ARK-E3020 Sustainable Design Principles

Computational Cycle: Found Form

Toni Kotnik

Professor of Design of Structures

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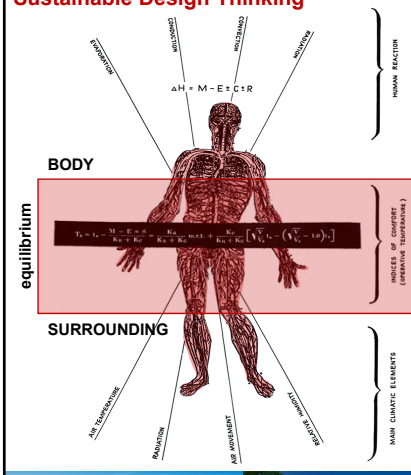
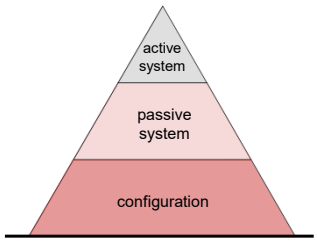
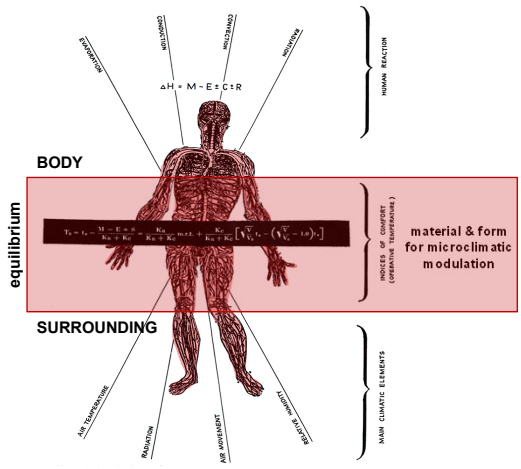
Sustainable Design Thinking





Science of Energy
ENG
ARCH

2



"Our need for protection is not any different from that of other species. Animals have always had enemies, in particular the climate, and other species seeking to prey upon them."

Mike Hansell
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Oxford University Press, 2009

