Tasks for the RBG String (Creature) GA Recreation Assignment

RBG-String GA Task 1: RBG-String

Evolution for the RBG-string GA takes place at the level of the RBG-string. An RBG-string is a list of random RBG values of length `*limit*`. As you perform the tasks specified below, you will be implementing a method to create random RBG-string objects.

The Subtasks

1. The getting started task ...

   Create a file called `rbg.l` in which to program a genetic algorithm which affords RBG-string evolution.

2. The task to define a simple constant ...

   Establish a global constant called `*limit*` and bind it to 25. This will signify the number of letters in one RBG-string.

3. The RBG letter generator task ...

   Define a method called `rbg` to nondeterministically generate one of three symbolic atoms – either `R` or `B` or `G`.

4. The RBG-string generator task ...

   An "RBG-string" will be represented as a list of symbolic atoms. With this in mind, write a **recursive** method called **rbg-string** to generate a "string" of letters drawn at random from `R`, `B`, `G`.

5. The demo task ...

   Craft a demo that corresponds, in the significant ways, to the following ...

   ```
   bash-3.2$  clisp

   [1]> (load "rbg.l")
   ;; Loading file rbg.l ...
   ;; Loaded file rbg.l
   T
   [2]> *limit*
   ```

```
25
[3]> (rbg)
B
[4]> (rbg)
G
[5]> ( list ( rbg ) ( rbg ) ( rbg ) ( rbg ) ( rbg )  )
(B G G G B)
[6]> ( list ( rbg ) ( rbg ) ( rbg ) ( rbg ) ( rbg )  )
(G R R G G)
[7]> ( rbg-string )
(G B G G B G B G G B R B G G R R G B R B B B G R G)
[8]> ( rbg-string )
(R R R G B G B G B B B R B G B B R R B B R R G G R)
[9]> ( rbg-string )
(B B R R B G G R R G G G R B G G B R B B R R B G B)
[10]> ( rbg-string )
(R G R B G R R B G R G R B G B G R B R B G B B R G)
[11]>
```

6. The solution document task ...

   Please add the source code associated with this task and the demo to the first section of your solution document.

RBG-String GA Task 2: Mutation

One of elements of the evolutionary process is mutation. We will need a method to mutate an RBG-string. This method will simply replace a random element of an RBG-string with a different value.

The Subtasks

1. The demo studying task ...

   Look carefully enough to observe that each mutation results in exactly one R or B or G being changed to a different R or B or G. Then, mentally circle the "mutation point" in each mutated string – the letter that differs in the mutation from its predecessor string.

```
bash-3.2$  clisp

[1]> ( load "rbg.l" )
;; Loading file rbg.l ...
```

```
;; Loaded file rbg.l
T
[2]> ( setf colors '(r g b r) )
(R G B R)
[3]> ( mutation colors )
(R G G R)
[4]> colors
(R G B R)
[5]> ( mutation colors )
(R G B B)
[6]> colors
(R G B R)
[7]> ( mutation colors )
(G G B R)
[8]> ( setf s '( r b g g b r ) )
(R B G G B R)
[9]> ( setf s ( mutation s ) )
(R B B G B R)
[10]> ( setf s ( mutation s ) )
(R G B G B R)
[11]> ( setf s ( mutation s ) )
(R G B G B G)
[12]> ( setf s ( mutation s ) )
(R G B R B G)
[13]> ( setf x ( rbg-string ) )
(R B R R R R B B R B R G G B G R G G G B B G R B B)
[14]> ( setf x ( mutation x ) )
(R B R R R R B B R B R G G B G R G B G B B G R B B)
[15]> ( setf x ( mutation x ) )
(R B R G R R B B R B R G G B G R G B G B B G R B B)
[16]>
```

2. The code studying task ...

   Please do your best to make sense of the following unrefined method in a manner that is consistent with the preceding demo.

```
( defmethod mutation ( ( rbg-str list ) &aux position symbol )
  ( setf position ( random ( length rbg-str ) ) )
  ( setf symbol ( others '( r b g ) ( nth position rbg-str ) ) )
  ( change rbg-str ( pick symbol ) position )
)
```

3. The code refinement task ...

   Refine the `mutation` method. To do so, define the `other` method and the `change` method and the `pick` method. There is no reason to be destructive in writing these functions (the usual connotation of "mutation" notwithstanding), so please write them in a way that is functional.

4. The demo task ...

   Craft a demo that corresponds, in the all of the significant ways, to the one previously illustrated.

5. The solution document task ...

   Please add the source code associated with this task and the demo to the second section of your solution document.

RBG-String GA Task 3: Crossover

Another element of the evolutionary process is crossover. We will need a method to crossover two RBG-strings. This method will construct a string consisting of the first N elments from one RBG-string with the last (*length* - N) elements of the other RBG-string.

The Subtasks

1. The demo studying task ...

   Take a look at the following demo. Look carefully enough to observe crossover point in each crossover. Then, mentally partition each crossover string into two parts, its "mother part" and its "father part".

```
bash-3.2$  clisp

[1]> ( load "rbg.l" )
;; Loading file rbg.l ...
;; Loaded file rbg.l
T
[2]> ( setf m '(a b c d e f g) )
(A B C D E F G)
[3]> ( setf f '(t u v w x y z) )
(T U V W X Y Z)
[4]> ( crossover m f )
(A B C W X Y Z)
[5]> ( crossover m f )
(A B C D E F G)
```

```
[6]> ( crossover m f )
(A B C D E F G)
[7]> ( crossover m f )
(A U V W X Y Z)
[8]> m
(A B C D E F G)
[9]> f
(T U V W X Y Z)
[10]> (setf m ( rbg-string ) )
(G B G B B B G R R G R B R R R R B B R B R G G B G)
[11]> (setf f ( rbg-string ) )
(R G G G B B G R B B R G R R B R G R B B B R G R B)
[12]> ( crossover m f )
(G B G B B B G R R G R B R R R R G R B B B R G R B)
[13]> ( crossover m f )
(G B G B B B G R R G R B R R B R G R B B B R G R B)
[14]> ( crossover m f )
(G B G B B B G R R G R B R R B R G R B B B R G R B)
[15]> m
(G B G B B B G R R G R B R R R R B B R B R G G B G)
[16]> f
(R G G G B B G R B B R G R R B R G R B B B R G R B)
[17]>
```

2. The code studying task ...

   Please do your best to make sense of the following unrefined method in a manner that is consistent with the preceding demo.

```
( defmethod crossover ( ( m list ) ( f list ) &aux pos)
  ( setf pos ( + 1 ( random ( length m ) ) ) )
  ( append ( first-n m pos ) ( rest-n f pos ) )
)
```

3. The code refinement task ...

   Refine the `crossover` method.

4. The demo task ...

   Craft a demo that corresponds, in the all of the significant ways, to the one previously illustrated.

5. The solution document task ...

   Please add the source code associated with this task and the demo to the third section of your solution document.

RBG-String GA Task 4: Demos for Mutation and Crossover

It is a good idea to write a suite of programs to demo your code as you develop it. The mutation code and the crossover code are significant enough to warrent demo programs.

The Subtasks

1. The `mutation-code` read/study and enter task ...

   Read/study and then enter the following code:

   ```
   ( defmethod mutation-demo (&aux s m)
     ( setf s ( rbg-string ) )
     ( dotimes ( i 10 )
       ( format t "s = ~A~%" s )
       ( setf m ( mutation s ) )
       ( format t "m = ~A~%~%" m )
     )
   )
   ```

2. The `mutation-code` demo task ...

   Run the demo, and observe the "mutation point" for each string/mutation pair.

3. The `crossover-code` read/study and enter task ...

   Read/study and then enter the following code:

   ```
   ( defmethod crossover-demo (&aux m f x)
     ( setf m ( rbg-string ) )
     ( setf f ( rbg-string ) )
     ( dotimes ( i 10 )
       ( format t "m = ~A~%" m )
       ( setf x ( crossover m f ) )
       ( format t "x = ~A~%" x )
       ( format t "f = ~A~%~%" f )
     )
   )
   ```

4. The `crossover-code` demo task ...

   Run the demo, and observe the "maternal influence" and the "paternal influence" for each individual resulting from a crossover operation.

5. The solution document task ...

   Please add the source code associated with this task and the demo to the fourth section of your solution document. If you are feeling ambitions, and would like to do something really nice, annotate the pdf file to (1) highlight the mutation point throughout the mutation demo, and (2) highlight (in different colors) the maternal influence and the paternal influence for each individual resulting from a crossover.

RBG-String GA Task 5: The Fitness Metric

A fitness metric will be needed for any GA. Sometimes several are useful. In this GA task, three very simple fitness metrics, `fitness-r`, `fitness-g`, and `fitness-b` will be written. Prior to running the GA, a variable will be bound to one of these three fitness metrics.

The Subtasks

1. The fitness metric definition task ...

   Write `fitness-r` which takes one RBG-string and returns the number of R values in the string. (Use the `count` primitive.) Write `fitness-b` which takes one RBG-string and returns the number of B values in the string. (Use the `count` primitive.) Write `fitness-g` which takes one RBG-string and returns the number of G values in the string. (Use the `count` primitive.)

2. The interactive demo task ...

   Engage in an interactive session that mimics the following demo in all significant respects:

   ```
   $ clisp
   [1]> (load "rbg.l")
   ;; Loading file rbg.l ...
   ;; Loaded file rbg.l
   T
   [2]> (setf x (rbg-string))
   (R G R R B B R G G G R R R G B B G B G B B G G B G)
   [3]> x
   (R G R R B B R G G G R R R G B B G B G B B G G B G)
   [4]> (fitness-r x)
   ```

```
7
[5]> (fitness-b x)
8
[6]> (fitness-g x)
10
[7]> (setf fitness #'fitness-r)
#<STANDARD-GENERIC-FUNCTION FITNESS-R>
[8]> (funcall fitness x)
7
[9]> (setf fitness #'fitness-b)
#<STANDARD-GENERIC-FUNCTION FITNESS-B>
[10]> (funcall fitness x)
8
[11]> (setf fitness #'fitness-g)
#<STANDARD-GENERIC-FUNCTION FITNESS-G>
[12]> (funcall fitness x)
10
[13]>
```

3. The encapsulated fitness function task ...

   Read/study and then enter the following code:

```
( defmethod fitness-demo (&aux x fitness)
  ( setf x (rbg-string) )
  ( format t "x = ~A~%" x )
  ( format t "Directly applying the fitness metrics ...~%" )
  ( format t "fitness-r = ~A~%" ( fitness-r x ) )
  ( format t "fitness-b = ~A~%" ( fitness-b x ) )
  ( format t "fitness-g = ~A~%" ( fitness-g x ) )
  ( format t "Indirectly applying the fitness metrics ...~%" )
  ( setf fitness #'fitness-r )
  ( format t "fitness-r = ~A~%" ( funcall fitness x ) )
  ( setf fitness #'fitness-g )
  ( format t "fitness-g = ~A~%" ( funcall fitness x ) )
  ( setf fitness #'fitness-b )
  ( format t "fitness-b = ~A~%" ( funcall fitness x ) )
)
```

4. The thinking task ...

   Any idea why you might want to bind a variable to a fitness function?

5. The encapsulated demo task ...

   Run the fitness demo, and do your best to make good sense of the output!

6. The solution document task ...

   Please add the source code associated with this task and the demo to the fifth section of your solution document.

RBG-String GA Task 6: The Individual Class

The framework of GA computation features “individuals”. Individuals (read with the quotation marks) are generally the focus of evolution in GA work. (For example, the individual might be a musical melody, or a neural network, or a path in some traveling salesperson problem.) Consequently, the modeling of an `individual` class will be useful.

The Subtasks

1. The Lisp code task ...

   Read/study and then enter the following code:

```
( defclass individual ()
  (
    ( rbg-string :accessor individual-rbg-string :initarg :rbg-string )
    ( fitness :accessor individual-fitness :initarg :fitness )
    ( number :accessor individual-number :initarg :number )
  )
)

( defmethod random-individual (&aux rbg)
  ( setf rbg ( rbg-string ) )
  ( make-instance 'individual
    :rbg-string rbg
    :fitness ( funcall *fitness* rbg )
    :number 0
  )
)

( defmethod new-individual ( ( nr number ) ( notes list ) )
  ( make-instance 'individual
    :rbg-string notes
    :fitness ( funcall *fitness* notes )
    :number nr
  )
```

```
)

( defmethod display ( ( i individual ) )
  ( display-nnl i ) ( terpri )
)

( defmethod display-nnl ( ( i individual ) )
  ( prin1 ( individual-number i ) )
  ( princ ( filler ( individual-number i ) ) )
  ( prin1 ( individual-rbg-string i ) )
  ( princ "  " )
  ( prin1 ( individual-fitness i ) )
  ( princ ( filler ( individual-fitness i ) ) )
)

( defmethod filler ( ( n number ) )
  ( cond
    ( ( < n 10 ) "     " )
    ( ( < n 100 ) "    " )
    ( ( < n 1000 ) "   " )
    ( ( < n 10000 ) "  " )
    ( ( < n 100000 ) " " )
  )
)

( defmethod fitness-b ( ( i individual ) )
  ( fitness-b ( individual-rbg-string i ) )
)

( defmethod fitness-r ( ( i individual ) )
  ( fitness-r ( individual-rbg-string i ) )
)

( defmethod fitness-g ( ( i individual ) )
  ( fitness-g ( individual-rbg-string i ) )
)
```

