

INDEX

Symbols & Numbers

- &body keyword, 344
- * (asterisk), in variable names, 23
- *board-scale* variable, 406
- *dice-scale* variable, 403
- *from-tile* variable, 411
- *num-players* variable, 418
- *print-circle* variable, 111
- *standard-output* variable, 364
- *top-offset* variable, 403
- @ (at), in control sequence parameters, 223
- ` (backquote), 344
 - for enabling switching from data to code mode, 73
- \ (backslash), for escaped characters, 35
- : (colon), for keyword parameters, 81, 122
- :@ flag, for columns in tables, 230–231
- :if-exists keyword parameter, 243
- :initial-value keyword parameter, 168
- :junk-allowed parameter, 260
- :pretty parameter, 117
- :radix parameter, 260
- :test keyword parameter, 141
 - to use equal, 204
- . (dot), for representing cons cells, 39
- " (double quotes), for strings, 35
- = (equal sign) function, 65
- # (hash mark), for array, 154
- #\newline, 89
- #\space, 89
- #\tab, 89
- #' (function) operator, 75
- #S prefix, for structures, 164
- < (less-than) function, with sort, 170

- () parentheses
 - for calling commands and functions, 22, 24
 - empty lists, 25
 - symmetry of nil and, 49–52
 - for list of declared variables in let, 28
 - for organizing code into lists, 33
- ' (single quote), as data indicator, 37
- ~ (tilde), for control sequences, 223
- ~& control sequence, 227
- ~< control sequence, 229
- ~> control sequence, 229
- ~;; control sequence, 232
- ~{ control sequence, 231
- ~} control sequence, 231
- ~\$ control sequence, 223, 226
- ~% control sequence, 227–228
- ~a control sequence, 223–224
- ~b control sequence, 225
- ~d control sequence, 225
- ~f control sequence, 226
- ~t control sequence, 228–229
- ~x control sequence, 225
- | (vertical pipe), for case-sensitive symbols, 89
- 404 error page, 265

A

- ab-get-ratings-max function, 395–396
- ab-get-ratings-min function, 395–396
- ab-rate-position function, 397
- academic research, 8
- accum function, 459
- accumulator, 332
- ~a control sequence, 223–224
- across in loop macro, 201, 320

- add-cops function, 140, 141–142
- add function, predicates in, 171
- add-new-dice function, 316–317, 333–334, 425
- add-passing-move function, 312, 384–385
- add-plants function, 204, 212
- add-two function, 299–300
- add-widget function, 296–297, 298
- AI (artificial intelligence), 8
- alists. *See* association lists (alists)
- Allegro Common Lisp, 18
- alpha beta pruning, 393–400
 - and chance nodes, 423
- alphanumericp function, 117
- always in loop macro, 201
- Amazon S3, 160
- anaphoric macros, 347
- and in loop macro, 201
- and operator, 58
- announce-winner function, 320
- ANSI Common Lisp (CL), 15–16, 17–18. *See also* Common Lisp (CL)
- append function, 75, 76, 143
- append in loop macro, 201
- apply function, 76
- apt-get install clisp, 18
- ARC assembly, 5
- Arc Lisp dialect, 17, 359, 459
- aref function, 154
 - and performance, 156
- arrayp function, 170
- arrays, 153–157
 - vs. lists, 156–157
 - for monsters, 173
 - sequence functions for, 166
 - sum function for, 169
- artificial intelligence (AI), 8
- ASCII code, 260
 - code-char function to convert, 308
- ash (arithmetic shift) function, 25–26
- as in loop macro, 201
- assemblers, 5
- assembly languages, 5
- assoc function, 71, 83, 112
- association lists (alists), 111–112, 141
 - attributes for print-tag, 359
 - of known nodes, 146
 - nested, 142
 - for nodes in city, 142
 - for scenery description, 70–71
 - web request parameters in, 261
 - writing to file, 243
- asterisk (*), in variable names, 23
- at (@), in control sequence
 - parameters, 223
- at-loc-p function, 78
- attacking-moves function, 313–314, 385, 419
- Attack of the Robots! game, 233–234
- Autocode, 5

B

- backquote (`), 344
 - for enabling switching from data to code mode, 73
- backslash (\), for escaped characters, 35
- ~b control sequence, 225
- being in loop macro, 200
- below in loop macro, 196
- bidirectional stream, 247
- bigger function, 27
- binary, number display as, 225
- binary search, 23, 26
- blocking operation, 247
- board-array function, 308
- board-attack-fail function, 419–420
- board-attack function, 315–316
- *board-scale* variable, 406
- &body keyword, 344
- Boolean values, manipulating, 58
- branching, 56–57
 - with case form, 57–58
- breaking out of loop, 198
- brevity of code, 459
- brightness function, 361
- bug fighters
 - Clojure Lisp, 461
 - comic book, 429–463
 - Common Lisp Object System (CLOS), 451
 - continuations, 454
 - domain-specific language, 450
 - exception handling, 444–445
 - functional programming, 441
 - generic setters, 447
 - lazy evaluation, 462
 - macros, 443

