



Mutualistic Architecture

Innovative approach towards a preservative densification

a colaboration between

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&

Virginia Scapinelli

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innovative approach towards a preservative densification

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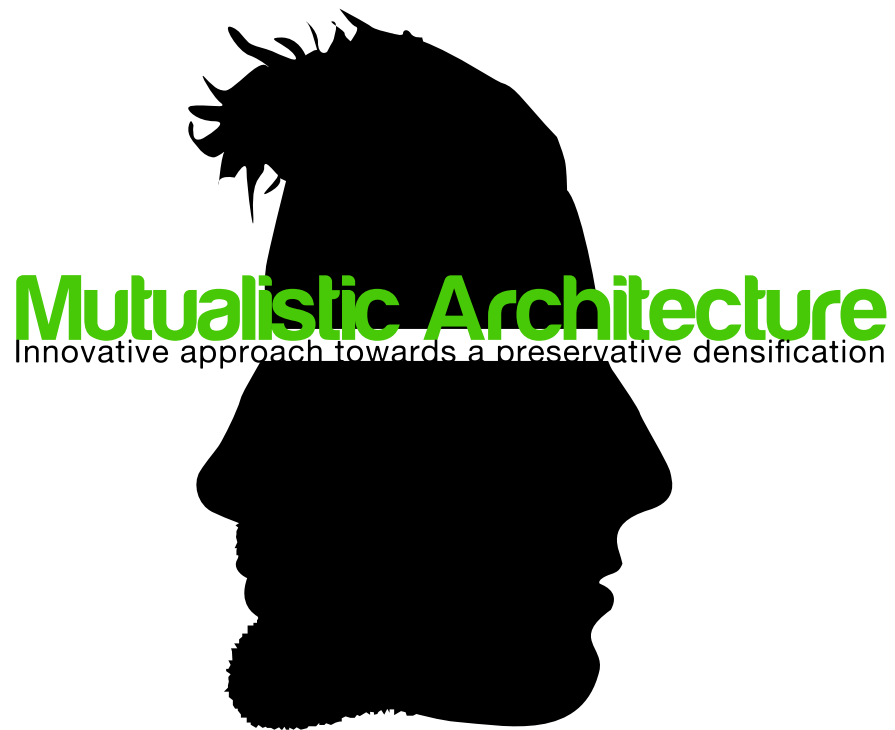
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M u t u a l i s t i c A r c h i t e c t u r e

innovative approach towards a preservative densification



VS&IdV.



Mutualistic Architecture

Innovative approach towards a preservative densification

Virginia Scapinelli

Igor de Vetyemy
Virginia Scapinelli
research

This book is the result of the collaboration of two graduates,
Virginia Scapinelli & Igor de Vetyemy
completing a Master of Science in Architecture, Urbanism and Building Sciences at the Explore Lab of TU Delft faculty of Architecture, The Netherlands.
(academic year 2011/2012)

The graduation process involves two parts: a research, where a certain topic is analysed
and a specific design, where the discoveries of the research are applied
into an architecture project.

The two sections are intended to be independently understandable and usable
as reference for further researches. For this reason, the work has been split into 2
autonomous products, one containing the research and the other the design.

This booklet embodies the research.

Throughout the whole process main mentors were responsible for regular consultations
in different areas: Research, Design and Building Technology.
In addition, other professors from TU Delft were sporadically consulted in order to gather
specific informations relative to the subject of their specialisation.

Organization

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Table of Contents

Organization
Research Question
Abstract
Chapters Description
Research Methodology
Research Network

p.1 *Background*

p.13 *Sustainable Design*

p.25 *New layers for the city*

p.51 *City as a Body*

p.71 *Symbiotic Relations in Biology*

p.109 *Symbiotic Architecture*

p.99 *Explicative Examples*

p.183 *Extrapolations*

p.163 *Conclusions*

Endnotes
Bibliography
Image Credits
Acknowledgments

Research Question

*How can a
symbiotic architecture
respond to
urban densification
in complex scenarios,
allowing
inner expansion and
preserving the existing?*

Abstract

In the current context of urban population growth, free space available within urban fabrics is each time more limited. The goal is to investigate an alternative way to deal with the densification process in complex scenarios, where the traditional approach of simply substituting existing buildings for denser ones is not possible: historical city centers constitute local cultural heritage and for this reason need to be preserved, establishing huge constraints. The intention of this research is to explore how to accommodate the future city within the existing one, in a necessarily intimate relation between present and future landscapes. In other words, the question raised is how to promote an architectonic symbiosis able to provide positive outcomes to all the parties involved, in biological terms: *Mutualism*.

Nine chapters described in the next page explore topics related to this challenge, providing examples of existing approaches and reflecting on each theme in order to apply strategies on how to proceed towards a *mutualistic architecture*.

Research Methodology

This work derives from the collaboration between two T.U. Delft Explore Lab graduates with matching interests, common and individual goals. A key element in the adopted research methodology is the constant exchange of information between the two researchers. This process is reflected in the structure of this combined document in which individual research topics written by each one were put into discussion on a daily basis, contributing and supporting each other's work and resulting in this unique output.

Various techniques were used in this research to answer the different fragments of the research question with the intention of acquiring a broader understanding of its key elements. The sources involved in first instance traditional literature research. In addition, articles, journals and researches published in paper or on Internet were used to provide more updated and specific information on each subject. When experts about a certain topic were available, interviews were made with the intention of obtaining more detailed and reliable inputs about it. Finally, visits to existing examples of symbiotic architecture were also part of the set of inputs collected for the research.

The preliminary goal of this thesis as an academic research was to analyse a specific trend of the predicted scenario for the coming decades and explore possible ways to face it, with efficiency and quality. Therefore, part of the developed work was focused in picturing the future scenario of Western European historical urban contexts; a picture that was based on the current and predicted tendencies regarding urban development patterns of population, environment, technology and culture.

The first part of the research, therefore, was dedicated to the definition of such scenario and the determination of all the constraints and potentials that would define the context for the proposal. The initial action in this research was, in other words, to "formulate a problem", based on existing reliable predictions. Only then, the following step could be developed: the elaboration of a plausible solution.

Given the multitude of factors involved in this story, an extensive research in different fields has been done: beginning from global demographic trends, back into visionary projects of the past, moving forward through the reign of nature and its diverse relationships, exploring related issues from the very specific to the very generic.

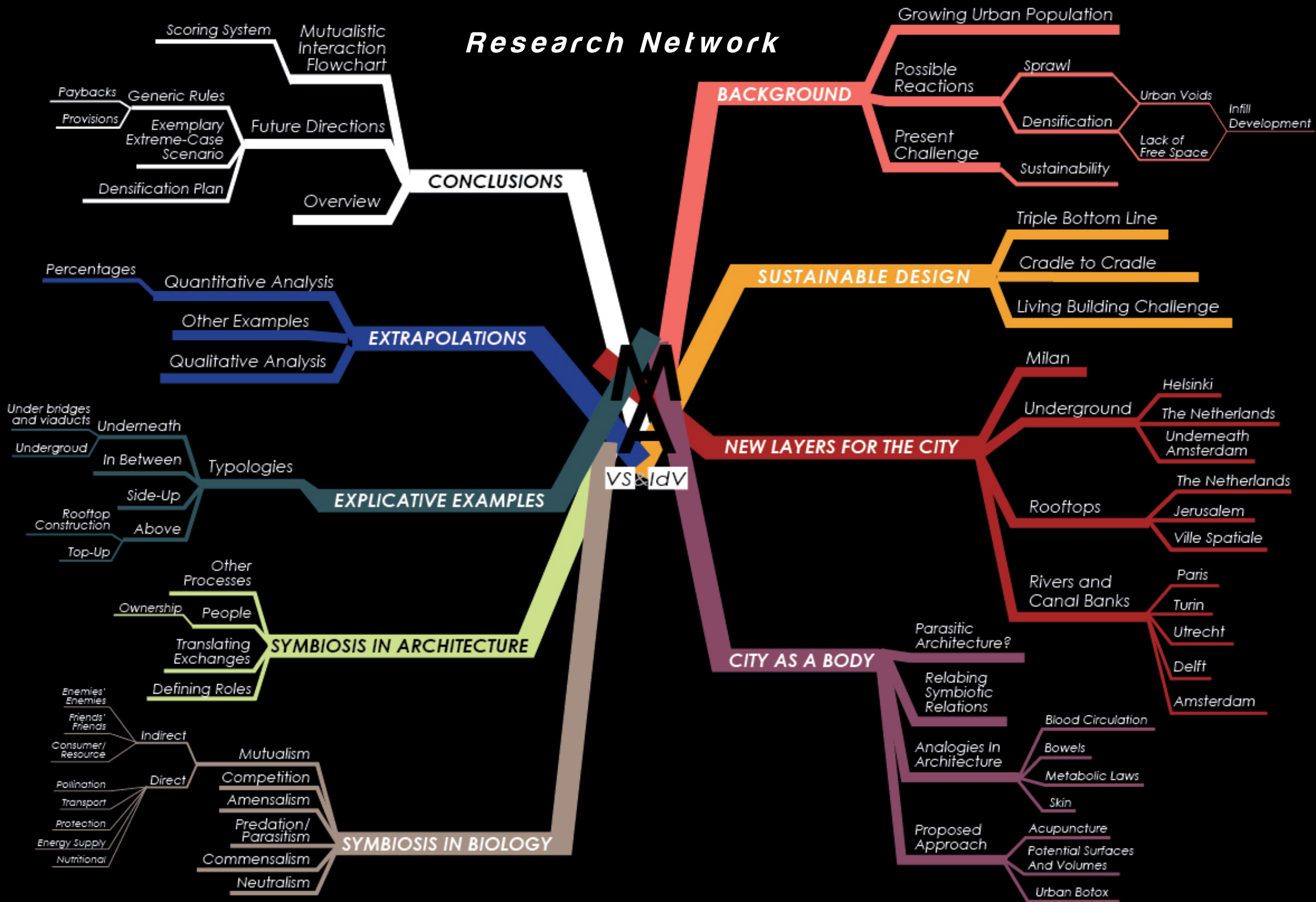
During this journey, personal opinions and positions towards each subject were constantly challenged, taking some subjects to a deeper investigation, while others were just briefly touched, and some were completely dropped out from the final output.

As a consequence of all this process, what has remained in this book represents what was considered important for the understanding of this story, hopefully as useful for the reader as it was interesting for the researchers to explore.

Chapters Description

1. **p.1** The first part is dedicated to understand the **background** of the current urban context, defining the process of densification, its origins and possible consequences. This is implemented to understand which directions cities point at within this process, and what kind of spatial configuration they tend to assume.
2. **p.13** The following chapter incorporates lessons from **sustainable design**, an attempt to understand contemporary responses to the challenges of our times that take into account the necessary balance for reaching a quality future within the current demands.
3. **p.25** Existing examples of researches that seek for alternative strategies towards densification with the creation of **new layers for the city** are explored in this chapter, with both realized and utopian projects, from which many inputs can be absorbed.
4. **p.51** In order to foresee a more fruitful relation between new and existing buildings, as well as between them and the city, the following chapter bridges this quest with examples of strategies belonging to biological symbiosis. In this direction, this part of the research goes back in history to learn from previous studies that similarly relate architecture with biology and analyse the **city as a body**.
5. **p.71** The following chapter goes deeper into the study of **symbiotic relations in biology** in order to understand how each different case occurs in nature. This analysis covers not only the currently (mis)used analogy of parasitism, but also neutralism, commensalism, amensalism, mutual predation and, finally, mutualism. In this specific last one, the focus is to understand the rules that in biology define such fruitful exchange of pay-backs between organisms.
6. **p.99** The relations studied in the previous chapter are translated into the architectural field, defining the analogy in terms of which are the organisms involved and how their interaction defines each kind of **symbiotic relations in architecture** possible.
7. **p.109** The cataloguing of **explicative examples** in existing symbioses in architecture brings the subject to a more palpable level, raising specific and useful inputs to the discussion. Classifications of typologies and kinds of symbioses are created, explaining advantages and costs of each case.
8. **p.157** **Extrapolations** from the examples are raised both in quantitative and qualitative analyses: the distribution of examples among the created categories and typologies are measured by percentage charts while a more specific analysis on the reasons that led to each kind of relation is summarized in a table with justifications for the labels applied, including specific lessons from each example and its relationships.
9. **p.177** The goal of the **conclusion** is to derive from all the studied topics possible architectonic techniques to be applied in a symbiosis with positive outcomes to all organisms involved or, in other words, to work as a guide towards **mutualistic architecture**.

Research Network





1. BACK-GROUND

Current patterns and future demands

GROWING URBAN POPULATION

A growing urgency to be dealt with

In the current context of exponential growth of the global urban population, a series of issues connected to this phenomenon are coming to the surface. The UN Department of Economic and Social Affairs projects that in the year 2030, 60% of the estimated 8.2 billion people on earth will live in cities.¹ In that sense, the dilemma is not in the growth of population itself but in the limited response that our increasingly saturated cities are able to provide. The space available to host this load of people is, in fact, finite.

TIMES SQUARE
39 millions visits a year

POSSIBLE REACTIONS

Inner and outer growth

As a consequence to this phenomenon, cities can react in two ways: they can grow horizontally, covering more area, or become denser, decreasing the available amount of space per person. As Justus Dahinden specifies in *Urban structures for the future*: "On the one hand it is a case of simple expansion, while on the other it involves a process of metabolic regeneration".² This kind of 'space recycling process', that he calls 'inward expansion', is exemplified by the medieval towns where growth, limited by walls, was achieved by increasing the density of the existing urban area.

HONG KONG
surface | 1104 km²
density | 6480 ppl/km²
4th densest city

SPRAWL

Horizontal expansion

Nowadays the same restriction is imposed by different limits. When cities spread horizontally, sooner or later they start to clash with neighbor cities, creating a well-known and studied kind of urban structure: the conurbation. This clash between urban areas is widely happening world and represents a strong physical limitation for many cities. At the same time, when not clashing with other municipalities, sprawl often swallows the countryside and agriculture areas, that are slowly disappearing to give space to urbanization. This option is also to be discarded, given the importance of natural landscape in so many senses. In this scenario, the current urban planning response is pushing each time more towards the densification of urban areas as the most plausible solution for answering future development's space demands.

LOS ANGELES
surface | 12561 km²
density | 2913 ppl/km²

MILAN'S HINTERLAND
conurbation between Milan
and the continuous
municipalities
urbanization | 50%

DENSIFICATION

*More inhabitants in
the same ground
area*

In an urban context, densification means to have more inhabitants occupying the same ground area. This differs in a very basic factor from the definition in physics. While originally it is a measure that takes into account quantity and volume, in architecture it uses ground surface instead of volume as the spatial factor of the equation. That is why, in architecture, high-rise areas are considered more dense than low-rise ones. In this way, horizontal distances between people and places decrease, bringing along both positive and negative effects in different fields and at different scales.

The drastic reduction of private and public spaces to reach the goal of “more people in the same space”² can lead to health or psychological issues of stress, loneliness, pollution, contagiousness, overproduction of waste, and so forth. At the same time, from an environmental point of view, dense cities use less energy and produce less CO₂ per person than the more dispersed suburban and rural areas, and usually provide faster and cheaper public ways of trans-

portation. Regarding resources and services distribution, urban areas are usually more efficient, providing more accessible structures and being able to answer more specific demands. Finally, living in dense cities increase the possibilities of human interactions and provides places for people to gather, giving them voice and power to attend their needs.

These facts push cities to the forefront of environmental sustainability issues and make the question of density critical in the 21st century's scenario, even because the exponential growth of population becomes even more critical in urban areas due to the migration tendency towards big centers. In March 2010 the British newspaper The Guardian published a headline in an alarming tone: “Urbanization is unstoppable, says UN”.³ By then, according to the report from United Nations³, for the first time in history more people lived in cities than in rural areas and for the following four decades, three quarters of the Earth population is expected to live in cities. In short, once densification is a fact, solving its issues becomes a primary urgency in both urban and architecture fields.

PARIS | La Défense

At the end of the 10 km historical axis grows the new high rise financial district of Paris



PRESENT CHALLENGE

*Increasing density
maintaining quality*

The challenge carried out by this research is how to add density through this process of inner growth maintaining the original quality of space. Currently the most common way for densifying urban areas is demolishing old and inefficient buildings and substituting them with denser and more efficient ones. But what will happen to historical sites when this pressure for more density reaches an even higher level of saturation? Nowadays the practice of demolition and reconstruction usually occurs in the outskirts of cities, where the existing built environment normally doesn't constitute any important heritage. Most of the European cities, nevertheless, carry in their city centers a history of hundreds or even thousands of years, and due to such a historical background, a big part of their prestige.

There is no doubt that historical centers need to be preserved from the voracious progress of urbanization, but on the other hand they need to stay alive and respond to the changes in society's lifestyle. These areas cannot become open-air dead museums. Cities like Rome are often so untouchable that they begin to silently decay over the decades, in a process that also makes its memory slowly fade away.

It has been proved, instead, that preservation doesn't mean untouchability or museification; on the contrary, when an historical building is being used, it will receive constant maintenance, inspection and restoration, as if it could live a second life. What is left empty and unattended instead, goes through a way faster end.

In this sense, it becomes interesting and challenging to investigate how to attend the new demands brought by the densification process in those precious historical centers without altering their evocative capability. This task requires that old and new find a very particular balance between them, keeping rooted to the origins but opened to the future.



ROMAN FORUM

Center of Roman public life for centuries, nowadays untouched under a process in which memories slowly fade away

Current limited development tool

"SLOAP": Residual urban spaces created by urban rearrangements; the acronym refers to "Space Left Over After Planning"

LACK OF FREE SPACE vs URBAN VOIDS

The concept of free urban space is becoming a far memory. Cities are made of a tight, compact, continuous and dense fabric of buildings, streets and squares. On the other hand, though, in the same context of development that generates this lack of space, cities often also experience an opposite phenomenon: with the creation of new centralities, the regrouping or rearrangement of dwellings and services tends to generate 'leftover urban spaces'. Together with a broader set of unused spaces, these gaps in the urban fabric are called 'urban voids'. Most of the times they represent very disagreeable areas that often grow and deform together with the city pattern, like scars that tell something about the local development's history. The expression 'urban voids', however, is extremely wide and has been used to describe many different situations, as shown in the opposite page.

INFILL DEVELOPMENT

As a result of this equation between the lack of free spaces and the creation of urban voids, a specific urban planning and development tool has recently been considerably explored: it is known as *urban infill*. This involves the use of gaps within a built-up urban area for further construction, focusing on the reuse and repositioning of obsolete or underutilized buildings and sites. Infill buildings are constructed on vacant or underutilized properties or between existing buildings, giving new meanings and functions to obsolete spaces that have lost their functionality. In architecture, the need for filling these gaps generates a variety of interventions, normally put together in publications under the definition of 'parasitic architecture', terminology that will be discussed in deeper detail later on in this thesis. The problem in this current development tool lays in its limitation in terms of space-creation potentials. If infill architecture is able, indeed, to help healing these leftover spaces, it is quite limited in reaching an urban response to matters like the densification issue, since its resulting changes in the urban landscape reflect much more a local improvement than a city-scale revolution.



PROGRAMATIC VOID

_Programmatic voids, meaning non-used spaces (built or not) that in some moment have lost their purpose and are, in fact, empty



TEMPORAL VOID

_Temporal voids, spaces built or used with a specific purpose and that for the most part of the year, when not in use, are left empty



MISSING TOOTH

_Unused spaces between existing buildings, not only created as a SLOAP, but sometimes after a demolition or an other event; popularly known as "missing tooth"



EDGE LANDS

_ "Edgelands", spaces in between new centralities or urban and rural areas. Without a clear function in the urban system, they end up becoming the host place for all contemporary societies' waste production, both literally and metaphorically

*a broader
challenge*

SUSTAINABILITY

The rhythm of these changes in the urban landscape remains in severe contrast to the rhythm at which the awareness of the consequences changes. Together with the demographic phenomenon, a huge issue concerning the sustainability of this constant growing global community makes the challenges raised for the future each time more sophisticated. In fact, the context in which such space scarcity is located, shows that these challenges are far more complex than the densification issue alone.

It is since the moment that the matter of ecology began to be present in everyday news with pressing warnings on environmental issues that the world began to be more sensitive towards the awareness of the planet and its health as a complete organism. And if it is already clear that at the present days the current means of resources management are not able to provide a sustainable organization, it is out of discussion that in the context predicted for the next fifty or hundred years the reaction will have to go beyond anything ever thought so far. And for achieving this, new systems have to be applied from now.

The way land and resources are currently being used has already begun to change in order to keep the environment safe. The word Sustainability itself, was only defined in 1987 by the Brundtland Commission of the United Nations.⁴ The so-called “sustainable design” now tries to eliminate negative environmental impact completely through skillful and sensitive design. Manifestations of sustainable design exclude non-renewable resources, impact the environment minimally, and relate people with the natural environment.

Beyond the “elimination of negative environmental impact”, sustainable design aims to create projects that are meaningful innovations and that can shift classical behaviors from the past. A dynamic balance between economy and society intends to generate long-term relationships between user and object/service, and finally to be respectful and mindful about environmental and social differences.

Given the great importance of this matter and the large amount of elements that it takes into account, a deeper investigation on the subject is made necessary, with the intention to define an effective way for designing future safe and healthy environments.





2. SUSTAINABLE DESIGN

From
“avoiding
the worst” to
“providing
the best”

CONCEPTS INTRODUCING SUSTAINABLE DEVELOPMENT

Since the 1990s, environmental evaluation methods and accreditation systems, like BREEAM (UK), LEED (US), HQE (FR) and DGNB (DE) have been developed. These methods comprehend different sets of criteria to be followed in the search for sustainability during the design process. In general lines, the criteria are grouped in categories such as: energy use, water, materials, waste, transport, land use and ecology. According to the overall score, the building under assessment is accredited a label/certificate usually from bronze to platinum.

Although these evaluation systems are being applied in many parts of the world already bringing important improvements to contemporary building systems, the application of such new strategies still doesn't result sufficiently spread, and the general agreement is that much more than this will be necessary for the future.

In fact, several new initiatives have been developed, with the only but substantial difference from the classical approaches in their methodology: first they state the goals, then achieve them over time by using specific plans. Some of these strategies raise the bar and conceive the most advanced measures of sustainability for the built environment, translating



the approaches into clear quantitative and/or qualitative objectives. In a final analysis, these new approaches not only try to limit waste, energy consumption and so forth, but aim at creating an added value to the building, its surrounding and the people who live or work in it.

This research points at gathering the best of some of the most successful methods. For this reason, the next pages present three explicative examples of such innovative and effective approaches, with the intention of acknowledging possible strategies to be applied in the design process of mutualistic densification that this thesis proposes. Hereafter, are presented a brief explanation of the "Triple bottom line", the "Cradle to Cradle", and the "Living Building Challenge" concepts.

TRIPLE BOTTOM LINE

One of the most widely accepted and used definitions of sustainable design of the past two decades is called "Triple Bottom Line". It relates at the same time to ecological, economic and social sustainability. According to its canons, these three different areas and their sustainable paths must retro-feed each other in order to reach a complete sustainable environment.

In *The Economist Guide to Management Ideas and Gurus*⁵, Tim Hindle explains that the expression "triple bottom line" was first coined in 1994 by John Elkington, the founder of a British consultancy called "SustAinability". After approaching the subject that year in *Towards the Sustainable Corporation: Win-Win-Win Business Strategies for Sustainable Development*⁶, in 1997, Elkington wrote a *Cannibals with forks: The Triple Bottom Line of 21st Century Business*⁷, in which he explains his concept, arguing that companies should be prepared for three different bottom lines.

- *Profit and loss account: so far, the only one traditionally used as a measure for corporate success.*
- *People account: a measure of how socially responsible an organization is throughout its operations*
- *Planet account: a measure of how environmentally responsible a company or initiative is.*

The triple bottom line (TBL) thus is known for these "three Ps": **Profit, People and Planet**. Only when taking into account the three of them, a company is taking responsibility of the full cost involved in doing any business. The concept claims that the responsibility of a given organization lies with stakeholders rather than shareholders. In this case, "stakeholders" refers to anyone who is influenced, either directly or indirectly, by the actions of the firm. According to the stakeholder theory, the business entity should be used as a vehicle for coordinating stakeholder interests, instead of maximizing shareholder (owner) profit.

With the ratification by the United Nations and the International Council for Local Environmental Initiatives, in early 2007 the Triple Bottom Line concept became standard for urban and community accounting. It also became the dominant approach to public sector full cost accounting.

But, in the words of Hindle, the idea had already achieved considerable success in the turn of the 21st century zeitgeist of corporate social responsibility, climate change and fair trade. He explains: "After more than a decade in which cost-cutting had been the number-one business priority, the hidden social and environmental costs of transferring production and services to low-cost countries such as China, India and Brazil became increasingly apparent to western consumers. These included such things as the indiscriminate logging of the Amazon basin, the excessive use of hydrocarbons and the exploitation of cheap labour. Growing awareness of corporate malpractice

in these areas forced several companies, including Nike and Tesco, to re-examine their sourcing policies and to keep a closer eye on the ethical standards of their suppliers in places as far apart as Mexico and Bangladesh, where labour markets are unregulated and manufacturers are able to ride roughshod over social and environmental standards. It also encouraged the growth of the Fair-trade movement, which adds its brand to products that have been produced and traded in an environmentally and socially 'fair' way (a concept, of course, open to interpretation)."⁵

Still according to Hindle, one problem with the Triple Bottom Line concept is that the three separate accounts cannot easily be added up. It is difficult to measure the planet and people accounts in the same terms as profits. The full cost of an oil-tanker spillage, for example, is probably immeasurable in monetary terms, as is the cost of displacing whole communities to clear forests, or the cost of depriving children of their freedom to learn in order to make them work at a young age.

But regardless of these difficulties in the method's measuring, the consequences of TBL concept raised awareness in important points for architectural design-related matters.

This approach started almost two decades ago, and led the following sustainability-related concepts to pay special attention to the construction process, leaving important lessons that are nowadays obsessively chased by whoever aims to a sustainable development.

– **The importance of the use of local materials:** *it touches all three bottom lines, due to the economical and ecological costs of long distance transportation and to the fact that local materials enhance local identity, culture and even economy when making use of specialized local labour.*

– **Sustainability in the conception of a design:** *decisions like the implantation, orientation and volumes created by an architectural project will influence and have consequences for the whole lifespan of a building, affecting its energy consume, for instance, according to local wind and sun orientations.*

– **Relationship with a building's surroundings:** *isolated sustainability does not exist. A building must communicate with its surroundings (built environment or not) and contribute for the area in order to become, indeed, sustainable.*

– **Social aspect of architecture:** *in the moment that the society is encouraged to engage with the choices and with the construction process of a building, the local community appropriates that space as partially "belonging" to themselves. This raises the safety of the building (by the constant vigilance of locals with this "appropriation" feeling), shrinks economic and natural costs with renovations (once the project is already responding to local needs) and contributes to the enhancement of local quality of life.*

Supply chains,
systems and manage-
ment of resources

CRADLE TO CRADLE

From an economical point of view there are plans for 2020 by the European Commission to transform the continent into a recycling society, with specific organizations involved in re-thinking life cycles. The goal is to "reduce environmental impact on natural resources and increase the resource efficiency of the European economy, which is essential for a sustained economic development."⁶

In 2006, the concept of Cradle to Cradle began to be popular - specifically in the Netherlands - inspiring people, industries and governments. This concept involves strategies of sustainable development, from products to buildings and whole areas; it is a manifesto calling for the transformation of human industry through ecologically intelligent design. With an innovative thinking, C2C mobilizes and inspires the collectivity, proposing a concept that incorporates both a different design approach and a necessary systematic way of thinking.

In the theoretical framework document written by P. Stouthuysen and D. le Roy about the C2C network in Europe its summarized the scope of the concept: "It covers supply chains, (the recycling of natural resources via product and manufacturing design, to high value reuse) and also involves systems (key supplies, ecosystems, space and energy) as well

as management (via money, rules, spatial planning). It is a concept that contributes to a reduction of the use of raw materials, generates less environmental pollution, contributes to our economic growth and allows to make better use of scarce space. It envisages a challenging future and incites us to move into a complete new way of product design and innovation. Cradle to Cradle is innovative given the very ambitious goals to create continuous loops in production, to integrate high standard principles in building and spatial design."⁷

The C2C Network aims at developing specific regional action plans, and a common language between parties - so that next to materials, also energy, logistics and social aspects will be included. The four target areas are: industry, building design, spatial development and governance.

Flanders DC* outlines 3 major phases in the development of the economy: a factor-driven economy, an efficiency-driven economy and an innovation-driven economy. C2C advocates the aspiration for the third kind of economy, driven by innovative partnerships and cooperations aiming at providing a response to the given social challenges. This means a proactive development where producers assume central responsibility for their products and services. The transition from eco-efficiency (that means minimizing the harm we inflict to nature) to eco-effectiveness (manufacture of fully healthy products) basically involves and requires a rethinking and redevelopment of the whole economic and social system.

The strong basic point on which Cradle to Cradle stands is the high level of ambition. In fact, as previously introduced, the type of changes that contemporaneity needs is huge and fundamental. And high ambitions build visions on how places regions and organizations should be in the future, setting the directions where innovation should point at. This means that the transition to the new industrial model requires more than an adjustment, but a total shift from “ownership” to “usership”⁷, where only an intensive new kind of cooperation between suppliers, producers, customers, consumers and material managers can make the system work.

When applying this concept to architecture, urban and regional planning, the rethinking involves not only design, but also the ways in which living, working, recreation, transport, nature, food production etc. are integrated in our lives. To fully implement C2C in architecture is necessary to enhance our working knowledge on materials and building products and their continuous cycles, so that buildings would recover nutrients and allow a proper material flow management.

The principles of C2C are developed in the 2002 book “Cradle to Cradle: Remaking the Way We Make Things”⁷ written by the two initiators of the concept: the German chemist Michael Braungart and the American architect William McDonough.

These principles are:

- **“waste equals food”:**

the idea that after the use of products and services, materials cannot be wasted, but should be part of a continuous loop. Much as in nature, materials do not need to come back to the original producer but, inspired by the functioning of living organisms, used materials change into nutrients after their use, for new natural or industrial production processes.

- **“use of current solar income”:**

After the Industrial and Technological revolution that created the illusion that humanity was no longer dependent on nature, the idea here is that the planet should rely – like all living organisms – on the energy of the sun, “eternal” and overabundant energy source. This should be implemented for heating, electricity and day lightning within buildings, and for manufacturing processes within industries. In addition to this, also wind, biomass, hydro, tidal, wave and geothermal energy can be integrated.

- **“celebrate diversity”:**

Just like diversity builds resilience in nature, such diversity should work as a model for human design, which would lead to more resilient organizations and even economies. And as nature is taking into account local conditions, the same principle leads in architecture to the ability of adapting to its local conditions, and maintaining its functionality in time.

C2C AND BUILDING DESIGN

A particular attention in the C2C concept focuses on the improvement of the current building design industry, mainly due to its high responsibility in global fossil fuel consumption (40%), greenhouse gas emissions (40%), raw material consumption, waste production and so forth. Given the gravity of such condition, the eco-effective approach is not simply a matter of limiting those bad effects, but on the contrary, a matter of inverting the process and pointing at a positive effect of buildings on the environment. McDonough and Braungart suggest a parallel with nature and introduce the concept of “houses like trees and cities like forests”, meaning that buildings should be harvesting energy from the sun, removing dust and CO₂ from the air, and so on.

C2C IN ARCHITECTURE

In 2009 an international group of architects published the manifesto “C2C in Architecture” with the ambition to translate the C2C principles into distinct and measurable milestones. They are listed hereafter:

a) Ecology

Materials

- *Eliminate waste: only use materials that will become resources for further biological or technical production loop.*
- *Only use materials whose impacts are measurably beneficial for human health and environment.*
- *Design buildings free of radioactive, hazardous and toxic off-gassing materials.*
- *If hazardous materials are necessary, they shall not be released in the environment but completely recoverable in technical pathways.*

Energy

- *Use only energy from present solar income.*

Site

- *Create topsoil, clean water and clean air and improve biodiversity as a result of human intervention.*

b) Economy

- *Design buildings that can be mined for materials in the future. If waste is a resource, materials become the new currency.*
- *Promote building products leasing and by doing so make producers responsible for them*

c) Equity | Society

- *Create a diverse environment of equal opportunity. Create a healthy, safe and inspiring environment.*

In this manifesto, these milestones were also translated into guiding principles for future architecture developments. According to it, Cradle to Cradle buildings shall work according to the following:

Guiding principles:

- Incorporate materials that are technical and biological nutrients which can be safely reusable nutrients.
 - Measurably use renewable energy. (Examples of renewable energy include solar, thermal, ground based and air-based heat exchange, wind, biomass, hydro and, photovoltaic).
 - Actively and measurably support biodiversity according to well-established biological tools for measuring species diversity.
 - Anticipate evolution and change, incorporating strategies and approaches that enhance the ability for the building to adapt to a variety of uses over time.
- Innovation concept to be actively used:*
- Think beneficially instead of how to be less bad.
 - Think big healthy footprint instead of a less bad minimized one.
 - Think eco-effectiveness instead of just eco-efficiency.
 - Improve quality of building systems, products and processes in measurable steps.
 - Partner with customers & suppliers to establish material partnership communities.
 - Think “materials opportunity” instead of “energy problem”.
 - Design building systems and pro-

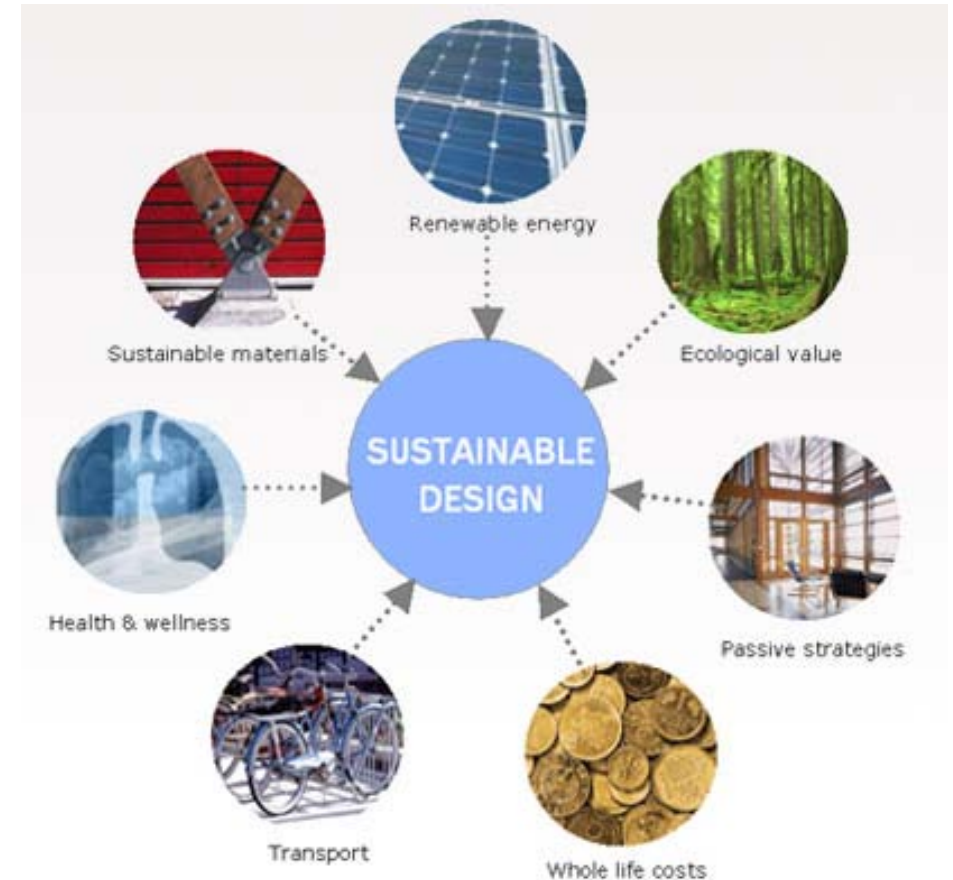
cesses according to their intended use for building occupants and for biological and technical metabolisms.