2. The interactive demo task ...

   Engage in an interactive session that mimics the following demo:

```
$ clisp
[1]> (load "rbg.l")
;; Loading file rbg.l ...
;; Loaded file rbg.l
T
[2]> ( setf rbg ( rbg-string ) )
```

```
(R B G B B R G G R R R G R G G B G G B R R B G R B)
[3]> rbg
(R B G B B R G G R R R G R G G B G G B R R B G R B)
[4]> ( setf *fitness* #'fitness-b )
#<STANDARD-GENERIC-FUNCTION FITNESS-B>
[5]> ( setf rbg-i ( new-individual 1 rbg ) )
#<INDIVIDUAL #x19EF4449>
[6]> ( individual-number rbg-i )
1
[7]> ( individual-rbg-string rbg-i )
(R B G B B R G G R R R G R G G B G G B R R B G R B)
[8]> ( display rbg-i )
1     (R B G B B R G G R R R G R G G B G G B R R B G R B)  7
NIL
[9]> ( funcall *fitness* rbg )
7
[10]> ( setf r ( random-individual ) )
#<INDIVIDUAL #x19ECFF71>
[11]> ( display r )
0     (G G B B R G B R G B R B R G B R B G G B B G B B R)  6
NIL
[12]> ( setf r ( random-individual ) )
#<INDIVIDUAL #x19EE17B9>
[13]> ( display r )
0     (R R G B G G G G G R B R G R B B R R G G R B R G R)  10
NIL
[14]>
```

3. The encapsulated demo code task ...

   Read/study and then enter the following code:

```
( defmethod individual-demo (&aux i0 i1 i2 i3 one two three)
  ( setf *fitness* #'fitness-r )
  ( setf i0 ( random-individual ) )
  ( display i0 )
  ( setf one ( rbg-string ) )
  ( setf i1 ( new-individual 1 one ) )
  ( display i1 )
  ( setf two ( rbg-string ) )
  ( setf i2 ( new-individual 2 two ) )
  ( display i2 )
  ( setf three ( rbg-string ) )
  ( setf i3 ( new-individual 3 three ) )
  ( display i3 )
  ( format t "Fitness of i0 = ~A~%" ( funcall *fitness* i0 ) )
```

```
    ( format t "Fitness of i1 = ~A~%" ( funcall *fitness* i1 ) )
    ( format t "Fitness of i2 = ~A~%" ( funcall *fitness* i2 ) )
    ( format t "Fitness of i3 = ~A~%" ( funcall *fitness* i3 ) )
    nil
  )
```

4. The encapsulated demo task ...

   Run the encapsulated demo, and observe ...

5. The solution document task ...

   Please add the source code associated with this task and the demos to the sixth section of your solution document.

RBG-String GA Task 7: The Population Class

The framework of GA computation features “populations” of individuals. Consequently, the modeling of a population class may be a good idea.

The Subtasks

1. The demo task ...

   Give the following demo a serious look. At least think through tentative answers to each of the following questions:

   (a) What does the `initial-population` method do?

   (b) What does the `display` method do when given a population object?

   (c) What does the `average` method do when given a population object?

   (d) What does the `select-individual` method do when given a population object?

```
bash-3.2$ clisp
...
[1]> (load "rbg.l")
;; Loading file rbg.l ...
;; Loaded file rbg.l
T
[2]> ( setf p ( initial-population ) )
```

```
#&lt;POPULATION #x1AF69435&gt;
[3]> ( display p )
Generation 0 population ...
1     (R R B B B G B G G G G B B G G G R G B G G G B G G) 8
2     (R G G B B B R R B R G G B R B B G R R B G G R G G) 8
3     (R R B B B R G B G R B R B G B R G B R G G G R B R) 9
4     (B B B R G G B B B R G R B R B B G R G B R R R B B) 12
5     (B B R R R B G G B B R R R R R R R B G B G G G R R) 7
6     (B G G G R R G B G B G B B B G B G R G B R B B B G) 11
7     (B R B B R R G B B R R R R G G B R G G R G B B G G) 8
8     (B R B B R B B G R R B R G R R G B G R B B G B G B) 11
9     (B R R G R G G G R B G B G R G B B B G R B G B B G) 9
10    (R R R B B B G G B B R B R G B G B B R R G R G B G) 10
11    (G R G B G G B B B B B B B B B R R B G G R B B G R) 13
12    (R B G B G R R B B G B G B R G G G G G G B R B B B) 10
13    (G B R B G R G B G R G R R B G B R G G G G G G R B) 6
14    (B R G B B R R R R B B B B B B R R G B R R G B R R) 11
15    (B R G R R G B B G B R B B G B B G R G B R B G B R) 11
16    (R B B B B G G B B G B R B R R R G B B R G B R R B) 12
17    (B B R R R G G G B B B G G B G R R G B R R R G G G) 7
18    (G B R B R G R G G R G B G G B B R R R R B G R R B B) 8
19    (R G R R B R G B G G R G G B G R R B R R B R B B G) 7
20    (R B G R B R B G R R B B B G B R G B G G R R G R G) 8
21    (G G G B G R R B G R G G G B B B G R B R R G G G R) 6
22    (R G B R R R B B R G R B G B B R B R R B R G G G R) 8
23    (G G G R R B R R B G B B R R R G G R B R G R G B B) 7
24    (B R B B G G G B R R B R R B G G B B R B B B R R G) 11
25    (G B B B G B G G B R B R R R G B B R B R R B B R R) 11
26    (R G R G G G G R B B G G B G G R R R B R R R R G R) 4
27    (G B B G B G R R B R R R R G R R G R G G B G R R R) 5
28    (B R G R B R B R B R R G G R B G G R R G G R B B G) 7
29    (B G G B R B G G G B G B B B R R B R R R R B B R G) 10
30    (R R R G G B G R B R G G G B B B G R B R B G R G R) 7
31    (B R B G B R G B B G R R B R G G B R B B B R B R B) 12
32    (G R R B R G B B R R B R G R G G B R G R B B B B B) 10
33    (B G B B G B B R B G R B G B B R G R G B B R R B R) 12
34    (R G R B B G G B R B R G R B R R R G B B G R G G R) 7
35    (G R B R G B R R R G B G B R R G R G G B R B B R G) 7
36    (R B G B R G R B B G R B B B R G R G G B R G G R G) 8
37    (R G R G G B B G B B B R R G R G G G G B B G B R G) 8
38    (R G R R G G R R B R R B B B B G R R B B G B B G R) 9
39    (G G R B G G B R B G B B G R R G R G G B G G B G B) 8
40    (B R B B G G G B B G G R G R B G R R R R R G R G G) 6
41    (R R R B R G B R B B G R G G B B R G R R R B R G R) 7
42    (B R B R R R G B G B G G G B G B G B R B G R R R G) 8
43    (B R B B G R B R G B R B G R B R R R B R G R R B R) 9
44    (G R R G R B G B G G B G G R R R B G R B B B B B R) 9
```

45	(G G R B G G B G G R R G G B G R G B R R R R G G G)	4
46	(B G R B G G R B R R B G R R B R B B G R B G G G B)	9
47	(G G G R G G G R G G G B B B B B G R G B R R B G G)	7
48	(G B R R G B R G G R G B G B R B B B B G R B R G R)	9
49	(R R G R G G B B G G R B G R B B R B B R B G G B R)	9
50	(G G R R B G R R R B R B B G R R B B R B G B B B G)	10
51	(R G G R G G G R B G B B G B G R B R G B G G G R B)	7
52	(R B R B B G B G B R R B B R B G B B R R B G G B R)	12
53	(G B G G G R G B B G G R G R B R R B G B G B B B B)	10
54	(G G R G G G B R G R R R G R G B B R R R R G R R R)	3
55	(G B B B B B R B R G B R G G B B G G R B B R B B B)	14
56	(G R G G B R G G R G R R B G R B R B R R B G B G G)	6
57	(R G R B R B G G R G B R G R B B B B G R B G G G R)	8
58	(R B G R G G B B B G B R B B G R R G R G R B B R B)	10
59	(G R R R B R B G R B R B B B B G G R B B G B B R G)	11
60	(G G R B G R R B B B B B R G R B B R G G R G G G B)	9
61	(B G R B G G R G R G G G R G B G G G B B G R G B R)	6
62	(B B B B R B R G B R B G R R B G G R B R R G G B G)	10
63	(G R R B B R G R B R R G R R G B B G G B B B B R B)	10
64	(R G B R G G G B G R B R G B R B G B R R B R B B B)	10
65	(R B G G B B R G B B B B G B G B G G B R R B B R B)	13
66	(G R R G B R G R R R B G B R B B B B B B B G G R B)	11
67	(R B R G G G B R G R R G G R R R B B B B B B B B G)	10
68	(R G B R G B R B R R R G B B R B G G G R B R B B B)	10
69	(G R B G G R R G B G B G R B B R B R B B R G G R B)	9
70	(B G B R B B G R G G R R R G B R B G B R G G B B B)	10
71	(G G G G B R R B B G R R R R R B B R G R B R B G R)	7
72	(R R B B G G B B G B G R R B B B G G B B G G G G R)	10
73	(B G B G B R B G B G R B G G B B B R G R R G B R G)	10
74	(G G R B R G G G B B B B B G G R B G R R B G B G R)	9
75	(G G G R R B G G G R G B R G B R R B B B G B R R G)	7
76	(G R G G B B R B R G G R R R R G R R R R G R R G B)	4
77	(R R G B R G G B B B G B R G B B B B R B G R B G G)	11
78	(B B G B G B R G R G R G G R B R G R G G R B B R B)	8
79	(R B B G G G R B B B B G B B G B B B G G B B G R B)	14
80	(R G G G B G R G G B G R R B G B R G B G B R R G R)	6
81	(G R R R R B B R G G R R B R R G B B B G R B G G B)	8
82	(R B R R G R R B B B G B R R B R B B R B R R R G B)	10
83	(G G B B B B R R G B G B R G R R G R R G R B G R B)	8
84	(G G G R R R G G G B G B B B G B R R B B R R B R B)	9
85	(R R B R R R G B B B G R R B R G R R R B G R G G R)	6
86	(R R R B G B R G B R G R G B R G R R G B R R G G R)	5
87	(R R G R R R B R B B G B R G R B R B R R R R G B R)	7
88	(R G B R G R G B B R B G G G G B B G B R B G R B B)	10
89	(G R G R G G R G B B R B B R B R G B G R G B B R B)	9
90	(B B R G R B G R R R R R B R B R B R G B R B G R G)	8
91	(R G B B R B B R B R G R G G G R R B R G R R R B G)	7

```
92    (R B R G R B G G B G G G R B G G R B R B B G G G R) 7
93    (B R R B B G R G B R G B B R G G R B G G R G B R B) 9
94    (B R G B R B G R R B G R R B B B G B B B G G G G R) 10
95    (R B G G G B R B R B G R R B B G G B B B B R B G R) 11
96    (G B B B B R B G B R R G R B G R B G B B G R B B R) 12
97    (B R R G R G B G R B G G R B R B R R G R G B B B R) 8
98    (G G R G G B R G R B B R G B R G B B B G R B R R G) 8
99    (R G G R G G G R R R G G G R B G R G B B B R G G G) 4
100   (G R R B R R R B G G B G R G G B B G G G G R B G B) 7
NIL
[4]> ( average p )
8.68
[5]> ( select-individual p )
#&lt;INDIVIDUAL #x1AF2365D&gt;
[6]> ( display ( select-individual p ) )
16    (R B B B B G G B B G B R B R R R G B B R G B R R B) 12
NIL
[7]> ( display ( select-individual p ) )
43    (B R B B G R B R G B R B G R B R R R B R G R R B R) 9
NIL
[8]> ( display ( select-individual p ) )
79    (R B B G G G R B B B B G B B G B B B G G B B G R B) 14
NIL
[9]> ( setf *select-demo* t )
T
[10]> ( display ( select-individual p ) )
the sample of individuals ...
86    (R R R B G B R G B R G R G B R G R R G B R R G G R) 5
41    (R R R B R G B R B B G R G G B B R G R R R B R G R) 7
3     (R R B B B R G B G R B R B G B R G B R G G G R B R) 9
23    (G G G R R B R R B G B B R R R G G R B R G R G B B) 7
27    (G B B G B G R R B R R R R G R R G R G G B G R R R) 5
57    (R G R B R B G G R G B R G R B B B B G R B G G G R) 8
75    (G G G R R B G G G R G B R G B R R B B B G B R R G) 7
14    (B R G B B R R R R B B B B B B R R G B R R G B R R) 11

the most fit of the sample ...
14    (B R G B B R R R R B B B B B B R R G B R R G B R R) 11

14    (B R G B B R R R R B B B B B B R R G B R R G B R R) 11
NIL
[11]> ( display ( select-individual p ) )
the sample of individuals ...
11    (G R G B G G B B B B B B B B B R R B G G R B B G R) 13
61    (B G R B G G R G R G G G R G B G G G B B G R G B R) 6
39    (G G R B G G B R B G B B G R R G R G G B G G B G B) 8
54    (G G R G G G B R G R R R G R G B B R R R R G R R R) 3
```

```
31    (B R B G B R G B B G R R B R G G B R B B B R B R B) 12
93    (B R R B B G R G B R G B B R G G R B G G R G B R B) 9
91    (R G B B R B B R B R G R G G G R R B R G R R R B G) 7
28    (B R G R B R B R B R R G G R B G G R R G G R B B G) 7

the most fit of the sample ...
11    (G R G B G G B B B B B B B B B R R B G G R B B G R) 13

11    (G R G B G G B B B B B B B B B R R B G G R B B G R) 13
NIL
[12]> ( display ( select-individual p ) )
the sample of individuals ...
47    (G G G R G G G R G G G B B B B B G R G B R R B G G) 7
33    (B G B B G B B R B G R B G B B R G R G B B R R B R) 12
59    (G R R R B R B G R B R B B B B G G R B B G B B R G) 11
13    (G B R B G R G B G R G R R B G B R G G G G G G R B) 6
40    (B R B B G G G B B G G R G R B G R R R R R G R G G) 6
97    (B R R G R G B G R B G G R B R B R R G R G B B B R) 8
58    (R B G R G G B B B G B R B B G R R G R G R B B R B) 10
81    (G R R R R B B R G G R R B R R G B B B G R B G G B) 8

the most fit of the sample ...
33    (B G B B G B B R B G R B G B B R G R G B B R R B R) 12

33    (B G B B G B B R B G R B G B B R G R G B B R R B R) 12
NIL
[13]> ( display ( select-individual p ) )
the sample of individuals ...
85    (R R B R R R G B B B G R R B R G R R R B G R G G R) 6
73    (B G B G B R B G B G R B G G B B B R G R R G B R G) 10
21    (G G G B G R R B G R G G G B B B G R B R R G G G R) 6
29    (B G G B R B G G G B G B B B R R B R R R R B B R G) 10
76    (G R G G B B R B R G G R R R R G R R R R G R R G B) 4
22    (R G B R R R B B R G R B G B B R B R R B R G G G R) 8
4     (B B B R G G B B B R G R B R B B G R G B R R R B B) 12
57    (R G R B R B G G R G B R G R B B B B G R B G G G R) 8

the most fit of the sample ...
4     (B B B R G G B B B R G R B R B B G R G B R R R B B) 12

4     (B B B R G G B B B R G R B R B B G R G B R R R B B) 12
NIL
[14]>
```

2. The Lisp task ...

   Give the following code a serious look. At least think through tentative answers to each of the following questions:

(a) What does `*population-size*` represent?