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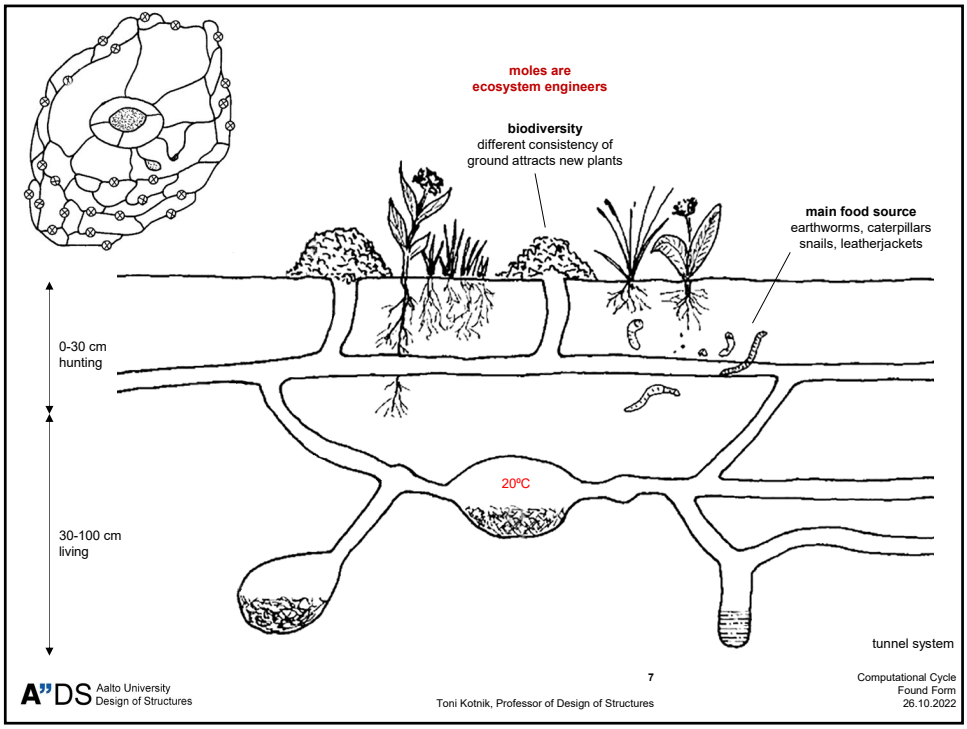
moles are
ecosystem engineers
biodiversity
different consistency of
ground attracts new plants
main food source
earthworms, caterpillars
snails, leatherjackets
0-30 cm
hunting
20ºC
30-100 cm
living
tunnel system
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material: tree trunks
construction: timber-framework
www.planet-wissen.de
Beaver
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Computational Cycle
Found Form
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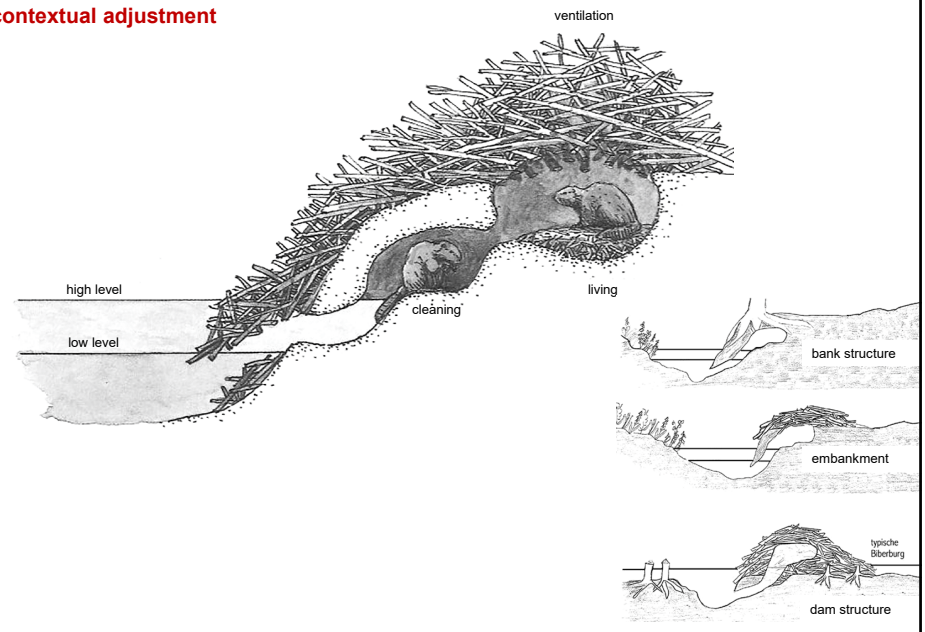
contextual adjustment



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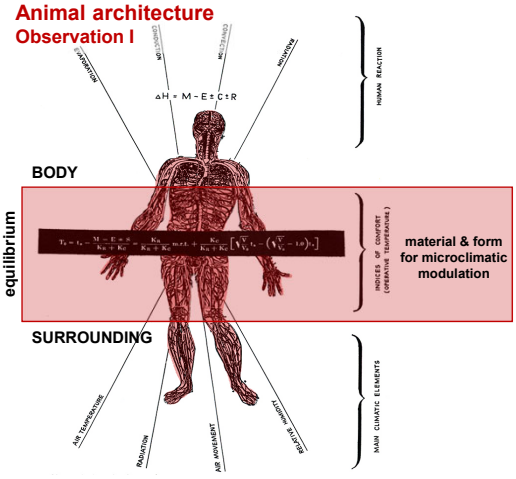
Animal architecture
Observation I



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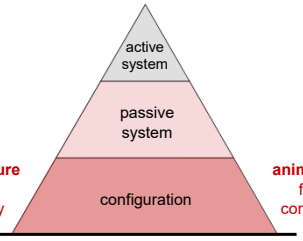

human architecture
many materials
simple geometry

animal architecture
few materials
complex geometry

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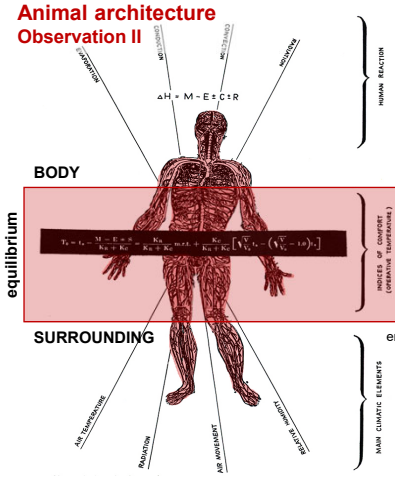
Animal architecture
Observation II



feedback loop

every interventions does not only react to its surrounding but also acts upon it!

