Activity 11

Treasure Hunt—*Finite-State Automata*

Summary

Computer programs often need to process a sequence of symbols such as letters or words in a document, or even the text of another computer program. Computer scientists often use a finite-state automaton to do this. A finite-state automaton (FSA) follows a set of instructions to see if the computer will recognise the word or string of symbols. We will be working with something equivalent to a FSA—treasure maps!

Curriculum Links

- ✓ Mathematics: Developing logic and reasoning—using words and symbols to describe and continue patterns
- ✓ Social Studies
- ✓ English

Skills

- ✓ Simple map reading
- ✓ Recognising patterns
- ✓ Logic
- ✓ Following instructions

Ages

- ✓ 9 and up

Materials

You will need:

- ✓ One set of island cards (the instructions must be kept hidden from those trying to draw the map!)
  Copy Photocopy Master: Island cards (page 92 onwards) and cut out.
  Fold along the dotted line and glue, so that the front of the card has the name of the island, and the back has the instructions.

Each child will need:

- ✓ Worksheet Activity: Find your way to the riches on Treasure Island (page 91)
- ✓ Pen or pencil

There are optional extension activities, for which each child will need:

- ✓ Worksheet Activity: Treasure islands (page 97)
- ✓ Worksheet Activity: The mysterious coin game (page 98)

Treasure Island

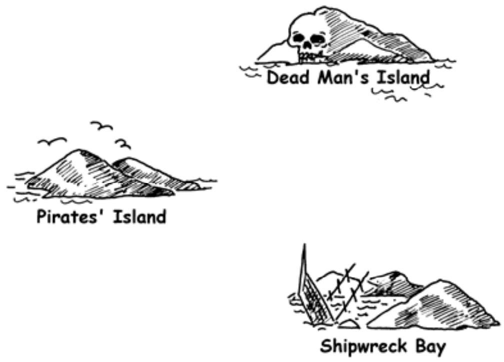
Introduction

Your goal is to find Treasure Island. Friendly pirate ships sail along a fixed set of routes between the islands in this part of the world, offering rides to travellers. Each island has two departing ships, A and B, which you can choose to travel on. You need to find the best route to Treasure Island. At each island you arrive at you may ask for either ship A or B (not both). The person at the island will tell you where your ship will take you to next, but the pirates don't have a map of all the islands available. Use your map to keep track of where you are going and which ship you have travelled on.

Demonstration

(**Note:** This is a different map from the actual activity.)

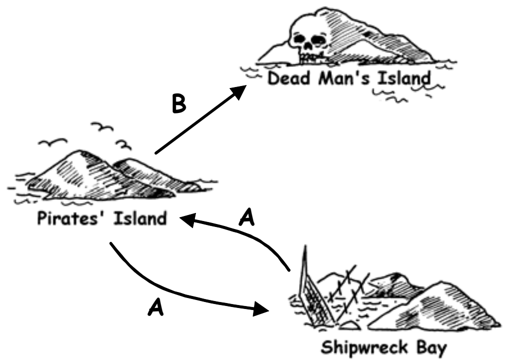
Using an OHP or board, draw a diagram of three islands as shown here:



Copy the three cards on the next two pages, and have one child hold each card. Note that the routes on these cards are different from those in the main activity.

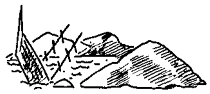
Starting at Pirates' Island ask for ship A. The child should direct you to Shipwreck Bay. Mark the route in on the map. At Shipwreck Bay ask for ship A again. You will be directed back to Pirates' island. Mark this on the map. This time ask for ship B. Mark this on the map. This route goes to Dead Man's Island, at which stage you will be stuck!

Your final map should look like this:



