation for indoor climate control. So my estimation for the geographical location of atria due to the climate is that open atria are mainly built in the Mediterranean to keep out the sun and the closed atria in Central- and West-Europe to capture the warmth of the sun in

the winter. So this paper gives an insight into the origins of the atrium house, the evolution and links it to the energy-efficiency question of the twenty-first century.

To place this thesis in the academic context I will point out what work was already completed by others and my own contribution to the knowledge about atrium houses. First line of the history will be based upon the work of F. Abass, L.H. Ismail and M. Solla in their text about the evolution of the courtyard house over the world. This text has the subject of the atrium house instead of the courtyard house and will also be limited to Europe. In order to get a clear image about the origin of the atrium house in Europe the literature of Allison, Berry et al., Flohr, Gazda, Graham, McKay, Stott and Wallace-Hadrill will be cited. My investigation is about the various typologies resulting from the atrium house. For every typology there will be a few examples chosen out of Europe. These will be combined with the history and the time they were built to make a timeline of the development of the atrium houses. After this work the atria will be related to the climate in which they are built in. Several theories will be used to support the research, like the theory about the European climate zones from D. Ho, the amount of daylight in the atrium by S. Sharples & D. Lash and the temperature differences in the atrium by J. Rojas-Fernández et al.. The correlation between my chosen examples of the typological variations and their climate will be determined by placing them in the climate zones of D. Ho by their geographical location.

The research on the development of the atrium house will be done by literature research. Beginning at the origins and looking at the historical evolution. The definitions of the atrium house and the variations of it, mentioned in this paper, will be quoted to make a clear distinction in the different terminology. The history, origin and development of the atrium house and the European climate will be done through literature review as well.
Every dwelling typology

resulting from the atrium house will be examined through examples and the history behind it. The moments in time when the atrium became a common part in architecture, the rise of each atrium variation and the overview of the historical development will be visualised into a timeline.

Thesis structure

The first chapter of the research will discuss the origin of the atrium house. Next up is the time period when the atrium became a common part of architecture. This history research will limit itself to Europe. Thus, the first chapter is the basis with where and when the atrium was first used frequently.

The second chapter will go into the different dwelling typologies that emerged from the classical atrium. The definitions of the atrium variants will be hauled from literature to show the subtle distinctions. Each alteration will be explained with a few examples and the history with it, like in which time period they arose in Europe. This information will then be captured in a timeline showing the evolution of the atrium house and its variations through time in Europe.

The final chapter will look at the role of the climate on the atrium. The correlation between the atrium and the climate will be examined by ordering the atrium variants, of the previous chapter, in the European climate zones.

Chapter 1: The origin of the atrium house

Originally, the atrium is an outdoor space in the centre of the ancient Roman house. This central inner hall is unroofed and there usually is a pool for collecting rainwater. In the traditional Roman house layout, the rooms were centred around the atrium and peristyle. A peristyle is a continuous row of columns surrounding an internal court, mostly gardens.

Mark Grahame, in the book *Cultural Identity in the Roman Empire*, describes both the atrium and the peristyle as courtyard spaces[1]. Next up he specifies three properties. First, these courtyards are the largest spaces in the house. Second, the narrow passages serve as 'conduits of movement' and stimulate interaction. Third, the spaces acts as a central point of access to the surrounding spaces. Hence, he states: "The courtyard is an important architectural feature, because it provides a certain order to arrangement of space and so we can consider it to be a basic 'building block' of spatial layouts."[2]. Now a days, the atrium is a sky-lit and open court with a house or building built around it[3].

The next paragraph will go into detail where the origin of the courtyard is, discuss the history of how that led to the atrium and give an answer to the question when the atrium became a common part of architecture.

1 Berry and Laurence, *Cultural Identity in the Roman Empire*, 166.
2 Berry and Laurence, 166.
3 Ching, *Architecture Form, Space, and Order*, 394.

1.1. Origin of the European atrium house

Excavations in the city of Kahun in Egypt, 1900 BCE[4], and the Chaldean city of Ur, 2000 BCE, showed the use of the courtyard. One of the oldest typology across the world is the courtyard house, which is over 5000 years old[5]. The place of origin of the courtyard is still debated. China is considered the birthplace by some while others argue that the birthplace lies in Egypt[6]. Chapter 2 will dive more into the Chinese courtyards. The ancient civilizations of Sumer and Pharaonic Egypt hold the oldest example of the courtyard[7]. It is plausible that the birth of the courtyard house lies here. Now we will take a look at the evolution of the atrium house in Europe. For that we jump to ancient Greece.

The Greek house has two principal types: the prostas house and the pastas house[8], see figure 2. The name prostas and pastas describe the semi-open space between the court and the living spaces (*oikos*), coloured in with purple. Both words describe their position in the house; pastas means "standing in between" and prostas "standing in front"[9]. The entrance leads to the court, directly or via a vestibule. The court is the central connection for most rooms, like the Roman atrium house. The pastas and prostas (can be seen as a corridor or broad portico) are identifiable in the majority of houses in the Greek site of Olynthus. An important variation of these two dwellings came up at this excavation site: in around eight of the hundred houses there was a court found with porticos on all four sides, meaning a complete 'peristyle'[10].

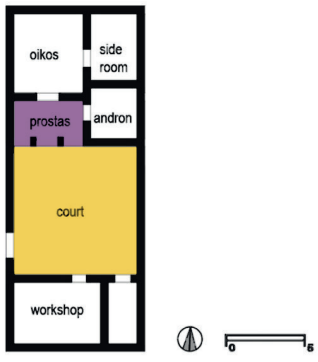


Figure 2: Prostas house type in Priene on the left and the Pastas house type on the right, image from Gönül, "Main Topics and Discussions on Ancient Greek Houses of West Anatolia.", 62. Edited by author.

4 Friedmann and Savage, "Interior Design.".
5 Zhang, Donia, 'Courtyard Housing and Cultural Sustainability Theory, Practice, and Product', 5.
6 Sanjunee and Guneratne, 'Morphology of the evolving courtyard', 107.
7 Abass et al., "A review of courtyard house", 2557.
8 Graham, "Origins and Interrelations of the Greek House and the Roman House.", 3.
9 Gönül, "Main Topics and Discussions on Ancient Greek Houses of West Anatolia.", 63.
10 Graham, "Origins and Interrelations of the Greek House and the Roman House.", 4.

The traditional Italian house with the atrium probably originated from the Etruscans[11]. The Etruscans were the first rivals of the Romans. The homeland of the Etruscans was located near Rome. During the sixth century BCE they even ruled the city, which explains the impact they had on Roman culture[12]. The amount of influence is debated, but it probably includes the following: fondness towards bloodthirsty games, the toga, 'Roman' numbers, the alphabet, realism in the art of sculpting, the Tuscan temple, urban planning and the atrium house[13]. The layout of Etruscan houses were centred around a large courtyard with a rainwater basin in the middle. This layout is similar to the Roman atrium house of later dates, which implies the Etruscan atrium house being the predecessor of the traditional Roman atrium house[14].

1.2. The Roman atrium house

The Roman atrium house came up at 700 BCE[15]. The design of the atrium house was a private outdoor courtyard, the atrium, with a rainwater container and surrounded by small rooms. The Roman atrium house became a mix with characteristics of Etruscan and Greek architecture, around 275 BCE[16]. The influence of the Greeks appeared in the incorporation of a peristyle at the back of the atrium house, containing the gardens that had been there[17]. The atrium house, hereby, evolved to an atrium-peristyle house, see figure 3.

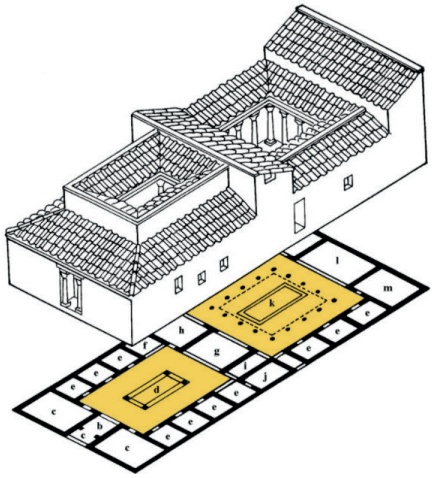


Figure 3: Plan of an atrium-peristyle house with shops and the atrium in front and the peristyle in the back, image from Allison, Pompeian Households, 12. Edited by author.

11 Gates, *Ancient Cities*, 362.
12 Gates, 317.
13 Gates, 317.
14 Gates, 321.
15 Abass et al., "A review of courtyard house", 2557.
16 Abass et al., 2558.
17 Gazda, *Roman Art in the Private Sphere*, 30.

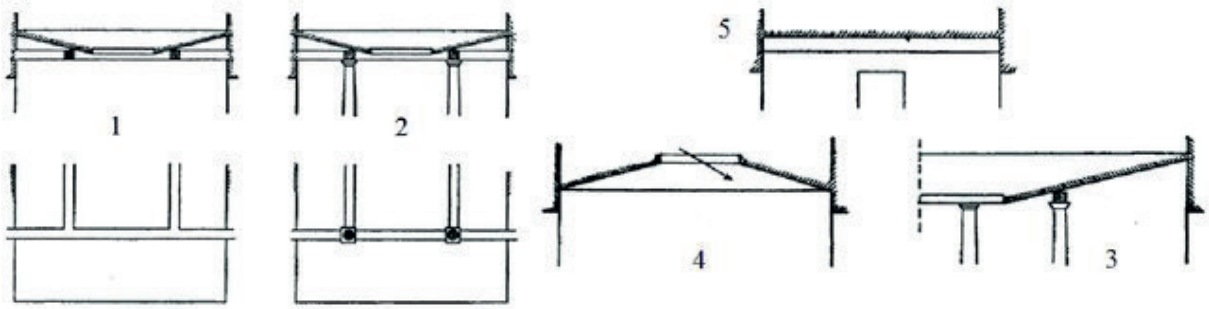


Figure 4: Drawings by Auguste Choisy, found in Zayats and Murgul. "Rainwater Systems in the Context of an Architectural Image.", 707.
Fig. 4.1: Tuscan atrium.
Fig. 4.2: tetrastyle atrium.
Fig. 4.3: Corinthian atrium, in which Choisy assumed two rows of columns.
Fig. 4.4: displuviate atrium.
Fig. 4.5: testudinate atrium.