- Improve indoor air quality so it contributes healthy air to the building occupants, and to the outdoors.
- Design buildings areas and processes that are energy positive.

Intentions and goals for buildings and sites:

- Use building materials whose contents are measurably defined in Cradle to Cradle terms of chemical contents, effects on air, soil and water, and effects on human health from manufacturing through use and recovery in biological or technical pathways.
- Integrate topsoil production and carbon re-use into structures and landscapes to produce more biomass and soil than before development. Topsoil is defined here as the upper layer of soil, used for growing biomass. Topsoil is a main repository for carbon and for CO₂ capture and storage. (Example: green roofs).

The implementation of Cradle to Cradle at the scale of spatial area development is new, and firstly introduced in The Netherlands, in the Greenport Venlo case. This first example together with the nationwide enthusiasm about the C2C concept inspired several stakeholders, giving a hint of the potentials linked to the application of such an innovative approach.



Most current measure of sustainability

LIVING BUILDING CHALLENGE CONCEPT

The Living Building Challenge is a philosophy, advocacy tool and certification program that promotes the most advanced measurement of sustainability in the built environment possible today. The challenge was launched in 2006 and originally conceived by the Canadian architect Jason McLennan, then developed and managed by the Cascadia Region Green Building Council and International Living building Institute.

Their concept can be applied to development at all scales, from buildings – both new construction and renovation – to infrastructure, landscapes and neighborhoods. Living Building Challenge comprises seven performance areas: site, water, energy, health, materials, equity and beauty. These are subdivided into a total of twenty Imperatives, each of which focuses on a specific sphere of influence. The “rules” derivable from such imperatives give a better understanding of the proactive type of approach that focuses on the creation of extra value, in opposition to “only damage limitation”.

The Living Building Challenge imperatives:

- *Projects may only be built on grey-fields or brownfields – previously developed sites.*
- *All projects must integrate opportunities for agriculture.*
- *For each hectare of development, an equal amount of land must be set aside as part of a habitat exchange.*
- *Each new project should contribute towards the creation of walkable, pedestrian-oriented communities.*
- *One hundred percent of occupants' water use must come from captured precipitation or closed loop water systems.*
- *One hundred percent of storm water and building water discharge must be managed on-site or on adjacent sites.*
- *One hundred percent of the project's energy must be supplied by on-site renewable energy on a net annual basis.*
- *Every usable space must have operable windows that provide access to fresh air and daylight.*
- *Projects must meet certain criteria to assure good indoor air quality.*
- *The project must be designed to include elements that nurture the innate human attraction to natural systems and processes.*
- *The project cannot contain any of the materials or chemicals on the Living Building Challenge Red List.*
- *The project must account for the total footprint of embodied carbon (tCO₂e) from its construction and projected replacement parts through a one-time carbon offset tied to the project boundary.*

- *The project must advocate for the creation and adoption of third-party certified standards for sustainable resource extraction and fair labor practices.*
- *Source locations for materials and services must adhere to certain restrictions to limit transportation distances to the building site.*
- *All project teams must strive to reduce or eliminate the production of waste during design, construction, operation, and end of life in order to conserve natural resources.*
- *The project must be designed to create human-scaled rather than automobile-scaled places, so that the experience brings out the best in humanity and promotes culture and interaction.*
- *All primary transportation, roads and non-building infrastructure that are considered externally focused must be equally accessible to all members of the public regardless of background, age and socio-economic class.*
- *The project may not block access to, nor diminish the quality of, fresh air, sunlight and natural waterways for any member of society or adjacent developments.*
- *The project must contain design features intended solely for human delight and the celebration of culture, spirit and place appropriate to its function.*
- *Educational materials about the performance and operation of the project must be provided to the public to share successful solutions and to motivate others to make a change.*



3. NEW LAYERS FOR THE CITY

METROPOLIS

a 1927 German expressionist science-fiction film, picturing a futuristic urban dystopia with series of different circulation levels

**New spaces
for future
developments**

Previous spatial researches

EXPANSION TO ALTERNATIVE LAYERS

Cities are made of a continuous and tight built pattern. At a ground level, streets and walkways represent the scene for human interaction and movement; the interiors of buildings accommodate private and collective spaces; and at underground levels fast lines of transportation have been created. In the context of urban densification and lack of free space previously described, it becomes now necessary to explore alternative ways for responding to the constant expansion of cities. In this view, portions of cities that have not been really thought to be implemented so far, start to represent a great potential.

Representing a very different solution than using urban voids and leftover spaces, proposals for the creation of new *layers* for the city have been under investigation as a possibility for future use, and - in some cases - have already been applied. More specifically, two layers that have been considerably

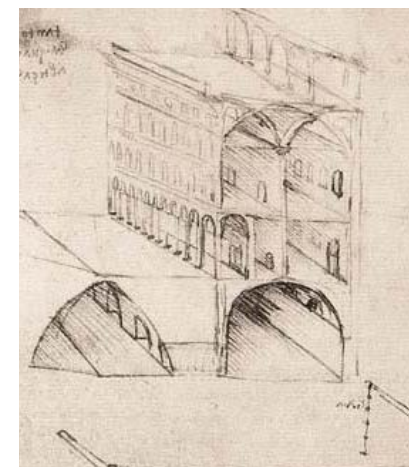
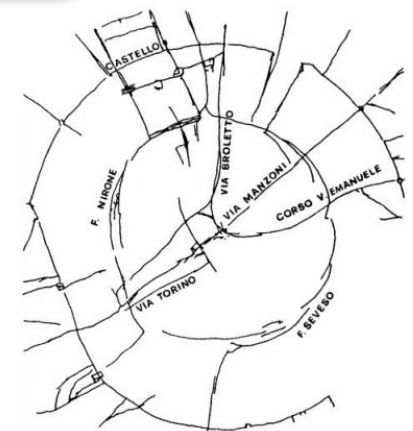
explored, are the immediate contiguous levels that frame the existing layer: the upper and lower levels of cities. In some cases these proposals had very similar goals to the one of this research: to work as an answer to densification demands.

In the course of the historical development of cities, each time dictated by a different trend of expansion, urban planners have visioned innovative ways to expand city boundaries, not only in a horizontal way. Given the constraints and the purposes of this research, hereafter are collected a number of examples of expansion to alternative levels. These examples show how the creation of such layers has been treated throughout ancient and more contemporary times. A combination of realized and hypothetical solutions gives an insight of what are the existing explored possibilities of dealing with *inwards growth*, where the existing pattern is left untouched.



THREE LAYERS OF MILAN

At the end of the 15th century Leonardo da Vinci was working for the Sforza family in Milan. For transport efficiency reasons, he designed a network of navigable artificial canals that connected the city of Milan with the nearby river Ticino. He therefore thought of a new circulation arrangement, so that transportation via water was placed just below the ground level. At the street level, the public flow was kept. The first floor, in the meanwhile, was reserved for the nobility. This kind of arrangement represented one of the first functional solutions for solving problems related to congestion of traffic (people and goods) when cities were starting to be involved in global trade. Only the space at ground level was not enough anymore, and new layers of circulation had to be integrated with the traditional ones. This represents one of the first upwards and downwards expansion in history, and is relevant still today given the underground transportation systems developed in the past two centuries.

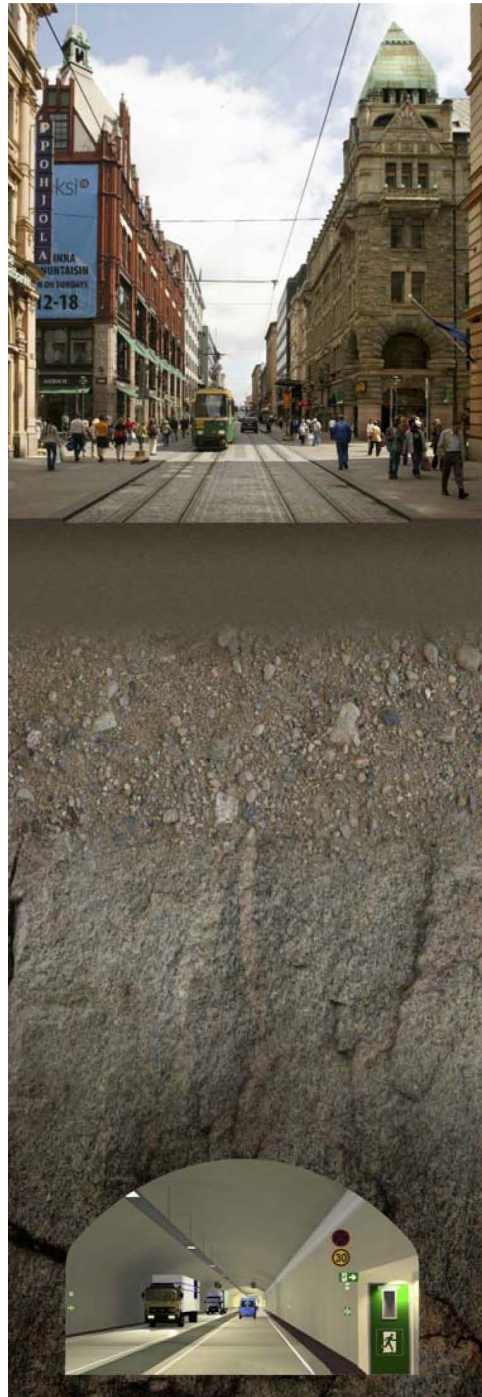


underground and
over street networks

RAPID TRANSIT SYSTEMS

Da Vinci's suggestions took more than three centuries before beginning to be considerably developed and applied in other cities. In 1863 the first section of underground railway of the world was built in London. Since then, rapid transit systems, typically located either in underground tunnels or on elevated rails above street level, spread to other cities in Europe, to the United States and then to the rest of the world. Elevated systems, actually, only began to be integrated to these networks three decades later, in 1893, with the Liverpool Overhead Railway. These systems are still the basis of urban mass transportation in the biggest capitals of the world and their success is basically due to the same logic that da Vinci explored - the use of an alternative layer for circulation, in order to avoid the over-saturated street level.

Nowadays the underground and "above-street" levels of big cities also extend the offer of that alternative levels for cars and pedestrians - either in networks to complement the rapid transports, like in Paris - or in independent networks, like numerous examples of underground and skyway pedestrian connection systems.



Helsinki's Underground City

UNDERGROUND MASTERPLAN AND 3D PROPERTY MAP

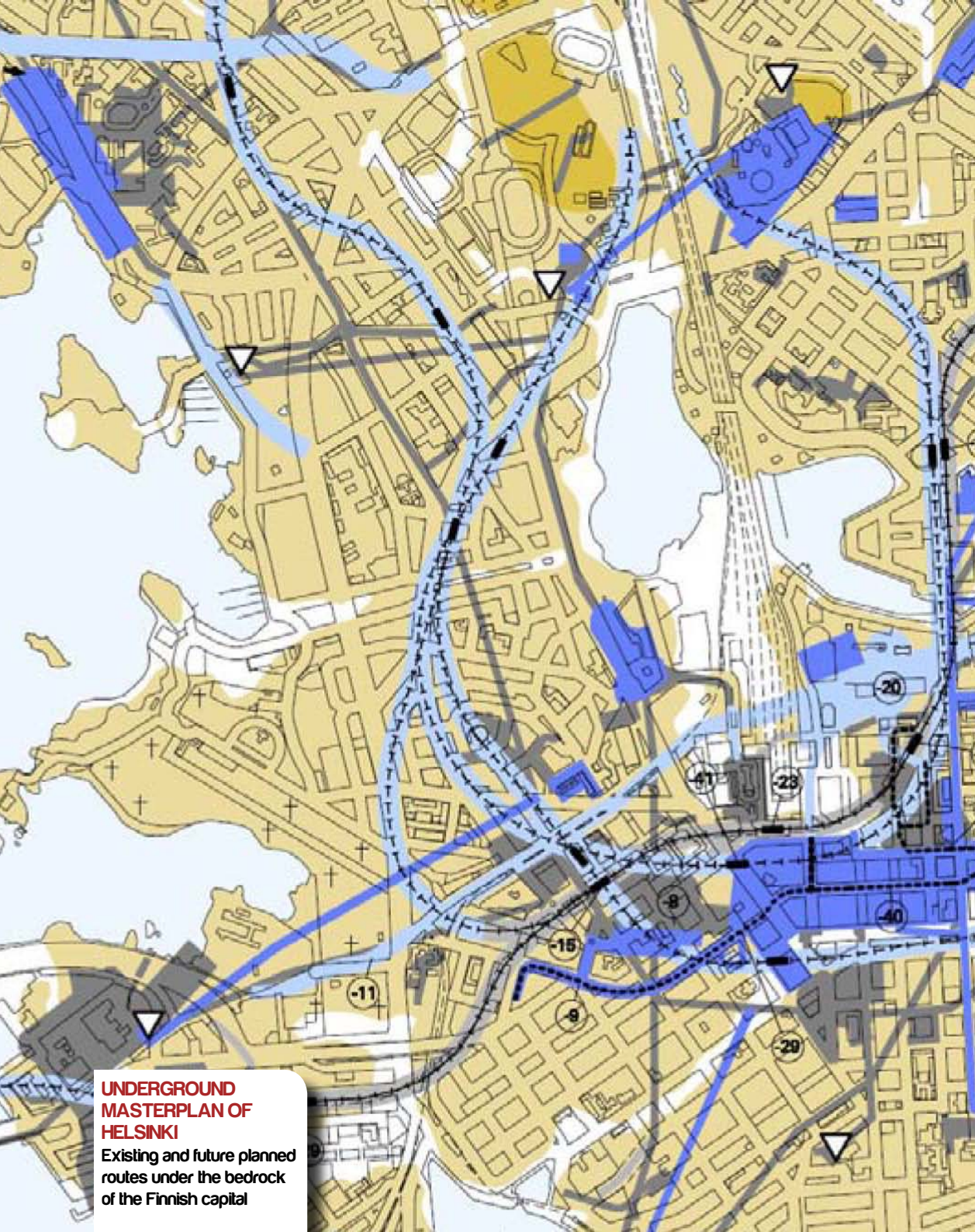
North American cities provide many examples of underground planning, Northern Europe also comprehends a very special one. In Helsinki an impressively extensive use of the underground level is shared by subway trains, pedestrians, cars, stores, public squares, an underground swimming center, escape routes for important official buildings (like the parliament) and even a church, the Temppeliaukion kirkko, excavated and built into the rock in the neighborhood of Töölö. The success of this strategy spread throughout the city center reached the outskirts, stimulating also the creation of a tunnel under the water to connect the neighbor island of Suomenlinna for emergency use.

Over several years the Finnish capital has built this vast network of tunnels under its bedrock. The main difference with most of the underground networks is that Helsinki's one does not focus on expanding the commercial retail space of buildings, but on hiding industrial uses from the city's historic core. Its Underground Master Plan (the first one in the world) involves utility services like district heating/cooling, coal storage, data centers, and various other uses that don't need the scarce Nordic sunlight. However, the scale and depth of this

network introduces a problem of underground property ownership. Helsinki is trying to solve property registry conflicts by taking them literally to another dimension. Property registration is becoming a 3D record moving beyond just a 2D plot of land. This makes it very different from the U.S.A. Model, where flat maps guarantee property rights to the owner from the core of the earth to the sky extension over one's land. Those rights, then, need to be regulated by various governmental agencies; the General Mining act for the underground, municipal zoning at ground level, and the FAA at a given height. The experience of Helsinki, on the other hand, acknowledges that ownership based on height can allow separate owners on the same plot at different levels. Helsinki's 3D approach exemplifies the future of property registration for urban landscapes under continuous densification.

According to the CNN program "*Europe's underground city*"⁸, in order to keep the low-rise characteristic of the city and avoid urban sprawl (once limited by the river on one side and the existing buildings on the other), the underground was the most plausible space for Helsinki to advance towards. And what made it possible was the hard bedrock over which the city lays.

The program emphasizes the functional variety of Helsinki's structure that differs its underground network from the others elsewhere: "The policy of putting industrial facilities beneath the surface helps to free up land above ground for



UNDERGROUND MASTERPLAN OF HELSINKI

Existing and future planned
routes under the bedrock
of the Finnish capital

more profitable real state developments”
“Down below there is the only world’s
fully automated underground coal storage
facility. Four enormous silos store
enough coal for half of the city’s annual
consumption and all that remains on the
surface is a discrete coal shaft. Perhaps
the most extensive use of the bedrock
is within the city’s district heating and
cooling system. 60 km of tunnel, deep
beneath the surface, provide heating and
hot water to Helsinki.”

Juha Sipila, employee of Helsinki’s
energy company, explains the advantages:
“in most cities, all the cables and pipes
go underneath the asphalt and for main-
taining you need to break the asphalt
and have a digging machine in between
the cars and the traffic, but in Helsinki
we have a very good tunnelling network
crossing underneath the city and we can
supply all the cables and pipes from tun-
nels and don’t need to disturb the traf-
fic.”

CNN Reports also comments the at-
titude of the government towards the
clash between heritage and the city’s
development: “the magnificent Uspenski
Orthodox Cathedral is proof that no part
of Helsinki remains untouched by the
underground city. The old and the new
come together wether it’s the pipes pro-
viding the heat for the worshippers here
or the revolution going on down below
in the Cathedral’s bomb shelter: 30m
beneath the surface 2 Finnish compa-
nies have joined forces and created the
world’s greenest data center of its time.

Jarmo Tuovinen, speaking in name of
the companies, sets the picture: “*data
centers are consuming at least 2% of all
energy consumed in the world. In most
data centers, just half of the energy con-
sumed is used by the computers them-
selves. The rest is used to cool the com-
puters down.*” The difference is that in
the case of Helsinki’s data center no en-
ergy at all is used for cooling purposes,
due to the good temperature insulation
on the underground and the opportunity
of being just by the freezing Finish sea
that provides an abundant source for di-
rect exchange of temperature to cool the
computers. The heated water created
by this exchange, in the words of the
reporter “leaves the data center through
pipes which carry it 70 m down to the
underground tunnelling network that lies
beneath Helsinki. From here that heat
continues its journey through the pipes
and arrives at its final destination heating
people’s homes.”

Interviewed for the program, Helsinki’s
mayor Jussi Pajunen says that it is rela-
tively inexpensive to build in the under-
ground and answers about the reasons
to use that space with another question:
“Why not?” The mayor’s vague answer
about the costs of building in the under-
ground, however, finds in another North-
ern European country a very precise set
of calculations to support his opinion.

THE NEW UNDERGROUND PLANNING MAP OF THE NETHERLANDS

Following the example of Helsinki's underground Master plan, in 1998 a *Feasibility Study of the Possibilities for the Use of Underground Space in the Netherlands* was conducted, aiming a more large-scale and systematic use of the underground in the western part of the country, the so-called 'Randstad'. In a country where land reclamation from the water plays a central role in the seek for new usable space (constituting 26% of the current area of the country), the government has foreseen the potentials of "space-reclaiming" also from the underground and elaborated a complete document about all the advantages, difficulties and consequences of the possibility.

According to a study published by *Elsevier Science* (a global company headquartered in Amsterdam), the Feasibility report from the government "examined the possibilities of improving an idealized model of the future spatial development (...) by using more extensively the underground space. Improvement meaning an enlargement of the efficiency of the use of space and maintenance or enlargement of the spatial quality of the area. Societal, cost, groundwater and policy aspects were investigated."⁹ Summarizing the document, the study from *Elsevier Science* exposes 11 important points, from which a core of 6 was extracted and briefly explained hereafter:

1 WHY TO GO UNDERGROUND?

In the study, three basic reasons for going underground were identified:

- **To strengthen the quality of the living environment.**

By constructing certain functions underground, nuisance and hazard can be limited. Disturbing effects such as sound, stench and emissions are isolated and safety risks for people living or working nearby the function can be diminished.

- **To achieve more efficient use of space.**

More building volume can be realized on the same ground area. Also, the use of underground space makes combination (piling) of several functions possible.

- **To strengthen the spatial-functional structure.**

By constructing certain facilities underground, valuable areas and functions can be spared. The character of historical centers or natural areas, for instance, can be saved by underground construction of infrastructure and also barriers can be prevented. Furthermore, underground construction offers possibilities to combine mutually reinforcing functions into a more effective functional structure (for example, the combination of retail, storage and parking).

2. SPATIAL EFFICIENCY ASPECTS OF GOING UNDERGROUND

Use of the underground space can lead to a higher spatial efficiency. Three situations were identified:

- **Proportional gain in space.**

The case of an environment where there are no special quality demands (with regards to green areas, open space etc), so that the space directly above the underground construction can be used for other buildings.

- **More than proportional gain in space.** Functions that normally cause considerable disturbance in their environment, e.g., highways or storage facilities for dangerous substances. Normally, either there would be no building in large noisy zones and/or there would be safety zones around these functions. Constructing the function underground therefore not only releases the space that such a function would take in itself, but also (a part of) the space of those disturbance zones.

- **Less than proportional gain in space, on behalf of spatial quality.** In certain cases the use of the underground can be aimed mainly at achieving more spatial quality. The space above ground thus released is then not wholly used for building again, but is left (partially) free, to create, for example, more green, light and space in an area that is densely built up.

Starting from the possibilities for using the underground for the different functions and the three forms of gaining space described above, an estimation was made of the maximum possible gain in space per type of area, when leaving the quality of the inner and outer space still at an acceptable level. This leads to estimates of possible gains in space ranging from 5-15% for city environments, to up to 100% for infrastructure areas.

3. GROUNDWATER ASPECTS OF GOING UNDERGROUND

Because building structures underground can have large and lasting effects on groundwater, these effects were taken into consideration. Groundwater has a number of essential functions, related to:

- **Ecology.** Groundwater determines the water balance in the soil on which natural environment strongly depends. Quality and quantity of groundwater perform an important role in this.

- **Public water supply.** Two-thirds of the groundwater in the Netherlands is used for drinking water and industrial uses. Therefore a high quality of ground water is necessary.

- **Feeding of agricultural crops.** For every type of crop, there is an optimal ground water level. Changes in the ground water level can lead to losses in yield.

- **Recreation.** Changes in the water mark influences vegetation and access to recreational areas, and the possibilities for using recreational waters.

- **Building and infrastructure.** For buildings on wooden pile foundations and for roads, dikes and networks of pipes, a more or less constant level of groundwater is desirable to avoid damage through subsidence.

To preserve these essential functions, the original ground water situation should be left intact as much as possible. However, some smaller or larger changes in the ground water situation will always occur if an underground structure is built. For a general understanding of these effects the following ground water aspects are important:

- **Infiltration:** vertical downward flow of ground water, for example the entry of rainwater from the surface into the soil.

- **Upward seepage:** vertical upward flow of ground water.

- **Groundwater system:** a (more or less) closed circuit of ground water flows within a defined area where (rain) water infiltrates, flows horizontally and wells upward again.

Underground construction will not cause too many problems for the groundwater situation if the conditions mentioned in Table 3 are taken care of.

4. COST ASPECTS OF GOING UNDERGROUND

The costs of buildings are determined by construction costs, prices of land and exploitation costs.

Exploitation costs are made up of costs for maintenance and use of energy. They are made during the whole duration of life of a building, in contrast to the construction costs and costs of land that have to be covered directly at construction. The table shows that underground construction has consequences for costs. In all cases, higher investments are needed for construction, but these can be (partially) recovered by savings on the costs of land and exploitation. Less surface is needed for the same amount of building, and less maintenance is needed for outer walls and roofs. Also, the use of energy for heating and cooling is lower (but the use of energy for lighting is higher). Underground construction can also be favorable for security and other reasons, but these were not included in the calculations.

Table 1. Comparative overview of construction costs, land costs and exploitation costs (relative, per square meter).

Type of Building	Percentage Under-ground	Construction Costs		Land Costs		Exploitation Costs	
		Above ground	Below ground	Above ground	Below ground	Above ground	Below ground
High-quality commercial and industrial building:							
• City centre, low ^a	33%	100	113	100	67	100	86
• City centre, high ^b	17%	100	107	100	83	100	83
• Outskirts, low ^a	20%	100	110	100	64	100	81
• Outskirts, high ^b	20%	100	110	100	60	100	81
Low-quality commercial and industrial building:							
• 1 storey underground	50%	100	170	100	50	100	81
• 2 storeys underground	67%	100	193	100	33	100	74
Residences:							
• Low-rise	25%	100	113	100	75	100	84
• High-rise	13%	100	112	100	87	100	87
• refers to predominantly low-rise buildings • refers to predominantly high-rise buildings							

^a refers to predominantly low-rise buildings

^b refers to predominantly high-rise buildings

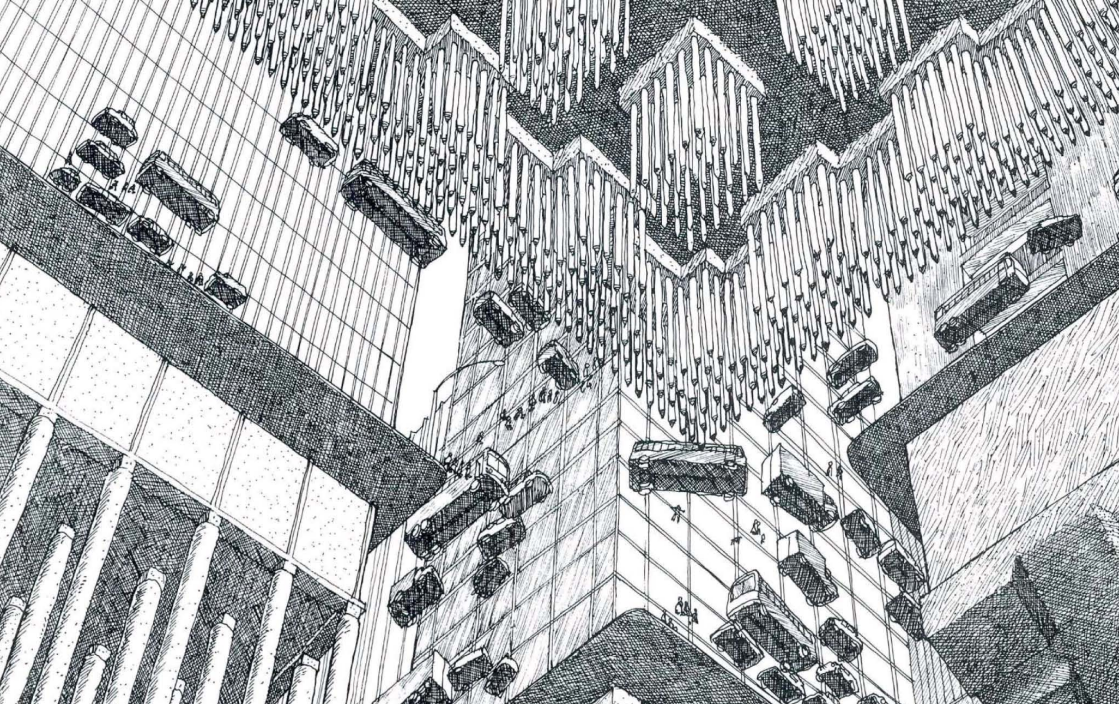
Type of Building	Percentage Underground	Share of construction costs, land costs and exploitation costs in total costs (%)						Total Costs (construction costs, land costs and exploitation costs)	
		Above ground			Below ground			Above ground	Below ground
		co	la	ex	co	la	ex		
High-quality commercial and industrial building:									
• City centre, low ^a	33%	61	8	31	68	6	26	100	101
• City centre, high ^b	17%	64	5	31	68	3	29	100	101
• Outskirts, low ^a	20%	64	14	32	61	9	30	100	98
• Outskirts, high ^b	20%	57	10	33	64	6	30	100	99
Low-quality commercial and industrial building:									
• 1 storey underground	50%	48	24	28	70	11	19	100	116
• 2 storeys underground	67%	48	24	28	76	7	17	100	122
Residences:									
• Low-rise	25%	37	25	38	44	18	37	100	96
• High-rise	13%	43	14	43	48	10	42	100	101

^a refers to predominantly low-rise buildings
^b refers to predominantly high-rise buildings

^a refers to predominantly low-rise buildings

^b refers to predominantly high-rise buildings

Urban area	None, the natural ground water situation is on average already seriously disturbed
Infiltration area	Preferably in large groundwater systems, possibly in small systems (dependent on the relationship between the size of the system and the size of the disturbance)
Areas independent of upward seepage	• Preferably in large groundwater systems, possibly in small systems • Lineshaped constructions (infrastructure) preferably in the aquifer • In aquifers: either parallel to the direction of the ground water flow or blocking no more than 50% of the height of the aquifer.
Areas dependent of upward seepage	• Not in small groundwater systems, unless when there is only a limited depth necessary for construction • Lineshaped constructions preferably in the aquifer • Lineshaped elements in aquifers: either parallel to the direction of the ground water flow or blocking no more than 50% of the height of the aquifer
Drinking water areas	No underground construction



the examples of Turin, Paris,
Utrecht, Delft, Amsterdam

RIVER AND CANAL BANKS

The height difference between the water surface and the street level in cities with canals or rivers represent one particular way of exploring a high quality part of the underground: the banks of rivers and canals. Those potential volumes hidden behind canal (and river) walls have been successfully explored through the last centuries.

In Turin, Italy, the huge difference from the Po river to the street level hosts bars and restaurants, while in Paris the banks of the River Seine host a reserved walkway, some meters away from the cosmopolitanism of the city, that helped to shape the romantic character of the French capital.

In Utrecht, a canal system designed for transportation and distribution of goods used to have an efficiency problem related to this difference of levels between water and street. The employees of canal-front warehouses needed to bring the goods one level up, in order to get inside the warehouses and only then go back one level down to store the goods in the cellar. A spontaneous initiative from an owner of opening doors and windows connecting the cellar and the canal level was quickly reapplied throughout the whole city. Nowadays, most of these cellars became restaurants, bars and galleries, exploring the new main use of the canals: the touristic potential of historical centers.

In Delft, a number of small stairs lead to compact public spaces dedicated to relaxing and enjoying the relation with the canals. In most of the cases, these spaces fit no more than a seat, and they are shared between the inhabitants of the city and those of the canals, like ducks and swans. Facing the Oude Kerk, a little door under the sidewalk that leads to Prince van Orange's "war-times residence" suggests an alternative escape route.

Another example is the old prison of Amsterdam, built inside the banks, behind the higher canal walls around a wide bridge over the Singel. Recently, the space has been used as a museum and at this moment hosts sporadic cultural events opened to the public. The access is made descending some stairs aside the canal walls and through a door entering the bank. Once inside, the interior space shows that the height needed to bridge over the boats provide a volume with extreme potential for utilization. That kind of potential volume is spread all over the Grachtengordel, in one of the most restricted urban environments, where the densification seems impossible to be hosted in the traditional layer of the city.

5. RECOMMENDATIONS FOR GOVERNMENTS

Among the roles the document suggests that governments should play, one can be highlighted:

Stimulating role. Provinces should "show the way" by paying attention to the use of the underground in their own spatial plans and other policy plans. Further, provinces could make available funding for executing exemplary projects. And, finally, in this role provinces could contribute financially to the extra costs of innovative underground solutions.

6. CONCLUSIONS OF THE FEASIBILITY STUDY

The conclusion of the study has an extremely optimistic tone towards the use of the underground as a base for future expansion in the Netherlands:

"the study showed some remarkable results. For one thing, gains in available space up to 50% in specific areas of the Randstad seem possible (even 100% for infrastructure areas). For another, when costs of energy and maintenance were taken into account, underground construction for offices, hospitals and parts of houses was no more expensive than above-ground construction, which contradicts a widely held belief in the Netherlands. Especially for commercial services, underground construction seems a viable option. Finally, once again the high potential of putting the distribution (and circulation) function underground was confirmed."



PARIS AND TURIN
leisure use of the river
banks in big European
cities



**AMSTERDAM, DELFT
AND UTRECHT**
intense use of canal net-
works in the Netherlands
led to different ways to
explore banks in each city



*plans by the
police department and
by Zwarts & Jasma*

UNDERNEATH AMSTERDAM

The specific space of Amsterdam constituted by the Grachtengordel, as a matter of fact, has been inspiration for a number of projects that gather the potentials of the Dutch underground (dissected in the last pages) with a very special position, the heart of the inner-city of Amsterdam. In an attempt to improve the efficiency of this symbol of Dutch traditional architecture, the police department, for instance, made a proposal in 1903 to transform the space under the canals in a special high-speed lane for emergency use. That potential volume in the middle of the city-center is hidden under a very thin layer of water and offers huge possibilities, like the potential of circulation. In fact, the network of canals above them was designed exactly with the goal of “circulation efficiency” when the main mean of transportation was naval. The proposal was never materialized, but the potential of the idea keeps producing proposals that explore the same logic until nowadays.

The most notable recent one is a study from Zwarts en Jansma called AMFORA (acronym in Dutch for Alternative Multifunctional Subterranean Development Amsterdam). The main goal of the project is to create a new layer for cars, “giving back the streets of the city to the pedestrians, as it used to be centuries ago”. But the project also intends to use the underground to host many other functions that, throughout time, ended up banned from the expensive city center, like sports facilities, big supermarkets and parking places, one of the biggest problems of the area.

