Algorithmic Sustainable Design: The Future of Architectural Theory.

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Lecture 6
6.1. Alexander's 15 fundamental properties
6.2. Three laws of architecture

6.1. Alexander's fifteen fundamental properties

Background

- The preceding lectures all build up to the fifteen fundamental properties
- Some of the properties will as a result be understood now as mathematically conclusive, practical, and logical
- The others become easier to accept, and together they form a complete set

Morphological features

- Already derived some structural rules
- UNIVERSAL SCALING
- WIDE BOUNDARIES
- SCALING COHERENCE
- UNIVERSAL DISTRIBUTION OF SIZES
- How many such rules are there altogether? Completeness?

Innate structure

- Morphological features that resonate with the human senses
- Found in man-made form and structure
- Independent of culture, period, or region — something innate
- Also present in natural forms and objects

Presentation

- Christopher Alexander derived the 15 properties by observing structure that "is alive" in buildings, cities, artifacts
- Alexander's "The Nature of Order, Book 1: THE PHENOMENON OF LIFE"

- **Hierarchy**: nature; biological forms; animals; human beings; cultures

List of properties

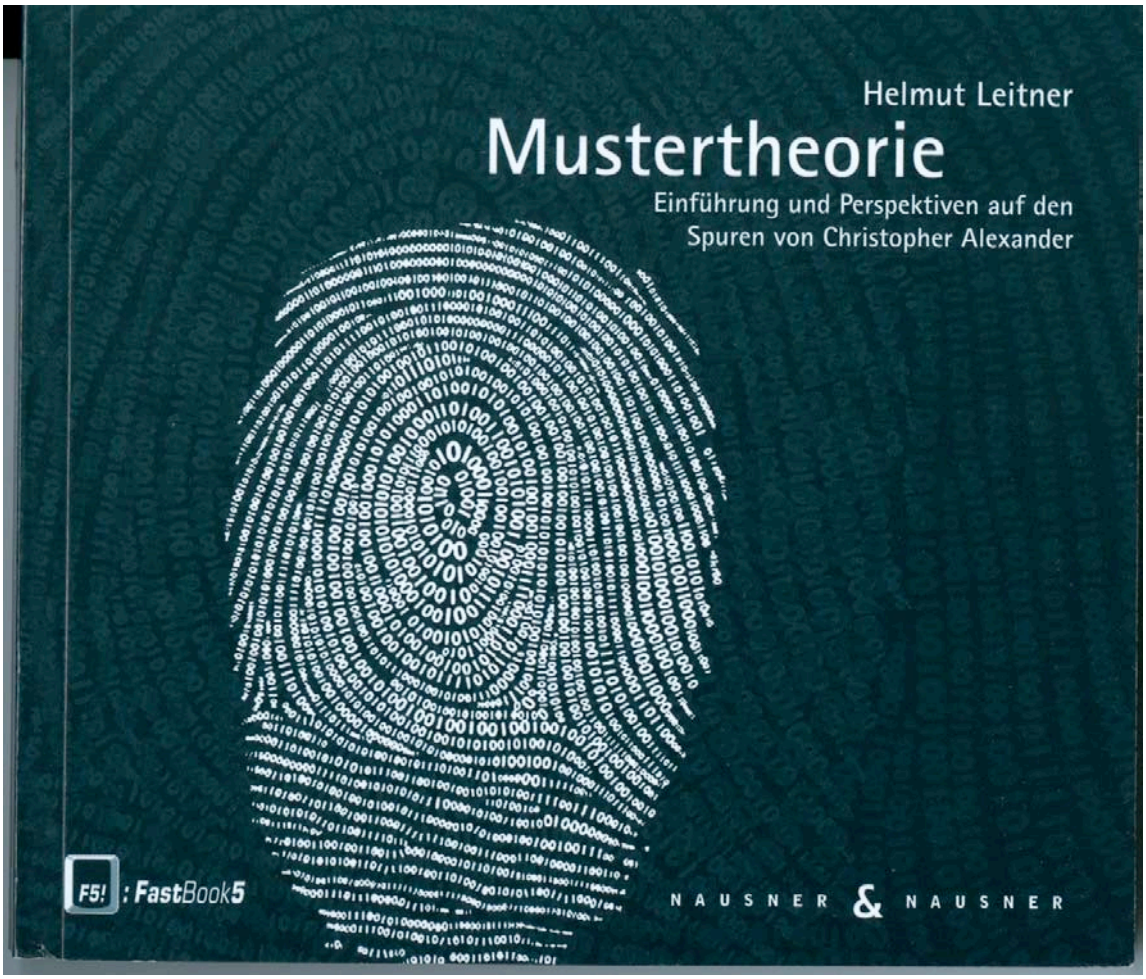
- **1. Levels of scale**
- **2. Strong centers**
- **3. Thick boundaries**
- **4. Alternating repetition**
- **5. Positive space**
- **6. Good shape**
- **7. Local symmetries**
- **8. Deep interlock and ambiguity**

List of properties (cont.)

