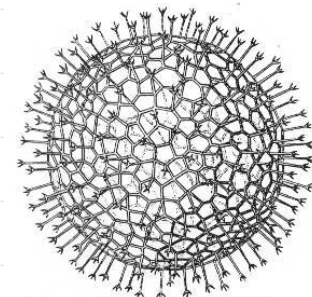
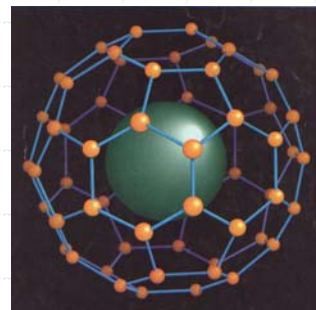
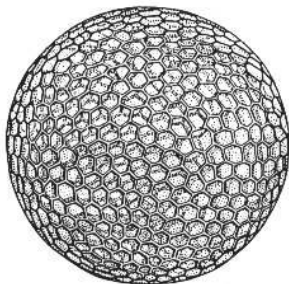


# Comprehensive Anticipatory Design Science



# Design Science



**Ocean Arks International's**

*Living Machines.*

- Finding ways to organize our matter-energy environment to better support life...
- ...By employing generalized principles ...
- ...To transform human life support systems in ways that...
- ...Support all humans and other living beings using less material resources...
- ...and without undermining Earth's ecological processes

# Whole Systems Thinking

- **Problem solving begins by first considering Whole Systems**
- **Proceed to examine the parts in relationship to the whole system (macro-to-micro)**
- **Analysis, the basis for most present day planning and policy-making, separates out parts from the whole for study**
- **Analysis does not acknowledge the concept of synergy**

# Synergy

- The behavior of whole systems unpredicted by the behavior of their parts taken separately
- Synergy describes the “laws of whole systems”
- Sometimes referred to as “The Science of Cooperation”

# Principle of Synergetic Advantage

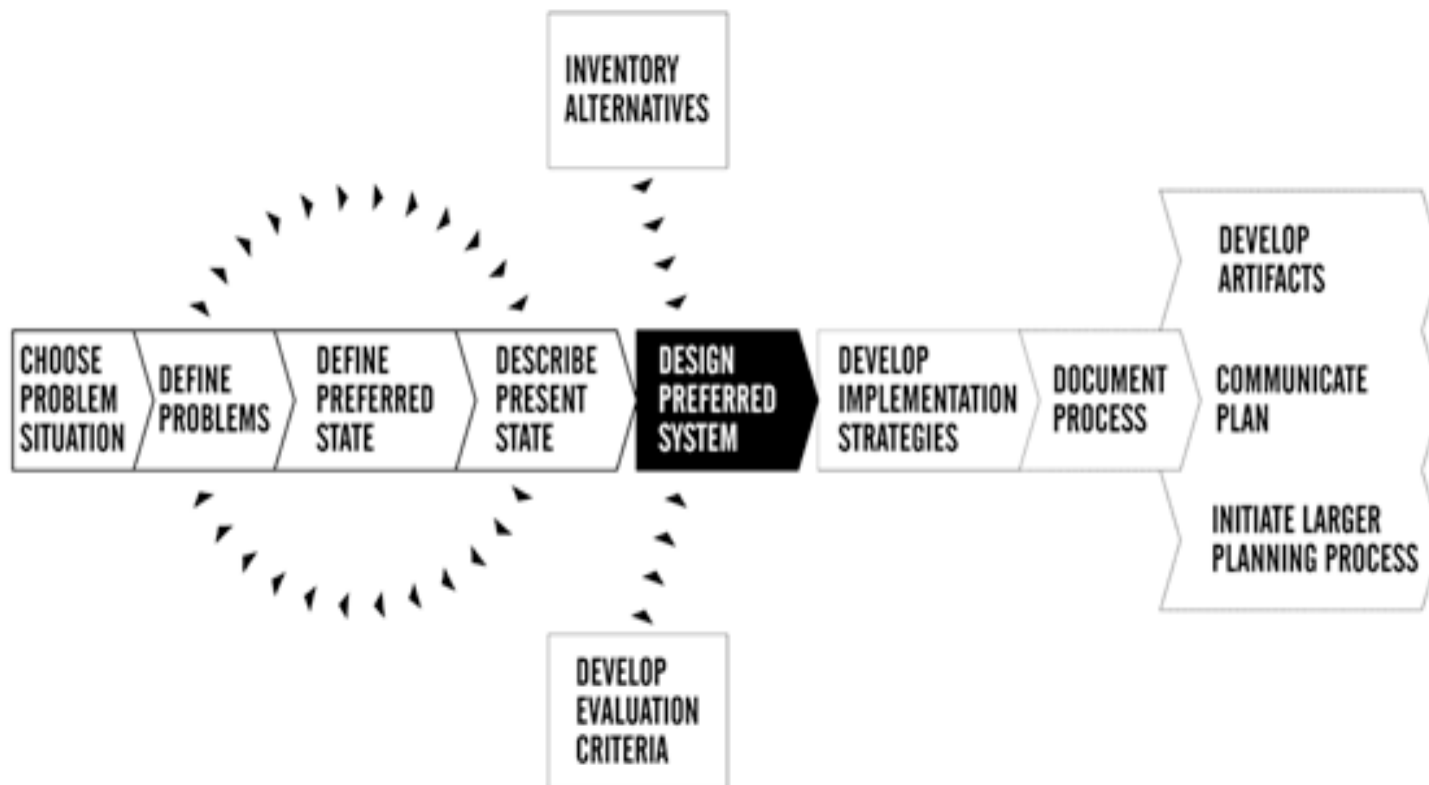
**Definition:** "The principle of synergetic advantage states that macro-to-micro does not equal micro-to-macro. Synergetic advantage is only to be effected by macro-to-micro procedure. Synergetic advantage procedures are irreversible. Micro-to-macro procedures are inherently frustrated."