Besides proposing this solution for the central issue of space scarcity, the authors of the project also list possible environmental advantages: “The water in the canals becomes cleaner, the underground spaces offer possibilities for the storage of heat and cold and the air quality is considerably improved, because particulate matter, CO₂, NO_x and other hazardous particles can be filtered from the air.” About the other big controversy of the project, the costs issue, they use a very simple calculation to defend the plausibility: “Less than € 30,000 per parking space. AMFORA is, therefore, not a utopian plan”¹³, they conclude.

AMFORA PLANS
project by Zwarts en Jansma aiming the complete replacement of Amsterdam city-center traffic to the underground level



*Communitarian
project and Constant
Nieuwenhuijs' New Babylon*

OVER THE ROOFS OF THE NETHERLANDS

Not only the underground, but also the space over Amsterdam's inner city inspired space-research projects and small-scale interventions. Recently, a group of neighbors from the surroundings of the Eenhoornsluis, in Korte Prinsengracht began to collect a list of signatures to support the proposal of a common rooftop-park. According to the project of the Argentinian architect Georgia Alaniz, who lives in one of the penthouses, the green surface would be developed over flatten rooftops of a group of 20th-century buildings, including a supermarket that would benefit from the insulation provided by the rooftop-park.

But bigger and more utopian proposals over the houses are also part of the city cultural heritage. In the early 1950's, the Dutch artist Constant Nieuwenhuijs, after reading Johan Huizinga's "Gay Ludens"¹⁴, developed the idea of a utopian city, his *New Babylon*. Conceived to be a place where men are free from physical labor in order to become exclusively devoted to the development of creative ideas living in an aerial structure over the existing city.

For almost 20 years Constant worked with the help of assistants on drawings that cover the whole map of the Netherlands. In addition, paintings, models (of plexiglass, wire and wood), collages, lithographs texts and even movies were part of the exhibitions and lectures about the *New Babylon*. He considered the project as "the design of a new culture".

According to the official website of the movement to which he was engaged, *Situationist International*, *New Babylon* envisages a society of total automation in which the need to work is replaced with a nomadic life of creative play, where traditional architecture has disintegrated along with the social institutions

that it propped up. The website recovers a text by Mark Wigley extracted from an old website (not online anymore, called: 'New Babylon - The Hyper-architecture of Desire'). Wigley explains in his text the architectural aspect of the project, that raised a lot of discussion in Dutch architecture by then:

"A vast network of enormous multilevel interior spaces propagates to eventually cover the planet. These interconnected 'sectors' float above the ground on tall columns. While vehicular traffic rushes underneath and air traffic lands on the roof, the inhabitants drift by foot through the huge labyrinthine interiors, endlessly reconstructing the atmospheres of the spaces. Every aspect of the environment can be controlled and reconfigured spontaneously. Social life becomes architectural play. Architecture becomes a flickering display of interacting desires."¹⁵

Constant always saw New Babylon as a realizable project, which provoked intense debates at schools of architecture and fine arts about the future role of the architect. Among the enthusiasts of the project, Rem Koolhaas, considers that New Babylon made many architects think and refers to Constant as "an example of courage".

Constant insisted that the traditional arts would be, in future, displaced by a collective form of creativity. The project had a major influence on the work of subsequent generations of architects. It was published widely in the international press in the 1960s and Constant quickly attained a prominent position in the world of experimental architecture.

Joost Kühne: air rights and costs issue

PORTIONS OF AIR IN ROTTERDAM

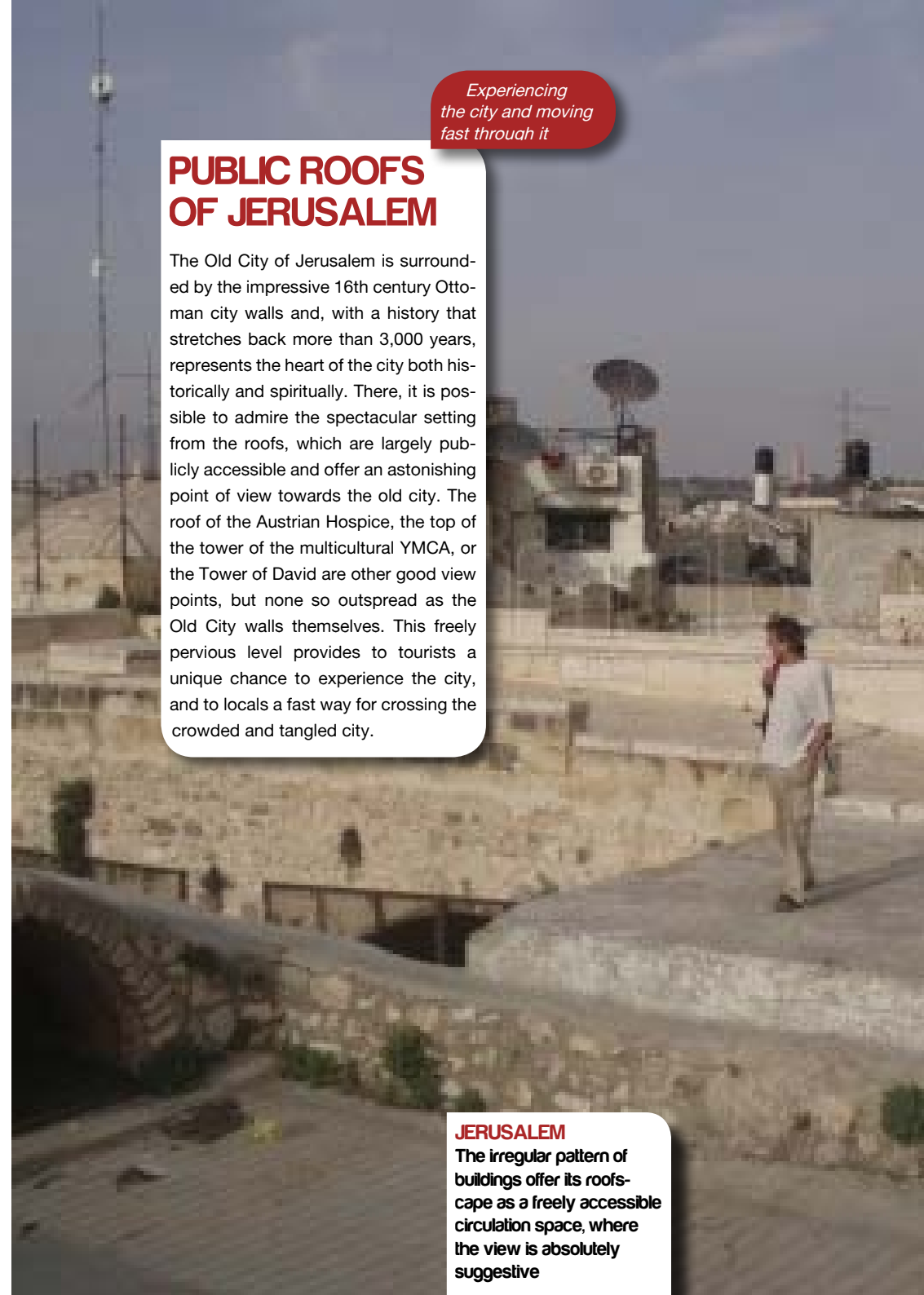
In Rotterdam, Second World War bombs made the heritage issue enormously less present, creating a lot of vacant spaces, (70% to 80% of the buildings went down due to the bombing). However, less than seven decades after, the densification issue is already a challenge present in the debates about the new city center. In its 2011 December issue, the architectural journal "Binnenstadkrant Rotterdam", brings an article called "building twice in the same plot"¹⁶, with an interview with the architect Joost Kühne. In that interview, he explains his search for spaces to build in the city center. His own Architecture Office, built on poles over a parking place in Boomgaardsstraat, was his first experience in buying the "air rights" from the municipality. The second floating building by him is already hanging two blocks ahead, above the Boomgaardhof. In his research for new spaces within the city center, he already pointed other 180 candidate-spaces to become "air plots" in the inner city of Rotterdam. According to him "After the war, people built a lot, but the buildings were not connected. This means that there are a lot of strange places and holes. By looking with a different eye to these places, one can see a lot of possible places to build in the inner-city". And his solution also finds financial balance, once "In general you pay less for the plot, however the building itself is more expensive. It is much harder to build on poles than on the ground".



Experiencing the city and moving fast through it

PUBLIC ROOFS OF JERUSALEM

The Old City of Jerusalem is surrounded by the impressive 16th century Ottoman city walls and, with a history that stretches back more than 3,000 years, represents the heart of the city both historically and spiritually. There, it is possible to admire the spectacular setting from the roofs, which are largely publicly accessible and offer an astonishing point of view towards the old city. The roof of the Austrian Hospice, the top of the tower of the multicultural YMCA, or the Tower of David are other good view points, but none so outspread as the Old City walls themselves. This freely pervious level provides to tourists a unique chance to experience the city, and to locals a fast way for crossing the crowded and tangled city.



JERUSALEM

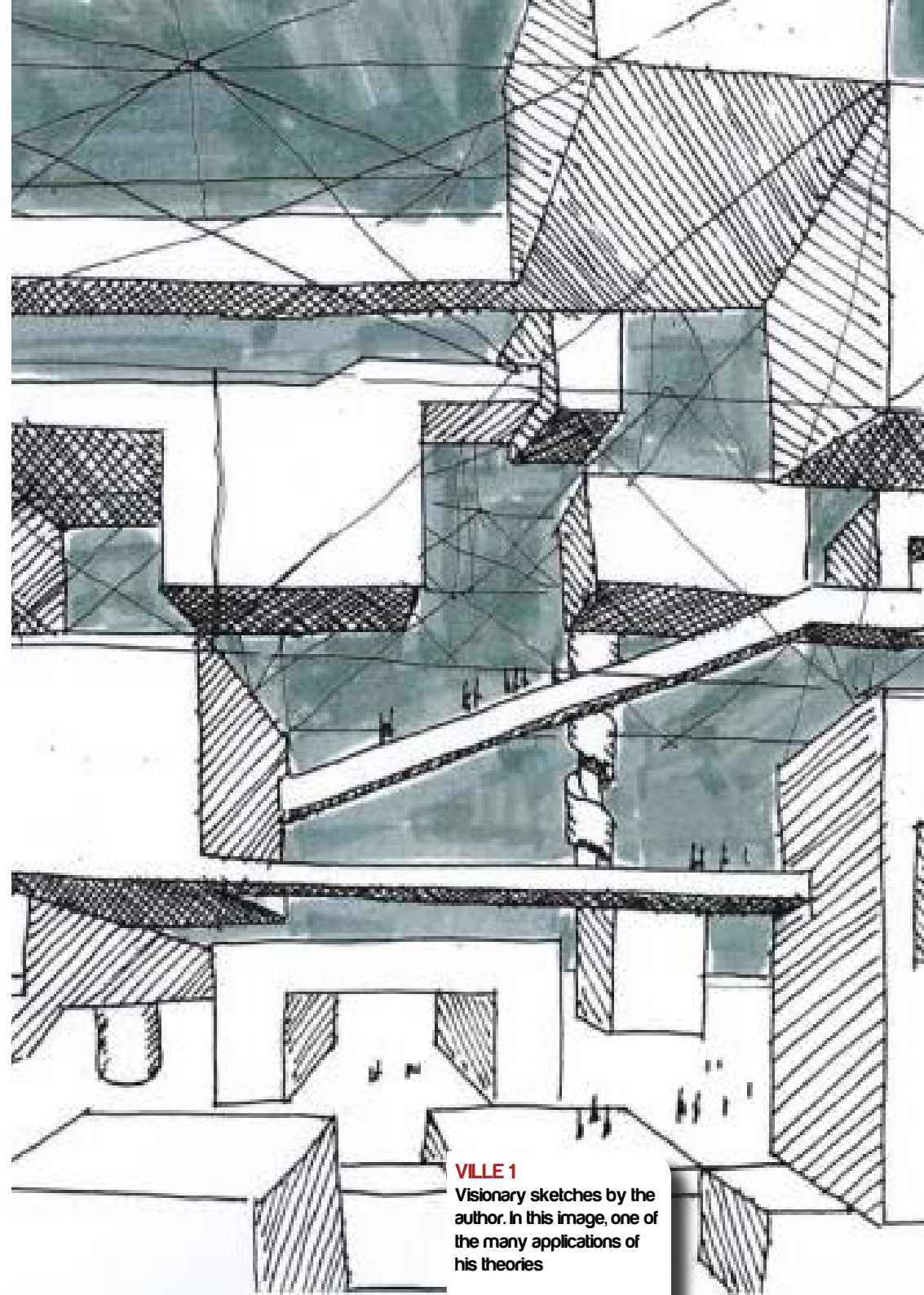
The irregular pattern of buildings offer its roofscape as a freely accessible circulation space, where the view is absolutely suggestive

VILLE SPATIALE

During the 1950s and 60s, architects and planners investigated alternative ways through which design could respond to the cultural and technological era, and developed new urban visions that were able to offer more freedom and grater opportunities for individual expression. In this scenario, and pushed by the French housing shortage of the late 1950s, Yona Friedman created new urban concepts such as the *Ville Spatiale* and *Mobile Architecture*, based on the free organization of a city by citizens, using low-cost materials and reusable modules.

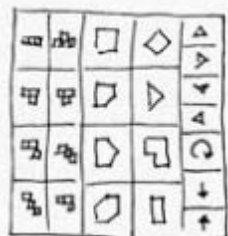
Ville Spatiale is an architectural mean of the democratization of urban design built up by the citizen themselves. It advocates an architecture without plans that adapts to people's desire and implement a negotiation between neighbors. Friedman embraces the unpredictability of future behavior and insists that planners should rather lay a framework within which the inhabitants can structure their surroundings however they like. In addition, this kind of architecture was meant to be able to be expressed in a large number of ways through prefabricated elements that could be arranged, altered and modified at a later stage according to the occupants' preferences. The architect, then, becomes only a mere consultant, only in charge of designing the (infra)structure that will provide space and necessary resources for the city to grow.

His vision was conceived of an urban structure on piles, appropriate for spaces where building is not possible or permitted (like water or wetlands, or above existing used areas such as farmlands or cities). That could leave untouched the level below. Basically, a second city was raised upon the existing one, fifteen to twenty meters above. This project was designed for being constructed anywhere, and meant to be adapted to any climate. The framework was the primary fixed structure, while the residences were conceived and built by the inhabitants and inserted into the framework's voids. On each level, half of the space should be left free in order to provide air and light to each residence, as well as to the city below. Several layers could be stacked on top of each other so that, for instance, the lower level could be utilized for public life, community services and pedestrian areas, while inside the structure piles vertical the means of transport were inserted. Finally, the superposition of many levels would make possible the creation of whole new cities.

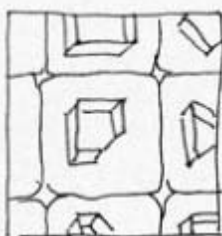


VILLE 1

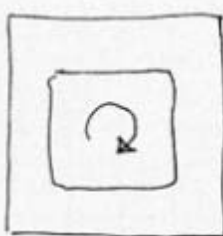
Visionary sketches by the author. In this image, one of the many applications of his theories



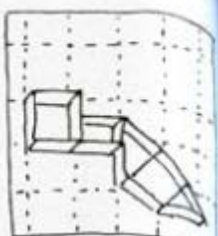
YOU HAVE TO WRITE USING A SPECIAL KEYBOARD



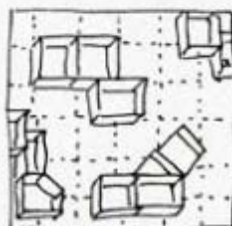
THE KEYS ARE REPRESENTING ROOM-SHAPES



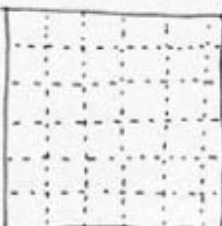
WHOSE POSITIONS CAN BE ROTATED WITH A SPECIAL KEY



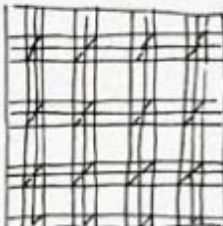
A "WORD" TYPED WITH THESE KEYS SHOWS A STRING OF ROOMS



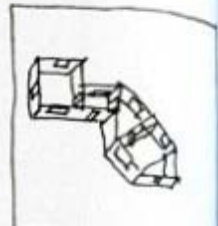
A "TEXT" IS A SUITE OF "WORDS": YOUR FLOOR PLAN AND THAT OF YOUR NEIGHBOURS



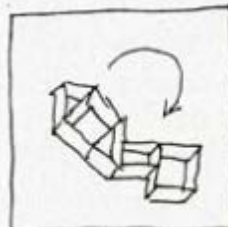
THE "WORDS" ARE TYPED ONTO A "GRID"



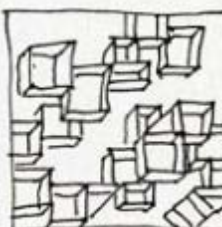
THIS "GRID" REPRESENTS THE "INFRASTRUCTURE" INTO WHICH THE PLANS ARE FITTED



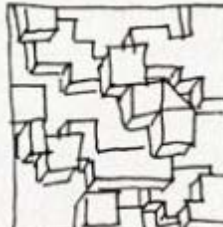
OBVIOUSLY YOUR PLAN HAS TO BE DETAILED: DOORS, WINDOWS, EQUIPMENTS (BATH, KITCHEN, WC, ETC.)



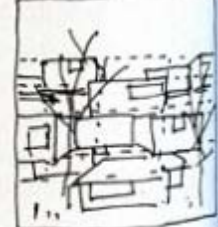
AND YOU HAVE TO DECIDE FINAL ORIENTATION ROTATING THE PLAN



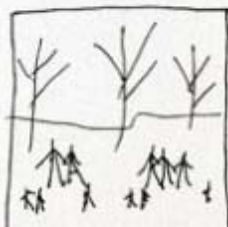
THE "TEXT" CAN BE OF SEVERAL "PAGES": EACH "PAGE" IS THE PLAN OF A DIFFERENT FLOOR



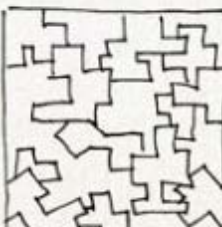
A "TEXT" TYPED BY MANY PEOPLE PRODUCES THE PLAN OF A NEIGHBOURHOOD



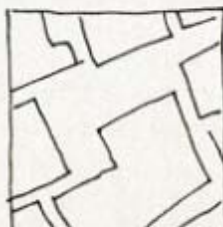
A CITY IS A COLLECTIVE "TEXT"



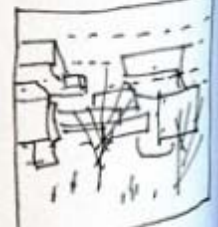
"TYPED" BY THOSE WHO WANT TO LIVE THERE



THE "TEXT" TYPED ON THE FLATWATER

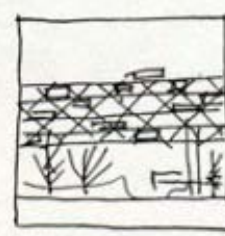


IS NOT THE COMPLETE CITY PLAN BUT RATHER A "WISHING LIST":



THE FIRST STEP TOWARDS HAVING YOUR TOWN BE AS YOU LIKE

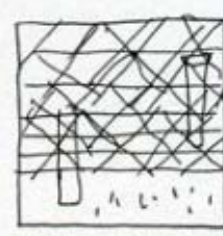
THE "VILLE SPATIALE"



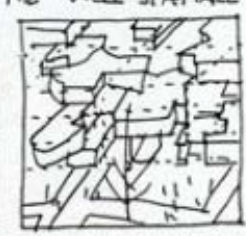
LAST, BUT NOT LEAST, I GET BACK TO MY FAVORITE IDEA: THE "VILLE SPATIALE"



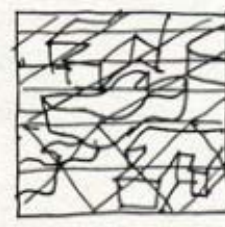
IT MEANS A PARTICULAR MIXTURE OF RULES AND IRREGULARITY



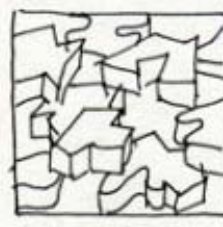
THE "VILLE SPATIALE" CONSISTS OF A MORE OR LESS REGULAR, RIGID SUPPORTING GRID: THE "INFRASTRUCTURE"



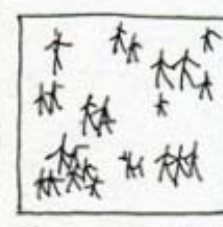
WITHIN WHICH INDIVIDUAL HOMES ARE INSERTED FORMING AN IRREGULAR PATTERN



AS FOR THE SHAPE OF THOSE INDIVIDUAL HOMES ANYTHING GOES



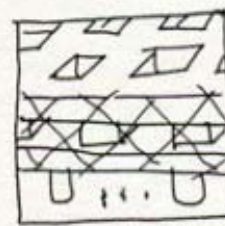
THUS THE "VILLE SPATIALE" IS A "MERZSTRUKTUR" AT URBAN SCALE FOR A MASS-SOCIETY CONSISTING OF INDIVIDUALISTS



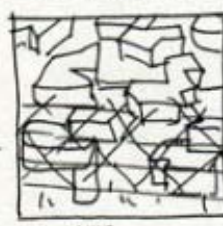
THIS IS OUR SOCIETY TODAY: A CROWD



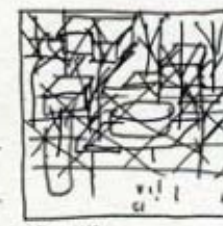
I DO NOT KNOW HOW A "VILLE SPATIALE" WILL LOOK



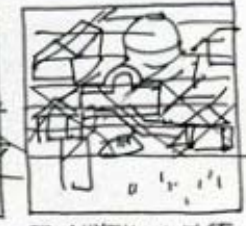
IT CAN BE THIS



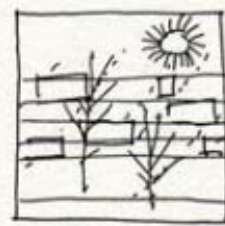
OR THIS



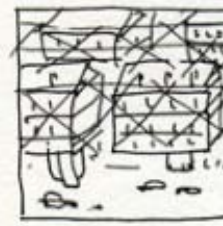
OR THIS



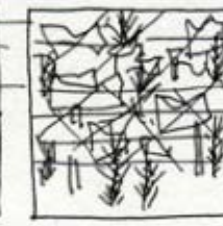
OR ANYTHING ELSE



THERE IS NO GRAMMAR TO THE "VILLE SPATIALE" EXCEPT RESPECT OF DAY-LIGHT



IT CAN LOOK AS WELL AS THE CITY YOU LIVE IN



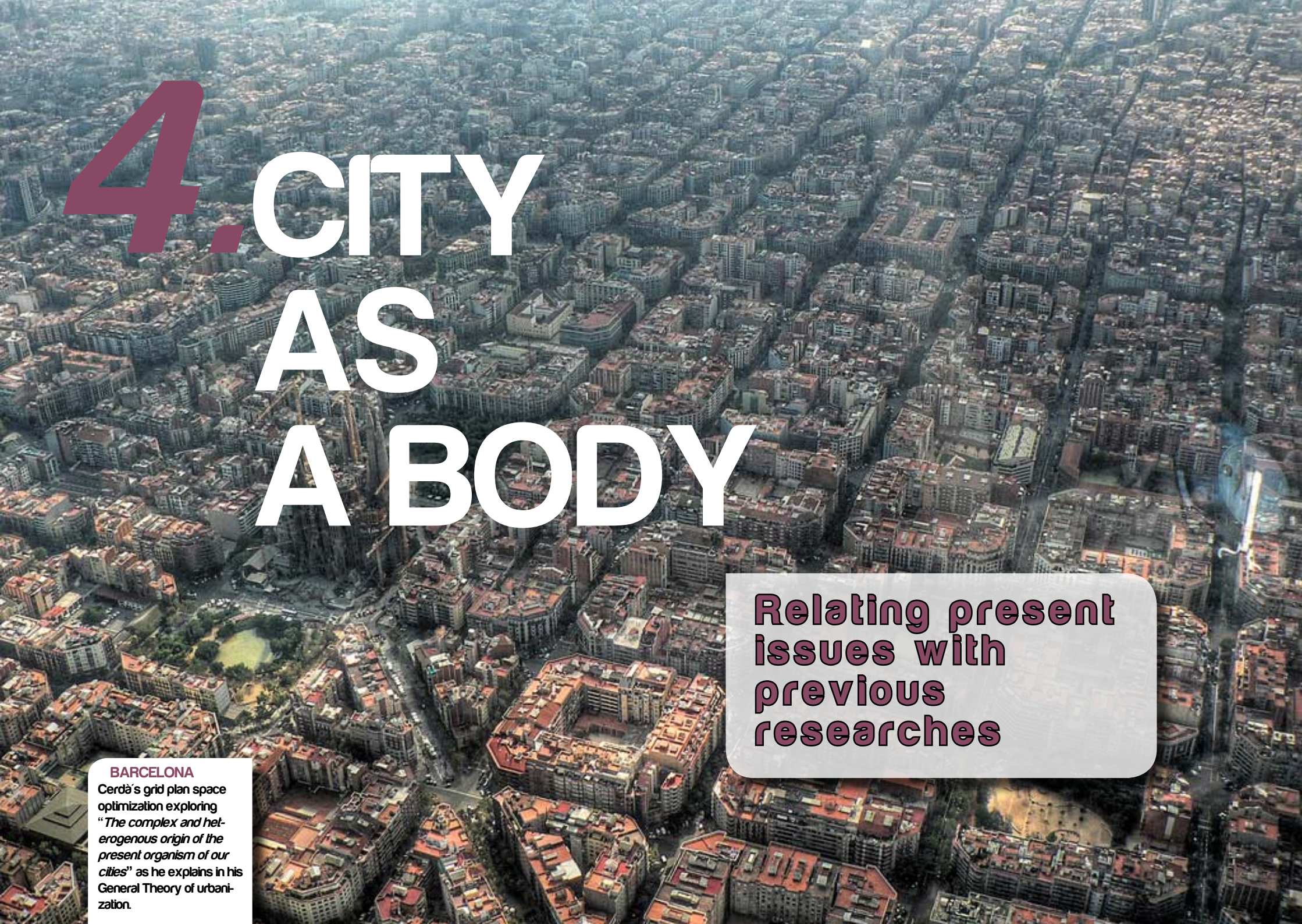
OR IT CAN BE COMPLETELY UNLIKE TO ANY CITY



IT CAN NOT BE PLANNED, IT CAN ONLY HAPPEN

VILLE SPATIALE

The concept of the ville spatiale explained in few points. From the book "Pro Domo"



4. CITY AS A BODY

Relating present
issues with
previous
researches

BARCELONA

Cerdà's grid plan space optimization exploring "The complex and heterogeneous origin of the present organism of our cities" as he explains in his General Theory of urbanization.

Really???

PARASITIC ARCHITECTURE?

A terminology issue

The idea of investigating a response to an urban problem (the densification issue described in the background) through an approach with urban scale but architectonic tools, raises the need to analyse similar approaches (of punctual architectonic interventions that “parasite” existing buildings because of the limited space available). In that sense, it is extremely important to first bring light to a terminology issue related to the outcome of these kind of approaches. Currently, it is common use to put together any intervention built in a close relation with existing buildings under the denomination of “parasitic architecture”. The huge differences between the outcomes of these interventions, though, raises the question if this is really the proper term to describe them. Even because when the term is analysed deeper, it doesn’t seem to describe the kind of relation that these buildings establish with their “hosts”.

In the Dutch book *Rooftop architecture*¹⁷, this terminology imprecision has already been pointed out when analysing Stuhlmacher’s intervention from 2001 on the top of Las Palmas building, in Rotterdam. The project itself is called “Parasite” and is part of an international “parasite project”, in which 30 architecture European firms designed “Prototypes for Advanced Ready-made Amphibious Small-scale Individual Temporary Ecological houses”. The acronym used the first letters to intentionally produce the

expression PARASITE, even leaving “scale” and “houses” out, once the term was already used in architecture to denominate projects like Stuhlmacher’s.

It is generally agreed that the term parasitism is originated in biology studies. And in biology, it indeed occurs in a “close relation” – a symbiosis – between different organisms. But in that original field, this specific kind of symbiosis, parasitism, represents a relation in which one of the organisms benefits on the expenses of another. The concept of parasitic architecture, therefore, should refer to the use of existing structures as a hosting object for new interventions to be implanted that somehow harm the host. In fact, it is possible that some of them produce negative outcomes as an oversaturation of accesses, circulations, energy or any supply provided by the host to the new structure. But actually most of the interventions that promote a symbiotic relation with existing buildings/urban structures provide, instead, more positive outcomes to the host than negative ones; otherwise they would hardly find space to exist. Some of them support the functionality (and ownership) of the existing structure while others, even serving a totally different purpose, still bring good outcomes, as an increase of public, efficiency, an increase of usable space, or even at a structural level, when the new intervention demands a structural reinforcement that solves problems from the existing one.

As Melet and Eric have put in their *Rooftop architecture*, “In most cases the host does not become seriously ill as a result. In fact, the reverse may be true for the species as a whole.” Because of that, the authors propose a new term to define them: Symbionts, which refers to the organisms that take part in any kind of symbiosis.



BIOLOGY VS ARCHITECTURE

Photomontage by the authors comparing the original sense of parasitism and the project “Parasite”, from 2001 by Korteknie Stuhlmacher architecten.

RELABELING SYMBIOTIC RELATIONS

Analogies with successful natural relationships studied in the biology field can provide ideas to be applied in architecture. That explains the importance of going back to the origin of the term. The idea of this study is to step further from than the simple substitution of the term “parasite” for the term “symbiont”. The intention is to analyse existing cases of this architectural “symbiotic relations” and re-label each case according to the proper biological terms, which depend on the outcomes that each of the involved structures inherits from that relation. The cataloguing of advantages and costs from many existing cases, will guide the research towards possible developments of these interactions, focusing on how these symbiotic buildings can provide a more fruitful outcome, both for the host building and for the city - in a rather ‘*mutualistic*’ relation than a ‘*parasitic*’ one.

With this perspective, a multiplication of architectonic-scale fruitful interventions could respond to the urban issue of densification in complex environments following a quite studied metaphor: the vision of the city as a body. Cities have long been compared to organisms since Plato talked about the city as a corporeal body in a sociological aspect¹⁸. But at an urban level, many studies published about the subject more than 2 millennia after that, can bring important inputs to this research, beginning with important observations about the use of the analogies themselves.

Collins,
Linnaeus, Buffon,
Colebridge and
Wright

ANALOGIES IN ARCHITECTURE

In 1965, professor Peter Collins published the book *Changing ideals in Modern architecture*¹⁹, a deep review about modern architecture tracing the theories and ideas which, during two centuries, made modern architecture what it was at that point. During the course of that history, Collins’ description reaches a point, in the mid nineteenth century, where the continuous cycles of analogies with past trends in architecture were not enough anymore to satiate the urgency for a new architecture. In his words, “The striving of the historians to evolve a new architecture by analogy with earlier architectures (...) seemed to have failed; but their failure had at least one important result. It forced theorists to study the heuristic possibilities of other kinds of analogy”.

These new analogies, described by Collins as the only possible ones left by that moment, were functional analogies: parallels with living organisms (biological), machines (mechanical) gastronomy and language. Specifically about the one that matters for this thesis, the biological analogy, Collins traces back its origin to 1750, when 2 epoch-making scientific books were published: *Species Plantarum*²⁰, in which Linnaeus classified the entire vegetable kingdom and Buffon’s *Histoire Naturelle*²¹, with an attempt to bring all biological phenomena into a general interpretation of the laws governing the universe.

Professor Collins points that Buffon’s vision that all species must have derived from a single type would be very much used later by architectural theorists, with two important features that deserve mention: the first is that his idea of evolution was based in a process of degeneration, and not of improvement, once his (and his time’s) religious beliefs prevented him from assigning the evolutionary process to any but the lower animals. On the other hand, he was the first one to distinguish between “vegetative” and specifically “animal” parts of animals, whereby an animal may be regarded simply as a vegetable organism able to move from place to place.

According to Collins, as a consequence of these two important books, “organic life” has come to mean for architectural theorists, the sum of the “vegetative” class, present in all living organisms, plants or animals. In that sense, this was when “the asymmetry of plants and viscera, rather than the symmetry of animal skeletons, came to be accepted as characteristics of

organic structures”.

Later on, three decades ahead, the most important enunciation on evolutionary theory was published by Lamarck, who, living in the age of Revolution, pointed that living forms had not evolved retrogressively as Buffon believed, but progressively²¹. Lamarck, though, suggested that evolution was due to the environment, writing “It is not the organs which have given rise to an animal’s habits and peculiar properties, but, on the contrary, it is its habits and manner of life and the conditions in which its ancestors lived that has in the course fashioned its bodies, its organs and its qualities.”

The word ‘biology’, Collins point, was invented by Lamarck in about 1800²²; at the same time, the word ‘morphology’ (in a much wider sense than we understand nowadays, including by then non-living forms, such as rocks), was created by Goethe, at his time as famous as a scientist as he was as a poet. These two new sciences raised a question that would not prolong itself that much in biology, but would be an essential discussion to modern architecture: does form follow function or function follows form?

In a first moment, when the biological analogy was first seriously applied to art, the dialectic subject was neglected, since interest was concentrated on the way forms grow, rather than on the way they work. But, according to Collins, when Colebridge published an essay about Herder ‘sand Goethe’s views over the topic, he not only translated their studies to English, but organized the attack against the whole ‘Mechanico-Corpuscular’ philoso-

phy of creation. In his words: “The form is mechanic when on any given material we impress a predetermined form (...) The organic form, on the other hand, is innate, it shapes as it develops itself from within, and the fullness of its development is one and the same with the perfection of its outward form.” This approach can be compared with Frank Lloyd Wright’s one, when he wrote, in 1914, his *In the cause of architecture*²³: “By organic architecture I mean an architecture that develops from within outward in harmony with the conditions of its being as distinguished from one that is applied from without.”

Collins takes this discussion over the biological analogy and its consequences to architectural form ahead analysing how the publications of Darwin favored the ‘form follows function’ idea, once the selection held “by nature” over accidental changes suggested that it was not an adaptational arbitrary strategy but simply a statement that nonfunctional forms never survive.

But the fact is that these discussions over form are not exactly what this thesis can inherit from Collins’ studies, once the analogy here is not about shape, but about the outcomes of relations between different organisms in nature and in architecture. In that sense, a passage of the same book that brings a lot to the discussion is when he analyses the tricky challenges of making these analogies, once, according to him, the number of exact parallels that can be done in this case is quite low.

