



# Wasp Nest Building

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after Theraulaz & Bonabeau (1995)

*J. Theor. Biol.* **177**: 381-400; *Science* **269**: 686-688

# Wasp Nests in Natural World



all images from <http://www-iasc.enst-bretagne.fr/PROJECTS/SWARM/nest.html>



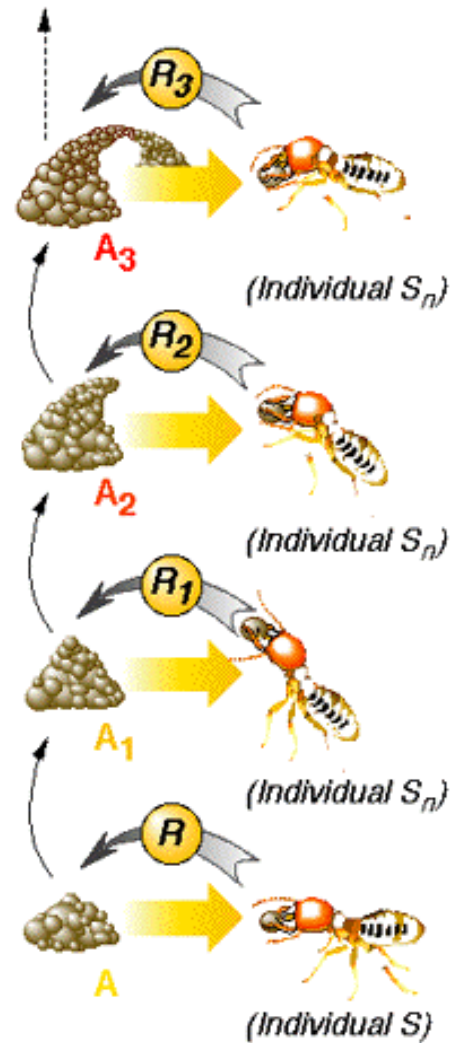
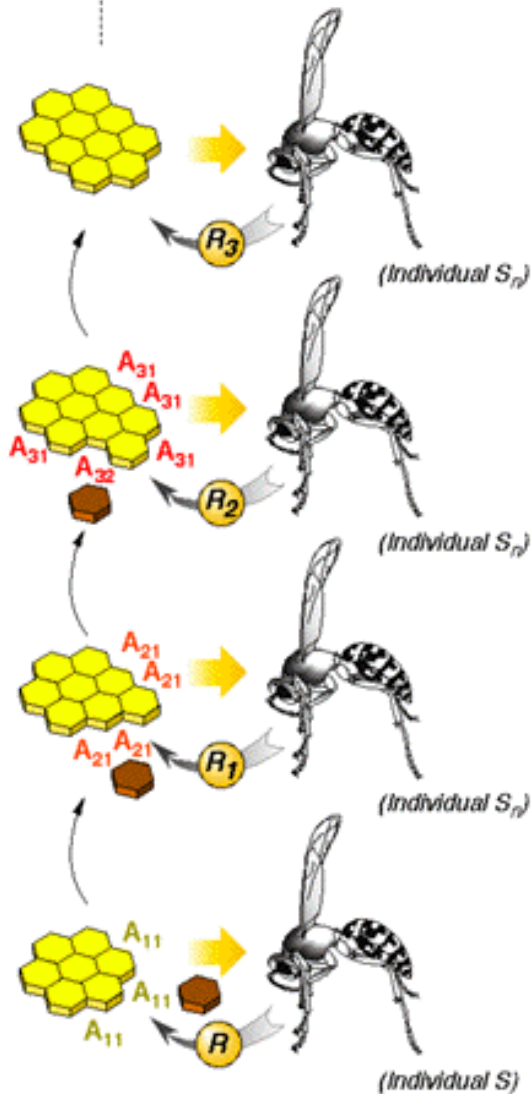
# Properties

- Complex
- Appearance varies greatly
- Highly repetitive structure -- pattern

# Increasing knowledge

- Each individual has a global image
- → Each individual has an innate image about how complex the nest will be
- → Individual behavior is an innate building program
- → Stimulus-driven (Figure 19.7)

