# Artificial Intelligence:
# State Space Search part 3
# Informed Search
# Hill Climbing video #4

- Russell & Norvig – Sections 3.5.1, 3.5.2, 4.1.1

# Today

1. State Space Representation
2. State Space Search
    a) Overview
    b) Uninformed search
        1. Breadth-first Search and Depth-first Search
        2. Depth-limited Search
        3. Iterative Deepening
        4. Uniform Cost
    c) Informed search
        1. Intro to Heuristics
        2. Hill Climbing


        3. Greedy Best-First Search
        4. Algorithms A & A*
        5. More on Heuristics
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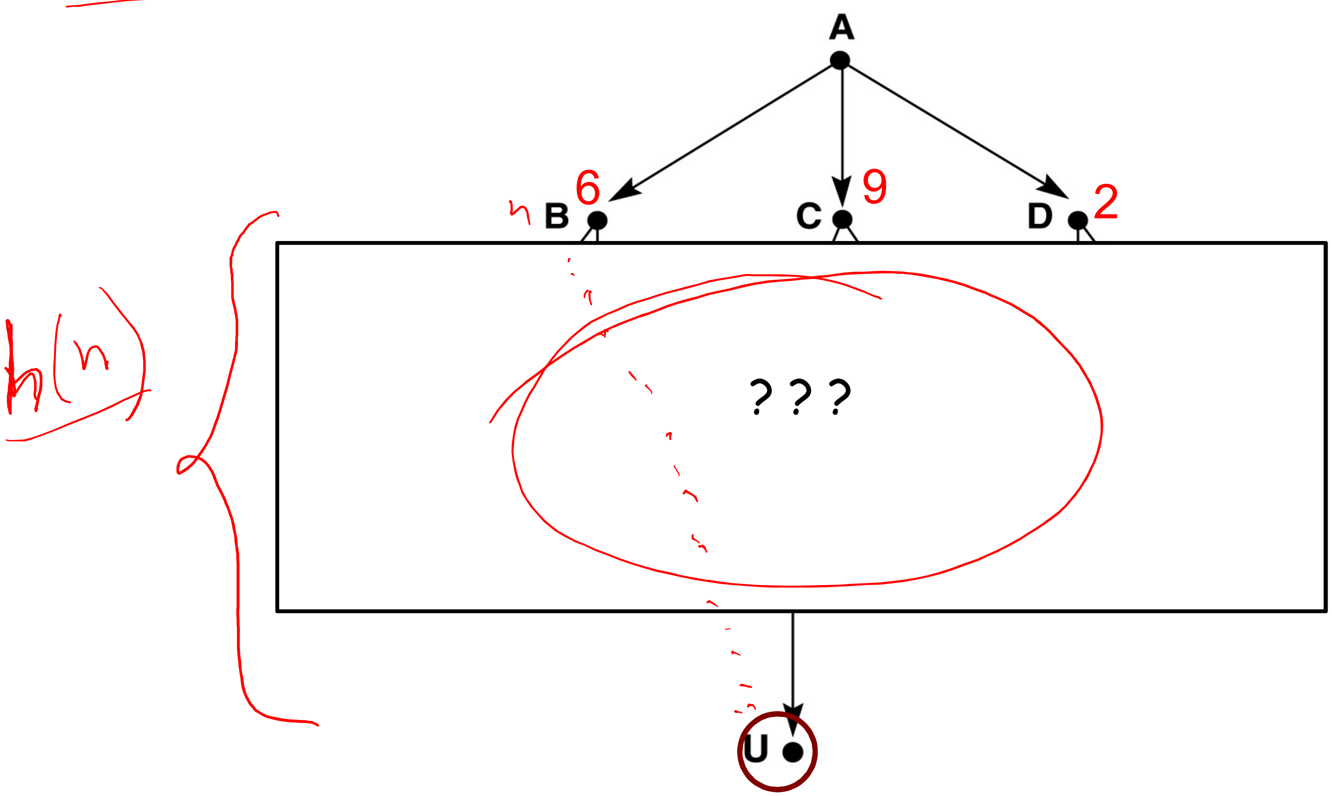
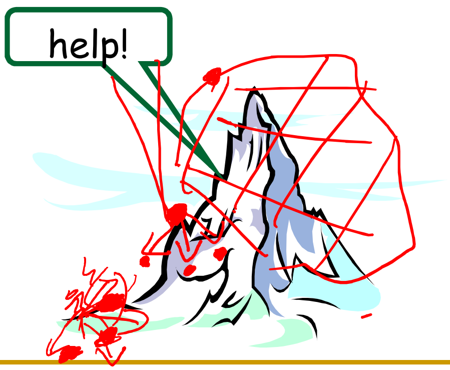
# h(n)




