Slide 1

ARK-E3009 Design of Structures Studio
ARK-E551801 Digital Speculative Urbanism Studio

Toni Kotnik
Professor of Design of Structures

Pia Fricker
Professor of Computational Methodologies in Landscape Architecture and Urbanism

Luka Piškorec
Lecturer in Design of Structures

Kane Borg
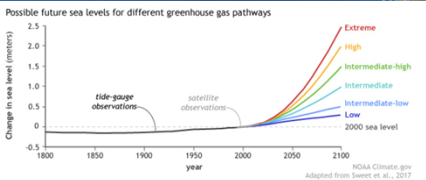PhD Student in Design of Structures

Tina Čerpnjak
Researcher at Design of Structures / Computational Methodologies in Landscape Architecture and Urbanism

A" DS Aalto University Design of Structures   A! CM Aalto University Computational Methodologies for Landscape Architecture and Urbanism

AUTUMN 2021
ARK-E3009 Design of Structures Studio
ARK-E551801 Digital Speculative Urbanism Studio

Performative Patterns of High Density

Sustainable visions between architecture and landscape

Digital design is driven by thinking in structures and systems, translated into pattern of order and their interaction. The studio is an introduction into such design thinking and emphasizes the exploration of spatial organizational pattern in various levels of abstraction and scale through the integration of computational methods and digital workflows. The studio is organized as joint studio between the professorships of Design of Structures and Computational Methodologies in Landscape Architecture and Urbanism and a continuation of a collaboration with the Singapore University of Technology and Design.

The studio in autumn will explore climate mitigation strategies through the study of performative qualities of organizational patterns on various architectural scales. By viewing the city not anymore as a collection of independent objects but rather as a systemic network of relationships the studio will explore new design strategies to engage with the surrounding urban and green systems and transform these concepts into an articulated landscape as new urban typology grounded in social and environmental sustainability. Computational methods and techniques will be developed to study the relation between buildings, the city and landscape and its underlying flows of different data streams like, people, material and culture, urban green. This knowledge will be used to speculate on new types of urban sustainability aiming at the connection of urban and green systems for future cities, taking the city of Porvoo as a test case.

The studio is organized as an experimental design lab. Teaching will be fully digital and exploring a data-driven encounter with urban phenomena. Studio teaching is supported by intense skill building workshops as well as reading & discussion rounds. The course is aiming at the rethinking of fundamentals of contemporary architecture and landscape architecture and can serve as starting point for a thesis research.

Prerequisite: completed Bachelor studies, basic modeling skills in Rhino & basic knowledge of Grasshopper (equivalent to ARK-E2512 Parametric Design) required

Credits: 30 ECTS

participants of the studio will be registered in parallel to the following four courses
ARK-E3009 Design of Structures Studio (12cr), ARK-E2514 Design of Structures Theory (3cr),
ARK-E551801 Digital Speculative Urbanism Studio (12cr), ARK-E551001 Digital Speculative Urbanism Lecture (3cr)

Number of participants: max. 30
Time: teaching period I - II, Tuesday 9h-15h & Thursdays 9h-17h

Teaching team: Prof. Toni Kotnik, Prof. Pia Fricker, Tina Čerpnjak, Luka Piškorec, Kane Borg (all Aalto) and Prof. Carlos Bañon (SUTD)

1

Slide 2

Climate Change Impact

Possible future sea levels for different greenhouse gas pathways

temperature	sea level rise	global warming 1.5°C // 2°C	Global net human-caused
From 1880 to 2012, the average global temperature increased by 0.85°C	2065: 24–30 cm 2100: 40–63 cm	Extreme changes: heatwaves, heavy precipitation > flooding, droughts, tsunamis and tropical cyclones, sea level rise	emissions of CO_2 would need to fall by about 45 percent from 2010 levels by 2030, reaching 'net zero' around 2050.

2

Pia Fricker, Professor of Computational Methodologies
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Climate Change

CO_2 CH_4

Industry 33%   Transportation 28%

humans ↑
2020: 7.6 bil. 2050: 10 bil.

urbanization

≈ 40%

living in cities ↑
2020: 4.2 bil. (55%)
2050: 7.7 bil. (68%)

Built Environment 39%

Masonry
Steel
Glass
Cement

Oil
Coal
Natural gas
Nuclear power
Wind
Solar

Material ←→ production construction ←→ **Energy**

Heating
Cooling
Light

Design

Active Systems
Passive Systems.
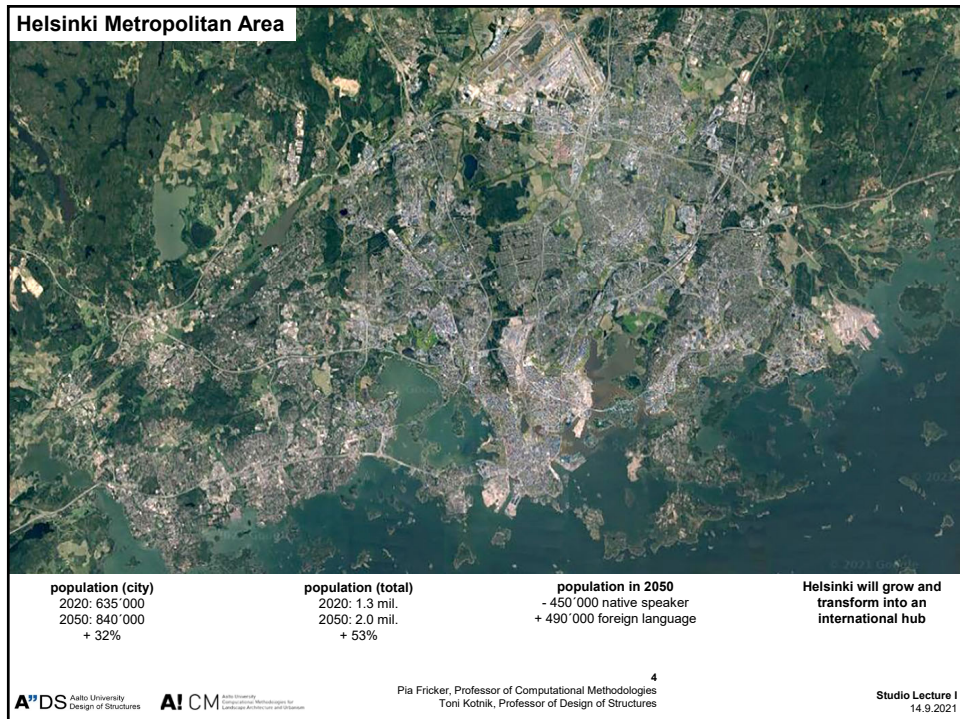Building Configuration