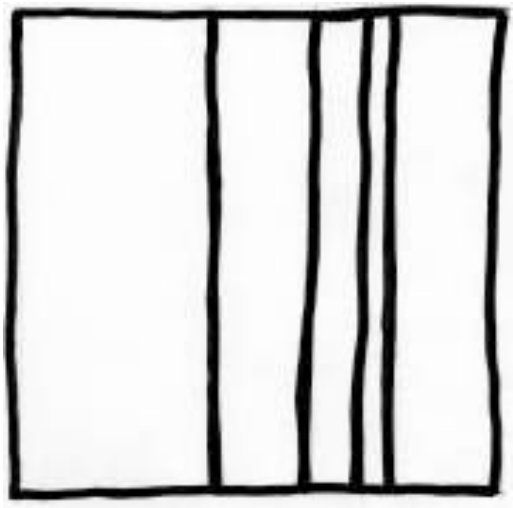
- **9. Contrast**
- **10. Gradients**
- **11. Roughness**
- **12. Echoes**
- **13. The void**
- **14. Simplicity and inner calm**
- **15. Not-separateness**

The second set of Leitner diagrams

- Diagrams drawn by Helmut Leitner, a software engineer in Graz, Austria
- Schematic sketches — illustrate the fifteen properties at a glance
- Presented at the 2007 conference entitled “Structure-Process-Patterns” in Vienna
- Leitner’s book “Mustertheorie (Pattern Theory)” does NOT contain his diagrams



Helmut Leitner's book: "Pattern Theory" (in German)



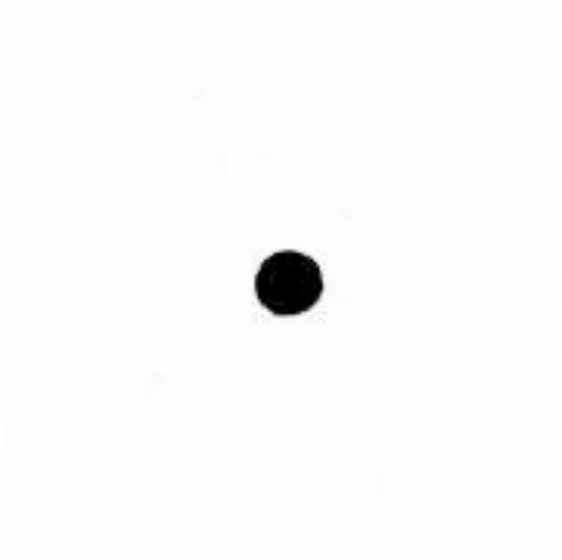
1. Levels of scale

Scaling hierarchy

- Levels of scale — spaced closely enough for coherence, but not too close to blur the distinction between nearby scales
- I gave mathematical rules (in the first lecture) for generating the correct scales via the logarithmic constant *e* and the Fibonacci sequence

Accessible scaling hierarchy is essential for adaptation

- The whole point of adaptive design is to satisfy needs on the human scales
- There is an entire range of human scales, from 2 m down to < 1 mm
- Build appropriate form — rule only says that you must accommodate all these scales; shape depends on centers!



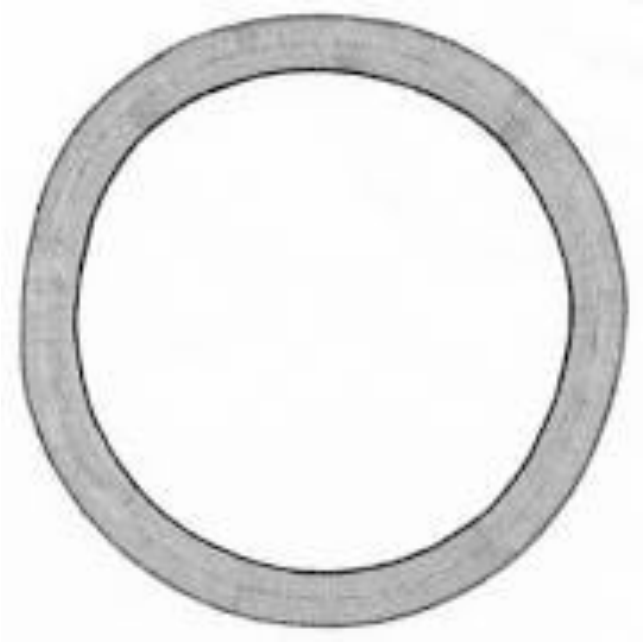
2. Strong centers

Theory of centers (lecture 5)