- **h(n)** = estimate of the lowest cost from *n* to *goal*

# Hill Climbing

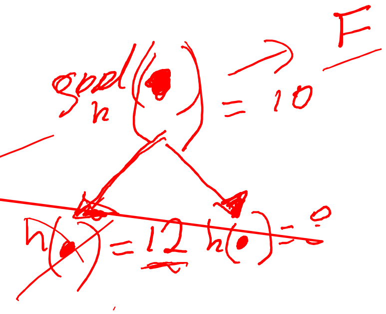
- General idea:
  - Similar to climbing a mountain in the fog with amnesia …
  - in the fog
    - --> only 1-step view of what is to come, so
    - if next step seems higher than where you are now -> go
    - otherwise, you assume you are at the top of the mountain -> stop
  - with amnesia -->
    - if you ever want to try other path, you can't because you did not keep track of where you came from



# Vanilla HC vs Steepest Ascent HC

## General Hill Climbing

- uses h(n)
- does not use an open list (amnesia)

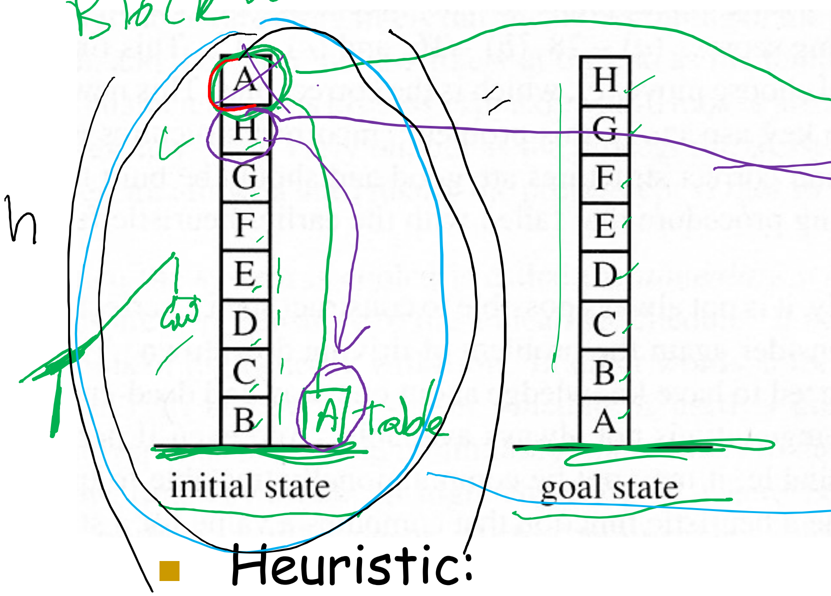



1. Vanilla Hill Climbing
   - take 1st successor s with better h() than current state n
   - i.e. if lower h(n) is better, chose 1st s with h(s) < h(n) // deep diving

2. Steepest ascent hill climbing:
   - generate all successor states S
   - run h() on all s ∈ S
   - among all successors s with better h() than current state n, take the successor s with the best h(n)