3

Pia Fricker, Professor of Computational Methodologies
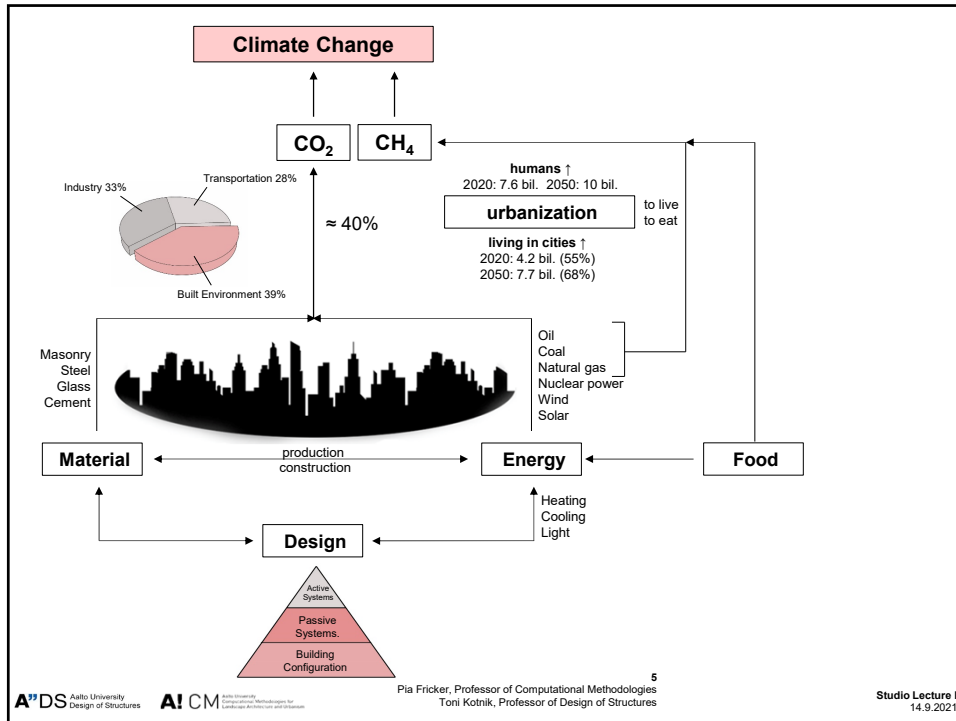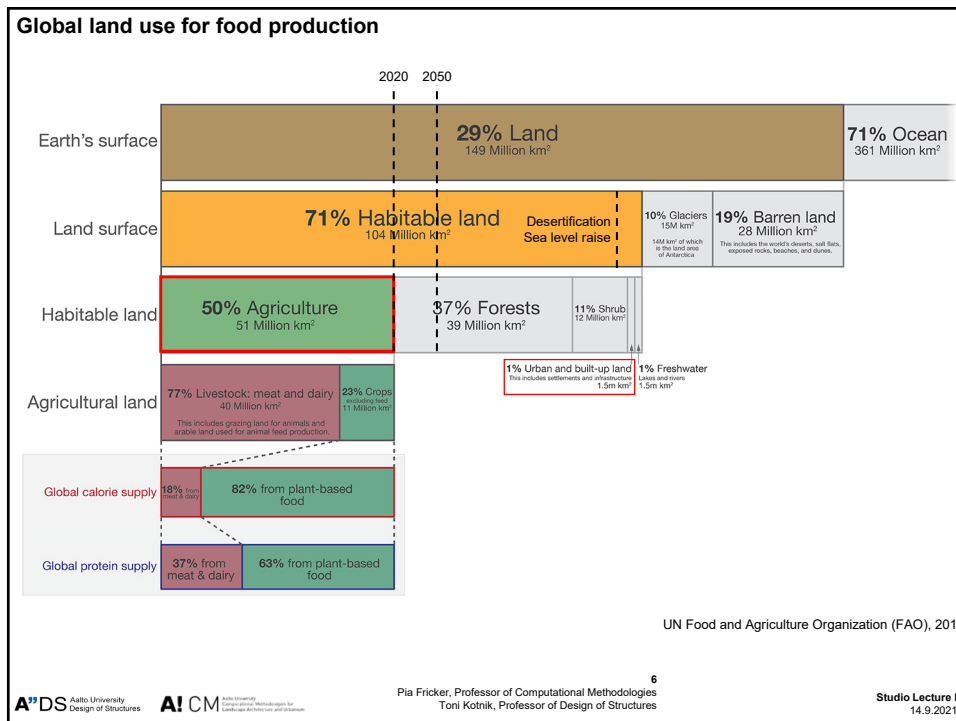Toni Kotnik, Professor of Design of Structures

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Helsinki Metropolitan Area

population (city)	**population (total)**	**population in 2050**	**Helsinki will grow and transform into an international hub**
2020: 635´000	2020: 1.3 mil.	- 450´000 native speaker	
2050: 840´000	2050: 2.0 mil.	+ 490´000 foreign language	
+ 32%	+ 53%		