Cards for demonstration activity

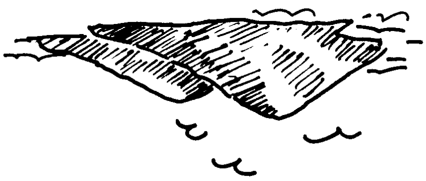
Pirates' Island

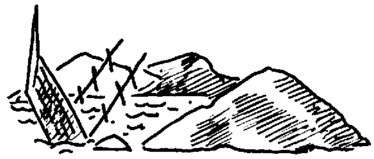
A → 

Shipwreck Bay

B → 

Pirates' Island





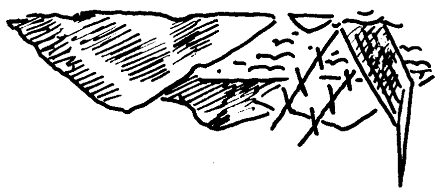
Shipwreck Bay

A → 

Pirates' Island

B → 

Shipwreck Bay



Cards for demonstration activity

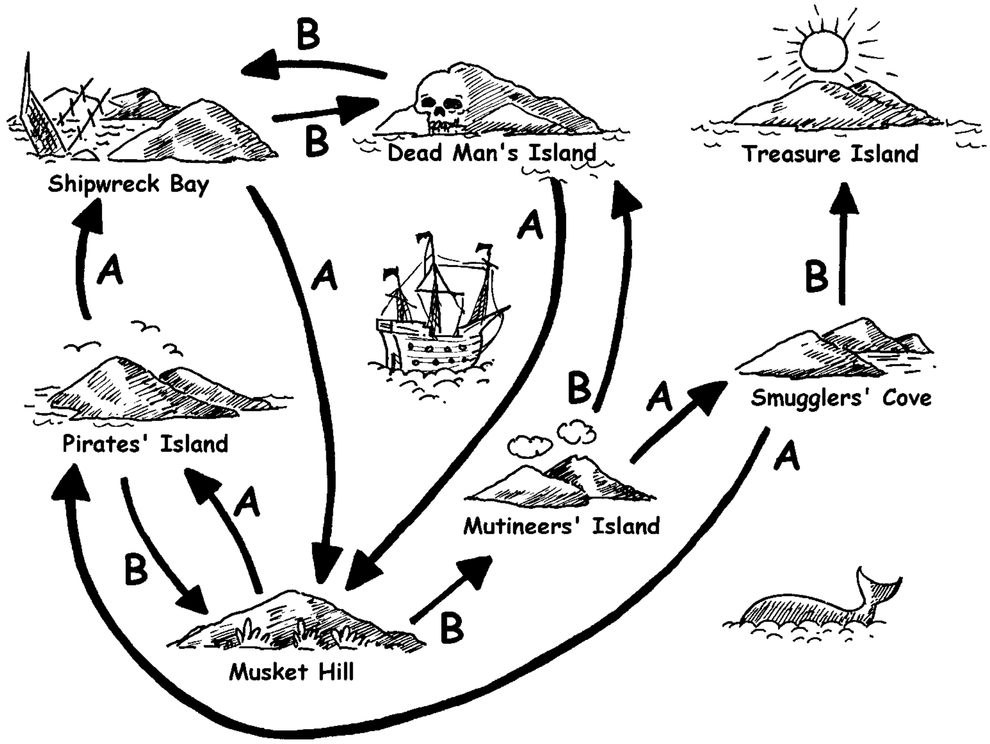
No ships sail from
Dead Man's Island!

Activity

Choose 7 children to be "islands". The children will hold cards identifying their island, with the secret instructions on the back. Position them randomly around the room or playground. The rest of the children are given the blank map and have to navigate a route from Pirates' Island to Treasure Island, marking it carefully on their maps. (It is a good idea to send the children off one at a time so they cannot hear the routes in advance.)

Fast Finishers: Try to find more than one route.