# Example: Hill Climbing

Block World




- **Operators:**
  - (1) `pickup&putOnTable(Block)`

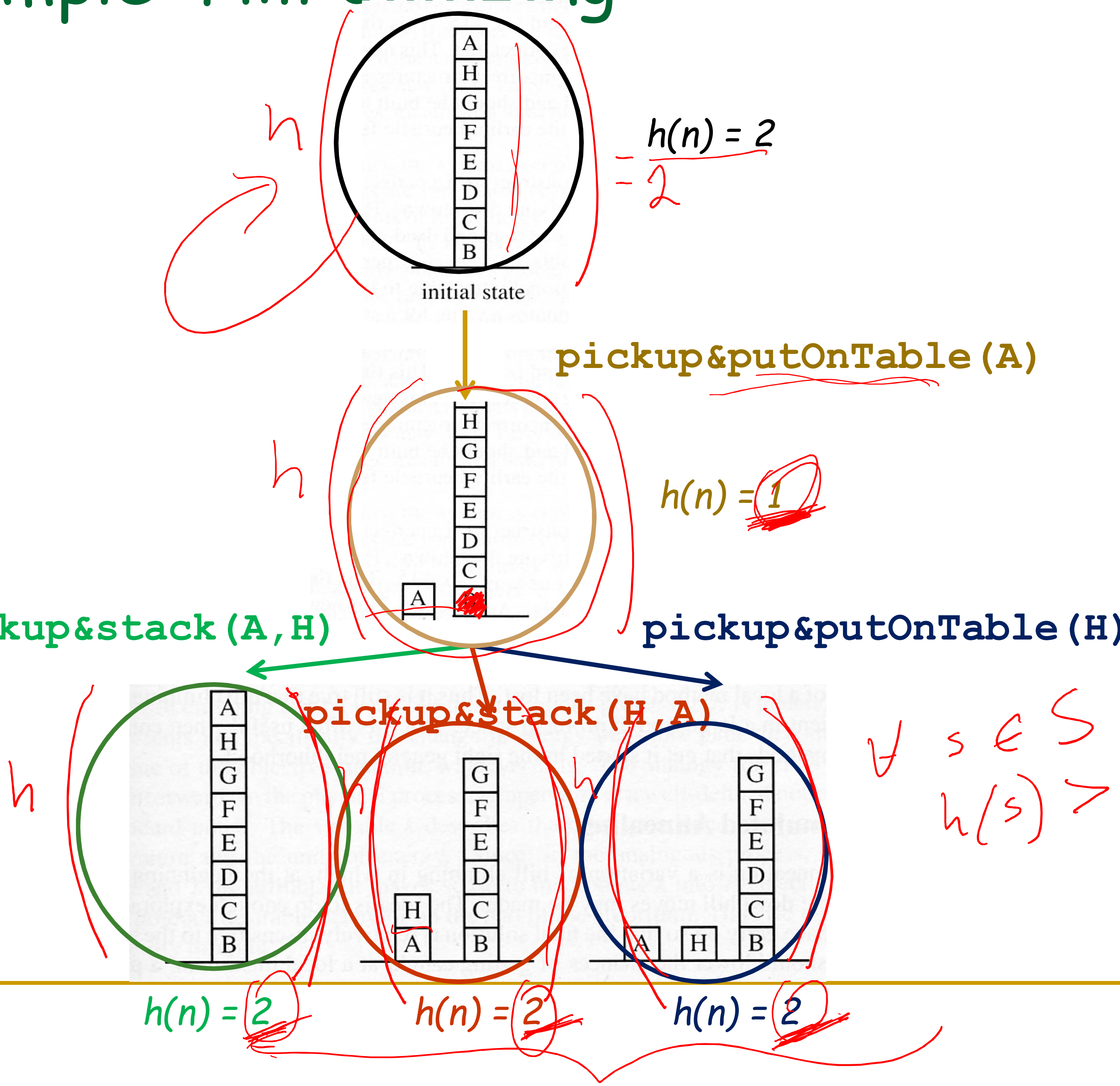
    pickup from Top of a stop & place on the Table
  - (2) `pickup&stack(Block1,Block2)`

    from the top of a stack & stack on Top of a stack

- **Heuristic:**
  - 0pt if a block is sitting where it is supposed to sit
  - +1pt if a block is NOT sitting where it is supposed to sit
  - so lower h(n) is better
    - h(initial) = 2
    - h(goal) = 0