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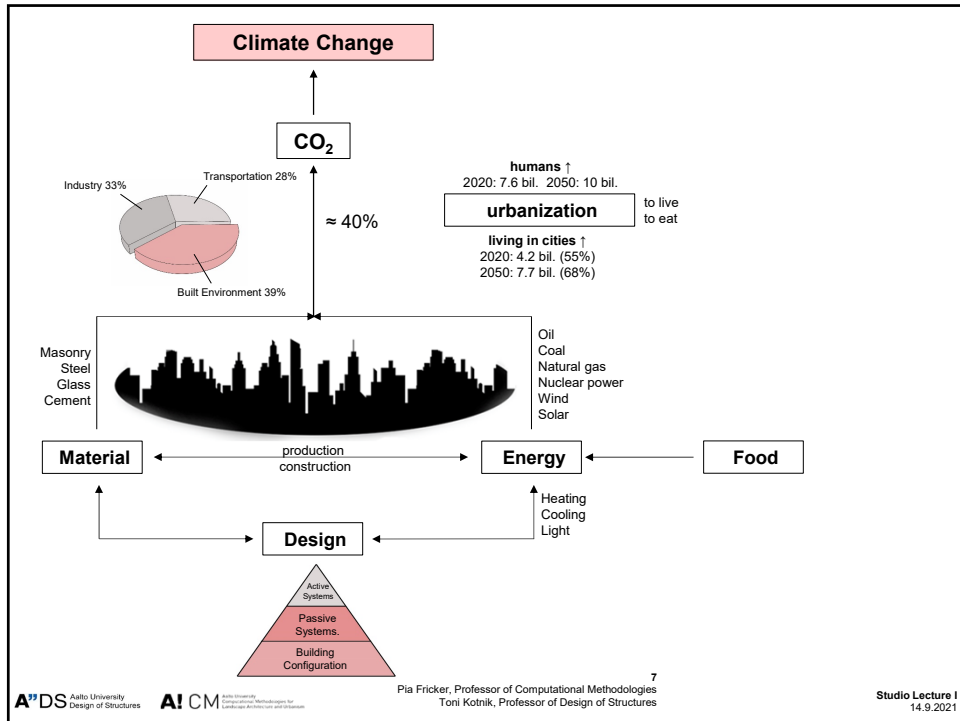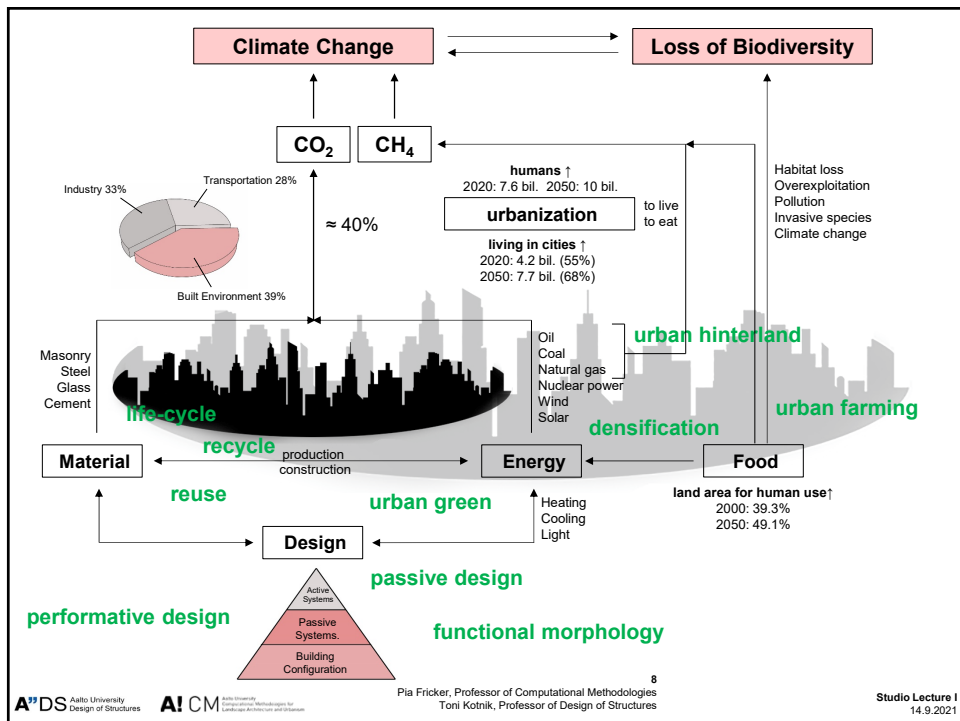
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Slide 5

Climate Change

CO_2 | CH_4

Industry 33%
Transportation 28%
Built Environment 39%

≈ 40%

humans ↑
2020: 7.6 bil. 2050: 10 bil.

urbanization   to live / to eat

living in cities ↑
2020: 4.2 bil. (55%)
2050: 7.7 bil. (68%)

Masonry
Steel
Glass
Cement

Oil
Coal
Natural gas
Nuclear power
Wind
Solar

Material ← production / construction → **Energy** ← **Food**

Heating
Cooling
Light

Design

Active Systems
Passive Systems.
Building Configuration

5
Pia Fricker, Professor of Computational Methodologies
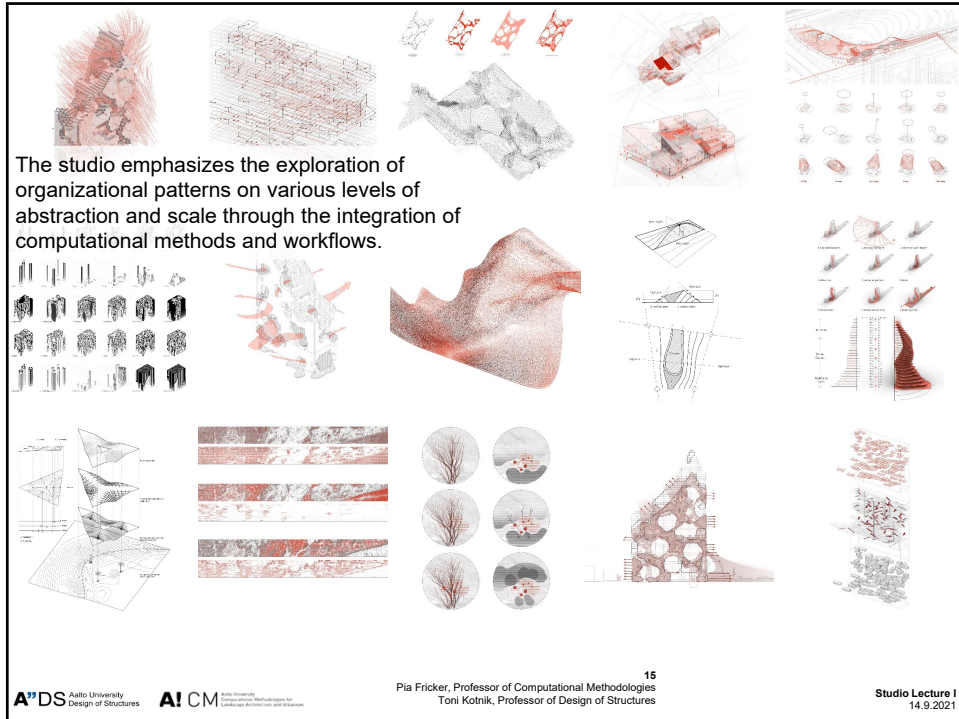Toni Kotnik, Professor of Design of Structures

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Slide 6

Global land use for food production

2020 2050

Earth's surface — **29% Land** 149 Million km² — **71% Ocean** 361 Million km²

Land surface — **71% Habitable land** 104 Million km² — Desertification Sea level raise — **10% Glaciers** 15M km² (14M km² of which is the land area of Antarctica) — **19% Barren land** 28 Million km² (This includes the world's deserts, salt flats, exposed rocks, beaches, and dunes.)