# Stigmergy





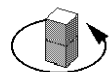
# Stimulus-driven

- Multiple stages
- Quantitative or qualitative
  - Multiple stimulus or single stimulus
- Relation between pre/post conditions

# Stages

- Pre-founding phase
  - Working on the base and preparing the materials
- Linear phase
  - Choosing starting point
  - Single pattern used – organized
- Nonlinear phase
  - Multiple works
    - Cell construction
    - Cell lengthening
    - Pedicel construction

Step 1

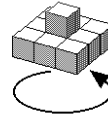


[GC=1]

+ 8  
Configurations



Step 2

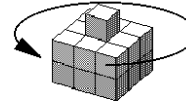


[GC=9]

+ 13  
Configurations



Step 3

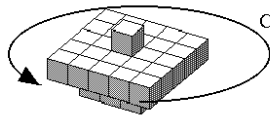


[GC=22]

+ 34  
Configurations



Step 4

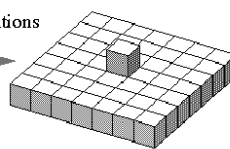


[GC=56]

+ 19  
Configurations



Step 5

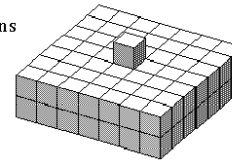


[GC=75]

+ 27  
Configurations

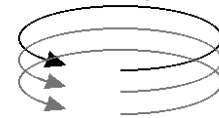
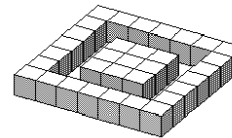


Step 6

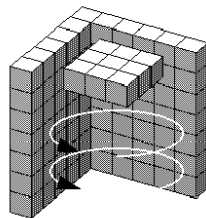


[GC=102]

+ 31  
Configurations



Step 7

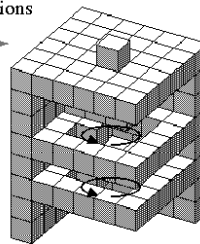


[GC=133]

+ 17  
Configurations



Step 8

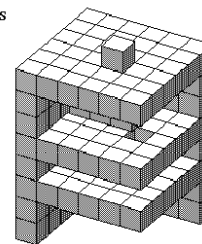


[GC=150]

+ 7  
Configurations



Step 9



[GC=157]



# Algorithm 6.3

...

