

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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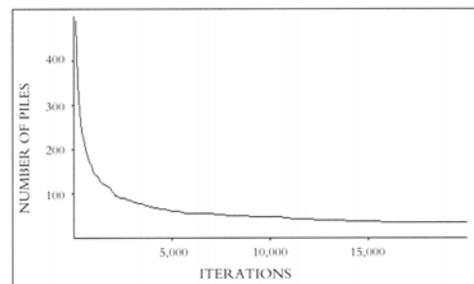
Demonstration

[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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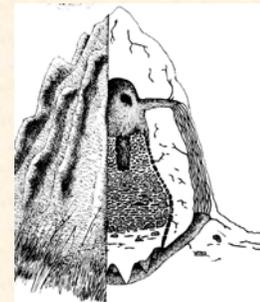
Mound Building by *Macrotermes* Termites



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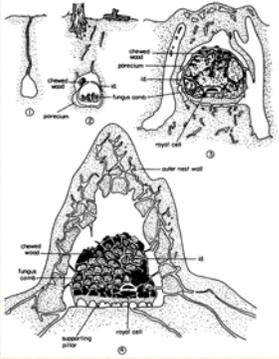
Structure of Mound



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figs. from Lüscher (1961)

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The diagram illustrates the four stages of mound construction by a termite colony. Stage 1 shows a small chamber made by the royal couple. Stage 2 shows an intermediate stage with a larger chamber and a surrounding wall. Stage 3 shows a further developed mound with a complex internal structure. Stage 4 shows a fully developed nest with a large, multi-chambered structure and a surrounding wall. Labels include: (1) chamber, (2) chamber, (3) chamber, (4) chamber, (5) chamber, (6) chamber, (7) chamber, (8) chamber, (9) chamber, (10) chamber, (11) chamber, (12) chamber, (13) chamber, (14) chamber, (15) chamber, (16) chamber, (17) chamber, (18) chamber, (19) chamber, (20) chamber, (21) chamber, (22) chamber, (23) chamber, (24) chamber, (25) chamber, (26) chamber, (27) chamber, (28) chamber, (29) chamber, (30) chamber, (31) chamber, (32) chamber, (33) chamber, (34) chamber, (35) chamber, (36) chamber, (37) chamber, (38) chamber, (39) chamber, (40) chamber, (41) chamber, (42) chamber, (43) chamber, (44) chamber, (45) chamber, (46) chamber, (47) chamber, (48) chamber, (49) chamber, (50) chamber, (51) chamber, (52) chamber, (53) chamber, (54) chamber, (55) chamber, (56) chamber, (57) chamber, (58) chamber, (59) chamber, (60) chamber, (61) chamber, (62) chamber, (63) chamber, (64) chamber, (65) chamber, (66) chamber, (67) chamber, (68) chamber, (69) chamber, (70) chamber, (71) chamber, (72) chamber, (73) chamber, (74) chamber, (75) chamber, (76) chamber, (77) chamber, (78) chamber, (79) chamber, (80) chamber, (81) chamber, (82) chamber, (83) chamber, (84) chamber, (85) chamber, (86) chamber, (87) chamber, (88) chamber, (89) chamber, (90) chamber, (91) chamber, (92) chamber, (93) chamber, (94) chamber, (95) chamber, (96) chamber, (97) chamber, (98) chamber, (99) chamber, (100) chamber.

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