He points that in biology, organic functions are classified into nine categories: digestion, nutrition, circulation, respira-

tion, secretion, ossification, generation, irritability and sensibility. Of all these, in Collins opinion based on the 1960’s context, only the circulation category could be compared with a building’s function.

At this point, one could argue that, opposing to what Collins says, it is very possible to compare the biological nutrition systems with the supply of energy, water and gas in buildings. Another comparison possibly neglected by Collins would be the one with the respiration function, once cooling and heating systems are mostly based on exchanges of air from inside and outside the body of the building. It is also possible argue that nowadays (what Collins could not predict) buildings are already designed incorporating some mechanisms that could be easily compared with the sensible function of a body, not only in high-tech hyperbody architectural experiments but also in simple “presence detector” systems for light, fire emergencies, cooling and warming control, opening and closing of doors and so forth.

But even if Collins considers the architectural-biological analogy lacking more precise parallels suggesting that these comparisons, in order to exist, must keep a “general and poetic” approach, he highlights four features held in common between the two fields, namely: the relationship of organisms to their environment, the correlation between organs, the relation of form to function and the principle of vitality itself. Of these four, the relation of form and function is the only one that he does not reject somehow. But even in respect to this one, he criticizes the superficiality of its most prominent

defenders, as Sullivan (who “founded a total architectural creed” based on it, but “never pursued it very deeply and made little distinction whether it referred to the object created or the process of design”) and Frank Lloyd Wright (who “was unable to explain the term himself because it had so many different meanings for him”).

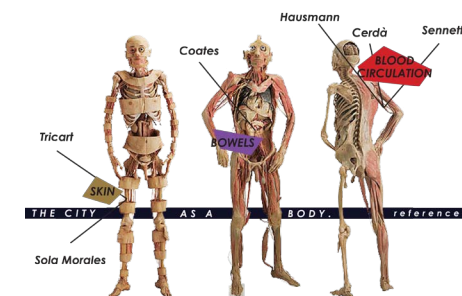
Collin’s rejections to the first two topics raised by him, though, deserve a more careful analysis, given the more direct relation with the central issue of this thesis. In what concerns the relationship between organisms and their environment, his arguments are based on an extremely dated notion that “improvements in air-conditioning equipment are making architectural form increasingly independent of climatic considerations”. That is a clearly contextualised thought from those times, that nowadays is strongly execrated by the huge current trend of sustainable architecture, the same one that rejects his other argument, of local materials loosing their importance because of the technologies for transport.

And if in this last topics, the validity of Collins’ rejection arguments was lowered by time, the other one – the correlation between organs – receives a whole new meaning when the biological analogy is applied in this thesis to the context of a city rather than the context of a sole building. Because the organs, in this thesis view, become organisms in symbiotic interactions that are represented by buildings, and not by parts of a building. Therefore, in order to understand better what previous studies can bring to the discussion here presented, the analogy must take a step away from the compari-

son with architecture as an organic body to approach a comparison with the city as a body, as Collins himself suggests that happened with the discussion during the twentieth century. He points that Claude Benard’s discoveries concerning the way the body adapts itself to changing conditions suggests clear parallels in that time’s urban context.

In this sense, this thesis moves towards other studies that specifically concern this urban context about which Collins refers to close this chapter on his book. The intention here is to put together other sources that focus their analogies in different specific systems or mechanism of the human body, like:

- The blood circulation and its distribution strategies;
- The skin and its sensitivity mechanisms;
- The guts of the city, with its infra-structure under the streets playing the role of our nerves, veins and digestive system.



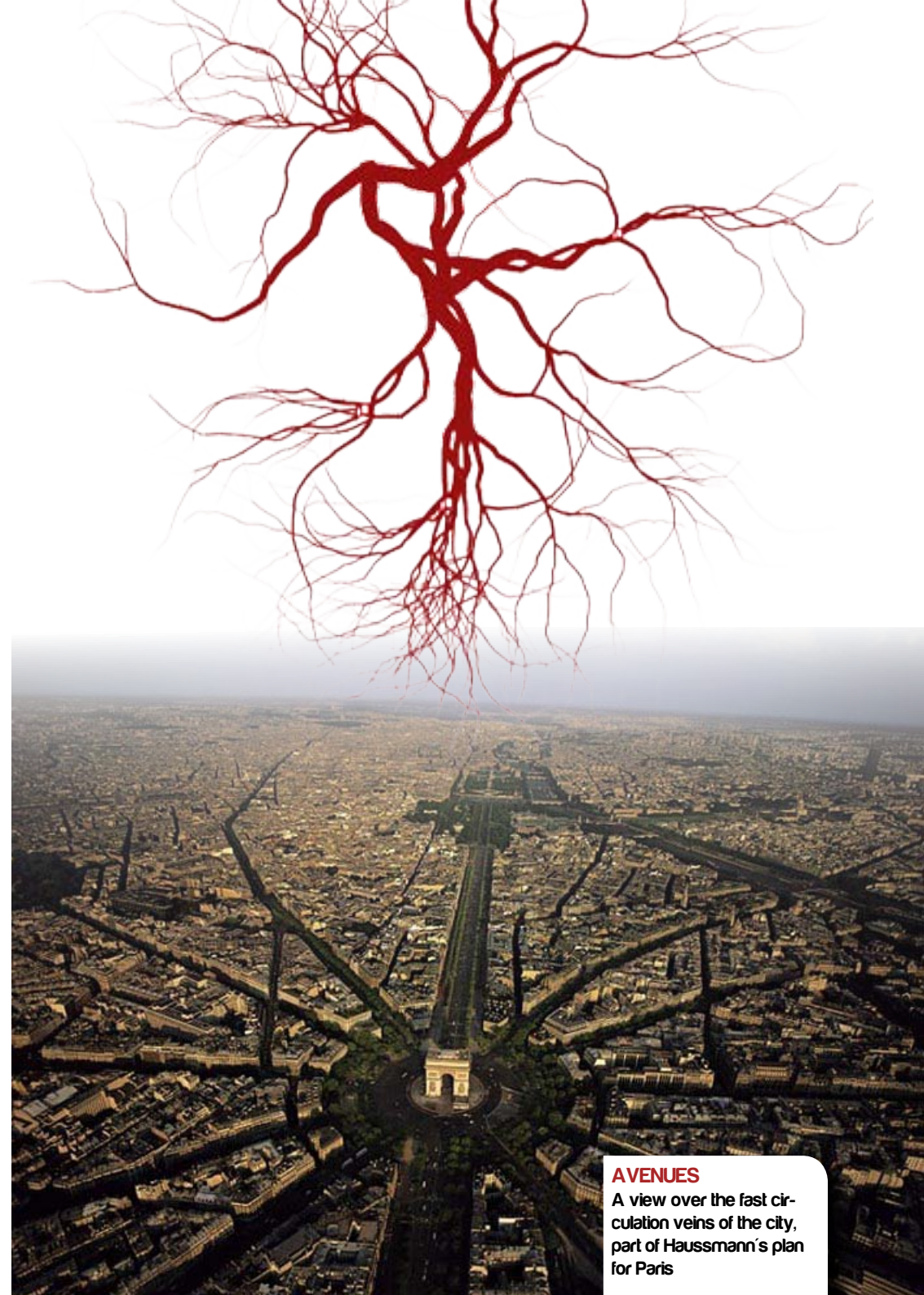
Cerdá, Haussmann,
Fraser and Choay

LESSONS FROM BLOOD CIRCULATION

In 1867, the Catalan Ildefonso Cerdá based his most influential work in the metaphor of the city as a body. Through that comparison, in his *General Theory of Urbanization*²⁴, he explores “The complex and heterogeneous origin of the present organism of our cities”, describing the task of urban planners both as a diagnostician, who shall understand sick areas of the city, and as surgeons, with “a true anatomical dissection of all cities and of all their constituent parts”. Even though Cerdá was not the first one to make this link between cities and human bodies, he is the one to first give it a special role in his work, establishing not only a metaphorical, but also a methodological significance to this comparison. Françoise Choay, in her book *Modern city: Planning in the Nineteenth century*²⁵, points out that not only Cerdá’s Barcelona, but also the revolution made in the urban landscape of Paris by Georges Haussmann (1809–1891) reproduced its streets as arteries in the model of a general circulation system.

Benjamin Frase recently approached the same subject in his book *Henri Lefebvre and the Spanish Urban Experience: Reading the Mobile City*²⁶, from 2011. Ac-

cording to him, despite the prominence of this metaphor in the work of Nineteenth-century well-known figures such as Cerdá and Haussmann, the notion that the city could be conceived as a body is from far before. He points out that the Seventeenth century had seen the discovery of blood circulation, generating quick responses in the way of thinking cities. The urban critic Richard Sennett, a reference in the relation between body and city since 1994, when he wrote about a bodily perception of the city in *Flesh and Stone: The Body and the City in Western Civilization*²⁷, recently wrote about the influence of that discovery in the Seventeenth century in his book *The Craftsman*²⁸. In his words, “The Scalpel had permitted anatomists to study the circulation of the blood: that knowledge, applied to the circulation of movement in cities, suggested that streets worked like arteries and veins; this was thus the era in which planners began to incorporate one-way streets in their designs.”



AVENUES

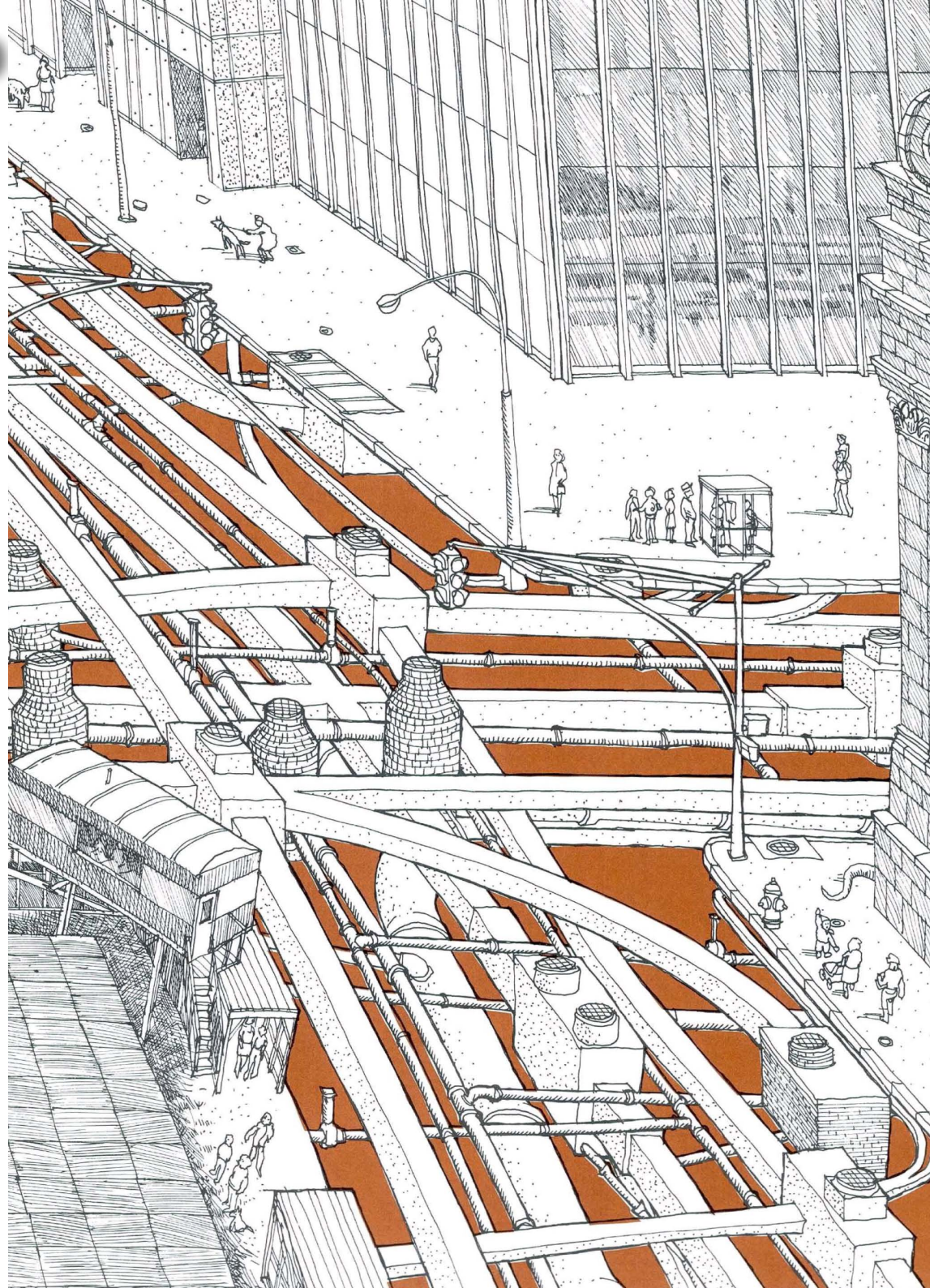
A view over the fast circulation veins of the city, part of Haussmann’s plan for Paris

THE BOWELS OF THE CITY

In 2003, in his book, *Guide to Ecstacy*²⁹, Nigel Coates brings up images and collages to materialize this metaphor of what he calls “the bowels of the city”, pushing the body-city metaphors to a visual field.

Four years later, writing directly from the underground of New York, a Journalist from *The New York Times*, and *Nature*, Jonah Lehrer wrote an article for the *Seed magazine*³⁰ about his experience inside what he called “the guts of the city”. In this article, he states that the experience of being in contact with the infra-structure of the North American metropolis turns the metaphor quite literal, with the big pipes playing the role of “metal intestines”, fiber-optic cables working as nerves, and subway tunnels as “thick jugular veins”. He goes on with the direct comparisons; In his words: “Energy is distributed, and waste is digested. All this generates a sort of animal heat, which escapes from the grates in the gutters. The foul steam is exhaled breath. But how true is this metaphor? Are cities really like living things?”

To answer his own question, Lehrer points at the work of a team of physicists and economists led by Geoffrey West at Santa Fe Institute. According to their research, in many respects, cities act just like creatures: “They obey the same metabolic laws that govern every organism. Their infrastructure follows a distinctly biological design, which helps explain why cities are able to grow.” pointing exactly towards the direction Collins predicted five decades earlier.



METABOLIC LAWS

This metabolic laws were studied In the early 1930's by the biologist Max Kleiber, who measured the metabolic rate of a vast range of different animals. He discovered that in virtually every species, the metabolic rate is equal to the mass of the animal raised to the 3/4 power. This simple equation could describe cows and humans and elephants and mice. It didn't matter what the creature looked like, or where it lived, or how it evolved. The formula always worked. In his article, Lehrer explains: “This means that animals with a bigger mass will consume less energy per pound than smaller animals. As life grows, it develops enormous economies of scale. The elephant is much more metabolically efficient than the mouse. Humans are more efficient than hummingbirds. Girth is a good thing, at least from the perspective of energy consumption.”

Working on this analogy, West and his team analysed data from various cities and concluded that in an urban context, this statement is also true: big cities are more “metabolically” efficient than smaller cities. “Cities are like elephants. They get more economical with size (...) the indicators of urban ‘metabolism’ — like the per-capita consumption of gasoline or the surface area of roads or the total length of electrical cables — scaled to an exponent of (population) 0.8, which is very similar to the biological equivalent of (mass) 0.75. This means that a city can double its population without doubling its resource

consumption. One of the basic principles of cities is that it's more efficient to bring people together", West says: (confirming the hypothesis raised in the first chapter of this thesis) "You need a little bit less of everything per person. It's the exact same way in biology. As animals get bigger, they require less energy to support each unit of tissue."

In his article, Lehrer points out that despite the bucolic image that a rural area can present, cities are much more of an environmental-friendly places. He writes: "Cities are bastions of environmentalism. (...) They consume fewer resources per person and take up less space. (...) While rural towns might look green (...) their per-capita rates of consumption and pollution are significantly higher. The secret for creating a more environmentally sustainable society is making our big cities bigger. We need more metropolises."

But even reaching sustainability through the obedience to biological metabolic laws, cities present an essential difference to animals: In bigger cities, people live - literally - faster, while in biological systems, the opposite trend occurs. "As creatures get bigger, their bodies slow down. Pulse rates decelerate. A brake is applied to the heart. This is why elephants live longer than mice: their bodies operate at a more leisurely setting." But West's research shows that in a city, as bigger it gets, each individual gets more and more productive. A doubling of population lead to a more than doubling of creative and economic output. Lehrer puts this point in a simple way: "Imagine an elephant that never stops growing, and whose growth just encourages more growth. That's what

a city is like."

But, even when a city doesn't face, like elephants do, a physical limit to its growth, at a certain point it tends to run out of resources. And there is one way to deal with this limitation, as West's research point out: they innovate. "The only way to avoid stagnation from a shortage of resources," West says, "is to change something. You have to reset the clock, reset the initial parameters of growth. We call this an innovation cycle, and they are clearly apparent throughout history. There's the invention of the steam engine, the car, the digital revolution. What these advances all have in common is that they allowed cities to continue growing." A city that isn't innovating is on its way to collapse. West points Detroit as a city that has failed to reinvent itself and suffered the consequences. Examples like this show that finding innovative ways to grow is an essential issue to a city's health.



Solà-Morales
and Tricart

THE SKIN

More than a simple layer to cover the city, the skin of an urban environment have important roles in its life, as Manuel de Solà-Morales explain in his book published in 2008 with a compilation of projects by many architects, urban planners and researchers, including himself and Kenneth Frampton. In this book, called *A Matter of Things*³¹, the comparison between the surface of a city and the human skin is a central narrative point. Morales defends the practice of urbanism as both "acupuncture" ("a gaze upon the city", that can be related with the diagnosis role Cerdà wrote about) and "prosthesis" ("incision" projects, or Cerdà's surgery). Solà-Morales indeed goes beyond and states his interest in what he calls "the skin of cities", or what Jean Tricart called in 1969 *Epidermis of the Earth*³². In Solà-Morales' definition, this skin is constituted of "constructions, textures and contrasts of streets and empty spaces, of gardens and walls, of contours and voids."

Morales uses the analogy with acupuncture to express the importance of the city skin, "not because it involves using needles or making small incisions, but because the epidermis is understood to form a system, not the covering of the interior, but the principal structure of the organism, the clear expression of its nature." And he completes: "To act with punctures, pressures, injections is to distribute energy through the skin".



ACUPUNCTURE

Photomontage by the authors representing Cerdà's epidermis, *"understood to form a system, not the covering of the interior, but the principal structure of the organism"*.

Updating strategies to choose areas of intervention

Sensitive points evenly spread around the city

ACUPUNCTURE

In a different approach towards the analysis of the biological metaphor, this research intends to apply the logic of biological relations to deal with the densification issue in complex scenarios. Therefore, the perspective of the comparison between city and body needs to be updated in what concerns the choice of areas for intervention. Cerdà talked about the need to determine 'sick' and 'healthy' areas, in order to know which parts of that organism needed punctual interventions.

But to respond to an issue that concerns the whole 'body' of the city, it is not possible to act only in 'sick areas', which are, in a current analysis, part of the phenomenon introduced in an earlier chapter as 'urban voids'. They are often hidden in undesired areas and even though they indeed need interventions to solve their particular problems, they are not present in enough quantity to respond to the city-scale demand that the densification issue brings, as suggested before.

POTENTIAL SURFACES AND VOLUMES

In that sense, Morales' acupuncture here receives a different level of metaphor. According to his own description, in the ancient oriental practice, 361 sensitive points scattered over the body transmit their sensory impressions to the rest of the organism. And that is precisely the idea of this research.

The goal is to work with spaces evenly spread around the city that were only not used previously because of the absence of need. These spaces will be referred in this research as "potential surfaces and volumes". They can be directly related to the sensitive points from acupuncture: just like them, the "injections" to be researched shall act not in sick points, but in points capable to spread their impressions and consequences to the rest of the city, multiplying its effectiveness through the so-called echo-effect.



missing
teeth



edgelands



programmatic
voids



chronological
voids

Urban Voids

VS

Potential Surfaces & Volumes



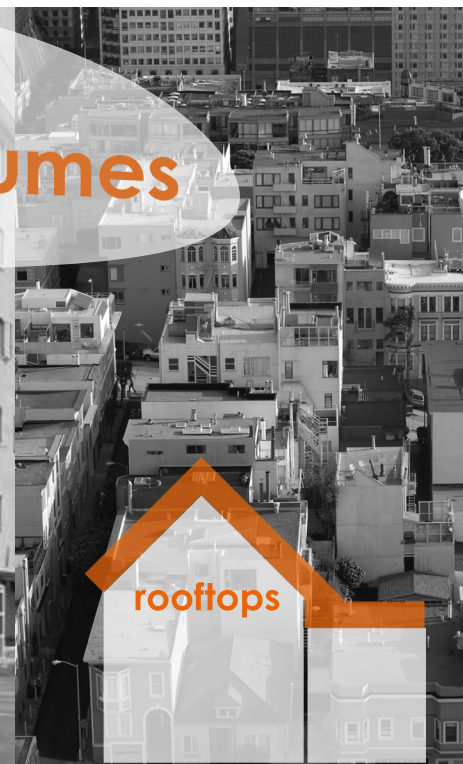
under
viaducts



under
bridges



blind
facades



rooftops



canal
banks

A strategy to relax tensions over historical urban tissues and preserve their image and identity

URBAN BOTOX

An even more defining differentiation from Morales' acupuncture, though, is the fact that there is no way to densify a city without necessarily building, injecting something, more than simply stimulating with a needle. In that sense, where the simple "punctures, pressures" cannot answer for itself and the injection is indeed essential, an "Urban botox" would be a more precise expression. Besides that essential difference, this metaphor also describes more contemporaneously the urban inhabitants. The idea is that botox injections, with subtle insertions in key points of the city might work as organic regenerators of the urban tissue.

And even though the metaphor of botox might seem undesirable when one understands its process and goals, it becomes easy to realize that it deals exactly with the goal of historical European cities, which see no way to grow inwards because of their historical frozen fabric. By the same time that they need to grow to keep economical strength, they also need to recall the history of ages ago, for attracting tourists and stating their cultural identity.

Despite what most people think, botox does not "kill" a muscle. The only power of botox is to paralyse a muscle - for a determined time span - to keep it relaxed and therefore with no wrinkles, no marks

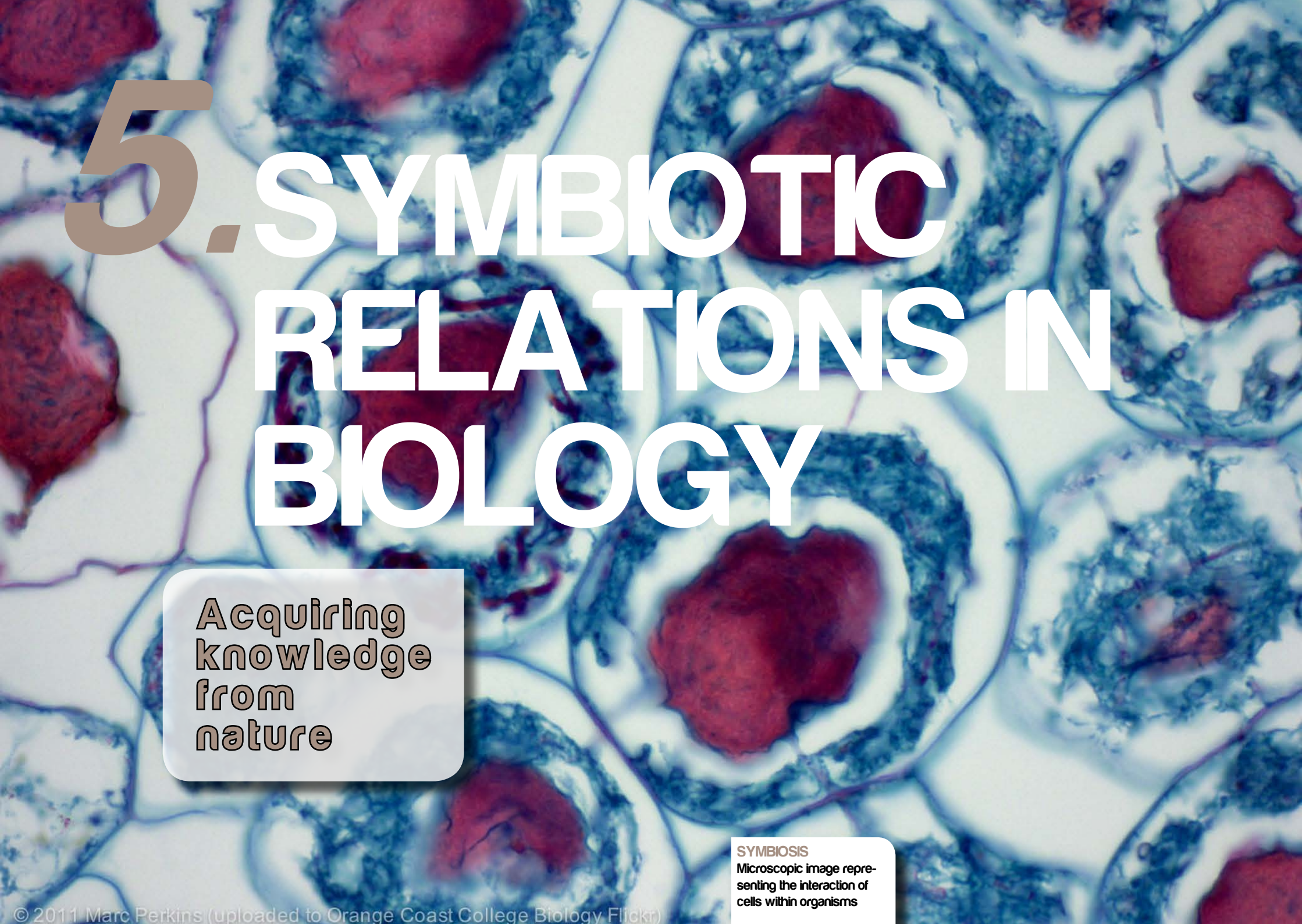
of time, as it was when the person was young. The urban botox would have the same effect in historical fabrics, relaxing the tension under which they are now, and therefore making them able to look exactly like they were when young. Finding alternative surfaces and volumes to respond to the necessary densification process would avoid more of the wrinkles that contemporary super-stores' displays have already caused in these cities.

But even more than the choice of the places to insert these injections, what most interests this research is how would they act and how would the city react. In that sense, the next chapter will be devoted to the dissection of possible kinds of interaction in nature, its classifications and reasons. The inputs raised in the study of these relations in biology will provide knowledge to elaborate rules that could assure a good outcome to all the structures involved in an architectural symbiosis. Following that, the analysis of existing cases in architecture will help to translate the inputs from biology to the field of interest.



BOTOX

Insertions under the skin fabric to relax and 'freeze' muscles and making one look like many years before.

A microscopic image of cells, likely from a tissue section, stained with a blue dye (possibly hematoxylin) and a red dye (possibly eosin). The cells are irregular in shape, with prominent red-stained nuclei and blue-stained cytoplasm and extracellular matrix. The overall appearance is that of a histological section.

5. SYMBIOTIC RELATIONS IN BIOLOGY

Acquiring
knowledge
from
nature

SYMBIOSIS

Microscopic image representing the interaction of cells within organisms

BIOLOGY

Scientists' personal opinions may considerably vary when defining biological symbioses, mainly because the understanding of the dynamics that make this phenomenon happen are still nowadays open to interpretation and don't leave space to an univocal explanation. However it is commonly agreed that a symbiosis in biology refers to an interaction between two or more organisms living together in considerably intimate relation. The openness of this definition in fact gives an impression on the reasons why scientists argue on the matter, being very subtle the dividing line between what can be considered a symbiosis and what can not. For bringing clearness to their discourse, experts have categorized and defined a number of ways in which it is possible to group symbiotic relations depending on the outcomes of a certain interaction.

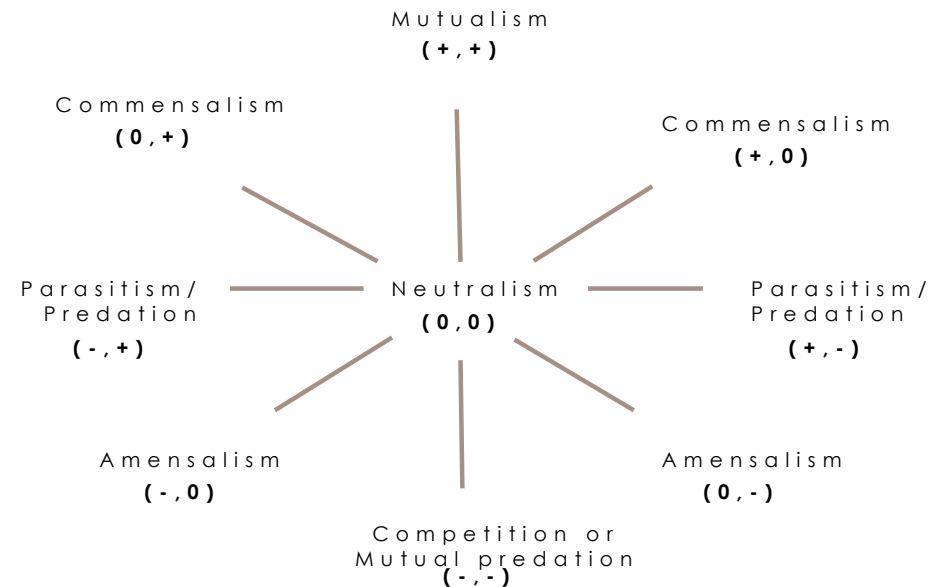
In general, the species involved in an interaction can experience:

- **nothing** at all and be indifferent **(0)**
- a **positive effect**, that may vary in kind **(+)**
- a **negative effect**, that may vary in kind as well **(-)**

According to these outcomes, different kind of symbiotic relations have been defined as follows:

Neutralism (0,0)
Amensalism (0,-)
Commensalism (0,+)
Competition or Mutual Predation (-,-)
Parasitism/Predation (+,-)
Mutualism (+,+)

SYMBIOTIC RELATIONS TYPOLOGY CHART



COMPETITION

anemone -|- anemone

The anemones compete for the surface of the rock they both want to occupy.



AMENSALISM

tree 0 | - short plants

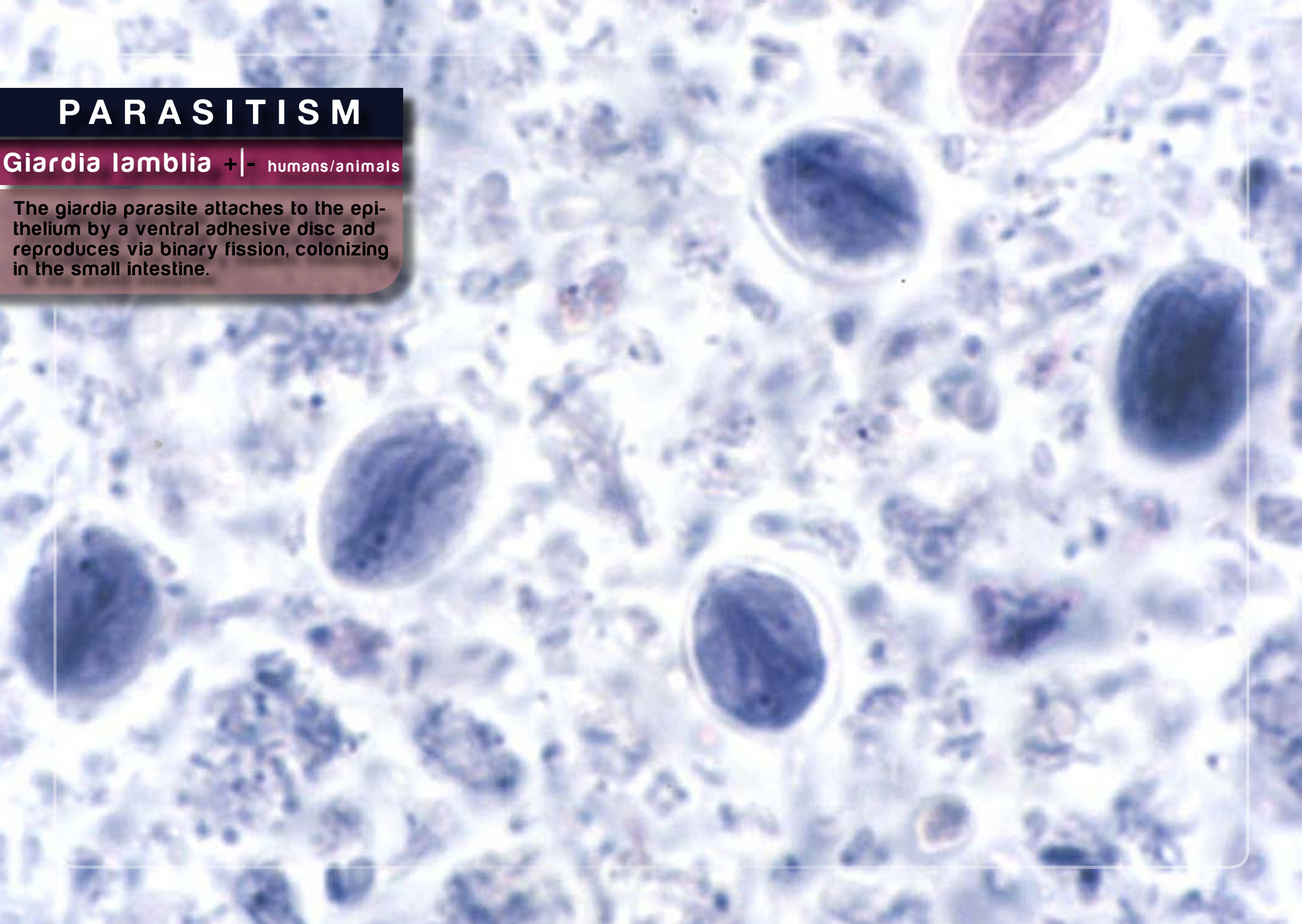
The big tree shadows the area below it, preventing shorter plants to reach the light necessary to live.



PARASITISM

Giardia lamblia +|- humans/animals

The giardia parasite attaches to the epithelium by a ventral adhesive disc and reproduces via binary fission, colonizing in the small intestine.



COMMENSALISM

epiphyte orchids +|0 tree

The orchids benefit from the trees by having a support where to grow on, so that more light and air will reach them.



MUTUALISM

crocodile + | + plover

The bird feeds himself with the residual food between the crocodile's teeth. The crocodile gets his teeth cleaned.