Buckminster Fuller  
*Synergetics*

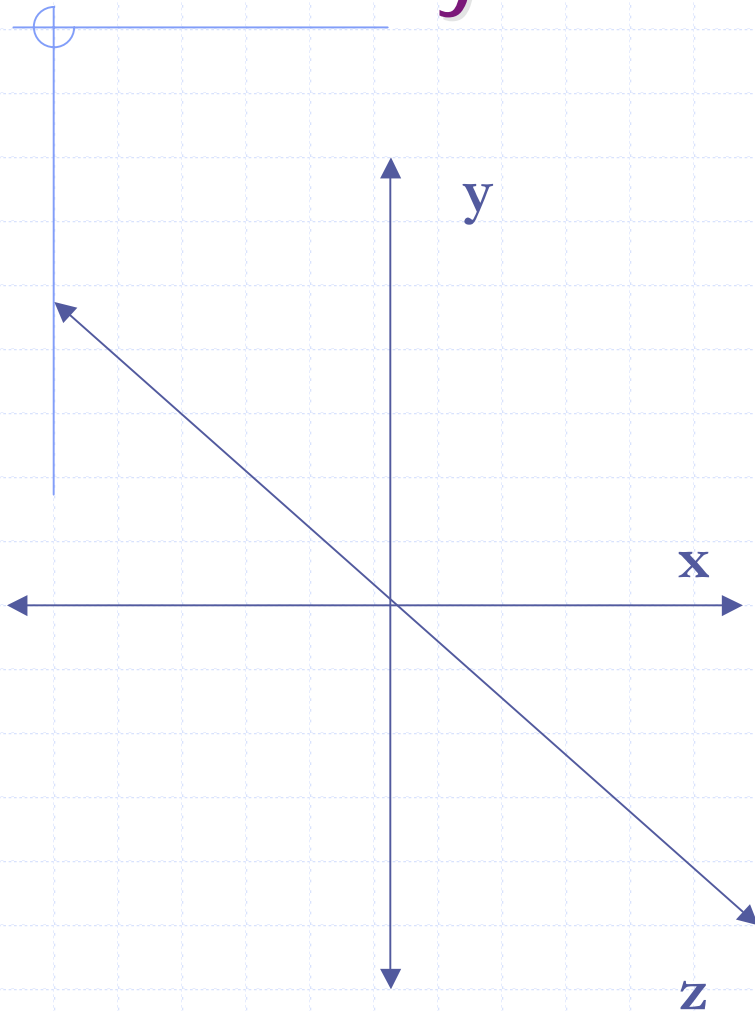
# Principle of Synergetic Advantage

- There is nothing in chemical compounds per se that predicts biological protoplasm.
- There is nothing in the biological protoplasm per se that predicts camels and palm trees and the intercomplementary interexchange of the waste gases given off by them
- There is nothing in the exchange of these gases that predicts galaxies and stars