- bugs, functional programming to
 - reduce, 301
- by in loop macro, 201
- C**
- C++ language, 9, 10, 32
 - #define directive, 340
- cached results, clearing, 398
- cache misses, performance
 - impact, 160
- cadadar function, 42
- cadadr function, 42
- cadr function, 40–41
- calc-pt function, 403
- capitalized text, converting all
 - caps to, 97
- capturing console output, 123
- car function, 40–41, 75
- case form, branching with, 57–58
- case-insensitivity, of symbols, 33
- case of text, adjusting, 97
- case-sensitive symbols, 89
- cdr function, 40, 143–144
- cells, retrieving item from first slot, 40
- centered columns, 230
- chain of cons cells, 40, 108
- chance nodes, in game tree, 418–420
- characterp function, 170
- characters
 - comparison, 65
 - literal, 89
 - for padding numbers, 225
- char-downcase function, 99
- char-equal function, 65
- charge function, 151
- char-upcase function, 99
- chosen-tile parameter, 407
- Church, Alonzo, 293
- circle function, 362
- circular lists, 110–111
- CISC (complex instruction set
 - computer), 8
- city.dot.png* picture, 145
- CL (Common Lisp), 15, 17–18. *See also* Lisp
 - basics, 441
 - tail call optimization support, 333
- client, for socket connection, 246
- CLISP, 18–19
 - installing, 18
 - printing of circular lists, 111
 - shutting down, 19
 - starting, 19
- Clojure Lisp, 17, 461
 - and lazy evaluation, 377, 462
 - lazy sequences, 380
- CLOS (Common Lisp Object
 - System), 166, 451
- closingp predicate, 358
- closing tag in XML, 358
- closures, 326–328, 379
- Closure CL, 18
- cl-sockets, 245
- clusters, finding in Dice of Doom,
 - 424–425
- cmd variable, 95
- CMUCL, 18
- COBOL, 8
- code
 - breavity, 459
 - vs. data, 35–37
 - symmetry between data and,
 - 91–92
- code-char function, 260, 308
- code composition, 298
- code mode, 35, 36
 - backquote (‘) for enabling
 - switching to, 73
- coerce function, 98, 260
- collect clause in loop, 137, 198
- colon (:), for keyword parameters,
 - 81, 122
- color
 - for dice, 407
 - manipulating, 361
- columns in table, centered, 230
- comic book, 4
 - bug fighters, 429–463
 - on functional programming,
 - 269–287
- command-line interface, 85
 - printing to screen, 86–87
- commands, adding to permitted
 - list, 368
- Common Lisp (CL), 15, 17–18. *See also* Lisp
 - basics, 441
 - tail call optimization support, 333

- Common Lisp HyperSpec, 170
 - on control sequences, 233
- Common Lisp Object System (CLOS), 166, 451
- communication, with other network computers, 245
- comparison, 62–65
 - eq1 for numbers and characters, 65
 - of symbols, 63
- compiler, 5
 - versions of function for, 172
- complex instruction set computer (CISC), 8
- computation, delayed, 124
- computer, as game opponent, 321–326
- concatenate command, 95
- cond command, 56, 208
- conditions, tricks with, 58–62
- Congestion City, 131, 132. *See also* Grand Theft Wumpus game
 - building final edges, 139–142
 - defining edges, 135–142
 - drawing map, 145–149
 - from partial knowledge, 146–148
 - nodes for, 142–144
 - preventing islands, 137–139
 - walking around town, 148–149
- connect-all-islands function, 139
- connect-edge-list function, 140
- connect-with-bridges function, 139
- Conrad’s Rule of Thumb for Comparing Stuff, 62–63
- cons cells, 37, 38, 107
 - in nested lists, 42
- conses, eq for comparing, 63
- cons function, 38–40
- consing, 39
- console output, capturing, 123
- console streams, 238
- consp function, 170
- constants, for game board dimensions, 402
- continuations, 454
- control sequences, 222–223
 - Common Lisp HyperSpec on, 233
 - for formatting numbers, 225–226
 - iterating through lists with, 231–232
 - for new lines, 227–228
- control string parameter, for format function, 222–223
- copy-list function, 211
- copy-structure function, problems from, 211
- count function, 167
- counting from starting point to ending point, 197
- count in loop macro, 201
- currencies, formatting, 226

D

- data
 - vs. code, 35–37
 - generic process for handling, 166–172
 - symmetry between code and, 91–92
 - tree-like, 113
- data mode, 35, 37
 - backquote (‘) for enabling switching to, 73
- data structures, self-referential, 111
- ~d control sequence, 225
- dead animals, in evolving environment, 212
- dead monsters, checking for, 179
- Debian-based Linux machine, CLISP on, 18
- debugging
 - in functional programming, 441
 - string streams and, 250–251
- defc function, 180
- decimal number, value displayed as, 225
- decimal point, and number type, 34
- declaration, of function, 29
- decode-param function, 259–260
- default, code mode as, 36
- define-condition function, 254–255
- defmacro command, 341, 342–344
- defmethod command, 171–172, 180
- defparameter command, 23, 24, 135
- defstruct command, 163, 164, 172, 173, 180, 208
 - for brigand, 185–186
 - for hydra, 183