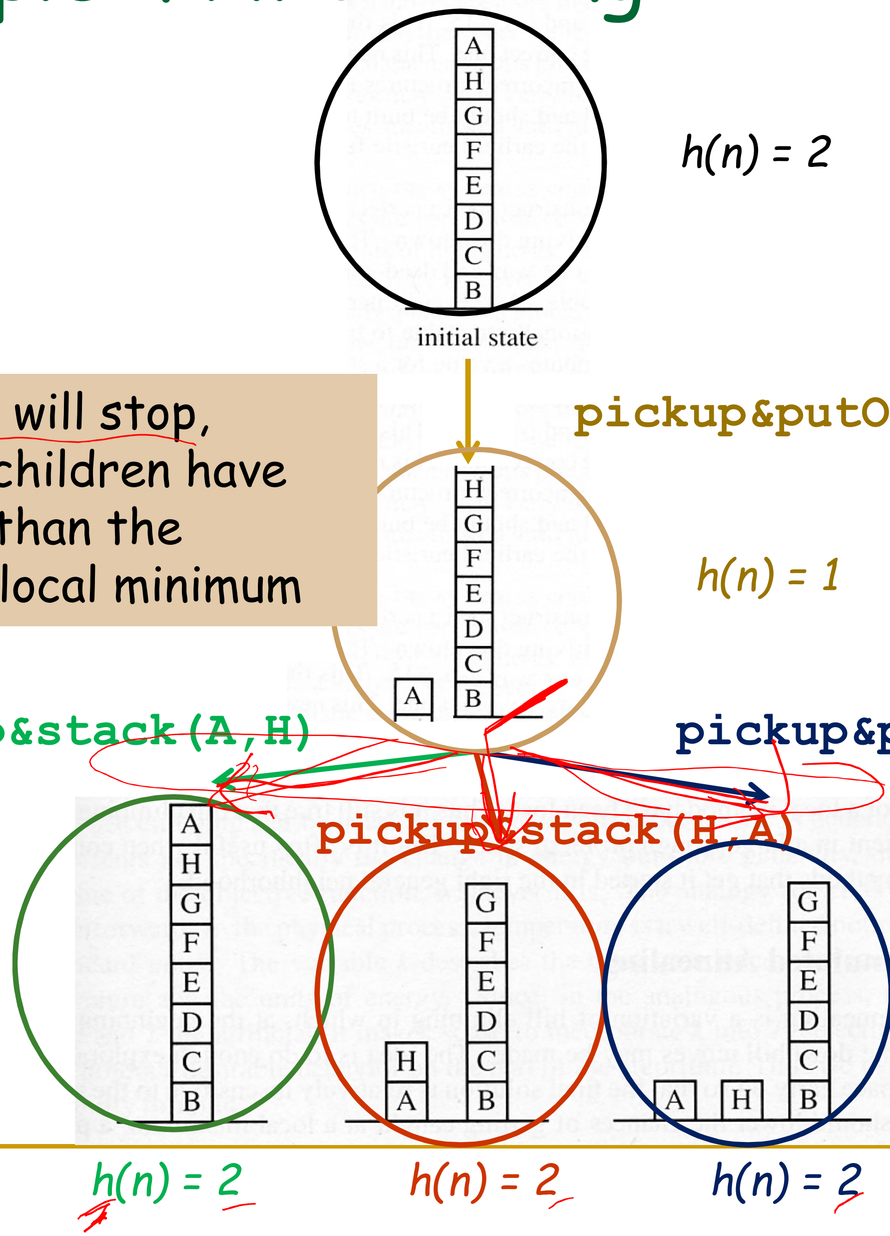

source: Rich & Knight, Artificial Intelligence, McGraw-Hill College 1991.