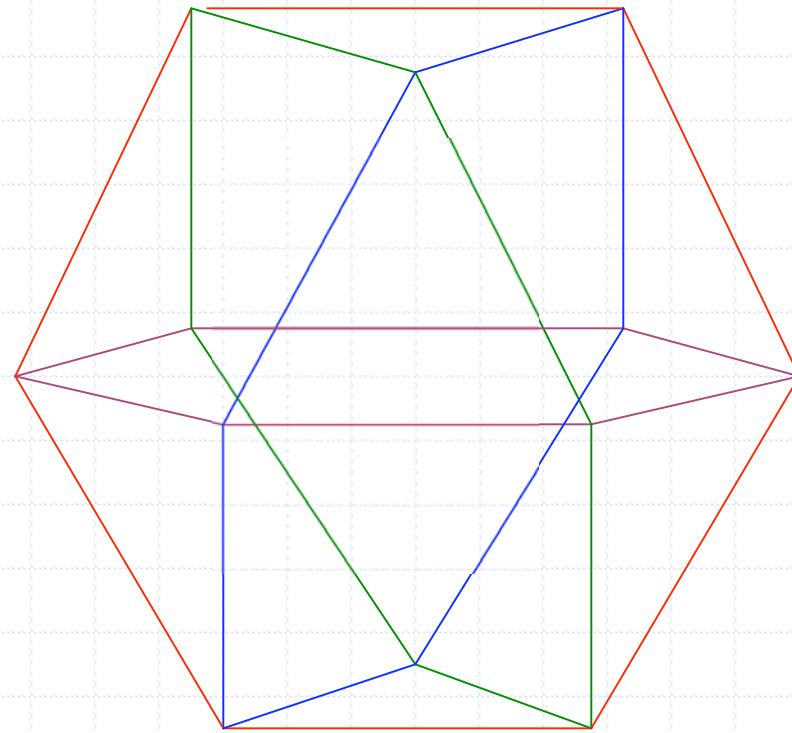
# Design Science Planning Process



# Whole Systems Coordinate System



**Cartesian Framework**



**Whole Systems Framework**

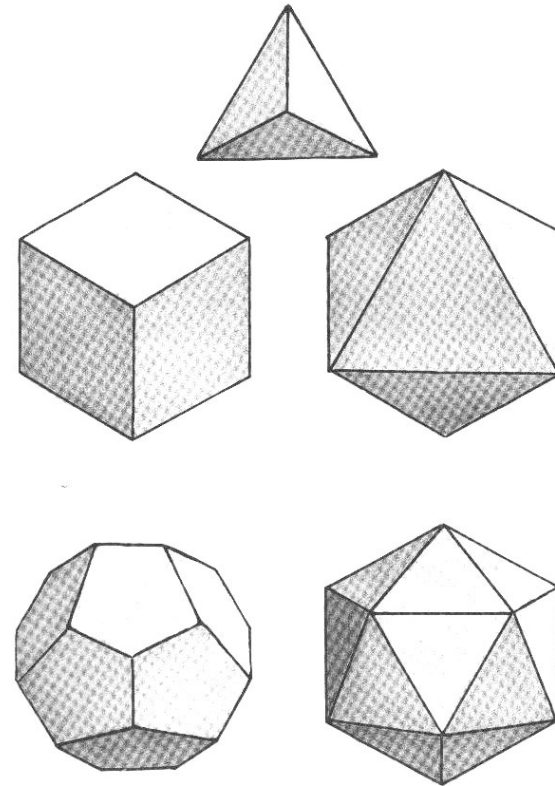
# Systems

“A system is the first subdivision of Universe into a conceivable entity separating all that is nonsimultaneously and geometrically outside the system, ergo irrelevant, from all that is nonsimultaneously and geometrically inside and irrelevant to the system”