(b) What does `*selection-size*` represent?

(c) What does `*fitness*` represent?

(d) Describe the nature of the value to which the `individuals` slot is bound in the manifestation of a `population` object.

Once you have your bearings, type in the code – being sure to fill in the two "blanks" that I "accedentally" inserted into the code. Then demo it in a fashion that mirrors, in all significant respects, the preceding demo.

```
( defconstant *population-size* 100 )
( defconstant *selection-size* 8 )
( setf *fitness* #'fitness-b )

( defclass population ()
  (
    ( individuals :accessor population-individuals :initarg :individuals )
    ( generation :accessor population-generation :initform 0 )
  )
)

( defmethod size ( ( p population ) )
  ( length ( population-individuals p ) )
)

( defmethod display ( ( p population ) )
  ( terpri ) ( terpri )
  ( princ "Generation " )
  ( prin1 ( population-generation p ) )
  ( princ " population ..." )
  ( terpri ) ( terpri )
  ( dolist ( i ( population-individuals p ) )
    ( display i )
  )
  ( terpri )
)

( defmethod initial-population ( &aux individuals )
  ( setf individuals () )
  ( dotimes ( i *population-size* )
    ( push ( new-individual ( + i 1 ) ( rbg-string ) ) individuals )
  )
```

```
  ( make-instance 'population :individuals ( reverse individuals ) )
)

( defmethod average ( ( p population ) &aux ( sum 0 ) )

)

( setf *select-demo* nil )

( defmethod select-individual ( ( p population )
    &aux i candidates rn )
  ( setf candidates ( select-individuals p ) )
  ( setf mfi ( most-fit-individual candidates ) )
  ( if *select-demo* ( select-demo-helper candidates mfi) )
  mfi
)

( defmethod select-individuals ( ( p population )
    &aux individuals candidates rn )
  ( setf individuals ( population-individuals p ) )
  ( setf candidates () )
  ( dotimes ( i *selection-size* )
    ( setf rn ( random *population-size* ) )
    ( push ( nth rn individuals ) candidates )
  )
  candidates
)

( defmethod most-fit-individual ( ( l list ) &aux max-value max-individual )

)

( defmethod select-demo-helper ( ( l list ) ( i individual ) )
  ( princ "the sample of individuals ..." ) ( terpri )
  ( mapcar #'display l )
  ( terpri )
  ( princ "the most fit of the sample ... " ) ( terpri )
  ( display i )
  ( terpri )
  nil
)
```

3. Encapsulated demo code ...

   Type in this one, and run it, and look the output over, to assure that it is reasonable:

```
( defmethod population-demo (&aux p)
```

```
( setf p ( initial-population ) )
( display p )
( format t "Average fitness = ~A~%~%" ( average p ) )
( setf *select-demo* t )
( format t "Sampling ...~%~%" )
( select-individual p ) ( terpri)
( format t "Sampling ...~%~%" )
( select-individual p ) ( terpri)
( format t "Sampling ...~%~%" )
( select-individual p ) ( terpri)
)
```

4. The solution document task ...

   Please add the source code associated with this task and the demos to the seventh section of your solution document.

RBG-String GA Task 8: Incorporating Mutation

Mutation operators that are applicable to individual objects will come into play when implementing the copy and crossover operators. Now is a good time to work on the incorporation of mutation into the code.

The Subtasks

1. The Lisp task ...

   The global constant in the following code, `*pc-m*`, represents an important EP paramter, the percent of newly created individuals that are mutated prior to being dropped into the next generation population. Generally speaking, the percent of individuals that are mutated before being droped into the next population is much smaller than 50 percent – but the 50 percent figure is nice for debugging purposes. Please check out the following code, and then type it in:

```
( defmethod mutate ( ( i individual ) &aux mutation )
  ( setf mutation ( mutation ( individual-rbg-string i ) ) )
  ( make-instance 'individual
    :number ( individual-number i )
    :rbg-string mutation
    :fitness ( funcall *fitness* mutation )
  )
)
```

```
( defconstant *pc-m* 50 )

( defmethod maybe-mutate ( ( i individual ) )
  ( if ( <= ( + 1 ( random 100 ) ) *pc-m* )
    ( mutate i )
    i
  )
)
```

2. The demo task ...

   Mimic this demo, in all of the significant respects. Be sure to closely inspect the output, and do your best to make sense of it.

```
$ clisp
[1]> (load "rbg.l")
;; Loading file rbg.l ...
;; Loaded file rbg.l
T
[2]> (setf i ( random-individual) )
#<INDIVIDUAL #x19EF6E91>
[3]> ( display i )
0     (B B R B G B B R R B B R R G G R B B R R B G G R R)  10
NIL
[4]> ( display ( mutate i ) )
0     (B B R B G B B R R B B R R G G R B B R R R G G R R)  9
NIL
[5]> ( display i )
0     (B B R B G B B R R B B R R G G R B B R R B G G R R)  10
NIL
[6]> ( display ( mutate i ) )
0     (B R R B G B B R R B B R R G G R B B R R B G G R R)  9
NIL
[7]> ( display i )
0     (B B R B G B B R R B B R R G G R B B R R B G G R R)  10
NIL
[8]> ( display ( maybe-mutate i ) )
0     (B B R B G B B R R B B R R G G R R B R R B G G R R)  9
NIL
[9]> ( display ( maybe-mutate i ) )
0     (B B R B G B B R R B B R R G G R B B R R B G G R R)  10
NIL
[10]> ( display ( maybe-mutate i ) )
0     (B B B B G B B R R B B R R G G R B B R R B G G R R)  11
NIL
[11]> ( display ( maybe-mutate i ) )
0     (B B R B G B B R R B B R R G B R B B R R B G G R R)  11
```

```
NIL
[12]> ( display ( maybe-mutate i ) )
0     (B B R B G B B R R B B R R G G R B B R R B G G R R)  10
NIL
[13]> ( display ( maybe-mutate i ) )
0     (B B R B G B B R R B B R R G G R B B R R B G G R R)  10
NIL
[14]>
```

3. The encapsulated demo task ...

   Type in and then run the following demos. Be sure to study the output for each in order to ascertain the reasonableness of it all. Color it if you like!

```
( defmethod mutate-demo ()
  ( setf i ( random-individual ) )
  ( display i )
  ( dotimes ( x 20 )
    ( setf i ( mutate i ) )
    ( display i )
  )
)

( defmethod maybe-mutate-demo ()
  ( setf i ( random-individual ) )
  ( display i )
  ( dotimes ( x 20 )
    ( setf n ( maybe-mutate i ) )
    ( display-nnl n )
    ( if ( not ( equal n i ) ) ( princ " *" ) )
    ( terpri )
    ( setf i n )
  )
)
```

4. The solution document task ...

   Please add the source code associated with this task and the demos, both `mutate-demo` and `maybe-mutate-demo`, to the eighth section of your solution document.

RBG-String GA Mutation Demos

This demo shows that mutation and occasional mutation are both working.

```
bash-3.2$ clisp
...

[1]> ( load "rbg.l" )
;; Loading file rbg.l ...
;; Loaded file rbg.l
T
[2]> ( mutate-demo )
0 (B B R G G B G B B B G R R G R B R R R R B B R B R) 10
0 (G B R G G B G B B B G R R G R B R R R R B B R B R) 9
0 (G B R G G B G B B B G R R B R B R R R R B B R B R) 10
0 (G B R G G B G B B B G R R B R B R R B R B B R B R) 11
0 (G B R G B B G B B B G R R B R B R R B R B B R B R) 12
0 (G B R G B B G B B B G R R B R B R R B R B B R G R) 11
0 (G B R G B B G B B B G R R B R B R R B R B G R G R) 10
0 (G B R G B B G B B B G R R B R B G R B R B G R G R) 10
0 (G B R G B B G B B B G R R B R B G G B R B G R G R) 10
0 (G B R B B B G B B B G R R B R B G G B R B G R G R) 11
0 (B B R B B B G B B B G R R B R B G G B R B G R G R) 12
0 (B B R B B B G B B B G R R B R B G G B R B G R G B) 13
0 (B G R B B B G B B B G R R B R B G G B R B G R G B) 12
0 (B G R B B B G B G B G R R B R B G G B R B G R G B) 11
0 (B G R B B B G B G B G R R B R B G G B R B G B G B) 12
0 (B G R B B B G B G B B R R B R B G G B R B G B G B) 13
0 (B G R B B B G B G B B R B B R B G G B R B G B G B) 14
0 (B G R B B B G B G B B R B B R B R G B R B G B G B) 14
0 (B G B B B B G B G B B R B B R B R G B R B G B G B) 15
0 (B G B B B B G B B B B R B B R B R G B R B G B G B) 16
0 (B G B B B B G B B B B R B R R B R G B R B G B G B) 15
NIL
[3]> ( maybe-mutate-demo )
0 (R R B R R R G R G R G R R R R G R R R G B R B G B) 4
0 (R R B R R R G R G R G R R R R G R R R G B R B G B) 4
0 (R R B R R R G R G R G R R R R G R R R G B G B G B) 4  *
0 (R R B R R R G R G R G R R R R B R R R G B G B G B) 5  *
0 (R R B R R R G R G R G R R R R B R R R G B G B G B) 5
0 (R R B R R R G R G R G R R R R B R R R G B G B G B) 5
0 (R R B R R R G R G R R R R R R B R R R G B G B G B) 5  *
0 (R R B R R R G R G R R R R R R B R R R G B G B G B) 5
0 (R R B R R R G R G R R R R R R B R R R G B G B G B) 5
0 (R R B R R R G R G R R R R R G B R R R G B G B G B) 5  *
0 (R R B R R R G R G R R R R R G B R R R G B G B G B) 5
0 (R R B R R R G R G R R R R R G B R R R G B G B G B) 5
0 (R R B R R R G R G R R R R R G B R R R G B G B G B) 5
0 (R R B R R R G R G R R R R R G B R R R G B G B G B) 5
0 (R R B R R R G R G R R R R G G B R R R G B G B G B) 5  *
0 (R R B R R R G R G R R R R G G B R R R G B G G G B) 4  *
0 (R R B R R R G R G R R R R G R B R R R G B G G G B) 4  *
0 (R R B R R R G G G R R R R G R B R R R G B G G G B) 4  *
0 (R R B R R R G G G R R R G G R B R R R G B G G G B) 4  *
0 (R R B R R R G G G R R R G G R B R R R G B G G G B) 4
0 (R R B R R R G G G R R R G G R B R R R G B G G G B) 4
NIL
```

[4]>

RBG-String GA Task 9: Copy

"Copy" is the most basic genetic operator in the context of evolutionary programming. **It amounts to (1) a favored random selection of an individual from the source population, followed by (2) a drop of the selected individual, sometimes after mutation, into the destination population.**

The Subtasks

1. The Lisp task ...

   In the code that follows, the `*copy-demo*` variable serves to switch tracing of the copy operation on and off. The `*pc-c*` parameter is another important EP parameter – this one indicating the percentage of genetic operators that will be copy, rather than crossover, operators. The `empty-population` method is used to establish an initial next-generation population which will be populated by means of genetic operations.

```
( setf *copy-demo* nil )

( defconstant *pc-c* 40 )

( defmethod perform-copies ( ( cp population ) ( np population ) )
  ( dotimes ( i ( nr-copies ) )
    ( perform-one-copy cp np )
  )
)

( defmethod nr-copies ()
  ( * ( / *pc-c* 100 ) *population-size* )
)

( defmethod perform-one-copy ( ( cp population ) ( np population )
    &aux x m mm new-i )
  ( setf m ( select-individual cp ) )
  ( if *copy-demo* ( format t "Selected individual = ~%" ) )
  ( if *copy-demo* ( display m ) )
  ( setf mm ( maybe-mutate m ) )
  ( if *copy-demo* ( format t "Possibly muted individual = ~&" ) )
  ( if *copy-demo* ( display mm ) )
  ( setf ( individual-number mm ) ( + 1 ( size np ) ) )
  ( if *copy-demo* ( format t "Renumbered individual = ~&" ) )
```

```
    ( if *copy-demo* ( display mm ) )
    ( setf new-i ( new-individual ( + 1 ( size np ) ) ( individual-rbg-string mm ) ) )
    ( setf
      ( population-individuals np )
      ( append ( population-individuals np ) ( list new-i ) )
    )
    nil
  )

  ( defmethod empty-population ( ( cp population ) &aux np )
    ( setf np ( make-instance 'population ) )
    ( setf ( population-individuals np ) () )
    ( setf ( population-generation np ) ( + 1 ( population-generation cp ) ) )
    np
  )
```

2. The embodied demo task ...

   Read/study and then enter this embodied demo code, run it, and do your best to make good sense of the ouptut.

```
( defmethod perform-copies-demo ( &aux cp np )
  ( setf cp ( initial-population ) )
  ( setf np ( empty-population cp ) )
  ( format t "-----------------------------------
  ( display np )
  ( format t "~%~%---------------------------------
  ( setf *select-demo* t )
  ( setf *copy-demo* t )
  ( dotimes ( i 10 )
    ( perform-one-copy cp np )
    ( format t "----------------------------------
    ( display np )
    ( format t "~%~%--------------------------------
  )
  ( setf *select-demo* nil )
  ( setf *copy-demo* nil )
  nil
)
```

3. The solution document task ...

   Please add the source code associated with this task and the demo, the one resulting from executing `perform-copies-demo`, to the nineth section of your solution document.