- to include monster type fields, 181
- for slime mold, 185
- defun command, 25, 27
- defvar command, 24
- delayed computation, 124
- deprecated function, 117
- depth-first search, 394
- describe-location function, 71
- describe-objects function, 78
- describe-obj function, 78
- describe-path function, 72–73
- describe-paths function, 73–74, 75, 77
- destination parameter, for format
 - function, 222
- Dewdney, A.K., “Simulated evolution; wherein bugs learn to hunt bacteria,” 202
- Dice of Doom game, 303–336
 - attacking, 315–316
 - calculating attacking moves, 313–314
 - calculating passing moves, 312–313
 - computer opponent, 321–326
 - game loop with AI player, 324–325
 - minimax algorithm, 323
 - minimax algorithm code, 323–324
 - decoupling rules from rest of game, 309–310
 - finding neighbors, 314–315
 - game board, 307–309
 - 3-by-3 sample game, 334–336
 - 5-by-5, 398–400
 - constants for dimensions, 402
 - using SVG format, 402–408
 - generating game tree, 311–312
 - new game-tree function, 317–318
 - performance improvement, 326–336
 - playing against another human, 318–321
 - input from human players, 319
 - main loop, 318
 - state of game information, 318–319
 - winner determination, 319–320
 - playing first human vs. computer game, 325–326
 - reinforcements, 316–317
 - rules, 304
 - sample game, 304–306
 - tail call optimization, 333–334
 - version 1, 306–321
 - global variables, 306–307
 - version 2, 384–386
 - alpha beta pruning, 393–400
 - lazy lists for game tree, 384
 - score-board function, 390
 - starting game on 4-by-4 board, 386
 - winning by a lot vs. winning by a little, 389–393
 - version 3 (web-based), 401
 - announcing winner, 410
 - drawing die, 403–405
 - drawing tile, 405–406
 - game board, 406–408
 - game board in HTML, 412
 - handling computer player, 412
 - handling human player, 410–411
 - initializing new game, 410
 - playing, 413–414
 - web server interface, 408–412
 - version 4
 - calling dice rolling code from game engine, 420–421
 - improving reinforcement rules, 423–425
 - increasing number of players, 417–418
 - rolling dice, 418–423
 - updaing AI, 422–423
- dice_of_doom.v2.lisp* file, 402
- *dice-scale* variable, 403
- digit-char-p function, 116
- digraph command (Graphviz), 115
- direct-edges function, 138
- directed graph, 124
- dirty code, 294, 296
- dividing by zero, 53
- division function, 34
- DOCTYPE declaration, 258
- dod-request-handler function, 408–409
- domain, explained, 355–356

- domain of function, 292
- domain-specific language (DSL), 231, 355, 450. *See also* macros
- dot (.), for representing cons cells, 39
- dot->png function, 123
- dotimes function, 161, 175
- DOT information generation,
 - 115–120
 - edges conversion, 119
 - labels for graph nodes, 117–118
 - node identifiers conversion, 116–117
 - for nodes, 118
 - turning DOT file into picture, 120–123
- dot-name function, 116
- do token, 197, 200
- dotted lists, 108–109
- double quotes ("), for strings, 35
- downfrom in loop macro, 201
- downto in loop macro, 201
- draw-board function, 309
- draw-board-svg function, 407
- draw-city function, 145
- draw-die-svg function, 403
- draw-dod-page function, 409, 412
- draw-known-city function, 147, 149
- draw-tile-svg function, 405
- draw-world function, 212–213
- DSL (domain-specific language), 231, 355, 450. *See also* macros
- dunk function, 368–369, 371
- dynamic variable, 24
- dynamic website, 265–267
 - testing request handler, 265–266

E

- each in loop macro, 200
- earmuffs, 23
- eat function, 209
- edge-pair function, 136, 139
- edges, 72
 - of Congestion City, 135–142
 - converting to descriptions, 74–76
 - converting to DOT format, 119
 - erasing duplicate, 126
 - replacing list with hash table, 162
- edges->dot function, 119
- edges-to-alist function, 139, 141
- EDSAC Initial Orders, 5
- else in loop macro, 201
- Emacs Lisp, 17
- empty lists (), 39
 - as false value, 50–51
 - other expressions as disguises for, 51–52
- end in loop macro, 201
- energy, in plants, 203
- eq function, 33, 57, 63
- eql function, 65, 331
- equal function, 63, 331
- equalp function, 65, 330
- = (equal sign) function, 65
- error command, 254
- escaped characters, in strings, 35
- eval command, 92
 - danger of, 101
 - improving, 96
- every function, 167, 179
- evolution function, 213–214
- evolving environment game, 202–218
 - animals, 205–212
 - anatomy, 205–207
 - eating process, 209
 - energy, 206
 - motion, 207–208
 - properties, 206
 - reproduction, 210–212
 - starting point, 207
 - tracking genes, 206
 - turn function, 208–209
 - bimodal distribution in, 217–218
 - drawing world, 212–213
 - plants
 - energy, 203
 - growth, 204
 - simulating day, 212
 - starting simulation, 214–218
 - user interface, 213–214
- exception handling, 95, 253–256, 444–445
 - custom conditions, 254–255
 - intercepting conditions, 255
 - resources protected against
 - unexpected conditions, 255–256
 - signaling condition, 254
 - for web server, 265
- exponent, 36

expressive language, 10
expt function, 34, 36

F

false value, empty list () as, 50–51
~f control sequence, 226
files
 streams to write and read, 242–243
 writing information to, 121
file streams, 238
finally in loop macro, 200
find-empty-node function, 144–145
find-if function, 61, 167
find-island function, 139
find-islands function, 139
Firefox, for Dice of Doom game,
 413–414
Firefox 3.7 alpha, for SVG
 support, 402
first-class values, functions as, 104
flet function, 29
 for local function definition, 95
floating-point numbers, 34
 control sequences for
 formatting, 226
force command, 378–380
for in loop macro, 196, 201
format function, 193. *See also* printing
 anatomy, 221–223
 control string parameter, 222–223
 destination parameter, 222
 and text justification, 228
formatting numbers, control
 sequences for, 225–226
forms, 36
 nested, 36
FORTRAN, 5
freeing of variables, 327
fresh-line command, 227
from in loop macro, 201
from-tile variable, 411
funcall function, 178, 327
functional programming, 54, 71, 441
 anatomy of program, 295–298
 benefits, 301–302
 comic book, 269–287
 higher-order, 105
 and loops, 315
 problems from, 375–376