Vitruvius (De architectura 6.3) talks about five types of atria (*Cavaedium*) configurations: Tuscan, Corinthian, tetrastyle, displuviate, and testudinate[18]. The Tuscan atrium has no column, so the roof is carried by rafters, see figure 4.1. The tetrastyle atrium has columns in the centre, see figure 4.2. The Corinthian atrium also has columns at the centre, but are generally taller and in more columns[19], see figure 4.3. The displuviate atrium has an outwards sloping roof[20], see figure 4.4. Finally, the testudinate atrium is totally roofed over with a short span and windows for lighting, which is illustrated in figure 4.5.

The rise of the typology of the apartment blocks (*insulae*) was first found after the fire of 64 CE in Neronian Rome[21]. This meant a progression from individual atrium houses to apartment blocks architecture for the masses, fueled by societal change[22]. Wallace-Hadrill sought an explanation for the gradual disappearance of the post-Pompeian domus. A domus is a single-family atrium house[23] for the wealthy upper class of ancient Rome. The atrium in these houses were used to receive friends and business clients and the peristyle was exclusively for the family. He connects the vanishing of the atrium house to the societal change of self-

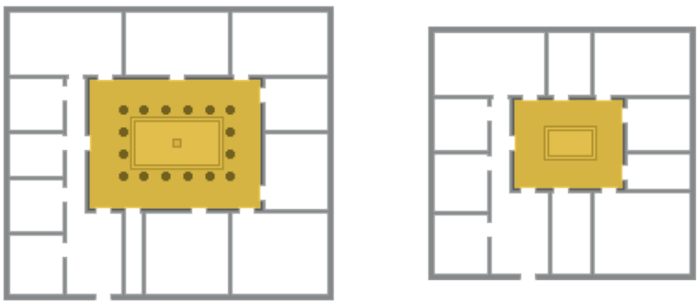


Figure 5: Floor plan of the Corinthian atrium on the left and floor plan of the Tuscan atrium on the right. Becker, Jeffrey, Plans Tuscan Atrium, Left (Both CC BY-SA 3.0) and Corinthian Atrium, Right. Edited by author.

18 Vitruvius, "Vitruvius: The Ten Books on Architecture.".
19 Becker, Jeffrey, "Roman Domestic Architecture (Domus).".
20 Becker, Jeffrey, "Roman Domestic Architecture (Domus).".
21 Gazda, *Roman Art in the Private Sphere*, 30.
22 Boethius, *The golden House of Nero*, 137.
23 Gazda, *Roman Art in the Private Sphere*, 8.

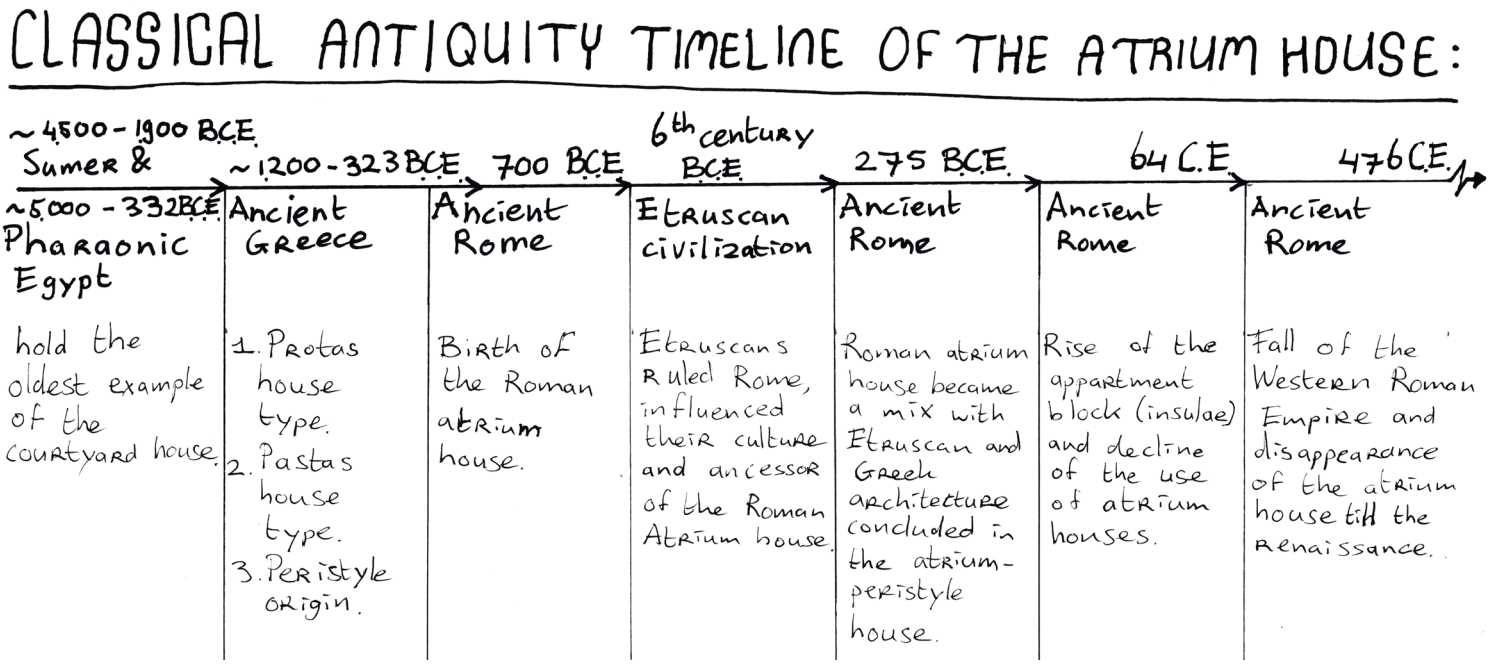


Figure 6: Timeline fragment of the evolution of the atrium house in classical antiquity. van der Straaten, Sem F.G.. Classical Antiquity Timeline of the Atrium House, Drawn by author.

presentation: the atrium was replaced by the appearance of 'audience rooms', therefore resulted in the decline of the atrium as an architectural feature[24]. The use of the atrium in residential buildings fell away after the fall of the Western Roman Empire by 476 CE[25] till the Middle ages. Chapter two will continue on this part of the history and onwards. The next paragraph will talk about the functions the atrium house had in classical antiquity.

1.3. Functions of the atrium

The atrium was a significant feature in Roman architecture, because it fulfilled multiple functions. Each function of the atrium will be discussed to form an image of what an societal influence the atrium had.

Social status

The architectural elements of the atrium and peristyle may be understood as indicators of status[26]. The atrium and peristyle have significance

24 Gazda, 40.
25 Abass et al., "A review of courtyard house", 2559.
26 Grahame, *Cultural Identity in the Roman Empire*, 172.

in Roman society, explains Wallace-Hadrill, because they provided "dignitas to the home in a society in which so much turned on social standing"[27]. Dignitas is a Roman social concept. Dignitas is about the standing, reputation and the good name of the man[28]. Thus, the atrium and peristyle were tools to express prosperity and prestige of the man of the household/family (*paterfamilias*).

Business and privacy

The atrium is the centre of social, political and commercial activities. It is the place where many business deals were made and the ritual of greeting the paterfamilias by clients, called *salutio*[29]. Leach shows that lobbying for social and political advantages happened in the atrium[30].

The atrium can be seen as a waiting area for clients and friends. Displaying luxury in it is a means to express your importance. Allison compares the atrium, as a reception, to the entrance hall of the elite in the mid-nineteenth century with clear distinctions between private, public and service spaces[31]. The degree of privacy that the atrium provides is essential for doing business, planning and plotting, that could not be done publicly[32]. Hence the atrium serves conducting private business ideally.

Religious

The atrium has, besides a social function, also a religious one[33]. The atrium was seen as the hearth of the house, the centre where household life took place. This was also the location of the shrine (*lararium*) of the ancestors. The masks of the ancestors were kept in the atrium by most prominent families[34]. These masks were wax images of the male ancestors, according to Polybius and Pliny, and worn at the funerals of the paterfamilias[35]. Besides funerals the atrium was also used to house ceremonies like marriage[36]. In Roman religion the atrium symbolised the family heritage.

Security

The atrium house was also designed to protect the residents, this was done in three ways.

27 Wallace-Hadrill, "The Social Spread of Roman Luxury", 167.
28 Balsdon. "Auctoritas, Dignitas, Otium.", 45.
29 Stott, "The Influence of the Roman Atrium-House's Architecture", 19.
30 Allison, *Pompeian Households*, 165.
31 Allison, 165.
32 Gazda, *Roman Art in the Private Sphere*, 29.
33 Gazda, 8.
34 Wescoat and Ousterhout, *Architecture of the Sacred*, 189.
35 Gazda, *Roman Art in the Private Sphere*, 26.
36 Gazda, 27.