- Each "center" ties a substantial region of space together coherently
- Each center combines surrounding centers and boundaries to focus
- Centers support each other on every scale — recursive hierarchical property

Two types of centers

- Two types of centers — "defined" and "implied" — interact coherently
- "Defined" center has something in the middle to focus attention
- "Implied" center has a boundary that focuses attention on its empty interior
- Visual focus enhances function



3. Thick boundaries

Thick boundary

- According to universal scaling, thick boundary arises as the next scale
- Thin boundaries are ineffective, because they skip over one or more terms in the scaling hierarchy
- The concept of **THICK BOUNDARY** is important enough to use as a separate structural property

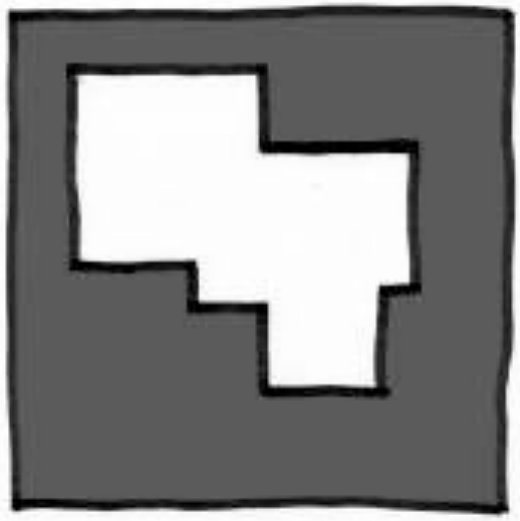
"Perforated, bent, and folded" (Lecture 2)

- An "implied" center is defined only through a thick boundary
- Therefore, thick boundaries play a focusing role as well as a bounding role
- Complex semi-permeable urban boundaries must be thick!

4. Alternating repetition

Informational definition

- Essential translational symmetry
- But simplistic repetition is collapsible information
- What repeats is trivially coded (X, repeat 100 times)
- **Contrast** and **repetition** reinforce each other through **alternation**



5. Positive space

Refers to Gestalt psychology

- Ties into the basis of human perception
- Convexity plays a major role in defining an object or a space (area or volume)

- Mathematical plus psychological reasons
- Strongly applicable to the spaces we inhabit
- Threat felt from objects sticking out

Positive background

- Apply positive space concept to both figure and background
- Urban space must be positive; not only the building's interior space
- Ignoring this property ruined most urban spaces built in the 20th century

6. Good shape

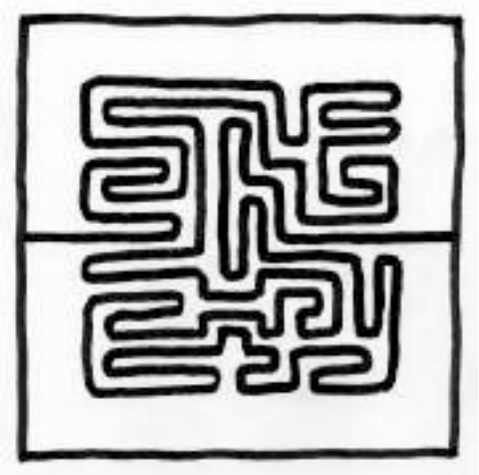
Good shape

- Symmetries reduce information overload
- Perceivable objects produce a represented shape from 2-D views, which the brain can computationally manipulate in 3-D
- "Good" means "easily graspable" — brain's innate need to compactify information
- Shapes not easily represented strain the computation, hence induce anxiety

7. Local symmetries

Symmetries within hierarchy

- Within universal scaling, symmetries must act on every scale
- "Symmetry" does not mean overall symmetry, as is usually envisioned
- We have multiple subsymmetries acting within larger symmetries
- Hierarchically nested symmetries