Habitable land — **50% Agriculture** 51 Million km² — **37% Forests** 39 Million km² — **11% Shrub** 12 Million km²

1% Urban and built-up land This includes settlements and infrastructure 1.5m km²   **1% Freshwater** Lakes and rivers 1.5m km²

Agricultural land — **77% Livestock: meat and dairy** 40 Million km² This includes grazing land for animals and arable land used for animal feed production. — **23% Crops** excluding feed 11 Million km²

Global calorie supply — **18%** from meat & dairy — **82% from plant-based food**

Global protein supply — **37% from meat & dairy** — **63% from plant-based food**

UN Food and Agriculture Organization (FAO), 2019

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Slide 7

Climate Change

CO$_2$

Industry 33%
Transportation 28%
Built Environment 39%

$\approx 40\%$

humans ↑
2020: 7.6 bil. 2050: 10 bil.

urbanization   to live / to eat

living in cities ↑
2020: 4.2 bil. (55%)
2050: 7.7 bil. (68%)

Masonry
Steel
Glass
Cement

Oil
Coal
Natural gas
Nuclear power
Wind
Solar

Material ← production construction → **Energy** ← **Food**

Heating
Cooling
Light

Design

Active Systems
Passive Systems.
Building Configuration

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Slide 8

Climate Change ← → **Loss of Biodiversity**

CO$_2$ **CH$_4$**

Industry 33%
Transportation 28%
Built Environment 39%

$\approx 40\%$

humans ↑
2020: 7.6 bil. 2050: 10 bil.

urbanization   to live / to eat

living in cities ↑
2020: 4.2 bil. (55%)
2050: 7.7 bil. (68%)

Habitat loss
Overexploitation
Pollution
Invasive species
Climate change

urban hinterland

Masonry
Steel
Glass
Cement

Oil
Coal
Natural gas
Nuclear power
Wind
Solar

life-cycle

urban farming

recycle

densification

Material ← production construction → **Energy** ← **Food**

reuse

urban green

Heating
Cooling
Light

land area for human use ↑
2000: 39.3%
2050: 49.1%

Design

passive design

performative design

Active Systems
Passive Systems.
Building Configuration

functional morphology

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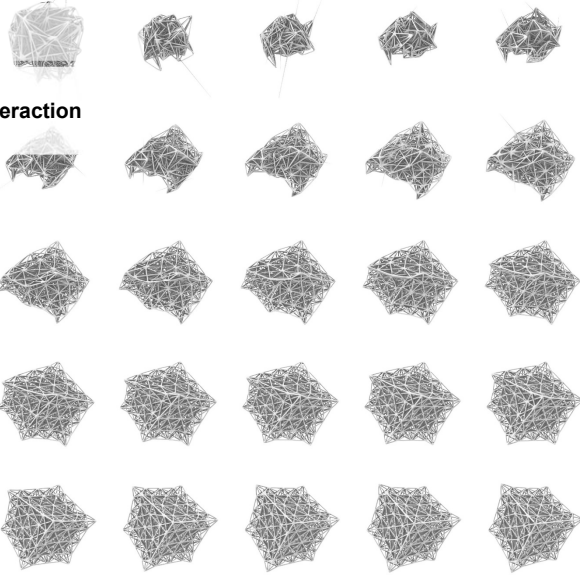
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Liam Young: Planet City, 2021

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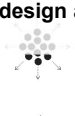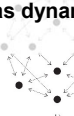Can an increase in quality of life be maintained as population densities increase? What role will nature, in the widest sense, play in such an increase in density?

convergence of architecture and landscape

The studio is a design-oriented reflection on 'new nature': a mix of technology and the natural, emphasizing nature's make-ability and artificiality.

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convergence of architecture and landscape

Stefano Boeri: Bosco Verticale
Milano, Italy, 2014

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convergence of architecture and landscape

Moshe Safdie: Jewel Changi Airport
Singapore, 2019

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What is a landscape?

Super Trees, Gardens By the Bay
Singapore, 2012

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Can we grow a building?

Living Root Bridge. Meghalaya, India

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The studio emphasizes the exploration of organizational patterns on various levels of abstraction and scale through the integration of computational methods and workflows.
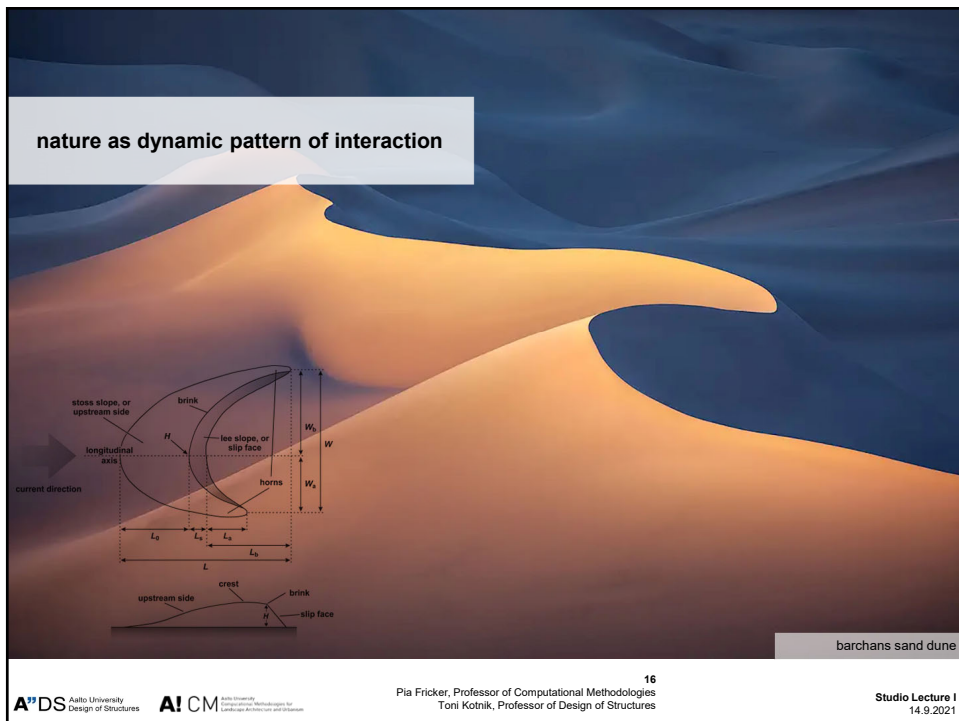
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nature as dynamic pattern of interaction

