

Algorithmic Architecture

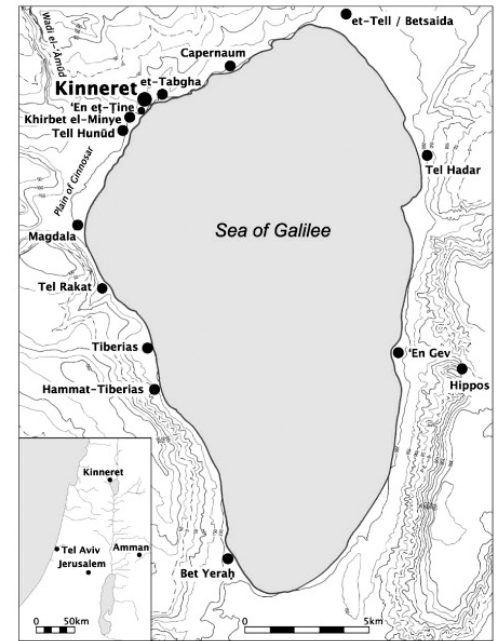
Part I

Toni Kotnik

Professor of Design of Structures

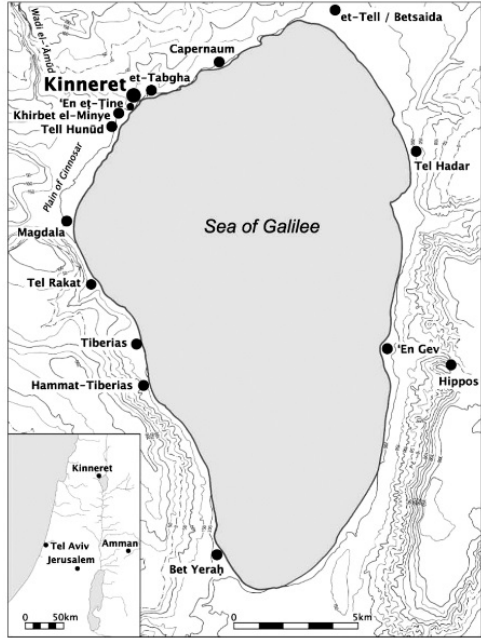
Aalto University
Department of Architecture
Department of Civil Engineering

Urban Life at the Iron Age

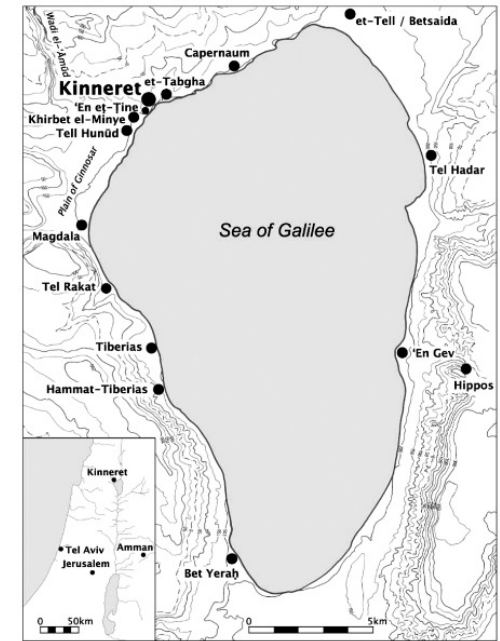


Tel Kinrot / Tell el-'Orēme
Israel, 1995

Urban Life at the Iron Age



Tel Kinrot / Tell el-'Orēme
Israel, 1995



when is a stone a stone and
when is a stone part of a wall?

Tel Kinrot / Tell el-'Orēme
Israel, 1995

“Imagine the purely physical world. This would have to be a giant aggregate composed of all the physical stuff in the universe. There is nothing nonphysical in this, but most philosophers prefer a less amorphous characterization; they begin with all physical objects, or all particles, or all space-time points. ... To add even this small amount of structure - the differentiation of the amorphous mass into individuals of some kind - is already to broach the mathematical.”

Penelope Maddy, *Realism in Mathematical*, 1990



similarity



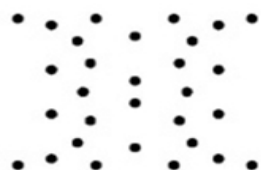
proximity



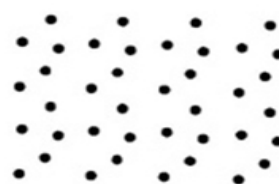
continuation



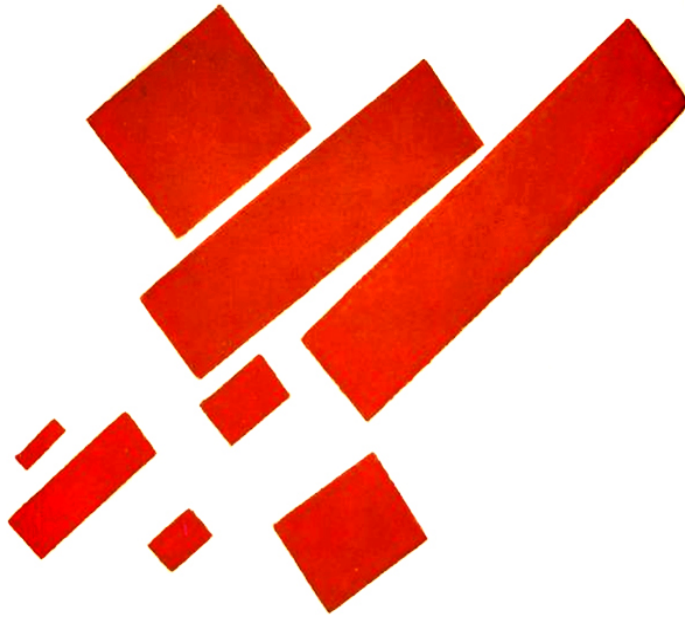
closure



symmetry



periodicity



Mathematics is the science of patterns based on bodily or mental perception of the surrounding world. Mathematics is a construct of the human brain!

Kasimir Malevich
Eight Red Rectangles, 1915

Patterns of Organization



Dun Aengus
Aran Island, Ireland, around 1000 BC



Andi Goldsworthy



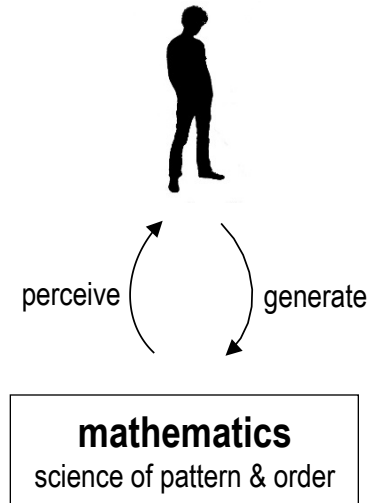
rice terraces, Longsheng, Guangxi, China

Patterns of Organization

Architecture is one of the most prominent manifestation of the basic human activity of structuring the living environment.

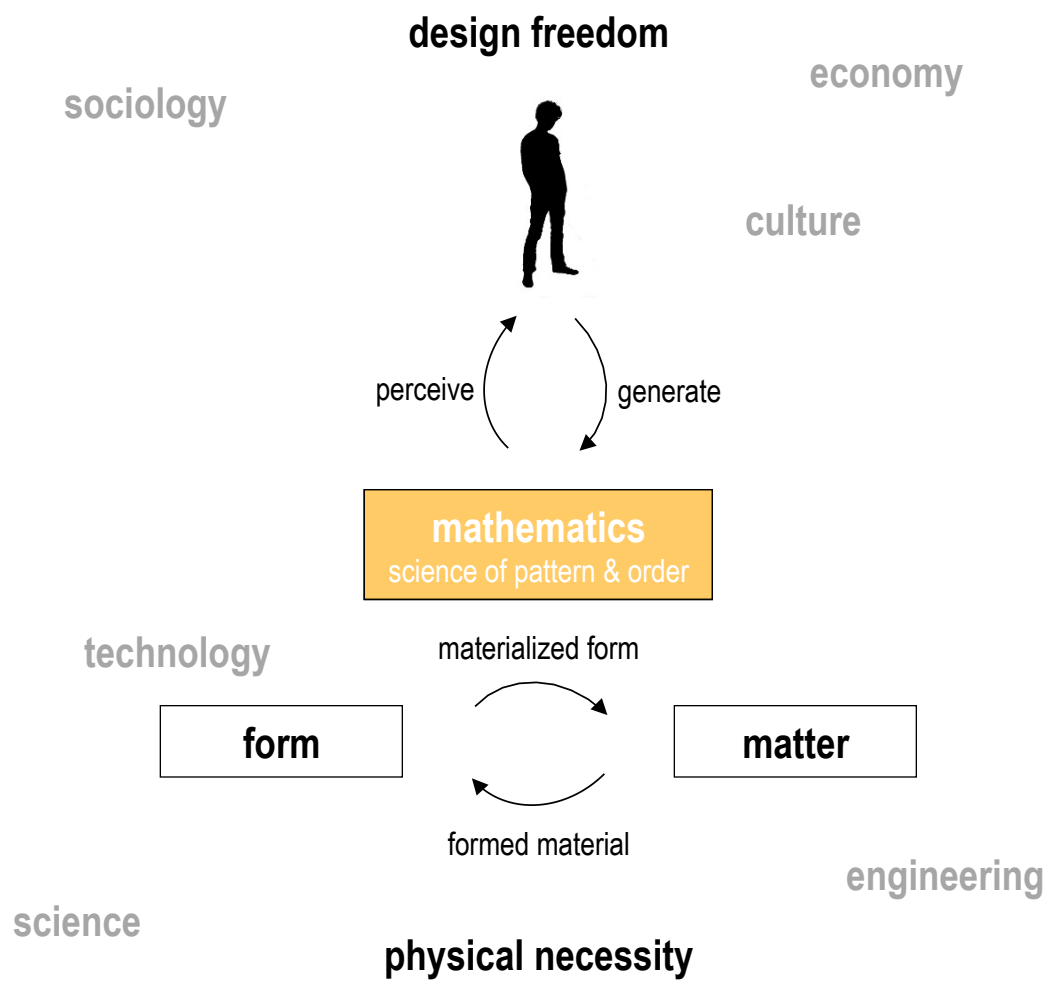


London, UK, 2016



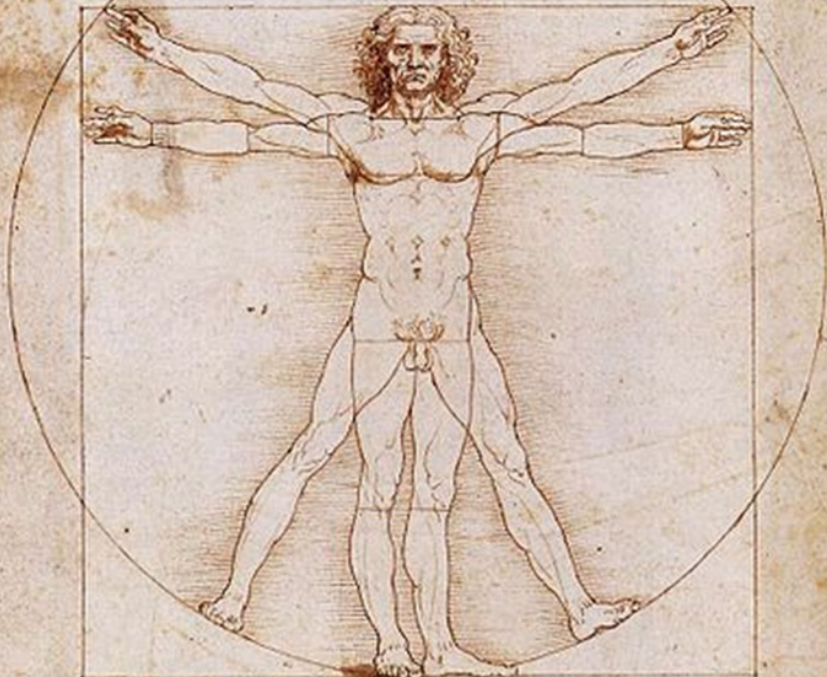
when is a stone a stone and
when is a stone part of a wall?

Architecture Patterns of Organization

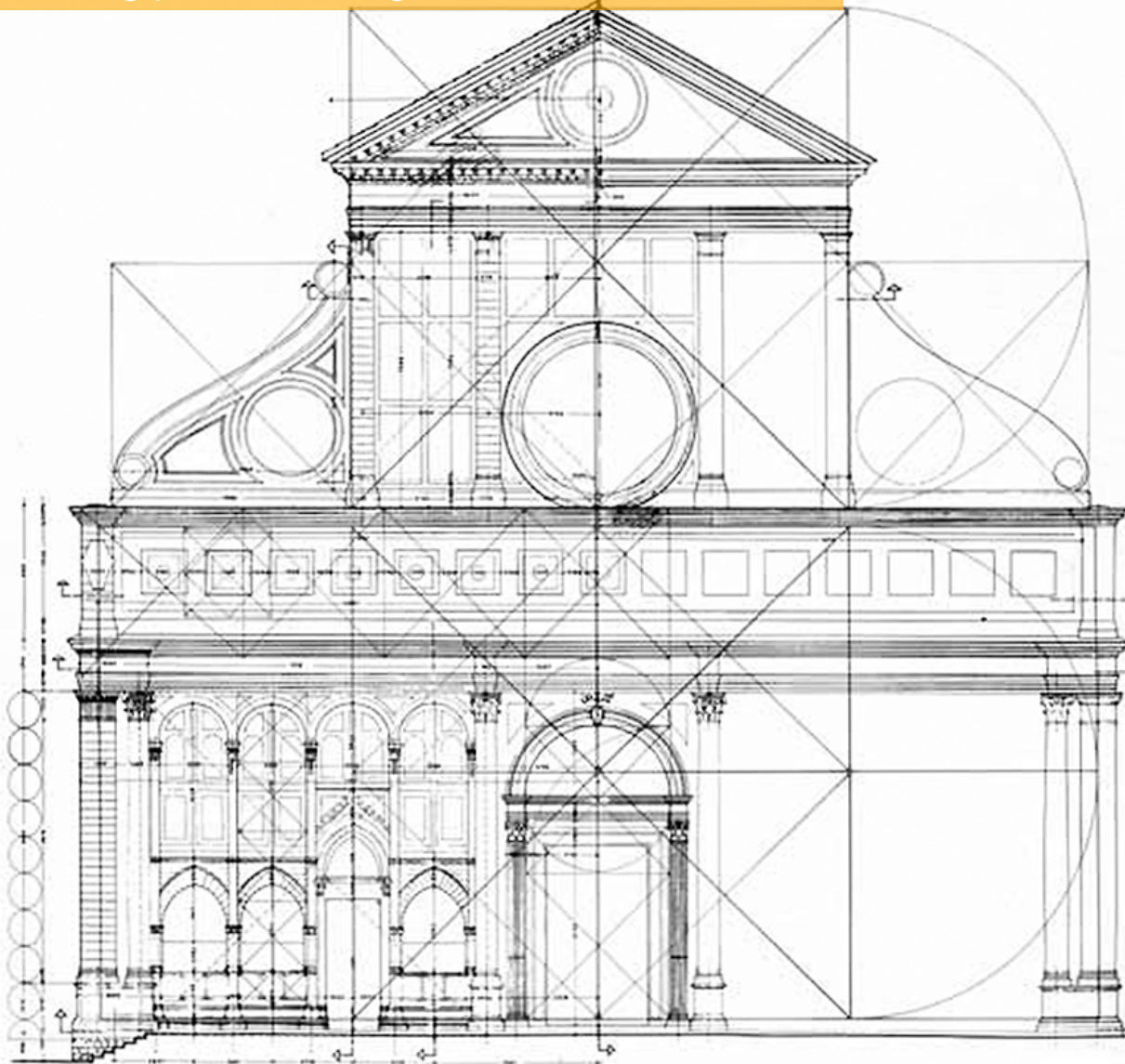


“The architect should be equipped with knowledge of many branches of studies and varied kinds of learning ... Let him be educated, skillful with the pencil, instructed in geometry, know much history, have followed the philosophers with attention, understand music, have some knowledge of medicine, know the opinion of the jurists, and be acquainted with astronomy and the theory of heavens.”