RBG-String GA Perfrom Copies Demo

This demo show that the “copy” operation is working.

```
bash-3.2$ clisp
...

[1]> ( load "rbg.l" )
;; Loading file rbg.l ...
;; Loaded file rbg.l
T
[2]> ( perform-copies-demo )
--------------------------------------------------------------------------


Generation 1 population ...


--------------------------------------------------------------------------
the sample of individuals ...
51 (R B B B B R G R G B G B B B R B G R G B B R R G R) 11
24 (B G G R G R G G G G B G G B G R B R G G R R G R B) 5
91 (G R B R R B G G R G R B R G R G R G R B R G B G B) 6
42 (R R B G R B G G B R R G R R R B B G B R B R R G B) 8
41 (G G G R G R R B G B R G G R G B R G B R R R R B R) 5
67 (G B G G B G B R G B B G R G R R B R G B G R G B R) 8
47 (R R B R R G B R G G G G R R G B R G B B B R R B G) 7
7 (R B G B G R R G G B G B R B R B R B R B B G B G G) 10

the most fit of the sample ...
51 (R B B B B R G R G B G B B B R B G R G B B R R G R) 11

Selected individual =
51 (R B B B B R G R G B G B B B R B G R G B B R R G R) 11
Possibly muted individual =
51 (R B B B B R G R G B G B B B R B G R G B B R R G R) 11
Renumbered individual =
1 (R B B B B R G R G B G B B B R B G R G B B R R G R) 11
--------------------------------------------------------------------------


Generation 1 population ...
1 (R B B B B R G R G B G B B B R B G R G B B R R G R) 11


--------------------------------------------------------------------------
the sample of individuals ...
4 (G R R R R G R R R G B R B G B G R G G B R B G B G) 6
8 (G G G B B R R R R R B B B B R R B R G G R G G R R) 7
26 (B R B B B G B B G R B B R G R G B G B G G G B R R) 11
80 (R R G R R G G R G B G G G B B B B B G B B G G B B) 10
```

```
47 (R R B R R G B R G G G R R G B R G B B B R R B G) 7
71 (R G G B B R R G B R R G B G B R G G G B B G R B B) 9
38 (B G G R R B R R R R G B B B R R B B R B B R R G G) 9
22 (B G G R B G B R B B R B G G R G B B R B B R R G G) 10

the most fit of the sample ...
26 (B R B B B G B B G R B B R G R G B G B G G G B R R) 11

Selected individual =
26 (B R B B B G B B G R B B R G R G B G B G G G B R R) 11
Possibly muted individual =
26 (B R B B B G B B G R B B R G R G B G B G G G B R R) 11
Renumbered individual =
2 (B R B B B G B B G R B B R G R G B G B G G G B R R) 11
------------------------------------------------------------------------


Generation 1 population ...
1 (R B B B B R G R G B G B B B R B G R G B B R R G R) 11
2 (B R B B B G B B G R B B R G R G B G B G G G B R R) 11


------------------------------------------------------------------------
the sample of individuals ...
78 (R G R B B G B G B G G B B B G R G B B B B B B R R) 13
72 (G G R R R B R R R B R B G R R R R B B R B R G R G) 6
87 (B R G B G R R B G B B G R R R B R R B R G B R G B) 9
24 (B G G R G R G G G G B G G B G R B R G G R R G R B) 5
87 (B R G B G R R B G B B G R R R B R R B R G B R G B) 9
86 (R R G B B R B R R B B B G R R B B G R B B G G G R) 10
32 (R G G R R R R B R B B B B R R R R R B B R B G R B) 9
22 (B G G R B G B R B B R B G G R G B B R B B R R G G) 10

the most fit of the sample ...
78 (R G R B B G B G B G G B B B G R G B B B B B B R R) 13

Selected individual =
78 (R G R B B G B G B G G B B B G R G B B B B B B R R) 13
Possibly muted individual =
78 (R G R B B G B G B G G B B B G R G B B B B B B R R) 13
Renumbered individual =
3 (R G R B B G B G B G G B B B G R G B B B B B B R R) 13
------------------------------------------------------------------------


Generation 1 population ...
1 (R B B B B R G R G B G B B B R B G R G B B R R G R) 11
2 (B R B B B G B B G R B B R G R G B G B G G G B R R) 11
3 (R G R B B G B G B G G B B B G R G B B B B B B R R) 13


------------------------------------------------------------------------
the sample of individuals ...
86 (R R G B B R B R R B B B G R R B B G R B B G G G R) 10
```

```
45 (R R G B G R B G G B G G B R R B G R R B B B G R R) 8
54 (R R G B G G R R R G R R B B R B B R R B R G R G B) 7
90 (R G G B R B G B R B R R G G B G R G B R G R B R G) 7
50 (R B G G G G G B R R G G B R B R B G R G R G R G R) 5
19 (R G G G G G R R G B R B B R G B R R B R G G G G G) 5
31 (B G G R B B B G G G B G R R B B G R B B R R R B G) 10
34 (B B B B R R R G R R B R G G R B B R B B G G G R R) 9

the most fit of the sample ...
86 (R R G B B R B R R B B B G R R B B G R B B G G G R) 10

Selected individual =
86 (R R G B B R B R R B B B G R R B B G R B B G G G R) 10
Possibly muted individual =
86 (R R G B G R B R R B B B G R R B B G R B B G G G R) 9
Renumbered individual =
4 (R R G B G R B R R B B B G R R B B G R B B G G G R) 9
------------------------------------------------------------------------


Generation 1 population ...
1 (R B B B B R G R G B G B B B R B G R G B B R R G R) 11
2 (B R B B B G B B G R B B R G R G B G B G G G B R R) 11
3 (R G R B B G B G B G G B B B G R G B B B B B B R R) 13
4 (R R G B G R B R R B B B G R R B B G R B B G G G R) 9


------------------------------------------------------------------------
the sample of individuals ...
15 (G G B R R G G G R G B R R R B B B G G G G G B B G) 7
55 (B B R R B G R R G G G G G B B B R R R G R B G B B) 9
95 (B B B G R R B B G R R B G G G R B B R R B R B G G) 10
48 (B B G B R B R B B R G B G G B R B G R B G G R R B) 11
36 (G R G B R B G R B B R G G G G B G G B G B R G B R) 8
44 (B G B R B G G R R B R B R R B B R R G B R B B G R) 10
30 (B B B B B G G R B G G G B R B G R G G G G B G B B) 11
27 (G R B B R B G R R R R G B B G B R B G R R R B R G) 8

the most fit of the sample ...
48 (B B G B R B R B B R G B G G B R B G R B G G R R B) 11

Selected individual =
48 (B B G B R B R B B R G B G G B R B G R B G G R R B) 11
Possibly muted individual =
48 (B B G B R B R B B R G B G G B R B G R B G G R R B) 11
Renumbered individual =
5 (B B G B R B R B B R G B G G B R B G R B G G R R B) 11
------------------------------------------------------------------------


Generation 1 population ...
1 (R B B B B R G R G B G B B B R B G R G B B R R G R) 11
2 (B R B B B G B B G R B B R G R G B G B G G G B R R) 11
3 (R G R B B G B G B G G B B B G R G B B B B B B R R) 13
```

```
4 (R R G B G R B R R B B B G R R B B G R B B G G G R) 9
5 (B B G B R B R B B R G B G G B R B G R B G G R R B) 11


-------------------------------------------------------------------------
the sample of individuals ...
56 (G R B G B B G B B B R G G G G B B G G B B B G B G) 12
37 (R B B G R B R R G B R G G R G B G R R G B G G B R) 7
96 (G B B G R R B R B G B B G B B G R B R G G R B B G) 11
44 (B G B R B G G R R B R B R R B B R R G B R B B G R) 10
22 (B G G R B G B R B B R B G G R G B B R B B R R G G) 10
34 (B B B B R R R G R R B R G G R B B R B B G G G R R) 9
29 (G R R G R G B B G G B R G R B R B R G G B B G B G) 8
97 (B B B B R G B B R R R R R G R R G R B G G B B B R) 10

the most fit of the sample ...
56 (G R B G B B G B B B R G G G G B B G G B B B G B G) 12

Selected individual =
56 (G R B G B B G B B B R G G G G B B G G B B B G B G) 12
Possibly muted individual =
56 (G R B G B B G B B B R G G G G B B G G G B B G B G) 11
Renumbered individual =
6 (G R B G B B G B B B R G G G G B B G G G B B G B G) 11
-------------------------------------------------------------------------


Generation 1 population ...
1 (R B B B B R G R G B G B B B R B G R G B B R R G R) 11
2 (B R B B B G B B G R B B R G R G B G B G G G B R R) 11
3 (R G R B B G B G B G G B B B G R G B B B B B B R R) 13
4 (R R G B G R B R R B B B G R R B B G R B B G G G R) 9
5 (B B G B R B R B B R G B G G B R B G R B G G R R B) 11
6 (G R B G B B G B B B R G G G G B B G G G B B G B G) 11


-------------------------------------------------------------------------
the sample of individuals ...
90 (R G G B R B G B R B R R G G B G R G B R G R B R G) 7
38 (B G G R R B R R R R G B B B R R B B R B B R R G G) 9
87 (B R G B G R R B G B B G R R R B R R B R G B R G B) 9
62 (R B B G B G R R B R G G B R G G B R B R G B G B R) 9
37 (R B B G R B R R G B R G G R G B G R R G B G G B R) 7
3 (R G R B B G B G B G G B B B G R G B B B B B B R R) 13
22 (B G G R B G B R B B R B G G R G B B R B B R R G G) 10
5 (G G G B G B R G B G G R R B R G R B B B B G B R G) 9

the most fit of the sample ...
3 (R G R B B G B G B G G B B B G R G B B B B B B R R) 13

Selected individual =
3 (R G R B B G B G B G G B B B G R G B B B B B B R R) 13
Possibly muted individual =
3 (R B R B B G B G B G G B B B G R G B B B B B B R R) 14
```

```
Renumbered individual =
7 (R B R B B G B G B G G B B B G R G B B B B B B R R) 14
------------------------------------------------------------------------


Generation 1 population ...
1 (R B B B B R G R G B G B B B R B G R G B B R R G R) 11
2 (B R B B B G B B G R B B R G R G B G B G G G B R R) 11
3 (R G R B B G B G B G G B B B G R G B B B B B B R R) 13
4 (R R G B G R B R R B B B G R R B B G R B B G G G R) 9
5 (B B G B R B R B B R G B G G B R B G R B G G R R B) 11
6 (G R B G B B G B B B R G G G B B G G G B B G B G) 11
7 (R B R B B G B G B G G B B B G R G B B B B B B R R) 14


------------------------------------------------------------------------
the sample of individuals ...
45 (R R G B G R B G G B G G B R R B G R R B B B G R R) 8
83 (B R R R G B G B B B R B R B B G B B R R G R B R R) 11
67 (G B G G B G B R G B B G R G R R B R G B G R G B R) 8
35 (R R R G B G R R R G G G B R G G B B B G B B R G B) 8
56 (G R B G B B G B B B R G G G G B B G G B B B G B G) 12
36 (G R G B R B G R B B R G G G G B G G B G B R G B R) 8
1 (R B B B B R G R G B G B B B R B G R G B B R R G R) 11
20 (R B B G R G B R G R B G G B B B B G R R G R B R R) 9

the most fit of the sample ...
56 (G R B G B B G B B B R G G G G B B G G B B B G B G) 12

Selected individual =
56 (G R B G B B G B B B R G G G G B B G G B B B G B G) 12
Possibly muted individual =
56 (G R B G B B G B B B R G G G G R B G G B B B G B G) 11
Renumbered individual =
8 (G R B G B B G B B B R G G G G R B G G B B B G B G) 11
------------------------------------------------------------------------


Generation 1 population ...
1 (R B B B B R G R G B G B B B R B G R G B B R R G R) 11
2 (B R B B B G B B G R B B R G R G B G B G G G B R R) 11
3 (R G R B B G B G B G G B B B G R G B B B B B B R R) 13
4 (R R G B G R B R R B B B G R R B B G R B B G G G R) 9
5 (B B G B R B R B B R G B G G B R B G R B G G R R B) 11
6 (G R B G B B G B B B R G G G G B B G G G B B G B G) 11
7 (R B R B B G B G B G G B B B G R G B B B B B B R R) 14
8 (G R B G B B G B B B R G G G G R B G G B B B G B G) 11


------------------------------------------------------------------------
the sample of individuals ...
23 (G G G G R G B R B B G R B R R B G B G B B R R G R) 8
69 (B R R B G G R B G R G G B G B G G R R R G B R G G) 6
5 (B B G B R B R B B R G B G G B R B G R B G G R R B) 11
```

```
95 (B B B G R R B B G R R B G G G R B B R R B R B G G) 10
28 (G G R B B G R G G B B G R B B G R B B R G G B G B) 10
56 (G R B G B B G B B B R G G G G B B G G B B B G B G) 12
70 (R G G B G B R G G R G G G G G G R B R B G B G R R) 5
33 (R G B B B B G R B B B B G B R G G R B G B G G G G) 11

the most fit of the sample ...
56 (G R B G B B G B B B R G G G G B B G G B B B G B G) 12

Selected individual =
56 (G R B G B B G B B B R G G G G B B G G B B B G B G) 12
Possibly muted individual =
56 (G R B G B B G B B B R G G G G B B G G B B B G B G) 12
Renumbered individual =
9 (G R B G B B G B B B R G G G G B B G G B B B G B G) 12
------------------------------------------------------------------------


Generation 1 population ...
1 (R B B B B R G R G B G B B B R B G R G B B R R G R) 11
2 (B R B B B G B B G R B B R G R G B G B G G G B R R) 11
3 (R G R B B G B G B G G B B B G R G B B B B B B R R) 13
4 (R R G B G R B R R B B B G R R B B G R B B G G G R) 9
5 (B B G B R B R B B R G B G G B R B G R B G G R R B) 11
6 (G R B G B B G B B B R G G G G B B G G G B B G B G) 11
7 (R B R B B G B G B G G B B B G R G B B B B B B R R) 14
8 (G R B G B B G B B B R G G G R B G G B B B G B G) 11
9 (G R B G B B G B B B R G G G G B B G G B B B G B G) 12


------------------------------------------------------------------------
the sample of individuals ...
60 (R R R B G B R B G G R G B G G R R G B G R R B B B) 8
55 (B B R R B G R R G G G G G B B B R R R G R B G B B) 9
84 (G R R B R R G G R R G G R R B R G R R R R R B B B) 5
54 (R R G B G G R R R G R R B B R B B R R B R G R G B) 7
39 (R B G G B G G G B G B B G G R R R B R B B R G B G) 9
62 (R B B G B G R R B R G G B R G G B R B R G B G B R) 9
13 (R B B G R G G G G R G G R B R B G B R G B R R R B) 7
90 (R G G B R B G B R B R R G G B G R G B R G R B R G) 7

the most fit of the sample ...
55 (B B R R B G R R G G G G G B B B R R R G R B G B B) 9

Selected individual =
55 (B B R R B G R R G G G G G B B B R R R G R B G B B) 9
Possibly muted individual =
55 (B B R R B G R R R G G G G B B B R R R G R B G B B) 9
Renumbered individual =
10 (B B R R B G R R R G G G G B B B R R R G R B G B B) 9
------------------------------------------------------------------------


Generation 1 population ...
```

```
1 (R B B B B R G R G B G B B B R B G R G B B R R G R) 11
2 (B R B B B G B B G R B B R G R G B G B G G G B R R) 11
3 (R G R B B G B G B G G B B B G R G B B B B B B R R) 13
4 (R R G B G R B R R B B B G R R B B G R B B G G G R) 9
5 (B B G B R B R B B R G B G G B R B G R B G G R R B) 11
6 (G R B G B B G B B B R G G G G B B G G G B B G B G) 11
7 (R B R B B G B G B G G B B B G R G B B B B B B R R) 14
8 (G R B G B B G B B B R G G G G R B G G B B B G B G) 11
9 (G R B G B B G B B B R G G G G B B G G B B B G B G) 12
10 (B B R R B G R R R G G G G B B B R R R G R B G B B) 9

--------------------------------------------------------------------------
NIL
[3]>
```