barchans sand dune

16
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Toni Kotnik, Professor of Design of Structures
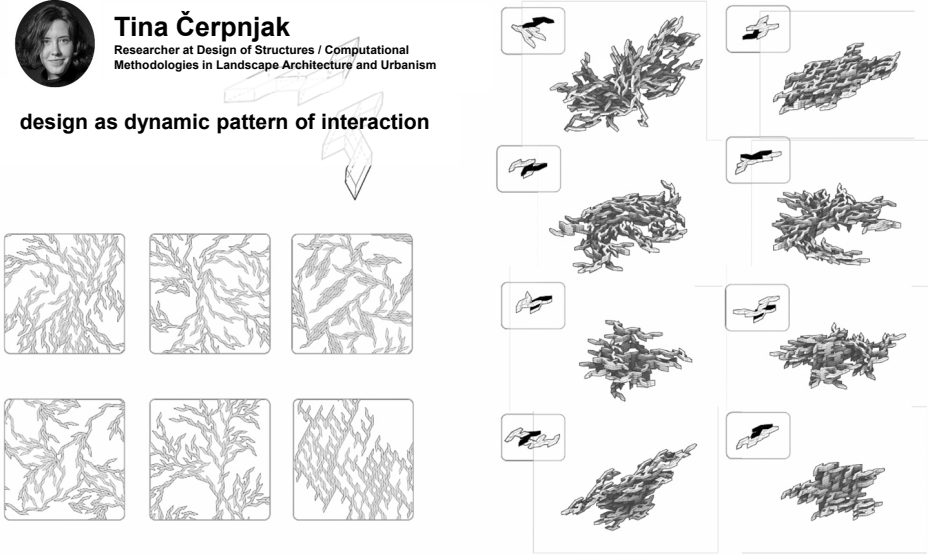
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Tina Čerpnjak
Researcher at Design of Structures / Computational Methodologies in Landscape Architecture and Urbanism

design as dynamic pattern of interaction

Tina Čerpnjak: Formal diffusions. Agent-based-systems in the context of architectural space making, Master Thesis, 2021

17

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Toni Kotnik, Professor of Design of Structures
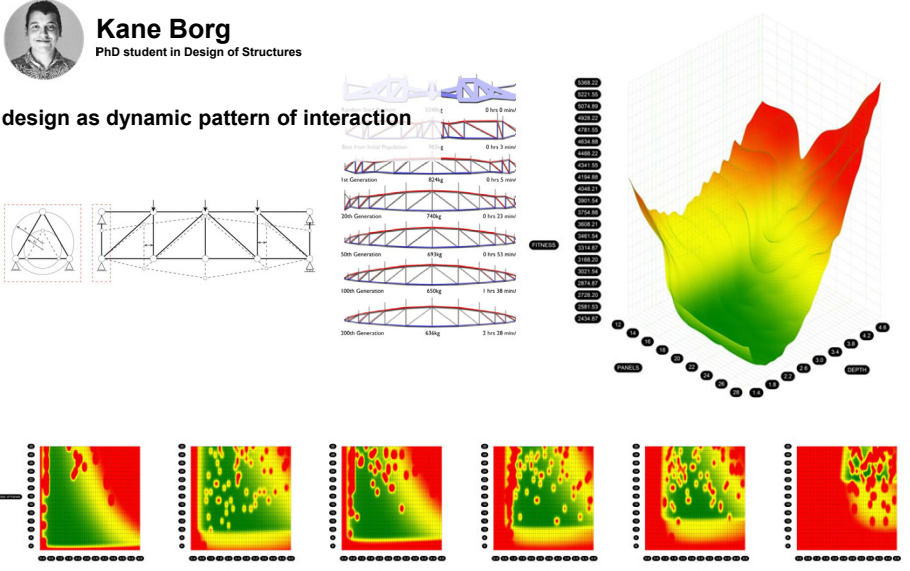
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Kane Borg
PhD student in Design of Structures

design as dynamic pattern of interaction
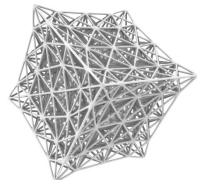
Kane Borg: Evolutionary optimisation techniques applied to structural trusses, Master Thesis, 2017

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Luka Piškorec : Explorations in Lattice Algebra

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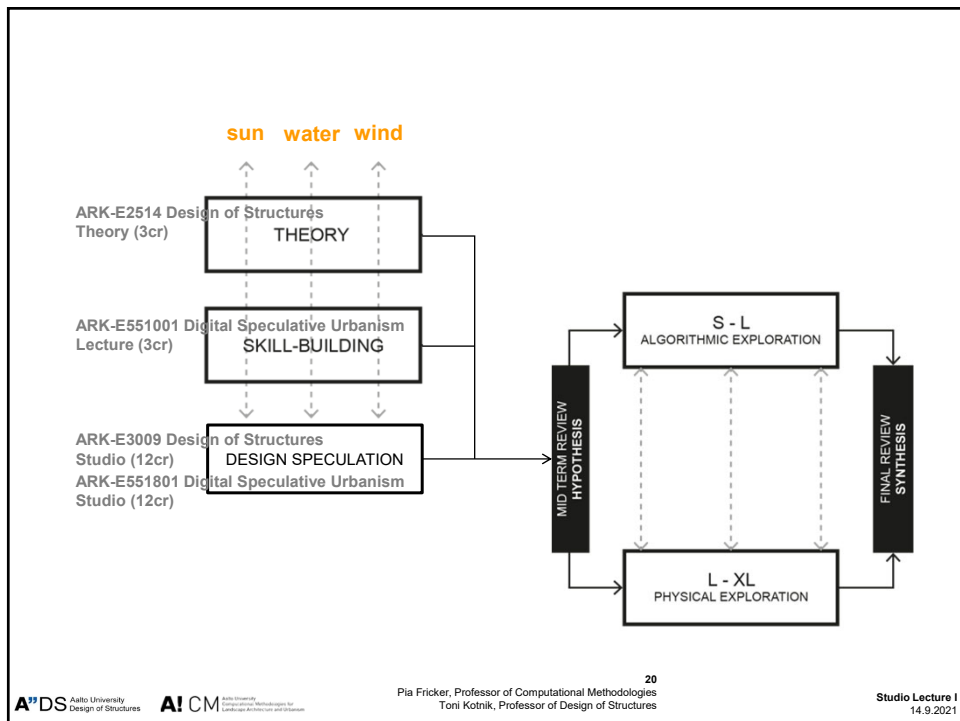
20

An element, we take it, is a body into which other bodies may be analysed, present in them potentially or in actuality (which of these, is still disputable), and not itself divisible into bodies different in form. That, or something like it, is what all men in every case mean by element.