architecture is ecosystem engineering

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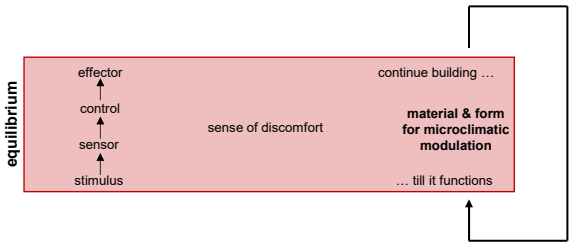
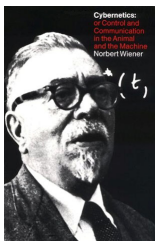
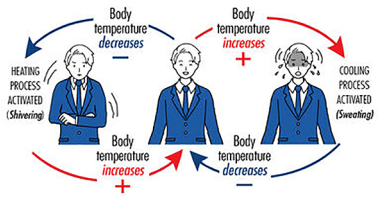
A **negative feedback** loop is a reaction that causes a decrease in function. It occurs in response to some kind of stimulus. Often, it causes the output of a system to be lessened; so, the feedback tends to stabilize the system.



feedback loop



Norbert Wiener: *Cybernetics or Control and Communication in the Animal and the Machine*, 1948



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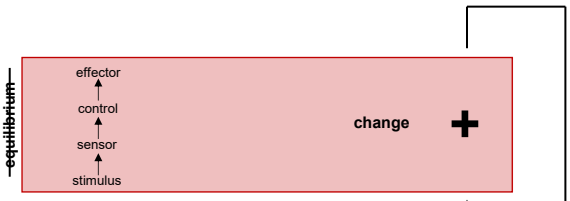
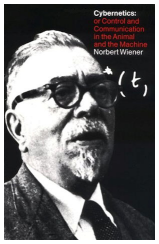
A **positive feedback** loop is a reaction that causes an increase in function. It occurs in response to some kind of stimulus and causes the output of a system to be enhanced; so, the feedback tends to exacerbate small disturbances.





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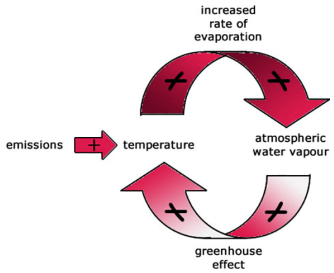

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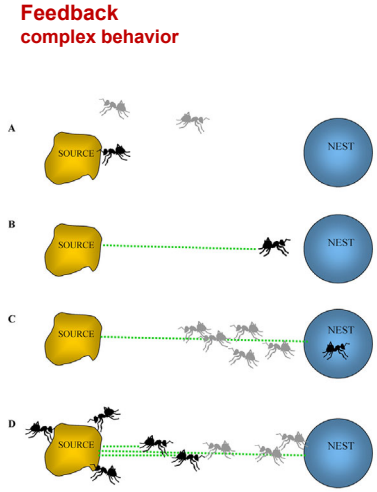
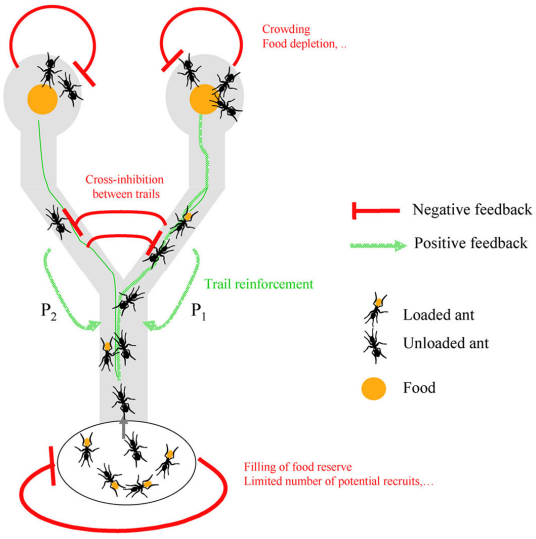
Feedback
complex behavior