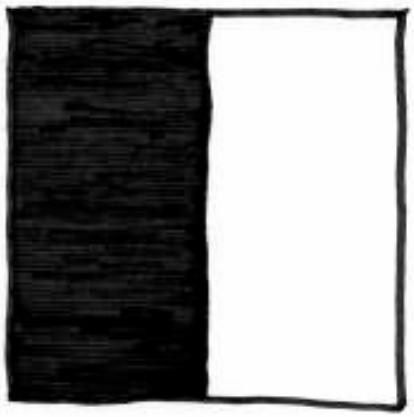
8. Deep interlock and ambiguity

Interlock

- Another strong way of connecting
- Forms interpenetrate to link together
- Analogy comes from fractals, where lines tend to fill portions of space, and surfaces grow with accretions
- Abrupt transition does not bind

"Perforated, bent, and folded"

- Geometrical concept introduced earlier (in second lecture)
- Two regions interpenetrate at a semi-permeable interface
- Because interface enables transition, ambiguity as to which side of the interface one belongs



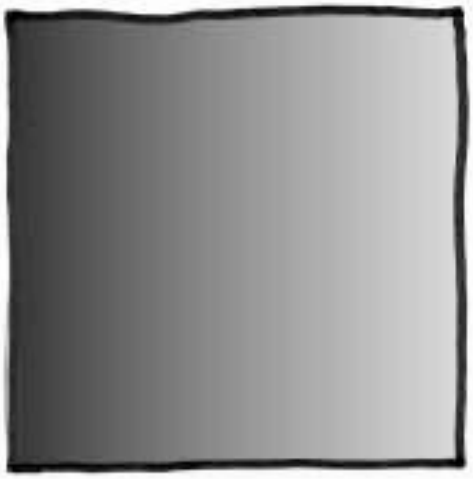
9. Contrast

Contrast is necessary:

- A. To establish distinct subunits
- B. To distinguish between adjoining units
- C. To provide figure-ground symmetry of opposites
- False transparency reduces contrast
- Reduced contrast weakens design

Uses of contrast

- Space under an arcade versus open street space
- Strongly contrasted, yet connected
- Weak spaces: inside versus outside a glass curtain wall — no contrast
- Use contrast with interlock



10. Gradients

Gradients = transitions

- Getting away from uniformity
- Subdivision does that, but…
- — sometimes we should not quantize form into discrete pieces, but need to change it gradually
- Urban transect: **city to countryside**
- Interior spaces: **public to private**

11. Roughness

Many different manifestations of roughness — all positive!

- A. Fractal structure goes all the way down in scales — nothing is smooth
- B. Relaxation of strict geometry to allow imperfections — more tolerant
- C. Ornament can be interpreted as "roughness" in a smooth geometry

Roughness and symmetry breaking

- So-called "imperfections" differentiate repeated units to make them similar but not identical — hand-painted tiles
- Symmetry breaking (approximate) prevents informational collapse
- Deliberate roughness in repetition

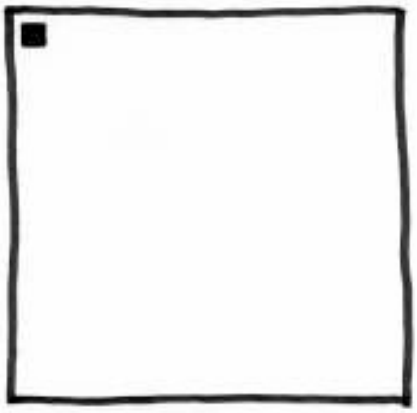
Roughness and adaptation

- Sustainability implies adaptation
- Local conditions create roughness — breaks regularity and perfect symmetry
- The whole changes according to its context thus it becomes unique
- HIERARCHY: sustainability; adaptivity; uniqueness; roughness

12. Echoes

Two types of echoes:

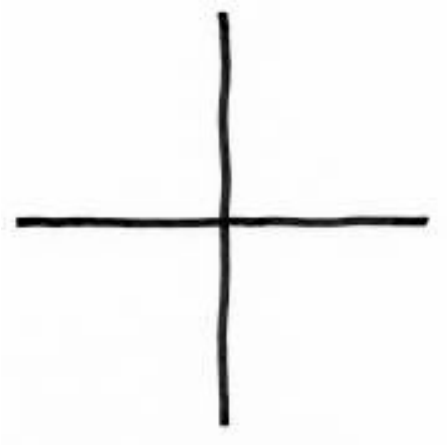
- A. Translational symmetry — similar forms found on the same scale but at a distance
- B. Scaling symmetry — similar forms exist at different scales
- All natural fractals obey fractal similarity — not exactly similar when magnified, but only "echoes"