 reduce function, 352–353
 side effects, 294, 300–301
 using, 299–300
 what it is, 292–295
function operator, shorthand for, 75
functionp function, 170
function pipeline, 309
functions
 calling in Lisp, 22
 call to itself, 30
 comprehensive list of
 sequence, 170
 creating with lambda, 103–105
 deprecated, 117
 generic, 116
 higher-order, 75
 names available in defined
 functions, 29–30
 namespaces for, 75
 nullary, 120
 parentheses for, 22
 sending string streams to, 249

G

game-action macro, 369–371
game board
 AI adjustments for larger, 387–400
 for Dice of Doom, 307–309
 3-by-3 sample game, 334–336
 5-by-5, 398–400
 constants for dimensions, 402
 using SVG format, 402–408
game-eval function
 approved list of commands for, 101
 limiting commands called, 96
game-loop function, 174–175
game-print function, 96–99
game-read function, 94–95
game-repl function, 93–94, 365
games. *See also* Dice of Doom game;
 evolving environment game;
 Grand Theft Wumpus
 game; Orc Battle game;
 Wizard’s Adventure Game
Attack of the Robots! game,
 233–234
Guess-My-Number, 21–23
loading code from REPL, 365–366
winning by a lot vs. winning by a
 little, 389–393

- game tree
 - branches hidden in clouds, 376–377
 - chance nodes in, 418–420
 - generating, 311–312
 - memoizing, 330
 - trimming, 387–389
 - game-tree function, 311, 317–318
 - garbage collection, 9, 327
 - Garret, Ron, 257
 - gen-board function, 308
 - generalized reference, 155
 - generic functions, 116
 - creating with type predicates, 170–172
 - generic setters, 154–156, 447
 - gensym function, 349
 - get-connected function, 138, 161, 162, 424, 425
 - get-connected-hash function, 163
 - get-content-params function, 263
 - gethash function, 155, 158, 160, 162
 - get-header function, 262
 - testing, with string stream, 262–263
 - get-ratings function, 324, 391, 422
 - new versions, 395
 - GET request, 257
 - request parameters for, 259
 - global functions, defining, 25–28
 - global variables
 - changing value, 27
 - defining, 23–24
 - in look function, 80
 - macros and, 370
 - for player and monsters, 173–174
 - setting inside conditional branch, 54
 - Google BigTable, 160
 - Graham, Paul, 17
 - Arc Lisp dialect, 359
 - Grand Theft Wumpus game. *See also* Congestion City
 - basics, 131–135
 - clues, 142
 - drawing map, 145–149
 - from partial knowledge, 146–148
 - with hash tables, 161–163
 - initializing new game, 144–145
 - playing game, 149–151
 - police roadblocks, 139
 - graph->dot function, 124
 - graphs
 - creating, 114–124
 - creating picture of, 123–124
 - directed, 124
 - labels for nodes, 117–118
 - undirected, 124–127
 - visualizing, 114
 - graph utilities, loading, 135
 - graph-util.lisp* file, 127
 - Graphviz, 114–124
 - Graphviz DOT file
 - edges conversion, 119
 - for graph drawing library, 115–120
 - labels for graph nodes, 117–118
 - node identifiers conversion, 116–117
 - for nodes, 118
 - turning DOT file into picture, 120–123
 - guess-my-number function, 25–27
 - Guess-My-Number game, 21–23
 - Guile Scheme, 17
- ## H
- hackers
 - and dangerous commands, 101
 - and read command, 262
 - handle-computer function, 324, 388, 397, 412, 421
 - handle-direction function, 148
 - handle-human function, 319, 385–386, 421
 - handle-new-place function, 149
 - handler-case function, 254
 - hash collisions, 160
 - hash-edges function, 162
 - hash-key in loop macro, 200
 - hash-keys in loop macro, 200
 - hash mark (#), for array, 154
 - hash-table-p function, 170