RBG-String GA Task 10: Crossover

The genetic operator "crossover" selects two favored individual from the current population, creates a new individual by taking elements of each favored individual (i.e., by performing crossover), possibly mutates the newly created individual, and then adds it to the new population.

The Subtasks

1. The Lisp task ...

   In the code that follows, the `*crossover-demo*` variable serves to switch tracing of the copy operation on and off. The `*pc-x*` parameter is another important EP parameter – this one indicating the percentage of genetic operators that will be crossover, rather than copy, operators. The `empty-population` method is used to establish an initial next-generation population which will be populated by means of genetic operations.

```
( setf *crossover-demo* nil )

( defconstant *pc-x* 60 )

( defmethod perform-crossovers ( ( cp population ) ( np population ) )
  ( dotimes ( i ( nr-crossovers ) )
    ( perform-one-crossover cp np )
  )
)

( defmethod nr-crossovers ()
  ( * ( / *pc-x* 100 ) *population-size* )
)
```

```
( defmethod perform-one-crossover ( ( cp population ) ( np population ) )
  ( let ( x m mm mother father new-i )
    ( setf mother ( select-individual cp ) )
    ( setf father ( select-individual cp ) )
    ( if *crossover-demo* ( format t "Selected mother = ~%" ) )
    ( if *crossover-demo* ( display mother ) )
    ( if *crossover-demo* ( format t "Selected father = ~&" ) )
    ( if *crossover-demo* ( display father ) )
    ( setf m ( crossover mother father ) )
    ( if *crossover-demo* ( format t "the crossover = ~&" ) )
    ( if *crossover-demo* ( display m ) )
    ( setf mm ( maybe-mutate m ) )
    ( if *crossover-demo* ( format t "the possiblly mutated individual = ~&" ) )
    ( if *crossover-demo* ( display mm ) )
    ( setf ( individual-number mm ) ( + 1 ( size np ) ) )
    ( if *crossover-demo* ( format t "the renumbered individual = ~&" ) )
    ( if *crossover-demo* ( display mm ) )
    ( setf new-i ( new-individual ( + 1 ( size np ) ) ( individual-rbg-string mm ) )
    ( setf
      ( population-individuals np )
      ( append ( population-individuals np ) ( list new-i ) )
    )
  )
  nil
)

( defmethod crossover ( ( mother individual ) ( father individual )
    &aux mi fi x i )
  ( setf mi (individual-rbg-string mother ) )
  ( setf fi (individual-rbg-string father ) )
  ( setf x ( crossover mi fi ) )
  ( setf i ( new-individual 0 x ) )
  i
)
```

2. The embodied demo task ...

   Read/study and then enter this embodied demo code, run it, and do your best to make good sense of the ouptut.

```
( defmethod perform-crossovers-demo ( &aux cp np )
  ( setf cp ( initial-population ) )
  ( setf np ( empty-population cp ) )
  ( format t "--------------------------------------------------------------------
  ( display np )
```

```
    ( format t "~%~%-----------------------------------------------------------------
    ( setf *select-demo* t )
    ( setf *crossover-demo* t )
    ( dotimes ( i 10 )
      ( perform-one-crossover cp np )
      ( format t "-----------------------------------------------------------------
      ( display np )
      ( format t "~%~%-----------------------------------------------------------------
    )
    ( setf *select-demo* nil )
    ( setf *crossover-demo* nil )
    nil
  )
```

3. The solution document task ...

   Please add the source code associated with this task and the demo, the one resulting from executing `perform-crossovers-demo`, to the tenth section of your solution document.