Number one is the amount of access given to certain areas. During the day the atrium was used for doing business, while the peristyle was limited to the household only. During the night the house was made inaccessible. Number two is the few entry points into the building. The domūs (plural) in Pompeii had one or two outside doors and few to no windows at the ground floor[37]. The windows were high up in the wall and covered with ceramic grills. The doors were shut with locks. Most locks were found around the atrium, thus concluding 'the atrium was the most secure part of the house'[38]. The main entrance of the Roman atrium house is the narrow hall (*Fauces*) between the shops (*tabernae*) at the street side, see figure 3. The *tabernae* had shutters against thieves at night[39]. These shutters are the third way of protection. The narrow *fauces* led to the open atrium. This architectural transition from narrow to open was specifically designed to impress the one approaching the atrium, mainly the clientele of the paterfamilias.

Collecting rainwater

In the middle of the atrium of the domus is the *impluvium* located. The *impluvium* is a sunken basin with the function of catching rainwater[40].

Shadow

The atrium in Roman times was open to the sky. Protection to excessive heat was necessary in the open-air atrium[41]. For this curtains were hung to give protection against the heat, sudden gusts and draughts. In the peristyle were paintings located. The paintings were protected from the sun and weather with awnings between the columns[42]. The atrium brought protection against the Mediterranean climate with the provision of shadow.

37 Gazda, *Roman Art in the Private Sphere*, 28.
38 Gazda, *Roman Art in the Private Sphere*, 28.
39 Wallace-Hadrill, *Houses and Society in Pompeii and Herculaneum*, 118.
40 Grahame, *Cultural Identity in the Roman Empire*, 172.
41 McKay, *Houses, Villas, and Palaces in the Roman World*, 141.
42 McKay, 141.

To conclude this chapter: the birth of the courtyard house in all likelihood lies in the ancient civilizations of Sumer and Pharaonic Egypt. From here on the ancient Greek civilization had three court house types: the prostas house, the pastas house and the peristyle. The origin of the atrium house probably originated from the Etruscans. The early Romans atrium house later became a mix of Etruscan and Greek architecture into the atrium-peristyle house. The atrium of Roman domestic architecture had seven functions: Providing privacy, security and shadow, collecting rainwater, religious, business and social status. The atrium house slowly got abandoned by the introduction of the popular apartment block. The atrium in residential buildings was not again used till the Middle ages and renaissance in Europe. Chapter two will continue on this part of the history, going over the variants that led from the atrium house and their differences.

Chapter 2: European variants on the atrium house

2.1. European atrium variants

Chapter 1 discussed the origin of the atrium house. It appears to be that the *domus* in the Roman period was the first example of an atrium house in Europe. This chapter will investigate which other typologies derived from this. The prostas house, the pastas house and Greek peristyle house originated before the atrium house, so they will not be mentioned. First all the possible typologies in Europe similar to the atrium were picked. Secondly the possible typologies were tested to three criteria to figure out if the typologies have a link to the atrium house. The remaining typologies will be discussed with their history, resemblance with the atrium typology and a few examples.

Europe has many typological variations on the Roman atrium house. The typological variants required to have an open and sky-lit space enclosed within four walls and/or buildings. Six possible variants were found with this requirement in the research. Every possible variant will be distinguished from each other by their definitions:

A quadrangle is a "rectangular open space completely or partially enclosed by buildings of an academic or civic character."[1].

A 'hofje' is the Dutch word for a complex of one-room houses grouped around an inner courtyard with a gate[2]. Hofjes were founded as a charity for the poor elderly and provided social security.

A court, in architecture, is an open space enclosed by

1 Britannica, Quadrangle".
2 Renes, *Historische Landschapselementen*, 71.

Table 1: Testing the possible variations of the atrium typology to three criteria.

Typology	Internal atrium	Residential function	Housing one family	Variant on the atrium?
Hofjes	✓	✓	✗	No
Courtyard houses	✓	✓	✓	**Yes**
Houses with a court	✓	✓	✓	**Yes**
Patio houses	✓	✓	✓	**Yes**
Quadrangle	✓	✗	✗	No
Cortile	✓	✓	✓	**Yes**
Appartement block with an enclosed outdoor space	✓	✓	✗	No

buildings or walls[3]. A Court can also be referencing a cul-de-sac.

A courtyard is "a court adjacent to or within a building, esp. one enclosed on all four sides"[4].

A patio is "a courtyard within a building, open to the sky, in Spanish and Latin American architecture"[5].

A cortile is an "internal court surrounded by an arcade, characteristic of the Italian palace, or palazzo, during the Renaissance and its aftermath"[6].

Now that the separation between the different typologies is clear, the next step is to determine which ones have a link to the atrium typology. The atrium house in Roman times had three generic characteristics. The first being the building has an internal atrium, surrounded on all sides by the building. The second characteristic is it has solely a residential function. The last one is that the building houses one family, not multiple. The possible typologies from the last paragraph will be tested to these three criteria to link them to the atrium typology, see table 1.

3 Britannica, "Court.".
4 Ching, *Architecture Form, Space, and Order*, 380
5 Britannica, "Patio.".
6 Britannica, "Cortile.".

All the possible variants on the atrium typology have an atrium-like space. The quadrangle type does not have any residential function, because the buildings around the rectangular space are used for academic or civic purposes. Hofjes and apartment blocks with an enclosed outdoor space do have a residential function. Both typologies house multiple families, so they are not built as a single family building. Thus, by testing the possible atrium house variants to the three criteria the following typologies remain: the courtyard, patio, cortile and court. These are the four dwelling typologies that resulted out of the atrium house in Europe.

2.2. Historical development of European atrium variants

The courtyard, patio, cortile and court are the four dwelling typologies that resulted out of the atrium house in Europe. The the history of atrium is intentionally left out of this chapter, because if already broadly talked about in previous parts. This paragraph will go over the history of each typological variant in combination with a case per type.

2.2.1. Courtyard

Origin

The man during the prehistoric ages was dependent on nature, but became disconnected from nature through the creation of dwellings[7]. The courtyard was a solution to re-establish the interaction with nature by accommodating it within the boundaries of the house. The outdoor world is captured in the courtyard of each dwelling. The courtyard is traditionally used to link the outdoor

7 Sanjunee and Guneratne, 'Morphology of the evolving courtyard', 107.

and indoor atmosphere and for spatial organization[8]. In later periods the courtyard became prominently known as a place of protection by the emphasis on the enclosure[9]. Other functions, nowadays, are ventilation, leisure, climate control, socialization[10] and capturing the light[11].

Courtyard houses can be found all over the world in continents like Asia, Latin-America, North-Africa and Europe. They can also be founded in Northern European nations as well as Arab countries[12]. As discussed in chapter 1, the origin of the courtyard house is disputed. The courtyard archetype appeared in different urban settlements: Mycenae from 1550–1100 BCE, Ur and Sumeria from 2175–2000 BCE and Mohenjo-Daro from 3000–2000 BCE[13]. Sanjunee and Guneratne consider the earliest stages of the courtyard to date back from Neolithic settlements, around 3000 BCE[14]. Gottfried Semper related the enclosure of the courtyard to southern Mediterranean agriculture to protect the harvest from the elements; G. Buti deducted that this society must have been Indo-European nomadic people[15]. Therefore concluding the birth of the courtyard took place in the Bronze ages[16]. Zhang brings forward excavations of the earliest courtyard house in China. The house dates back from the Middle Neolithic period linking to the Yangshao culture (5,000-3,000 BCE)[17].

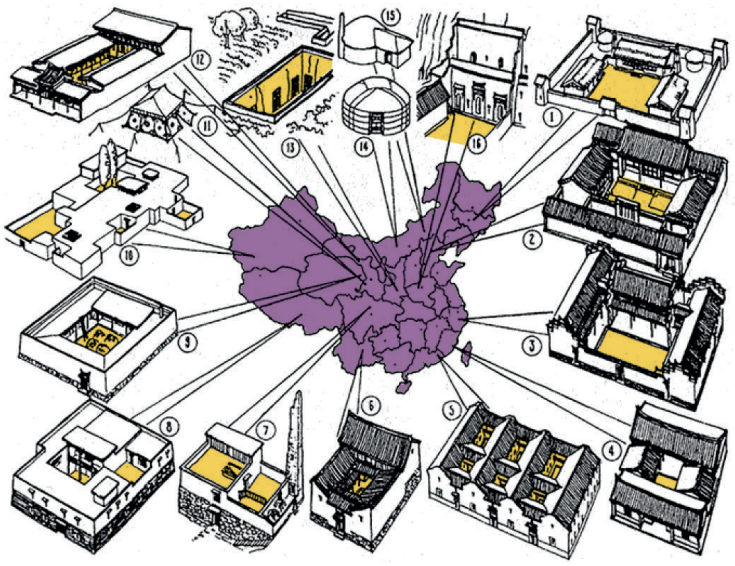


Figure 7: Different types of courtyard houses across China. Drawing by Fu Xinian and image found in Zhang, Donia, 'Courtyard Housing and Cultural Sustainability Theory, Practice, and Product', 7. Edited by author.