- hash tables, 155, 157–163
 - Grand Theft Wumpus game
 - with, 161–163
 - inefficiency for small tables, 160
 - performance, 160–161
 - for plants, 204
 - returning multiple values,
 - 159–160
 - hash-value in loop macro, 200
 - hash-values in loop macro, 200
 - Haskell, 17, 296
 - and lazy evaluation, 377
 - have function, 367
 - health meter, for monsters, 180
 - hello-request-handler function, 265
 - heuristics, 389
 - hexadecimal, number display as, 225
 - Hickey, Rich, 17
 - hidden state, 299
 - hierarchical data, 113
 - higher-order functions, 75
 - higher-order programming, 105,
 - 298–300
 - homoiconic programming code, 91
 - HTML5 standard, 402
 - HTML code, 97
 - embedding SVG pictures, 402
 - page skeleton, 265
 - tag macro to generate, 360–361
 - html tags, 258
 - HTTP (Hypertext Transfer Protocol), 256
 - http-char function, 260
 - HTTP escape codes, 259
 - http.lisp* file, 257
 - Hughes, John, “Why Functional Programming Matters,” 310
 - Hunt the Wumpus, 129
 - hyperlinks, in SVG image, 361
 - Hypertext Transfer Protocol (HTTP), 256
- I**
- if command, 50, 52–54
 - :if-exists keyword parameter, 243
 - if in loop macro, 201
 - imperative code, 294
 - code composition with, 298–299
 - imperative game engine, 310
 - implicit progn, 55
 - incf function, 179
 - indentation of code, 28
 - infinite loop
 - getting out of, 93
 - preventing, 111
 - infinity, positive and negative, 397
 - Information Processing Language, 5
 - in in loop macro, 201
 - initially in loop macro, 200
 - :initial-value keyword parameter, 168
 - init-monsters function, 178
 - input-stream-p command, 240
 - input streams, 238, 240–241
 - installing CLISP, 18
 - instruction set of processor, 5
 - integers, 34
 - control sequences for
 - formatting, 225
 - intern command, 262
 - interpreter, 5
 - versions of function for, 172
 - intersection function, 141
 - into in loop macro, 201
 - inventory function, 83
 - IP address, in socket address, 245
 - islands, preventing, 137–139
 - isomorphic item, 63
 - iterating
 - across sequence, 167–170
 - through lists, with format control
 - sequences, 231–232
 - through list values, 197
- J**
- Java language, 10
 - Jones, Simon Peyton, 300
 - :junk-allowed parameter, 260
 - justified text, 228–231
- K**
- key/value pair
 - returning for alist, 112
 - storage, 160
 - keyword parameter, 117–118, 122
 - for find function, 81

known-city.dot.png file, 148
known-city-edges function, 146–147
known-city-nodes function, 146

L

labels, for graph nodes, 117–118
labels function, 29–30, 78
 for local function definition, 95
lambda calculus, 6, 105, 293
lambda function, 178, 179, 255, 314
 and closures, 326–327
 importance, 105
 purpose, 103–105
largest-cluster-size function, 424–425
launching website, 266–267
lazy-car command, 380
lazy-cdr command, 380
lazy command, 378–380
lazy-cons command, 380
lazy evaluation, 376–384, 423, 462
lazy-find-if function, 383
lazy game tree, 310
lazy lists
 adjusting AI functions to use,
 387–400
 converting between regular lists
 and, 381–382
 converting to regular lists, 382
 for Dice of Doom game tree, 384
 library for, 380
 mapping and searching, 383–384
lazy-mapcar function, 383, 385
lazy-mapcar function, 383
lazy-nil function, 381, 385
lazy-nth function, 383
lazy-null function, 381
legality of game move, 148
legal-tiles parameter, 407
length function, 166–167
less-than (<) function, with sort, 170
let* command, 140
let command, 28, 123, 140, 327, 340
 progn command and, 344
lexical variable, 123, 327–328
library, for lazy lists, 380
limit-tree-depth function, 388,
 395, 423
line breaks, 28

linking data pieces, cons function for,
 38–40
Lisp. *See also* Common Lisp (CL)
 basic etiquette, 24–25
 dialects, 15–18
 for scripting, 17
 features, 2–3
 Guess-My-Number game, 21–23
 origins, 4–9
 source of power, 10–11
 technologies supporting, comic
 book, 429–463
 up-and-coming dialects, 17
 valid expression example, 3
LispWorks, 18
list function, 41, 359
list-length function, 167
listp function, 170, 240
lists, 33, 37–42. *See also* association list
 (alist); lazy lists
 vs. arrays, 156–157
 association, 111–112
 benefits of using, 71
 calculating length, 51
 checking for membership, 60–61
 circular, 110–111
 control sequences for iterating
 through, 231–232
 dotted, 108–109
 empty, 39
 as false value, 50–51
 other expressions as disguises
 for, 51–52
 functions, 38–42
 iterating through with loop, 197
 joining multiple into one, 76
 macro for splitting, 346–347
 nested, 41–42
 of objects, 77–78
 pairs, 109–110
 sequence functions for, 166
 vs. structures, 165–166
 sum function for, 169
literal characters, 89
lit variable, and capitalization
 rules, 99
load command, 135
local functions, defining, 29–30

- local variables
 - defining, 28
 - for value returned by read
 - function, 88
 - log information, streams for, 249
 - long strings, 250
 - look function, 80, 93
 - lookup key, of hash table, 158
 - loop macro, 93, 136–137, 193, 195–202
 - breaking out, 198
 - collect clause, 198
 - counting from starting point to ending point, 197
 - do token, 197
 - iterating through list values, 197
 - with multiple for clauses, 198–199
 - nested, 199
 - periodic table of, 200–201
 - when token, 197
 - loops
 - with `dotimes` function, 175
 - for evolving environment, 202–218
 - and functional programming, 315
 - getting out of infinite, 93
 - preventing infinite, 111
- M**
- machine language, 4
 - macroexpand command, 345, 348, 349–350
 - macro expansion, 341–342
 - macros, 54, 82, 104–105, 339, 443. *See also* domain-specific language (DSL); programming language
 - avoiding repeated execution, 347–348
 - avoiding variable capture, 348–350
 - dangers and alternatives, 352–353
 - for defining new function, 370
 - helper function, 358
 - to implement lazy command, 379
 - reader, 101
 - recursive, 350–352
 - simple example, 340–345
 - for splitting lists, 346–347
 - svg, 361–362
 - transformation, 342–344
 - main-loop function, 296, 298
 - make-array command, 154
 - make-city-edges function, 139, 140
 - make-city-nodes function, 143
 - make-edge-list function, 136, 140
 - make-hash-table command, 157–158, 161
 - make-lazy function, 381
 - make-orc function, 181
 - make-person function, 164, 165
 - make-string-input-stream function, 249, 263
 - make-string-output-stream
 - command, 249
 - mapcan function, 146, 147, 314, 363
 - mapcar function, 74, 141, 359
 - mapc function, 118, 138, 162
 - map function, 169–170
 - maplist function, 126
 - map of city
 - drawing, 145–149
 - showing only visited nodes, 146–148
 - mapping lazy lists, 383–384
 - mathematical functions,
 - properties, 293
 - mathematical sets, hash tables for, 204
 - mathematical syntax, languages
 - using, 6
 - max function, 212
 - maximize in loop macro, 201
 - McCarthy, John, 6–7
 - “Recursive Functions of Symbolic Expressions and Their Computation by Machine,” 7
 - member function, 60–61, 96
 - memoization, 328–331
 - memory, 5, 156
 - software transactional, 461
 - Metaobject Protocol (MOP), 451
 - minimax algorithm code, game tree
 - analysis with, 394
 - minimize in loop macro, 201
 - mod (remainder) function, 208