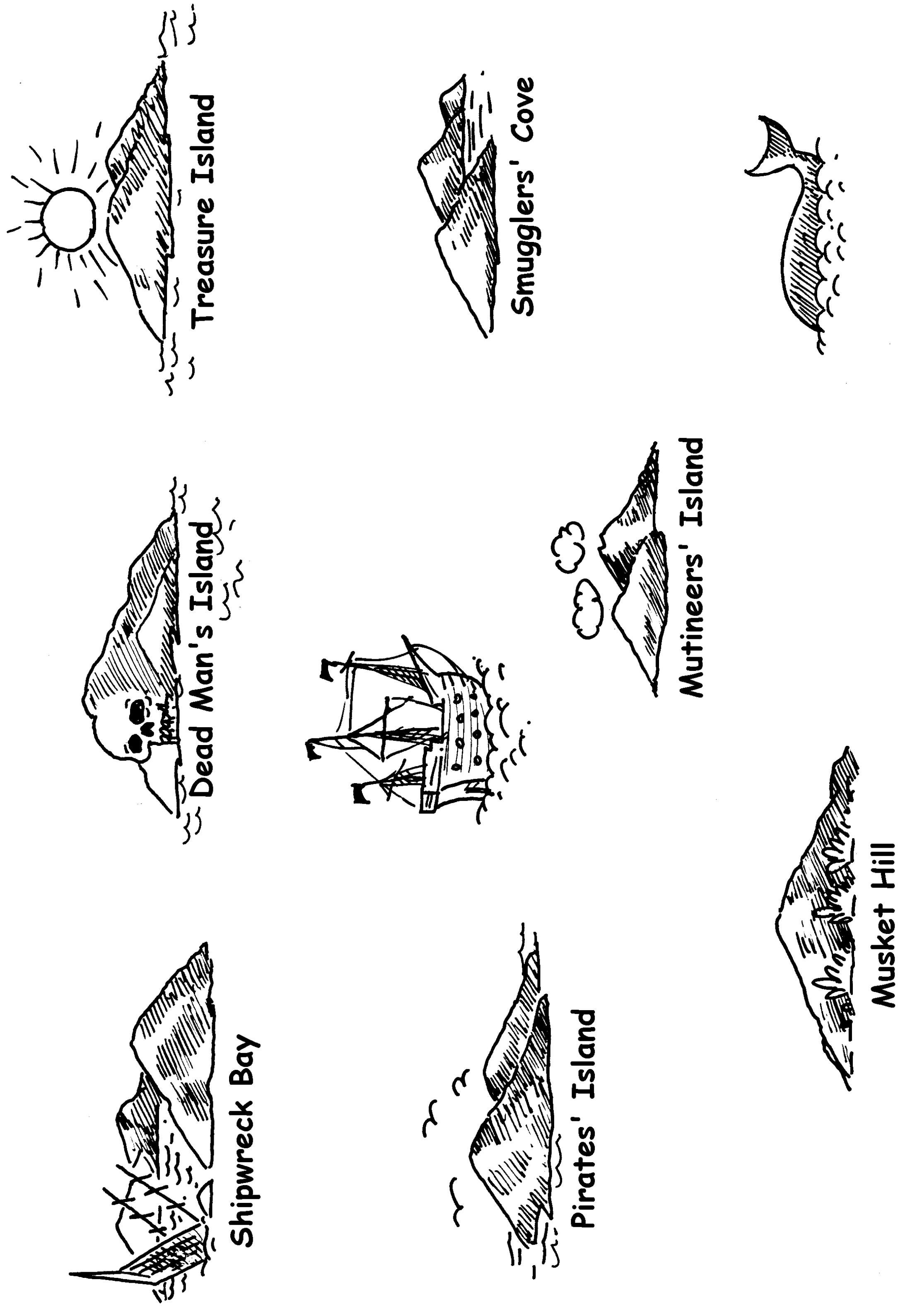
The complete map looks like this:



