

COS 116
The Computational Universe
More about self-reproducing programs

This handout gives more details on the construction of self-reproducing programs, which was sketched in Lecture 10. In this construction we assume that the machine has an “output” tape on which it can write English symbols. (Alternatively, we can assume that instead it represents English letters using some binary code.)

The self-reproducing program has two parts -- Part A followed by Part B.

First we consider Part B. It is some kind of a translator program, which is capable of two types of translations. First, whenever it is started with some sequence of bits on the tape, say *V*, it first produces the sequence of instructions that would print this sequence. For example, if *V* is the series of bits 001, the sequence of instructions that produce it could be:

```
PRINT 0
GO RIGHT
PRINT 0
GO RIGHT
PRINT 1
GO RIGHT
```

It simply writes these symbols (P-R-I-N- etc) on the tape. This is the first act of “translation.”

Next Part B will print the program whose binary code is exactly *V*, the sequence of bits it was given. In our simple example where *V* is 001, this program would simply be “PRINT 1” according to the notation in the Davis article. This is the second act of “translation.”

Note that Part B is easy to write since the two “translations” are so mechanical (although it is a bit more complex than in our 001 examples above).

Having written Part B, we turn to Part A. It is simply the sequence of PRINT instructions that would print the binary code of B.

How does the self-reproduction happen? When we run the program with a blank tape, Part A executes first, and prints a bit sequence of bits onto the tape – these bits are the binary code of Part B. Then Part B takes over. It finds a sequence of bits on the tape (which happen to be its own binary code, but it doesn’t “know” this). After Part B does its two translations, it produces both Part A and Part B (itself!)

This construction of a self-reproducing program can be easily modified to give the self-reproducing program any desired functionality – such as deleting your files, or mailing itself to all email addresses in your address book. This is how computer viruses work.

Finally, just for fun, here is a program in the language “C” that reproduces itself:

```
main() { char *s="main() { char *s=%c%s%c; printf(s,34,s,34); }"; printf(s,34,s,34); }
```