Aristotle: On the Heavens

Giuseppe Arcimboldo: The four elements, 1566
allegories of the antique four elements about the creation
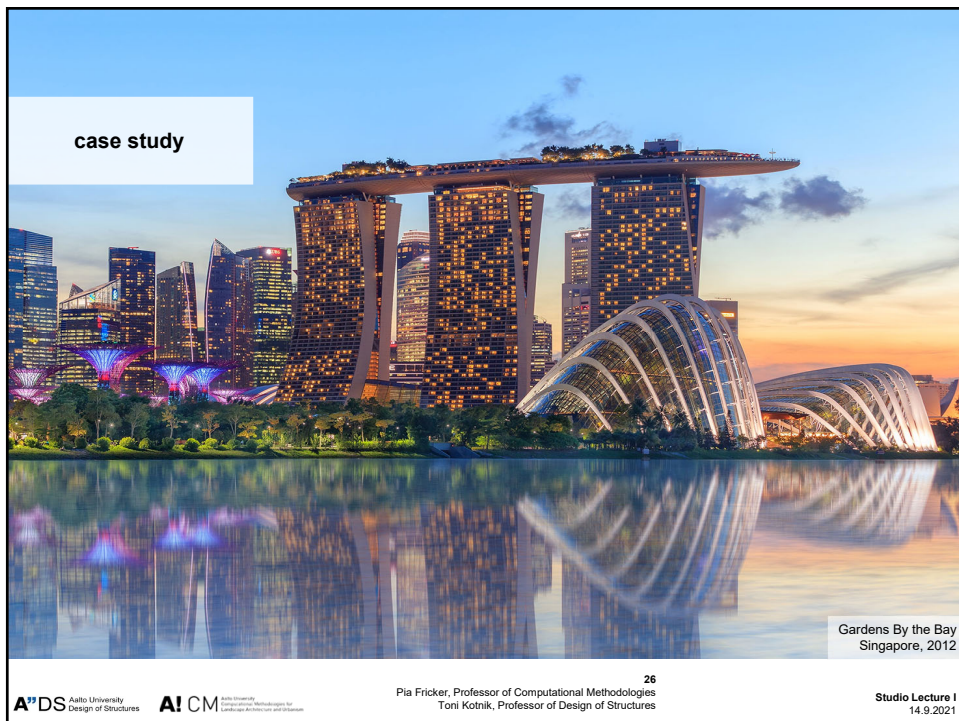of harmony from chaos by the careful arrangement

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Pia Fricker, Professor of Computational Methodologies
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evaporative/adiabatic cooling

evaporative cooling as principle for wind towers
in traditional Iranian architecture
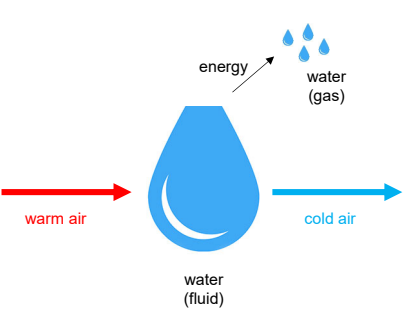
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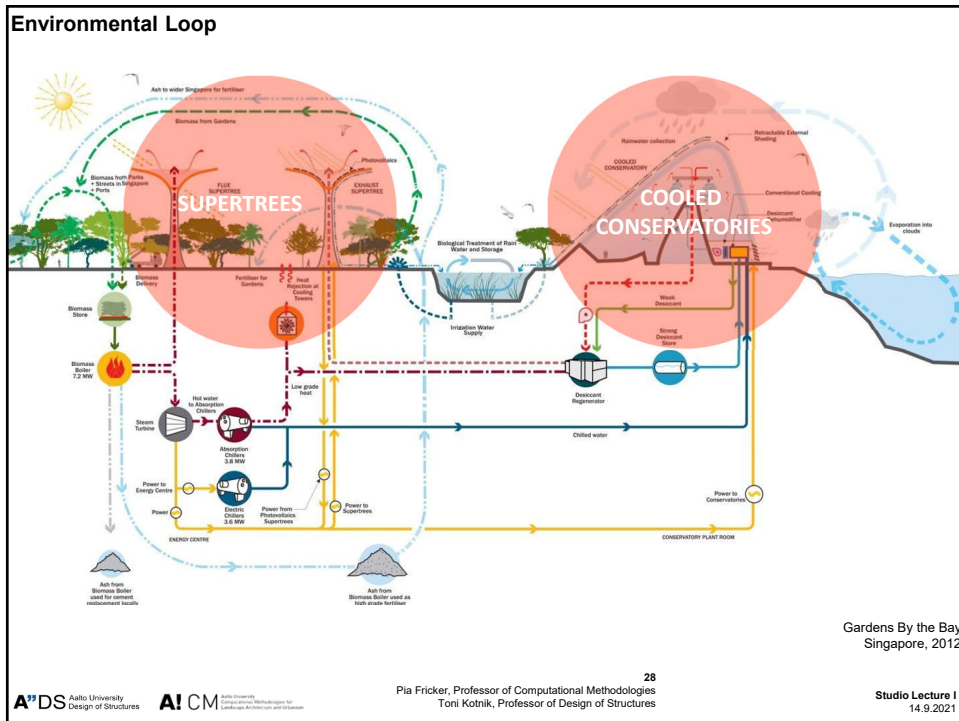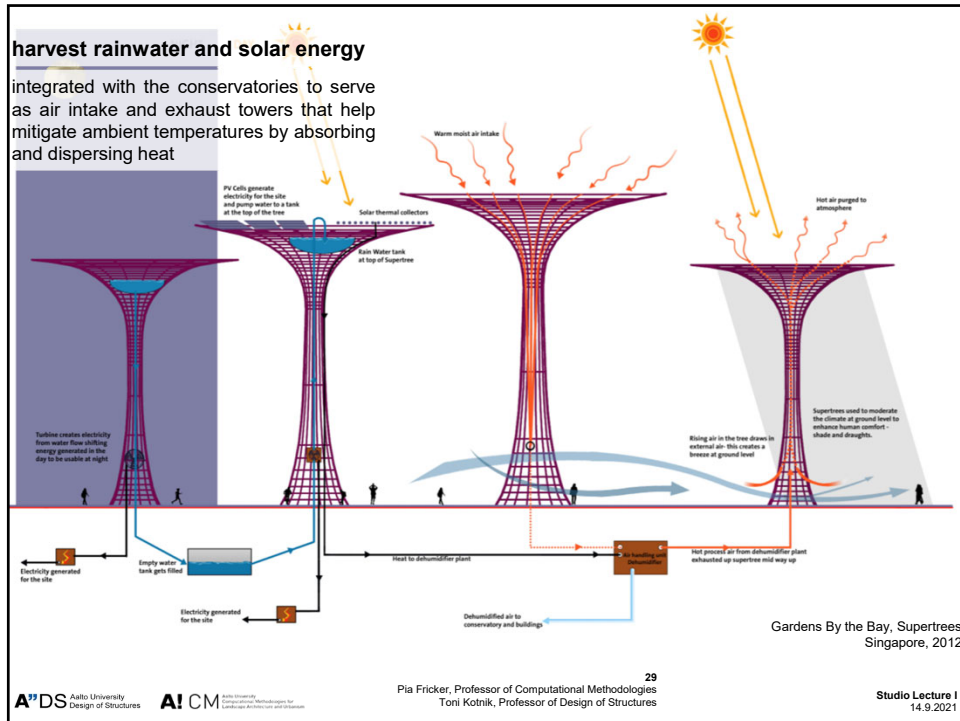evaporative/adiabatic cooling