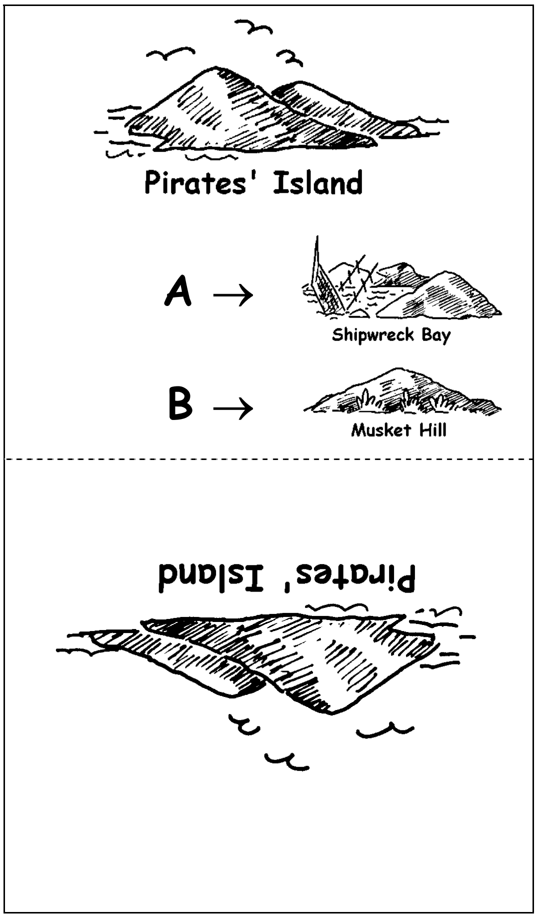
Follow-up discussion

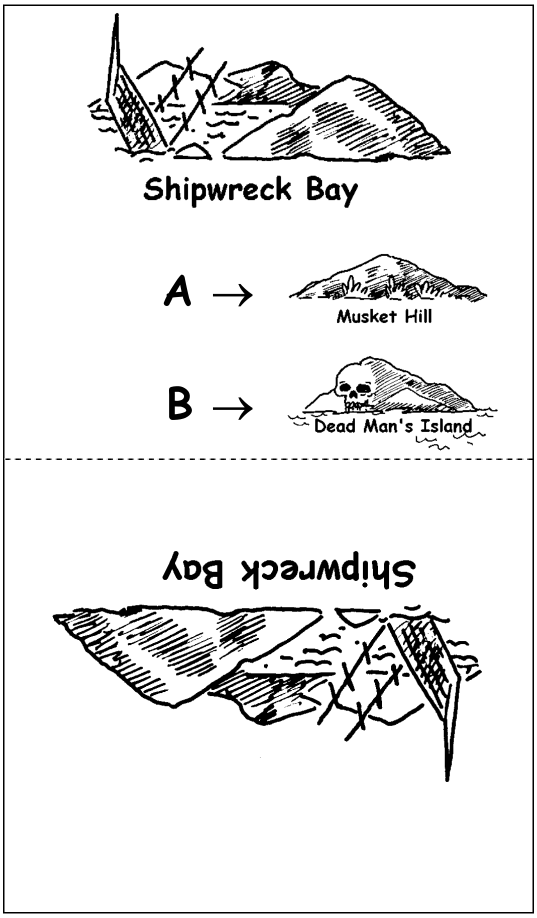
What is the quickest route? What would be a very slow route? Some routes may involve loops. Can you find an example of this? (For example, BBBABAB and BBBABBABAB both get to Treasure Island.)

Worksheet Activity:
Find your way to the riches on Treasure Island

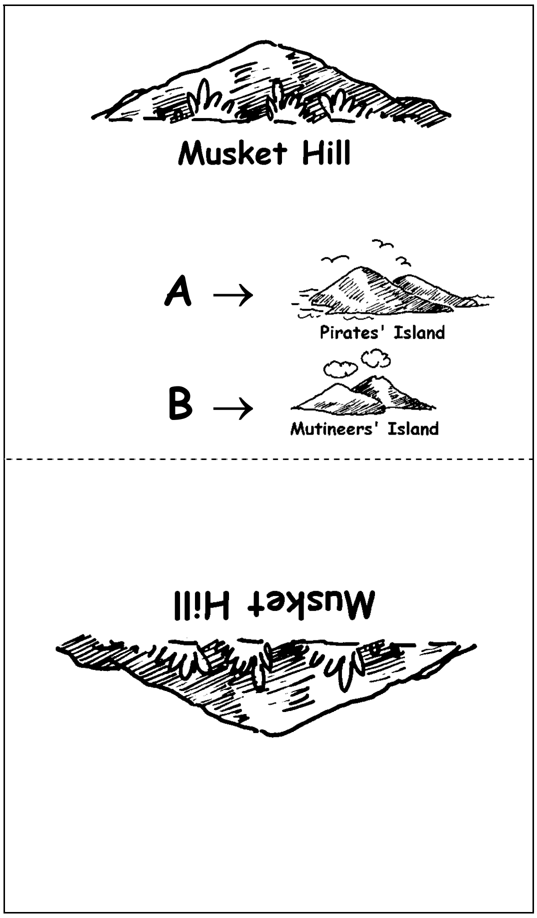


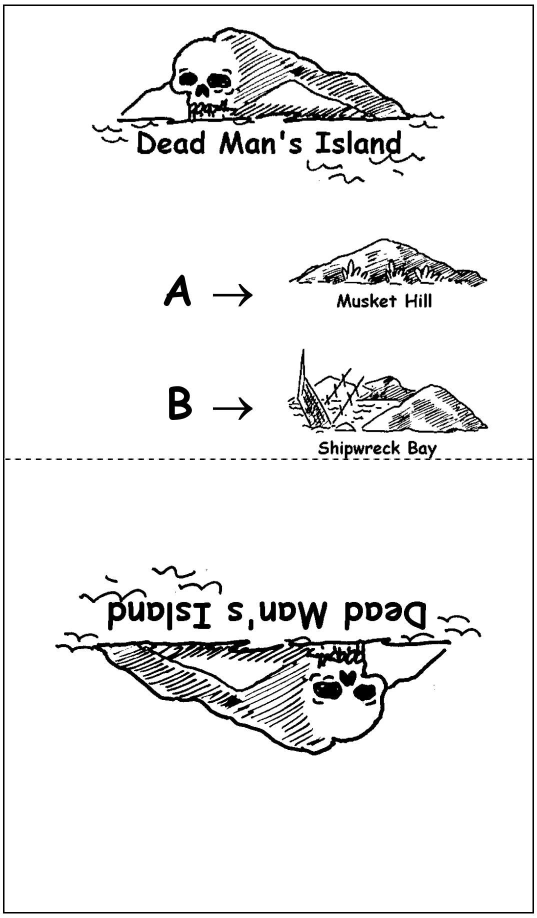
Photocopy Master: Island cards (1/4)





