

CONTENTS

Acknowledgments	3
Introduction	4
Evolving Monkey	5
The Past and Present	5
The Future	7
Use This Book	8
1 Compilers & Virtual Machines	10
Compilers	11
Virtual and Real Machines	14
Real Machines	14
What Is a Virtual Machine?	19
Why Build One?	21
Bytecode	23
What We're Going to Do, or: the Duality of VM and Compiler	24
2 Hello Bytecode!	26
First Instructions	27
Starting With Bytes	28
The Smallest Compiler	32
Bytecode, Disassemble!	37
Back to the Task at Hand	41
Powering On the Machine	43
Adding on the Stack	49
Hooking up the REPL	55
3 Compiling Expressions	57
Cleaning Up the Stack	57
Infix Expressions	61
Booleans	65
Comparison Operators	69
Prefix Expressions	76
4 Conditionals	82
Jumps	85
Compiling Conditionals	87
Executing Jumps	100
Welcome Back, Null!	103
5 Keeping Track of Names	110

The Plan	111
Compiling Bindings	112
Introducing: the Symbol Table	114
Using Symbols in the Compiler	117
Adding Globals to the VM	120
6 String, Array and Hash	125
String	125
Array	130
Hash	134
Adding the index operator	140
7 Functions	146
Dipping Our Toes: a Simple Function	146
Representing Functions	147
Opcodes to Execute Functions	148
Compiling Function Literals	151
Compiling Function Calls	164
Functions in the VM	166
A Little Bonus	176
Local Bindings	176
Opcodes for Local Bindings	177
Compiling Locals	180
Implementing Local Bindings in the VM	191
Arguments	200
Compiling Calls With Arguments	201
Resolving References to Arguments	205
Arguments in the VM	208
8 Built-in Functions	216
Making the Change Easy	217
Making the Change: the Plan	222
A New Scope for Built-in Functions	223
Executing built-in functions	227
9 Closures	233
The Problem	234
The Plan	235
Everything's a closure	236
Compiling and resolving free variables	246
Creating real closures at run time	257
10 Taking Time	262
Resources	267
Feedback	270
Changelog	271