# Langton’s Ant

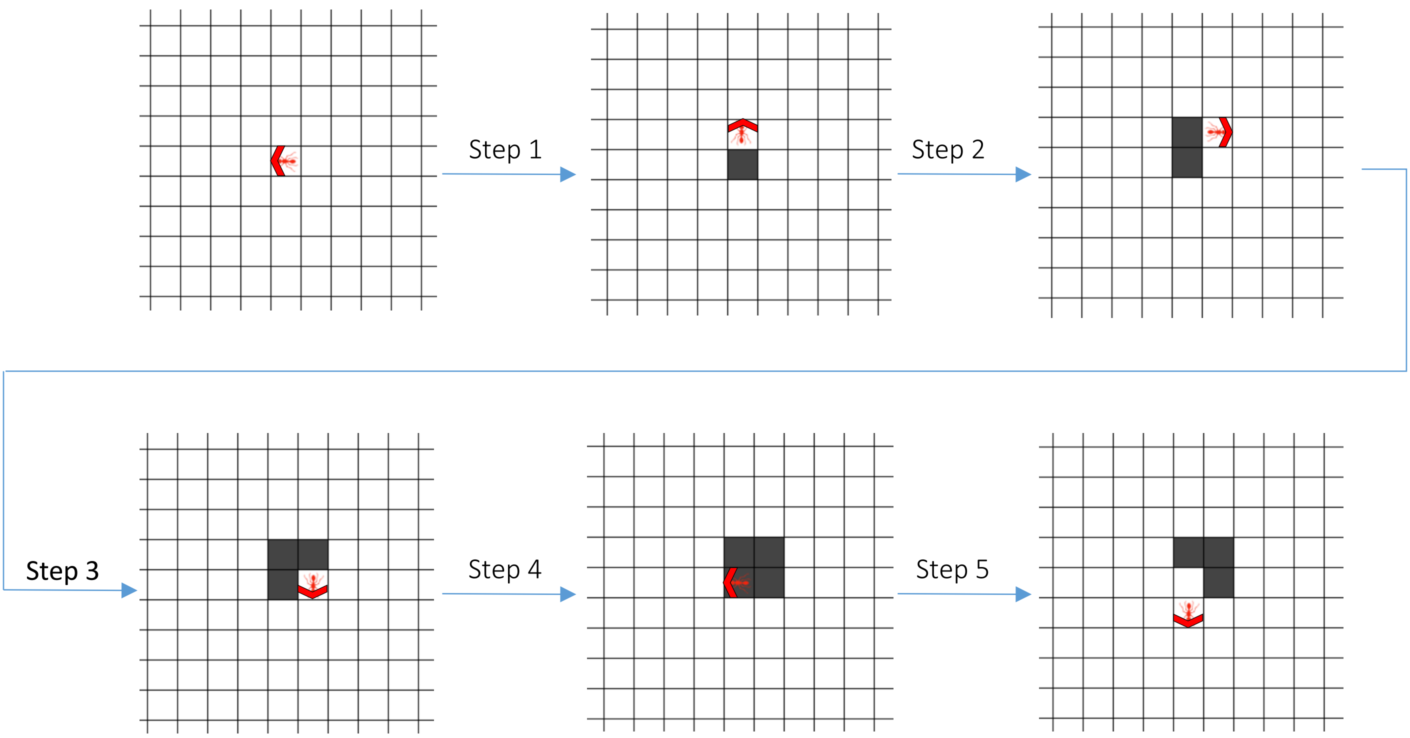
Langton’s ant (which, in this article, I’ll call Larry) is named after Chris Langton, who described it in 1986.

Larry moves on a grid whose cells (little squares) are either black or white, but this colour ‘flips’ if trodden on by Larry.

To make the ‘rules’ clear, I’ll set out the algorithm (set of instructions) for a single step here:

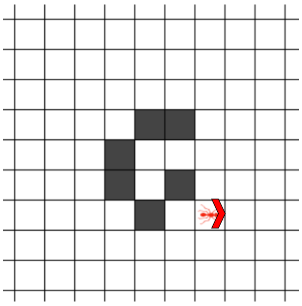
1. Larry arrives on a cell.
2. If this cell is white, she turns 90 degrees clockwise. If the cell is black, she turns 90 degrees anti-clockwise.
3. The colour of the cell flips (from white to black or from black to white)
4. Larry moves forward to the next cell.

Here are diagrams showing what happens for the first 5 steps (or *iterations* if you’d like to use a longer word) if we start on a grid of white squares, and consider that Larry has just arrived on the cell, facing left. (The makes clearer which direction Larry is facing, having arrived at a cell.)