Photocopy Master: Island cards (2/4)





Photocopy Master: Island cards (3/4)

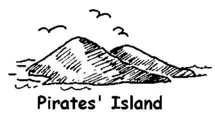
Mutineers' Island

A → 

B → 

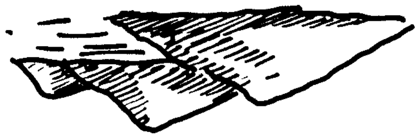
Mutineers' Island

Smugglers' Cove

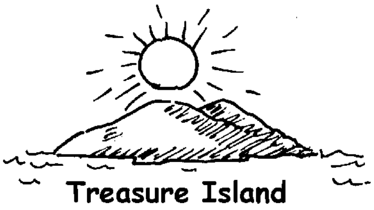
A → 

B → 

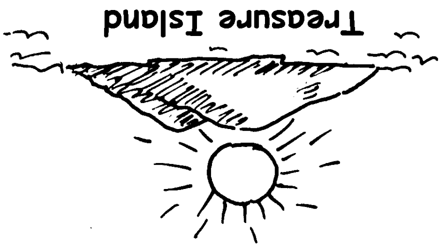
Smugglers' Cove



Photocopy Master: Island cards (4/4)

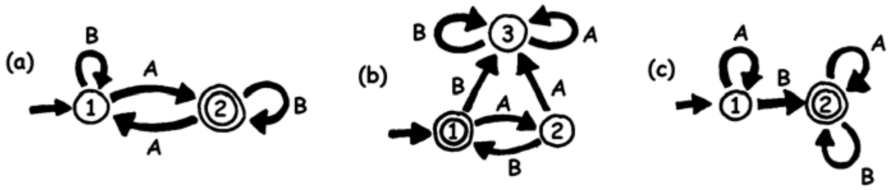


Congratulations!



Finite-State Automata

Another way of drawing a map is like this:



The islands are shown as numbered circles, and the final island (with the treasure) has a double circle. What routes can we travel around to get to the final island?

Note: Map (a) will finish at the double circle (island 2) only if the sequence has an odd number of As (for example, AB, BABAA, or AAABABA).

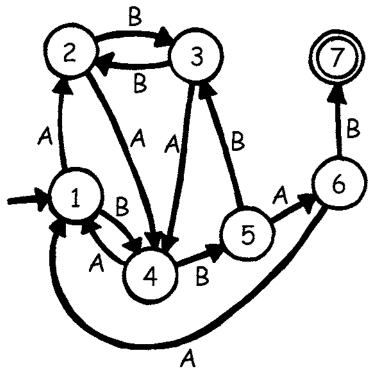
Map (b) only gets to the double circle with an alternating sequence of As and Bs (AB, ABAB, ABABAB, ...).

Map (c) requires that the sequence contains at least one B (the only sequences *not* suitable are A, AA, AAA, AAAA, ...).

Worksheet Activity: Treasure Islands

Can you hide your buried treasure well? How hard can you make it to find the treasure? It's time to make your own map!

1. Here is a more complicated version of the same idea of representing a map. This map is the same as for the previous exercise. Computer Scientists use this quick and easy way of designing routes for their patterns.

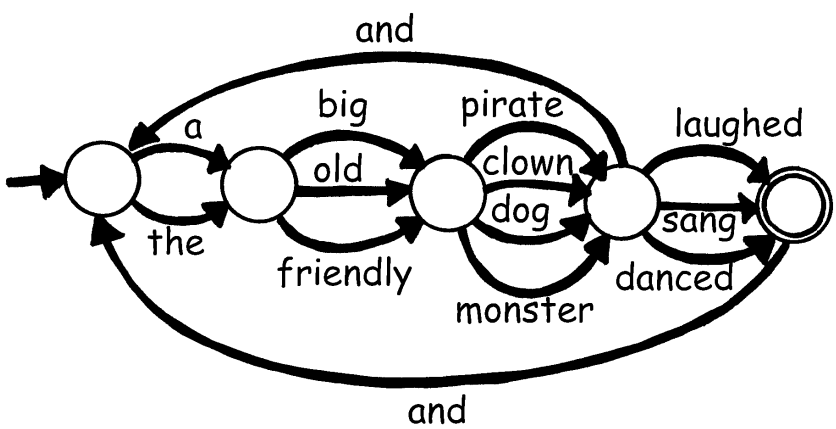


Draw your own basic plan like this so you can clearly see the routes your Pirate ships will travel and then make up your own blank maps and island cards. What is the most efficient sequence of routes to reach your Treasure Island?