Detrain, C & Deneubourg, JL: *Self-organized structures in a superorganism: do ants "behave" like molecules?*, Physics of Life Reviews, 3 (2006), 162-187

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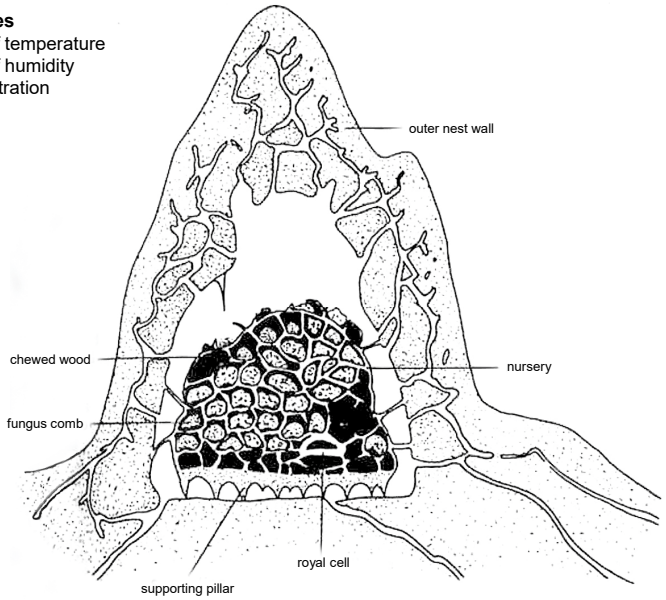
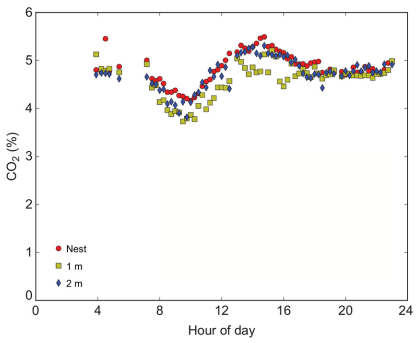
three challenges
- regulation of temperature
- regulation of humidity
- CO_2 concentration



termite mound of *Macrotermes michaelseni*

21

three challenges
- regulation of temperature
- regulation of humidity
- CO_2 concentration



termite mound of *Macrotermes michaelseni*

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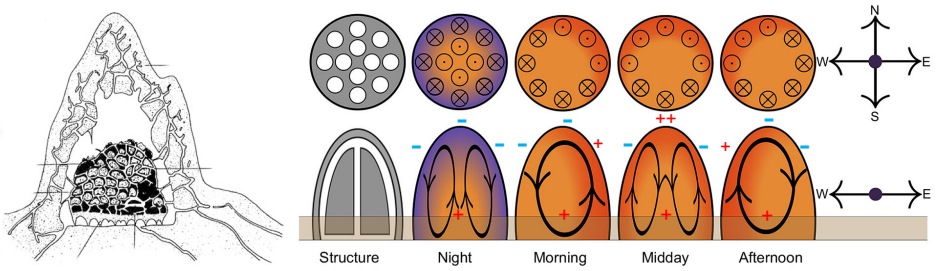
convection cell following oscillating thermal schedule

- temperature in nest is around 30ºC ± 2 ºC the whole day
- CO_2 concentration stable due to continues exchange of air



schematic airflow in termite mound

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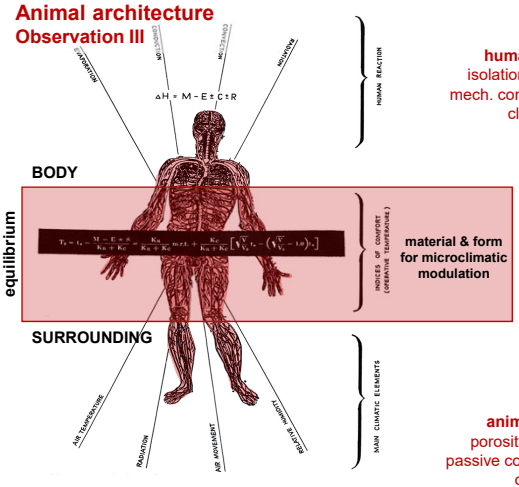
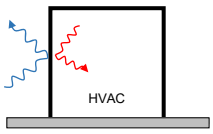
Animal architecture
Observation III



human architecture
isolation between out & in
mech. control of indoor climate
closed system