Vitruvius: Ten Books On Architecture, around 33 BC
Book I, Chapter 1, The Education of the Architect



Leonardo da Vinci: Vitruvian Man
Italy, around 1490

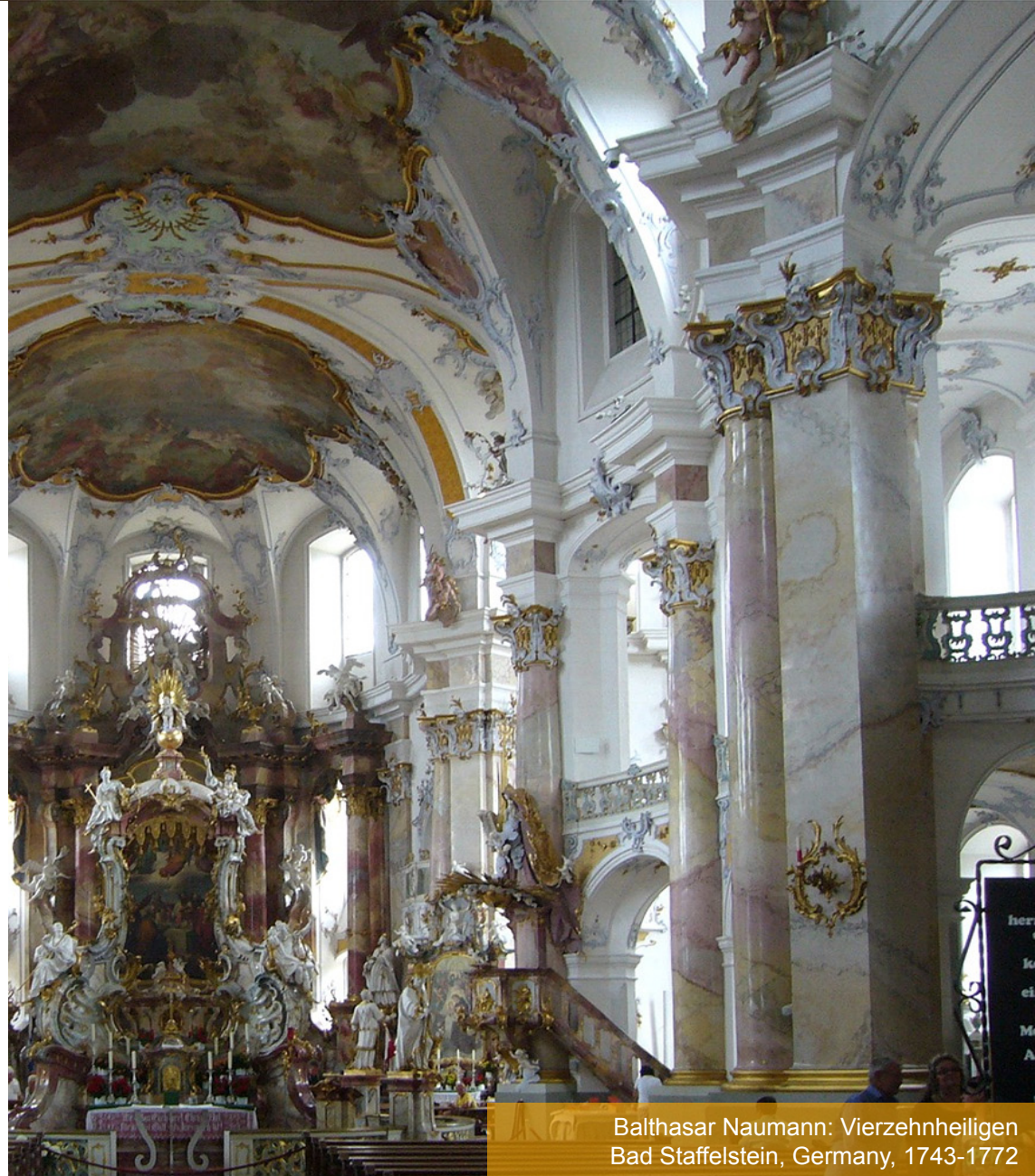
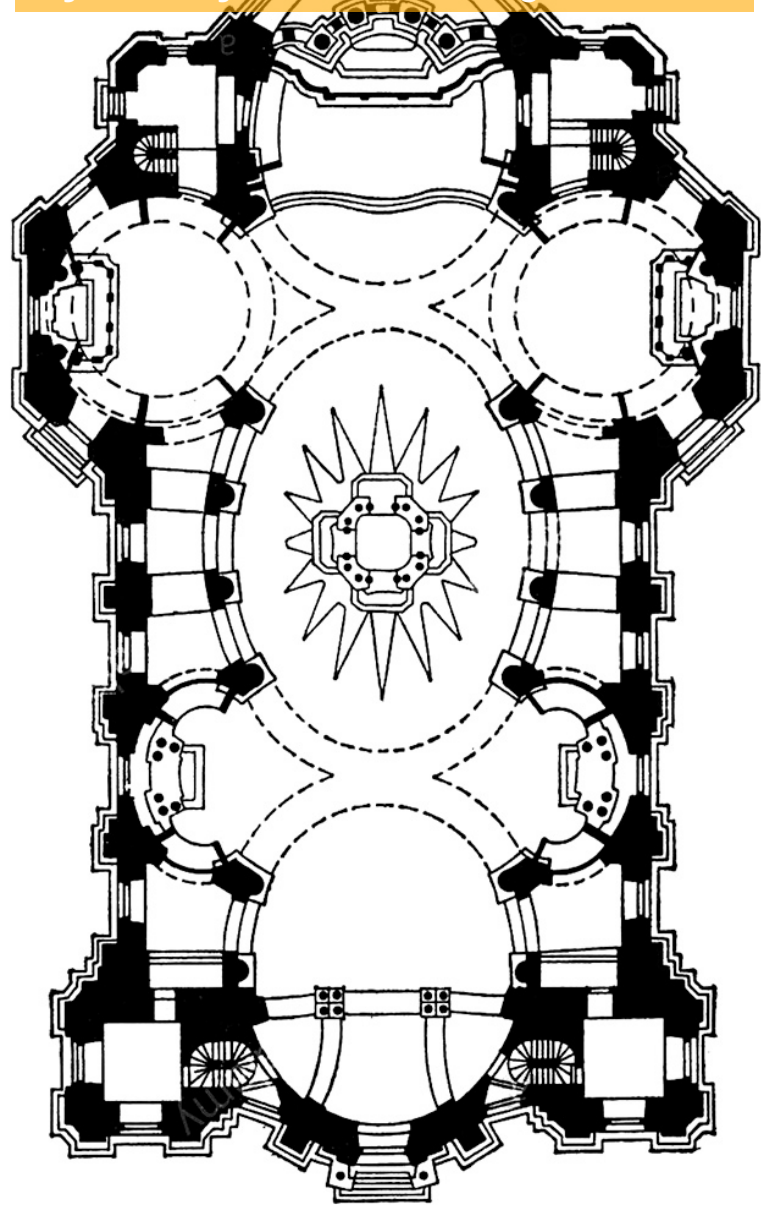


Leon Battista Alberti
Santa Maria Novella, Florence, 1470

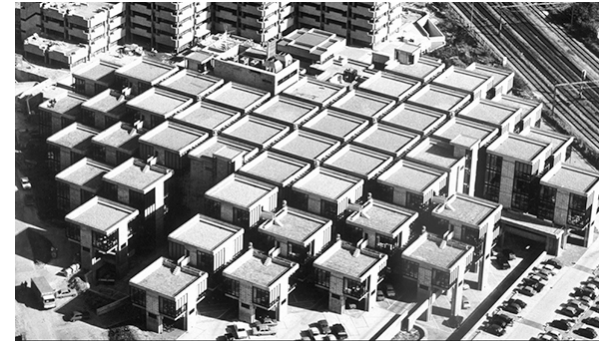
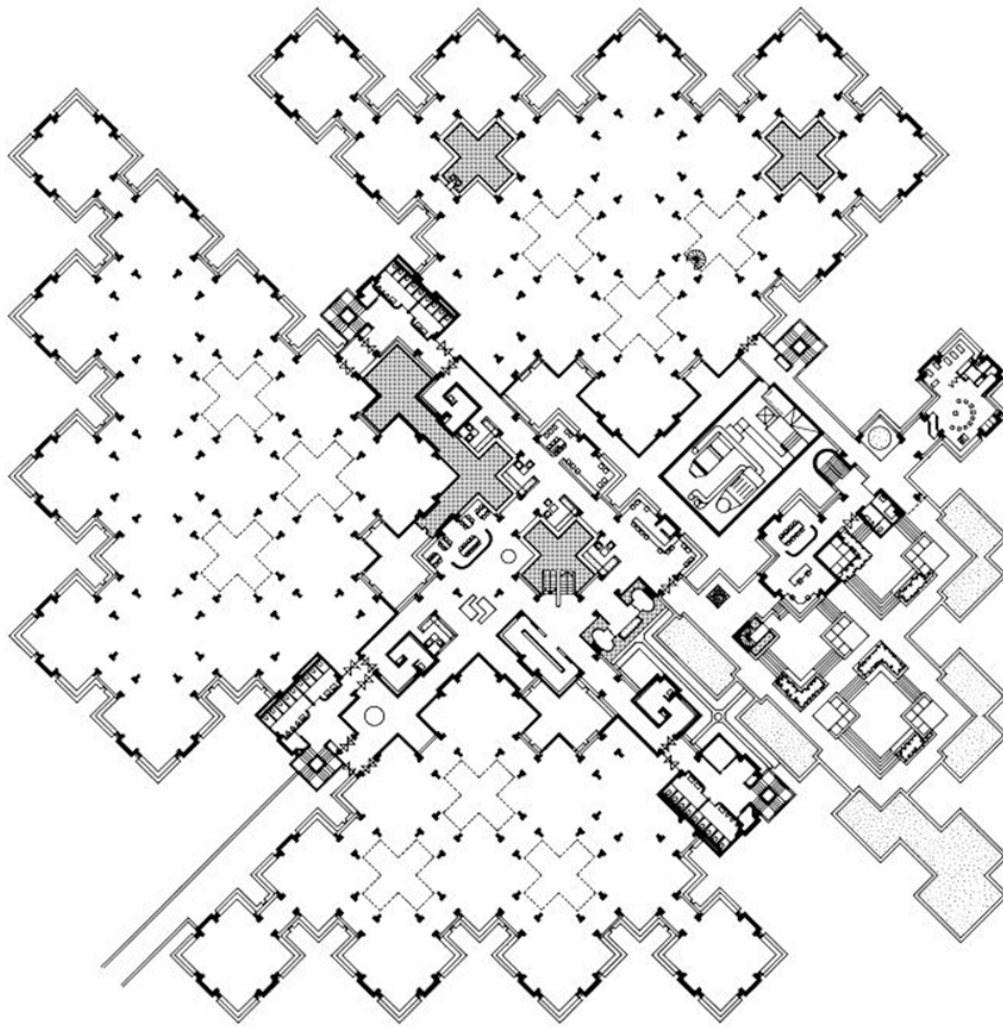


Gian Lorenzo Bernini: St. Peter Square
Vatican 1656-67

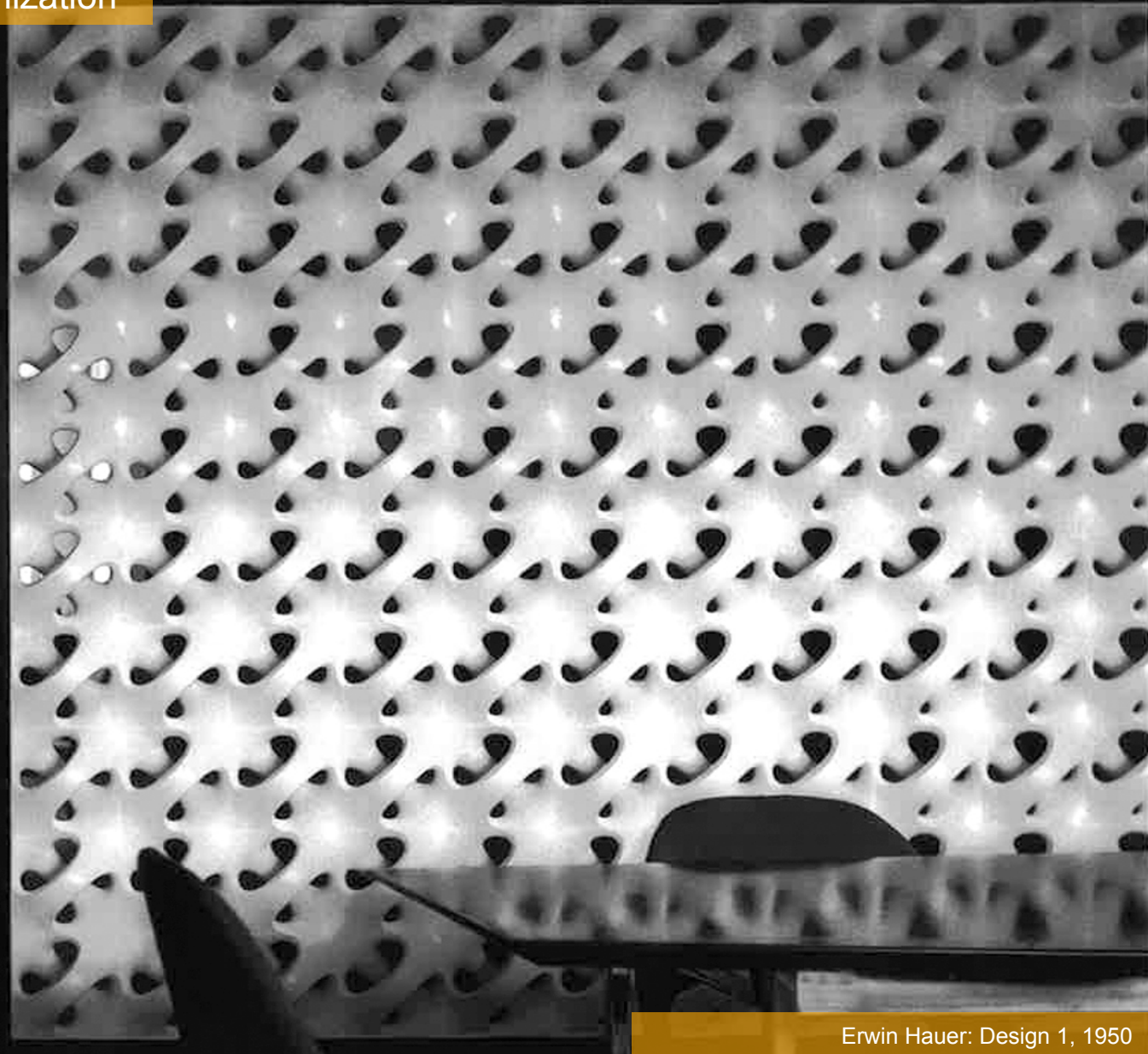
Symmetry Patterns of Organization



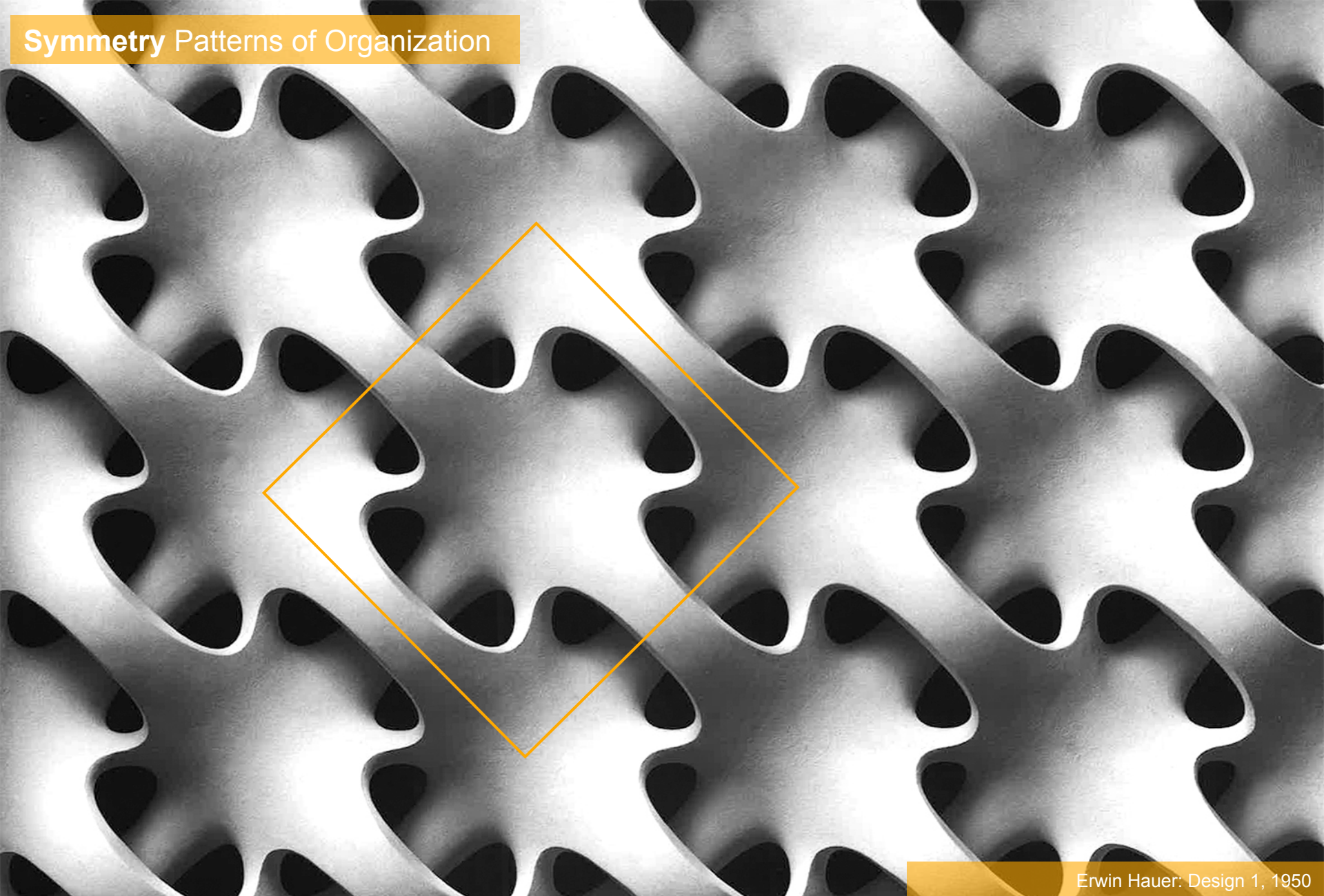
Balthasar Neumann: Vierzehnheiligen
Bad Staffelstein, Germany, 1743-1772