energy
water (gas)

warm air

cold air

water (fluid)

evaporative cooling as principle for wind towers in traditional Iranian architecture

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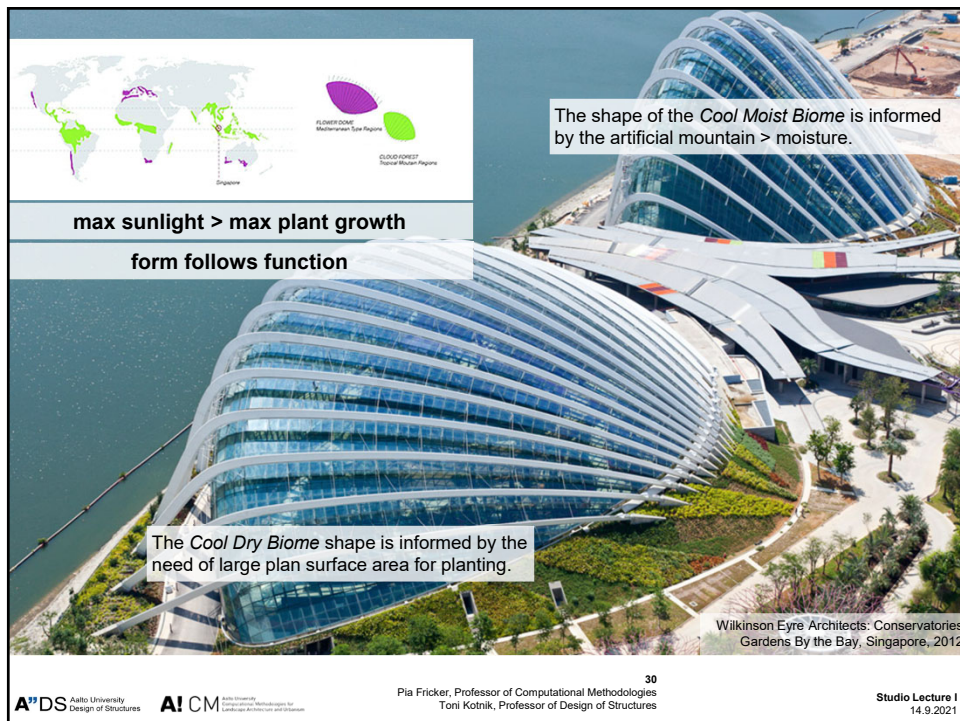Toni Kotnik, Professor of Design of Structures

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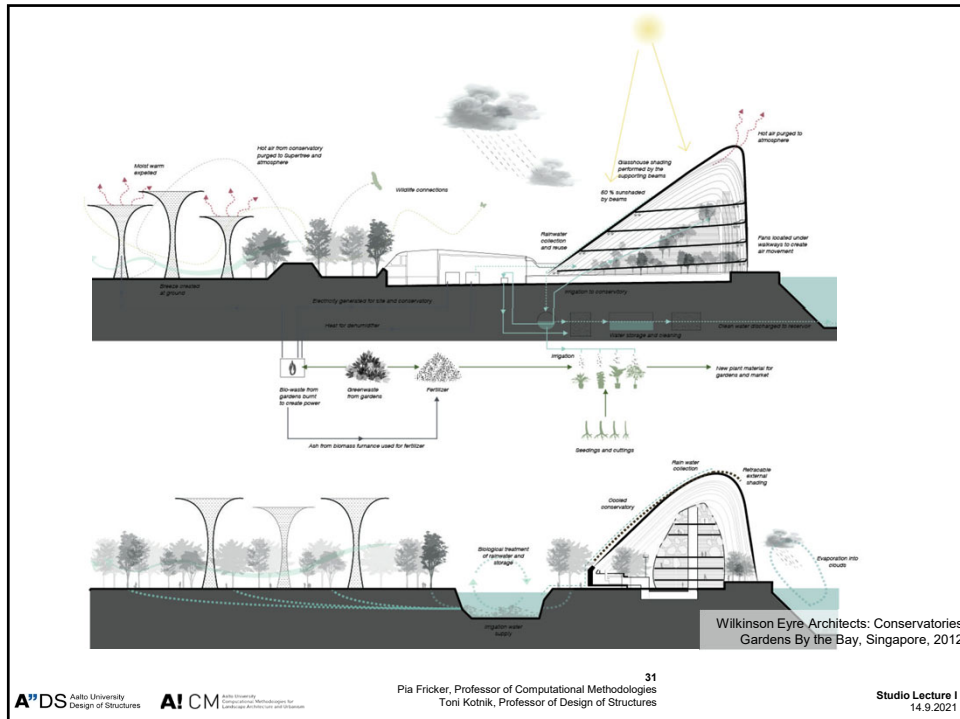Palacio de Comares, Alhambra, Granada, Spain

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from
nature as dynamic pattern of interaction
to
design as dynamic pattern of interaction

Super Trees, Gardens By the Bay
Singapore, 2012

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case study

Gardens By the Bay
Singapore, 2012

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Gardens By the Bay
Singapore, 2012

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Environmental Loop

Gardens By the Bay
Singapore, 2012

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harvest rainwater and solar energy

integrated with the conservatories to serve as air intake and exhaust towers that help mitigate ambient temperatures by absorbing and dispersing heat

Gardens By the Bay, Supertrees
Singapore, 2012

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The shape of the *Cool Moist Biome* is informed by the artificial mountain > moisture.

max sunlight > max plant growth

form follows function

The *Cool Dry Biome* shape is informed by the need of large plan surface area for planting.