- monetary floating-point value, 223
- monster-attack function, 181
 - for orcs, 182
 - for slime mold, 185
- monster-hit function, 176, 184
- monsters. *See* Orc Battle game
- monster-show function, for orcs, 182
- MOP (Metaobject Protocol), 451
- most-negative-fixnum, 397
- most-positive-fixnum, 397
- move function, 207–208
- move in game, checking legality, 148
- multiparadigm language, 18
- multiple dispatch, 452
- multiple-value-bind command, 159
- mutations, 165, 210
 - with reproduce function, 211
- my-length function, 331–332
 - custom, 345
 - improving, 350–352

N

- named in loop macro, 200
- names of functions, available in
 - defined functions, 29–30
- namespaces, for variables and
 - functions, 75
- nconc in loop macro, 201
- neato command (Graphviz), 115
- negative infinity, 397
- neighbors function, 142, 314–315,
 - 329–330
- nested alists, 142
- nested forms, 36
- nested lists, 41–42
- nested loop macro, 199
- nested tags, in XML, 357
- network computers, communication
 - between, 245
- never in loop macro, 201
- new-game function, 144
 - to draw known city, 147
- `#\newline`, 89
- new line
 - control sequences for, 227–228
 - in printed output, 226
 - before printing, 87

- nil, 38, 39, 52, 107
 - lists not ending with, 109
 - symmetry of () and, 49–52
- nodes, 118
 - for Congestion City, 142–144
 - identifiers, converting, 116–117
- nodes->dot function, 118, 119
- nondeterministic programming, 454
- nonvisible characters, literals for, 89
- nth function, 156
- nullary functions, 120
- null function, 61–62
- numberp function, 170
- numbers, 34–35
 - comparison, 65
 - control sequences for formatting,
 - 225–226
- *num-players* variable, 418

O

- object-oriented programming (OOP)
 - languages, 9, 163, 451
 - vs. Lisp, 165
- objects
 - descriptions
 - at specific location, 77–78
 - visible, 78–79
 - inventory check, 83–84
 - picking up, 82–83
- objects-at function, 78, 82, 83
- on in loop macro, 201
- OOP (object-oriented programming)
 - languages, 9, 163, 451
 - vs. Lisp, 165
- optimizing functional code, 326
 - closures, 326–328
 - memoization, 328–331
 - tail call optimization, 331–334
- orc-battle function, 174, 187–188
- Orc Battle game, 172–188
 - global variables for player and
 - monsters, 173–174
 - helper functions for player
 - attacks, 177–178
 - main game functions, 174–175
 - monster management functions,
 - 178–179

- monsters, 179–186
 - checking for dead, 179
 - Cunning Brigand, 185–186
 - functions for building, 174
 - generic, 180–181
 - hydra, 183–184
 - Slimy Slime Mold, 184–185
 - Wicked Orc, 181–182
- player management functions, 175–177
- starting game, 187–188
- orc datatype, 181
- or operator, 58
- orthogonal issues, 387
- output-stream-p function, 240
- output streams, 238, 239–240
 - with-open-file command for, 242

P

- padding value, for format function, 223
- padding parameter, for number
 - width, 225
- pairs, 109–110
- pairs function, 351, 359
- parallel games, web server for
 - multiple, 410
- parameters, quoting, 95
- parametric polymorphism, 9
- paranoid strategy, 418
- parentheses ()
 - for calling commands and functions, 22, 24
 - empty lists, 25
 - symmetry of nil and, 49–52
 - for list of declared variables
 - in let, 28
 - for organizing code into lists, 33
- parse-integer function, 260
- parse-params function, 261
- parse-url function, 261–262
- path descriptions
 - in game, 72–77
 - multiple at once, 73–77
- performance
 - arrays vs. lists, 156–157
 - cons cells and, 113
 - for Dice of Doom game, 326–336
 - functional programming and, 300
 - hash tables and, 160–161, 163
 - tail calls and, 333
 - periodic table of loop macro, 200–201
 - permitted commands, adding to
 - list, 368
 - person-age function, 164
 - pick-chance-branch function, 420–421
 - pick-monster function, 176
 - pickup function, 82
 - pi constant, 226
 - picture, from DOT file, 120–123
 - player-attack function, 176, 177
 - player function, 314
 - play-vs-computer function, 324–325, 389
 - play-vs-human function, 386
 - police roadblocks, 139
 - polygon function, 362–363
 - polygons, for die, 403
 - port
 - number in socket address, 245
 - taking control of, 246
 - port 80, 264
 - port 8080, 264
 - position function, 167, 261
 - positive infinity, 397
 - POST request, 258
 - power, 193
 - predicates, 78, 116
 - :pretty parameter, 117
 - prin1 function, 87
 - prin1-to-string function, 98, 116
 - princ function, 35, 90–91, 222, 223–224
 - *print-circle* variable, 111
 - printed representation, creating
 - object from, 164
 - print function, 86–87
 - priority use, 88
 - printing. *See also* format function
 - creating stream for functions, 121
 - multiple lines of output, 226–228
 - to screen, 86–87
 - text justification, 228–231
 - print-tag function, 358
 - problem solving, 20
 - progn command, 54
 - programming
 - heuristic techniques, 389
 - nondeterministic, 454