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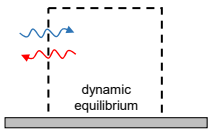
animal architecture
porosity between out & in
passive control of indoor climate
open system



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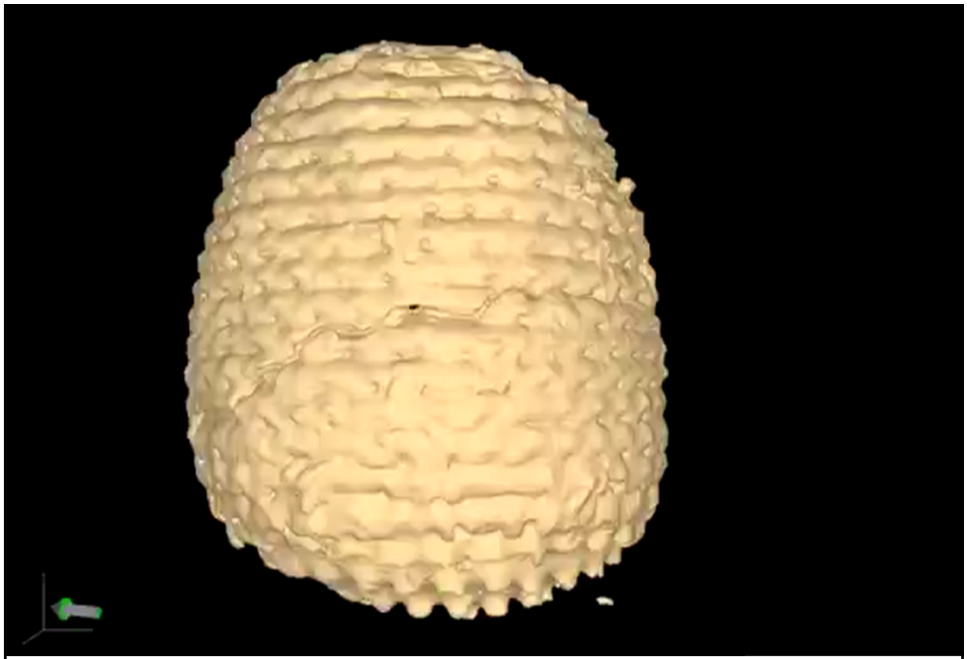

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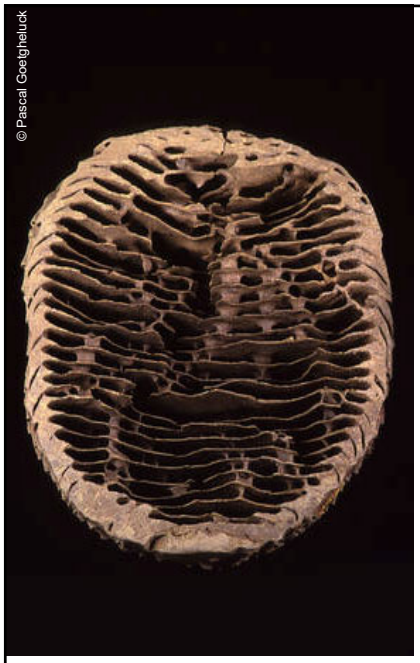