Chinese courtyards

The sheltered courtyard served as a connection with the cosmos during the ancient Mesopotamian, Egyptian and Chinese civilizations[18]. During

8 Sanjunee and Guneratne, 106.
9 Sanjunee and Guneratne, 'Morphology of the evolving courtyard', 108.
10 Jitwattanasilp, 'Stockholm Courtyards', 1.
11 Sanjunee and Guneratne, 'Morphology of the evolving courtyard', 108.
12 Jitwattanasilp, 'Stockholm Courtyards', 1.
13 Pica, Relationship between Urban Morphology and Patio Housing, 77.
14 Sanjunee and Guneratne, 'Morphology of the evolving courtyard', 108.
15 Edwards et al., *Courtyard Housing Past, Present and Future*, 3.
16 Edwards et al., 4.
17 Zhang, Donia, 'Courtyard Housing and Cultural Sustainability Theory, Practice, and Product', 5.
18 Sanjunee and Guneratne, 'Morphology of the evolving courtyard', 107.

the Han dynasty (c.206 BCE-220 CE) in China the courtyard was seen as a link between Earth and Heaven[19]. Courtyards are also named skywells (*tianjing*) or lightwells. Four types of courtyard houses can be found across China[20]:

1. Square/rectangular-shaped courtyard houses with 1-storey (*siheyuan*) appear in the northeast of China.
2. Lightwell / courtyard houses with 2-3 storeys (*sanheyuan*) meanly appear in the east-west of China. U-shaped courtyard/ lightwell houses with 2-storeys (*yikeyin*) appear in central and southern provinces of China.
3. Octagonal, elliptical or circular fort-like structures (*tulou*) appear in southern regions of China with 3-4-storeys.
4. In northern and Northwest regions appear the underground courtyard houses.

Islamic courtyard

The rise of the *insulae* (apartment blocks) led to the abandonment of the *domus* (Roman atrium house). This transition happened sporadically in pre-colonial Arab Islam[21]. In the transition from single-family to multi-family courtyard houses, the courtyard lost its cosmic value[22]. In the Italian Renaissance very large houses with a series of courtyards were turned into palaces. In Arab the same house would not have been rehierarchized, but linked by an elevated passage, a *sabat*[23]. The urban open spaces from the classical times, the *forum* and *agora*, became prey to densification in the Middle ages, especially in Arab cities[24]. This provided the urban tissue for patio houses, which will further be discussed in the next section.

The continuity of Byzantine culture, after the fall of the western Roman empire, is the reason for the widespread presence of the courtyard house[25]. The courtyard type was inherited from Byzantium within the Islamic world, because of the Muslim necessary requirement of protecting and secluding women[26]. The courtyard with four boundaries symbolises the femininity and inwardness

19 Zhang, Donia, 'Courtyard Housing and Cultural Sustainability Theory, Practice, and Product', 6.
20 Zhang, Donia, 'Courtyard Housing and Cultural Sustainability Theory, Practice, and Product', 6.
21 Edwards et al., *Courtyard Housing Past, Present and Future*, 13.
22 Edwards et al., 13.
23 Edwards et al., 8.
24 Edwards et al., 7.
25 Edwards et al., 13.
26 Edwards et al., 13.

of the dwelling[27]. The women, in Islamic belief, should not be exposed to the street or be seen by outsiders[28]. Courtyards in Islamic countries provide a place to relax and ensure privacy in favour of their women and children[29]. The survival of the monofamilial courtyard house is thanks to the change of the patriarchal structure of the family in Muslim society in the second half of the last century[30].

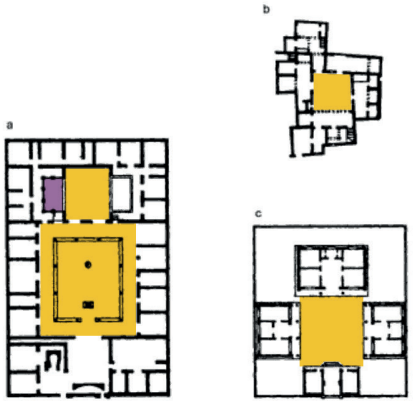


Figure 8: Despite the similarities, the domus in Italica, Spain, the courtyard houses in Fez, Morocco and in Jilin, China are different from each other. Image from Edwards et al., Courtyard Housing Past, Present and Future, 4. Edited by author.

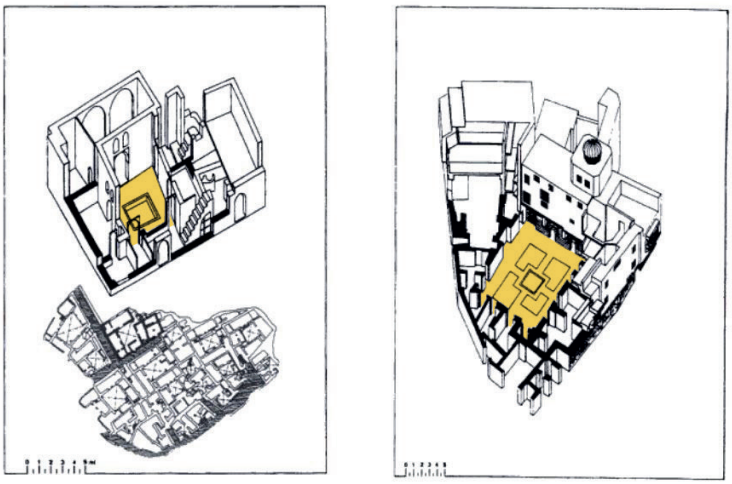


Figure 9: Courtyard houses in Spain. Image from Edwards et al., Courtyard Housing Past, Present and Future, 12. Edited by author.

Thus, the courtyard is the space that enables women to enjoy activities without being seen from the outside and for this concept the courtyard typology survived till this day.

Modern European courtyards

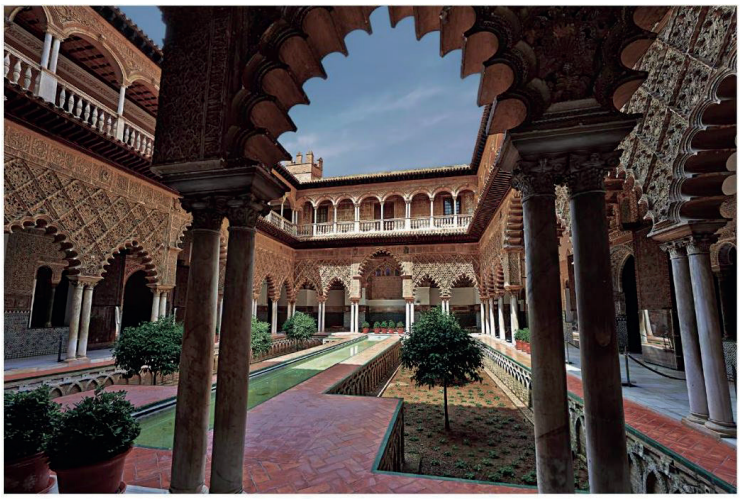
Courtyards appear in the urban context of European cities. The courtyards in medieval cities were not uniform in size and shape, but this changed when they became a part of the housing model by the late 18th century in urban planning regulation[31]. The automotive era develops the term courtyard to a new meaning: "to describe any small garden area within a proximity of the property"[32]. A courtyard can now exist in any kind of building despite the function or density.

Courtyards, in the urban context, rise up again in the late 20th Century[33]. The use of the perimeter block decreased and shifted to the courtyard block in new urban development[34]. The courtyard now fills the role of climatic benefits, strengthening the community and the social interactions. Courtyards are social spaces, as Jitwattanasilp and Jirapatr put it: "a sociable

27 Sanjunee and Guneratne, 'Morphology of the evolving courtyard', 108.
28 Sanjunee and Guneratne, 108.
29 Sanjunee and Guneratne, 112.
30 Edwards et al., *Courtyard Housing Past, Present and Future*, 8.
31 Jitwattanasilp, 'Stockholm Courtyards', 1.
32 Jitwattanasilp, 2.
33 Jitwattanasilp, 2.
34 Jitwattanasilp, 2.

space"[35]. Thus, the courtyard is not only an organizational principle, but also gives room to social life.
The modern courtyard, also referred to as an atrium, developed from a square or rectangle plan to three dimensional forms. This development is also correlated to the change from single-family to multi-family courtyards; this stimulated to build upwards, to the sky above. The courtyard moved from the ground to upper levels in skyscrapers, during the new century[36]. This movement can be interpreted as relinking the courtyard with the cosmos. Since the 20th century the courtyard evolved in form and use.

Figure 10: Patio de las Doncellas, Seville, Spain, 1360 CE. Image from Wickham, Medieval Europe, XXXVII.



2.2.2. Patio

The patio is the Spanish variant on the courtyard, also used in Latin-American architecture. The patio dates back around 2000 BCE, known from the houses of Ur[37], a Sumerian city-state in ancient Mesopotamia. The patio house is present in Islamic medina and settlements in rural Byzantine territory[38]. The patios in old urban centres are formed by "the juxtaposition of two or more median walls to the other houses"[39]. The word patio is also related to the size of the open space[40]: '*patinejo*' means small patio, *patio* is presumably mid-sized and big courtyards are described as '*corralejo*', '*corral*' or '*corralas*'.

The patio is different from the Roman domus (atrium-house) or Renaissance palace (cortile) in its symmetry. The single *bayt* (Arabic word for house) is in asymmetry relating to the doors facing the patio[41]. The doors mark the axes of symmetry with sometimes a fountain at the intersection. The symmetry of the atrium house and the cortile use their whole building, while the patio

35 Jitwattanasilp, 15.
36 Jitwattanasilp, 'Stockholm Courtyards', 2.
37 Giedion, *Space, Time and Architecture*, XLIV.
38 Pica, Relationship between Urban Morphology and Patio Housing, 76.
39 Pica, 77.
40 Pica, 84.
41 Edwards et al., *Courtyard Housing Past, Present and Future*, 9.