13. The void

Largest scale of fractal

- Largest open component of a fractal survives as the void
- Not possible to fill in all of a fractal with detail
- In "implied" centers, a complex boundary focuses on the open middle — the void



14. Simplicity and inner calm

More subtle quality

- Lack of clutter — a separate property
- Balance achieved by overall coherence
- Symmetries all cooperating to support each other — nothing extraneous or distracting
- Appears effortless (though such coherence is in fact very difficult to achieve)

Simplicity in nature

- Never actually "simple" in the sense of being minimalist
- "Simple" in nature means extremely complex but highly coherent
- A system appears "simple" to us because it is so perfect; the form is seamless

15. Not-separateness

Achieving coherence

- Coherence is an emergent property — not present in the individual components
- In a larger coherent whole, no piece can be taken away
- Decomposition is neither obvious, nor possible

Measure of coherence

- When every component is cooperating to give a coherent whole, nothing looks separate, nothing draws attention
- This is the goal of adaptive design
- A seamless blending of an enormous number of complex components
- The opposite of willful separateness

Extending outside

- Not-separateness goes beyond internal coherence
- The whole connects to its environment
- Connects with everything beyond itself
- Try as much as possible to generate large-scale coherence

Breaking the 15 properties for fun

- 15 properties give coherent form, which is so natural that it is hardly noticed — like nature!
- Architects and students most often wish to draw attention to their designs
- Draw attention by violating properties
- But doing so causes physiological anxiety for user

Moral quandary

- Do I follow the 15 properties to design an adaptive, nourishing environment?
- Or do I deliberately break them and design an eye-catching project?
- Is playing with emotions (especially anxiety) likely to promote my work?
- What does the client demand?

Suppression of the 15 properties

- Whether consciously or unconsciously, architectural design in the 20th century has cultivated the **absence** of the 15 properties
- Students and architects respond emotionally (very negatively) to them, from their image-based conditioning

Now architects have a choice

- The 15 properties question the validity of the contemporary built environment, and the

ideology that gave rise to it

- Weak arguments support those forms
- Emotionally nourishing coherence, reflected in all traditional architectures, is both logical and inevitable