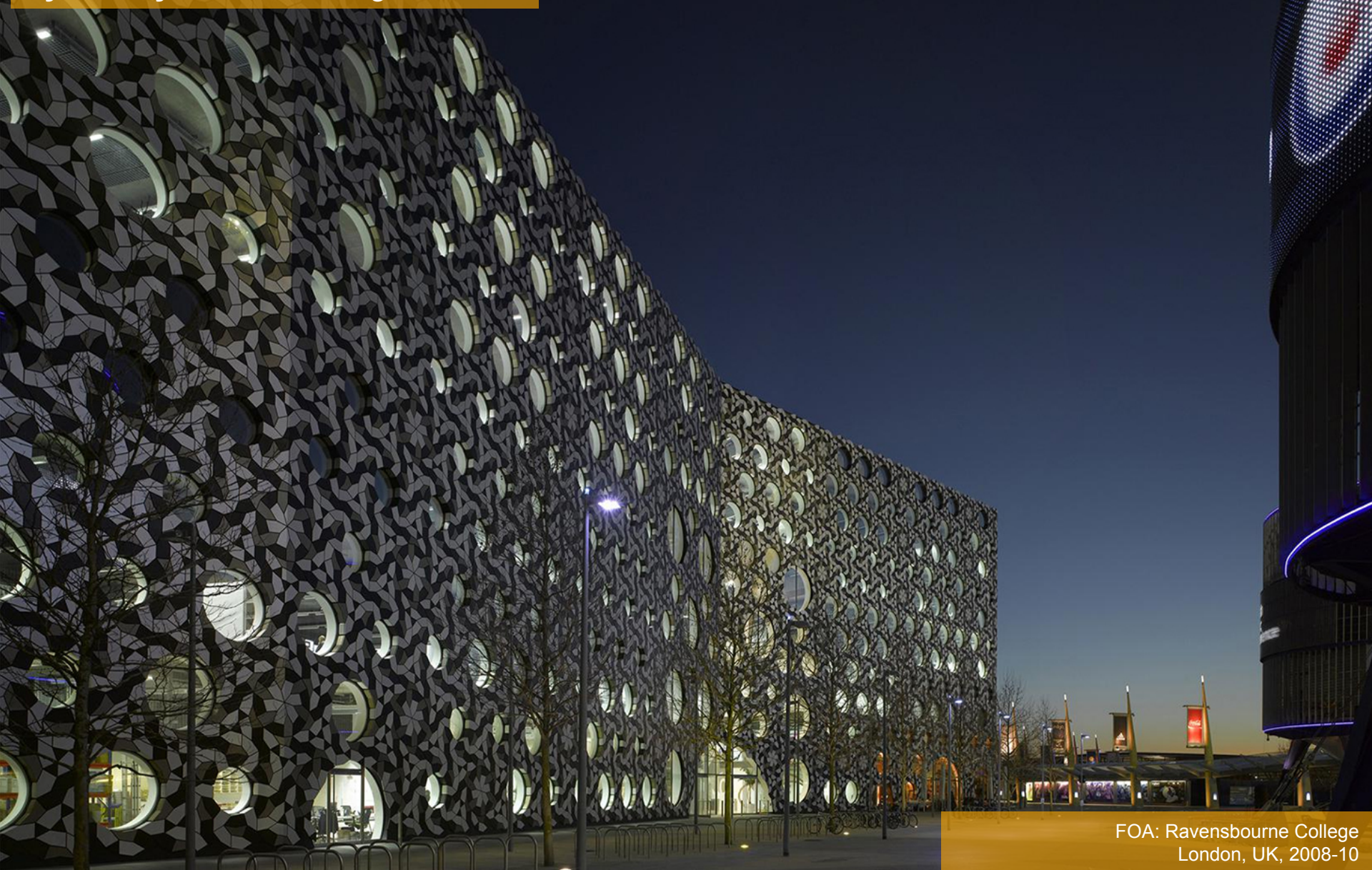
Hermann Hertzberger: Centraal Beheer
Apeldoorn, Netherlands, 1970-72



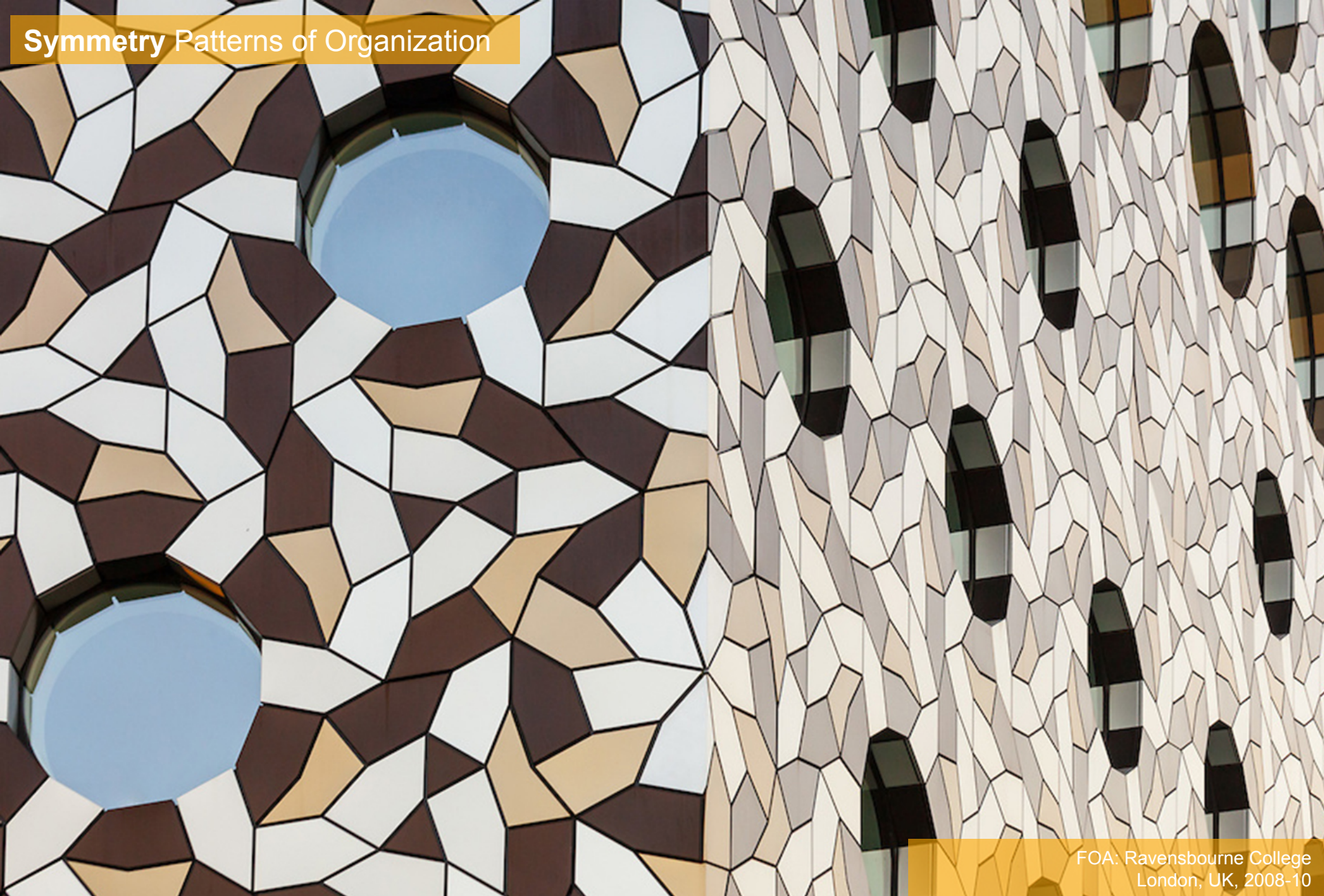
Erwin Hauer: Design 1, 1950



Erwin Hauer: Design 1, 1950



FOA: Ravensbourne College
London, UK, 2008-10



FOA: Ravensbourne College
London, UK, 2008-10



Lab Architecture Studio: Federation Square
Melbourne, Australia, 1999-2002

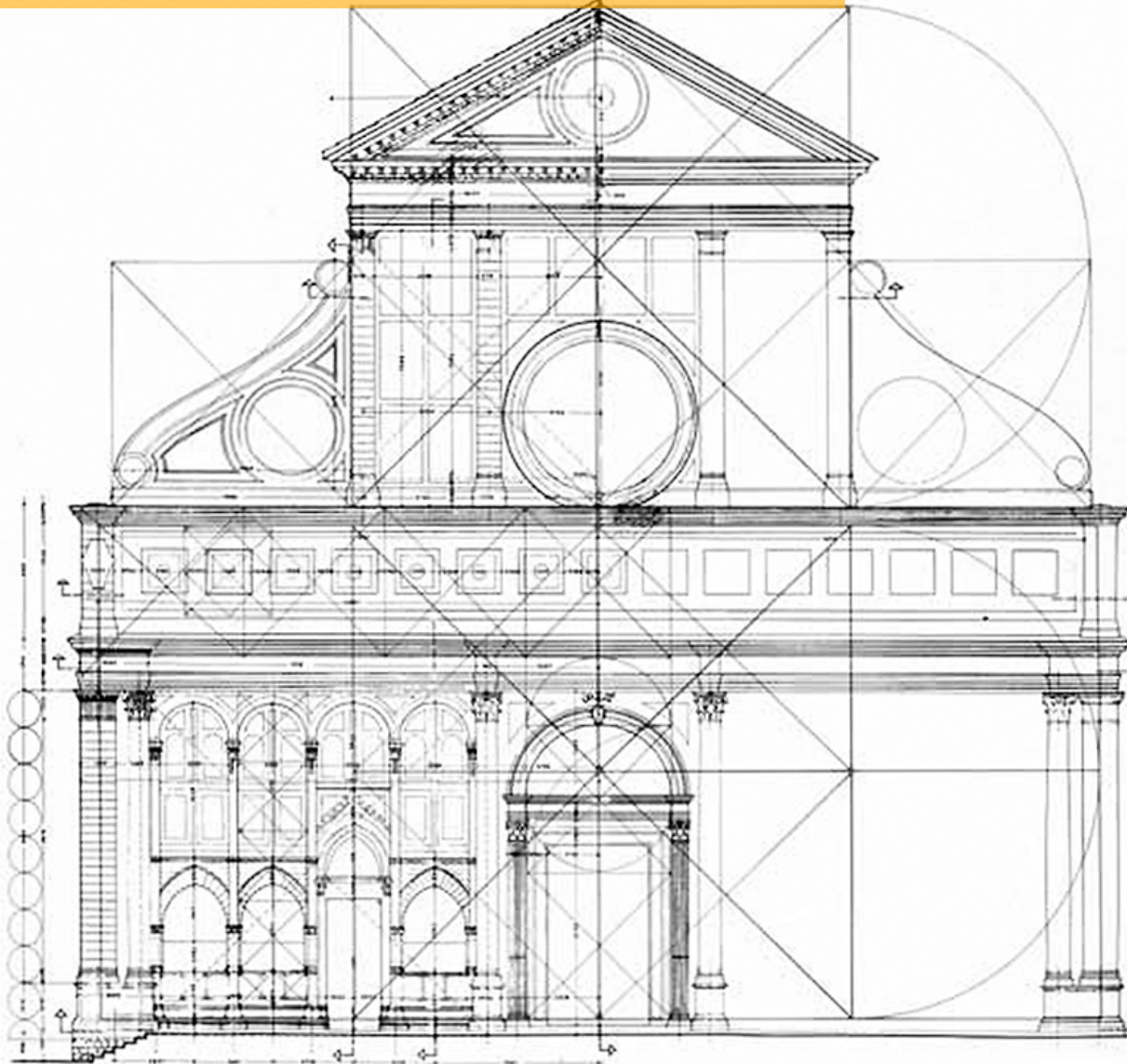
Symmetry Patterns of Organization



Lab Architecture Studio: Federation Square
Melbourne, Australia, 1999-2002



Zaha Hadid: Heydar Aliyev Center
Baku, Azerbaijan, 2007-12



Leon Battista Alberti
Santa Maria Novella, Florence, 1470

Architectural Design

Drawing patterns of organization

Computing patterns of organization

from
to

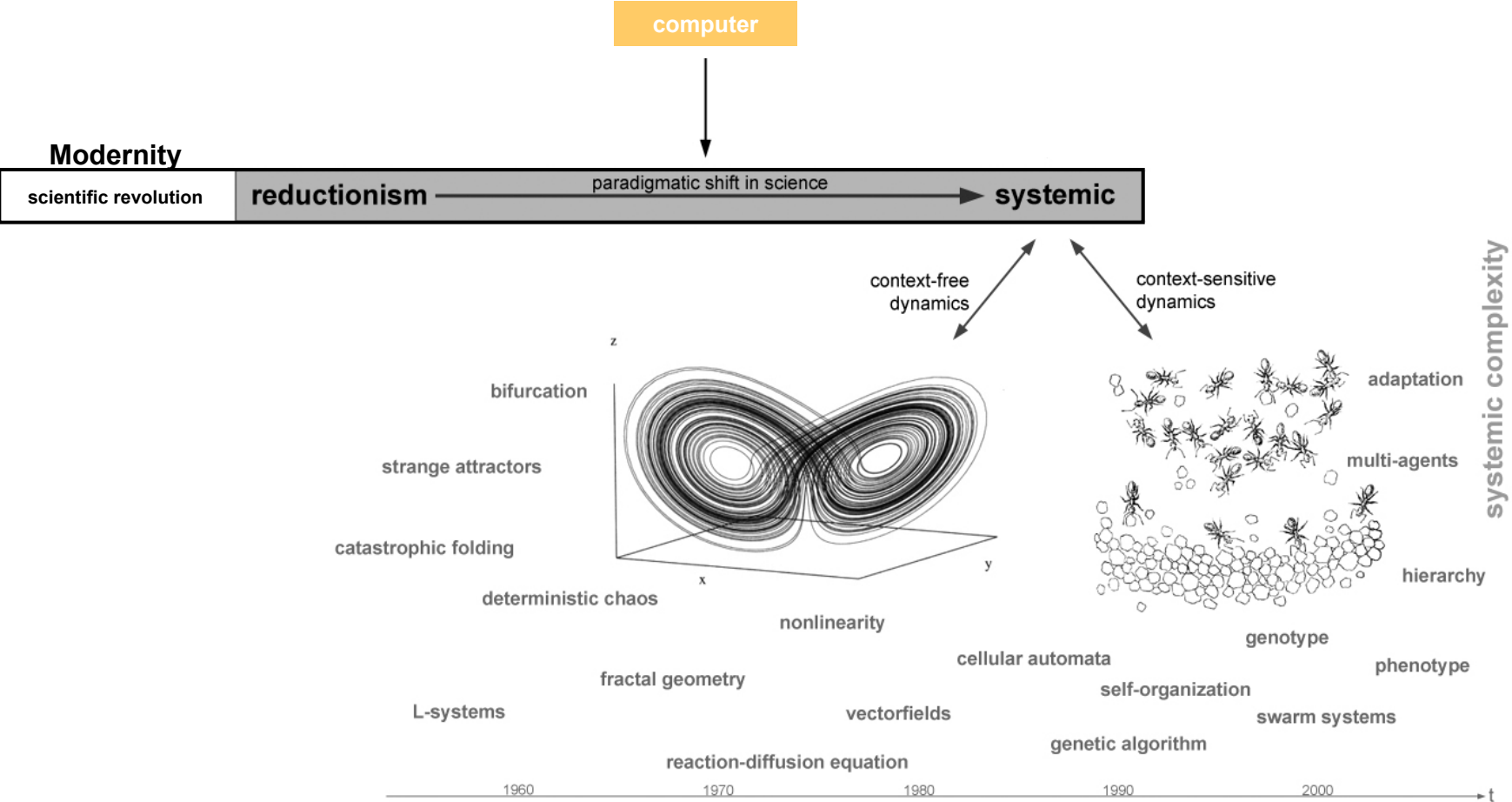


Ivan Sutherland
Sketchpad Console, 1962

Digital Revolution

"An intellectual revolution is happening all around us, but few people are remarking on it. Computational thinking is influencing research in nearly all disciplines, both in the sciences and the humanities. ... [The Computer] is changing the way we think. ... If you want to understand the 21th century then you must first understand computation."