RBG-String GA Perfrom Crossovers Demo

This demo show that the "crossover" operation is working.

```
bash-3.2$ clisp
...

[1]> ( load "rbg.l" )
;; Loading file rbg.l ...
;; Loaded file rbg.l
T
[2]> ( perform-crossovers-demo )
--------------------------------------------------------------------


Generation 1 population ...


--------------------------------------------------------------------
the sample of individuals ...
51 (R B B B B R G R G B G B B B R B G R G B B R R G R) 11
24 (B G G R G R G G G G B G G B G R B R G G R R G R B) 5
91 (G R B R R B G G R G R B R G R G R G R B R G B G B) 6
42 (R R B G R B G G B R R G R R R B B G B R B R R G B) 8
41 (G G G R G R R B G B R G G R G B R G B R R R R B R) 5
67 (G B G G B G B R G B B G R G R R B R G B G R G B R) 8
47 (R R B R R G B R G G G G R R G B R G B B B R R B G) 7
7 (R B G B G R R G G B G B R B R B R B R B B G B G G) 10
```

```
the most fit of the sample ...
51 (R B B B B R G R G B G B B B R B G R G B B R R G R) 11

the sample of individuals ...
8 (G G G B B R R R R R B B B B R R B R G G R G G R R) 7
26 (B R B B B G B B G R B B R G R G B G B G G G B R R) 11
80 (R R G R R G G R G B G G G B B B B B G B B G G B B) 10
47 (R R B R R G B R G G G G R R G B R G B B B R R B G) 7
71 (R G G B B R R G B R R G B G B R G G G B B G R B B) 9
38 (B G G R R B R R R R G B B B R R B B R B B R R G G) 9
22 (B G G R B G B R B B R B G G R G B B R B B R R G G) 10
94 (G B G G B R G R R R R R B B B B B B R G B B R B R) 11

the most fit of the sample ...
26 (B R B B B G B B G R B B R G R G B G B G G G B R R) 11

Selected mother =
51 (R B B B B R G R G B G B B B R B G R G B B R R G R) 11
Selected father =
26 (B R B B B G B B G R B B R G R G B G B G G G B R R) 11
the crossover =
0 (R B B B B G B B G R B B R G R G B G B G G G B R R) 11
the possiblly mutated individual =
0 (R B B B B G B B G R B B R G R G B G B G G G B R R) 11
the renumbered individual =
1 (R B B B B G B B G R B B R G R G B G B G G G B R R) 11
------------------------------------------------------------------------


Generation 1 population ...
1 (R B B B B G B B G R B B R G R G B G B G G G B R R) 11


------------------------------------------------------------------------
the sample of individuals ...
78 (R G R B B G B G B G G B B B G R G B B B B B B R R) 13
72 (G G R R R B R R R B R B G R R R R B B R B R G R G) 6
87 (B R G B G R R B G B B G R R R B R R B R G B R G B) 9
24 (B G G R G R G G G G B G G B G R B R G G R R G R B) 5
87 (B R G B G R R B G B B G R R R B R R B R G B R G B) 9
86 (R R G B B R B R R B B B G R R B B G R B B G G G R) 10
32 (R G G R R R R B R B B B B R R R R R B B R B G R B) 9
22 (B G G R B G B R B B R B G G R G B B R B B R R G G) 10

the most fit of the sample ...
78 (R G R B B G B G B G G B B B G R G B B B B B B R R) 13

the sample of individuals ...
45 (R R G B G R B G G B G G B R R B G R R B B B G R R) 8
54 (R R G B G G R R R G R R B B R B B R R B R G R G B) 7
90 (R G G B R B G B R B R R G G B G R G B R G R B R G) 7
50 (R B G G G G G B R R G G B R B R B G R G R G R G R) 5
19 (R G G G G G R R G B R B B R G B R R B R G G G G G) 5
```

```
31 (B G G R B B B G G G B G R R B B G R B B R R R B G) 10
34 (B B B B R R R G R R B R G G R B B R B B G G G R R) 9
83 (B R R R G B G B B B R B R B B G B B R R G R B R R) 11

the most fit of the sample ...
83 (B R R R G B G B B B R B R B B G B B R R G R B R R) 11

Selected mother =
78 (R G R B B G B G B G G B B B G R G B B B B B B R R) 13
Selected father =
83 (B R R R G B G B B B R B R B B G B B R R G R B R R) 11
the crossover =
0 (R G R B B G B G B G G B R B B G B B R R G R B R R) 10
the possiblly mutated individual =
0 (R G R B G G B G B G G B R B B G B B R R G R B R R) 9
the renumbered individual =
2 (R G R B G G B G B G G B R B B G B B R R G R B R R) 9
--------------------------------------------------------------------------


Generation 1 population ...
1 (R B B B B G B B G R B B R G R G B G B G G G B R R) 11
2 (R G R B G G B G B G G B R B B G B B R R G R B R R) 9


--------------------------------------------------------------------------
the sample of individuals ...
15 (G G B R R G G G R G B R R R B B B G G G G G B B G) 7
55 (B B R R B G R R G G G G G B B B R R R G R B G B B) 9
95 (B B B G R R B B G R R B G G G R B B R R B R B G G) 10
48 (B B G B R B R B B R G B G G B R B G R B G G R R B) 11
36 (G R G B R B G R B B R G G G G B G G B G B R G B R) 8
44 (B G B R B G G R R B R B R R B B R R G B R B B G R) 10
30 (B B B B B G G R B G G G B R B G R G G G G B G B B) 11
27 (G R B B R B G R R R R G B B G B R B G R R R B R G) 8

the most fit of the sample ...
48 (B B G B R B R B B R G B G G B R B G R B G G R R B) 11

the sample of individuals ...
37 (R B B G R B R R G B R G G R G B G R R G B G G B R) 7
96 (G B B G R R B R B G B B G B B G R B R G G R B B G) 11
44 (B G B R B G G R R B R B R R B B R R G B R B B G R) 10
22 (B G G R B G B R B B R B G G R G B B R B B R R G G) 10
34 (B B B B R R R G R R B R G G R B B R B B G G G R R) 9
29 (G R R G R G B B G G B R G R B R B R G G B B G B G) 8
97 (B B B B R G B B R R R R R G R R G R B G G B B B R) 10
93 (B G R B G R R B B R G R B B G G B R B B R G R G G) 9

the most fit of the sample ...
96 (G B B G R R B R B G B B G B B G R B R G G R B B G) 11

Selected mother =
48 (B B G B R B R B B R G B G G B R B G R B G G R R B) 11
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Selected father =
96 (G B B G R R B R B G B B G B B G R B R G G R B B G) 11
the crossover =
0 (B B G B R B B R B G B B G B B G R B R G G R B B G) 13
the possiblly mutated individual =
0 (B B G B R B B R B G B B G B B G R B R B G R B B G) 14
the renumbered individual =
3 (B B G B R B B R B G B B G B B G R B R B G R B B G) 14
---------------------------------------------------------------------------


Generation 1 population ...
1 (R B B B B G B B G R B B R G R G B G B G G G B R R) 11
2 (R G R B G G B G B G G B R B B G B B R R G R B R R) 9
3 (B B G B R B B R B G B B G B B G R B R B G R B B G) 14


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the sample of individuals ...
90 (R G G B R B G B R B R R G G B G R G B R G R B R G) 7
38 (B G G R R B R R R R G B B B R R B B R B B R R G G) 9
87 (B R G B G R R B G B B G R R R B R R B R G B R G B) 9
62 (R B B G B G R R B R G G B R G G B R B R G B G B R) 9
37 (R B B G R B R R G B R G G R G B G R R G B G G B R) 7
78 (R G R B B G B G B G G B B B G R G B B B B B B R R) 13
22 (B G G R B G B R B B R B G G R G B B R B B R R G G) 10
5 (G G G B G B R G B G G R R B R G R B B B B G B R G) 9

the most fit of the sample ...
78 (R G R B B G B G B G G B B B G R G B B B B B B R R) 13

the sample of individuals ...
35 (R R R G B G R R R G G G B R G G B B B G B B R G B) 8
56 (G R B G B B G B B B R G G G G B B G G B B B G B G) 12
36 (G R G B R B G R B B R G G G G B G G B G B R G B R) 8
51 (R B B B B R G R G B G B B B R B G R G B B R R G R) 11
20 (R B B G R G B R G R B G G B B B B G R R G R B R R) 9
6 (B R R G B G G B B G G B R B B B R G B R R R G B G) 10
77 (B R G R B R R G G G B R B R B B R B G G G B B B G) 10
47 (R R B R R G B R G G G G R R G B R G B B B R R B G) 7

the most fit of the sample ...
56 (G R B G B B G B B B R G G G G B B G G B B B G B G) 12

Selected mother =
78 (R G R B B G B G B G G B B B G R G B B B B B B R R) 13
Selected father =
56 (G R B G B B G B B B R G G G G B B G G B B B G B G) 12
the crossover =
0 (R G R B B G B G B G G B B B G R G G G B B B G B G) 11
the possiblly mutated individual =
0 (R G R B B G B G B G G B B B G R G G G B B B G B G) 11
the renumbered individual =
4 (R G R B B G B G B G G B B B G R G G G B B B G B G) 11
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Generation 1 population ...
1 (R B B B B G B B G R B B R G R G B G B G G G B R R) 11
2 (R G R B G G B G B G G B R B B G B B R R G R B R R) 9
3 (B B G B R B B R B G B B G B B G R B R B G R B B G) 14
4 (R G R B B G B G B G G B B B G R G G G B B B G B G) 11


--------------------------------------------------------------------------
the sample of individuals ...
28 (G G R B B G R G G B B G R B B G R B B R G G B G B) 10
56 (G R B G B B G B B B R G G G G B B G G B B B G B G) 12
70 (R G G B G B R G G R G G G G G R B R B G B G R R) 5
33 (R G B B B B G R B B B B G B R G G R B G B G G G G) 11
77 (B R G R B R R G G G B R B R B B R B G G G B B B G) 10
66 (R B R G G R G G G R B G R G B R G R B B R R G R G) 5
35 (R R R G B G R R R G G G B R G G B B B G B B R G B) 8
45 (R R G B G R B G G B G G B R R B G R R B B B G R R) 8

the most fit of the sample ...
56 (G R B G B B G B B B R G G G G B B G G B B B G B G) 12

the sample of individuals ...
62 (R B B G B G R R B R G G B R G G B R B R G B G B R) 9
13 (R B B G R G G G G R G G R B R B G B R G B R R R B) 7
90 (R G G B R B G B R B R R G G B G R G B R G R B R G) 7
72 (G G R R R B R R R B R B G R R R R B B R B R G R G) 6
23 (G G G G R G B R B B G R B R R B G B G B B R R G R) 8
69 (B R R B G G R B G R G G B G B G G R R R G B R G G) 6
48 (B B G B R B R B B R G B G G B R B G R B G G R R B) 11
95 (B B B G R R B B G R R B G G G R B B R R B R B G G) 10

the most fit of the sample ...
48 (B B G B R B R B B R G B G G B R B G R B G G R R B) 11

Selected mother =
56 (G R B G B B G B B B R G G G G B B G G B B B G B G) 12
Selected father =
48 (B B G B R B R B B R G B G G B R B G R B G G R R B) 11
the crossover =
0 (G R B G B B G B B B R G G G B R B G R B G G R R B) 10
the possiblly mutated individual =
0 (G R B G B B G B B B R G G G B R B G R B G G R R B) 10
the renumbered individual =
5 (G R B G B B G B B B R G G G B R B G R B G G R R B) 10
--------------------------------------------------------------------------


Generation 1 population ...
1 (R B B B B G B B G R B B R G R G B G B G G G B R R) 11
2 (R G R B G G B G B G G B R B B G B B R R G R B R R) 9
3 (B B G B R B B R B G B B G B B G R B R B G R B B G) 14
```

```
4 (R G R B B G B G B G G B B B G R G G G B B B G B G) 11
5 (G R B G B B G B B B R G G G B R B G R B G G R R B) 10


------------------------------------------------------------------------
the sample of individuals ...
36 (G R G B R B G R B B R G G G G B G G B G B R G B R) 8
60 (R R R B G B R B G G R G B G G R R G B G R R B B B) 8
93 (B G R B G R R B B R G R B B G G B R B B R G R G G) 9
9 (R G B B B B B R G G G R R R G G R B R R G G R B R) 7
48 (B B G B R B R B B R G B G G B R B G R B G G R R B) 11
60 (R R R B G B R B G G R G B G G R R G B G R R B B B) 8
55 (B B R R B G R R G G G G G B B B R R R G R B G B B) 9
84 (G R R B R R G G R R G G R R B R G R R R R R B B B) 5

the most fit of the sample ...
48 (B B G B R B R B B R G B G G B R B G R B G G R R B) 11

the sample of individuals ...
46 (G B B B B G B G R B G B G R R B R B R G B B G B R) 12
49 (R G R B G R G R B R G B B G B G R B G G R B G R G) 7
31 (B G G R B B B G G G B G R R B B G R B B R R R B G) 10
8 (G G G B B R R R R R B B B B R R B R G G R G G R R) 7
33 (R G B B B B G R B B B B G B R G G R B G B G G G G) 11
77 (B R G R B R R G G G B R B R B B R B G G G B B B G) 10
99 (G B G R B B R G R B B R B G R R R B B G R R B R G) 9
13 (R B B G R G G G G R G G R B R B G B R G B R R R B) 7

the most fit of the sample ...
46 (G B B B B G B G R B G B G R R B R B R G B B G B R) 12

Selected mother =
48 (B B G B R B R B B R G B G G B R B G R B G G R R B) 11
Selected father =
46 (G B B B B G B G R B G B G R R B R B R G B B G B R) 12
the crossover =
0 (B B G B R B R B B R G B G G B R B G R B G G R R R) 10
the possiblly mutated individual =
0 (B B R B R B R B B R G B G G B R B G R B G G R R R) 10
the renumbered individual =
6 (B B R B R B R B B R G B G G B R B G R B G G R R R) 10
------------------------------------------------------------------------


Generation 1 population ...
1 (R B B B B G B B G R B B R G R G B G B G G G B R R) 11
2 (R G R B G G B G B G G B R B B G B B R R G R B R R) 9
3 (B B G B R B B R B G B B G B B G R B R B G R B B G) 14
4 (R G R B B G B G B G G B B B G R G G G B B B G B G) 11
5 (G R B G B B G B B B R G G G B R B G R B G G R R B) 10
6 (B B R B R B R B B R G B G G B R B G R B G G R R R) 10


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the sample of individuals ...
74 (B B R B B R G B R B B B G R G B G R G R B B G R R) 11
68 (G G R G G B G R R G G R G R G G R R B B R G B G B) 5
14 (B R G G R R R G R R B G G B R B G R B G B R B G G) 7
32 (R G G R R R R B R B B B B R R R R R B B R B G R B) 9
18 (G R G R G R B G R R R B G B G B B G B B B G R G G) 8
29 (G R R G R G B B G G B R G R B R B R G G B B G B G) 8
44 (B G B R B G G R R B R B R R B B R R G B R B B G R) 10
23 (G G G G R G B R B B G R B R R B G B G B B R R G R) 8

the most fit of the sample ...
74 (B B R B B R G B R B B B G R G B G R G R B B G R R) 11

the sample of individuals ...
100 (G G R R B B G R R G B B B G G R B G G G G R B G G) 7
100 (G G R R B B G R R G B B B G G R B G G G G R B G G) 7
67 (G B G G B G B R G B B G R G R R B R G B G R G B R) 8
59 (B R R B R B B B R R G R R G G R R R R B B R R R G) 7
39 (R B G G B G G G B G B B G G R R R B R B B R G B G) 9
14 (B R G G R R R G R R B G G B R B G R B G B R B G G) 7
62 (R B B G B G R R B R G G B R G G B R B R G B G B R) 9
67 (G B G G B G B R G B B G R G R R B R G B G R G B R) 8

the most fit of the sample ...
39 (R B G G B G G G B G B B G G R R R B R B B R G B G) 9

Selected mother =
74 (B B R B B R G B R B B B G R G B G R G R B B G R R) 11
Selected father =
39 (R B G G B G G G B G B B G G R R R B R B B R G B G) 9
the crossover =
0 (B B R B B R G G B G B B G G R R R B R B B R G B G) 11
the possiblly mutated individual =
0 (B B R B B R G G B G B B G G R G R B R B B R G B G) 11
the renumbered individual =
7 (B B R B B R G G B G B B G G R G R B R B B R G B G) 11
--------------------------------------------------------------------------


Generation 1 population ...
1 (R B B B B G B B G R B B R G R G B G B G G G B R R) 11
2 (R G R B G G B G B G G B R B B G B B R R G R B R R) 9
3 (B B G B R B B R B G B B G B B G R B R B G R B B G) 14
4 (R G R B B G B G B G G B B B G R G G G B B B G B G) 11
5 (G R B G B B G B B B R G G G B R B G R B G G R R B) 10
6 (B B R B R B R B B R G B G G B R B G R B G G R R R) 10
7 (B B R B B R G G B G B B G G R G R B R B B R G B G) 11


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the sample of individuals ...
53 (R B B G G R G B R R G B G R G G B R R R R G R G B) 6
95 (B B B G R R B B G R R B G G G R B B R R B R B G G) 10
70 (R G G B G B R G G R G G G G G R B R B G B G R R) 5
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98 (B G B B G R G R R G B R G G R B R G B G B G B R B) 9
34 (B B B B R R R G R R B R G G R B B R B B G G G R R) 9
33 (R G B B B B G R B B B B G B R G G R B G B G G G G) 11
1 (B B R G G B G B B B G R R G R B R R R R B B R B R) 10
69 (B R R B G G R B G R G G B G B G G R R R G B R G G) 6

the most fit of the sample ...
33 (R G B B B B G R B B B B G B R G G R B G B G G G G) 11

the sample of individuals ...
99 (G B G R B B R G R B B R B G R R R B B G R R B R G) 9
76 (B B B G G R B G G G G R B B B B B B R B R B R G B) 13
39 (R B G G B G G G B G B B G G R R R B R B B R G B G) 9
64 (R R R R R G R R B B B G G G R G G R G G R G R R G) 3
95 (B B B G R R B B G R R B G G G R B B R R B R B G G) 10
29 (G R R G R G B B G G B R G R B R B R G G B B G B G) 8
57 (G B R G R R G R B G G B R R G G B G R B B B B G R) 8
5 (G G G B G B R G B G G R R B R G R B B B B G B R G) 9

the most fit of the sample ...
76 (B B B G G R B G G G G R B B B B B B R B R B R G B) 13

Selected mother =
33 (R G B B B B G R B B B B G B R G G R B G B G G G G) 11
Selected father =
76 (B B B G G R B G G G G R B B B B B B R B R B R G B) 13
the crossover =
0 (R G B B B B G R G G G R B B B B B B R B R B R G B) 13
the possiblly mutated individual =
0 (R G B B B B G R G G G R B B B B B B R B R B R G B) 13
the renumbered individual =
8 (R G B B B B G R G G G R B B B B B B R B R B R G B) 13
--------------------------------------------------------------------------


Generation 1 population ...
1 (R B B B B G B B G R B B R G R G B G B G G G B R R) 11
2 (R G R B G G B G B G G B R B B G B B R R G R B R R) 9
3 (B B G B R B B R B G B B G B B G R B R B G R B B G) 14
4 (R G R B B G B G B G G B B B G R G G G B B B G B G) 11
5 (G R B G B B G B B B R G G G B R B G R B G G R R B) 10
6 (B B R B R B R B B R G B G G B R B G R B G G R R R) 10
7 (B B R B B R G G B G B B G G R G R B R B B R G B G) 11
8 (R G B B B B G R G G G R B B B B B B R B R B R G B) 13


--------------------------------------------------------------------------
the sample of individuals ...
91 (G R B R R B G G R G R B R G R G R G R B R G B G B) 6
29 (G R R G R G B B G G B R G R B R B R G G B B G B G) 8
23 (G G G G R G B R B B G R B R R B G B G B B R R G R) 8
91 (G R B R R B G G R G R B R G R G R G R B R G B G B) 6
9 (R G B B B B B R G G G R R R G G R B R R G G R B R) 7
14 (B R G G R R R G R R B G G B R B G R B G B R B G G) 7
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30 (B B B B B G G R B G G G B R B G R G G G G B G B B) 11
47 (R R B R R G B R G G G G R R G B R G B B B R R B G) 7

the most fit of the sample ...
30 (B B B B B G G R B G G G B R B G R G G G G B G B B) 11

the sample of individuals ...
38 (B G G R R B R R R R G B B B R R B B R B B R R G G) 9
35 (R R R G B G R R R G G G B R G G B B B G B B R G B) 8
36 (G R G B R B G R B B R G G G G B G G B G B R G B R) 8
99 (G B G R B B R G R B B R B G R R R B B G R R B R G) 9
8 (G G G B B R R R R R B B B B R R B R G G R G G R R) 7
23 (G G G G R G B R B B G R B R R B G B G B B R R G R) 8
45 (R R G B G R B G G B G G B R R B G R R B B B G R R) 8
98 (B G B B G R G R R G B R G G R B R G B G B G B R B) 9

the most fit of the sample ...
38 (B G G R R B R R R R G B B B R R B B R B B R R G G) 9

Selected mother =
30 (B B B B B G G R B G G G B R B G R G G G G B G B B) 11
Selected father =
38 (B G G R R B R R R R G B B B R R B B R B B R R G G) 9
the crossover =
0 (B B B B B G G R B G G B B B R R B B R B B R R G G) 13
the possiblly mutated individual =
0 (B B B B B G G R B G G B B B R R B B R B B R R G G) 13
the renumbered individual =
9 (B B B B B G G R B G G B B B R R B B R B B R R G G) 13
--------------------------------------------------------------------------


Generation 1 population ...
1 (R B B B B G B B G R B B R G R G B G B G G G B R R) 11
2 (R G R B G G B G B G G B R B B G B B R R G R B R R) 9
3 (B B G B R B B R B G B B G B B G R B R B G R B B G) 14
4 (R G R B B G B G B G G B B B G R G G G B B B G B G) 11
5 (G R B G B B G B B B R G G G B R B G R B G G R R B) 10
6 (B B R B R B R B B R G B G G B R B G R B G G R R R) 10
7 (B B R B B R G G B G B B G G R G R B R B B R G B G) 11
8 (R G B B B B G R G G G R B B B B B B R B R B R G B) 13
9 (B B B B B G G R B G G B B B R R B B R B B R R G G) 13


--------------------------------------------------------------------------
the sample of individuals ...
78 (R G R B B G B G B G G B B B G R G B B B B B B R R) 13
65 (B B G B B G R R B G R B R G G B G B R G G R B G B) 10
97 (B B B B R G B B R R R R R G R R G R B G G B B B R) 10
23 (G G G G R G B R B B G R B R R B G B G B B R R G R) 8
63 (G G R B G B B B R R R R R G B B B B G G R B R R G) 9
78 (R G R B B G B G B G G B B B G R G B B B B B B R R) 13
98 (B G B B G R G R R G B R G G R B R G B G B G B R B) 9
79 (G B R G B G B B R R R G R B G R B R G B G B G R B) 9
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the most fit of the sample ...
78 (R G R B B G B G B G G B B B G R G B B B B B B R R) 13

the sample of individuals ...
73 (G R G B B B R B B R G B R G R G B R B R R G R B B) 10
59 (B R R B R B B B R R G R R G G R R R R B B R R R G) 7
77 (B R G R B R R G G G B R B R B B R B G G G B B B G) 10
75 (G R G R G G R G B G G B G R G R G G B G R G G B B) 5
29 (G R R G R G B B G G B R G R B R B R G G B B G B G) 8
1 (B B R G G B G B B B G R R G R B R R R R B B R B R) 10
46 (G B B B B G B G R B G B G R R B R B R G B B G B R) 12
3 (R G R B G B G G R R B G B G R R R B R R R G R G R) 5

the most fit of the sample ...
46 (G B B B B G B G R B G B G R R B R B R G B B G B R) 12

Selected mother =
78 (R G R B B G B G B G G B B B G R G B B B B B B R R) 13
Selected father =
46 (G B B B B G B G R B G B G R R B R B R G B B G B R) 12
the crossover =
0 (R B B B B G B G R B G B G R R B R B R G B B G B R) 12
the possiblly mutated individual =
0 (R B B B B G B G R B G B G R R B R B R G B B G B R) 12
the renumbered individual =
10 (R B B B B G B G R B G B G R R B R B R G B B G B R) 12
--------------------------------------------------------------------------


Generation 1 population ...
1 (R B B B B G B B G R B B R G R G B G B G G G B R R) 11
2 (R G R B G G B G B G G B R B B G B B R R G R B R R) 9
3 (B B G B R B B R B G B B G B B G R B R B G R B B G) 14
4 (R G R B B G B G B G G B B B G R G G G B B B G B G) 11
5 (G R B G B B G B B B R G G G B R B G R B G G R R B) 10
6 (B B R B R B R B B R G B G G B R B G R B G G R R R) 10
7 (B B R B B R G G B G B B G G R G R B R B B R G B G) 11
8 (R G B B B B G R G G G R B B B B B B R B R B R G B) 13
9 (B B B B B G G R B G G B B B R R B B R B B R R G G) 13
10 (R B B B B G B G R B G B G R R B R B R G B B G B R) 12


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NIL
[3]>
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RBG-String GA Task 11: The GA

The GA! Note that the next generation method mimics the pseudocode presented in class. Note also that the application mimics spotted moth evolution!

The Subtasks

1. The read/study task ...

   Please read and study the following code ...