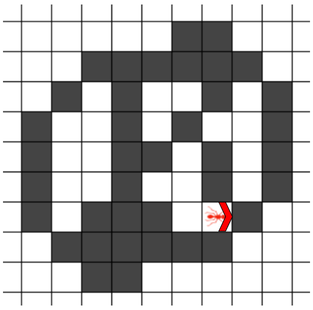



Even though Larry’s movement and the colours of the board are dictated by quite simple instructions, interestingly, the movement and pictures that follow appear fairly chaotic:

After 20 steps:



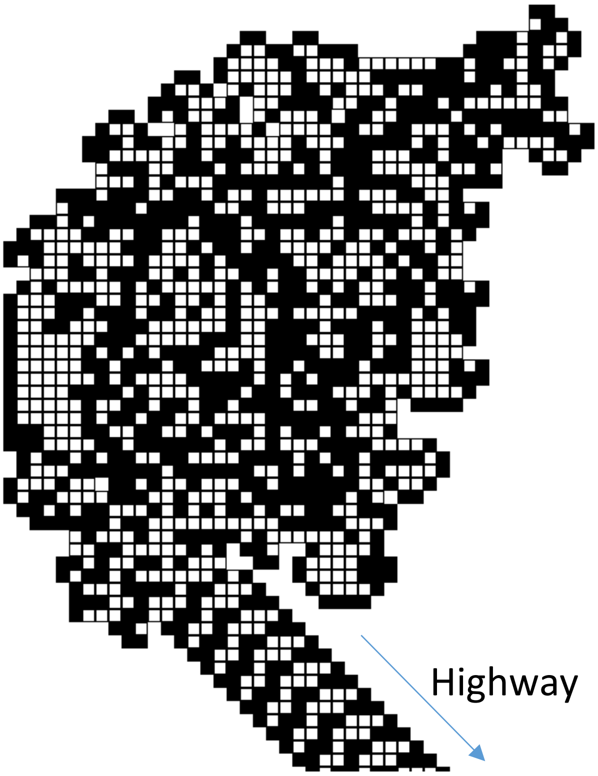
After about 200 steps:



Larry's movement remains quite chaotic for about 10,000 steps.

Then something remarkable happens.

The movement suddenly becomes *regular*, with a 104-step repeating effect that has come to be known as a *highway:*




Larry spends the rest of time travelling in the direction of the arrow, repeating a 104-step 'highway'-creating cycle.

The best way to see this is not in a static document but in an animation. It's easy to find an animation on the internet by searching for *Langton's Ant*. I recommend it!

Langton's ant serves as an example of how some simple instructions can lead to some seemingly unpredictable and surprising behaviour.

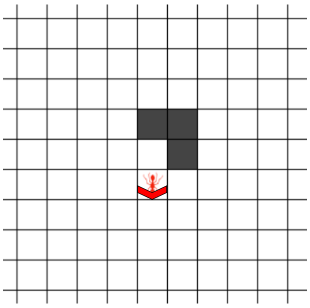
It is also an example of an unsolved problem in Maths:

We considered Larry's movement starting from a completely white grid. Many people have programmed simulations from grids that aren't just plain white. Fascinatingly, these all *seem to* end with a *highway* being built, like the one in the picture above, but **nobody has yet proved** that this is the case, at least at time of writing. Perhaps you will gain mathematical immortality by being the first to either prove that Larry will always end up building a highway, or, if this is not the case, be the first to find a grid pattern of black and white cells which doesn't end in a *highway* being built.

If you found this interesting, you may like to investigate other so-called *cellular automata.* Arguably the most famous is called *Conway's Game of Life*, which is rich with surprises from comparatively simple instructions.

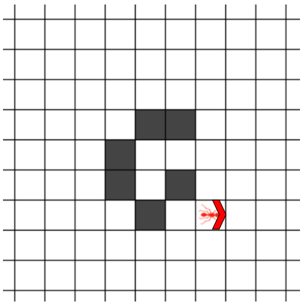
## Langton's Ant: Comprehension Questions:

1. After Step 5, the picture is as below:



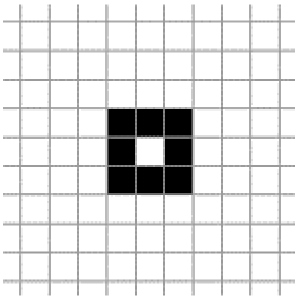
   Draw a picture to show the picture after step 6.

2. After Step 20, the picture is as below:



   Draw a picture to show the picture after step 21.

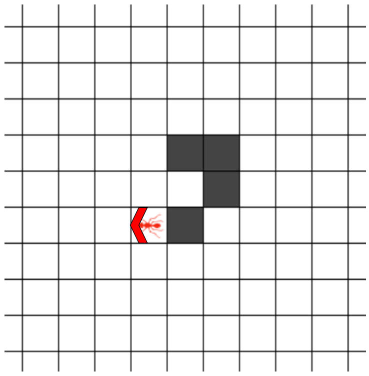
3. Suppose we place Larry on a board with the following configuration (You can assume that all cells that you can't see are white):



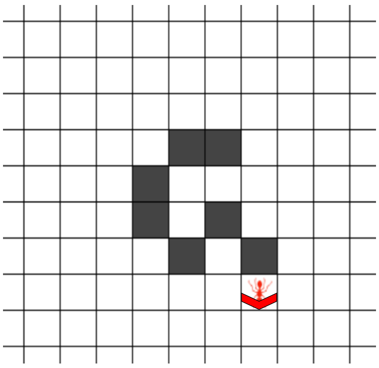
   Will Larry end up building a *highway*?

# Langton's Ant: Comprehension Answers:

1.



2.



3. Probably. No one has yet found a configuration that doesn't end up in a highway, but no one has been able yet to prove that they all will.

   I admit that I don't know for sure; I haven't tested this 'square' configuration.