Alan Bundy



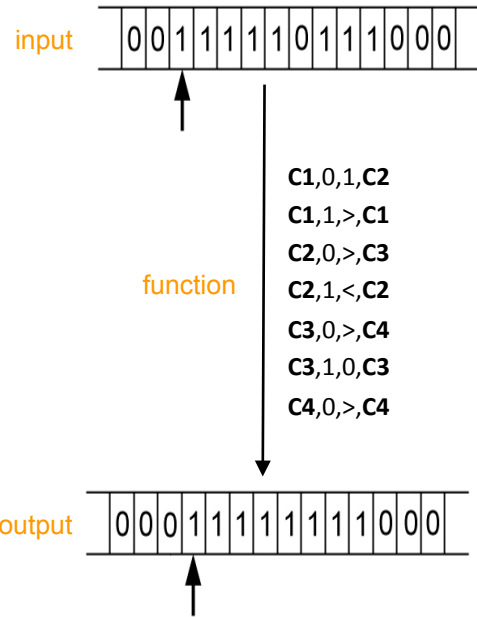
What is computation?



Computation

"Turing's 'Machines'. These machines are human who calculate."

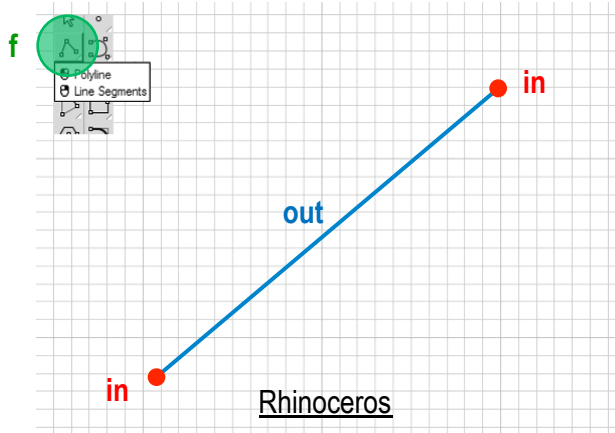
Ludwig Wittgenstein



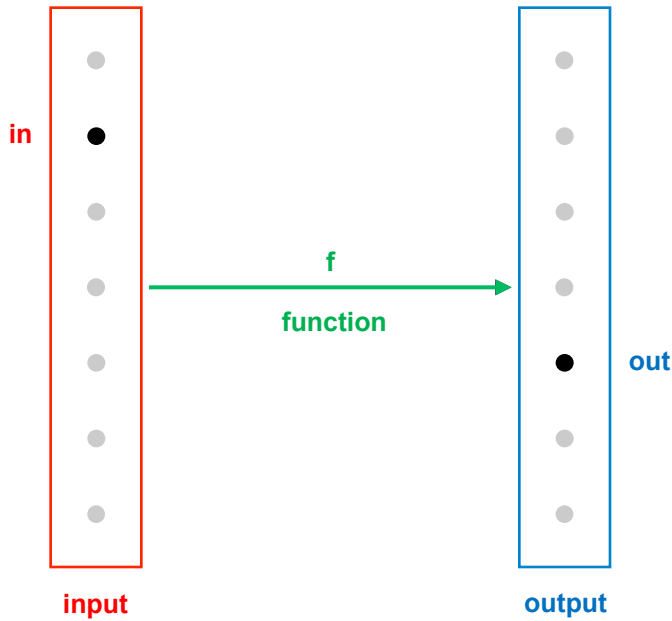
computability is the definition of a mathematical function by means of a sequence of formalizable operations

abstract machine model of computation based on Alan Turing

Computation



Grasshopper



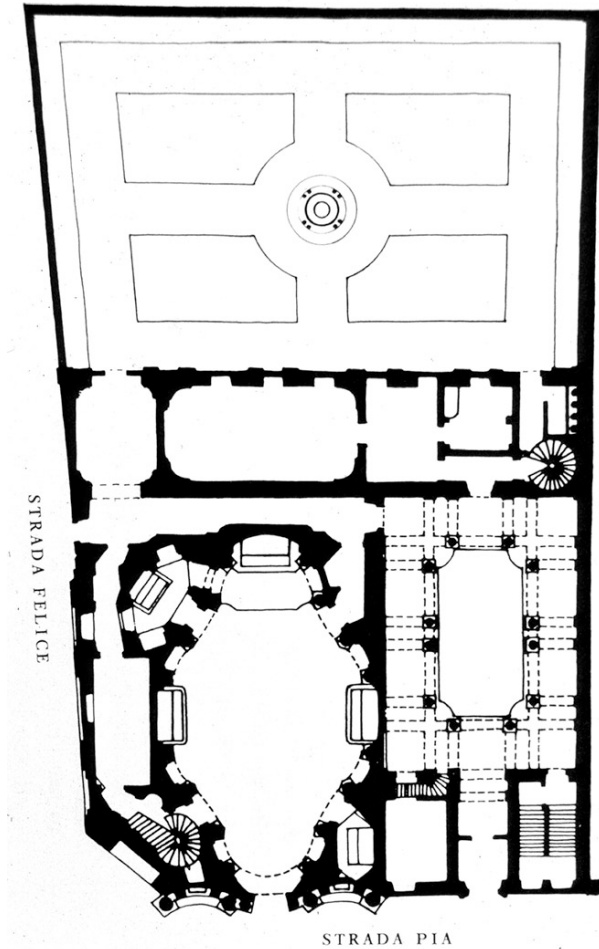
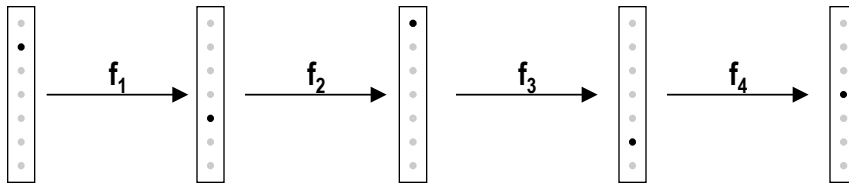
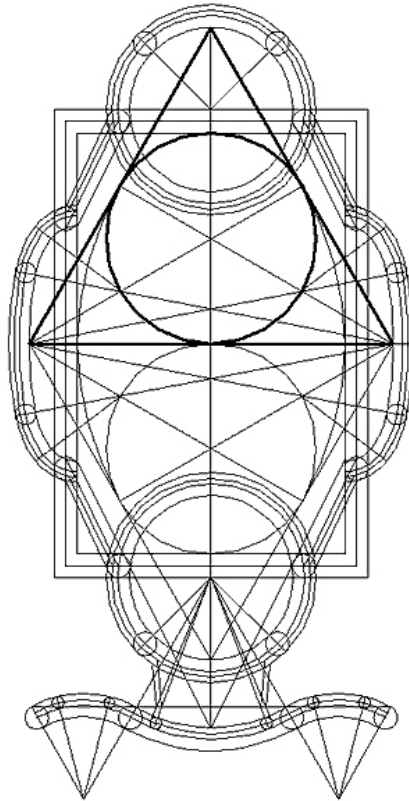
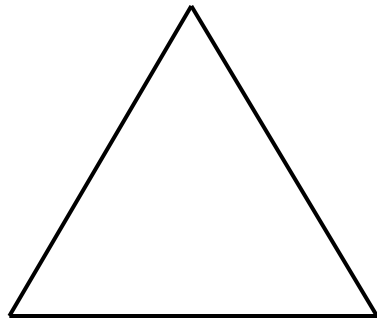
```
lineID = Rhino.AddLine (arrStart, arrEnd)
```

Rhinoscript

drawing a line as mathematical function



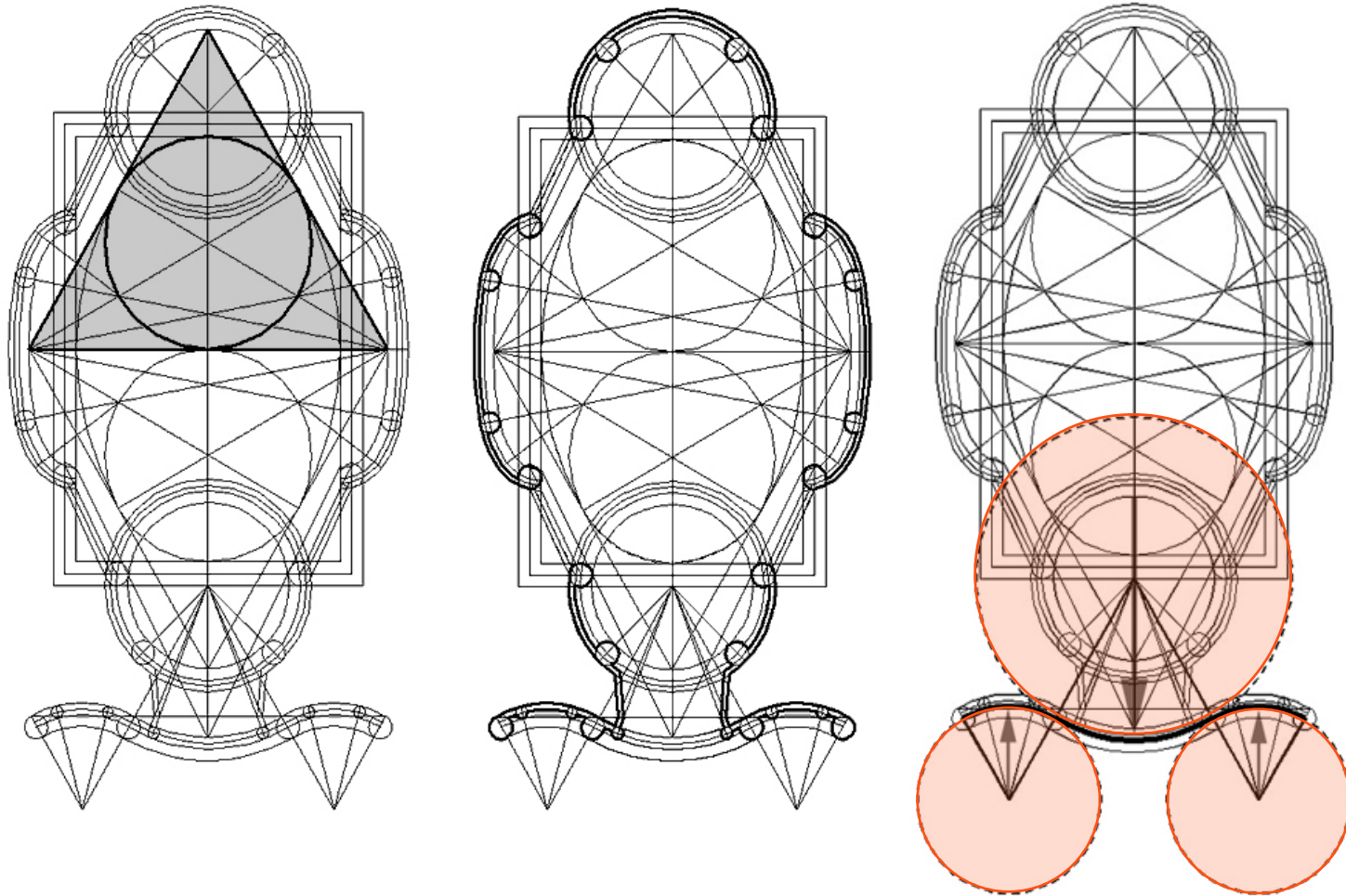
Borromini: San Carlo alle Quattro Fontane
Rome, Italy, 1638-1677



Borromini: San Carlo alle Quattro Fontane
Rome, Italy, 1638-1677



Borromini: San Carlo alle Quattro Fontane
Rome, Italy, 1638-1677

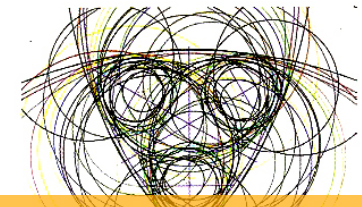
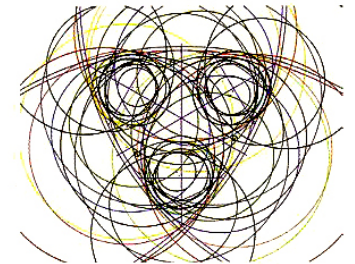
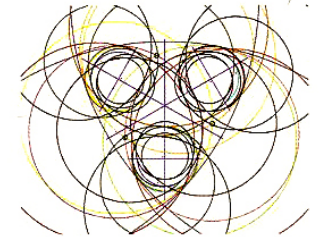
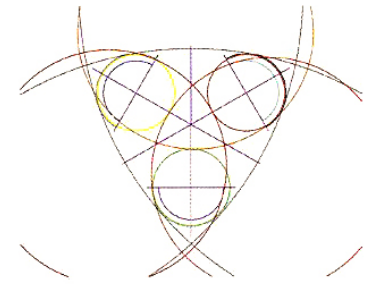
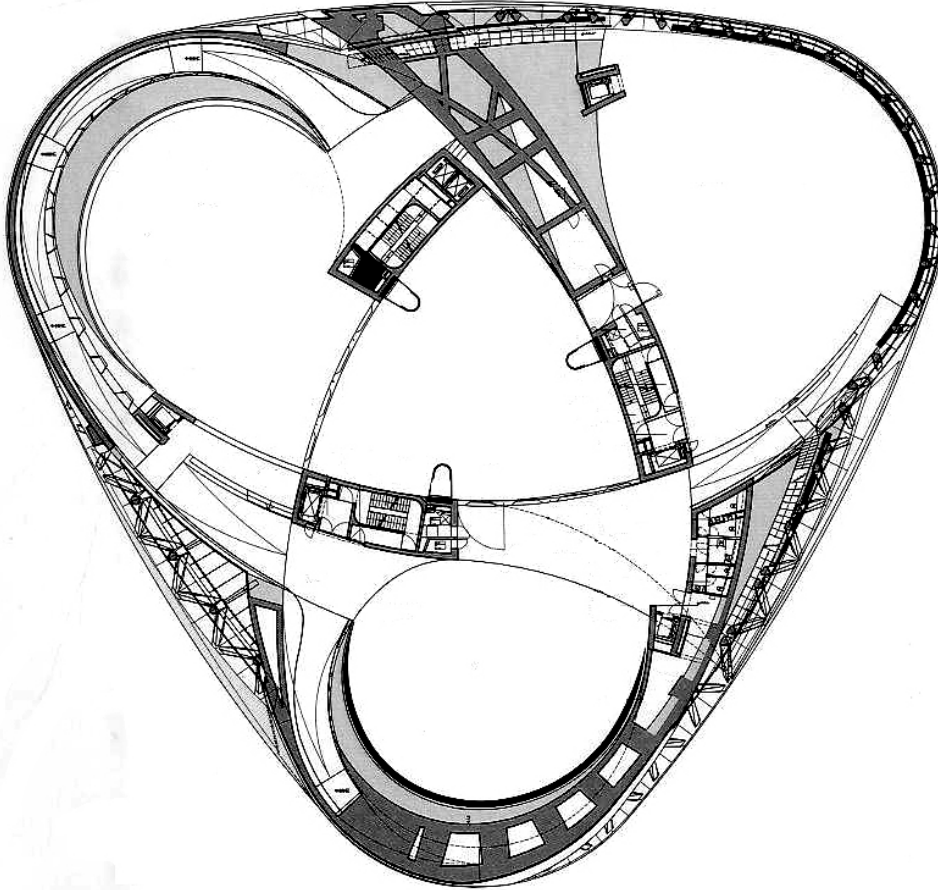