2. How well can your friends follow your map? Give them a sequence of As and Bs, and see if they can reach the correct island.

You can make up a variety of games and puzzles based on this idea of finite-state automata.

3. Here is a way of constructing sentences by choosing random paths through the map and noting the words that are encountered.



Now try the same idea for yourself. Perhaps you could even make up a funny story!

Worksheet Activity: The Mysterious Coin Game

Some friends downloaded a game from the Internet in which a robot flipped a coin and they had to guess whether it would turn up heads or tails. At first the game looked very easy. At least they would have a 50/50 chance of winning—or so they thought! After a while though they started to get suspicious. There seemed to be a pattern in the coin tosses. Was the game rigged? Surely not! They decided to investigate. Joe wrote down the results of their next attempts at the game and this is what they found: (h = heads, t = tails)

```
h h t h h t h h h t t h h h h t t h t t t h h h h h t h h h
t t t h h h t t t h h h h h t t h t t t t t h t t h t t t
h h h t t h h h t h h h h h h h h t t h h h t t t t h h h
h h t t t t t t t
```

Can you find a predictable pattern?

There is a very simple 'map' that will describe the sequence of coin tosses. See if you can figure it out. (**Hint:** it has just 4 'islands')

What’s it all about?

Finite-state automata are used in Computer Science to help a computer process a sequence of characters or events.

A simple example is when you dial up a telephone number and you get a message that says “Press 1 for this … Press 2 for that … Press 3 to talk to a human operator.” Your key presses are inputs for a finite state automaton at the other end of the phone. The dialogue can be quite simple, or very complex. Sometimes you are taken round in circles because there is a peculiar loop in the finite-state automaton. If this occurs, it is an error in the design of the system—and it can be extremely frustrating for the caller!

Another example is when you get cash from a bank cash machine. The program in the machine’s computer leads you through a sequence of events. Inside the program all the possible sequences are kept as a finite-state automaton. Every key you press takes the automaton to another state. Some of the states have instructions for the computer on them, like “dispense $100 of cash” or “print a statement” or “eject the cash card”.

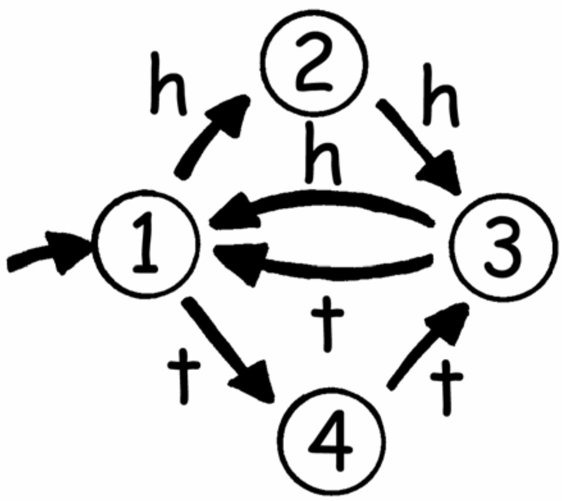
Some computer programs really do deal with English sentences using maps like the one on page 97. They can both generate sentences themselves, and process sentences that the user types in. In the 1960s a computer scientist wrote a famous program called “Eliza” (after Eliza Dolittle) that had conversations with people. The program pretended to be a psychotherapist, and came out with leading questions like “Tell me about your family” and “Do go on.” Although it didn’t “understand” anything, it was sufficiently plausible—and its human users were sufficiently gullible—that some people really did think they were talking to a human psychotherapist.

Although computers are not really very good at understanding natural language, they can readily process artificial languages. One important type of artificial language is the programming language. Computers use finite-state automata to read in programs and translate them into the form of elementary computer instructions, which can then be “executed” directly by the computer.

Solutions and hints

The Mysterious Coin Game (page 98)

The mysterious coin game uses the following map to toss coins:



If you follow it, you will see that the first two coin tosses of each three have the same outcome.