For each step {

    sense local configuration

    if (local configuration is in lookup table) {

        Deposit brick specified by lookup table

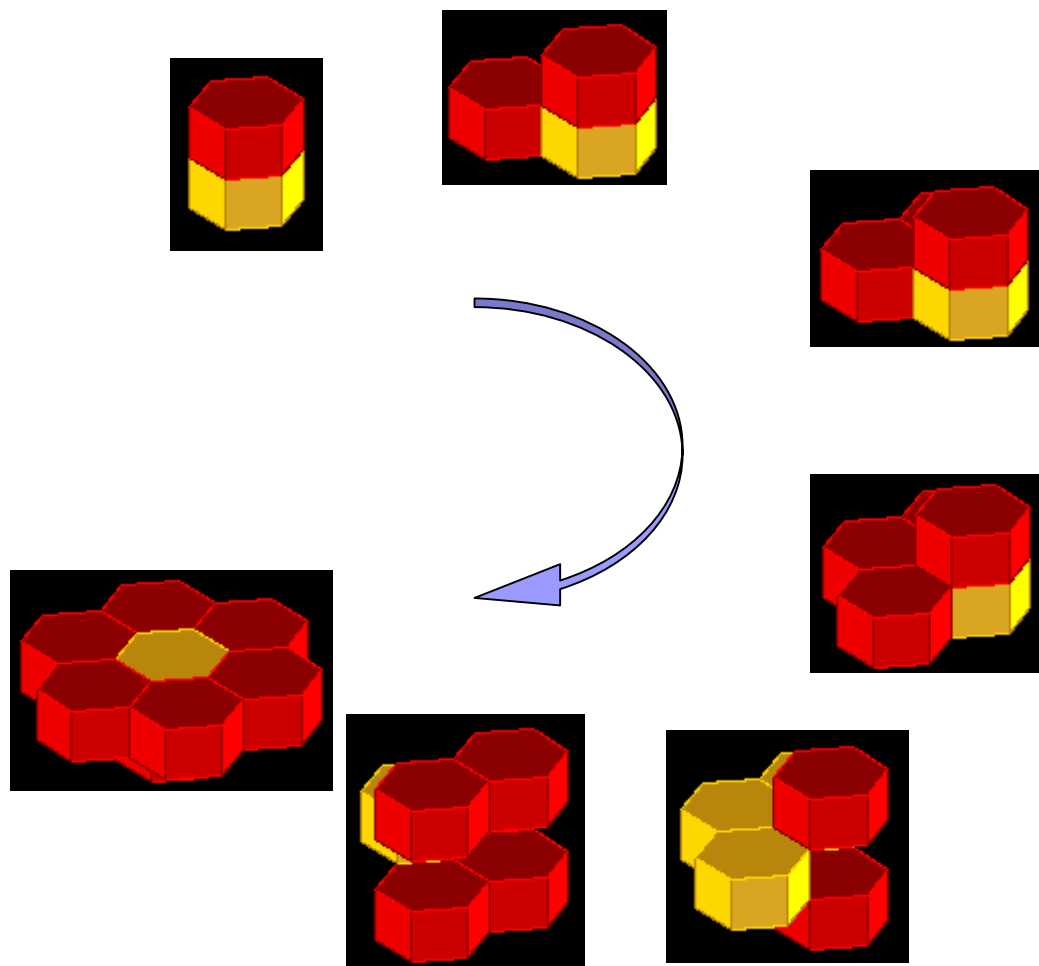
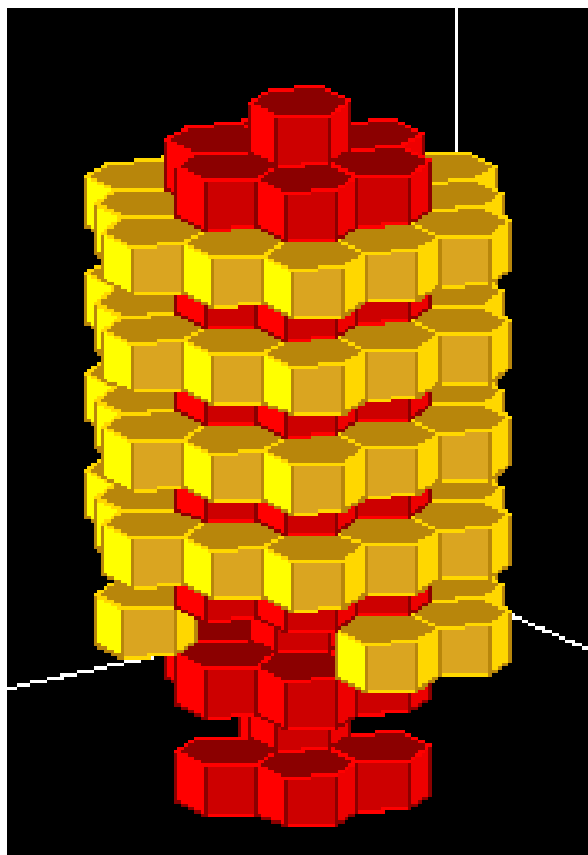
        Draw new brick

    }

}

...

# Sample ruleset







# How to find rules


- Testing
  - Difficult
- Genetic algorithms (GA)
  - Code
  - Fitness

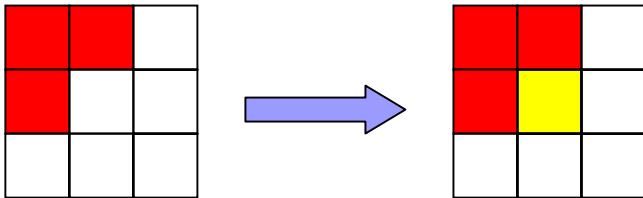
# GA representation

## ■ Code

 = 2

 = 1

 = 0





# GA representation

## ■ Fitness

- Many/few rules used
- Compact/loose
- Patterns repeated frequently/rarely

# Beyond biology

- Self-assembling robots
  - Metamorphic robots: a collection of independently controlled mechatronic modules
  - Fracta: collection of three-layered structure units
  - 3-D self-reconfiguration
- Architectural design