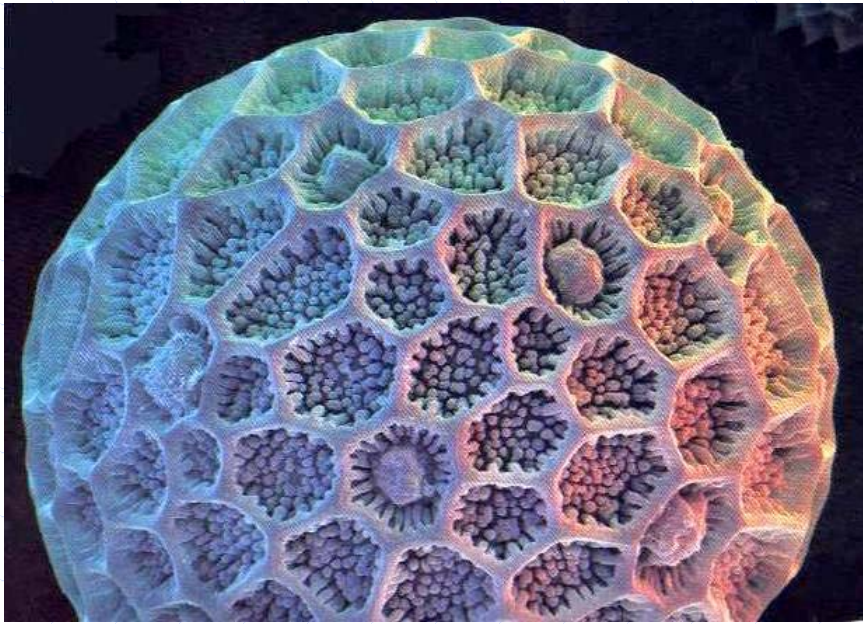
Buckminster Fuller. *Synergetics*

# Polyhedra

- All systems are polyhedra
- Polyhedra represent the inventory of Nature's structural/energy patterning options
- Defined by Whole Systems Framework



