

III Autonomous Agents & Self-Organization

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Autonomous Agent

- “a unit that interacts with its environment (which probably consists of other agents)
- but acts independently from all other agents in that it does not take commands from some seen or unseen leader,
- nor does an agent have some idea of a global plan that it should be following.”
—Flake (p. 261)

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Nest Building by Termites (Natural and Artificial)

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Resnick’s Termites (“Turmites”)

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Basic procedure

- Wander randomly
- If you are not carrying anything and you bump into a wood chip, pick it up.
- If you are carrying a wood chip and you bump into another wood chip, put down the woodchip you are carrying

— Resnick, *Turtles, Termites, and Traffic Jams*

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Microbehavior of Termites

1. *Search for wood chip:*
 - a) If at chip, pick it up
 - b) otherwise wiggle, and go back to (a)
2. *Find a wood pile:*
 - a) If at chip, it's found
 - b) otherwise wiggle, and go back to (a)
3. *Find an empty spot and put chip down:*
 - a) If at empty spot, put chip down & jump away
 - b) otherwise, turn, take a step, and go to (a)

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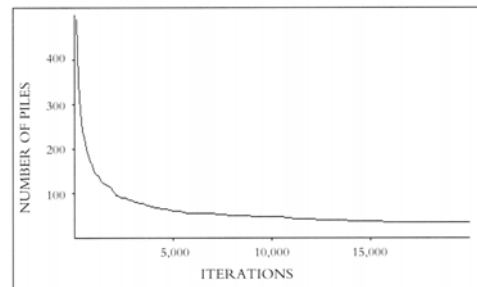
Demonstration

[Run Termites.slogo](#)

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Decrease in Number of Piles



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Why does the number of piles decrease?

- A pile can grow or shrink
- But once the last chip is taken from a pile, it can never restart
- Is there any way the number of piles can increase?
- Yes, and existing pile can be broken into two

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More Termites

Termites	2000 steps		10 000 steps		
	num. piles	avg. size	num. piles	avg. size	chips in piles
1000	102	15	47	30	
4000	10		3	80	240

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Termite-Mediated Condensation

- Number of chips is conserved
- Chips do not move on own; movement is mediated by termites
- Chips preferentially condense into piles
- Increasing termites, increases number of chips in fluid (randomly moving) state
- Like temperature

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An Experiment to Make the Number Decrease More Quickly

- Problem: piles may grow or shrink
- Idea: protect “investment” in large piles
- Termites will not take chips from piles greater than a certain size
- Result: number decreases more quickly
- Most chips are in piles
- But *never* got less than 82 piles

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Conclusion

- In the long run, the “dumber” strategy is better
- Although it’s slower, it achieves a better result
- By not protecting large piles, there is a small probability of any pile evaporating
- So the smaller “large piles” can evaporate and contribute to the larger “large piles”
- Even though this strategy makes occasional backward steps, it outperforms the attempt to protect accomplishments

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Flake’s Version of Termites

[Run CBN Mac version of termites](#)

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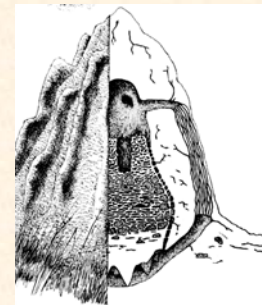
Mound Building by *Macrotermes* Termites



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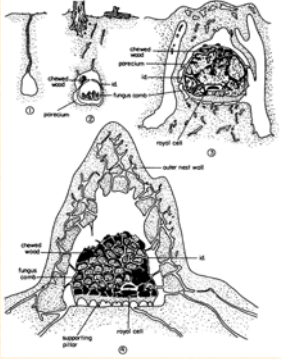
Structure of Mound



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figs. from Lüscher (1961)

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Construction of Mound

- (1) First chamber made by royal couple
- (2, 3) Intermediate stages of development
- (4) Fully developed nest

9/15/04 Fig. from Wilson (1971) 17

The diagram illustrates the four stages of mound construction. Stage 1 shows a small chamber with labels for 'royal cell', 'queen', and 'king'. Stage 2 shows a larger chamber with labels for 'queen cell', 'king cell', 'royal cell', and 'queen'. Stage 3 shows a more complex structure with labels for 'queen cell', 'king cell', 'royal cell', 'queen', and 'king'. Stage 4 shows a fully developed nest with labels for 'queen cell', 'king cell', 'royal cell', 'queen', 'king', 'chamber wall', 'fungus chamber', and 'supporting pillar'.