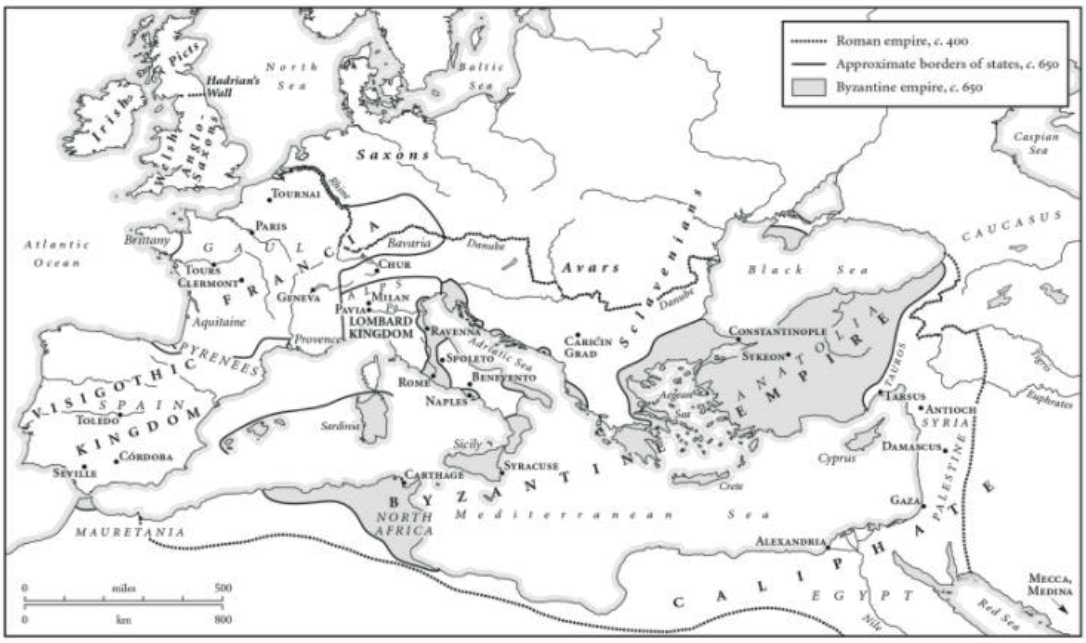


Figure 11: Map of Europe in 550. Illustration from Wickham, Medieval Europe, IX.

Figure 12: Map of western Europe in 850. Illustration from Wickham, Medieval Europe, X.

house does not[42].

Houses with a patio are orientated towards solar light. The preferential orientation since the Antiquity is north-south. This fact carried on to Islamic cities of the West Mediterranean and Byzantine cities of the Eastern Mediterranean in the Middle Ages[43]. The reason for this is the similar aspects of Islamic and Byzantine urbanism[44]. Southern and central parts of Italy underwent Byzantine domination and some Italian territories were under Muslims control for a short period of time (9th–10th centuries in most of Sicily)[45](see figure 11-12), which explains the similarities in urbanism. The example of Patio de las Doncellas, also known as Alcázar of Seville, illustrates the mix of Muslim and Christian styles[46]. The traditional courtyard houses or patios in these occupied regions in Italy did not last; they mainly survived in the Middle East and Spain[47]. The Latin-American forms of the patio, like the Zaguan house typology, were a mix of the patio design that the Spanish Colonists brought over[48].

The historic centre of Granada shows the last types of patio houses in Spain[49]. The patios,

42 Edwards et al., *Courtyard Housing Past, Present and Future*, 9.
43 Pica, Relationship between Urban Morphology and Patio Housing, 78.
44 Pica, 78.
45 Pica, 78.
46 Wickham, *Medieval Europe*, XXXVII.
47 Pica, Relationship between Urban Morphology and Patio Housing, 80.
48 Sanjunee and Guneratne, 'Morphology of the evolving courtyard', 112.
49 Pica, Relationship between Urban Morphology and Patio Housing, 81.

city walls and ditches (water channels) are a survival of Andalusian housing customs when Christian residents arrived in Granada in 1492.[50] The compact layout of the city and use of private patios correlates to the bioclimatic effect it has[51]. Furthermore, a rain-water tank was situated in the middle of most patios for supplying drinking water to the home[52]. This shows perfectly the influence of the Italian domus. Thus, supporting the notion of the patio being a variant on the atrium house.

2.2.3. Cortile

The focus of the fifteenth century was towards reviving Antiquity[53]. The buildings in this period tried to appropriate Antiquity more directly by using spoliated columns[54] in the new courtyards, the cortile, see figure 14. The cortile is different from the other atrium variants by the colonnade on all sides of the inner courtyard. The cortile can be seen as the move from the villa, Roman domus, to the urban house, the palazzo[55]. The palazzo, the urban palace, was an office, warehouse and dwelling in one. The starting of this typology lies in Roman towns of the Middle ages utilised by the growing group of merchants[56]. The cortile acts as an organizational

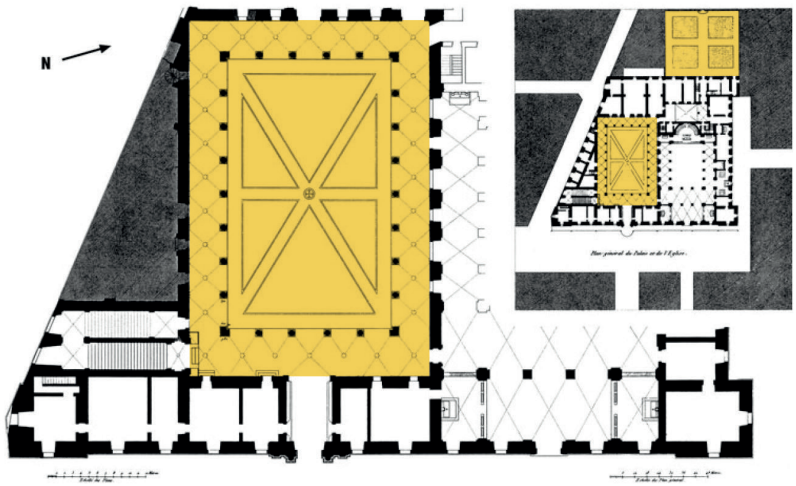


Figure 13: Left, Floor plan of Palazzo della Cancelleria, Rome, Italy (after Letarouilly). Illustration from Waters, Reviving Antiquity with Granite, 160. Edited by author.

Figure 14: Right, Courtyard of Palazzo della Cancelleria, Rome, Italy. Image from Waters, Reviving Antiquity with Granite, 160.

50 Pica, Relationship between Urban Morphology and Patio Housing, 81.
51 Pica, 84.
52 Pica, 84.
53 Waters, Reviving Antiquity with Granite, 149.
54 Waters, 156-157.
55 Aben and de Wit, *The Enclosed Garden*, 129.
56 Aben and de Wit, 129.

principle of the floor plan, just as the courtyard and patio. The cortile also provides air, light and a paved surface for collecting rainwater[57]. These characteristics link the cortile to its predecessor the atrium house, the domus. The outsides of the palazzos manifest a strengthened, fort-like facade to keep the merchant and his wealth safe; figure 15 illustrates this well.

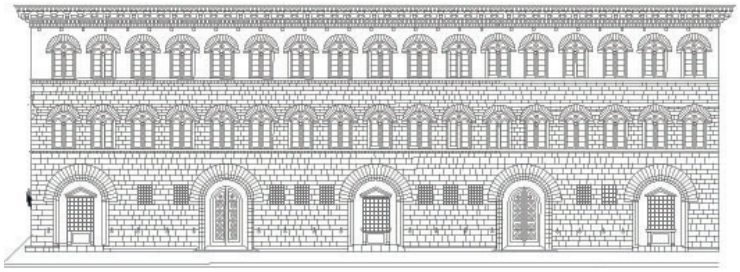


Figure 15: Facade of Palazzo Medici Riccardi, Florence, Italy. Illustration: Röhrig, The Palace.

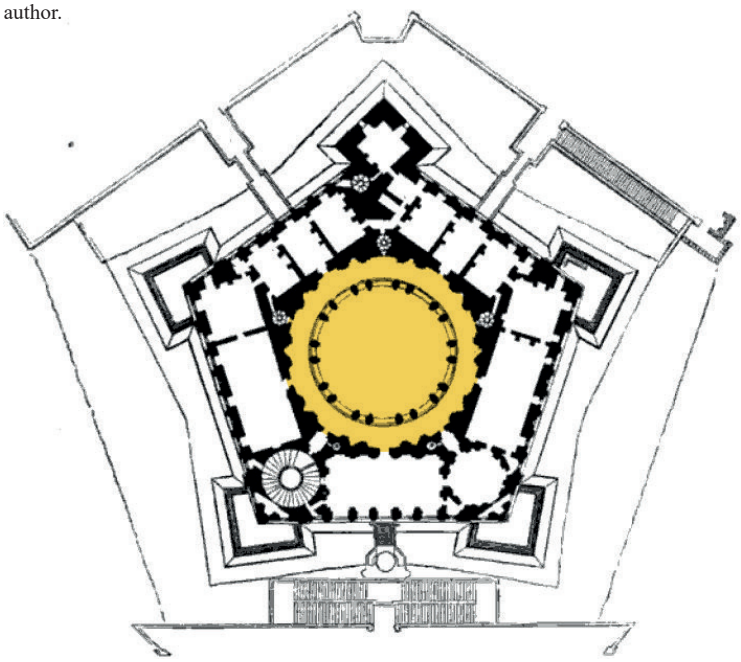
2.2.4. Court

As mentioned in chapter 1, the prostas house and pastas house were one of the first examples containing a court. The court was used in early Christian architecture as the entrance to churches[58]. Before entering the church the visitors washed their hands in the well or fountain in the middle of the open court. This characteristic link the court to the atrium. It seems that the term Court is mainly used as a synonym for courtyard. Besides, a courthouse is also a term used to describe a building that houses the court of law and local government. This text focuses on the court as an enclosed space within a residential building.