Borromini: San Carlo alle Quattro Fontane
Rome, Italy, 1638-1677

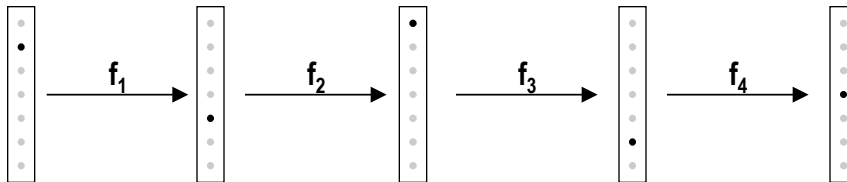


UN Studio: Mercedes Benz Museum
Stuttgart, Germany, 2001-06

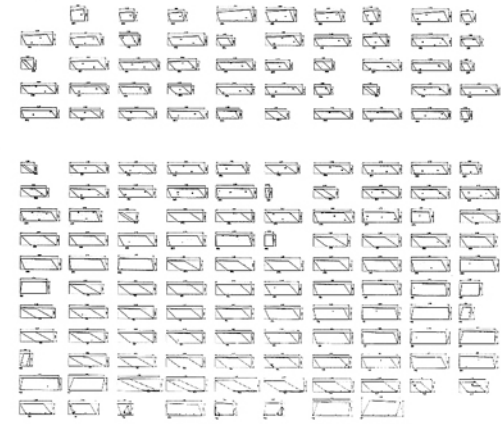
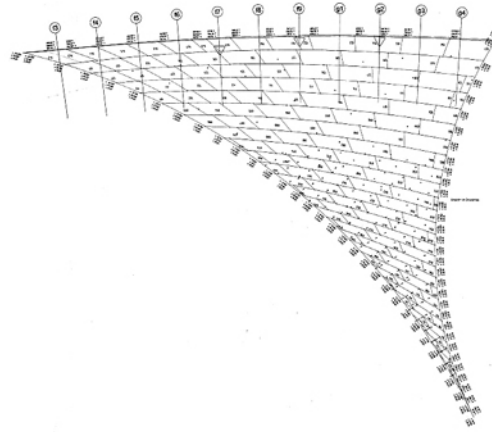
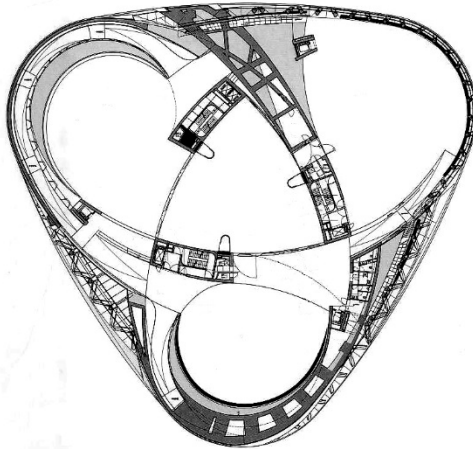
Drawing as Computation



UN Studio: Mercedes-Benz Museum
Stuttgart, Germany, 2001-06



Drawing as Computation



structure

design

fabrication

assembly

materials

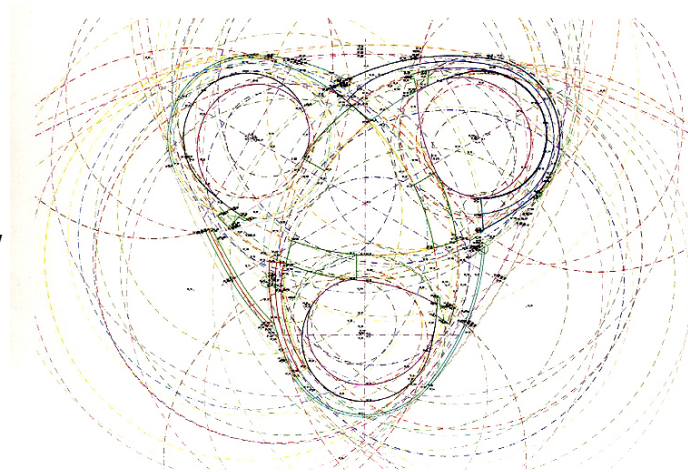
user data

construction details

...

BIM

geometry



UN Studio: Mercedes Benz Museum
Stuttgart, Germany, 2001-06

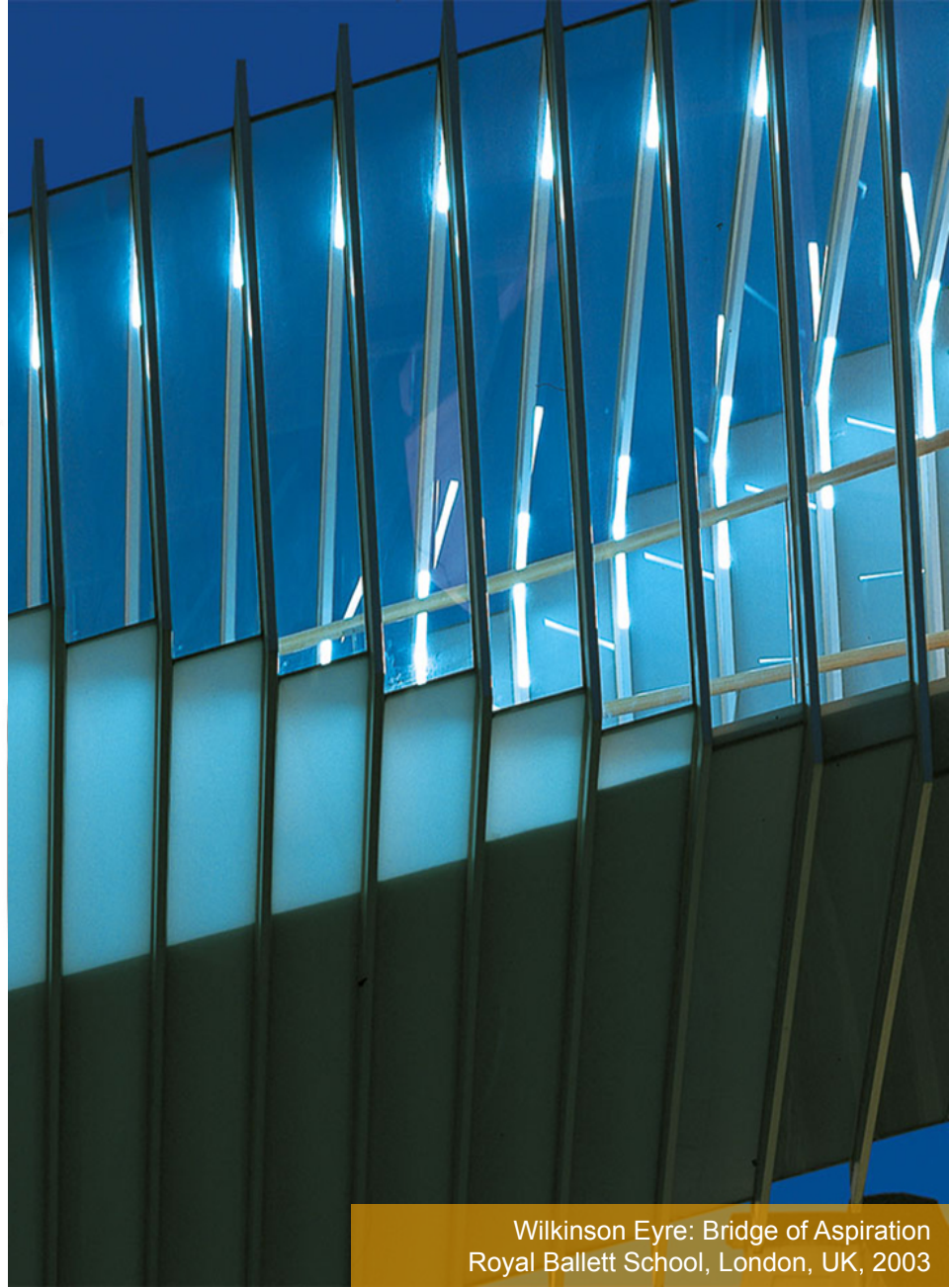
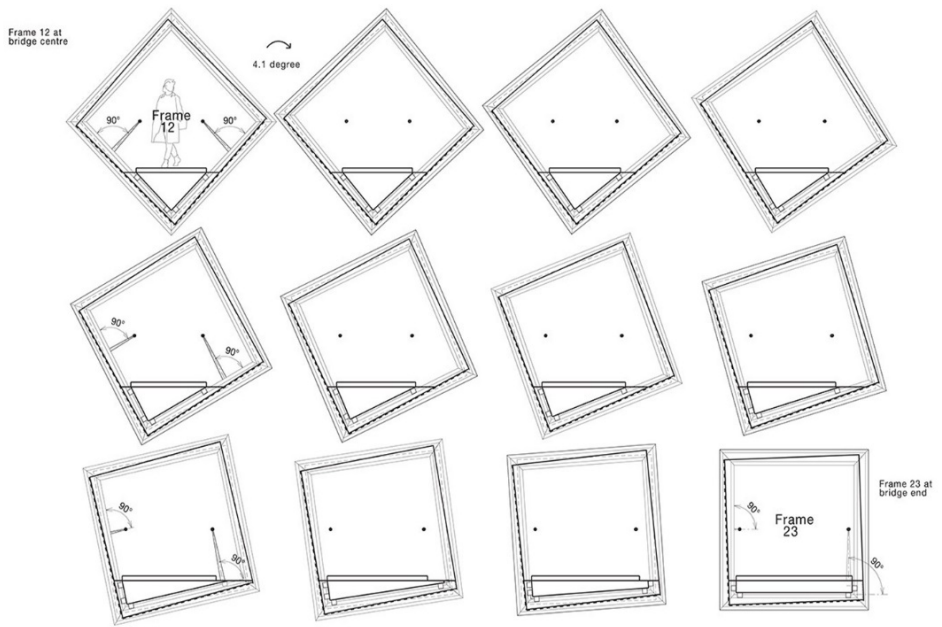
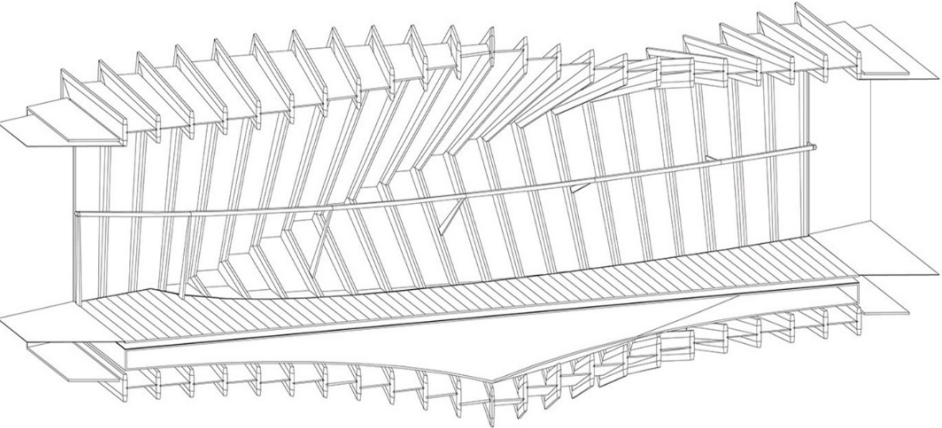


Wilkinson Eyre: Bridge of Aspiration
Royal Ballet School, London, UK, 2003

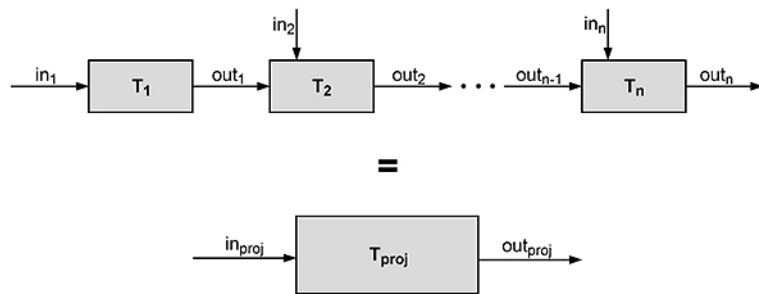


Wilkinson Eyre: Bridge of Aspiration
Royal Ballet School, London, UK, 2003

Drawing as Computation Variation



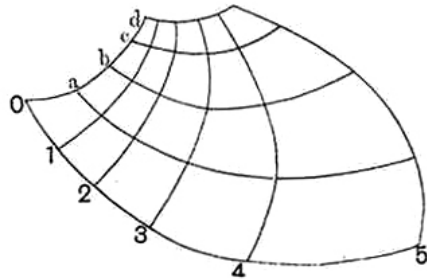
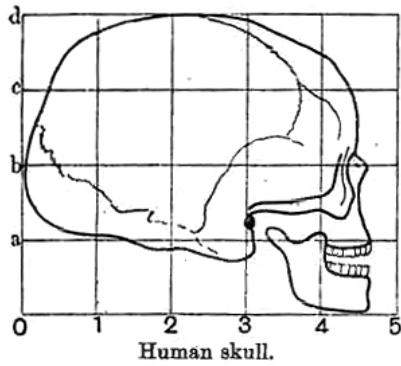
Wilkinson Eyre: Bridge of Aspiration
Royal Ballet School, London, UK, 2003



every architectural drawing carries an inherent logic defined by the sequence of geometric operations

IN-FORM
form is information

Adaptation of Form



Coordinates of chimpanzee's skull, as a projection of the Cartesian coordinates



Skull of chimpanzee.



Skull of baboon.

form

force

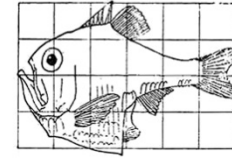


Fig. 517. *Argyropelecus Olfersi*.

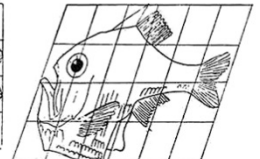


Fig. 518. *Sternopygus diaphana*.

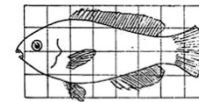


Fig. 519. *Scarus sp.*

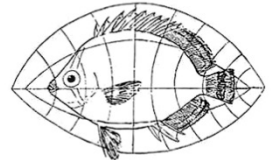


Fig. 520. *Pomacanthus*.

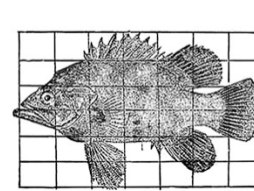


Fig. 521. *Polyprion*.

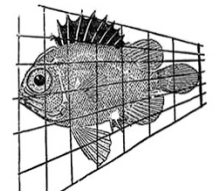


Fig. 522. *Pseudopriacanthus altus*.

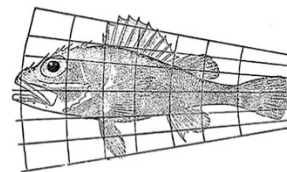


Fig. 523. *Scorpaena sp.*

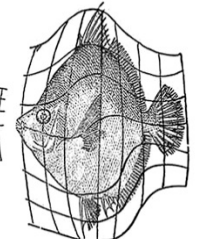


Fig. 524. *Antigonia capros*.

D'Arcy Thompson: *On Growth and Form*, 1942

IN-FORM
architectural form as
resultant of urban forces

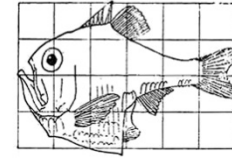
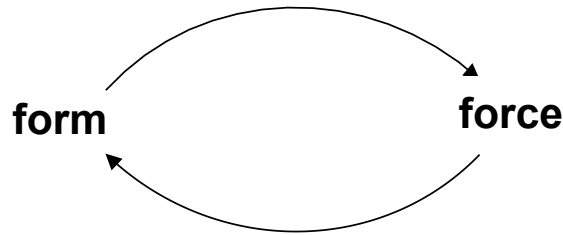
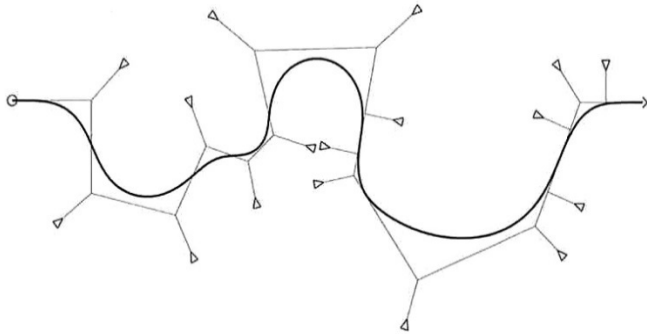


Fig. 517. *Argyropelecus Olfersi*.