An interaction
with positive outcomes
for everybody

MUTUALISM

While symbiosis is the "living together" of two organisms in close association, the term mutualism is used to define an interaction between species that is beneficial to both, thus - in general - as a +/+ interaction. Also in this case, biological studies on mutualism don't lead to an unequivocal and easy interpretation of natural rules, so that the world of mutualism remains still nowadays something to be fully understood and explained. In general, an enormous number of ecologically and (and even economically) important interactions found throughout the biosphere would seem to be mutualistic. But at the same time only a limited number of studies are able to demonstrate the actual reasons and dynamics within them. According to Boucher's, James's and, Keeler's publication (1982) *The Ecology of Mutualism*, "mutualism may be everywhere, but its existence remains practically unproven."³³

DIFFERENT KINDS

Within the sphere of mutualism, biologists have distinguished two different kinds of interactions, which are defined by the level of intimacy between the two individuals. On one hand there is the *direct mutualism*, in which the two species interact physically; on the other hand, there is the *indirect mutualism*, in which each species benefit from each other's presence but there is no direct contact. Direct mutualisms are also divided into *symbiotic* and *non-symbiotic* mutualism, using physiological integration as the basic criterion.

Hereafter are listed the three main types of exchanges between species:

- **Resource-resource** interactions, in which one type of resource is traded for a different resource; are considered the most common form of mutualism.
- **Service-resource** relationships, also common, especially between flowers and insects or animals.
- **Strict service-service** interactions, very rare for reasons that are far from being clear, since very often these symbiosis comprehend also a service-resource component.



DIRECT MUTUALISM

RESOURCE | RESOURCE
nutritional

fungus + | + plant

An underground structure developed as a result of the mutualistic association between fungi and the roots of almost all plant species. Plants benefit by having enhanced root development and increased absorption of water and minerals. The fungus, in return, receives an organic food supply from the plant.

In a more specific level of interpretation, it is possible to identify a few main types of exchanges:

(a) nutritional: both mutuals contribute to each other providing simple organic nutrients, inorganic minerals, or digestive enzymes for the digestion process;

(b) supply of energy: generally from photosynthesis;

(c) protection: either from environmental variation or from enemies;

(d) transport: either from unsuitable to suitable environments or by the dispersal of gametes or propagules.

(e) pollination: the mutual benefit exchanged between flower-visiting small birds, and insects like butterflies and bees with flower bearing plants, in which the former receives nectar while pollinating the latter. Symbiotic mutualists generally exchange the first two services, sometimes the third, and rarely the fourth.

Non-symbiotic mutualisms can involve all four of them.

DIRECT MUTUALISM

SERVICE | SERVICE
protection

anemone + | + clown fish

The territorial fish protects the anemone from anemone-eating fishes, and in return the stinging tentacles of the anemone protects the clownfish from its predators. Special mucus on the clownfish protects it from the stinging tentacles.



DIRECT MUTUALISM

SERVICE/RESOURCE | SERVICE
protection

remora + | + shark

Remoras attach themselves to the shark and eat his leftover food, cleaning it. Moreover, they receive protection.



DIRECT MUTUALISM

SERVICE | RESOURCE

pollination

flower + | + bee

The bee collects the nectar from the flower, while its pollen sticks on its body and get spread around, favouring to the reproduction of the flower.



SYMBIOTIC MUTUALISMS

supplies and paybacks

Most symbiotic mutualisms involve the supply of energy from one partner to the other, and a number of benefits may be provided in exchange:

- (a) breakdown of compounds, facilitating digestion;
- (b) supply or concentration of nutrients;
- (c) environmental constancy;
- (d) bio-luminescence.

as an ultimate result of a given interaction

EVOLUTION

The evolution of symbiotic mutualisms is generally thought to begin through the proximity of the organisms involved. In this case, parasitism is also one possible starting point. In fact, a model system has experimentally demonstrated the reduction of virulence of a bacterial infection of an *Amoeba*, which ultimately became dependent on the bacteria. Reduction of detrimental effects of the parasite on the host must be accompanied by the development of host dependency on the parasite. Two routes are given to the evolution of dependence. The first is through a parasite-relationship of low virulence in which the parasite leaks nutrients, increasing host survival and thus its own fitness. Alternatively, an increase in ecologically imposed limitations, which the parasite helps to overcome.

Important relations, though with no intimate contact

NON-SYMBIOTIC MUTUALISMS

Non-symbiotic mutualisms are those in which the two species are physically unconnected, in fact there are no direct physiological links. Hereafter some examples:

- **Transport:** pollination and dispersal both involve the transport of particles used for reproduction, and for both there are non-mutualistic alternatives. In both interactions, transport is effectuated in exchange either for some sugar-rich substance (nectar, ovarian tissue of fruits) or the consumption of some of the particles to be transported (pollen, nuts).
- **Protection:** protection from predators, parasites, diseases, toxins, and occasionally competitors is a quite common exchange between organisms. While one individual offers protection, the other may provide reciprocal protection or help in the search for food, housing, or some combination of these. Mutual protection in this case could appear as a simple consequence of living together. The reasons that could explain this kind of interaction between different species, instead, could lay in the fact that heterogeneous groups are able to increase their efficiency of foraging and predators avoidance.

Distribution, number of partners, formation and breakdown

THEORIES ON MUTUALISM

Ecological theory about mutualism has been directed towards the investigation and the understanding of the principles that govern the formation and the persistence of mutualistic relations. Relatively the formation of direct mutualisms, four kinds of models were distinguished:

- (a) Those of individual selection, which are often of a cost-benefit type;
- (b) population dynamics models, with two, three, or many species;
- (c) models of shifts of interactions from mutualistic to predatory or competitive;
- (d) the "keystone mutualist" concept.

Mutualism is expected when it is valuable (e.g. protection in areas of high predation pressure) and when it is cheap and efficient (e.g. extrafloral nectaries when ants and sunlight are abundant). What is still lacking is a theory that will predict when mutualistic solutions are preferred to non-mutualistic ones, assuming both are possible.

DISTRIBUTION

Mutualisms are known in all kingdoms of organisms, and there is a tendency for the partners to come from different kingdoms. This is particularly true for obligate and symbiotic mutualisms, and may simply be a reflection of nutritional complementarity.

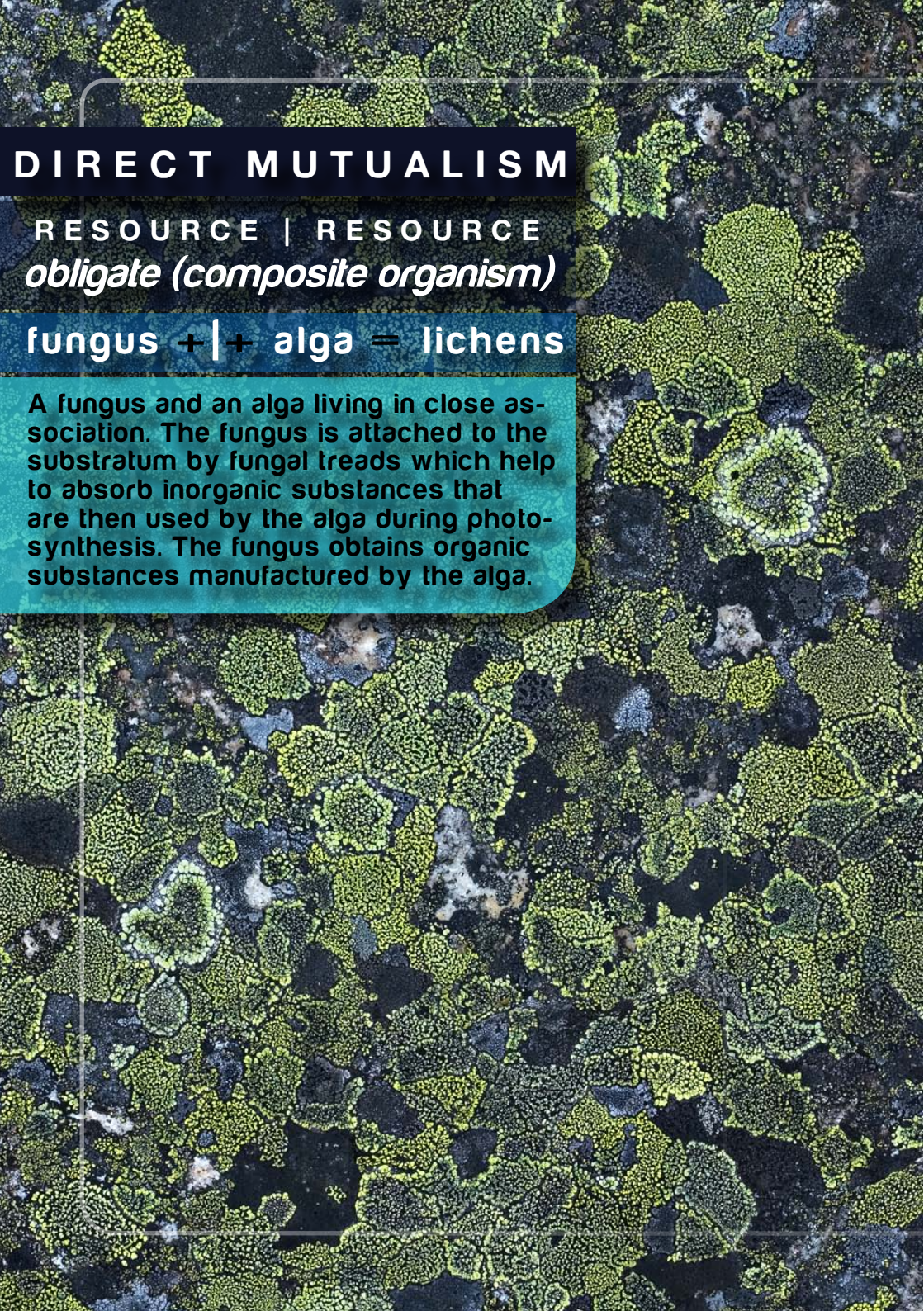
NUMBER OF PARTNERS

The numbers of individuals with which one partner is mutualistic ranges from one to millions. The interaction of a single pair of species is known as "monophily". "Oligophily" is the presence of a few species in each role (less than five). Finally, "polyphily" involve multiple species simultaneously.

- **Monophily:** Monophily is often hard to understand being that two species with clearly separate genomes and independent evolutionary histories interact cooperatively. When monophily is obligate and symbiotic, the two species are often considered as one. This brings evolutionary risks because of the mutual dependence on the other and, at the same time, their independent evolutionary process. In this case, the mutualist becomes a victim of the fitness of its partner, rather than a direct participant.

- **Oligophily:** Being the compromise between the risks entailed by specialization and the inefficiency of generalist interactions, oligophilic mutualists would appear to have the most safe and fruitful relationship. Much of pollination belongs to this category, or mixed feeding flocks of birds, but in general it is common in both facultative and obligate, symbiotic and non-symbiotic mutualisms.

- **Polyphily:** Most relations of this category are facultative, simply because these broad interactions encompass many species.



DIRECT MUTUALISM

RESOURCE | RESOURCE
obligate (composite organism)

fungus + | + alga = lichens

A fungus and an alga living in close association. The fungus is attached to the substratum by fungal threads which help to absorb inorganic substances that are then used by the alga during photosynthesis. The fungus obtains organic substances manufactured by the alga.

*no physical
contact but positive
effects on each other*

INDIRECT MUTUALISM

In a considerable number of cases, theoretical studies have indicated that species that never come into physical contact may nevertheless positively affect each other's fitnesses or population growth's rates. Nevertheless, researches on indirect mutualisms should be considered even more speculative than the direct ones. Indirect mutualisms have been divided in the following groups:

final class of indirect mutualism involves species whose interactions with third species tend to reduce predation on each other. The third species may be a predator whose rate of predation on each of two prey is reduced when an enough number of both is present.

- **Consumer-Resource:** an intriguing aspect of this mutualism is that it follows directly from competition and predation, when the annihilation of competition for resources occurs. Plants are unlikely to experience this kind of indirect mutualism, while it is more seen among herbivores.

- **Enemies' Enemies:** Here again, species with no direct interaction may affect each other's growth rates positively: if species A competes with B, and B with C, the net interaction between A and C may be mutualistic.

- **Friends' Friends:** The reverse of the above situation can also exist: if A and C are both mutualistic with B, A and C can benefit each other indirectly.

- **Protection without interaction:** A

FORMATION AND BREAKDOWN

Mutualisms can be the result of an evolutionary processes from other types of symbioses, or can easily be formed without evolution through the development of traits presumably evolved with different partners elsewhere. However, other apparent mutualisms have been observed to develop rapidly with little pre-adaptation.

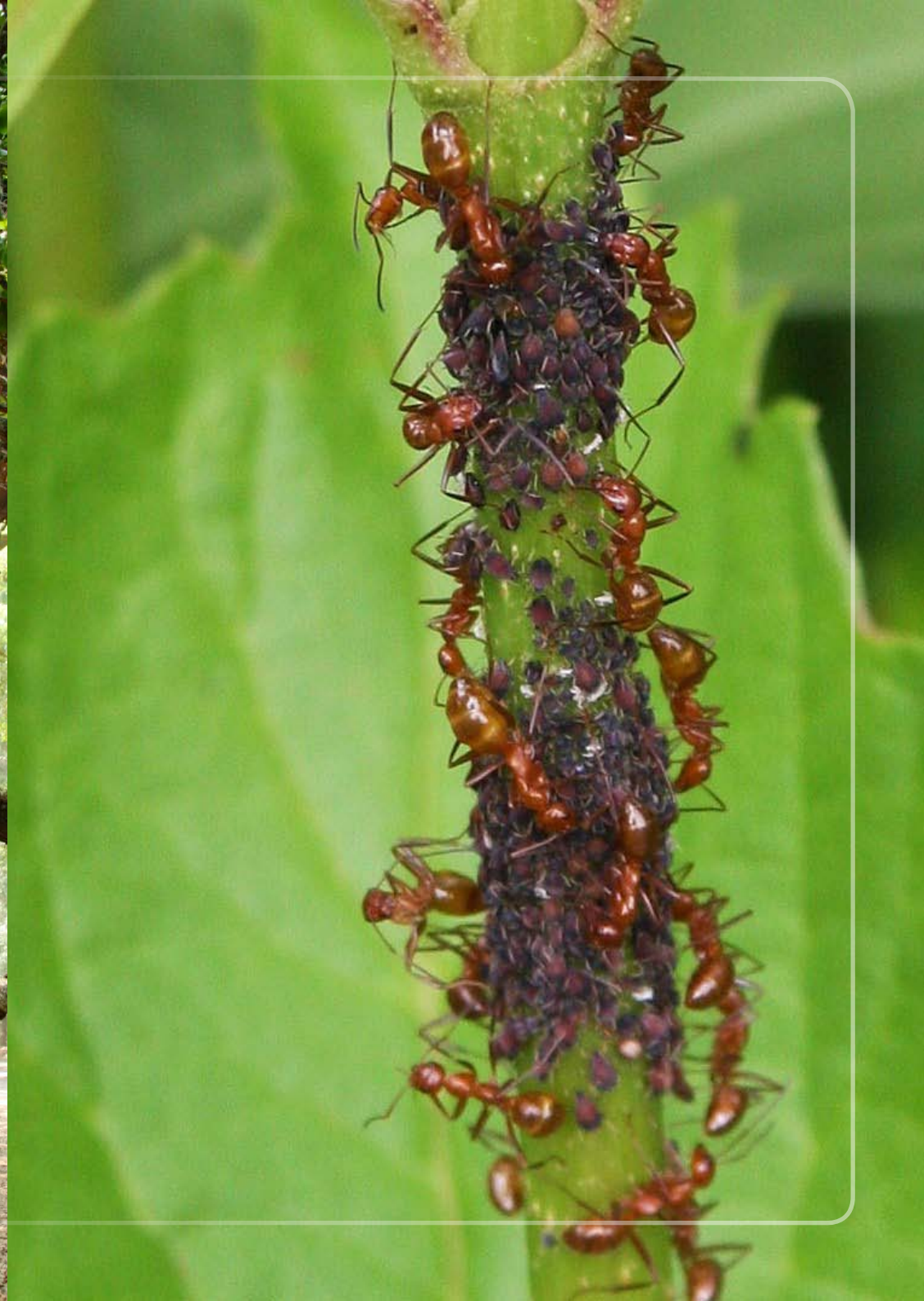
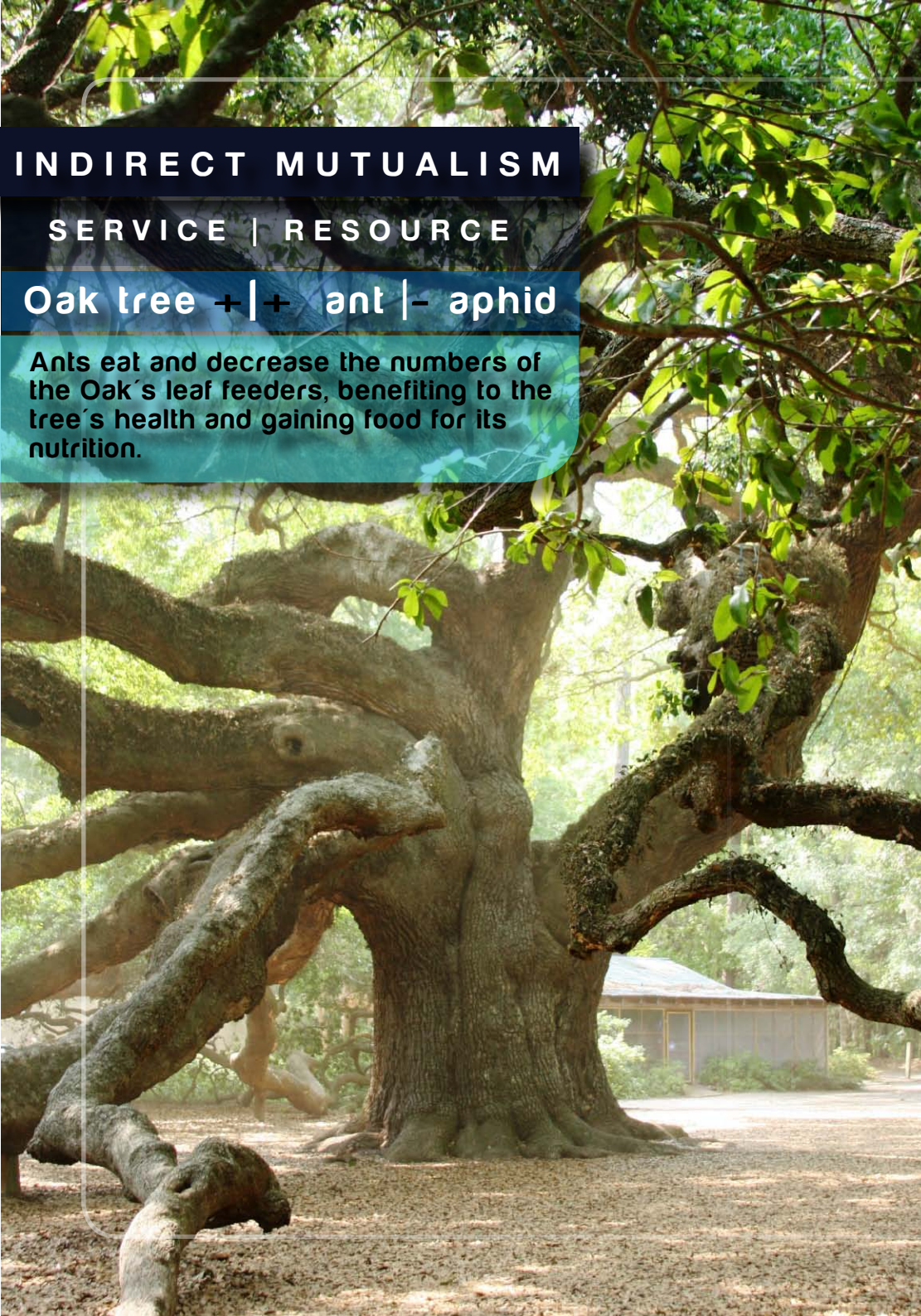
The understanding of the set of lessons deriving from the biology field just listed here provide material and inspiration on how to classify examples of symbiotic relations in architecture. An attempt to translate these inputs to the field of interest constitutes the next chapter.

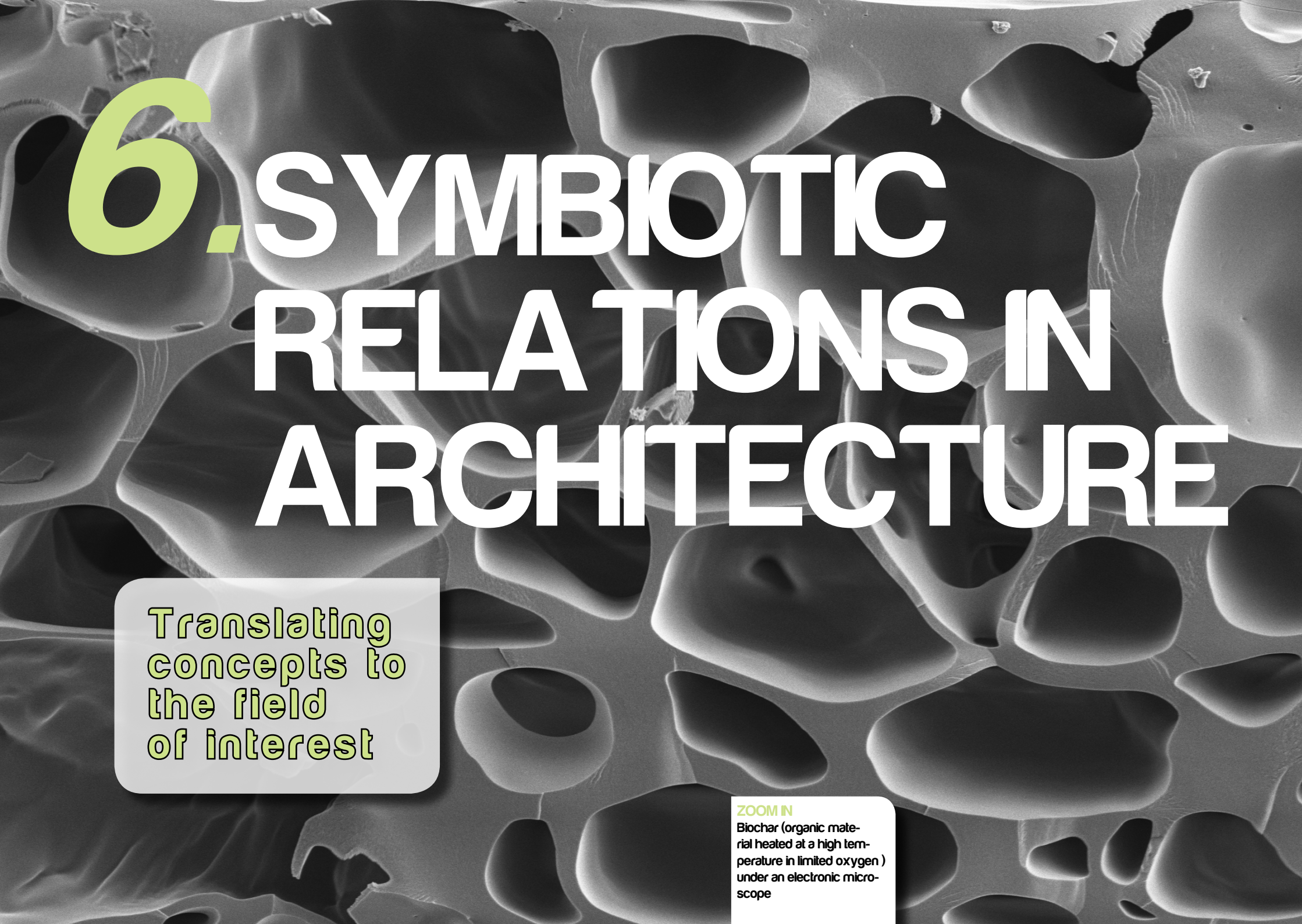
INDIRECT MUTUALISM

SERVICE | RESOURCE

Oak tree +|+ ant |- aphid

Ants eat and decrease the numbers of the Oak's leaf feeders, benefiting to the tree's health and gaining food for its nutrition.



A scanning electron micrograph (SEM) showing a dense collection of biochar particles. The particles are irregular in shape, ranging from small, rounded grains to larger, more complex, and elongated structures. The surface of the particles appears textured and porous. The background is a dark, granular material.

6. SYMBIOTIC RELATIONS IN ARCHITECTURE

Translating
concepts to
the field
of interest

ZOOM IN

Biochar (organic material heated at a high temperature in limited oxygen) under an electronic microscope

*who is who and
what is what?*

DEFINING ROLES

In order to make a proper analogy between symbiotic relations in biology and in architecture, two things need to be defined in beforehand:

- Which “organisms”, in architecture, should be considered involved in a given symbiosis, in order to define the situations to be analysed;
- Which are the consequences that can be considered as defining outcomes for each organism in a given symbiosis, in order to properly label that relation;

In an architectural frame, just like in biology, symbioses are developed between 2 or more “organisms”. These organisms, in architecture, have a very sharp role, defined by the chronological factor: there is always the “new intervention” and its “host structure” (no matter if another building or an urban structure, such as a viaduct, a bridge, riverbanks, a square or anything else). These relations produce a number of reactions in the surrounding environment - in this case, the city and its inhabitants - but this doesn’t mean that the environment itself is part of that specific relation.

On the other hand, if the relation between each building and the city cannot be directly considered part of that symbiosis, it neither means that those buildings have no relation at all with the city. On the contrary: going back to biology, every single

living organism has a very intimate relationship with the environment in which it lives. And an urban environment, with its defined limits, reacts as a closed system to each intervention in its “body”. It is not without any reason that “the city” has been studied for centuries as an organism, a system and a body, in researches that were already subject of a previous chapter of this thesis.

This relation of each building with the city can embrace a set of direct and an indirect symbioses. Indirect because any building or urban structure tends to establish a programmatic and a visual relation with its surrounding. That surrounding, somehow, will influence and be influenced by it. And direct because new interventions often need to be directly connected to city systems of energy, water and gas supply, circulation of people, and so forth. A building with a door that does not connect with the street has a quite reduced chance of “survival”. The same logic also often makes sense in relation to supplies of water, gas and/or energy.

For all that reasons - and as a strategy to broaden the outcomes and the utility of this research - the relation that each new intervention establishes with the city will also be investigated here as another symbiotic relation, one that any existing building also experiences. The difference between this symbiosis with the city and the one between two buildings is actually a matter of scale. In nature, symbioses can also happen; either between individuals of the same species (just like a building-building relation) or between individuals from different species, which in some cases present even the same scale

difference than the one between a building and a city.

In a final analysis, “Zooming out” one level and observing the relation between the city’s body and its many little symbionts leads to a constructive search for paybacks to the city as well. City which is, indeed, a host, only at a bigger scale like an elephant with its flees, bacteria or any other microscopic symbiont.

*Supply of resources
and services: space, energy,
“nutrients”, protection and
transport systems*

TRANSLATING EXCHANGES

With the organisms defined, the next step is to analyse the possible exchanges between them in terms of what is provided and what is gained. Still inspired on biology’s method of classification, these exchanges will define the different kinds of symbioses in architecture.

Literally translating it from biology, the possible exchanges between new structure and host can involve **resources and/or services**.

The one exchange that is always necessarily present is the **supply of space** from the host (both existing structure and/or city) to the new structure. The reverse can also be possible - in this case not as a rule - but when the new intervention includes additional usable space for

the host. This would mean an extension if the host structure is a private building, or additional public space when dealing directly with the city.

In terms of resources, the **supply of energy** in nature has a very direct translation in architecture, with the supply of electricity. This exchange could be present in both kind of relations, once the new structure can receive energy either directly from the public system (city) or through the connection with a host building. Besides that, it could also work the other way around, with new structure generating energy for itself and providing the host structure with its surplus.

The other resource exchanged in nature, **nutrients**, can be translated into architecture as the supply of provisions that “feed” other systems of the building, such as water and gas. In this case, the common direction would consist in the host supplying the new structure, but the reverse could become true if the new structure would include, for instance, a system of rain water caption to supply to the host.

In terms of services, one among these exchanged in nature, **protection**, could be directly translated as a form of shading (against excessive light and sun) or insulation against erosion (by wind or rain). Both cases could work either directions: from host or from new addition towards the other. A third possible translation is the protection gained in terms of maintenance, when the new addition brings a new function and, consequently, new users that will contribute to take care of the existing structure.

TRANSLATING

SYMBIOTIC ROLES

BIOLOGY

ARCHITECTURE

ORGANISMS

INVOLVED:

Species A + Species A
or
Species A + Species B

Building + Building
or
Building + City

POSSIBLE

EXCHANGES:

Resources

Space supply

Space supply

Supply of energy

Supply of electricity

Nutritional

Provisions that “feed” building systems,
such as water and gas.

Services

Protection

Renovation + Maintenance

Insulation against erosion (by wind/rain)

Shading (against light and/or heat)

Transport

of goods
of people
of waste

The other service commonly exchanged in nature is **transport**. This is the one with the most distant translation, but not less important for the relation in architecture. The reason is simple: up to the present days, buildings and cities don't move (except for experimental mobile architectures and poetic utopias like Archigram's "walking city"). In this sense, the transport that can be analysed in this case does not refer to the organisms involved in the symbiosis themselves, but to goods, waste and people within those organisms. And that leads to the key point of any architecture study: the users.

*ultimate beneficiary
of any architecture*

PEOPLE

All the possible exchanges and paybacks just seen are clearly referring to the buildings and the urban environment involved in that symbiosis. But once the ultimate goal of practically any construction within the city is to attend human needs, its outcomes will affect the users of that structures more than anything else.

The ultimate intention of the symbiotic approach, therefore, is to always point at a mutualistic relation between users, where each other's resources are implemented in the most fruitful way, and the good outcomes are shared among the parties. Buildings should work in collaboration and support each other, in a way that what is impossible for one structure

alone, together becomes feasible.

Another important aspect to be considered is that an attempt to apply a mutualistic logic to guide new interventions in architecture would raise the need to introduce a new set of "rules"; only when followed, the system will work (for instance regarding the sharing of space or of produced energy). Therefore, the participation and acceptance from the users is also a necessary aspect that takes part of the mutualistic architecture logic. It will be most of the times a matter of compromising between owners' demands and constraints, a subtle mediation between give and take. In this sense, a mutualistic relation is preferable among all symbioses because it is defined by positive outcomes for both symbionts. And once everybody have a positive outcome, these symbiotic relations (necessary to respond the urban densification process) become not only possible, but desired.

*providing hints
about the nature of
each symbiosis*

OWNERSHIP

The ownership of each structure can tell a lot about a given symbiotic relation. When host and new structure are not owned by the same individual, the established relations between owners will provide important information to be analysed. For instance, money compensation between them would denote that one of the structures/owners is somehow having more positive architectonic outcomes than the

other, suggesting a relation of parasitism, commensalism or amensalism. On the other hand, when there is no exchange of money between the owners, it is a clear sign that the relation might lay among the categories of mutualism, neutralism or even competition/mutual predation.

The same facts that rule these relations between owners can also be applied when one of them is "the public", represented by a government. In this sense, the public-private relation also passes through a shift that implies consequences concerning privacy and property boundaries. For instance, a symbiotic intervention could occupy a potential surface on the edge of a private property in response to scarcity of public space and, in return, provide new usable space for the private owner.

In other situations, in which the owner of host and new structure is the same, the relation between organisms will tend to generate positive outcomes for both, once one single individual will probably avoid harming one of his own structures. The most likely chance in this case, however, is that the new structure will work as a simple extension of the existing one, and in this case it will not even represent an actual symbiosis, once there are no different organisms, and therefore no relation between "them".

Different biological phenomena as analogies for cases without proper symbioses

OTHER PROCESSES

Cases like this last example, in which not even a symbiosis is present, add even more confusion to the misused term "parasitic architecture". This specific mistake, though, is absolutely comprehensible, because actually the "intimate relation" between a previous and a contemporary architecture is indeed present. But once this research has the goal of vanishing the imprecision of the biological analogy, other terms were also imported from that field to architecture in order to define properly also these situations.

This is the case of unused buildings that pass through a transformation with the addition of a new part. Together, the two "structures" begin to work as one, with a single and new purpose. A very similar situation occurs in nature, when an organism, facing an extreme condition or environment, joins another one to be able to survive. From this moment on they live in an intimate relation, to such an extension that their behavior resembles the one of a single organism. This phenomenon is called in biology "**composite organism**" and the close intimacy between them induces a change in their morphology, physiology and biochemistry, just like in the architectural example, which often passes through a change of program, arrangement and shape.

Another case is represented by a physical expansion of a given structure, in which 2 organisms can not be defined. This process of enlargement of an existent structure can be compared with the process of expansion of the human's brain and skull through history that made us evolve from the Archaic Homo Sapiens to our contemporary form. The enlarged skull can not be considered a second organism and therefore this process does not represent a symbiosis but, instead, a process of "evolution".

A third case in which a proper symbiosis can not be appointed is when a change of program brings the need for some physical adaptations, but no need for an addition of a second organism. When this "programmatic change" happens in nature, with a differentiation of an individual's genomic sequence, it is called "mutation". Just like in nature, in architecture this process can lead to an evolution, once a successful change of program can lead to a demand for more space or other shape adaptations in the future. In this case, an important point must be clarified: the difference between this combination of processes (mutation + evolution) and the process that generates a composite organism.

In the combination of processes, the mutation represented by a programmatic change doesn't mean an immediate change of morphology. This second change can happen or not as a consequence of the action of time when that mutation is successful. Just like in nature, where mutations only achieve the status of evolution after crossing successive generations. In the other case, of com-

posite organisms, the morphological (shape) change occurs immediately as a result of the union of organisms and physiological (programmatic) change.

In order to sharpen these definitions in biology and its translations to architecture, a summary chart closes this chapter in the next page.

COMPOSITE ORGANISM

Two different organisms that live in intimate relation and resemble the behaviour of a single organism. This close intimacy induces a change in their morphology, physiology and biochemistry. They live in extreme environments or simply where each original organism wouldn't be able to survive alone.

MUTATION

Change in the individual's genomic sequence (internal arrangement) that can lead to an evolution or not

EVOLUTION

Change across successive generations in the heritable characteristics of a species.

TERMINOLOGES/TRANSLATIONS

NEUTRALISM (0,0):

structures with physical contact without any outcome from that contact

MUTUALISM (+,+):

structures with physical contact and positive outcomes from it

COMMENSALISM (+,0):

the new structure uses space from the host but doesn't harm it, neither bring any positive outcome

PARASITISM (+,-):

oversaturation, shadowing, view obstruction or pollution caused by the new structure, which benefits from the space provided by the host

AMENSALISM (0,-):

oversaturation, shadowing, view obstruction, pollution caused by the presence of a new structure, which has no gain or loss from that relation

COMPETITION (-,-):

Two structures compete for space, sun, view or any physical resource harming each other

COMPOSITE ORGANISM

Existing and new structures share the same program and behave as a single building. The host structure experiences a change of morphology due to the intervention.