Wilkinson Eyre Architects: Conservatories
Gardens By the Bay, Singapore, 2012

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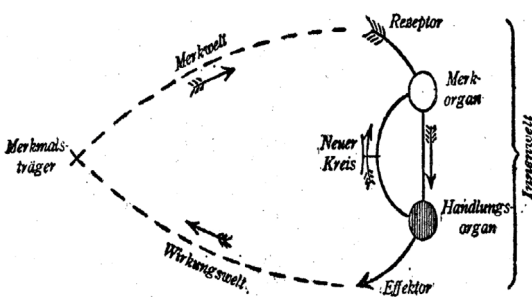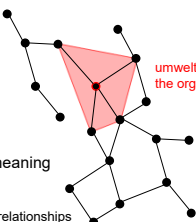Wilkinson Eyre Architects: Conservatories
Gardens By the Bay, Singapore, 2012

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Flower Dome section, also known as the cool-dry biome. This conservatory is maintained at a
temperature and humidity suitable for growing European plants (25°C and 65% relative maximum
humidity during the day). Air is introduced for cooling at ground level through integrated slots in
the internal structures. Liquid desiccants are used to remove moisture from the air prior
to cooling by chilled water. The desiccants are regenerated using a combination
of waste heat from a biomass CHP system and solar energy. Additional
radiant cooling is incorporated in pathways to absorb incoming
solar radiation and return air is drawn from high levels in
the space back to the plant in the basement

1. Return air duct to reuse cold air
2. Hot air purged to outside via openings in facade
3. Active shading on exterior of facade
4. Displacement ventilation integrated to planting areas
5. Air intake
6. Air handling plant rooms contain both supply and extract
   air handling units

7. Underfloor supply duct
8. Fabric cooling to all hard flooring
9. Displacement grilles at regular intervals
10. Motorised mounted impulse fans to ensure air velocity is 0.5 - 1m/s
11. To energy centre
12. Desiccant conditioner to dehumidify air before reaching AHU

Wilkinson Eyre Architects: Conservatories
Gardens By the Bay, Singapore, 2012

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Wilkinson Eyre Architects: Conservatories
Gardens By the Bay, Singapore, 2012

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evaporative/adiabatic cooling

de-humidified air in dome

cooling of occupied zone only

minimizing of solar heat gain

plants for shading

Space conditioning relies on both passive and active technologies. Optimizing the building envelope included the specification of solar protective glass (g-value 0.35) with low-emissivity properties, using the internal flora to create shading and natural stratification of temperature, keeping the occupied zones naturally comfortable for visitors. The high amount of daylight (daylight transmittance 0.7) assures growth and flowering of the respective plants. Space conditioning is performed through activation of the radiant concrete floor, whereas fresh air is provided through mechanical yet efficient displacement ventilation - at occupant level only.

Wilkinson Eyre Architects: Conservatories
Gardens By the Bay, Singapore, 2012

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Wilkinson Eyre Architects: Conservatories
Gardens By the Bay, Singapore, 2012

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create Mediterranean zone in tropical zone

evaporative/adiabatic cooling

de-humidified air in dome

cooling of occupied zone only

minimizing of solar heat gain

plants for shading

adapt to arid zone

evaporative/adiabatic cooling

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Earthrise, 24 Dec 1968
William Anders, Apolllo 8

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Umwelt
concept of mutual benefit

If the flower were not bee-like
And the bee were not flower-like
The unison could never be successful

Ueküll: The theory of meaning

environment as network of relationships

umwelt of
the organism

Jakob Johann von Uexküll
1864-1944

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Modern Architecture

environmental concept

The roof gardens. The flat roof demands in the first place systematic utilization for domestic purposes: roof terrace, roof garden. On the other hand, the reinforced concrete demands protection against changing temperatures. Over-activity on the part of the reinforced concrete is prevented by the maintenance of a constant humidity on the roof concrete. The roof terrace satisfies both demands (a rain-dampened layer of sand covered with concrete slabs with lawns in the interstices; the earth of the flowerbeds in direct contact with the layer of sand). … The roof gardens will display highly luxuriant vegetation. Shrubs and even small trees up to 3 or 4 metres tall can be planted. In this way the roof garden will become the most favoured place in the building. In general, roof gardens mean to a city the recovery of all the built-up area.

Le Corbusier: Five Points Towards a New Architecture, 1924

Le Corbusier: Villa Savoye Poissy, France, 1931

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Modern Architecture

Le Corbusier: Villa Savoye Poissy, France, 1931

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Modern Architecture

environment as the other

Every country builds its houses in response to its climate. At this moment of general diffusion, of international scientific techniques, I propose: only one house for all countries, the house of exact breathing. The Russian house, the Parisian, at Suez or in Buenos Aires, the luxury liner crossing the Equator will be hermetically sealed. In winter it is warm inside, in summer cool, which means that at all times there is clean air inside at exactly 18°. The house is sealed fast! No dust can enter it. Neither flies nor mosquitos. No noise!"

Le Corbusier, lecture in Buenos Aires, 1929

Le Corbusier: UNO Headquarter,
New York, USA, 1952

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Pia Fricker, Professor of Computational Methodologies
Toni Kotnik, Professor of Design of Structures

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Umweltecture

architecture as part of the umwelt

architecture as benefit for nature

architecture for the anthropocene

man is the dominant geo-physical impact on earth and with this comes the responsibility for planet earth

the anthropocene, the time of man, implies a thinking beyond the human, the post-human

Earthrise, 24 Dec 1968
William Anders, Apolllo 8

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Pia Fricker, Professor of Computational Methodologies
Toni Kotnik, Professor of Design of Structures

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Assignment #1: SUN - WIND - WATER

Task: Explore the physical behaviour of your assigned phenomena: sun, wind or water. Each of these phenomena interacts with the field of architecture through different forms, behaviour and stages of matter.
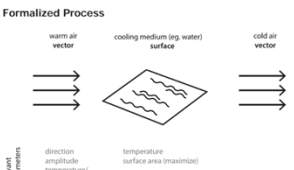
Study at least 3 particular physical articulation of your phenomena and extract the most relevant knowledge onto the knowledge template. Enrich the explanation of the underlying physical principle through diagrams and relevant examples.
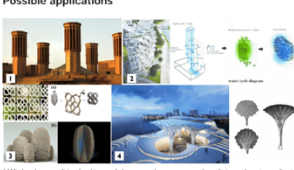
Your findings are the starting point for further research and discussion into those conditions and the computational possibilities to modify and to manipulate matter as a generative design component.

Format: Group work
Deadline: Monday 20.09.2021/18.00h, MyCourses

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