# Polyhedral Design

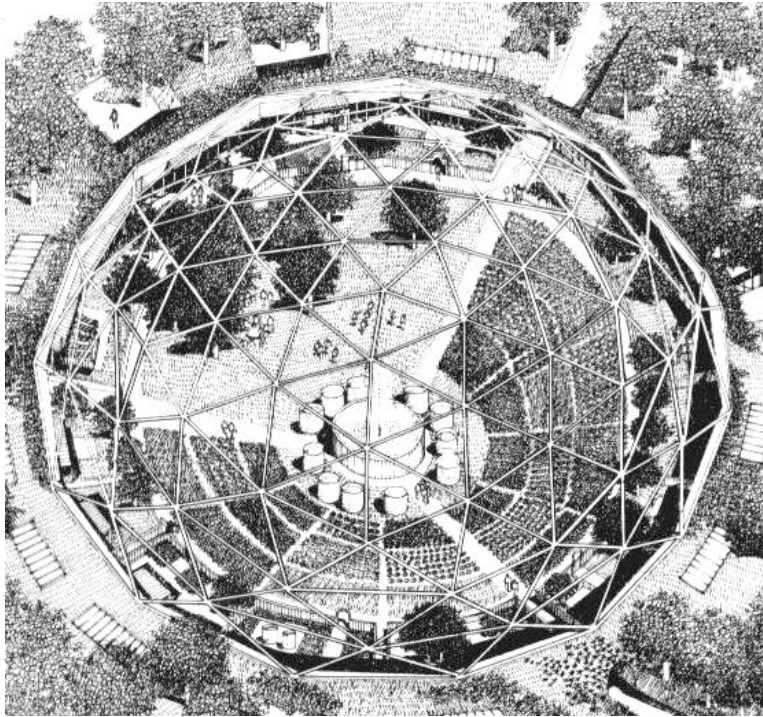


**Polle  
n**

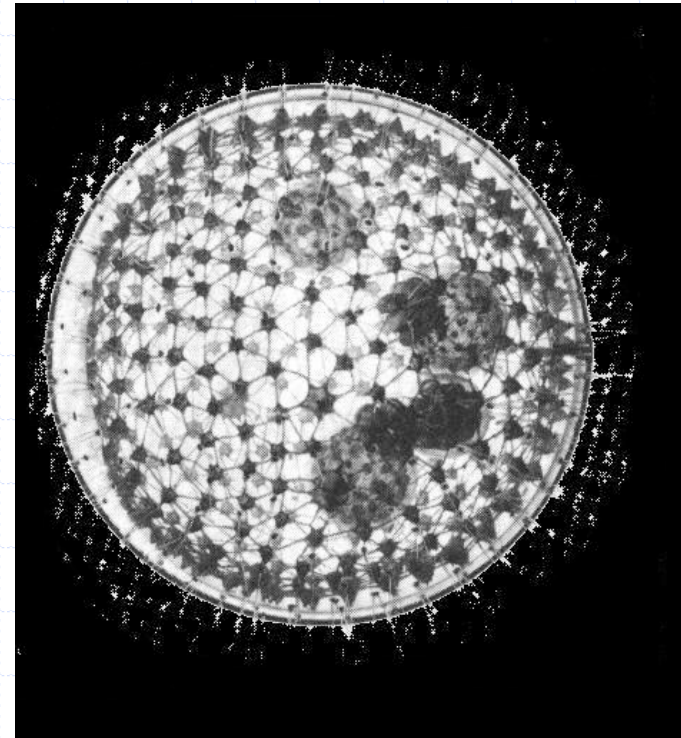


**Hive**

# Polyhedral Design



Geodesic Dome design  
by Paul Sun



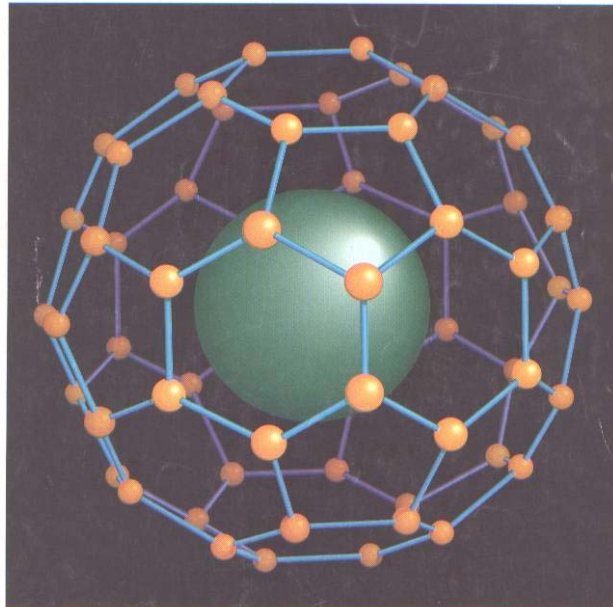
Volvox- freshwater  
colonial protozoan

# Buckminsterfullerenes

## SCIENTIFIC AMERICAN

OCTOBER 1991  
\$3.95

*Remnants of a planet that failed to form.  
Still no technological fix for oil spills.  
What made higher life-forms possible?*