MUTATION

Change of program with internal adaptations to the new program, that can lead or not to a physical expansion

EVOLUTION

Physical expansion; Change of the shape and physical aspect, responding or not to a programmatic change

6. EXPLICATIVE EXAMPLES

The background image shows a historic building with classical architectural features, including columns and arches. A modern, white, box-like structure is attached to the top of the building, featuring a glass-enclosed section and a flat roof. Several people are visible on the rooftop platform. The sky is clear and blue.

**Making the
theoretical
approach
palpable**

THE CUBE

A temporary restaurant that travels to cities and lands on the rooftop of antique buildings to enjoy a unique view over the urban environment

examples of
each of the 9 pro-
cesses described

LEARNING FROM EXISTING CASES

All the translations developed in the previous chapter define rules and allow the understanding on how could an architectural approach benefit from strategies of nature. In this direction, some of the most important outcomes of this research can only be visualized and understood when all these theoretical comparisons materialize in palpable examples.

For this reason, existent explicative examples of symbiotic relations in architecture were catalogued and are presented in the next pages, with a brief explanation of each situation. After having acquired important inputs from all of them, a conclusion for this thesis will be introduced, based on reflections over the lessons that were inherited from each example.

The criteria for the choice of examples followed what is nowadays (mis)called “parasitic architecture”. This includes cases of proper symbioses, but also cases of the other sorts of biological processes explored at the end of the previous chapter. This means that in some of the following examples, a symbiotic relation doesn’t even exist, once there are no different organism in that relation.

The scope here is to present a variety of examples that would include, at least, one of each of the 9 biological processes

(symbiotic or not) defined and translated before. However, this is not the criteria for the organization for the examples, since another important aspect can define with more efficiency the starting point for a system to be possibly applied in future symbiotic projects: the physical position of the new structure in relation to the host.

Above, side-up, in-
between and underneath

TYOLOGIES: ARCHITECTONIC KAMA SUTRA

The classic ‘Kama Sutra’ organized the possibilities of interaction between humans during an intimate relation according to the positions of one towards each other. In the same way, the criteria to organize the intimate relations between buildings in this research takes into account the position that one stipulates towards the other. These positions present restrictions and potentials that can be grouped in specific typologies, but each case can still respond to them with any of the studied relations.

The most common typology is the ‘Above’, which can be divided in ‘top-up’ (extensions of the host) and ‘rooftop construction’ (new independent spaces). The biggest potential of this one is that, literally, ‘the sky is the limit’. On the other hand, access and connection to the systems of energy, gas, water and sewers are very much dependent on the host structure as an intermediate, due to the distance from the street level. Another typology that presents basically the same difficulties is the ‘Side-up’. The disadvantages, however,

go far beyond, once space becomes a complicate matter and the visibility from the street raises many issues (related, for instance, with heritage or legislation).

A very similar category is the ‘In-between’, which is placed in a similar level but with spatial constraints from both sides.

The last typology is the other big group, labelled here as ‘Underneath’. With the chance of being covered by the host, it tends to occur under bridges and viaducts, but often utilizes the underground level instead. These cases tend to create usable space also at the street level, that often results into a spatial payback for the city.

In the following pages, existing examples of architecture that promotes this symbiotic relations will expose more clearly advantages and costs of each category and each possible symbiotic approach.

ARCHITECTONIC KAMA SUTRA

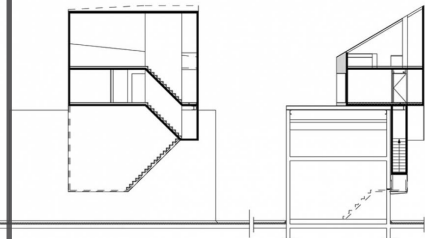
Contextual adaptation of
Rem Koolhaas’s “delirious
NY” illustration about the
city as a metaphor for the
incredible variety of human
behaviour.

MUTUALISM

TPOLOGY: ABOVE



LAS PALMAS PARASITE



Existing Structure: Las Palmas building

Original program: Warehouse, abandoned by then

Location: Rotterdam, The Netherlands

New Structure: "Parasite": Prototype for **Advanced Ready-made Amphibious Small-scale Individual Temporary Ecological-house** (2001)

Project by: Korteknie Stuhlmacher

Paybacks: Visibility that lead to future renovation

Symbiotic Relations: With existing structure: Direct mutualism

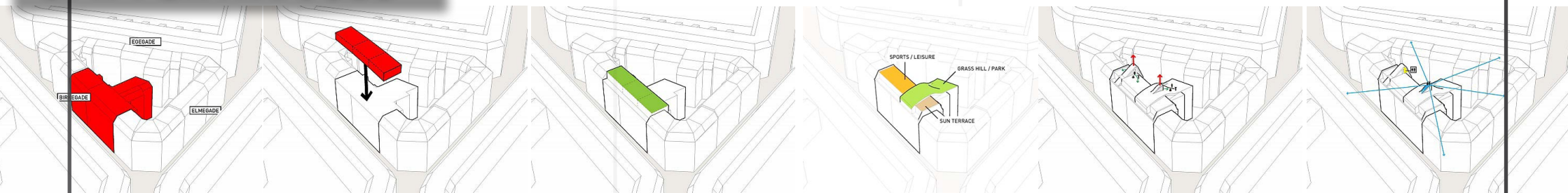
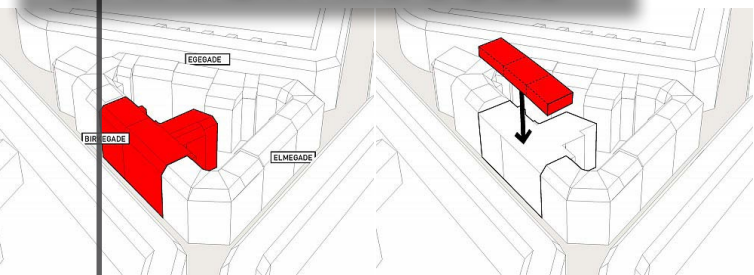
With the city: Indirect mutualism

The former warehouse building Las Palmas was temporarily occupied by various exhibitions during Rotterdam's year as European cultural capital in 2001. One of the exhibitions was called Parasites and presented designs of small-scale objects for unused urban sites making 'parasitic' use of the existing infrastructure. One of the designs was built in full scale, but the 'parasitic' nature of it was already contested by the book *Rooftop Architecture*. Services like water supply, sewage and the electric system, linked to the existing installations, didn't overload something that was not in use. On the contrary, the installation ended up leading to the restoration and permanent use of the building, nowadays with a new "symbiont" on it's top.

MUTUALISM

TYPOLGY: ABOVE

CPH PENTHOUSES



Existing Structure: Existing building block

Original program: Apartments

Location: Copenhagen, Denmark

New Structure: New penthouses and rooftop terrace (2011)

Project by: JDS Architects

Paybacks: Rooftop garden/Leisure space freely accessible for the co-op's neighbours and city residents in general

Symbiotic Relations: With existing structure: Direct mutualism.

With the city: Direct mutualism.

Elmegade is a densely populated area of inner Nørrebro, in Copenhagen. Because of the scarcity of space, the driving concept of this project is to create the 'missing garden' at the top of the existing housing block in association with 3 new public-use penthouses, so all residents gain access to a genuine outdoor garden. On the rooftop garden different functions are placed, each one associated to a specific materiality. This is reflected in a playground with shock-absorbing surface and a playful suspension bridge, a green hill with varying accommodation backed by real grass and vegetation, a viewing platform, an outdoor kitchen and barbecue, and a more quiet wood deck.

MUTATION + MUTUALISM

TYPOLGY: ABOVE

CUSTOMS HALL 12



Existing Structure: Customs Hall 12

Original program: Customs hall, abandoned by them

Location: Cologne, Germany

New Structure: 18 apartments, commercial spaces (2010)

Project by: Molestina Architects

Paybacks: Restoration

Symbiotic Relations: With mutant existing structure: direct mutualism.

With the city: Indirect mutualism

The original building on the banks of the Rhine was a former customs hall, which needed restoration together with the whole riverside. Besides the restoration, a new addition was designed by Molestina architects to cover the old building. The result brings a restored look to the stone façade and a new roof cladding, hosting 18 apartments in a contemporary interpretation of the twenties, while the original building now hosts 1,300 m² for commercial use. Both private terraces and balconies, together with the host stone building can enjoy gorgeous view of the Rhine.

COMMENSALISM

TYPOLGY: ABOVE



STUDIO EAST DINING



Existing Structure: South London Gallery
Original program: Westfield Stratford City development headquarters
Location: London, United Kingdom
New Structure: Temporary restaurant Studio East Dining (2010)
Project by: Carmody Groarke
Paybacks: Public attention to the Olympics building construction
Symbiotic Relations: With existing structure: Commensalism
With the city: Direct mutualism

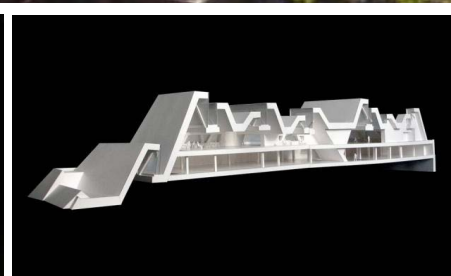
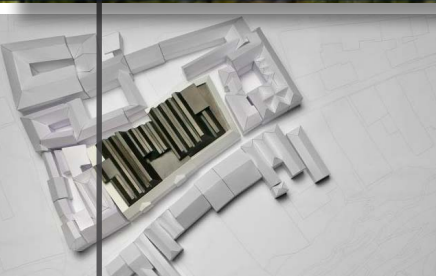
This is a project that was only open for three weeks. The client had intended the venue to draw attention to the forthcoming opening of the vast Westfield shopping centre by London's 2012 Olympic Park. The structure is made of scaffolding and boards borrowed from the construction site, covered in recyclable plastic sheeting. The cladding material which encases the roof, is a semi-translucent membrane, using industrial grade heat retractable polyethylene which is 100% recycled after use; as with the other materials, all will be returned to the site afterwards and recycled without any waste. Winner of the Emerging Architecture Awards 2010

EVOLUTION

TPOLOGY: ABOVE



KASTER & OHLER



Existing Structure: Kastner & Ohler

Original program: Department store

Location: Graz, Austria

New Structure: Offices, malls, parking, rooftop public deck (2010)

Project by: Carmody Groarke & Nieto Sobejano

Paybacks: New panorama of the city freely accessible to population

Symbiotic Relations: No different organisms, therefore no symbiosis with existing structure; expansion of it, meaning evolution.

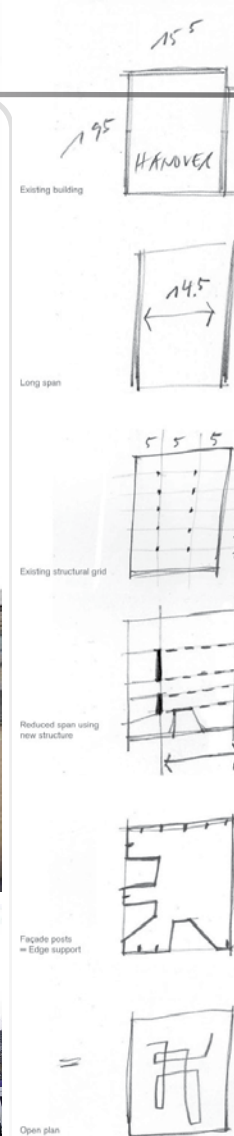
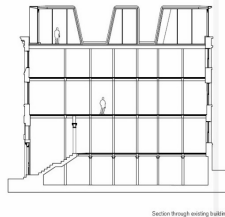
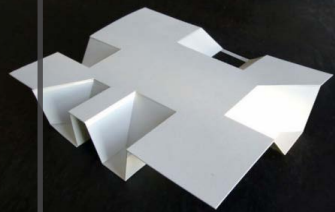
With the city: Indirect mutualism

A clever expansion policy allowed the traditional department store in Graz (which downtown makes part of UNESCO's World Cultural Heritage) to grow about 10,000 square meters. The decision was made in favor of a newly designed roof area with viewing platform and catering area. After a structural renovation by Szyszkowitz & Kowalski an underground parking garage was realised largely beneath the 400 year old building of Admonter Hof. After that, the realisation by 2010 of a spectacular roovescape, designed by Spanish architects Nieto Sobejano, reorganised the roof in a further expansion.

EVOLUTION

TYPOLGY: ABOVE

VICTORIAN WAREHOUSE



Existing Structure: Victorian Warehouse (Industrial age residential building)

Original program: Dwellings

Location: Bradford, United Kingdom

New Structure: More dwellings on the rooftop (2008)

Project by: Kraus & Schönberg

Paybacks: Making room for the urban densification process

Symbiotic Relations: No different organisms, therefore no symbiosis with existing structure; expansion of it, meaning evolution.

With the city: Indirect mutualism

Together with the surrounding buildings, the host structure is a reminiscence of the early industrial age in Bradford, England. A residential extension was conceived on its rooftop with a folding prefabricated plate used to form living spaces and balconies. The sculptural aspect of the folding plate reflects the surrounding roofscape. A three dimensional self supporting truss made of solid cross laminated timber boards directs the roof loads into the existing external walls. The spatial concept has merged with the construction and has formed one entity.

COMPOSITE ORGANISM

TPOLOGY: ABOVE

WATER HOUSE



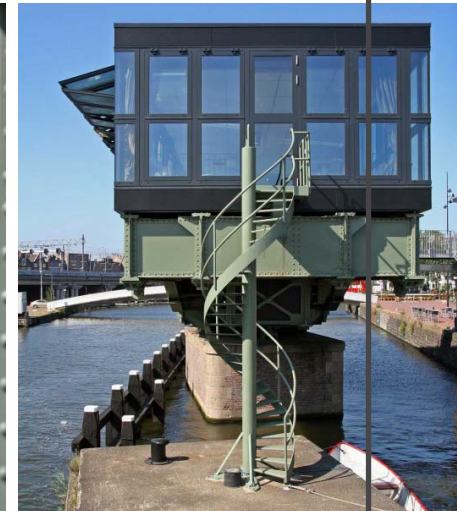
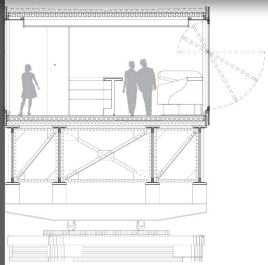
Existing Structure: Abandoned military building
Original program: Japanese military headquarters, abandoned by then
Location: Shanghai, China
New Structure: Boutique-Hotel & Dwelling (2011)
Project by: NHDRO, architects Lyndon Neri e Rossana Hu
Paybacks: Renovation, new usage
Symbiotic Relations: Within the composite organism: Mutualism
With the city: Indirect mutualism

The concept lays on the extreme contrast in the union of old and new. The original building was built in concrete, while for the new intervention corten steel was implemented, emotionally recalling the industrial historical background of the banks of Huangpu river. The design focuses on the integration between interiors and exteriors, as well as between private and public spaces, so that the guests are induced to continuously get confronted both with the internal circulation within the hotel and with the city. An important attention is given to the maintenance of the heritage of the existing building; in that sense, damaged parts are intentionally left unfinished and shown to the visitors.

COMPOSITE ORGANISM

TYPOLGY: ABOVE

OPEN RESTAURANT



Existing Structure: Abandoned swing bridge

Original program: Railway

Location: Amsterdam, The Netherlands

New Structure: Café-Restaurant (2008)

Project by: de Architekten Cie.

Paybacks: Partial restructuring, new usage

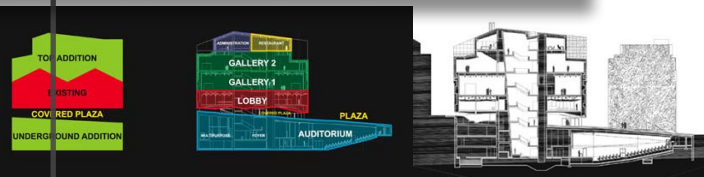
Symbiotic Relations: Within the composite organism: Mutualism

With the city: Indirect mutualism

After an absence of eight months, the last surviving swing railway bridge in the Netherlands was re-installed between the Westerdoksdijk and Westerdokskade. Weighing more than 300 tonnes, the bridge was transported on a pontoon and piloted through the Westerdokssluis lock. The swing bridge, designed in 1922 by the engineer P. Joosting, is being transformed into a café-restaurant at its age-old site to a design by de Architekten Cie. of Amsterdam that was commissioned by café-restaurant OPEN. The structural skeleton for the highly distinctive fenestration of the design was realized in the process.

COMPOSITE ORGANISM

TYPOLOGY: ABOVE & UNDERNEATH



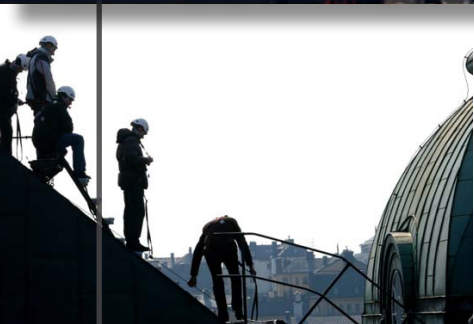
Existing Structure: Abandoned building
Original program: 19th century power station
Location: Madrid, Spain
New Structure: Social and cultural center (2009)
Project by: Diller Scofidio + Renfro
Paybacks: Restructuring and new usage
Symbiotic Relations: Within the Composite organism: Mutualism
With the city: Direct mutualism

The former power station (dating from 1899), an example of the industrial architecture of the late 19th century of the old town, was converted into an iconic social and cultural centre for the capital. Conceived as an urban magnet, not only for art-lovers but also for the building itself, the architects lifted the building off the ground, to draw visitors inside through "a surgical operation, separating and removing the base and the parts of the building no longer needed." The separation of the structure from the ground level created two worlds; one below (theatre, service rooms, parkings), and the other above the ground (lobby, galleries, restaurant and administrative offices).



COMMENSALISM

TYOLOGY: ABOVE



Existing Structure: Houses of Stockholm
Original program: Houses' roofs
Location: Stockholm, Sweden
New Structure: Rooftop promenade (2003)
Project by: Spontaneous architecture
Paybacks: None to the structure; clear goal of promoting the city.
Symbiotic Relations: With existing structure: Commensalism
With the city: Direct mutualism

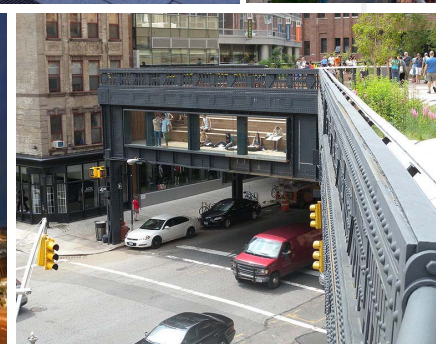
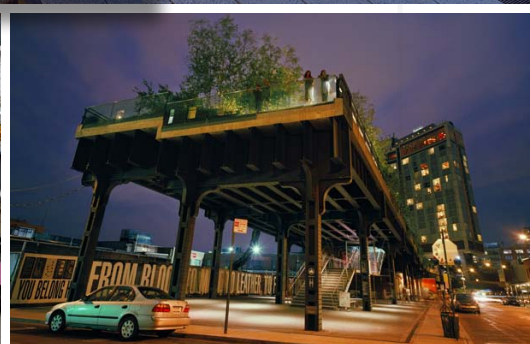
Upplev mer (experience more) is a Swedish enterprise that have hit upon the clever idea of showing off their capital city from a bird's eye view. They organize tours above Stockholm's oldest roofs, where the guides will lead you on an aerial tour of the city's history and architecture as you literally walk on the rooftops of Stockholm's buildings. The tour's rooftop route reaches heights of over 65 meters above the pavement, while a guide supervises the urban climbers with security equipment. Upplev Mer has official authorization from the National Bureau of Urban Planning (National Board of Housing, Building and Planning), who agreed to open this activity to the public.

COMPOSITE ORGANISM

TYPOLGY: ABOVE



HIGHLINE PARK



Existing Structure: Abandoned viaduct

Original program: Railway

Location: New York, United States of America

New Structure: Elevated park (2009)

Project by: Diller Scofidio + Renfro

Paybacks: Partial restructuring, Publicly accessible park

Symbiotic Relations: Within the composite organism: Mutualism

With the city: Direct Mutualism

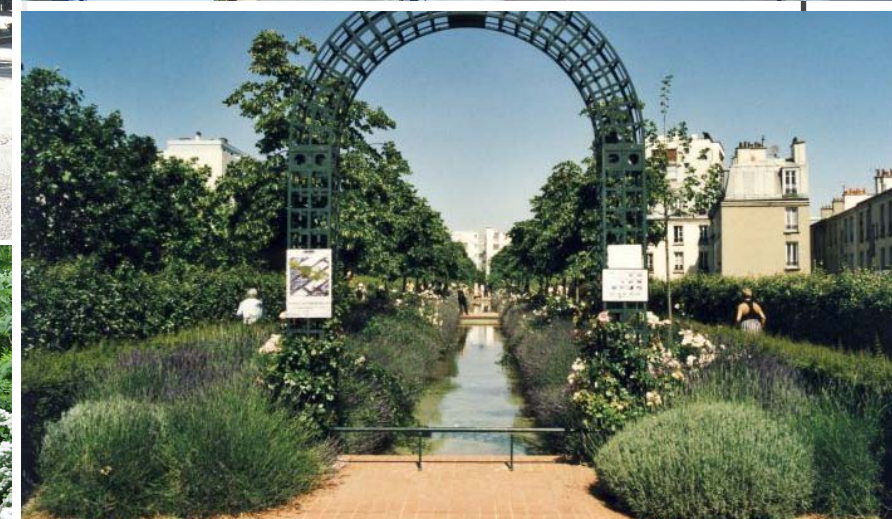
The High Line was built in the 1930s, as part of a massive public-private infrastructure project. It lifted freight traffic 30 feet in the air, removing dangerous trains from the streets of Manhattan's largest industrial district. In the 80's the last train ran on the High Line and, after 20 years, (in 1999) a community residents called "Friends of the High Line" fought for the High Line's preservation and transformation at a time when the historic structure was under the threat of demolition. The High Line is now a public space, redesigned and planted as an aerial greenway.

COMPOSITE ORGANISM

TYPOLOGY: ABOVE AND UNDERNEATH



PROMENADE PLANTÉE



Existing Structure: Abandoned viaduct

Original program: Elevated railway

Location: Paris, France

New Structure: Elevated park and retail under the arches (1993)

Project by: Jacques Vergely & Philippe Mathieux

Paybacks: Partial restructuring, Publicly accessible park

Symbiotic Relations: Within the composite organism: Mutualism

With the city: Direct Mutualism

The Promenade plantée is an extensive green belt covering the former Vincennes railway line, 4.7 km long. It ceased operation in 1969 and part of the line was integrated into the existing public transportation system, while other parts were completely abandoned. Beginning in the 1980s, the area was renovated, and the Promenade Plantée was put into place at the same time in order to reuse the abandoned line. The parkway was the only elevated park in the world for some years. Under the arches, stores, galleries and studios occupied covered spaces unused so far.

MUTUALISM + EVOLUTION

TYPOLOGY: ABOVE, IN BETWEEN AND UNDERNEATH



Existing Structure: Concert house

Original program: Concert hall and conventions centre

Location: Rotterdam, The Netherlands

New Structure: Music/dance School, offices, shops, café, restaurant (1999)

Project by: Jan Hoogstad

Paybacks: Expansion of existing rooms and new supporting programs

Symbiotic Relations: With existing structure: Direct mutualism.

With the city: Direct Mutualism

De Doelen is a concert hall and convention centre in Rotterdam, Netherlands. It was originally built in 1934 and destroyed in May 1940 during World War II. It was rebuilt between 1962 and 1966, originally with one hall (highlighted in red in the biggest image) to which two more were added between 1993 and 1999.

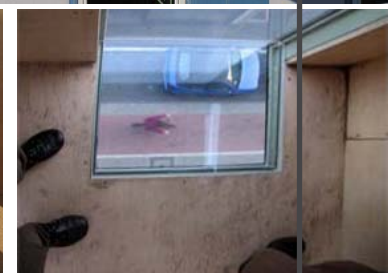
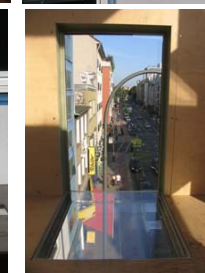
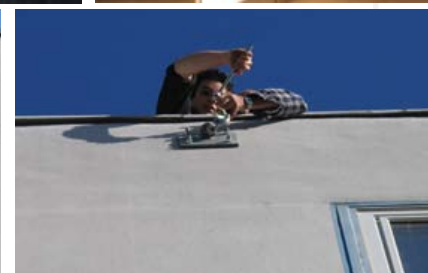
It has a variety of facilities, including the Grote Zaal (Grand Hall), a 2,200-seat concert hall, two smaller halls which each seat about 700 people, and convention rooms.

EVOLUTION

TYPOLGY: SIDE-UP



Foto: Hana S



Existing Structure: Apartment buildings

Original program: Buildings' facades

Location: Stockholm, Sweden

New Structure: Hanging room (2004)

Project by: Stefan Eberstadt

Paybacks: Piece of art/ extra room for existing apartments

Symbiotic Relations: No different organisms, therefore no symbiosis with existing structure; expansion of it, meaning evolution.

With the city: Direct mutualism

Stefan Eberstadt's backpack house is a 2.50 m x 2.50 m x 3.60 m box that can be moved and suspended to façades of residential buildings. Even though the idea was intended as a work of art one can access it by crawling through the host building's external windows. It explored ideas of small apartments and the social and architectural themes of flexibility and mobility. The box is suspended from steel cables that are anchored to the roof or to the facade of the existing building. The construction is a welded steel cage with a light birch veneered plywood interior empty space, free from connotations and open to its user's needs.

EVOLUTION

TYPOLGY: SIDE-UP



PONTE VECCHIO



Existing Structure: Ponte Vecchio

Program: pedestrians Bridge with commerce

Location: Florence, Italy

New Structure: New shops (Seventeenth century)

Project by: Spontaneous architecture

Paybacks: Expansion of the original program

Symbiotic Relations: Shops were originally there, so, no different organisms, therefore no symbiosis with existing structure; expansion of it, meaning evolution.

With the city: Direct mutualism

Ponte Vecchio ("Old Bridge", in Italian) is a Medieval stone closed-spandrel segmental arch bridge over the Arno River, in Florence, Italy. It was originally built by the Roman empire already with some shops along it, a common trend those times. Butchers initially occupied the shops. Shops and merchants displayed their goods on tables after authorization of the Bargello (a sort of a lord mayor, a magistrate and a police authority). The back shops (retrobotteghe) that may be seen from upriver, were added in the seventeenth century. The present tenants are jewellers, art dealers and souvenir sellers.

PARASITISM

TYPOLGY: SIDE-UP



YELLOW TREEHOUSE



Existing Structure: Tree

Program: -

Location: Warkworth, New Zealand

New Structure: Tree-house restaurant (2009)

Project by: Pacific Environments Architects Ltd.

Paybacks: None. Negative outcomes: Amputation and perforation

Symbiotic Relations: With the existing structure: Parasitism

With the environment: Direct mutualism



The Yellow Treehouse was commissioned as part of a marketing campaign by the telephone directory Yellow Pages. For gaining publicity, they sponsored the construction of an elevated tree house restaurant attached to a redwood tree, in the middle of a forest. The structure is made of wood and connects with the tree through a belt that perforates the tree. For gaining the right amount of necessary space, branches were cut off, partially affecting the health of the immediate host, the tree. On the other hand, for the “big scale host”, which in this case is not the city but the forest, it provides protection against destruction through the social control created by the presence of people.

MUTATION + EVOLUTION

TYPOLOGY: IN BETWEEN

DELAMAR THEATER

Existing Structure: Delamar Theatre

Original program: Cinema, music theatre, theatre

Location: Amsterdam, The Netherlands

New Structure: Renovation and expansion (2010)

Project by: AMA Group Architecten; Jo Coenen & Co

Paybacks: Added area for existing structure

Symbiotic Relations: No different organisms, therefore no symbiosis. Evolution

With the city: Direct Mutualism

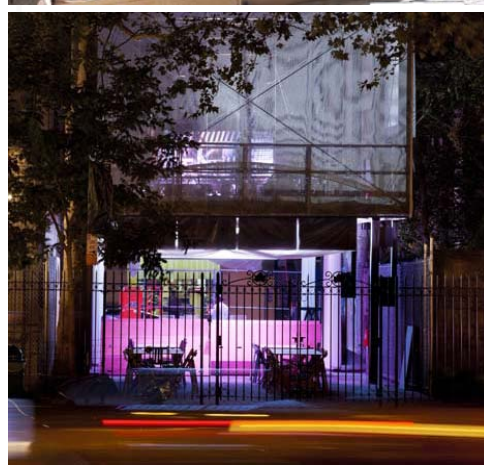
The original school building, transformed into a warehouse, had a second programmatic change when it became a theatre in 1930. In 2005 a big renovation came with no programmatic change. The New theatre now counts on 2 highly qualitative auditoriums and 2 multifunctional rehearsal rooms. With the renovation designed by Jo Coenen & Co, the buildings' monumental façade at the Mar-nixstraat, dating from 1880, was maintained, but a large amount was rebuilt, with a contemporary architectural language creating a big contrast to highlight the traditional facade that was left.



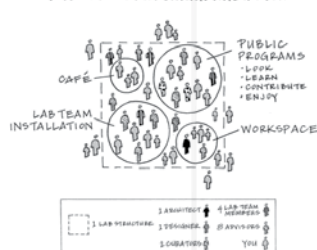
NEUTRALISM

TYPOLOGY: IN BETWEEN

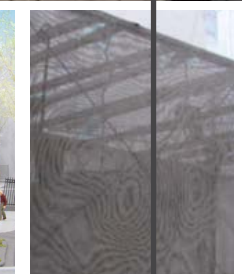
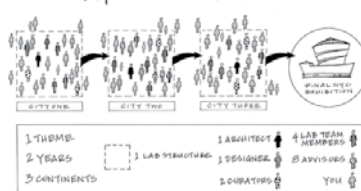
BMW GUGGENHEIM LAB



1 VENUE - BMW GUGGENHEIM LAB



1 CYCLE - BMW GUGGENHEIM LAB



Existing Structure: Missing tooth (void between existing buildings)

Program: Programmatic void

Location: New York, USA / Berlin, Germany / Mumbai, India

New Structure: Mobile structure for the BMW Guggenheim Lab (2011)

Project by: Atelier Bow-Wow

Paybacks: Workshops free for the community to generate specific ideas to urban situation with innovative and sustainable designs.

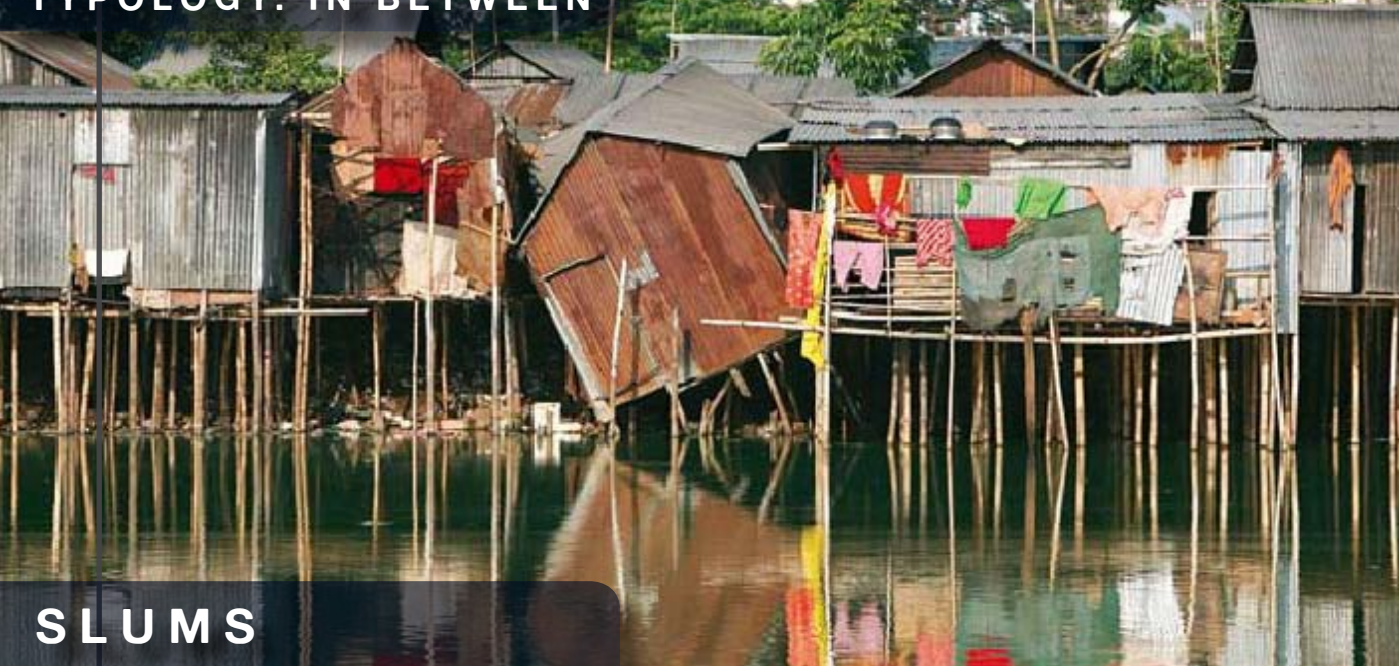
Symbiotic Relations: With the existing structures: Neutralism

With the city: Direct mutualism

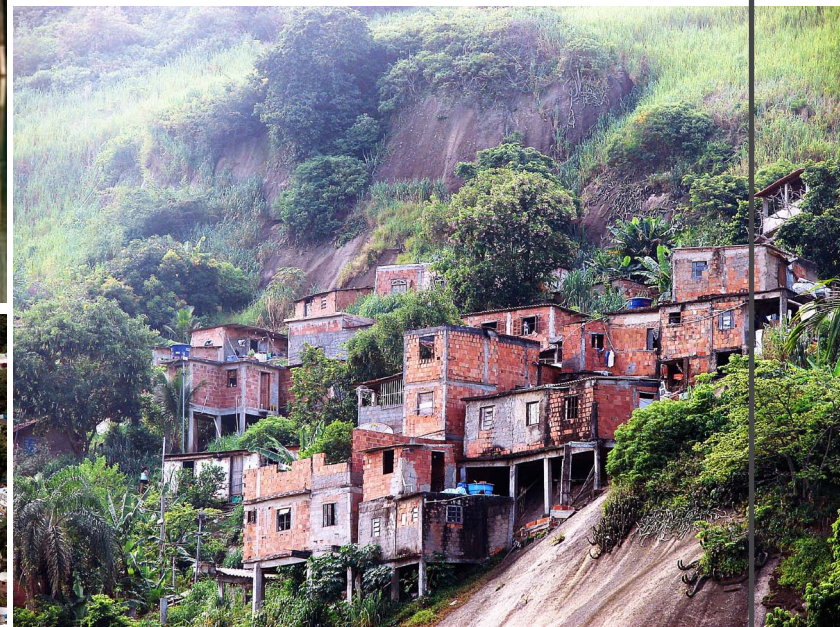
The mobile structure for the first cycle of the BMW Guggenheim Lab has been designed by the Tokyo-based Atelier Bow-Wow as a lightweight and compact "travelling toolbox." The 2,200-square-foot structure can easily fit into dense neighbourhoods and be transported from city to city. In New York, the two-story structure is nestled between two buildings on a three-quarter-acre T-shaped site; at its southern end, it opens out onto an inviting landscaped public space and cafe. The program is totally devoted to the community and to the generation of ideas to deal better with specific issues from each city where it passes.