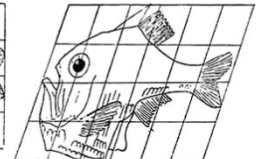


Fig. 518. *Sternopygus diaphana*.

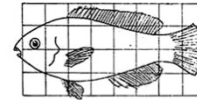


Fig. 519. *Scarus sp.*

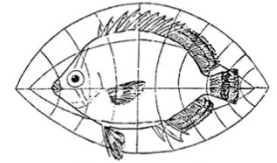


Fig. 520. *Pomacanthus*.

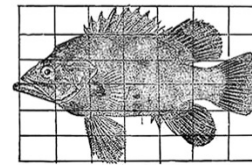


Fig. 521. *Polyprion*.

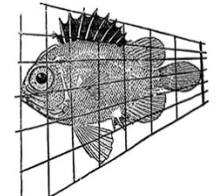


Fig. 522. *Pseudopriacanthus altus*.

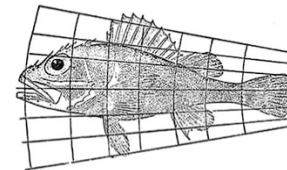


Fig. 523. *Scorpaena sp.*

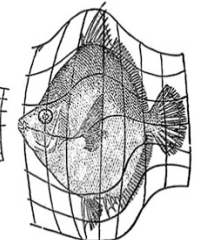


Fig. 524. *Antigonina capros*.

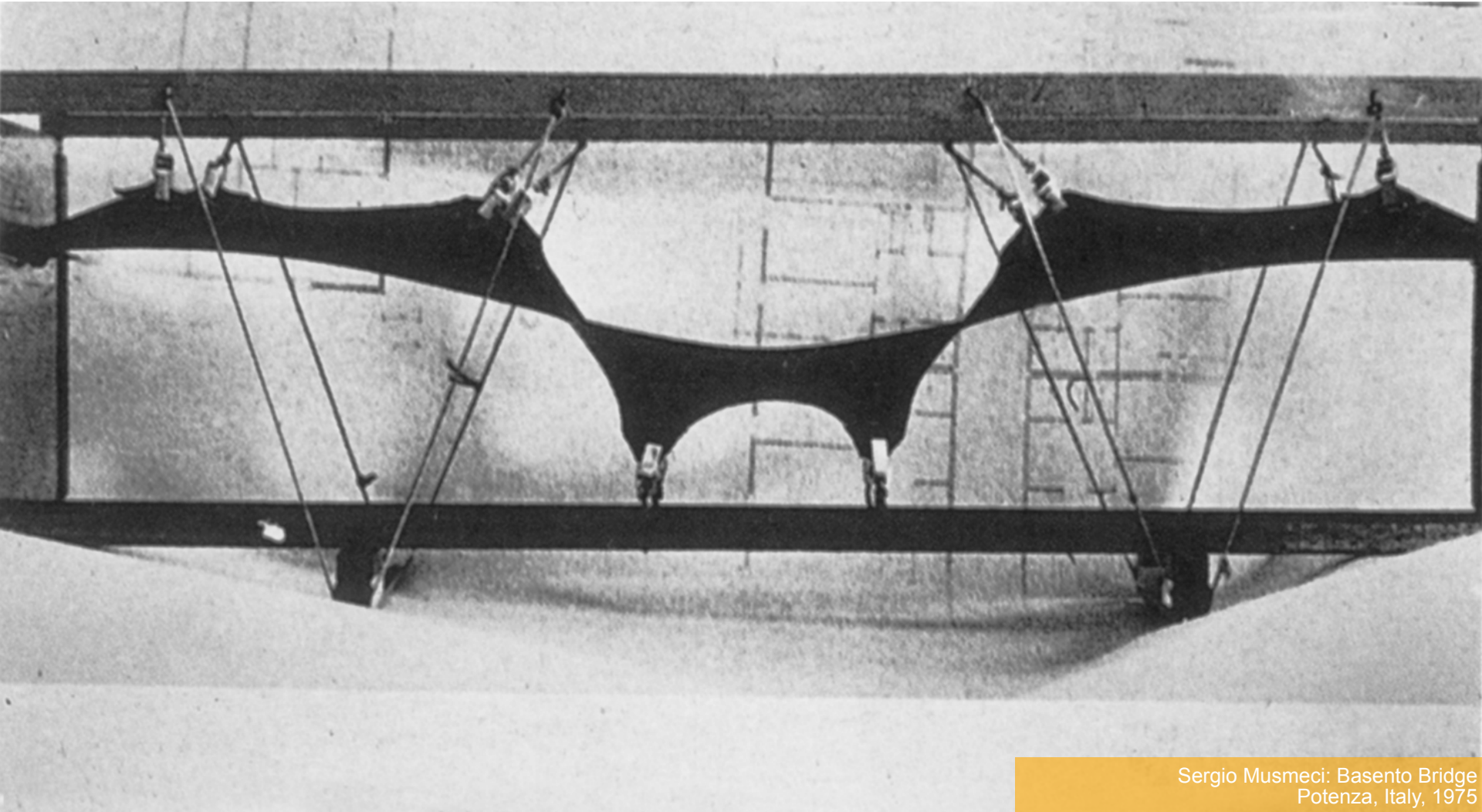
D'Arcy Thompson: *On Growth and Form*, 1942



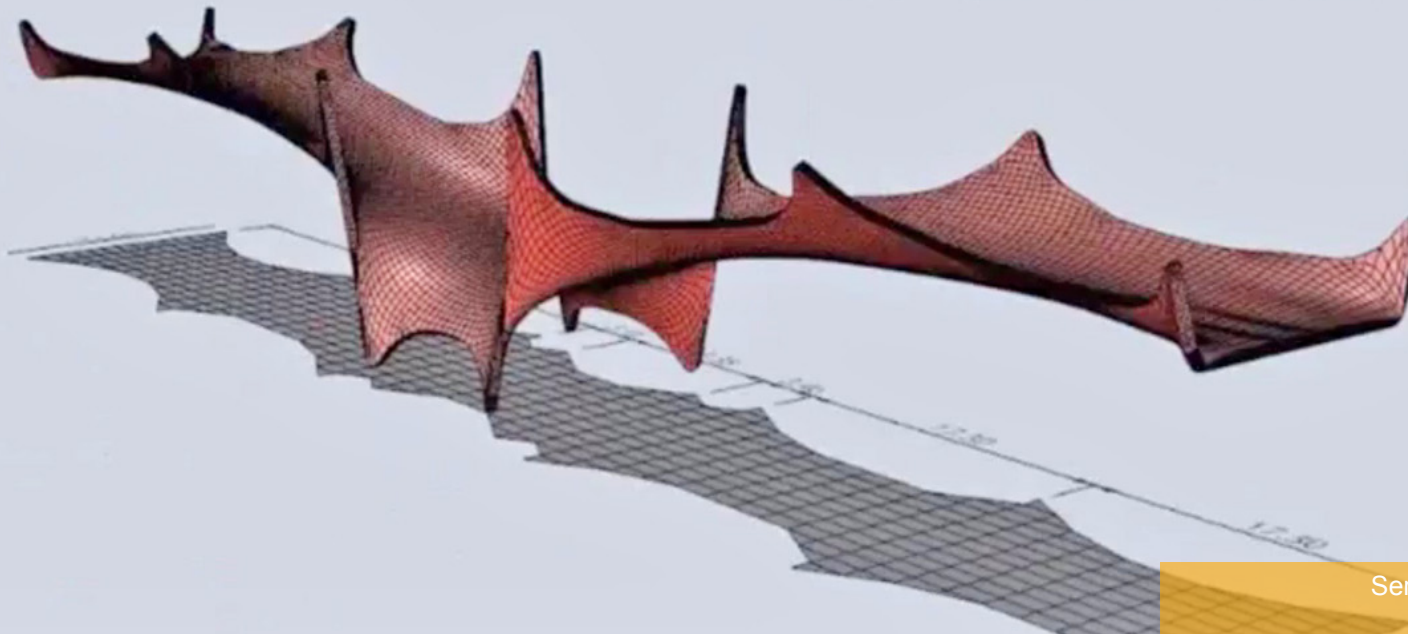
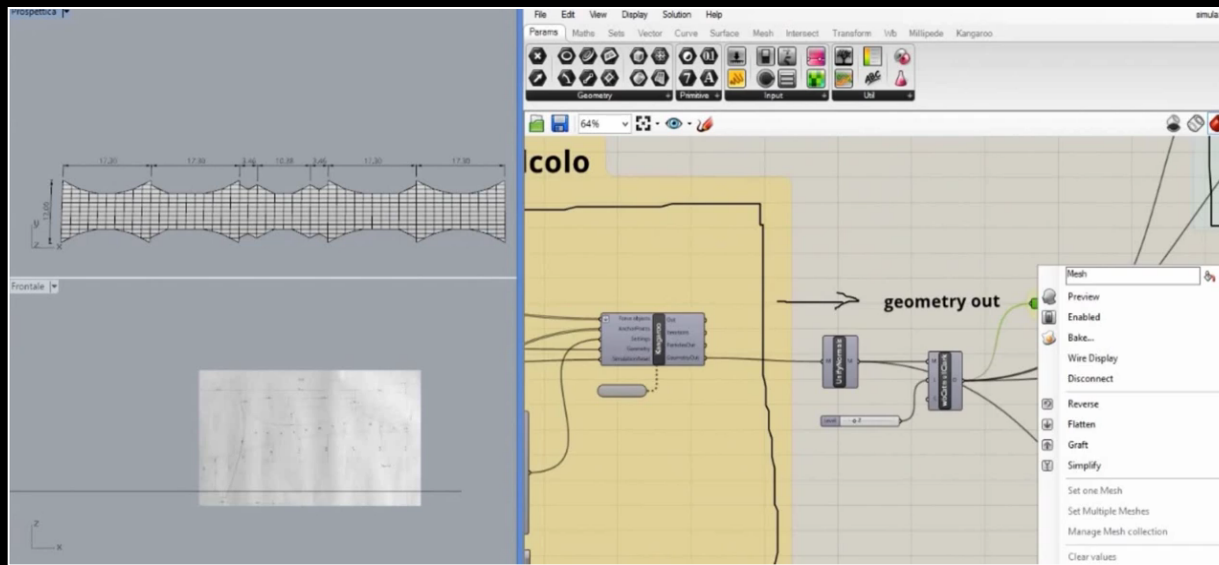
Sergio Musmeci: Basento Bridge
Potenza, Italy, 1975



Sergio Musmeci: Basento Bridge
Potenza, Italy, 1975



Sergio Musmeci: Basento Bridge
Potenza, Italy, 1975



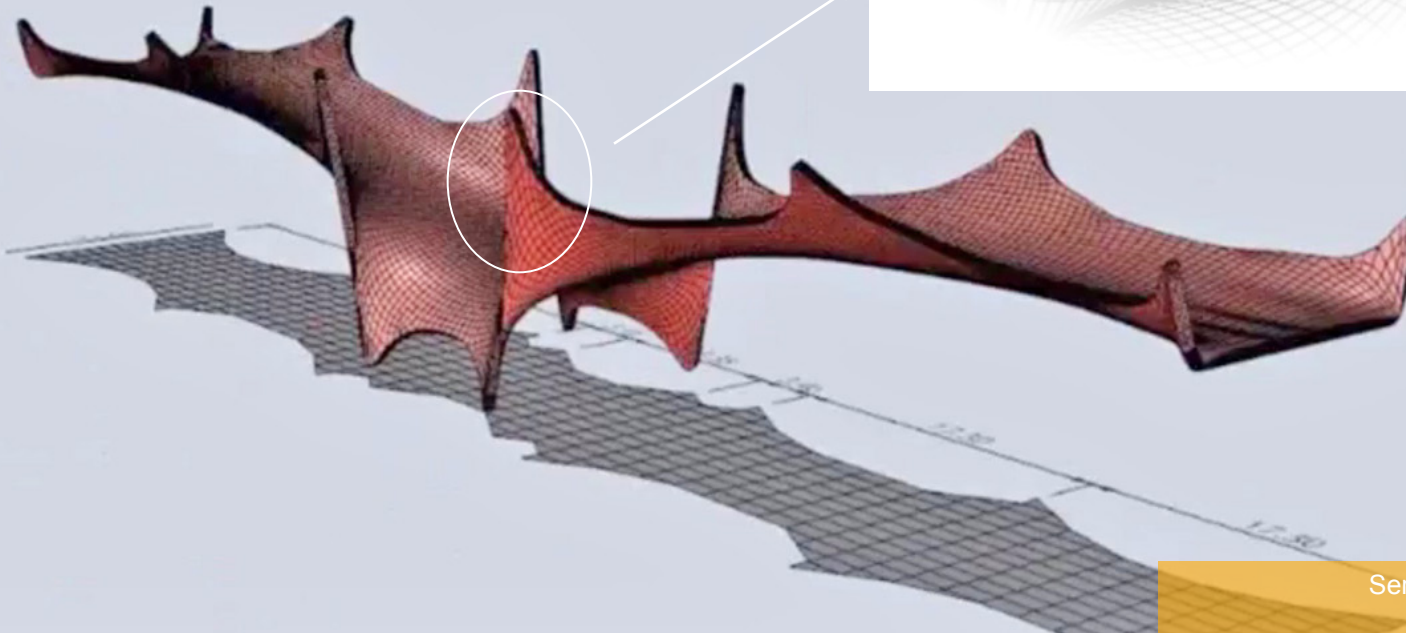
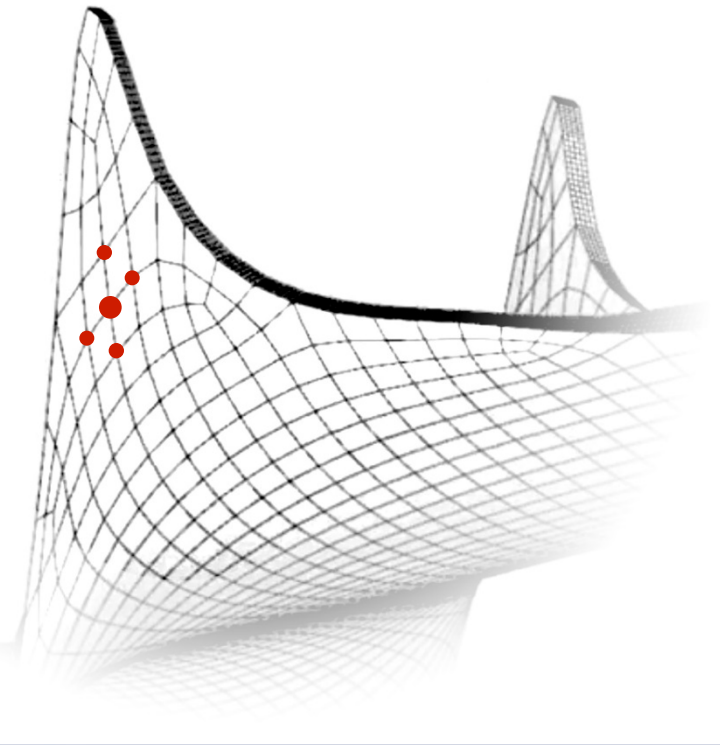
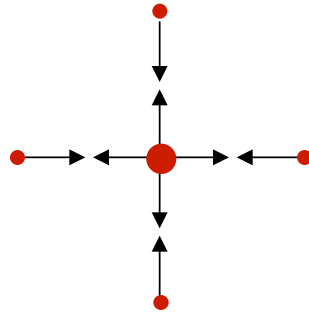
Sergio Musmeci: Basento Bridge
Potenza, Italy, 1975