*Buckyball, the third form of pure carbon, cages an atom in its lattice.*



5-YEAR NEW CAR GUIDE

# Popular Science

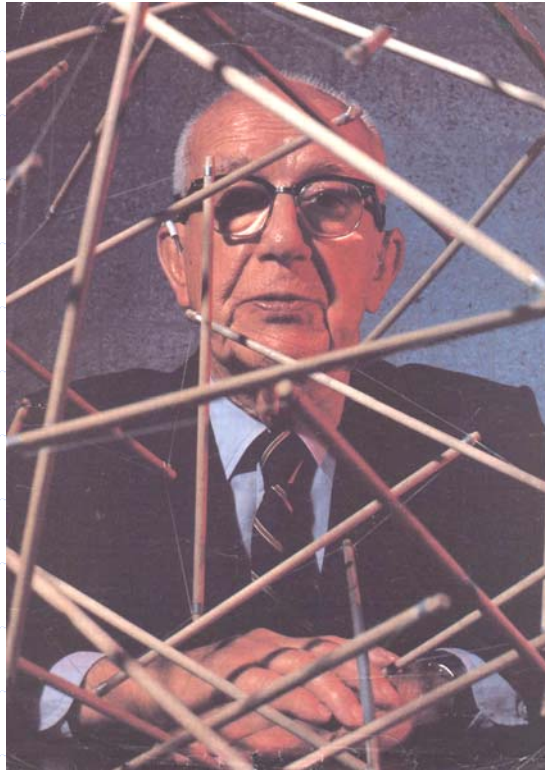
NEW TINY 35s

## BUCKYBALL

MAGIC MOLECULE FOR NEW MATERIALS

AUGUST 1991  
\$2.00  
CANADA \$2.50

# Nature's Tensegrity Design Strategy



Scientific American  
January 1998

## The Architecture of Life

*A universal set of building rules seems to guide the design of organic structures—from simple carbon compounds to complex cells and tissues*

by Donald E. Ingber

**L**ife is the ultimate example of complexity at work. An organism, whether it is a bacterium or a baboon, develops through an incredibly complex series of interactions involving a vast number of different components. These components, or subsystems, are themselves made up of smaller molecular components, which independently exhibit their own dynamic behavior, such as the ability to catalyze chemical reactions. Yet when they are combined into some larger functioning unit—such as a cell or tissue—utterly new and unpredictable properties emerge, including the ability to move, to change shape and to grow.

Although researchers have recognized this intriguing fact for some time, most discount it in their quest to explain life's fundamentals. For the past several decades, biologists have attempted to advance our understanding of how the human body works by defining the properties of life's critical materials and molecules, such as DNA, the stuff of genes. Indeed, biologists are now striving to identify every gene in the complete set, known as the genome, that every human being carries. Because genes are the "blueprints" for the key molecules of life, such as proteins, this Holy Grail of molecular biology will lead in the near future to a catalogue of essentially all the molecules from which a human is created. Understanding what the parts of a complex machine are made of, however, does little to explain how the whole system works, regardless of whether the complex system is a combustion engine or a cell. In other words, identifying and describing the molecular puzzle pieces will do little if we do not understand the rules for their assembly.

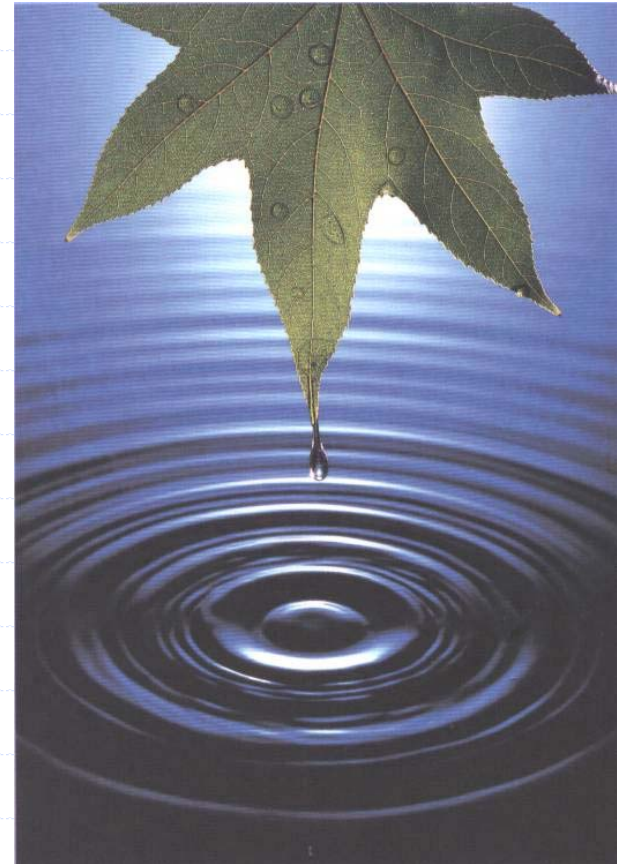
That nature applies common assembly rules is implied by the recurrence—at scales from the molecular to the macroscopic—of certain patterns, such as spirals, pentagons and triangulated forms. These patterns appear in structures ranging from highly regular crystals to relatively irregular proteins and in organisms as diverse as viruses, plankton and humans. After all, both organic and inorganic matter are made of the same building blocks: atoms of carbon, hydrogen, oxygen, nitrogen and phosphorus. The only difference is how the atoms are arranged in three-dimensional space.