COMPETITION

TYPOLGY: IN BETWEEN



SLUMS



Existing Structure: Slums

Program: Dwellings, commerce, services

Location: Mostly in economically undeveloped regions

New Structure: New dwellings, commerce, services

Project by: Spontaneous architecture

Paybacks: None. Negative outcome: oversaturation of the structural system, overshadow, interrupted view and air circulation

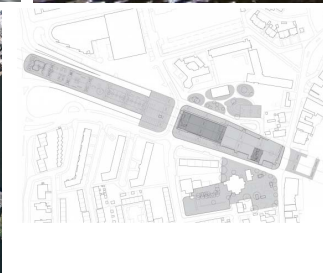
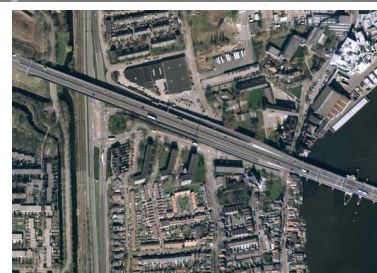
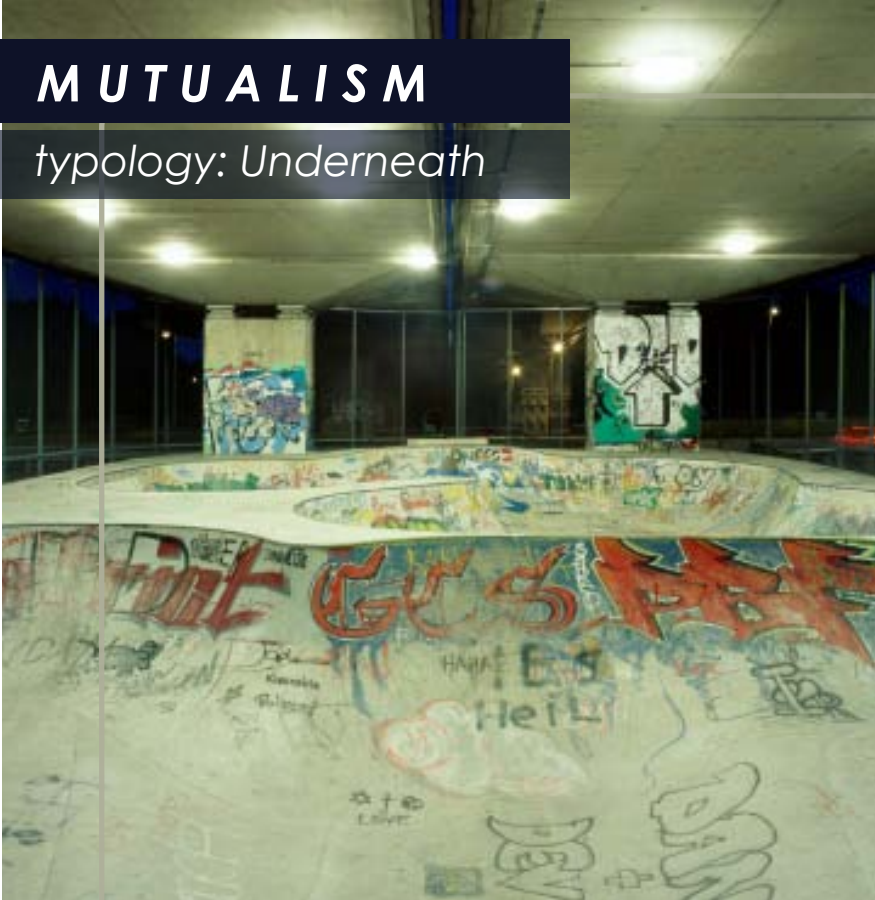
Symbiotic Relations: With the existing structures: competition

With the city: parasitism

Slums in general represent a very direct metaphor of a relationship that is called in biology “competition”. It happens when both organisms involved have the same goals and aims but the success of one of them can lead to the failure of the other. A classic example used in biology is in forests when high trees compete with each other for sun. Spontaneous irregular settlements like slums represent the same struggle for space, harming all the previous buildings each time a new one is built covering the sun, air circulation and view of the others and oversaturating the fragile structures built without any know-how by the inhabitants themselves.

MUTUALISM

typology: Underneath



Existing Structure: Highway A8

Program: Highway

Location: Zaanstad, Netherlands

New Structure: Multi-functional community services (2003)

Project by: NL Architects

Paybacks: The program chosen by the community has the specific goal of recovering that blind spot and re-link both sides of the urban tissue.

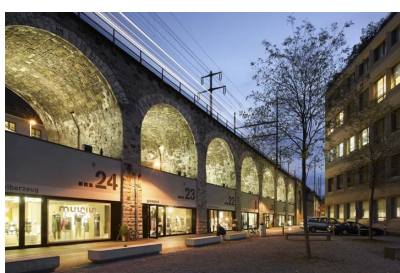
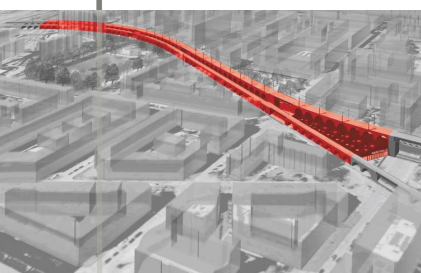
Symbiotic Relations: With the existing: Direct mutualism.

With the city: Direct Mutualism

In order to cross a river, Highway A8 was build on columns. The new road crossing the town produced a brutal cut in the urban tissue. The project A8ernA is an attempt to restore the connection between both sides of the town and to activate the space under the road. The programme, chose by the populaton includes: Skate bowl, Toy Area, Break Dance Stage, table soccer, soccer field, basketball pitch, parking, covered square, supermarket, flower and fish shop, light fountain, sculptural bus stop, mini-marina, and a panorama deck for the River.

COMMENSALISM

typology: Underneath



Existing Structure: Letten Viaduct

Program: elevated railway

Location: Zurich, Austria

New Structure: Markthalle in the viaduct (shops, cafes and services)

Project by: EM2N, Architects AG, Zurich

Paybacks: Maintenance.

Symbiotic Relations: With the host: Commensalism.
With the city: indirect mutualism

For almost 120 years, the Letten Viaduct has led northwards across a former industrial area close to Zurich city-center. The 43 natural stone arches of the structure have always been used as storage areas, mostly in an improvised fashion, but also for shops and restaurants. By 2010, under the label "In the Viaduct", new uniformly designed spaces for shops, cafés and general services were created in the arches. Even with limited building costs met the increased requirements for energy efficiency. At the junction with the Wipkinger Viaduct emerged in addition Zurich's first covered market hall.

MUTUALISM

typology: Underneath

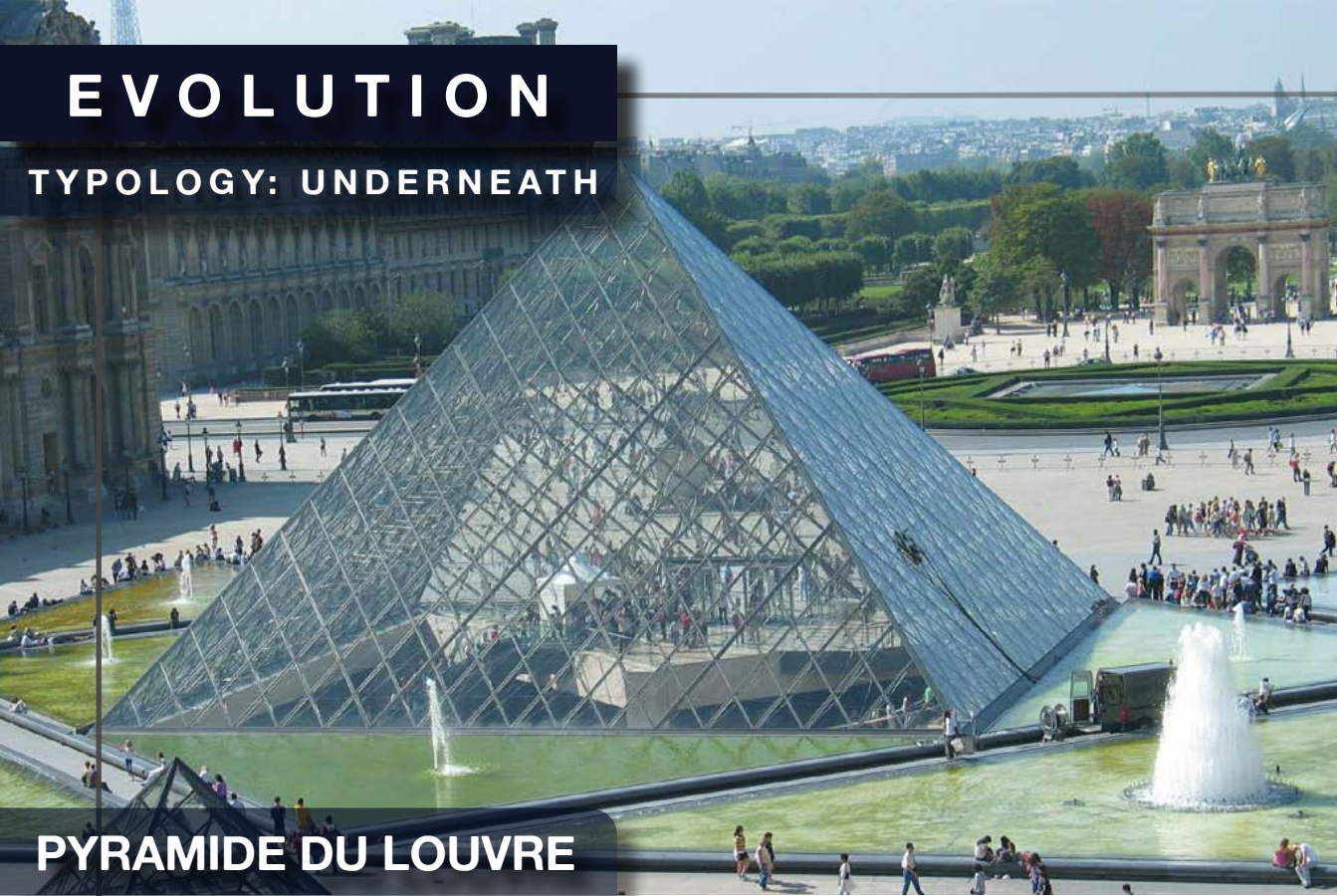


Existing Structure: London Bridge
Location: London, United Kingdom
Program: Pedestrian Bridge
New Structure: Commerce and housing
Project by: Originally Roman Empire. Re-built by John Rennie
Paybacks: Maintenance.
Symbiotic Relations: With the host: Direct mutualism
With the city: Indirect mutualism

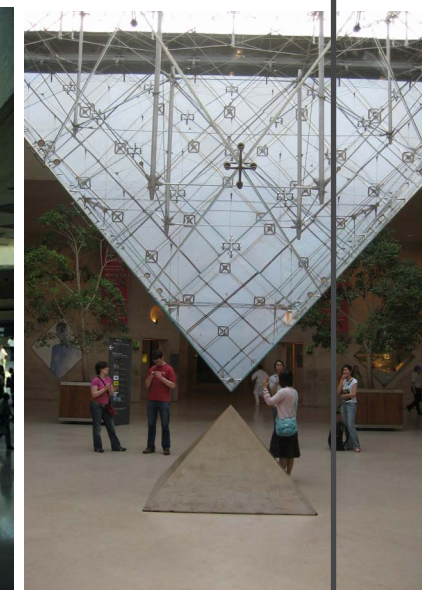
In one of the reconstructions of the original bridge in 1209, King John licensed the building of houses on the bridge, as a direct means of deriving revenue for its maintenance - one of the paybacks studied by this research - and it was soon colonised by shops.
 The current Bridge is the earliest example of an elevated railway line, built in 1836 with 851 semi-circular arches and 27 skew arches. The directors of the structure originally envisaged using the arches for low cost housing, but were soon dissuaded of the plan substituting it by commerce

EVOLUTION

TYPOLOGY: UNDERNEATH



PYRAMIDE DU LOUVRE



Existing Structure: Cour Napoléon (courtyard of Louvre Palace)
Program: Courtyard, access for the Palace (Musée du Louvre)
Location: Paris, France
New Structure: Pyramide with entrance hall and connection hub (1989)
Project by: I.M. Pei
Paybacks: Evolution of the circulation and access systems
Symbiotic Relations: No different organisms, therefore no symbiosis with existing structure; expansion of it, meaning evolution.
With the city: Direct mutualism.

The pyramid and the underground lobby beneath it were created because of a series of problems with the original main entrance of the Louvre museum, which could no longer handle the enormous number of visitors on an everyday basis. Visitors entering through the pyramid descend into the spacious lobby then re-ascend into the main Louvre buildings. For design historian Mark Pimlott, "I.M. Pei's plan distributes people effectively from the central concourse to myriad destinations within its vast subterranean network..." Besides, the lobby gives access to a subway station and shops, improving the accessibility of an important cultural equipment for the city.

MUTUALISM

TYPOLOGY: UNDERNEATH



APPLE STORE NY



Existing Structure: Square

Program: Public square

Location: New York city, USA

New Structure: Apple store (2011)

Project by: Bohlin Cywinski Jackson

Paybacks: Evolution of the circulation and access

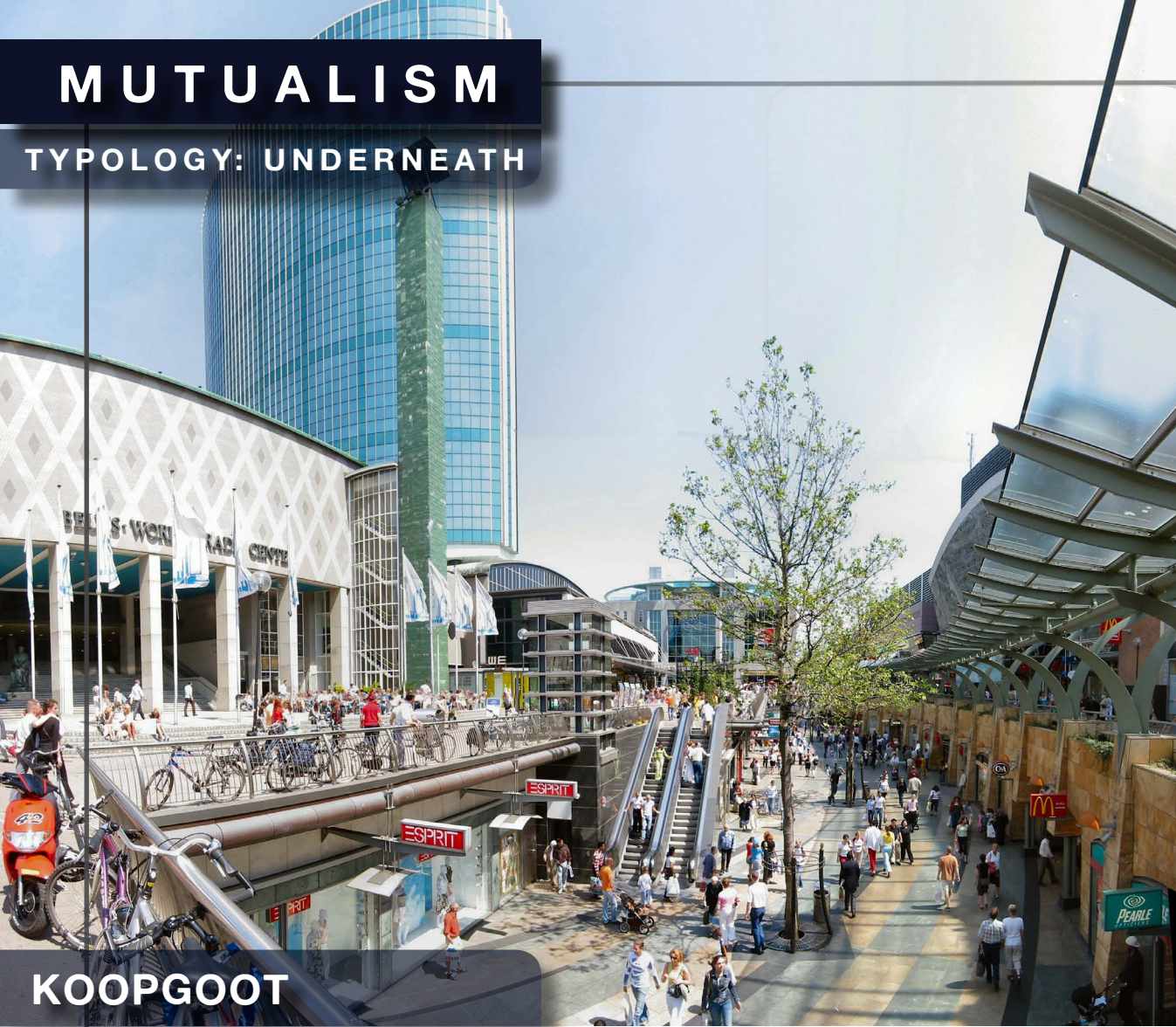
Symbiotic Relations: With the host: Mutualism

With the city: Direct mutualism

The Apple store in New York occupies the underground retail concourse of the General Motors Building, renovating its host: A plaza in the level above, which works as its access. The intervention was very welcomed by the population in the dense center of Manhattan. By the inauguration, the newspapers celebrated: “*The new plaza in front of the General Motors building on Fifth Avenue at 59th Street is a triumph of urban design*” said James Gardner in the New York Sun. “*Suddenly, as if out of nowhere, New York has a new public space that will prove to be a source of civic pride and aesthetic delight.*”

MUTUALISM

TPOLOGY: UNDERNEATH



KOOPGOOT



Existing Structure: Pedestrian street and stores

Program: Stock exchange, square and shops

Location: Rotterdam, The Netherlands

New Structure: Underground shops and traverse under Coolsingel (1996)

Project by: Pi de Bruijn

Paybacks: reduction of the traffic stagnation, new usable space to the stores.

Symbiotic Relations: With the host: Direct mutualism

With the city: Direct mutualism

The Beursstraverse (or Koopgoot) is a shopping street in Rotterdam located below the street level, crossing under Coolsingel. Originally it was only a small tunnel for pedestrians coming from Beurs Metro Station to cross under the busy Coolsingel. But on busy shopping days, traffic was still stopped on the Coolsingel for the crossing of pedestrians. A big achievement of this project is that the stagnation of traffic was greatly reduced. Most shops located in the Beursstraverse are only at the lower level, but the big department stores like C&A, Hema and Bijenkorf also have gained an entrance through which one can come to the higher level.

8. EXTRA- POLATIONS

evolution
11%

indirect
actualism
15%

**Quantitative
and qualitative
analyses of
the collected
material**

DISTRIBUTION GRAPHICS

Graphics elaborated ac-
cording to the distribution
of the symbiotic relations in
each created category

QUALITATIVE ANALYSIS

Project

Relation with host structure
Relation with host city

defining outcomes

explanations and main lessons



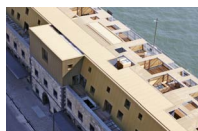
Las Palmas Parasite
Direct mutualism
Indirect mutualism

Temporary intervention
bringing new possibilities
for the hosts



Copenhagen penthouses
Direct mutualism
Direct mutualism

Reorganization of
spaces for the hosts



Customs Hall 12
Mutation + Direct mutualism
Indirect mutualism

Change of program +
addition enabling
restoration of a city's icon



Studio East Dinning
Commensalism
Direct mutualism

Temporary intervention
to bring public awareness to the
Olympics building construction



Kastner & Ohler
Evolution
Indirect mutualism

Expansion with a
contemporary language for
a heritage tribute



Victorian Warehouse
Evolution
Indirect mutualism

Expansion with
re-interpretation of forms
and integration of structure



Waterhouse
Composite organism
Indirect mutualism

New program
bringing revitalization
and preservation

Acknowledging specific information from each of the examples, a summary chart is presented hereafter extrapolating a set of lessons. These lessons justify the labels of symbioses applied to each case and help to understand how to make the whole process fruitful for all the parties involved.

with an empty host, the addition did not harm or overload it connecting to unused pipes and electricity. The existing building actually earned visibility making possible its restoration and reuse, an indirect payback also to the revitalized area;

a new usable space accessible for the owners of the existing structure means a payback for them. In this case, it is also accessible to the general public, meaning a direct payback to the city. When there is scarcity of space at the street level, public spaces can be inserted over the rooftops;

new programs for host and for new intervention economically enables the restoration of building and region. Setback of new part preserves the integrity and visibility of the existing structure and gains space for terraces;

an intervention created with the specific goal of attending the city, with a ephemerality suitable to respond to momentary needs or conditions. Relation with host structure uses its potential surface but offers nothing back ;

in order to expand in a heritage context, a tribute to local sculptural roof-scape was made with a contemporary interpretation and a contrast of materials that emphasizes the two styles. Public accessibility as a consequence of the program is considered an indirect mutualism with the city;

in another make a tribute to the existing, this expansion re-interprets the city language in order to make its evolution fit to the local heritage and highlights it in an indirect payback. Continuous connection with original structure below allows a free plan;

this intervention on an abandoned structure brings new usage and maintenance to it. Respectful approach for re-uses that preserves the existing structure. Suggested when dealing with structures with heritage value;

Project

Relation with host structure
Relation with host city

defining
outcomesexplanations and
main lessons

Open restaurant
Composite organism
Indirect mutualism

New program bringing
revitalization and preservation
of urban structures

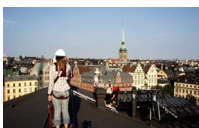
Unused host structure receives an intervention that brings a new program and interacts with the city through the public. Not only buildings can be revitalized, but also bridges of any kind of urban structure/infra-structure



Caixa Forum
Composite organism
Direct mutualism

Change of program bringing
renovation and expansion
with public accessibility

abandoned structure receives a new public program that requires a renovation of the host. Lifting the whole structure created a large access, visible and reachable brings a continuity of the public pedestrian level.



Upplev mer
Commensalism
Direct mutualism

Local identity promotion

the existing structures are not gaining anything from the symbiosis, while allowing the use of their rooftops. The promenade offers a suggestive point of view for experiencing the city, therefore giving the opportunity to enhance its local identity, receiving energy from it in return. revitalization of abandoned structure with new public function.



Highline park
Composite organism
Direct mutualism

New program bringing
revitalization and preservation
of urban structures, and
local identity promotion

Implementing elevated surfaces is an effective way to extend public circulation in a more calm and quiet setting that gives a new interesting point of view for experiencing the city. revitalization of abandoned structure with new public function.



Promenade plantée
Composite organism
Direct mutualism



De doelen
Direct mutualism
Direct mutualism

supporting (but different)
program and spatial paybacks

an extension of the existent program that doesn't connect to any system of the city (energy/water/gas), but, being part of an artwork, provides culture to it.



Backpack house
Evolution
Commensalism

Extension of the program
and piece of art

an extension of the existent program that doesn't connect to any system of the city (energy/water/gas), but, being an artwork, provides culture to it.



Ponte Vecchio
Evolution
Direct mutualism

Original hanging structures
enhanced in quantity
with public access program

the success of the original "symbiotic look" led to the multiplication of hanging structures mainly responding to touristic and city branding matters.



Yellow tree-house cafe
Parasitism
Direct mutualism

New structure harms its host,
feed from environment
and provides preservation back

harming of the host is literal, with branches of the tree cut off to host the cafe. From the "city", environment around, it receives energy and water and provides back preservation through the awareness brought by the exposition of it to human eyes.

Project

Relation with host structure
Relation with host city

defining
outcomesexplanations and
main lessons

DeLaMar Theatre
Mutation + evolution
Direct mutualism

Success of program change,
with time, lead to change of form:

a successful mutation (programatic change), with time, led to an evolution (change of shape). Connected to the city's systems, provides back the public accessibility and culture.



Guggenheim temp. pavilion
Neutralism
Direct mutualism

No exchange
with neighbours
Aid to the city as a goal:

using a "missing tooth" space, new structure is not supported by the host (neighbours) or offers any physical payback to them, but keeps a close relation with the city to which it is connected, with spatial payback and program conceived to help solving local urban problems.



Slums
Competition
Parasitism

competition for light space, view;
harmful occupation of the city:

literal competition (for light, space, view) with neighbour structures (organisms of the same "species"). Together, group of organisms parasite the city, occupying preservation areas and deflecting energy and water from the public systems.



Highway A8
Direct mutualism
Direct mutualism

City reconnected and
structure earning
maintenance

goal of new structure is to solve an urban problem caused by the host (the disruption of the city). The host itself, an abandoned space before, ends up earning maintenance derived from the new function.



In the viaduct
Commensalism
Indirect mutualism

space provision
with no return to the host but
indirect benefits for the city

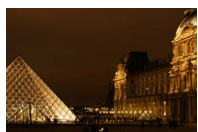
original structure hosts the intervention, but earns nothing back, once it was already in use and with maintenance. The program, that primarily seeks profit, ends up benefitting the city indirectly with the offer of jobs and services for the population.



London Bridge
Direct mutualism
Indirect mutualism

space provision
with maintenance to the host
and indirect benefits for the city

original abandoned structure hosts the intervention, and earns back maintenance. The program, that primarily seeks profit, ends up benefitting the city indirectly with the offer of jobs and services for the population.



Pyramide du Louvre
Evolution
Direct mutualism

Enhance in usability to the host
and in circulation to the city
+ spatial payback

host structure (access square) evolves, using a new layer in the underground to optimise its function (access to museum) and with this new layer connects public transportation system with the street level, besides creating new usable public accessible space.



Apple store NY
Direct mutualism
Direct mutualism

spatial provision with
spatial paybacks
both to the host and to the city

creation of new usable space generates an extensive exchange of that resource: new addition uses the potential volume in the underground from host and city and generates back space to both in a square above it, on the street level.



Koopgoot
Direct mutualism
Direct mutualism

spatial provision with
access + spatial payback to hosts and
circulation enhancement to city

creation of new usable space on the underground provides new access to the stores and new space with natural light for the structures around and solves a circulation problem of the city, besides giving back the space reclaimed on the street level.

strengthening
the precision of a
quantitative analysis

OTHER EXAMPLES

Besides these main examples presented in the last chapter and dissected in the last pages, a number of other symbiosis in the current urban scene were also studied or visited during the process of this thesis. In order to strengthen the precision of a quantitative analysis, some of these other projects were included, with a short explanation of each case hereafter, reaching a wider range cases of 80 symbioses.

DELFT ZUID STATION Underneath; neutrality with host viaduct; direct mutualism with city



The provision that the viaduct could offer, protection from rain, is not used by the station, that has its own cover not even structurally supported by the host. In relation to the city, the offer of a station enhances the quality of the neighborhood and of the local accessibility and circulation.

DELFT ZUID GARAGE HOEK BV

Underneath;
direct mutualism;
commensalism



The car dealer and showroom uses the existing structure of the viaduct and provides back a good maintenance. From the city it gets energy and water, but the service provided back aims primarily its own profit and not a need from the city.

NIEUWELAAN RESIDENTIAL BUILDINGS

Above;
neutrality; commensalism



The relation between these buildings in Delft is purely spatial with one growing over the rooftop of the other, without touching it. Both connect directly to the city and provide nothing back besides its own goal, the residential function.

MIXED USE BUILDING ON DELFT VIADUCT

Above/underneath;
composite organism; direct
mutualism



A leftover part of an old viaduct in stone arches was used to host stores underneath and apartments over it. The new structures changed the purpose of the host, assuring its survival in a new context and becoming one single organism. The possibility of preserving a historical piece of the place works as a payback to the city.

IBIS HOTEL OVER RAIL- WAY IN AMSTERDAM

Above;
direct mutualism;
indirect mutualism



Using an opportunistic space for its own purpose, over the railway just by Amsterdam Central Station, Ibis Hotel provides back an essential service for the station itself and for the city center around. In this case, even with own profit as primary intention, the value of the program to the city-center is so unquestionable that becomes an essential payback.

DIDDEN VILLAGE

Above;
evolution;
direct mutualism



An expansion that intentionally aims for the contrast with the surrounding landscape, in a manifesto to support the idea of contrasting techniques and materials to improve the environment and highlight its characteristics, even in a heritage scenario. The contrasting materials and techniques with its design tribute to the existing roof-scape is used here in a clear didactic way, as a solution for the densification of historical areas, and was a primary intention of the intervention, as the leading author Winy Maas often says in his lectures at T.U Delft.

HOFBOGEN VIADUCT BY THE HOFPLEIN

Above/underneath; direct
mutualism; direct mutualism



Part of an old deactivated railway in the center of Rotterdam, the viaduct was sold by the symbolic price of one Euro to a pool of companies with the condition of improving that area of the city and taking care of the maintenance of the host structure. The absence of money in the negotiation between “owners” proves the mutualistic character of the symbiosis with the host. So far a few stores were already installed under the viaduct, while the use of the top as a park has just received a tremendous push: in a contest about the most important initiative for the city, with a maximum funding of 4 million Euros by the municipality, the majority of citizens of Rotterdam voted for the construction of a wooden bridge that will link the city center to the top of the viaduct, crossing over the Hofplein and proving the mutualistic character that the symbiosis between intervention and the city.

DE BRUG UNILEVER

Above/ in between
evolution; direct mutualism



Above the historic factory complex of Unilever, on the river bank, an expansion of its office space was built in an elevated structure stretching 130 meters above the ground to pass over the old building. The project was based on bridge design, hence the name “De Brug,” and conceived to be supported by only three axes in order to span over the host without touching it for heritage issues. Adding to the the preservation, the contrast of techniques and materials also worked as a branding strategy, transforming the new complex in an architectural landmark of the city, reinforcing its identity of contrast between old and new architecture in the Netherlands.

GROOT WILLEMSPLEIN

Above; mutation, than evolution;
indirect mutualism



At the protected area of Willemsplein, an old distillery from the 1940's was transformed into an office building in the 70's and then abandoned for several years. Currently, the building passes through a big transformation getting a new life. The the addition of three transparent floors over the brick building are creating more office space and new commercial features on the ground floor will provide a lively 24-hours atmosphere to the protected area. Thanks to the transparent material from the new structure that penetrates vertically the host in a central atrium, the daylight reaches deep into the old building. This and other efficiency strategies, like the new cooling and heating system connected to the groundwater and the new roof garden that collects rainwater, make the building much more sustainable than before.

BLACK MADONNA SALVATION PLAN

Above; direct mutualism;
competition



The closed block around a courtyard was a social housing building close to Den Haag Central Station. In the 2000's, the development plans of the municipality included the demolition of that building among many others to open space for office and residential towers and ministries. A “salvation plan” for the preservation of

the social building was elaborated in the form of a top up symbiont with 75 luxury dwellings, in order to make the complex economically viable. Even having very mutualistic intentions towards the host building, the project was competing with the municipality plans for the area and ended up not being realized. In 2007 the black Madonna was demolished to make way for two new ministries. But the whole process with the idea of a new architecture turning viable an existing building in a new context raised a huge discussion about the social role that architecture could assume in certain circumstances.

TATE MODERN

Above; direct mutualism;
direct mutualism



The museum is housed in the abandoned brickwork building of the former Bankside power Station, built in two stages between 1947 and 1963 and closed in 1981. In the 2000 transformation, the building passed through big changes inside and had two glazed facade floors added on the top, reaching a height of 99m after it. The southern third of the building was retained by a French power company as an electrical substation (in 2006, the company released half of this holding).

The museum houses one of the biggest publicly accessible collections, once donations are suggested, but the entrance to the biggest part of the museum is free.

THE HARBOUR VIEW PENTHOUSES

Above; composite organism;
direct mutualism



The harbour of Scheveningen was originally a fishing harbour that, with time, declined together with the decline of importance of fishery. As a result, many old warehouses in the Harbour became redundant and programmed to be demolished. At the same time, there was a large demand for building ground in the area. By renovating the warehouses and placing steel penthouses on their rooftops, the harbour was given a new lease of life. A two-story, lightweight steel penthouse has been constructed on top of a brick base consisting of two structures that face one another. The penthouse was to be used as a home/office and/or studio consisting of a single space that occupies both floors. After the penthouse had been completed, similar steel penthouses were placed above other warehouses that had been declared unusable and were due for demolition (IJsvis, Nautilus and Rokerij). The Scheveningen harbour thus became

an example of stepping-stone urban planning. These projects raised the discussion about rooftop housing in the Netherlands and Archipelontwerpers, the author office, has become a model for the experimental status of the Rotterdam local authority.

INFOPOINT UNDER PIAZZA DEL DUOMO

Underneath; direct mutualism;
direct mutualism



An old bunker built under the Cathedral square became an underground info point as part of a framework governmental agreement on "restoration and enhancement of the Cathedral", from 2010. The concept, developed by the architect Aldo Maiocchi, calls for the renovation and redevelopment of the area of 1700 m² below the churchyard of the cathedral. The project also includes the reopening of a portion of tunnel closed for years, connecting it through glass tubes to the subway station, allowing visibility and access to a historical landmark of Milan. With this design solution, a so far hidden archaeological heritage was placed in full evidence, in the middle of a stream of 150000 people/day. The result is a public hub in an underground plaza, a place to connect business community, cultural institutions, finance and fashion. As the

subway brings people, this hub spreads knowledge, providing information about the city, and the region. An enclosed space by definition therefore, converts to an open space, both in the material sense (by the creation of the underground plaza, by facilitating the flow of visitors and improving accessibility to the early Christian site), and in the immaterial the sense (by the new center of information and communications, and by the "voice" returned to an archaeological site so far rather neglected). A synthesis of paybacks to the hosts ranging from culture to interaction.