Component System

elements components

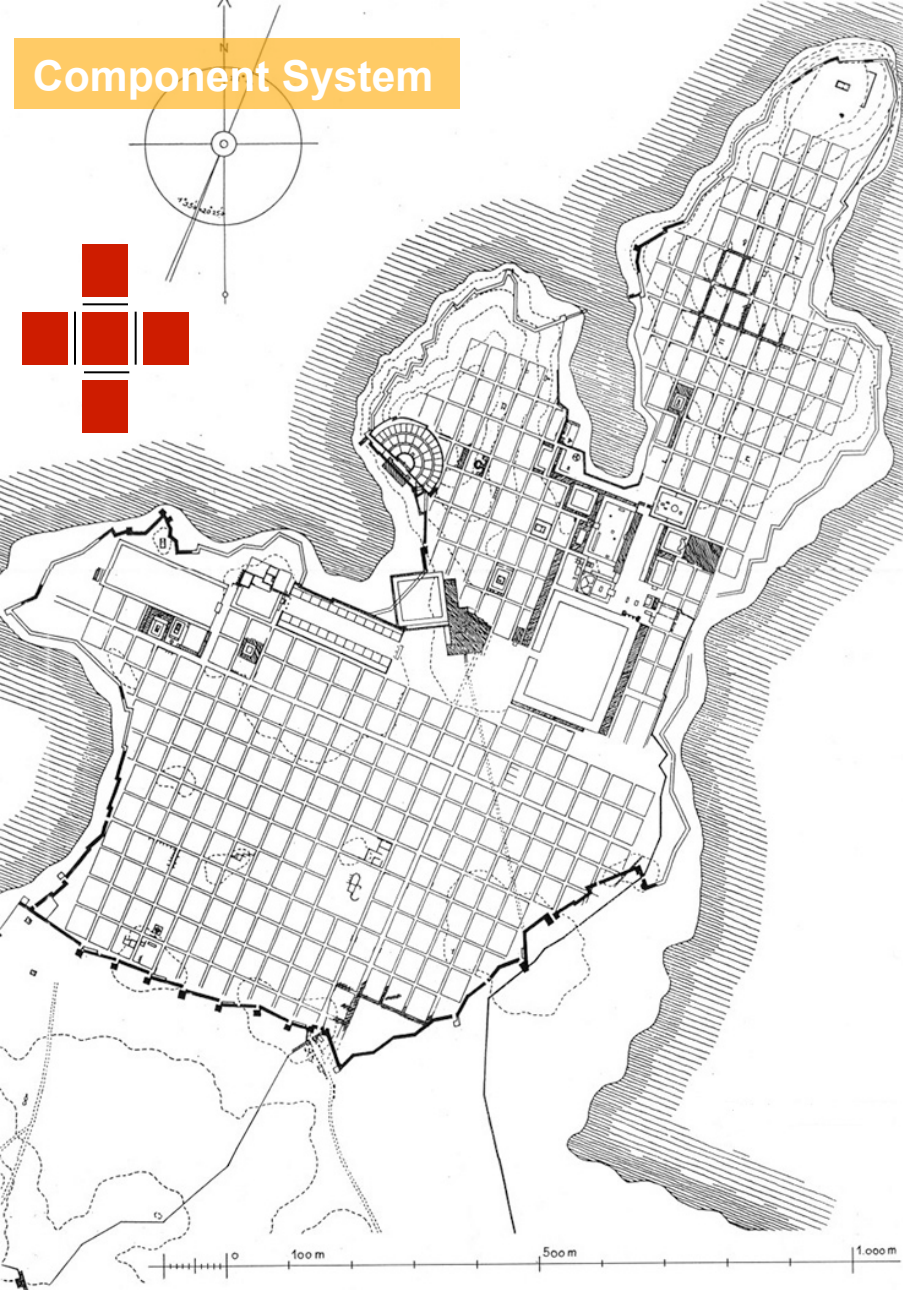
neighborhood topology

equilibrium rules of interaction

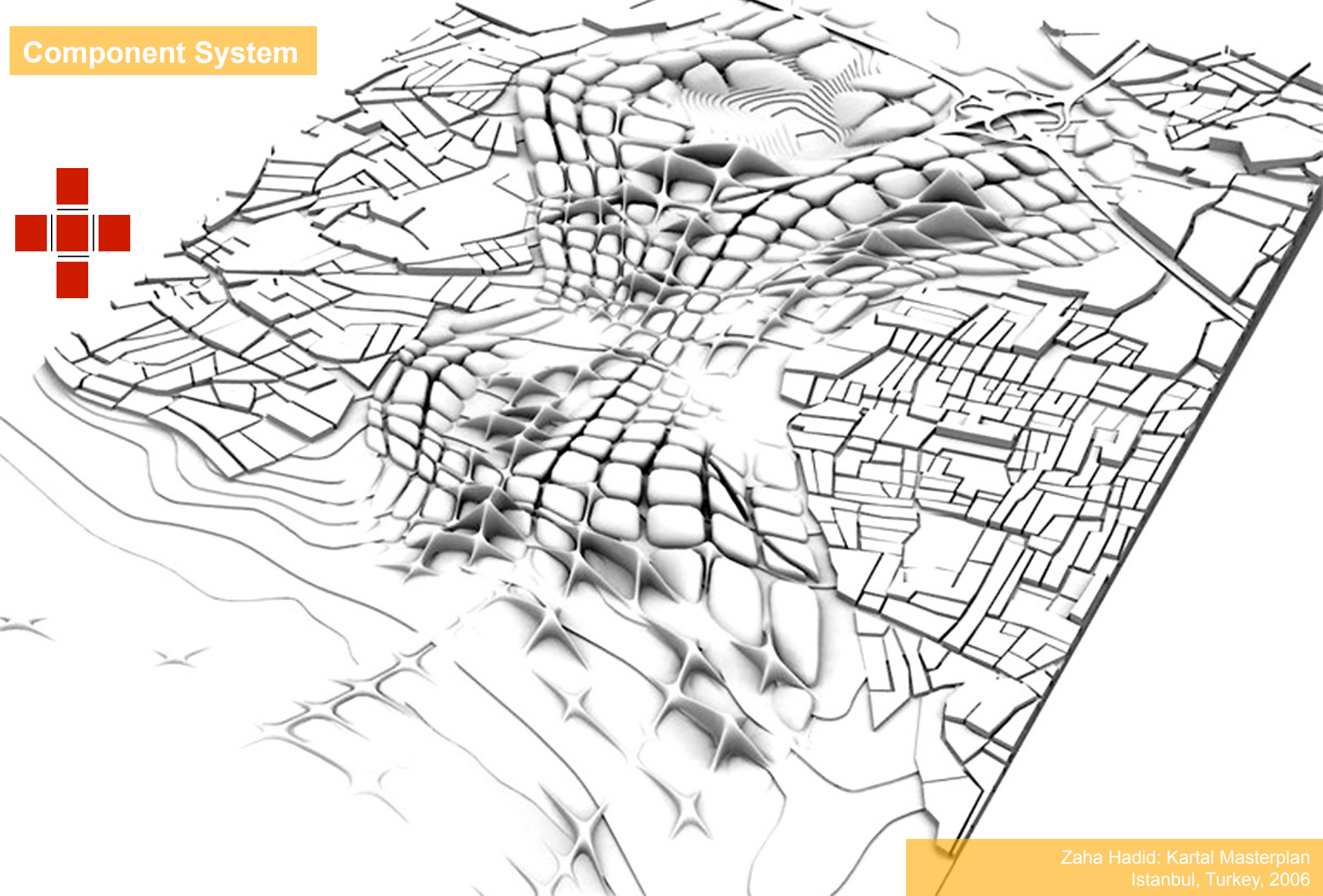
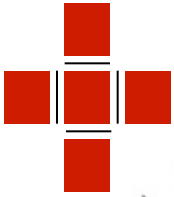


Sergio Musmeci: Basento Bridge
Potenza, Italy, 1975

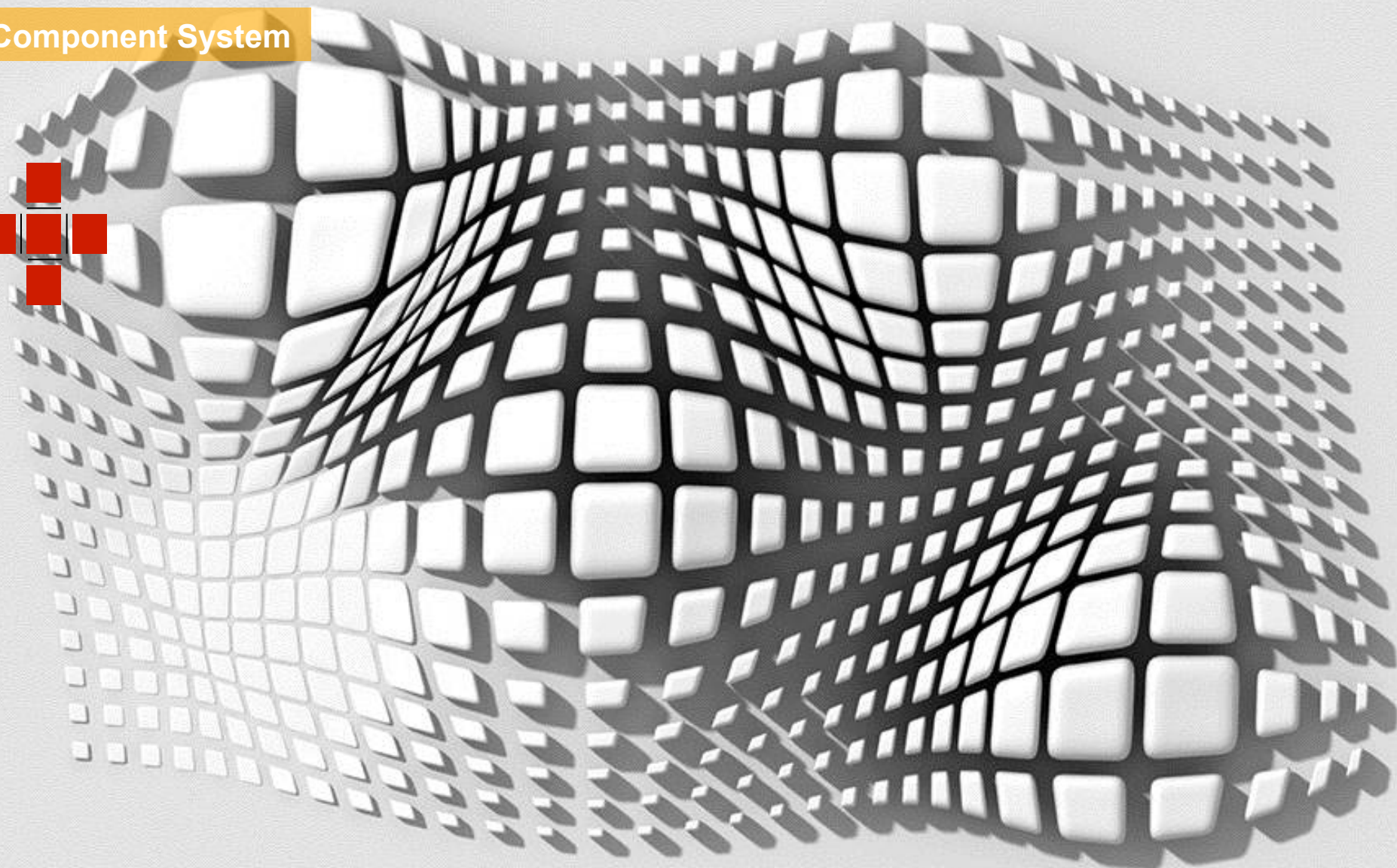
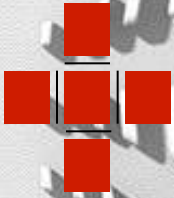
Component System