```
;; THE NEXT GENERATION METHOD FOR THE GA

( defmethod next-generation ( ( cp population ) &aux np )
  ( setf np ( empty-population cp ) )
  ( perform-copies cp np )
  ( perform-crossovers cp np )
  np
)

;; THE GA!

( defconstant *nr-generations* 25 )

( defmethod ga ( &aux p )
  ( format t "THE WORLD IS BLUE ~%~%" )
  ( setf *fitness* #'fitness-b )
  ( setf p ( initial-population ) )
  ( terpri )
  ( summarize p )
  ( dotimes ( i *nr-generations* )
    ( setf p ( next-generation p ) )
    ( check-average p )
  )
  ( terpri )
  ( summarize p )
  ( format t "THE WORLD IS RED ~%~%" )
  ( setf *fitness* #'fitness-r )
  ( dotimes ( i *nr-generations* )
    ( setf p ( next-generation p ) )
    ( check-average p )
  )
  ( terpri )
  ( summarize p )
  ( format t "THE WORLD IS GREEN ~%~%" )
  ( setf *fitness* #'fitness-g )
  ( dotimes ( i *nr-generations* )
    ( setf p ( next-generation p ) )
    ( check-average p )
  )
```

```
  ( terpri )
  ( summarize p )
)

;; METHODS TO PROVIDE INFORMATION ON "PROGRESS"

( defmethod summarize ( ( p population ) )
  ( display p )
  ( check-average p )
  ( terpri )
)

( defmethod check-average ( ( p population ) )
  ( format t "average fitness of populatioon ~A = ~A~%"
    ( population-generation p )
    ( average p )
  )
)
```

2. The enter/run/observe task ...

   Please enter the code, run the code (ga), and observe the output.

3. The solution document task ...

   Please add the source code associated with this task and a demo resulting from executing the `ga` method to the eleventh section of your solution document.

RBG-String GA Demo

What follows is output from a run of the RBG genetic algorithm. This is just text, but it contains plenty of information to appreciate that the program (ga) is doing its GA thing!

```
bash-3.2$ clisp
...

[1]> ( load "rbg.l" )
;; Loading file rbg.l ...
;; Loaded file rbg.l
T
[2]> ( ga )
THE WORLD IS BLUE


Generation 0 population ...
```

1 (B B R G G B G B B B G R R G R B R R R R B B R B R) 10
2 (G G B G R G G G B B G R B B R G R R B R G R B B B) 9
3 (R G R B G B G G R R B G B G R R R B R R R G R G R) 5
4 (G R R R R G R R R G B R B G B G R G G B R B G B G) 6
5 (G G G B G B R G B G G R R B R G R B B B B G B R G) 9
6 (B R R G B G G B B G G B R B B B R G B R R R G B G) 10
7 (R B G B G R R G G B G B R B R B R B R B B G B G G) 10
8 (G G G B B R R R R R B B B B R R B R G G R G G R R) 7
9 (R G B B B B B R G G G R R R G G R B R R G G R B R) 7
10 (R B G R B B G G B B B B G G B G R B B G R R R R G) 10
11 (R R G B G B R R B R B R G G R G R G B G R R R R G) 5
12 (R G R R B R B G G B B R G B B B B G R G R G G R R) 8
13 (R B B G R G G G G R G G R B R B G B R G B R R R B) 7
14 (B R G G R R R G R R B G G B R B G R B G B R B G G) 7
15 (G G B R R G G G R G B R R R B B B G G G G G B B G) 7
16 (B G B R R R G B G G R R B R B B B B R R R B G G R) 9
17 (R B G R G B R G B B G G B R B G G R G R G B G B R) 8
18 (G R G R G R B G R R R B G B G B B G B B B G R G G) 8
19 (R G G G G G R R G B R B B R G B R R B R G G G G G) 5
20 (R B B G R G B R G R B G G B B B B G R R G R B R R) 9
21 (B G R R R G B R B G G G B G G B B B G G R R R B B) 9
22 (B G G R B G B R B B R B G G R G B B R B B R R G G) 10
23 (G G G G R G B R B B G R B R R B G B G B B R R G R) 8
24 (B G G R G R G G G G B G G B G R B R G G R R G R B) 5
25 (B G G R B R G G B R B R R R G R R G B B R R B R G) 7
26 (B R B B B G B B G R B B R G R G B G B G G G B R R) 11
27 (G R B B R B G R R R R G B B G B R B G R R R B R G) 8
28 (G G R B B G R G G B B G R B B G R B B R G G B G B) 10
29 (G R R G R G B B G G B R G R B R B R G G B B G B G) 8
30 (B B B B B G G R B G G G B R B G R G G G G B G B B) 11
31 (B G G R B B B G G G B G R R B B G R B B R R R B G) 10
32 (R G G R R R R B R B B B B R R R R R B B R B G R B) 9
33 (R G B B B B G R B B B B G B R G G R B G B G G G G) 11
34 (B B B B R R R G R R B R G G R B B R B B G G G R R) 9
35 (R R R G B G R R R G G G B R G G B B B G B B R G B) 8
36 (G R G B R B G R B B R G G G G B G G B G B R G B R) 8
37 (R B B G R B R R G B R G G R G B G R R G B G G B R) 7
38 (B G G R R B R R R R G B B B R R B B R B B R R G G) 9
39 (R B G G B G G G B G B B G G R R R B R B B R G B G) 9
40 (G R R G G R G B G B R G R G B B B G B G G B B B R) 9
41 (G G G R G R R B G B R G G R G B R G B R R R R B R) 5
42 (R R B G R B G G B R R G R R R B B G B R B R R G B) 8
43 (B B B R G G R R R G R G G R B B G R R B B R R R B) 8
44 (B G B R B G G R R B R B R R B B R R G B R B B G R) 10
45 (R R G B G R B G G B G G B R R B G R R B B B G R R) 8
46 (G B B B B G B G R B G B G R R B R B R G B B G B R) 12
47 (R R B R R G B R G G G G R R G B R G B B B R R B G) 7
48 (B B G B R B R B B R G B G G B R B G R B G G R R B) 11
49 (R G R B G R G R B R G B B G B G R B G G R B G R G) 7
50 (R B G G G G G B R R G G B R B R B G R G R G R G R) 5
51 (R B B B B R G R G B G B B B R B G R G B B R R G R) 11
52 (B R B R G G R B G R B R G G B G B R G G R R R B G) 7
53 (R B B G G R G B R R G B G R G G B R R R R G R G B) 6
54 (R R G B G G R R R G R R B B R B B R R B R G R G B) 7

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55 (B B R R B G R R G G G G B B B R R R G R B G B B) 9
56 (G R B G B B G B B B R G G G G B B G G B B B G B G) 12
57 (G B R G R R G R B G G B R R G G B G R B B B B G R) 8
58 (G R R B G G B R R G G R B R R G G B G G R G R G G) 4
59 (B R R B R B B B R R G R R G G R R R R B B R R R G) 7
60 (R R R B G B R B G G R G B G G R R G B G R R B B B) 8
61 (R G R B R R G R B G R G G G G R G R B R B B B G R) 6
62 (R B B G B G R R B R G G B R G G B R B R G B G B R) 9
63 (G G R B G B B B R R R R R G B B B B G G R B R R G) 9
64 (R R R R R G R R B B B G G G R G G R G G R G R R G) 3
65 (B B G B B G R R B G R B R G G B G B R G G R B G B) 10
66 (R B R G G R G G G R B G R G B R G R B B R R G R G) 5
67 (G B G G B G B R G B B G R G R R B R G B G R G B R) 8
68 (G G R G G B G R R G G R G R G G R R B B R G B G B) 5
69 (B R R B G G R B G R G G B G B G G R R R G B R G G) 6
70 (R G G B G B R G G R G G G G G G R B R B G B G R R) 5
71 (R G G B B R R G B R R G B G B R G G G B B G R B B) 9
72 (G G R R R B R R R B R B G R R R R B B R B R G R G) 6
73 (G R G B B B R B B R G B R G R G B R B R R G R B B) 10
74 (B B R B B R G B R B B B G R G B G R G R B B G R R) 11
75 (G R G R G G R G B G G B G R G R G G B G R G G B B) 5
76 (B B B G G R B G G G G R B B B B B B R B R B R G B) 13
77 (B R G R B R R G G G B R B R B B R B G G G B B B G) 10
78 (R G R B B G B G B G G B B B G R G B B B B B B R R) 13
79 (G B R G B G B B R R R G R B G R B R G B G B G R B) 9
80 (R R G R R G G R G B G G G B B B B B G B B G G B B) 10
81 (R G G B R G G B R R B R G R G G R R B G B R R G R) 5
82 (G R R R B R B B R R R R G R B B B R R B R B G R G) 8
83 (B R R R G B G B B B R B R B B G B B R R G R B R R) 11
84 (G R R B R R G G R R G G R R B R G R R R R R B B B) 5
85 (R G B G R R G G B B B R G G R B G R G B R R R G B) 7
86 (R R G B B R B R R B B B G R R B B G R B B G G G R) 10
87 (B R G B G R R B G B B G R R R B R R B R G B R G B) 9
88 (R G G R B R B R B G G R R B R G B G G G B G G B G) 7
89 (G R R G G B G G R R G B G R R G R B R B G B R G G) 5
90 (R G G B R B G B R B R R G G B G R G B R G R B R G) 7
91 (G R B R R B G G R G R B R G R G R G R B R G B G B) 6
92 (G R G R B B R G G G B G G G R B R B B R R G B G R) 7
93 (B G R B G R R B B R G R B B G G B R B B R G R G G) 9
94 (G B G G B R G R R R R R B B B B B B R G B B R B R) 11
95 (B B B G R R B B G R R B G G G R B B R R B R B G G) 10
96 (G B B G R R B R B G B B G B B G R B R G G R B B G) 11
97 (B B B B R G B B R R R R R G R R G R B G G B B B R) 10
98 (B G B B G R G R R G B R G G R B R G B G B G B R B) 9
99 (G B G R B B R G R B B R B G R R R B B G R R B R G) 9
100 (G G R R B B G R R G B B B G G R B G G G R B G G) 7
average fitness of populatioon 0 = 8.17

average fitness of populatioon 1 = 11.04
average fitness of populatioon 2 = 13.23
average fitness of populatioon 3 = 15.01
average fitness of populatioon 4 = 16.84
average fitness of populatioon 5 = 18.78
average fitness of populatioon 6 = 20.01
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average fitness of populatioon 7 = 21.07
average fitness of populatioon 8 = 21.86
average fitness of populatioon 9 = 22.55
average fitness of populatioon 10 = 23.07
average fitness of populatioon 11 = 23.51
average fitness of populatioon 12 = 23.6
average fitness of populatioon 13 = 23.69
average fitness of populatioon 14 = 23.96
average fitness of populatioon 15 = 24.51
average fitness of populatioon 16 = 24.5
average fitness of populatioon 17 = 24.45
average fitness of populatioon 18 = 24.52
average fitness of populatioon 19 = 24.48
average fitness of populatioon 20 = 24.48
average fitness of populatioon 21 = 24.53
average fitness of populatioon 22 = 24.51
average fitness of populatioon 23 = 24.44
average fitness of populatioon 24 = 24.53
average fitness of populatioon 25 = 24.52

Generation 25 population ...
1 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
2 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
3 (B B B B B B B B B B B B B B B B B B B R B B B B B) 24
4 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
5 (B B B B B B B B B B B B B B B B B B R B B B B B B) 24
6 (B B B B B B B B B G B B B B B B B B B B B B B B B) 24
7 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
8 (B B B B B B B B B B B B B B G B B B B B B B B B B) 24
9 (B B R B B B B B B B B B B B B B B B B B B B B B B) 24
10 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
11 (B B B B B B B B B B B B B B B B B B G B B B B B B) 24
12 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
13 (B B B B B B B B B B B B B B B B G B B B B B B B B) 24
14 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
15 (B B B B B B B B B B R B B B B B B B B B B B B B B) 24
16 (B B B B B B B B B B B B B B B B B B B B B B B B G) 24
17 (B B B B R B B B B B B B B B B B B B B B B B B B B) 24
18 (B B B B B B B B B B B B B B B B B B B B B B R B B) 24
19 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
20 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
21 (B B B B B B B B B B B B B B B G B B B B B B B B B) 24
22 (B B B B B B B R B B B B B B B B B B B B B B B B B) 24
23 (R B B B B B B B B B B B B B B B B B B B B B B B B) 24
24 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
25 (B G B B B B B B B B B B B B B B B B B B B B B B B) 24
26 (B B B B B B B B B B B B B B B B B B B B B G B B B) 24
27 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
28 (B B B B B B B B B B B B B B B B B B G B B B B B B) 24
29 (B B B B B B B B B B B B B G B B B B B B B B B B B) 24
30 (B B B B B B B B B B B B B B G B B B B B B B B B B) 24
31 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
32 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
33 (B B B B B B B B B G B B B B B B B B B B B B B B B) 24
```