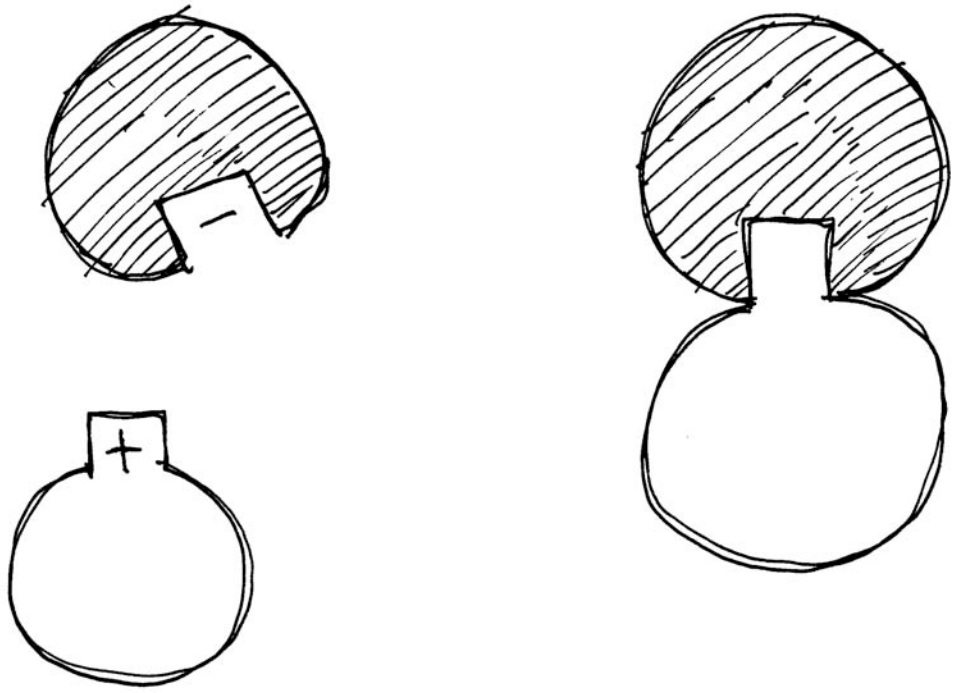
6.2. Three laws of architecture

Rule compression

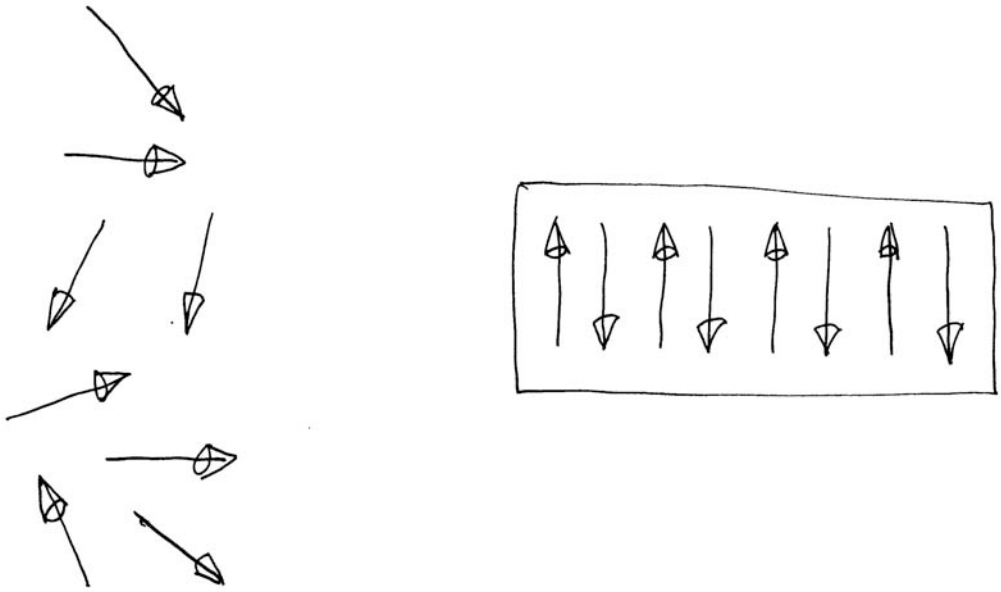
- Can we find a reduced basis that includes most of the 15 properties?
- "A Theory of Architecture" argues by analogy with physical processes
- My own complementary approach — reinforces without in any way trying to substitute for the 15 properties

Law 1. Order on the smallest scale

- Established by paired contrasting elements
- Pairs create balanced visual tension
- Elementary particles with opposite characteristics couple — positive and negative charges, opposite spin states, opposite isospin states, etc.
- Pairwise binding on subatomic, atomic, and molecular levels, all on the short scale