This paragraph will give two examples of court buildings during the Renaissance from Italy and England to illustrate the connection between the court and cortile. First off the Palace of Caprarola, also known as Villa Farnese, from the Mannerist era, the Late Renaissance. Built by Giacomo Barozzi da Vignola and located in Caprarola, Italy. This project is unique in its pentagon shape

57 Aben and de Wit, *The Enclosed Garden*, 129.
58 Abass et al., "A review of courtyard house", 2559.

Figure 16: Floor plan of the palace. Scale 1 inch: 100 feet. Illustration from Fergusson, A History of Architecture in All Countries, 109. Edited by author.



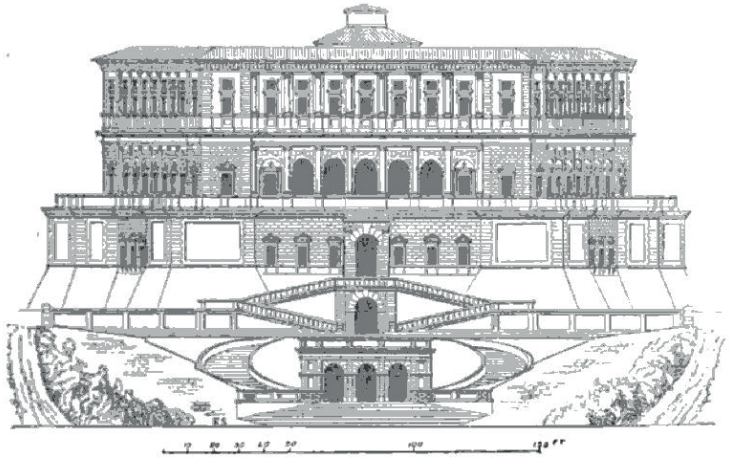


Figure 17: Facade of the Palace of Caprarola. Illustration from Fergusson, A History of Architecture in All Countries, 109.

plan with a circular court in the middle[59], see figure 16. The facade of the palace, as seen in figure 17, has two orders: the closed defensible lower storey and the two open storeys above with windows. As Fergusson puts it: "The whole is so well designed, the angles are so bold, and the details are so elegant, that it is one of the finest palaces in Italy"[60]. The pentagon shape, large dimensions and bastions at each corner were to represent its fortified appearance, just like the defensive character of the palazzo with the cortile.

Next up is the project of Longleat House in England. Designed by John of Padua and built between 1567-1579. The square footage is about the same compared to the Villa Farnese, but in height and other dimensions it is superior[61]. The many features in the facade, like the tapered ornaments, elegant details and large and mullioned windows[62], projects the standing of the English Nobleman. The monumental facade is comparable with the grandeur of Italian palazzos[63].

59 Fergusson, *A History of Architecture in All Countries*, 108.
60 Fergusson, 109-110.
61 Fergusson, 249.
62 Fergusson, 249.
63 Fergusson, 250.

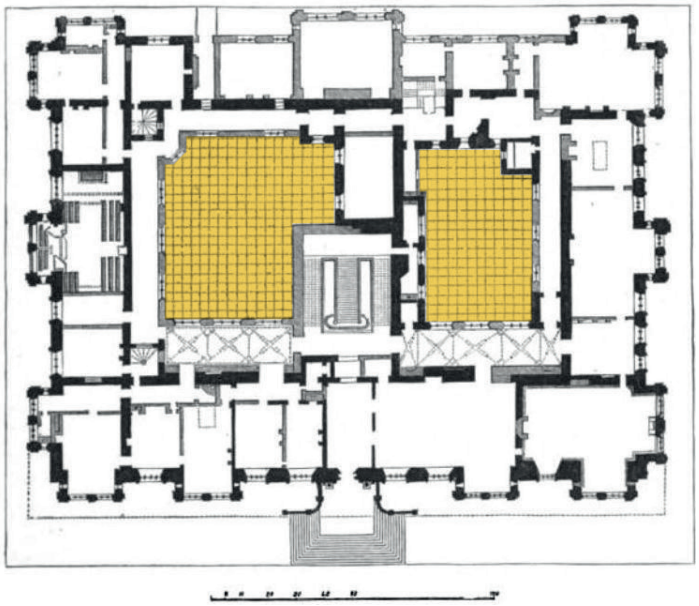


Figure 18: Left, Floor plan of the Longleat House in England. Illustration from Fergusson, A History of Architecture in All Countries, 249. Edited by author.

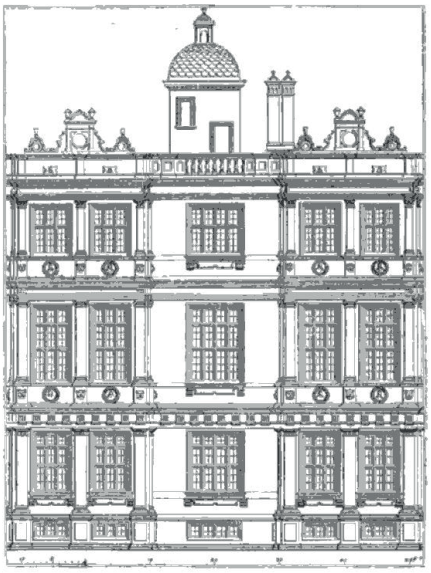


Figure 19: Right, Elevation of the Lonheat House. Illustration from Fergusson, A History of Architecture in All Countries, 250.

A Dutch example of a residential building with a court is a hofje. Hofje translates to 'small court'[64], but is used as a communal space for multiple households instead of one. All English houses are distinguished from French or Italian houses by the court[65]. A typical English house is square without any courtyard in the middle. Only a nobleman who had travelled abroad and learned about foreign ways of building sporadically implemented the Italian cortile or French basse-cour[66].

The court is a modification of the Italian Cortile[67]. The cortile is an architectural element connecting the exterior and interior. Fergusson argues that the architect is 'justified' in making the emphasis in one or the other[68]. Later on the cortile was being roofed over and used as a hall. The courts were covered by glass at the roof level[69]. Development in iron and glass technologies allowed for the first appearance of the roofed court in the 19th century[70]. From this point onwards the room lost its external property and was used as an internal decoration in this country[71]. Thus, the palazzo style architecture spread from Italy to countries like England. The court did not stick for very long by it being roofed over and

64 Aben and de Wit, *The Enclosed Garden*, 125.
65 Fergusson, *A History of Architecture in All Countries*, 249-250.
66 Fergusson, 250.
67 Fergusson, 310.
68 Fergusson, 310.
69 Edwards et al., *Courtyard Housing: Past, Present and Future*, 130.
70 Sharples & Lash, Daylight in Atrium Buildings, 301.
71 Fergusson, *A History of Architecture in All Countries*, 311.

used as a hall, which became a more prominent feature of English architecture.

To conclude, four dwelling typologies resulted out of the atrium house: the courtyard, the patio, the cortile and the court.

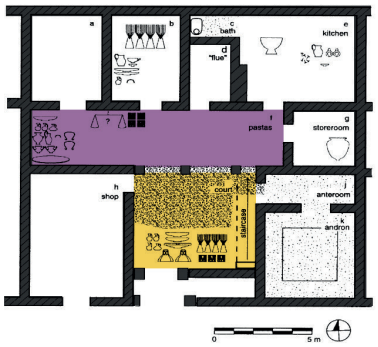
2.3. Typology timeline

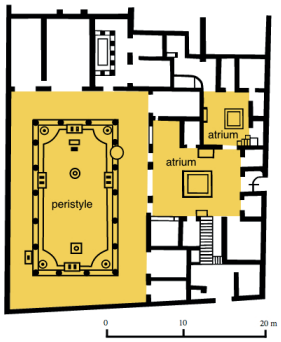
Now that the four variants of the atrium are discussed, the following timeline, on the next page, illustrates examples of each typology with where and when the structures were built. The data of the locations will be used in chapter three to research the correlation between the climate and location where atrium houses were built.

Timeline

1 2 3 4

Figure 17.9 Plans, House no. 33, Priene: (a) Phase 1-West; and (b) Phase 2





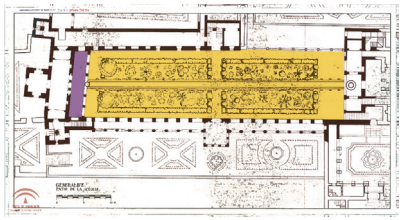
Name: House no. 33
Location: Priene, Turkey
Typology: From Pastas to Courtyard
Year of construction: Ca. 432 BCE – ca. 348 BCE

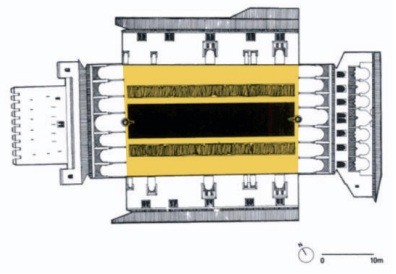
Name: House of many Colors
Location: Olynthus, Greece
Typology: Pastas house
Year of construction: Ca. 432 BCE – ca. 348 BCE

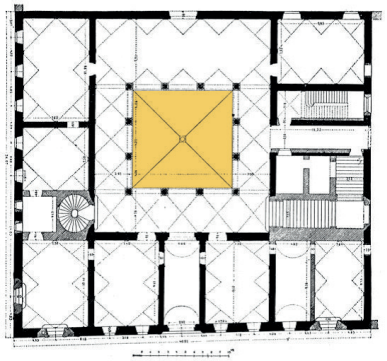
Name: The House of Menander
Location: Pompeii, Italy
Typology: Atrium-peristyle house
Year of construction: 3rd century BCE

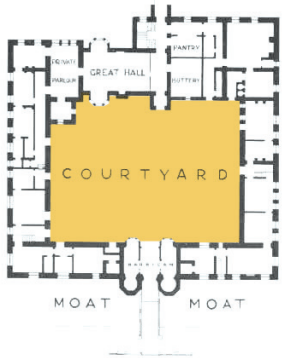
Name: House of the Vettii
Location: Pompeii, Italy
Typology: Atrium-peristyle house
Year of construction: Destroyed 79 CE