plan of Miletus, around 400 BC



Zaha Hadid: Kartal Masterplan
Istanbul, Turkey, 2006



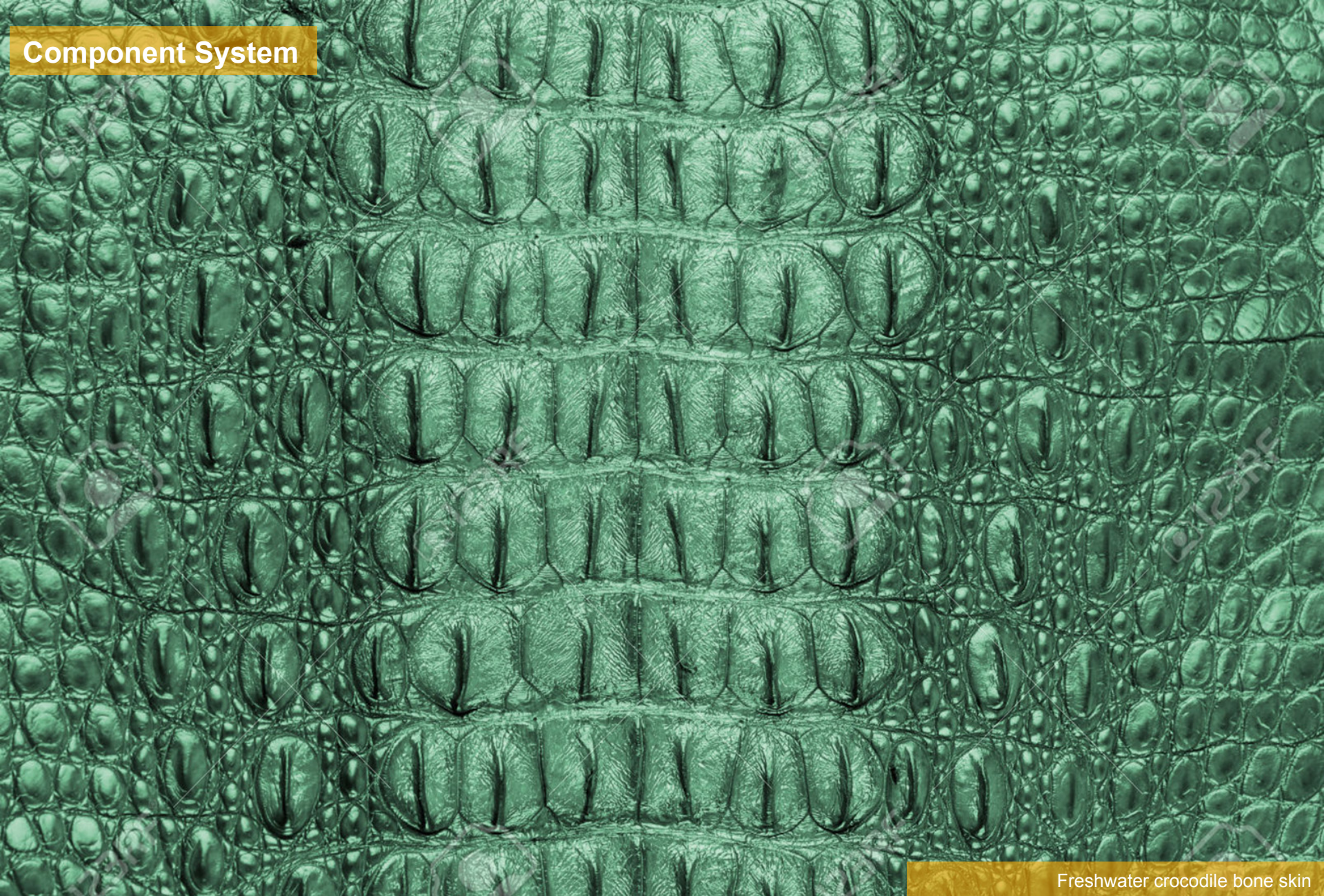
field conditions



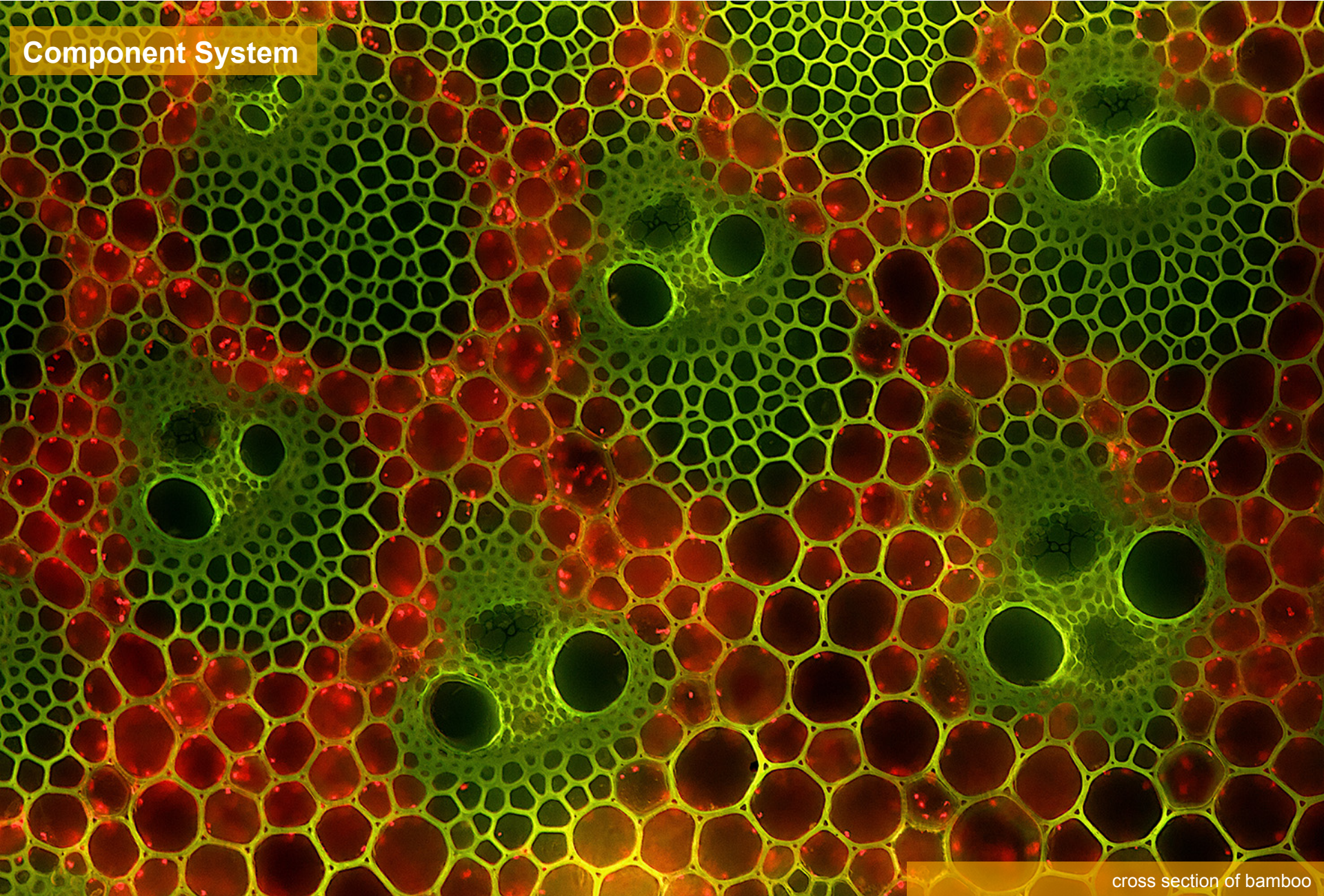
dry stone wall, Aran Island, Ireland



dry stone wall, Aran Island, Ireland



Freshwater crocodile bone skin



cross section of bamboo



nest of Southern Masked Weaver

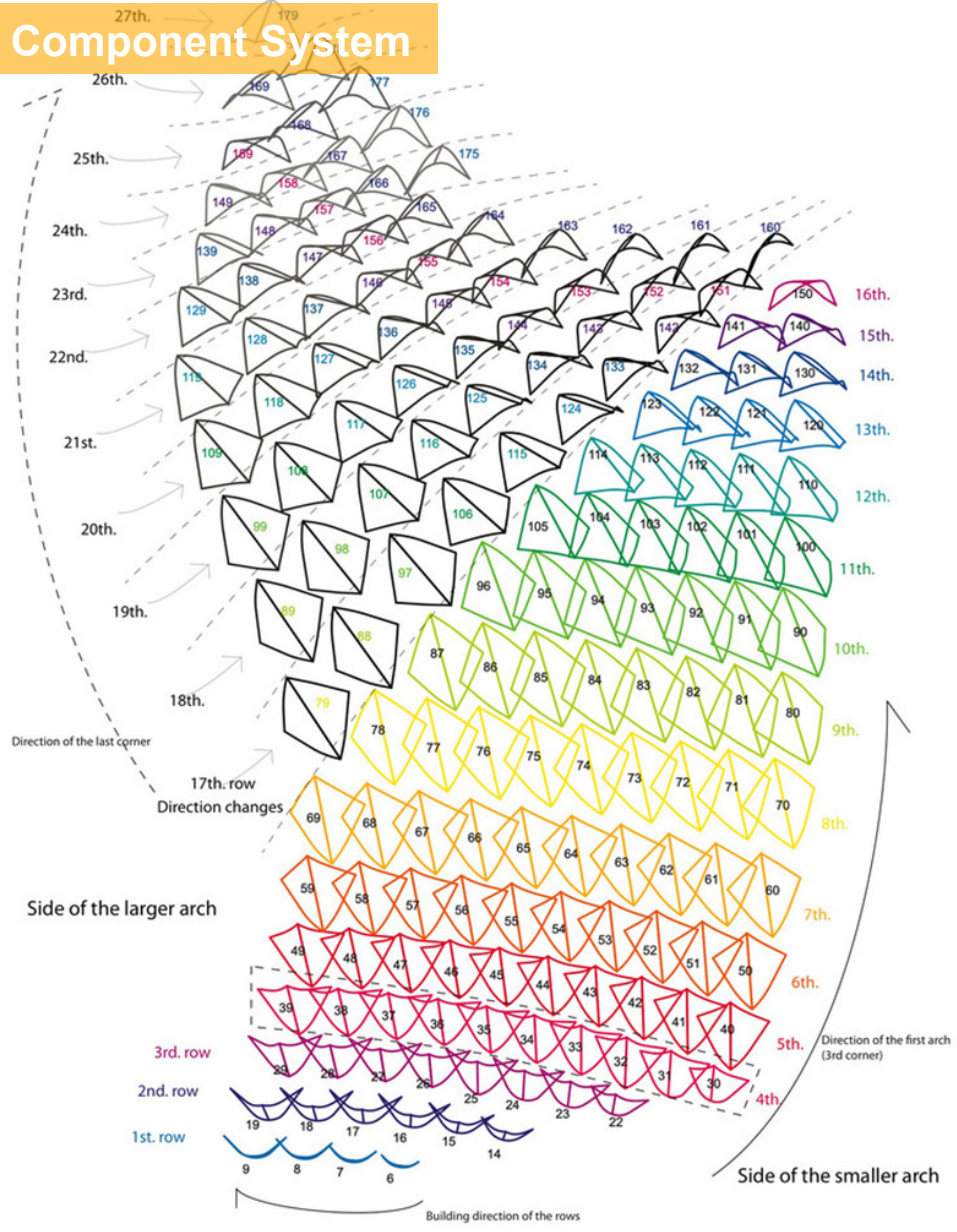


reciprocal frame structure
ETH Zurich, Switzerland, 2012



Dragon Skin Pavilion
Kowloon Park, Hong Kong, 2012

Component System



Dragon Skin Pavilion
Kowloon Park, Hong Kong, 2012

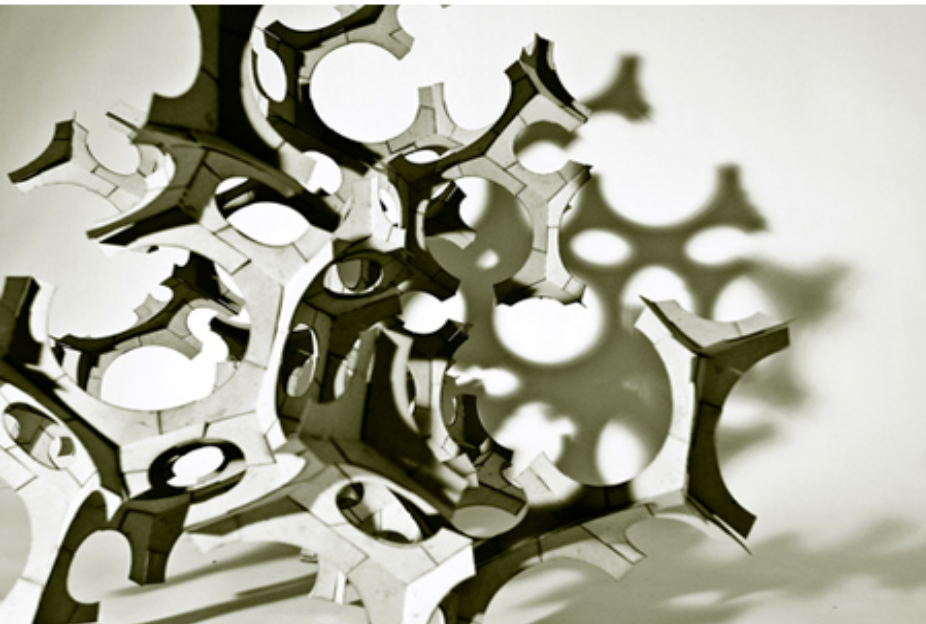
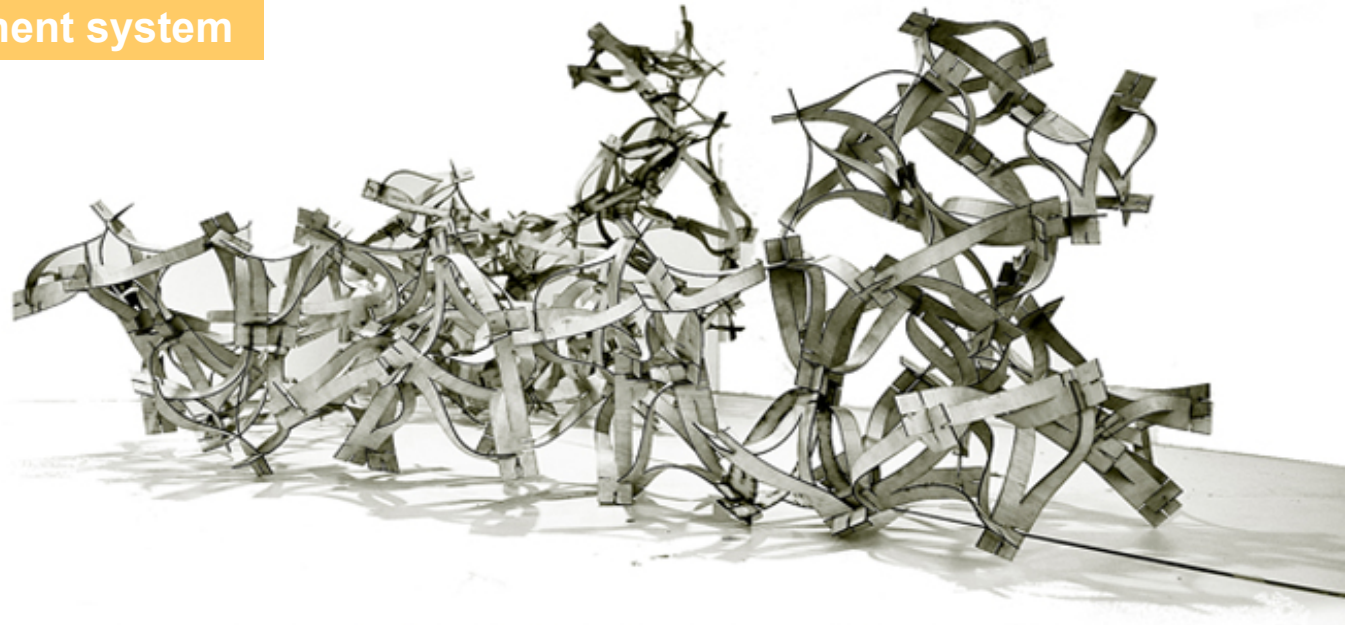
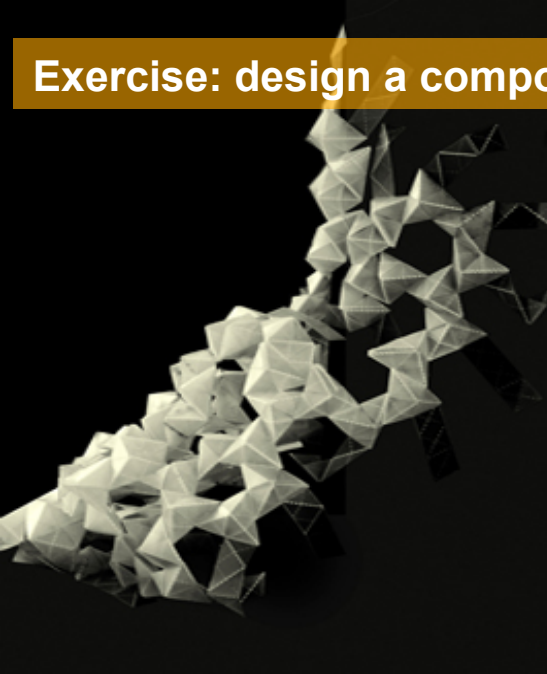


Soma Architects: White Noise
Salzburg, Austria, 2011



Soma Architects: White Noise
Salzburg, Austria, 2011

Exercise: design a component system



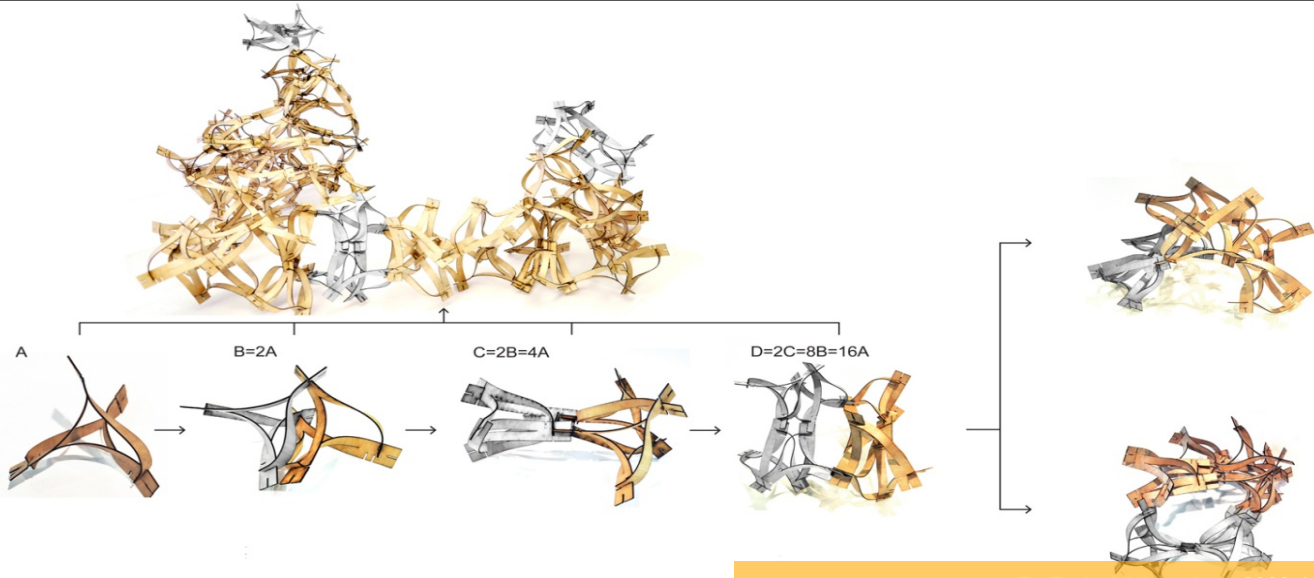
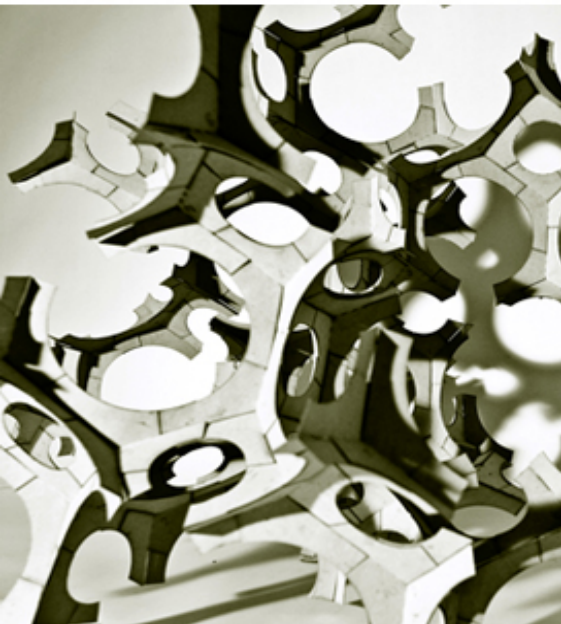
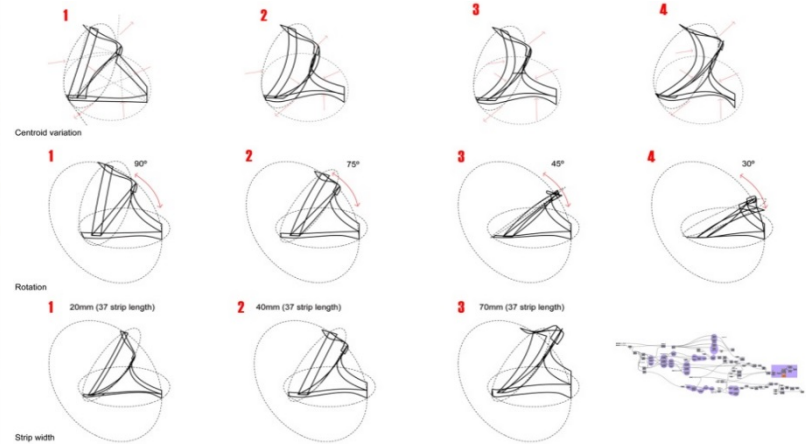
EmTech, AA London, 2009-11

Exercise: design a vault as component system

elements components

neighborhood topology

rules of interaction



EmTech, AA London, 2009-11

JUST DO IT
and enjoy