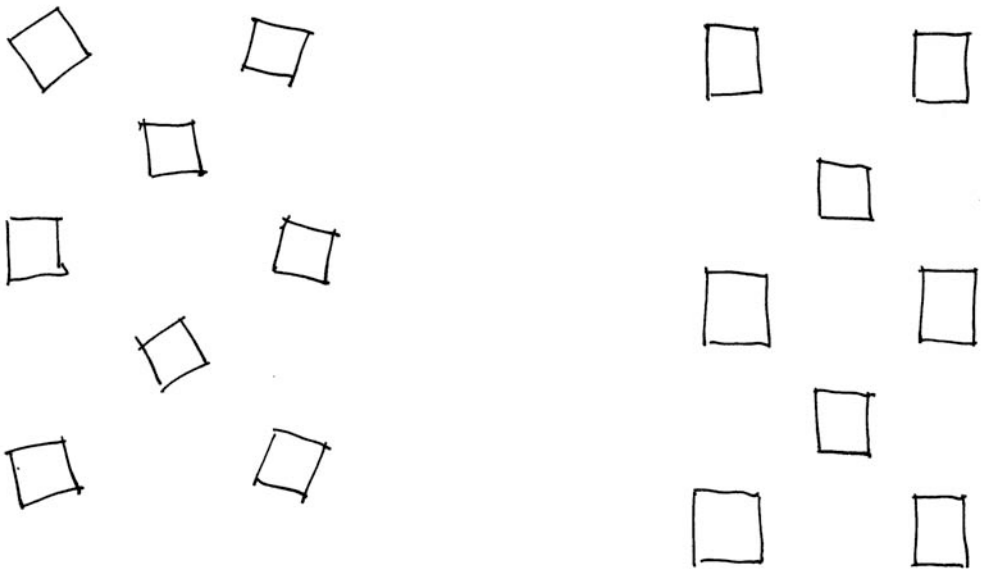
Pairwise coupling



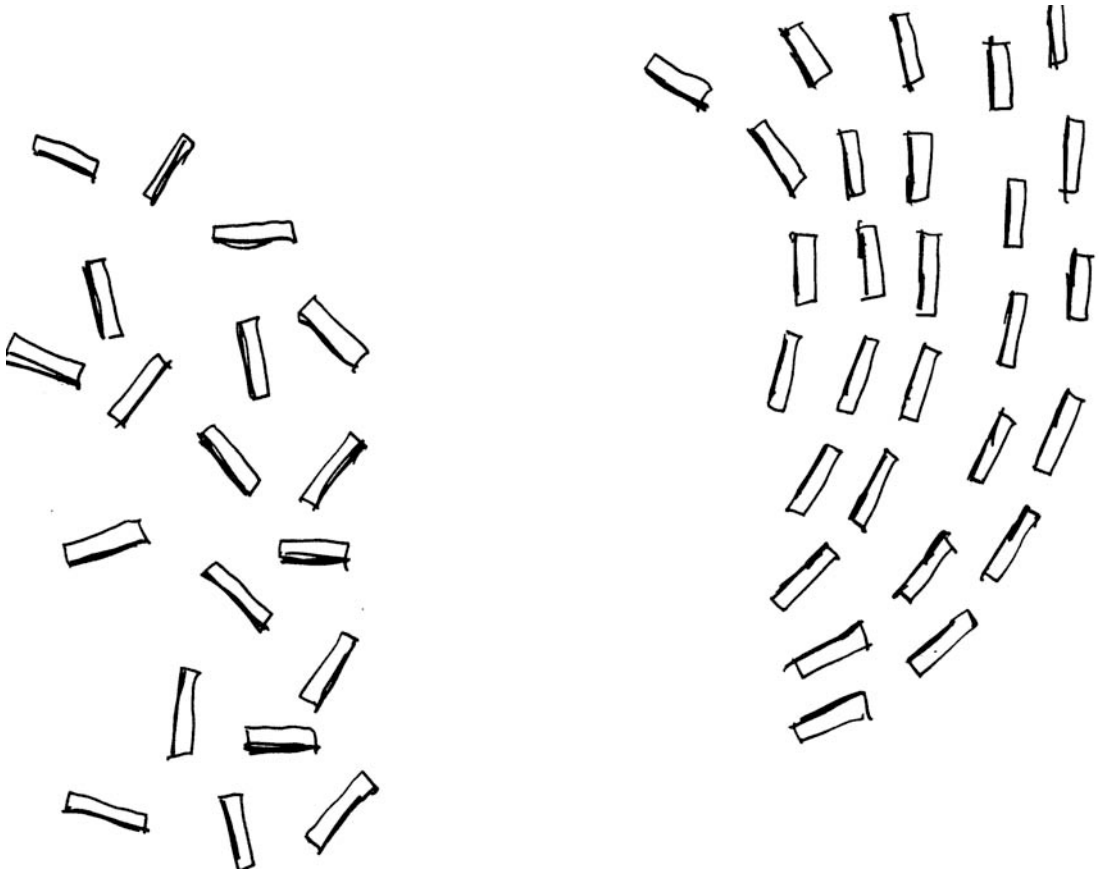
Crystallization

Law 2. Order on the large scale

- Elements relate to each other at a distance
- Configuration tries to reduce entropy (disorder) by shedding randomness
- Physical fields reduce energy by alignment
- Magnets align along field lines
- Crystallization reduces entropy
- Long-range forces imply ordering