5 6 7 8









Name: Patio de la Acequia
Location: Granada, Spain
Typology: Patio
Year of construction: 13th century

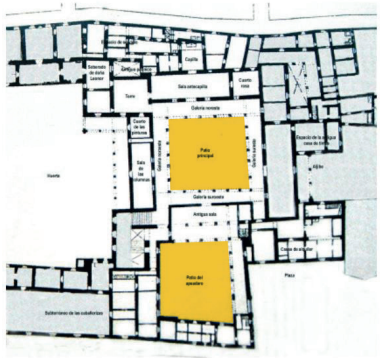
Name: Patio de los Arrayanes
Location: Granada, Spain
Typology: Patio
Year of construction: 1370

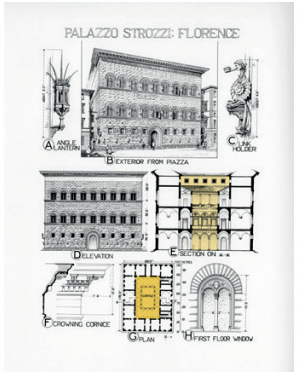
Name: Palazzo Medici Riccardi
Location: Florence, Italy
Typology: Cortile
Year of construction: 1444

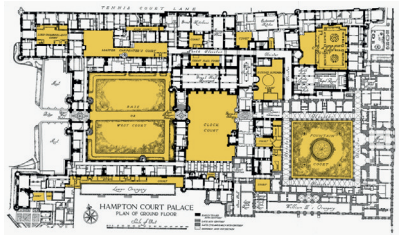
Name: Oxburgh Hall
Location: Oxborough, UK
Typology: Courtyard
Year of construction: 1482

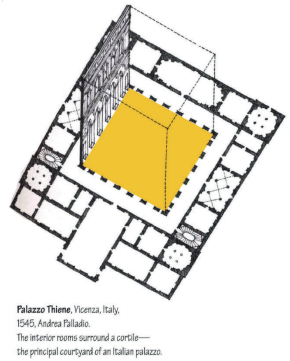
Timeline

9 10 11 12









Name: Casa de Pilatos
Location: Seville, Spain
Typology: Patio
Year of construction: 1483

Name: Palazzo Strozzi
Location: Florence, Italy
Typology: Cortile
Year of construction: 1489

Name: Hampton Court Palace
Location: London, UK
Typology: Court
Year of construction: 1515

Name: Palazzo Thiene
Location: Vicenza, Italy
Typology: Cortile
Year of construction: 1545

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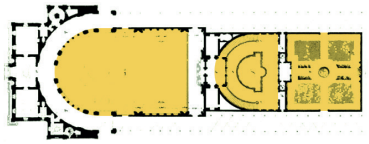

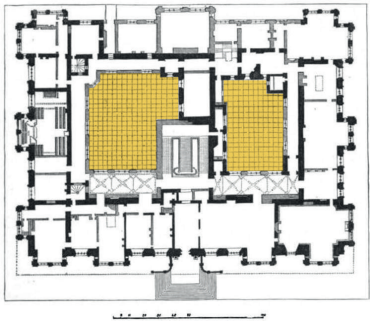

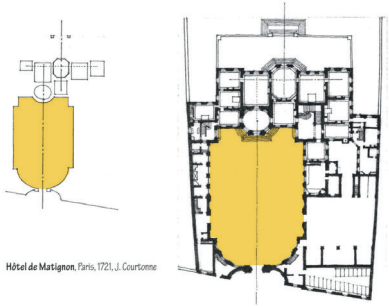

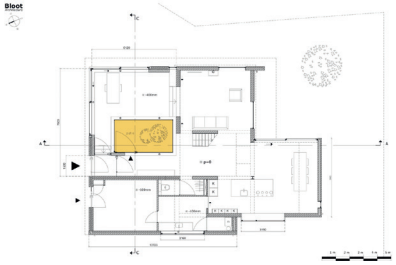

Name: Villa Giulia
Location: Rome, Italy
Typology: Courtyard
Year of construction: 1551

Name: Longleat house
Location: Warminster, UK
Typology: Court
Year of construction: 1568

Name: Hôtel de Matignon
Location: Paris, France
Typology: Courtyard
Year of construction: 1721

Name: Patio house
Location: Velp, the Netherlands
Typology: Patio
Year of construction: 2017

Chapter 3: Climate

Ever since the birth of the courtyard house in the neolithic period, the courtyard house survived over 5000 years. The reason for this is their potential to offer a climatically comfortable living space. Courtyard buildings contribute three main climatic factors: humidity, wind and sun[1]. Especially in arid climates the humidity plays a role in achieving a comfortable micro-climate by using natural elements like plants and water. The courtyard guides the external flow of wind and regulates internal circulation of air. For the sun, the building can collect the heat of the sun and provide shade when necessary. Courtyards offer light, air and a comfortable temperature, whether that is heat or coolness[2]. They are often seen as micro-climate modifiers or micro-climate changers. This is because of their ability to regulate temperatures, redirect breezes and balance the humidity[3]. Other elements in combination with the courtyard or atrium help to sustain a pleasant micro-climate. Examples of this are water pools, discussed in chapter one and two, for evaporative cooling and trees as a natural form of shade[4]. All these elements conclude in the quality of the courtyard typology: passive climatic design. An exemplar of passive ventilation in a courtyard house is illustrated in figure 20. The goal of this chapter is to give answers to the question what role climate plays in where atrium houses are built.

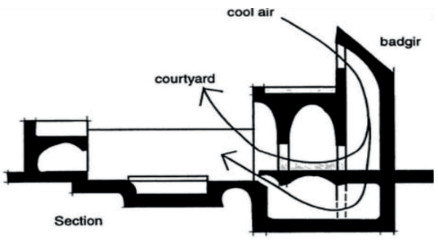

Figure 20: The section of a wind catcher in a traditional Persian home. Illustration from Jaberansari and Elkadi, Influence of different atria types on energy efficiency and thermal comfort, 2.

1 Taleghani, Tenpierik and van den Dobbelsteen, Environmental impact of courtyards, 122.
2 Taleghani, Tenpierik and van den Dobbelsteen, 121.
3 Abass et al., "A review of courtyard house", 2562.
4 Taleghani, Tenpierik and van den Dobbelsteen, Environmental impact of courtyards, 123.

Around the turn of the 19th to 20th century building enclosures gradually transitioned to the modern atrium typology, especially in offices[5]. The modern atrium was commonly used from 1950-1960s[6]. From the 1970s onwards the atrium had become the most favoured architectural form, which led to the new 'atrium age'[7]. In the contemporary era buildings are cooled and heated mechanically instead of passively. According to Jaberansari and Elkadi, HVAC is used when the structure is poorly designed in order to provide thermal comfort[8]. These climate installations and other energy consumptions in buildings are responsible for 40% of the carbon dioxide pollution[9]. Residential buildings account for two-ninth of the European greenhouse gasses emitted[10]. One way of decreasing the energy consumption of buildings is using an atrium. The principle is to allow natural ventilation and daylight to provide a pleasing indoor environment. Other benefits are self-shading and acting as an air reservoir[11], with a more mild temperature compared to the surroundings. Yet, an inadequate atrium design can lead to higher energy consumption and troublesome temperatures[12]. Mainly in extreme climates the atrium requires more means to minimize temperature differences[13]. This sketches the environmental benefits of the atrium, but also the importance of it being well designed for optimal performance.

The usage of the atrium is not bound to the hot and arid climates. Taleghani et al. defined four climates where courtyards are found: temperate, snow, hot and tropical climates[14]. The atrium is used in various climates by the ability of offering sunlight inside (large) buildings[15]. Atria are utilized in both warm and cold climates. A note must be made that the atrium building works differently in each climate. A study from Omrany et al. pointed out that the thermal performance of the atrium without local

5 Jaberansari and Elkadi, Influence of different atria types on energy efficiency and thermal comfort, 2.
6 Jaberansari and Elkadi, 2.
7 Sharples & Lash, Daylight in Atrium Buildings, 301.
8 Jaberansari and Elkadi, Influence of different atria types on energy efficiency and thermal comfort, 1.
9 Sanjunee and Guneratne, 'Morphology of the evolving courtyard, 109.
10 Taleghani, Tenpierik and van den Dobbelsteen, Environmental impact of courtyards, 115.
11 Abass et al., "A review of courtyard house", 2562.
12 Omrany et al., Is atrium an ideal form for daylight in buildings?, 47.
13 Ho, Climatic responsive atrium design in Europe, 65.
14 Taleghani, Tenpierik and van den Dobbelsteen, Environmental impact of courtyards, 121.
15 Omrany et al., Is atrium an ideal form for daylight in buildings?, 50.