# Example: Hill Climbing

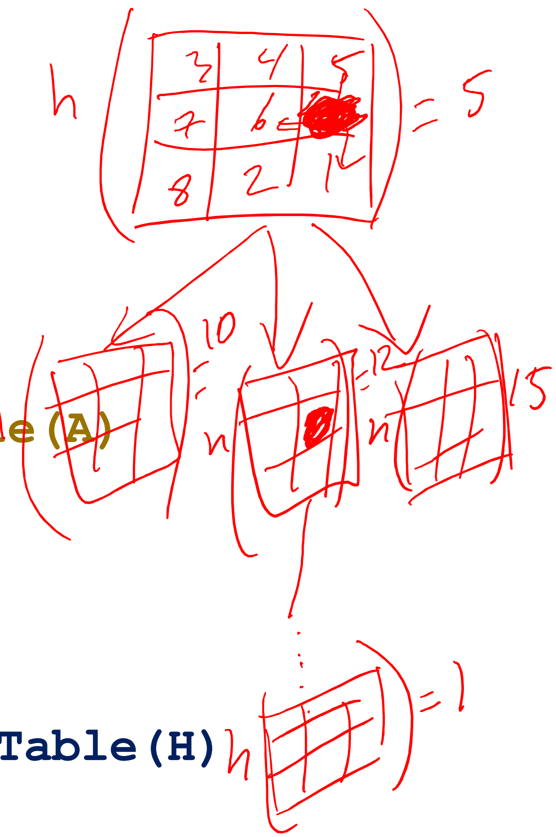



$\forall s \in S$
$h(s) > h(\text{parent})$

# Example: Hill Climbing




hill-climbing will stop, because all children have higher h(n) than the parent... --> local minimum




Don't be confused... a lower h(n) is better...

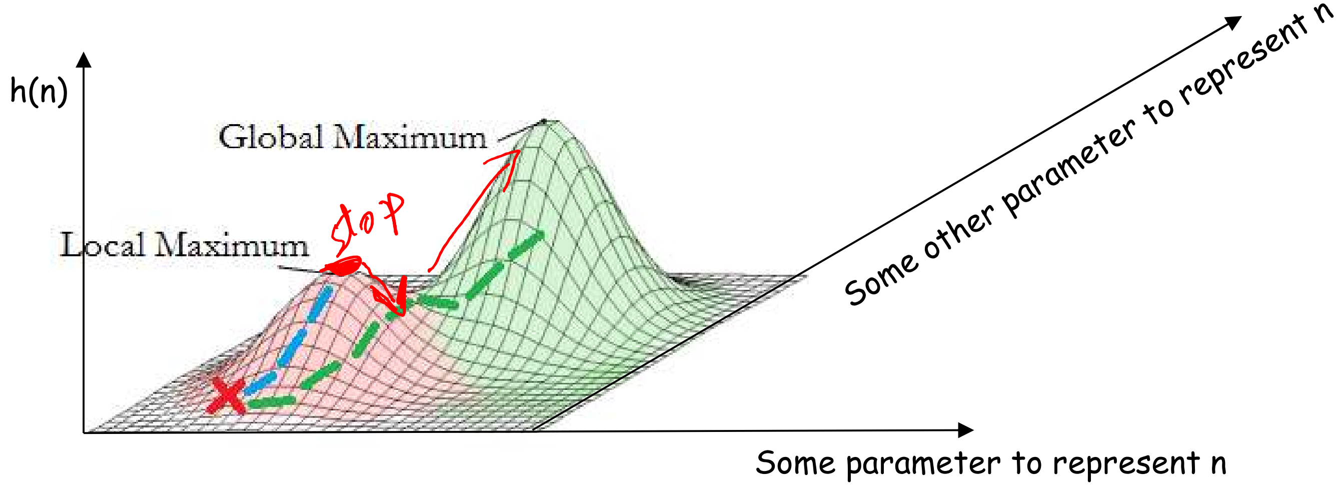
# Steepest Ascent Hill Climbing

```
currentNode = startNode;
    loop do
        L = CHILDREN(currentNode);
        nextEval = +INFINITY;
        nextNode = NULL;

        for all c in L
            if (HEURISTIC-VALUE(c) < nextEval) // lower h is better
                nextNode = c;
                nextEval = HEURISTIC-VALUE(c);

        if nextEval >= HEURISTIC-VALUE(currentNode)
            // Return current node since no better child state exist
            return currentNode;

        currentNode = nextNode;
```