This phenomenon, in which components join together to form larger, stable structures having new properties that could not have been predicted from the characteristics of their individual parts, is known as self-assembly. It is observed at many scales in nature. In the human body, for example, large molecules self-assemble into cellular components known as organelles, which self-assemble into cells, which self-assemble into tissues, which self-assemble hierarchically as tiers of systems within systems. Thus, if we are to understand fully the way living creatures form and function, we need to uncover these basic principles that guide biological organization.

Despite centuries of study, researchers still know relatively little about the forces that guide atoms to self-assemble into molecules. They know even less about how groups of molecules join together to create living cells and tissues. Over the past two decades, however, I have discovered and explored an intriguing and seemingly fundamental aspect of self-assembly. An astoundingly wide variety of natural systems, including carbon atoms, water molecules, proteins, viruses, cells, tissues and even humans and other living creatures, are constructed using a common form of architecture known as tensegrity. The term refers to a system that stabilizes itself mechanically because of the way in which tensional and

# Precession

- Precession is the effect of any moving system upon any other moving system
- Precessional effects are always angular and always something other than 180 degrees; they are very likely to be 90 degrees or 60 degrees



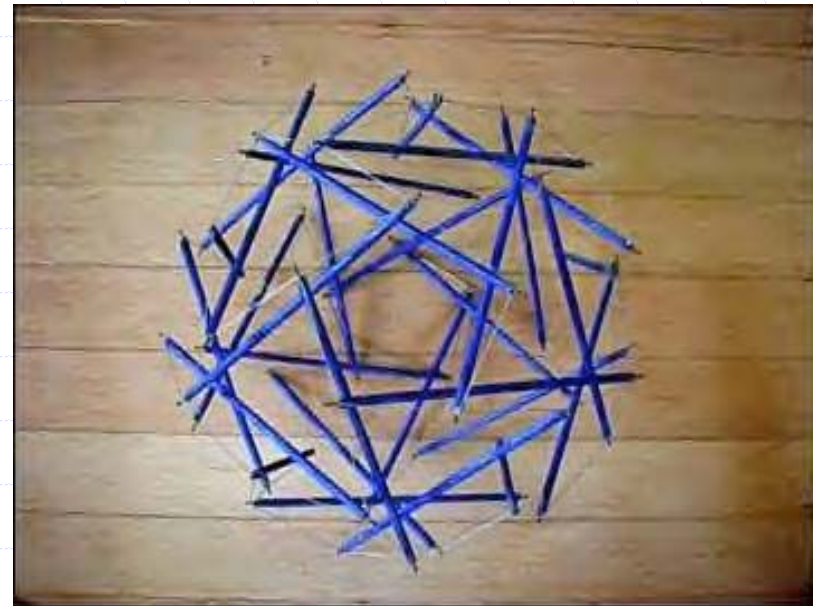
# Precession



- Pollination is a precessional phenomenon
- It is an inadvertent, unconscious 90-degree “by-product” of the honey bee’s instinctual urge to collect honey

# Tensegrity

- Tensional Integrity
- Structures emphasize tension and de-emphasize compression
- A Tensegrity system is a set of discontinuous compressive components interacting with a set of continuous tensile components to define a stable volume in space



# Ephemerization



- In a finite world with limited resources...
- ...the key to sustainability...
- ...is understanding how to do **MORE WITH LESS**

# Technology As Pure Principle

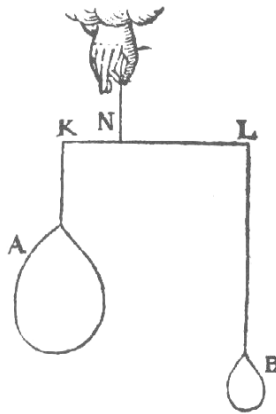


Figure 2.4 The law of the lever:  $A : B = NL : NK$ .



General Principal  
Leverage  
 $A : B = NL : NK$



Special Case  
(Applications)