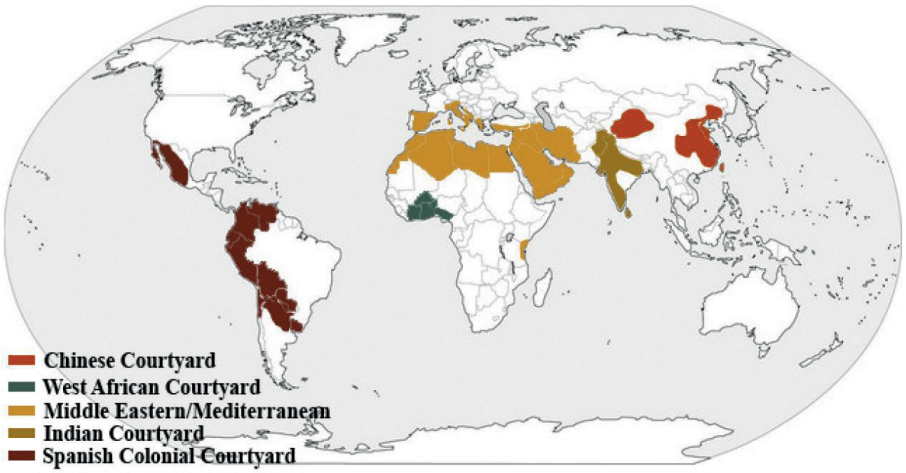

Figure 21: Location of courtyards around the world. Image from Taleghani, Tenpierik and van den Dobbelsteen, Environmental impact of courtyards, 118.

adaptations fluctuated highly in the various climates[16]. To illustrate, atria in colder climates want the full benefits of the radiations of the sun for heating and have protection from the chilly winds, while warmer locations require sun shading and catching the breeze for cooling[17]. Thus, atria are applied in diverse climates, but fulfil different purposes and need local adaptations to the climate.

Where are atria built? Taleghani et al. in combination with Vellinga et al. visualised the spread of courtyard around the world, see figure 21. Most of the courtyards are located around the tropic of cancer. Furthermore half of the area is situated in the places of birth of the courtyard and atrium: the Mediterranean, Middle East and China, as discussed in the previous chapters. The other places where the courtyards appear were inherited from the Spanish colonialists.

In order to zoom in on the distribution of the atria typologies in Europe, I will be placing the examples out of the typology timeline in the climatic map of Ho. Hereby the spread of atria will be visible, as well as in which climate they appear.

16 Omrany et al., Is atrium an ideal form for daylight in buildings?, 60.
17 Ho, Climatic responsive atrium design in Europe, 64.

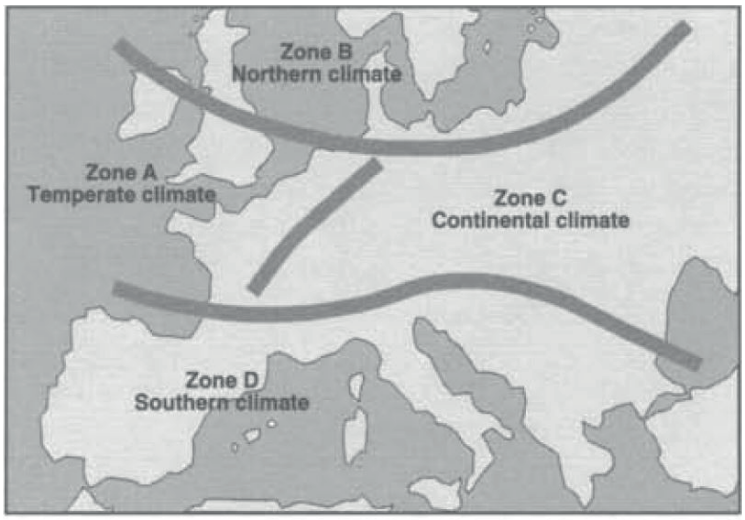

Figure 22: The four climate zones of Europe. Illustration from Ho, Climatic responsive atrium design in Europe, 65.

Dennis Ho wrote a paper on European climate zones and connected it to atrium design. The theory of Ho about the European climates will be used to conduct the research about the distribution of atrium houses in Europe. Ho's theory about the European climates can not be compared to the different climate zones out of the theory of Taleghani, Tenpierik and van den Dobbelsteen. The temperate, snow, hot and tropical climates of Taleghani et al. relate to the world and Ho's climate zones are related to Europe. Ho divided the European climate into four zones: temperate, northern, continental and southern climate. The effects of each zone on the atrium will be discussed.

First off zone A, the temperate climate, has small temperature fluctuation during the seasons compared to the other zones[18]. Secondly zone B, the northern climate, benefits for a longer period from solar energy compared to the southern climate[19]. Thirdly, zone C, the continental climate, has higher temperature fluctuations during the day and more radiation in the winter and summer[20]. Fourth and final, the southern climate, has hot summers and mild winters with high solar radiation[21]. In figure 22, the separation of the four climates within Europe is illustrated.

The sixteen examples of the atrium, courtyard, patio, cortile and court out of the typology timeline have been implemented into the climate map of Ho, see figure 23. This is to get an idea in which climate zones the examples are mainly located, not to know exactly in which climate zone most atrium forms occur. Most projects are located in the southern climate and the remainder in the temperate climate.

18 Ho, Climatic responsive atrium design in Europe, 67.
19 Ho, 67.
20 Ho, 67.
21 Ho, 64.

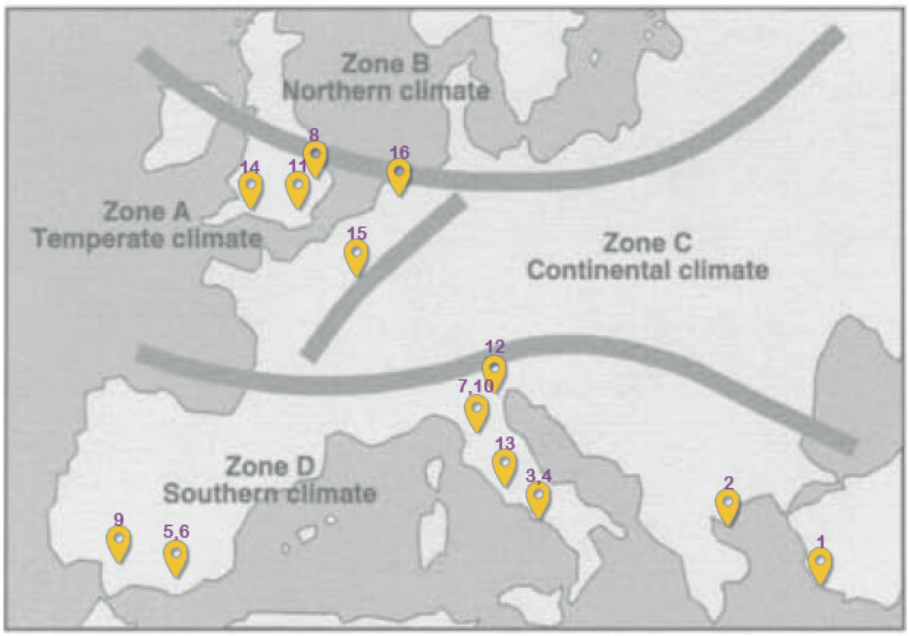

Figure 23: The atrium examples of the typology timeline implemented in the European climate map of Ho. Illustration from Ho, Climatic responsive atrium design in Europe, 65. Edited by author.

For the atria and its variations in the southern climate have the benefits of providing natural ventilation, light, and shadow. Also, the space acts as a place for social gathering as well as a circulation area. These are the main reasons for applying this architectural building form. For the temperate climate the benefits of daylight, ventilation, solar gain and a space for social interactions have the upper hand for choosing these typologies.

To conclude, the atrium and its typological variants have a climatic benefit by utilizing natural elements of sun, wind and humidity. The atrium can have a positive effect on the micro-climate of a building if it is well designed. The atrium needs local adaptations on the specific climate it is located in to be successful and optimal. This is the role that climate plays in where atrium houses are built.

Conclusion

The atrium became a common part of architecture during the reign of the Roman empire. The story of the evolution of the atrium house starts a few millennia back with the courtyard house typology. The first courtyards trace back to the ancient civilizations of Sumer, Pharaonic Egypt and China during the Neolithic period. In Europe, the development towards the atrium takes place in ancient Greece. The Greek civilization had three court house types: the prostas house, the pastas house and the peristyle. The final step before the atrium house was formed took place near Rome with the Etruscans, rivals of the Romans. The Roman atrium house probably originated from the Etruscans. Later on the Roman atrium house evolved into the atrium-peristyle house and became a mix of Greek and Etruscan architecture. The atrium in Roman domestic architecture had seven functions: Providing privacy, security and shadow, collecting rainwater, religious, business and social status. The use of the atrium diminished after the inventions of the apartment blocks (insulae) and audience halls, before the fall of the Western Roman empire. The atrium was not again used in residential buildings till the Middle ages and renaissance.

Around this period multiple variants on the atrium typology emerged. Four dwelling typologies resulted from the atrium house in Europe. The first typology, as predecessor to atrium, is the courtyard, who survived the introduction of the insulae in Islamic and Byzantine countries around the Mediterranean. Each occupied Italy briefly and by this reintroduced the atrium-like typology back. Out of this rose

the second typology, during the Renaissance: the cortile. The cortile was utilized in palazzos (urban villa's) with a colonnade on all sides. The third typology is the patio who mainly thrived in Spain and Islamic parts of North Africa. This type was spread to Latin-America by Spanish colonists. Fourth is the court typology who was introduced in countries like England as a modification of the cortile typology. The lifespan of the type was short lived, because it was later on roofed over and became a hall. Thus, the courtyard, cortile, patio and court are the European variants on the atrium typology.

This paper secluded its research to Europe. Further research can be made about typologies with enclosed outdoor space around the world. For example the Zaguan house typology in Latin-America could stem off from the patio typology who was brought over by the Spanish colonists. Also Asian examples like the Nalukettu house typology can be looked at.

The atrium provides climatic benefits by utilizing natural elements of sun, wind and humidity. If the building is well designed the atrium and its variants create a micro-climate. This micro-climate is affected by the climate in which the atrium is built in. For this reason, the atrium needs local adaptations to achieve a comfortable indoor climate. This is the role that climate plays in where atrium houses are built.

The typologies with enclosed outdoor space are used ever since the beginning of human civilization. Still today, these building typologies are used for their ability to provide a comfortable micro-climate, a private and secluded outside space, and stimulate close social interaction.

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