*Adapted from https://en.wikipedia.org/wiki/Hill_climbing*

# Problems with Hill Climbing

- Foothills (or local optimum maxima)
  - reached a local maximum, not the global maximum
  - a state that is better than all its neighbors but is not better than some other states farther away.
  - at a local maximum, all moves appear to make things worse.
  - ex: 8-puzzle: we may need to move tiles temporarily out of goal position in order to place another tile in goal position



# Use of Hill Climbing

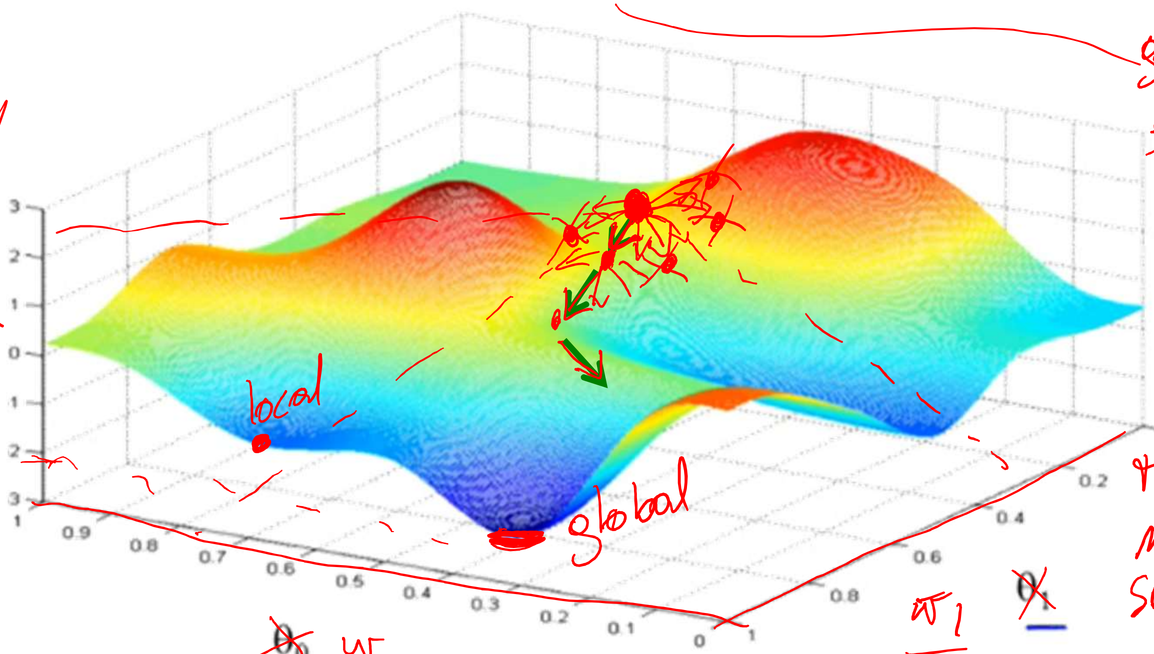
goal ( 1 2 3 / 4 5 6 / 7 8 ) → T, → F

- mostly for optimization problems
- i.e. goal defined not as a function of the state alone, but with respect of other states (eg. the *best* state I can reach)

goal ( ☐ ☐ ☐ )

eg

error/ loss function




find best combination of variables that minimizes some error function

Source: Andrew Ng

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# Problem with Hill-Climbing

- used mostly for optimization problems
  - where the goal state is defined with respect to other states
  - ex.  shortest path, longest....

- if goal state is independent of other states
  - we should be able to backtrack, and find another path to the goal
  - i.e. we should use an OPEN list
  - i.e. Greedy Best First Search

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