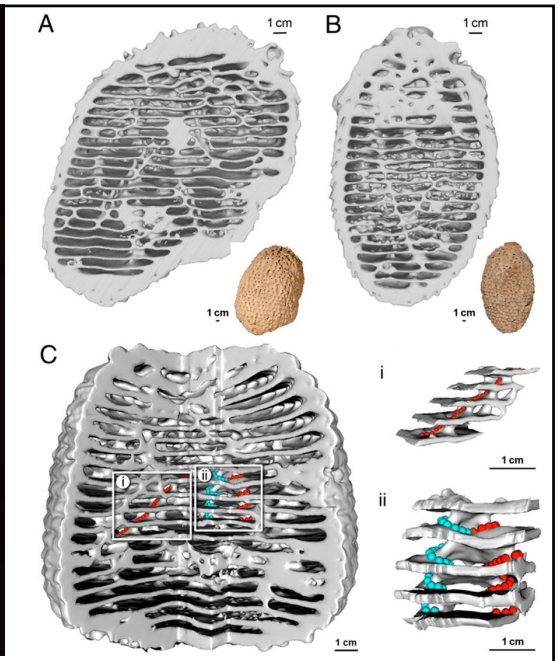

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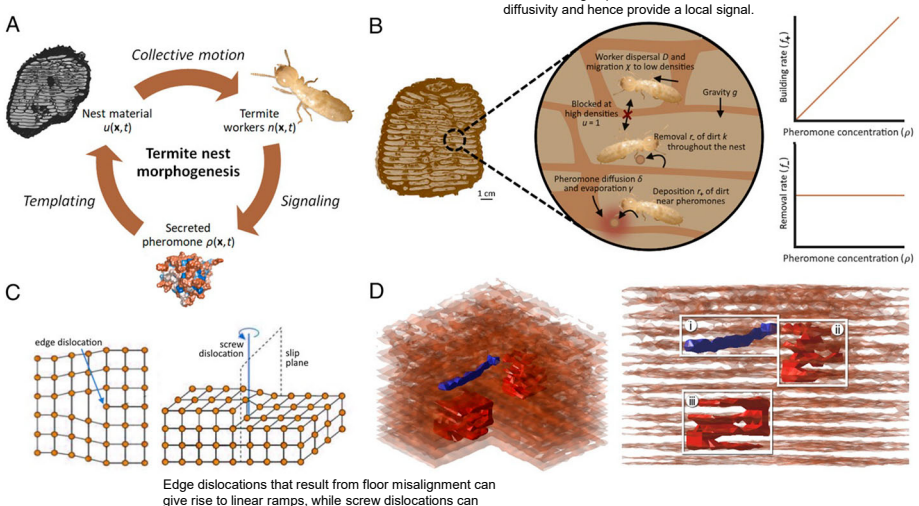
development of architecture out of interaction of

- nest material density
- termite worker density
- pheromone concentration

Termite workers migrate preferentially to low-density regions and cannot travel through very high-density regions. Workers remove dirt throughout the nest but are more likely to deposit dirt near pheromones which they release during deposition. Pheromones are assumed to have a low diffusivity and hence provide a local signal.



Edge dislocations that result from floor misalignment can give rise to linear ramps, while screw dislocations can lead to helicoidal ramps that pivot about a slip plane.

modelling of spatiotemporal dynamics *of Aicotermes lamani*

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development of architecture out of interaction of

- nest material density
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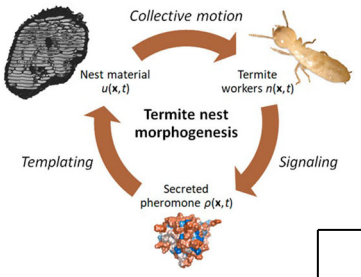
A



dirt to constitute the nest, termite workers to shape the nest, and secreted pheromone to mark active regions of the nest.

feedback loop

- material property
- behavior (as simple rules)
- environmental information

modelling of spatiotemporal dynamics *of Aicotermes lamani*

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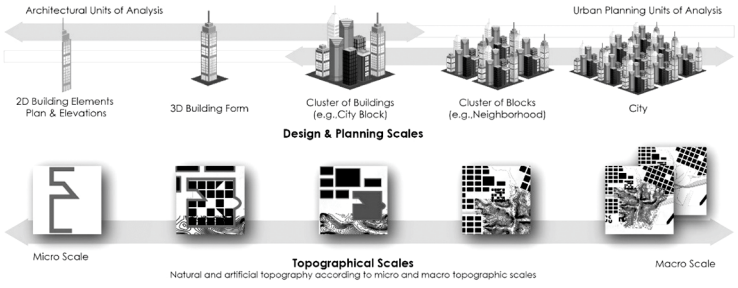
Animal architecture
Observation IV

from global to local ← define form

human design
top-down process



animal design
bottom-up process

find form → from local to global

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Animal architecture
view from the outside

Observation I

from material multiplicity to geometric complexity
materials are expensive, form is cheap

Observation II

architecture is ecosystem engineering
architecture is prosthetic nature

Observation III

from static isolation to dynamic porosity
architecture as an open system of fluid exchange

Observation IV

from top-down control to bottom-up process
architecture as adaptive generation to environmental conditions