programming language. *See also*
 macros
 higher-order, 298–300
 learning, 2
properties in structures, 163
push function, 82–83, 112, 138, 240
 for hash table values, 162
pushnew command, 368, 370
Python, 9

Q

quasiquoting, 73
quit command, 19
quote command, 95
quoting, 37
quote-it function, 95

R

:radix parameter, 260
raise-price function, 445
RAM, 156
random edges
 generating, 135–136
 and island prevention, 137–139
random function, 177, 308, 363
random-monster function, 177
random-node function, 136
random numbers, generating, 177
random-plant function, 204
random walk, 363
randval function, 177, 180
range of function, 292
rate-position function, 323–324,
 330–331, 391
 new versions, 397
rational number, function
 returning, 34
RDF (Resource Description
 Framework), 3
read-char command, 241
reader, 33
reader macros, 101
read-eval-print loop (REPL), 19, 22
 loading game code from, 365–366
 setting up custom, 93–94
 testing, 99–100
read-from-string function, 95, 410

read function
 danger of, 101
 local variable for value
 returned by, 88
reading data, input streams for,
 240–241
read-line function, 91
recurse macro, 350–351
recursion, 30, 50, 332
 in macros, 350–352
reduced instruction set computer
 (RISC) hardware
 architecture, 8
reduce function, 167–169
 initial value for, 168
reference, generalized, 155
referential transparency, 293, 301
reinforcements, rules for choosing
 number in Dice of
 Doom, 425
remhash function, 209
remove-duplicates function, 141, 320
remove-if function, 320
remove-if-not function, 78, 138
repeat in loop macro, 200
REPL. *See* read-eval-print loop (REPL)
reproduce function, 210
 mutations with, 211
request body, 257
 parsing, 263
request handler, testing, 265–266
request-handler function, 264
request-handler parameter, 264
request header, 257
 parsing, 261–262
request parameters
 decoding lists of, 260–261
 decoding values for HTTP,
 259–260
 for web server, 258–261
Resource Description Framework
 (RDF), 3
resources, freeing up, 248–249
response body, 258
response header, 258
restarts, 444–445
return-from in loop macro, 200
return in loop macro, 200
return value, for command, 25

- reverse function, 222
- RISC (reduced instruction set computer) hardware architecture, 8
- roll-dice function, 420
- round function, 159
- Ruby, 9
- rule engine, 310
- runtime, 342

S

- say-hello function, 87–88
- SBCL (Steel Bank Common Lisp), 18
- scalable vector graphics (SVG). *See* SVG images
- scenery description, association list for, 70–71
- Scheme, 15
 - namespace for, 76
 - tail call optimization in, 333
- score-board function, 390
- screen, printing to, 86–87
- Script-Fu Scheme, 17
- scripting, Lisp dialects for, 17
- searching
 - lazy lists, 383–384
 - sequence functions for, 167
- security, eval function and, 92
- self function, 351–352
- self-referential data structures, 111
- semantics, 31–32
- Semantic Web, 3
- sending message over socket, 246–248
- sequence functions, 166
 - for searching, 167
- sequences, 166–170
 - iterating across, 167–170
- serve function, 263–265
- server, for socket connection, 246
- set-difference function, 139
- setf function, 27, 83, 111, 329, 447
 - for array, 154–155
 - to change structure property, 164
- shallow copy of structure, 211
- Short Code, 5
- shortcut Boolean evaluation, 59
- show-monsters function, 179
- shutting down CLISP, 19

- side effects, 441
 - of functional programming, 294, 300–301
- signaling condition, for error handling, 254
- sin function, 293
- single quote ('), as data indicator, 37
- slots, 163
- smaller function, 27
- socket, serve function creation of, 264
- socket-accept command, 247
- socket-connect command, 247
- sockets, 244–249
 - addresses, 245
 - connections, 246
 - sending message over, 246–248
- socket-server-close command, 249
- socket-server function, 246
- socket streams, 238
- software transactional memory, 461
- some function, 167
- sort function, 170
- #\space, 89
- special form
 - if as, 53
 - let command as, 340
- special variable, 24
- splash command, 371
- split macro, 346–347
- splitting lists, macro for, 346–347
- #s prefix, for structures, 164
- *standard-output* variable, 364
- starting CLISP, 19
- start-over function, 28
- statistics, of dice rolls, 422
- Steel Bank Common Lisp (SBCL), 18
- Steele, Guy L., 16
- streams, 121, 237–238
 - bidirectional, 247
 - closing on network computer, 248–249
 - commands to interact with, 242
 - for files, 242–243
 - types, 238–241
- string builders, 250
- string datatype, 70
- string-downcase function, 358
- string-equal function, 65
- stringp function, 170