PARASITE

Side-up; commensalism;
direct mutualism



The last example that will be taken in consideration for the research is again another one that is called parasite even if the proper denomination for its relations would not be that one. Architecture for Humanity is a non-profit organization that provides humanitarian design services to communities in need world-wide. The social character of the NPO already provides a hint that the buildings created by the initiative would not exactly harm the host. Since 1999, the organization has been challenging architects and designers to build more sustainable and

socially responsible projects and has collected hundreds of proposals from design professionals around the world. Their book "*Design Like You Give a Damn*"³¹ present the first decade of such responses to a range of global humanitarian crises. Among many examples in the book, there is this paraSITE project, by Michael Rakowitz. It provides 'urban nomads' with shelter and warmth by attaching plastic tents to building heating and ventilation exhaust ducts. This "attachment" only brings good outcomes to the new addition indeed, but doesn't really harm the host building, once it only changes the flow of the warmth that was already thrown away from it. For the city, even occupying part of the pavement and disturbing the circulation, it takes care of providing shelter for the street population and awareness about this social problem to the rest of the population, two big social "mutualistic" goals of the project that define this symbiosis as a mutualism.

conclusions from
percentage charts

QUANTITATIVE ANALYSIS

The arrangement of all the examples (with their labelled symbioses) in groups according to their categories is able to generate graphics that help to understand the tendencies of each group. The next page shows which categories tend to produce each kind of symbiosis. The pages after extract information from this division according to the percentage of each kind of symbiosis in general and within each group.



Las Palmas Parasite
Direct mutualism
Direct mutualism



Studio East Dining
Commensalism
Direct mutualism



CPH penthouses
Direct mutualism
Direct mutualism



Victorian Warehouse
Evolution
Indirect mutualism



Open restaurant
Composite organism
Indirect mutualism



Upplev mer
Commensalism
Direct mutualism



Highline park
Composite organism
Direct mutualism



Customs Hall 12
Mutation + Direct mutualism
Indirect mutualism



Ibis hotel
Direct mutualism
Indirect mutualism



Tate Modern
Direct mutualism
Direct mutualism



Black Madonna
Direct mutualism
Competition



Harbour penthouses
Composite organism
Direct mutualism



De Brug Unilever
Evolution
Direct mutualism



Waterhouse
Composite organism
Indirect mutualism



Kastner & Ohler
Evolution
Indirect mutualism



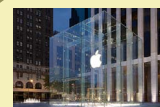
Mixed-use on
viaduct in Delft
Composite organism
Direct mutualism



Groot Willemsplein
Direct mutualism
Indirect mutualism



Hofbogen viaduct
Direct mutualism
Direct mutualism



Apple store NY
Direct mutualism
Direct mutualism



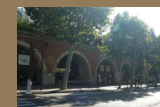
Slums
Competition
Parasitism



DeLaMar Theatre
Mutation + Evolution
Direct mutualism



Caixa Forum
Composite organism
Direct mutualism



Promenade plantée
Composite organism
Direct mutualism



De doelen
Direct mutualism
Direct mutualism



In the viaduct
Commensalism
Indirect mutualism



Koopgoot
Direct mutualism
Direct mutualism



Delft Garage Hoek
Direct mutualism
Commensalism



Guggenheim
temp. pavilion
Neutralism
Direct mutualism



Ponte Vecchio
Evolution
Direct mutualism



ParaSITE
Commensalism
Direct mutualism



Rucksack house
Commensalism
Neutralism



Yellow
tree-house cafe
Parasitism
Direct mutualism



Highway A8
Direct mutualism
Direct mutualism



London Bridge
Direct mutualism
Indirect mutualism



Pyramide du Louvre
Direct mutualism
Direct mutualism



Delft Zuid Station
Neutralism
Direct mutualism



Milan infopoint
Direct mutualism
Direct mutualism

GENERAL PERCENTAGES

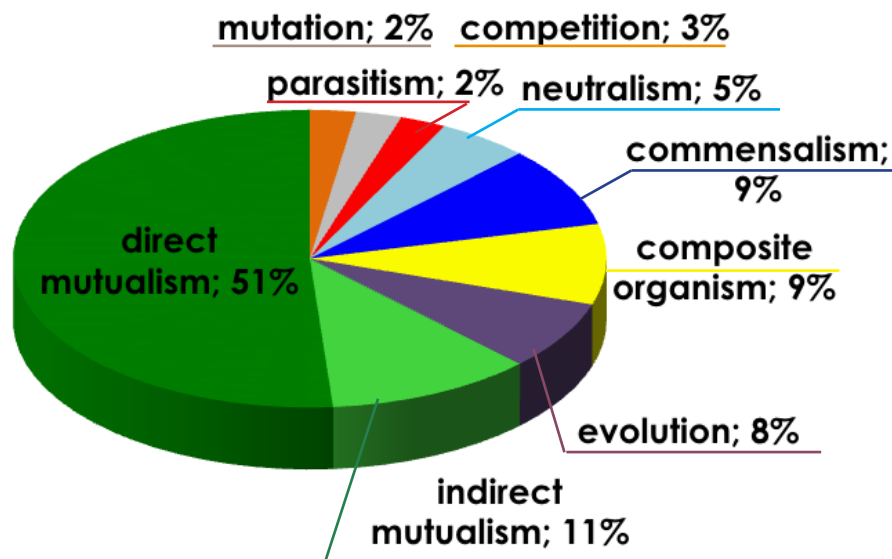
confirming mutualistic tendencies

The first striking message from the general graphic below is the massive presence of mutualism in the current scene. It comprehends more than half of the analysed examples. Far from being a surprise, this proves how much the urban dynamics already push towards the need for fruitful outcomes to all the parties.

The other phenomenon more present in the analysed examples is evolution, which represents the very simple – and therefore very common – case of expansion of a property. The huge presence of it derives from the low level of complexity of the intervention. Any owner who has a potential surface inside the limits of his property can create an intervention without having to deal with third parties.

Right after the number of cases of evolution, cases of composite organisms also reach significance, for a simple reason: interventions on abandoned hosts tend to be performed under this particular pattern. When a building is unused, normally it means that its original program was not suitable anymore for that context. If a new intervention recovers that building or space, normally it brings with itself a new program that is extended for the recovered structure, repeating the behavior of composite organisms in biology.

One information that must be extracted carefully from this chart is the small amount of mutations derived from these examples. Mutation as a programmatic change is probably more common in the current urban scene than any of the other phenomena here presented. The fact is that this phenomenon doesn't appear for itself in the hall of the misnamed "parasitic" interventions. That is why only one example appears here - the one that only ap-



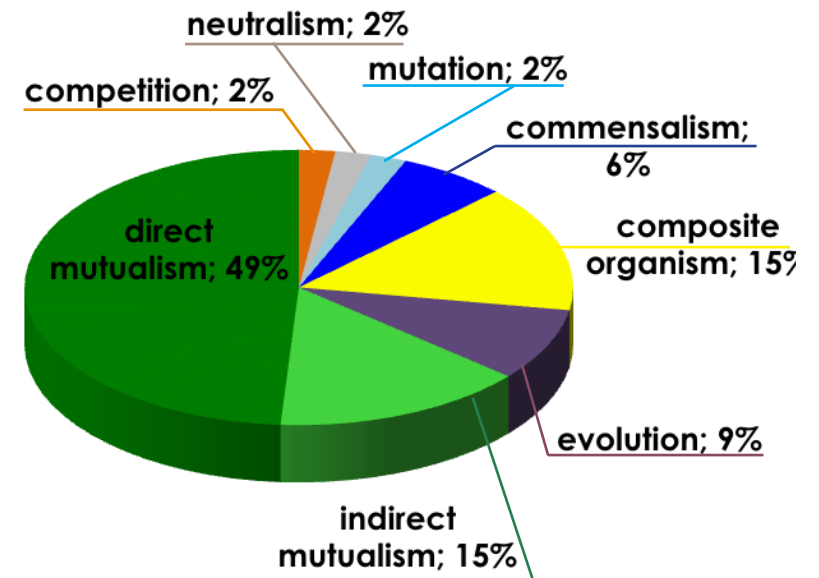
peared because of the later evolution that derived from this mutation.

The last (and perhaps most bold) information provided very clearly by the general chart is how rare cases of parasitism are. Only one of the symbiotic relations with the host was classified as such. But the information becomes even stronger when acknowledging the fact that this single example was intentionally pursued by the researchers in order to attest if it is even an existing phenomenon. The fact is that the only example found actually only harms the host because it does it quite literally, due to the fact that the host is a tree. The interaction between a living organism and building components such as screws and nails materialize this negative outcome as no other example was able to show. In the relationships between new additions and city, the only parasitic example found was in slums, cases in which the relation is not "official" and therefore is not based in "fair" exchanges.

behaving as composite organisms

ABOVE

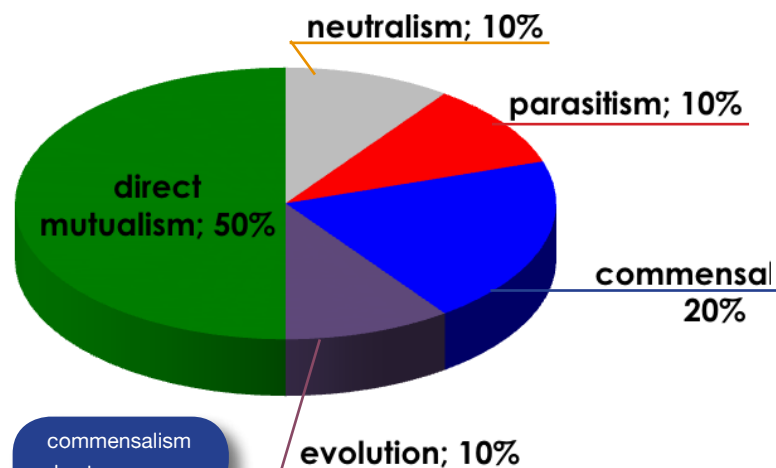
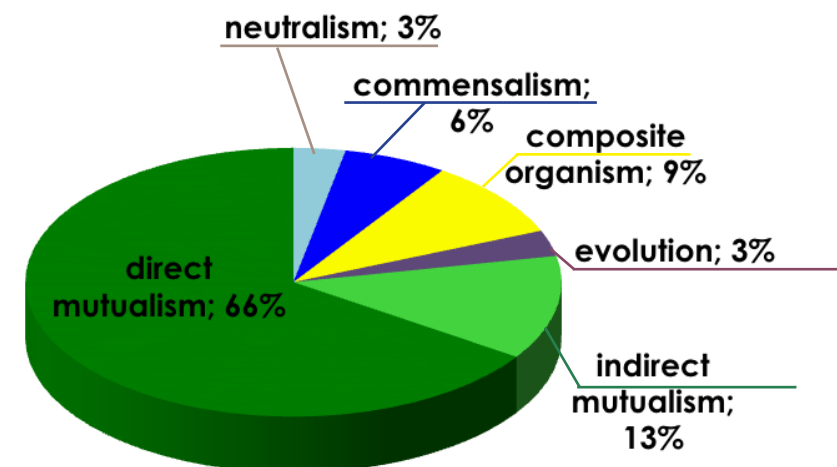
Interventions placed on the top of a host building have a clear tendency to follow the behavior of composite organisms (almost doubling the general percentage of it) This happens because when a new addition is placed on top of an abandoned building, the access must be done through it and the chance of a renovation that will change its old use to a new one integrated with the addition's program is considerably bigger. Another pattern that can be seen in buildings from this category is to establish a commensalistic relation with the city. This happens because of its position, which makes it connect almost always with the host building instead of doing it directly to the city systems. In this sense, whenever it can offer something to the city, the relation will be commensalistic because it will be rarely taking something in exchange from the big-scale host.



UNDERNEATH

The most striking outcomes of all the individual charts are the ones from “underneath” interventions. More than 3/4 of these interventions (79%) act like mutualistic symbioses. Once the analysed universe is quite big, it seems quite unlikely that this number would reveal a coincidence. And if one analyses the conditions of this category, it will be easy to realize that this position indeed offers very simple possible exchanges that easily make it mutualistic: by one side, the host will always offer protection (mainly from erosion). On the other, the interventions will offer: either a space provision back to the hosts (when it is an underground intervention) or maintenance (when it is under viaducts and bridges). In this last case, the possibility of using abandoned urban structures will also reveal a tendency to produce composite organisms, once the unused “body” will be probably integrated in the program with an intervention also on the top.

tive interventions. As one could imagine, the outputs are very similar to the ones from side-up interventions, and the range of possibilities is what makes it distort the percentage of mutualistic cases. Despite the relative low amount of examples, all the possible symbioses are present in this category except for commensalism, what probably derives from a coincidence of the chosen examples without apparent reason. Composite organisms and evolutions appear in a bigger frequency in this category, what seems to happen for the position and, opposite to the last conclusions, shows a tendency of this kind of interventions to behave like these symbioses. The fact that the interventions, in this case, are surrounded by the host, brings this tendency, due to the access issue. When the intervention is in-between abandoned hosts it will probably act as composite organism in this category and when it is in-between hosts in use it will tend to be only an evolution, meaning an “inner expansion” of the host.



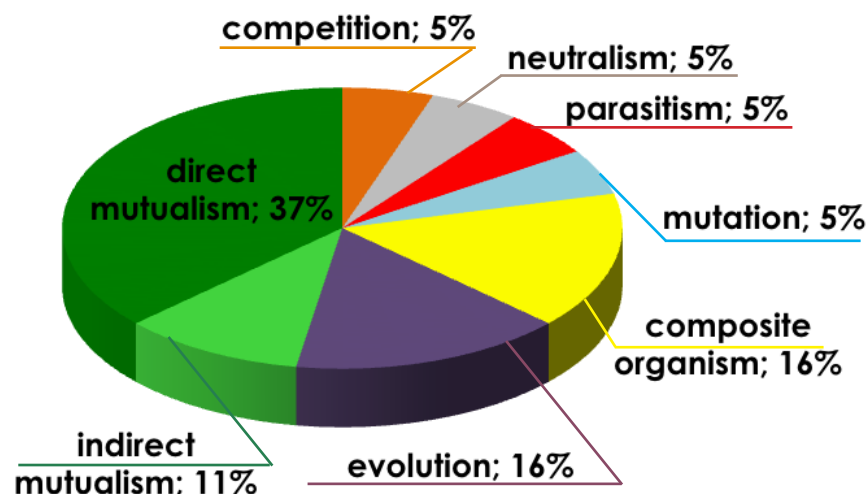
SIDE-UP

The quantitative analysis of side-up interventions is the one that deserves the most careful look, once the small universe of interventions found makes any early conclusion imprecise. Still, a clear message from this chart is that these kind of interventions can vary from one extreme to the other (from parasitism to mutualism) and can also be in the “mid-way” of neutralism. It is the only category in which com-

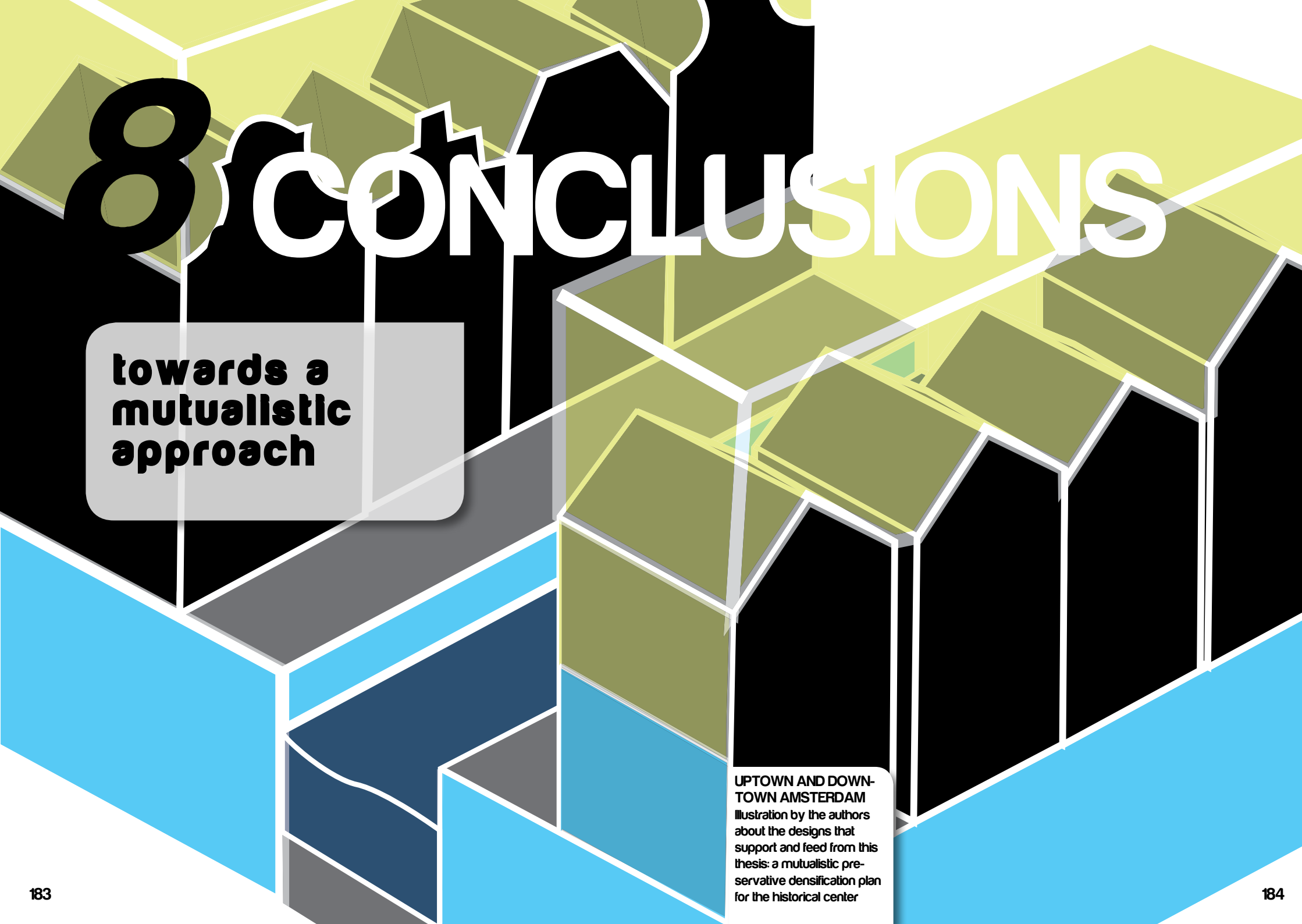
mensalism appears as the biggest trend after mutualism, due to the facility to forge good outcomes from the host without providing anything back.

IN BETWEEN

This category is the only one in which mutualism appears in less than half of the cases. But this does not attest a tendency of this category to host less posi-



8 conclusions



**towards a
mutualistic
approach**

UPTOWN AND DOWNTOWN AMSTERDAM
Illustration by the authors
about the designs that
support and feed from this
thesis: a mutualistic pre-
servative densification plan
for the historical center

lessons from each chapter of this thesis

OVERVIEW

This research was developed as an attempt to analyse and comprehend the process of urban symbiosis, since its causes until its consequences. Therefore, all the topics raised have the common purpose of exploring how the interaction of buildings (between themselves and between them and the city) can provide more fruitful outcomes for the urban environment and its users.

And it is in the context of lack of space - presented in the background - that the question on how to link people, buildings and city more efficiently becomes a necessity. Existing researches about creation of new layers for the city brought important inputs about the relation between new buildings and existing heritage.

Other researches that relate the city with a body introduced important aspects about the biological analogy and about the use of analogies themselves, in order to understand pitfalls, potentials and limitations of the adopted strategy.

A deeper study about symbiotic relations in nature - and about how the biology field classifies them - raised all the necessary vocabulary to be used in this thesis.

Explicative examples made the topic palpable, showing case by case how can architecture learn from the biology field and

what are the consequences of each kind of possible interaction between urban structures.

The overview of all these topics suggests a new way to look towards the current construction methods and preoccupations. The outcome of this allows architects, urban planners and contractors to rethink the future city through a more solidary approach that, in the end, brings advantages to all the parties involved.

specific legislations to organize the development of complex areas

DENSIFICATION PLAN

With the compilation of all the material raised by this thesis, an ideal outspread of this research would be to use this study as an input for the elaboration of specific legislations for the development of complex areas. The prognosis is that the densification issue will bring each time more pressure over the urban fabrics and that this study can act as a basis for possible organizations of this process. With this theoretical basis, future contextual urban analyses will be able to materialize a “*densification plan*” for each specific situation.

A “*densification plan*”, in this sense, would mean a controlled process of densification that aims at expanding the city within its boundaries; depending on the level of “untouchability” of each scenario, new structures can be suggested to be placed in a specific space within the set of existing buildings. This choice of place shall follow the lessons acquired accord-

ing to the typologies developed in the previous chapter: “above”, “side-up” “in between” or “underneath”.

Projects that support and feed from this thesis

EXEMPLARY EXTREME-CASE SCENARIO

In order to exemplify this process, this thesis is accompanied by two complementary projects comprehending a densification plan for one chosen city, where the complexity of the scenario demands the use of all the strategies raised in this study. The intention is to support the hypothesis of the research, defining ways to use existing structures to accommodate new buildings and/or activities through mutualistic interventions, which shall feed from the existing potential surfaces and volumes available, but offer paybacks that provide benefits both for the host structure and for the city, responding both to the densification issue and to specific local needs.

As the primary intention of the thesis is to analyse the densification issue and experiment possibilities to deal with it, the choice of scenario for the exemplary densification plan needed to provide an extreme situation on this matter in order to deliver the opportunity of coping with a broader set of constraints. That leads to the achievement of more extensive results, which can easily be applied through contextual adaptations in other simpler cases, rather than the other way around.

For this scope, the “worst case scenario” aimed by this choice presents numerous constraints that play essential roles for the design process. The area taken in consideration is the historical center of Amsterdam, with its frozen fabric and its untouchable canal houses that apparently leave no space for densification. Besides the huge heritage restriction, The Netherlands is, indeed, one of the most dense countries in the world. While its population appears only in the 60th position in the world rank, because of its size and urbanization rate its density appears in 20th place among all countries in the world. More than that, the density of the specific chosen area, if it was a country itself, would be the third most dense of the world and by far the most restricted one in terms of heritage, structure, representational role and frozen urban tissue.

The densification plan in the grachtengordel of Amsterdam is composed by two projects: one to use the space over the rooftops of the canal houses and one under the street level, with windows in the canal walls.

Each researcher developed one of these projects providing a number of paybacks both to the city and to the canal houses. These paybacks vary according to the potentials of the place in which an intervention is located.

In that sense, the next page organizes methodologically the process of exchanges of resources, services and paybacks that must be present in a mutualistic intervention.

Method to achieve a mutualistic architecture

GENERIC RULES TO BE APPLIED ELSEWHERE

After gathering all the possibilities suggested in the examples, the intention is to provide strategies to aim at a mutualistic approach whenever a symbiotic architecture is required.

Mutualistic interventions must always aim good outcomes to the host. These outcomes, or paybacks, are not represented by simple consequences of the new addition's own interests, but by clearly stated advantages intentionally offered to the host building and to the host city.

The following paragraphs transform the acquired lessons in generic rules for this process, working as a method for the application of future mutualistic interventions. These rules will be numbered below, but this doesn't mean that they are the only possible paybacks for any new intervention. On the contrary, the organization of the existing ones intends to stimulate the creation of new paybacks that would follow the same logic of the ones presented hereafter.

necessarily provided by both hosts

1. PROVISIONS

The two hosts are the providers of essential resources and services for the new structure. These provisions can be offered either by the host city or by the

small-scale host, depending on the specific case of each intervention. In a mutualistic relation, the hosts should provide, together, at least the item **a** of each of the following groups and at least one of the other items:

I- RESOURCES:

- a. Space
- b. Connections to electricity
- c. Connections to its system of water
- d. Connections to its system of gas

II- SERVICES:

- a. Access
- b. Protection
- c. Structural support

The mutualistic architecture must generate positive outcomes in both directions AND in the exchanges with both hosts (host structure and host city). Because of that, both hosts should provide at least one positive outcome for the addition. In that sense, if one of the hosts provides the obligatory **a** item of both the resource and service groups, it doesn't mean that the other host is free from this responsibility. In this case, it will still need to provide at least one resource OR one service, preferably both.

Every item of the listed resources is possible to be provided by any of the hosts. The connections to the public networks of energy, water and gas, for instance, can be either connected to the existing structure network or directly to the public service. Access and space for implantation are often provided by the host structure, but they can also be directly provided by the host city - when the new addition is

not based over another building's envelope (*above* and *side-up* categories), but *underneath* or *in-between* it's volumes. In these cases the supporting surface is the street level or the underground of the city).

Both hosts can also provide any of the services listed on the group II. The categories will also define the tendencies about which of them provides the specific services that each new additions need. Access will be mostly provided by the host structure (and rarely directly by the city) in case of *side-up* and *above* symbioses. When the new structure is placed in between, the access could be provided by any of the hosts. When the insertion is underneath, the access will be mostly provided by the city, but it can also be by the host structure.

Protection is a service that, when provided in this direction (from host to addition) is most likely in underneath symbioses. In this case, the subcategory is what will define which host will be the responsible for the provision. When the underneath symbiont is placed under an existing structure, such as a bridge or a viaduct, this direct host will be responsible for the protection (mostly against rain and sun). When the addition is placed underground, in the majority of cases, the surface of the city will be providing this protection.

Structural support, will be mostly provided by the host with which the new addition is in contact. In *side-up* and *above* interventions, it will be mostly provided by the host building (but not necessarily), while *in-between* and *underneath* interventions, it will most likely be provided by the city.

necessarily provided by the addition to both hosts

2. PAYBACKS

In the other direction, the introduction of a new intervention may involve many different outcomes for the host structure and for the city. These outcomes can be either positive or negative, as extrapolated from the studied examples. In order to become a mutualistic intervention, the new addition must provide more positive outcomes – the so-called paybacks - than negative ones. This measuring can be tricky because the same intervention can provide an indefinite number of outcomes for the host. In that sense, the most important paybacks raised by the existing examples analysed are listed below.

In addition to that, an important lesson extracted from those examples is that considerably different situations derive from dealing, in one case, with an abandoned host structure, and in the other, with a host still in use. Likewise, the same logic can be applied to the city, with different possibilities of paybacks when the intervention is in an urban scar (an urban void, or SLOAP) or in a "healthy" part of the city.

I- OBLIGATORY PAYBACKS TO ABANDONED SPACES:

- a. Healing payback (renovation of the host and/or/revitalization of the area)
- b. Maintenance of the host/the area
- c. Structural reinforcement (when applicable, depending on structural situation of host and load of the new addition)

A mutualistic intervention in a left-over structure and/or area, depending on the conservation conditions of the host, must necessarily aim at the provision of all these paybacks when needed by the host. The renovation/restoration of the host structure, as well as the revitalization of the area must constitute one of the primary goals of interventions in such hosts.

Besides that, when an unused space becomes actively used, it automatically becomes better maintained than before, having the necessary maintenance linked to the new usage.

In similar terms, structural problems must be solved by the new addition in order to create enough support not only to assure a proper solidity of the host, but for the stability of the implantation itself. The original structural system, in these cases, must be either substituted or reinforced, integrating it with a new supporting one.

I- POSSIBLE PAYBACKS TO USED OR UNUSED HOSTS:

- a. Provision of new space to the hosts
- b. Improvement of existing circulation
- c. Creation of new accesses
- d. Resources provision
- e. Protection/insulation against rain/sun/cold/heat
- f. Positive incomes deriving from enhanced visibility
- g. Structural reinforcement

These are paybacks that do not need to be necessarily provided all by the same time in any intervention. But the provision of a set of them is essential. Thus, at least

one of them must be provided back to the host building and at least one to the host city. In an ideal situation, a new intervention should aim to provide as much as possible of these items for both hosts.

When the hosts are not suffering problems caused by the lack of use or don't need any intervention to recover from specific problems, positive paybacks must be intentionally chased in order to achieve a mutualistic development. This means that a new intervention will always need to present altruistic intentions among its primary goals. These altruistic intentions, or paybacks, are not represented by simple consequences of the new addition's own interests; they must constitute clearly stated advantages to the host building and city.

In this direction, a basic but important payback involves the provision of new usable space back to the host, therefore either an extension of the private property or of the public space.

In order to reach the new additions, the intervention will often involve the extension of existing circulation systems and accesses, so that another positive outcome can be achieved with an improvement of the current circulation network.

In relation to energy, a new installation can also offer it as a payback if it includes collectors of resources (such as rainwater, sunlight or wind) and systems for transforming them into usable resources to be given to the host.

Other positive incomes can derive from an enhanced visibility to the host and to

the city. Contemporary interventions that somehow relate to the identity of the host building and city with a tribute to their traditional shapes, materials, or any important characteristic can reinforce an original cultural identity and bring branding opportunities to both hosts.

ensuring good outcomes to everyone

SCORING SYSTEM

Following these rules, the idea is that any needed intervention in a symbiotic relation with existing hosts can pursue positive outcomes and achieve a mutualistic architecture.

Inspired by the study of sustainable labels and methods for energy-efficiency certifications, the last output of this thesis is a scoring system able to attest the mutualistic nature of an architectonic symbiosis. The system aims to ensure 3 things:

- At least the items **a** from groups 1-I and 1-II must be provided by the hosts. If possible, all items are welcome.
- At least the items **a** and **b** from the group 2-I must be provided (when applicable, meaning in cases of intervention over abandoned hosts). Depending on the structural situation of host and load of the new addition, the item **c** can also become obligatory
- At least one of the paybacks of the group 2-II is provided to each of the hosts.

In this sense, each of the items from the groups 1-I and 1-II represents 1 point in the scoring system, with the exception of the items **a** of each group, obligatory pro-

visions that represent 10 points.

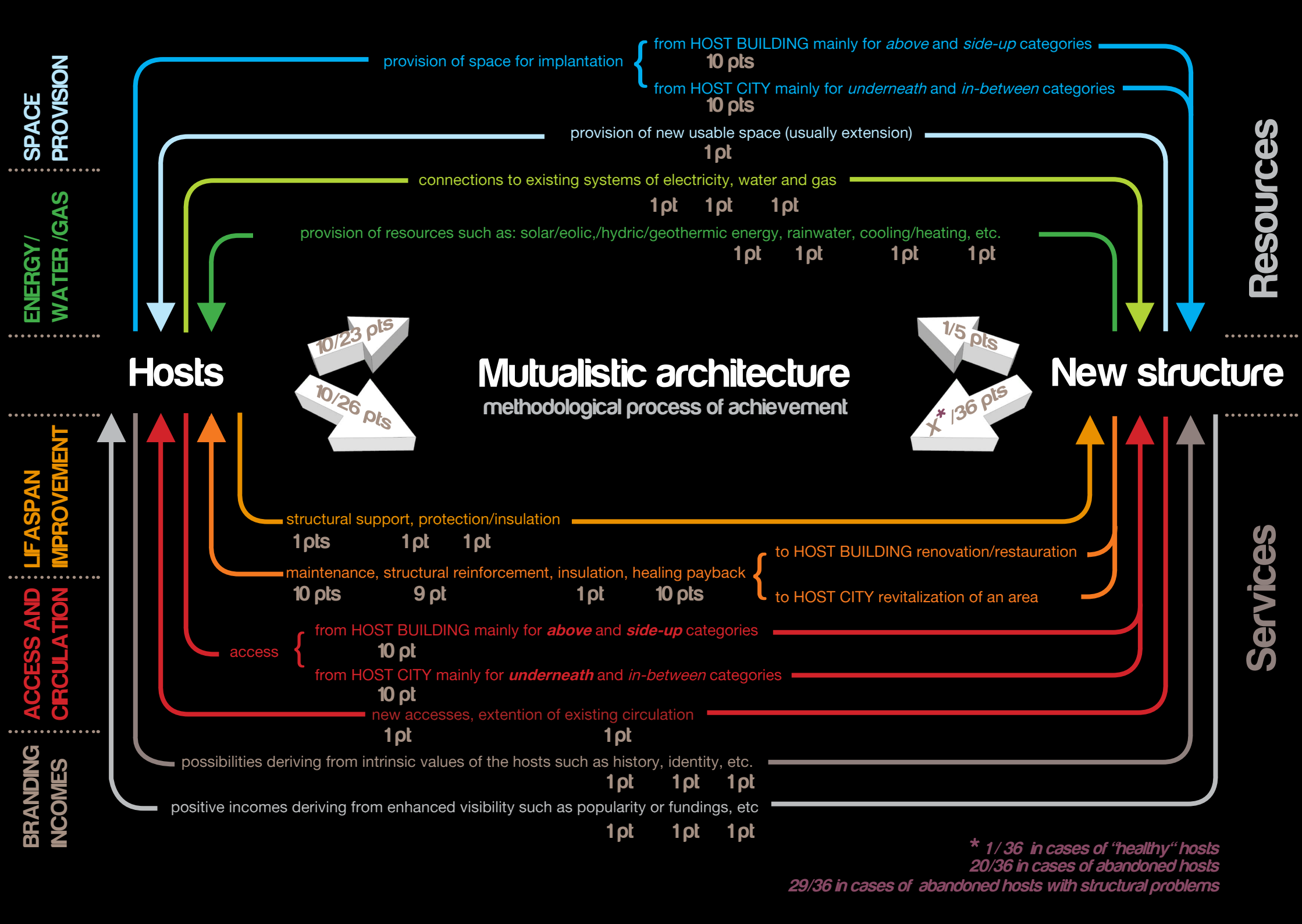
Deriving from this, the hosts must offer together at least 20 points to the new addition (10 resource points and 10 service points), with each contributing with at least 1 point. This means that each host can offer one of the necessary service/resource. But if one of the hosts offers both obligatory provisions, the other one will need to provide at least one non-obligatory resource or service.

Concerning to the paybacks from group 2-I, **a** and **b** represent 10 points and **c** represents 9. Paybacks from the group 2-II represent 1 point. That difference aims to make interventions over abandoned hosts necessarily provide the paybacks from the group 2-1, despite how many possible paybacks from the group 2-II it offers to the hosts. In this sense, new additions must offer at least 2 points in symbioses with healthy hosts, at least 21 in symbioses with abandoned hosts and at least 30 points in relations with abandoned hosts.

method's summary

MUTUALISTIC INTER-ACTION FLOWCHART

Hereafter is presented a conclusive diagram about mutualistic architecture that summarizes the rules described above. It shows the types of exchanges that can be involved in mutualism - with the score attributed to each of them - and the flow of exchanges that should be involved on a mutualistic architecture. This scheme closes the thesis and its final intention is to guide the development of future mutualistic designs, organizing possible ways for such a fruitful interaction to be achieved.



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Pages 177_178_ Drawing by the authors

Pages 185_186_ Diagram by the authors

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