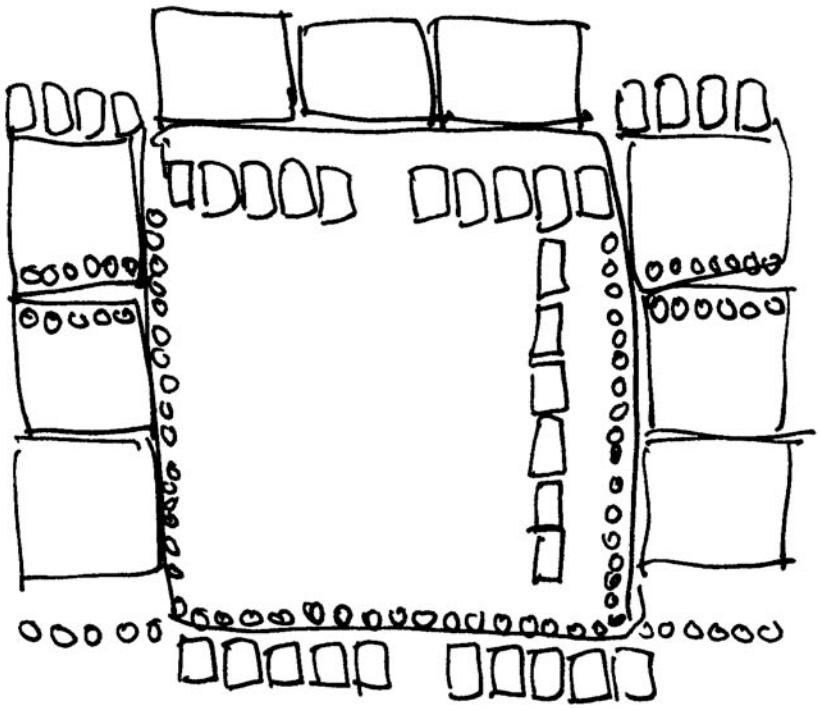
Alignment — reorientation



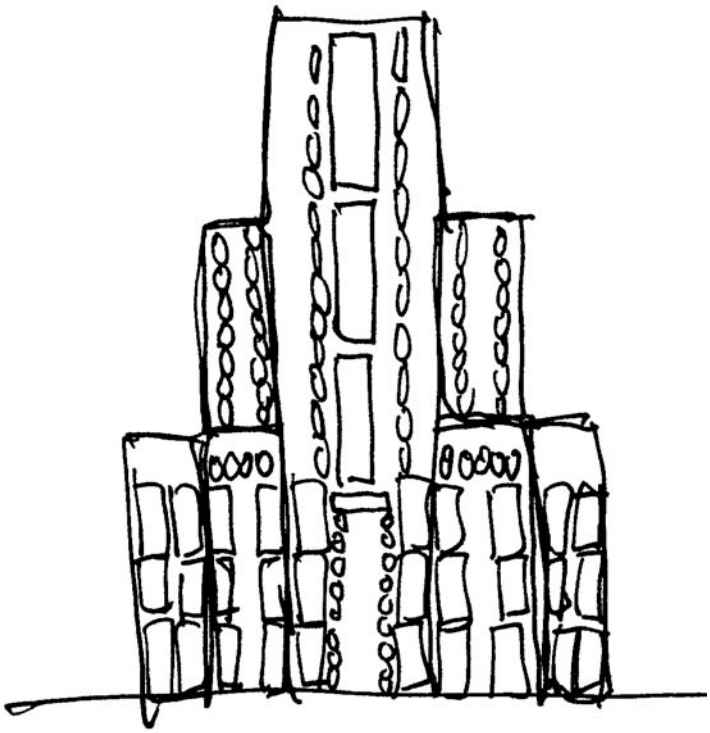
Alignment along field

Law 3. Links small to large scale

- Linking occurs through a regular scaling hierarchy
- Universal scaling with factor $e = 2.7$
- Scales from the largest to the smallest are related by the same scaling ratio
- Already discussed in the first lecture



Scaling hierarchy in plan of urban space



Scaling hierarchy in building façade

Which of the 15 properties relate to the first law?

- "**Alternating repetition**" — repetition of contrasting pairs, not of single unit
- "**Deep interlock and ambiguity**" — local coupling occurs through geometrical interlock
- "**Contrast**" — the basis for coupling of units having opposite qualities

Which of the 15 properties relate to the second law?

- "**Local symmetries**" — disorder is reduced by local symmetries
- "**Echoes**" — similarity at a distance reduces entropy
- "**Not-separateness**" — field effect ties components together on different scales

Which of the 15 properties relate to the third law?

- **"Levels of scale"** — consequence of scaling hierarchy
- **"Thick boundaries"** — boundary is next-smallest scale in hierarchy
- **"The void"** — largest scale in hierarchy exists to balance all the smaller scales

Conclusion

- Alexander's 15 fundamental properties are an incredibly essential set of practical design tools
- Arguments based on mathematics, physics, chemistry, and biology
- Architects have to accept them as universal, deciding on stylistic reasons whether to follow them or not

Conclusion (cont.)

- Traditional practitioners intuitively recognize some of the 15 properties as part of their own design method
- Yet, some are unknown to them
- Now put together into a coherent set
- I find it more useful to introduce them after having derived basic design rules