- strings, 35
 - converting symbol list to, 98
 - sequence functions for, 166
- string streams, 238, 249–251
 - debugging and, 250–251
 - get-header function testing with, 262–263
- Stroustrup, Bjarne, 10
- structures, 163–166
 - vs. lists in Lisp code, 165–166
 - when to use, 165–166
- subseq function, 170
- substitute-if function, 116–117
- substitute-if-not function, 117
- sum function, for arrays and lists, 169
- sum in loop macro, 196, 201
- suspension, 120. *See also* thunks
- Sussman, Gerald Jay, 16
- SVG images
 - attributes for, 361
 - circles, 362
 - Dice of Doom game board using, 402–408
 - polygons, 362–363
 - writing, 356–364
- svg macro, 361–362
- svg-style function, 362
- SVG Web, 356
- symbol-function command, 329
- symbolp function, 170
- symbols, 33–34
 - benefits of using, 71
 - comparing, 63
 - converting list to string, 98
- symmetry
 - of () and nil, 49–52
 - between code and data, 91–92
- syntax
 - building blocks for Lisp, 32–35
 - and semantics, 31–32

T

- #\tab, 89
- tables
 - output as, 228–229
 - trick for creating pretty, 232–233
- tab variable, 331
- tag macro, 359–360
 - to generate HTML, 360–361
- tail call, 332
- tail call optimization, 331–334
- take-all function, 382
- take function, 382
- ~t control sequence, 228–229
- TCP/IP, 256
- TCP packets, 245
- technologies supporting Lisp, comic book, 429–463
- terpri function, 226–227
- test functions, 116
- testing
 - get-header function with string stream, 262–263
 - user interface, 99–100
- :test keyword parameter, 141
 - to use equal, 204
- text. *See also* strings
 - breaking into equal length pieces, 232
 - converting all caps to capitalized, 97
 - justified, 228–231
 - processing, 67
- text game interface, 92–99
 - testing, 99–100
- the in loop macro, 200
- then in loop macro, 201
- thereis in loop macro, 201
- threatened function, 391
- threatened hex, in Dice of Doom, 390
- three-way-if macro, 443
- thunks, 120–121
 - for creating graph picture, 123
- tilde (~), for control sequences, 223
- time command, 161
- to in loop macro, 201
- top-level definition of variable, 23
- *top-offset* variable, 403
- tree-like data, 113
- true/false functions, 78
- turn function, for animals, 208–209
- tweak-text function, 98
- type-checking, 166
 - in generic functions, 167
- type dispatching, 172

type-of function, 180–181
type predicates, for generic functions,
170–172

U

uedges->dot function, 126
ugraph->dot function, 126
ugraph->png function, 126, 145
undirected graphs, 124–127
unless, 55
 in loop macro, 201
until in loop macro, 200
unwind-protect function, 256, 264
update-world function, 212
upfrom in loop macro, 201
upto in loop macro, 201
URLs for web pages, name/value
 pairs in, 260
user interface, 85
 command-line, 85
 printing to screen, 86–87
 for evolving environment game,
 213–214
 testing, 99–100
 for Wizard’s Adventure Game,
 92–99
using in loop macro, 200
usocket, 245

V

vacuum-tube computer systems, 4
values function, 159
variable capture, 348–350
variables. *See also* global variables;
 local variables
 asterisks (*) in names, 23
 declaration in let command, 28
 defining, 140
 destruction, 327
 in functional programming,
 293, 301
 function to create unique
 name, 349
 lexical, 123, 328
 for location descriptions, 70
 modifying value, 447
 namespaces for, 75

variable shadowing, 333
versions of function, 172
vertical pipe (|), for case-sensitive
 symbols, 89
virtual memory paging, performance
 impact, 160
visible objects, describing, 78–79
visualizing graphs, 114
visual noise, 340

W

walk function, 81–82, 148
web-announce-winner function, 410
web forms, 258
web-handle-human function, 410–411
web-initialize function, 409, 410
web resources
 downloading CLISP installer, 18
 for Graphviz, 115
 Lisp projects, 3
web server, 256–265
 continuation-aware, 454
 how it works, 256–258
 interface for Dice of Doom,
 408–412
 for computer player, 412
 for human player, 410–411
 limitations, 409–410
 parsing request body, 263
 parsing request header, 261–262
 request parameters, 258–261
 serve function, 263–265
webserver.lisp file, 402
website
 dynamic, 265–267
 launching, 266–267
weld function, 367–368, 370–371
when in loop macro, 201
when token, 55, 197
while in loop macro, 200
winners function, 319–320
with in loop macro, 200
with-open-file command, 121, 122,
 123, 242–244
with-open-stream macro, 264
with-output-to-string macro, 250–251

- Wizard's Adventure Game
 - basic requirements, 69–70
 - custom game commands, 365–373
 - dunk, 368–369
 - game-action macro, 369–371
 - welding, 366–368
 - custom interface, 92–99
 - DOT information for, 119–120
 - location descriptions, 71
 - look command, 79–80
 - map of house in alists, 114
 - object descriptions at specific location, 77–79
 - object inventory check, 83–84
 - path descriptions, 72–77
 - picking up objects, 82–83
 - playing completed version, 371–373
 - scenery description with association list, 70–71
 - walk function, 81–82
 - world for, 68–69
 - write-char command, 240
- X**
- ~x control sequence, 225
 - XML, 113
 - XML format
 - nested tags, 357
 - and SVG format, 357
 - xmlns attribute, 361
- Z**
- zero, dividing by, 53