34 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
35 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
36 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
37 (B B B B B B B B B B B B B B B B B B R B B B B B B) 24
38 (B B B B G B B B B B B B B B B B B B B B B B B B B) 24
39 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
40 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
41 (B B B B B B B B B B B B B B B B B B B B B B B G B) 24
42 (B B B B B B B B B B B G B B B B B B B B B B B B B) 24
43 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
44 (B B B B B B R B B B B B B B B B B B B B B B B B B) 24
45 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
46 (B B B B R B B B B B B B B B B B B B B B B B B B B) 24
47 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
48 (B B B B B B B B B B B B B R B B B B B B B B B B B) 24
49 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
50 (B B B R B B B B B B B B B B B B B B B B B B B B B) 24
51 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
52 (B B B B B B B B B B B B B G B B B B B B B B B B B) 24
53 (B B B B B G B B B B B B B B B B B B B B B B B B B) 24
54 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
55 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
56 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
57 (B B B B B B R B B B B B B B B B B B B B B B B B B) 24
58 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
59 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
60 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
61 (R B B B B B B B B B B B B B B B B B B B B B B B B) 24
62 (B B B B B B B B B R B B B B B B B B B B B B B B B) 24
63 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
64 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
65 (B B B B B B B B B B B B B B B B B B B B B B B B R) 24
66 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
67 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
68 (B B B B B B G B B B B B B B B B B B B B B B B B B) 24
69 (B B B B B B B B B B B B B G B B B B B B B B B B B) 24
70 (B B B B B B B B R B B B B B B B B B B B B B B B B) 24
71 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
72 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
73 (B B B B B B B B B B B B B B B B B B G B B B B B B) 24
74 (B B B B B B B B B B B B R B B B B B B B B B B B B) 24
75 (B B B B B R B B B B B B B B B B B B B B B B B B B) 24
76 (R B B B B B B B B B B B B B B B B B B B B B B B B) 24
77 (B B B B B B R B B B B B B B B B B B B B B B B B B) 24
78 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
79 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
80 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
81 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
82 (B B B B B B B B G B B B B B B B B B B B B B B B B) 24
83 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
84 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
85 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
86 (B B B B B B B R B B B B B B B B B B B B B B B B B) 24
87 (B B B B B B B B B B B B B B B G B B B B B B B B B) 24

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88 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
89 (B B B B B B B B B B B B B B B B B B B B B B B G B) 24
90 (B B B B B B G B B B B B B B B B B B B B B B B B B) 24
91 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
92 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
93 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
94 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
95 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
96 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
97 (R B B B B B B B B B B B B B B B B B B B B B B B B) 24
98 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
99 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
100 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
average fitness of populatioon 25 = 24.52

THE WORLD IS RED


Generation 25 population ...
1 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
2 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
3 (B B B B B B B B B B B B B B B B B B B R B B B B B) 24
4 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
5 (B B B B B B B B B B B B B B B B B B R B B B B B B) 24
6 (B B B B B B B B B G B B B B B B B B B B B B B B B) 24
7 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
8 (B B B B B B B B B B B B B B G B B B B B B B B B B) 24
9 (B B R B B B B B B B B B B B B B B B B B B B B B B) 24
10 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
11 (B B B B B B B B B B B B B B B B B B G B B B B B B) 24
12 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
13 (B B B B B B B B B B B B B B B B B G B B B B B B B) 24
14 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
15 (B B B B B B B B B B R B B B B B B B B B B B B B B) 24
16 (B B B B B B B B B B B B B B B B B B B B B B B B G) 24
17 (B B B B R B B B B B B B B B B B B B B B B B B B B) 24
18 (B B B B B B B B B B B B B B B B B B B B B B R B B) 24
19 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
20 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
21 (B B B B B B B B B B B B B B B G B B B B B B B B B) 24
22 (B B B B B B B R B B B B B B B B B B B B B B B B B) 24
23 (R B B B B B B B B B B B B B B B B B B B B B B B B) 24
24 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
25 (B G B B B B B B B B B B B B B B B B B B B B B B B) 24
26 (B B B B B B B B B B B B B B B B B B B B B G B B B) 24
27 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
28 (B B B B B B B B B B B B B B B B B B G B B B B B B) 24
29 (B B B B B B B B B B B B B G B B B B B B B B B B B) 24
30 (B B B B B B B B B B B B B B G B B B B B B B B B B) 24
31 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
32 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
33 (B B B B B B B B B G B B B B B B B B B B B B B B B) 24
34 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
35 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
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36 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
37 (B B B B B B B B B B B B B B B B B B R B B B B B B) 24
38 (B B B B G B B B B B B B B B B B B B B B B B B B B) 24
39 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
40 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
41 (B B B B B B B B B B B B B B B B B B B B B B B G B) 24
42 (B B B B B B B B B B B G B B B B B B B B B B B B B) 24
43 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
44 (B B B B B B R B B B B B B B B B B B B B B B B B B) 24
45 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
46 (B B B B R B B B B B B B B B B B B B B B B B B B B) 24
47 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
48 (B B B B B B B B B B B B B R B B B B B B B B B B B) 24
49 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
50 (B B B R B B B B B B B B B B B B B B B B B B B B B) 24
51 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
52 (B B B B B B B B B B B B B G B B B B B B B B B B B) 24
53 (B B B B B G B B B B B B B B B B B B B B B B B B B) 24
54 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
55 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
56 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
57 (B B B B B B R B B B B B B B B B B B B B B B B B B) 24
58 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
59 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
60 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
61 (R B B B B B B B B B B B B B B B B B B B B B B B B) 24
62 (B B B B B B B B B R B B B B B B B B B B B B B B B) 24
63 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
64 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
65 (B B B B B B B B B B B B B B B B B B B B B B B B R) 24
66 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
67 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
68 (B B B B B B G B B B B B B B B B B B B B B B B B B) 24
69 (B B B B B B B B B B B B B G B B B B B B B B B B B) 24
70 (B B B B B B B B R B B B B B B B B B B B B B B B B) 24
71 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
72 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
73 (B B B B B B B B B B B B B B B B B B G B B B B B B) 24
74 (B B B B B B B B B B B B R B B B B B B B B B B B B) 24
75 (B B B B B R B B B B B B B B B B B B B B B B B B B) 24
76 (R B B B B B B B B B B B B B B B B B B B B B B B B) 24
77 (B B B B B B R B B B B B B B B B B B B B B B B B B) 24
78 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
79 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
80 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
81 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
82 (B B B B B B B B G B B B B B B B B B B B B B B B B) 24
83 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
84 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
85 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
86 (B B B B B B B R B B B B B B B B B B B B B B B B B) 24
87 (B B B B B B B B B B B B B B B G B B B B B B B B B) 24
88 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
89 (B B B B B B B B B B B B B B B B B B B B B B B G B) 24

```
90 (B B B B B B G B B B B B B B B B B B B B B B B B B) 24
91 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
92 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
93 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
94 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
95 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
96 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
97 (R B B B B B B B B B B B B B B B B B B B B B B B B) 24
98 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
99 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
100 (B B B B B B B B B B B B B B B B B B B B B B B B B) 25
average fitness of populatioon 25 = 0.24

average fitness of populatioon 26 = 1.1
average fitness of populatioon 27 = 2.23
average fitness of populatioon 28 = 3.66
average fitness of populatioon 29 = 5.34
average fitness of populatioon 30 = 7.15
average fitness of populatioon 31 = 8.91
average fitness of populatioon 32 = 10.49
average fitness of populatioon 33 = 12.06
average fitness of populatioon 34 = 13.27
average fitness of populatioon 35 = 14.45
average fitness of populatioon 36 = 15.98
average fitness of populatioon 37 = 17.13
average fitness of populatioon 38 = 17.95
average fitness of populatioon 39 = 18.7
average fitness of populatioon 40 = 19.6
average fitness of populatioon 41 = 20.53
average fitness of populatioon 42 = 21.57
average fitness of populatioon 43 = 22.05
average fitness of populatioon 44 = 22.59
average fitness of populatioon 45 = 23.36
average fitness of populatioon 46 = 23.56
average fitness of populatioon 47 = 23.89
average fitness of populatioon 48 = 24.23
average fitness of populatioon 49 = 24.41
average fitness of populatioon 50 = 24.59

Generation 50 population ...
1 (R R R R R R R R R R R R R R R R R R B R R R R R R) 24
2 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
3 (R R R R R R R R R R R R R R R R R R R R R R R R B) 24
4 (R R R R R R R R R R G R R R R R R R R R R R R R R) 24
5 (R R R R R R R R R R R R R G R R R R R R R R R R R) 24
6 (R R R R R R R R G R R R R R R R R R R R R R R R R) 24
7 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
8 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
9 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
10 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
11 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
12 (R R R R R R R R R R R R R R R R R R R R R R R R B) 24
13 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
14 (R R R R R R R R R R R R R R R R R R R R B R R R R) 24
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15 (R R G R R R R R R R R R R R R R R R R R R R R R R) 24
16 (R R R R R R R R R R R R R R R R R R R R R R B R R) 24
17 (R R B R R R R R R R R R R R R R R R R R R R R R R) 24
18 (R R R R R R R R R R R R R R R R R G R R R R R R R) 24
19 (R R G R R R R R R R R R R R R R R R R R R R R R R) 24
20 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
21 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
22 (R G R R R R R R R R R R R R R R R R R R R R R R R) 24
23 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
24 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
25 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
26 (R R R R R R R R R R R R R R R R R R R R R R R B R) 24
27 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
28 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
29 (R R R R R R R R R R R R R R R G R R R R R R R R R) 24
30 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
31 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
32 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
33 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
34 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
35 (R R R R R R R R R R R R R R R R B R R R R R R R R) 24
36 (R R R R R R R R R G R R R R R R R R R R R R R R R) 24
37 (R R R R R R R B R R R R R R R R R R R R R R R R R) 24
38 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
39 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
40 (R R R R R R R R R R B R R G R R R R R R R R R R R) 23
41 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
42 (R R R R R R R R G R R R R R R R R R R R R R R R R) 24
43 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
44 (R R R R R R R R R R R R R R R R R R R R R B R R R) 24
45 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
46 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
47 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
48 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
49 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
50 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
51 (R R R R R R R R R R R R R R R R R R R G R R R R R) 24
52 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
53 (R R R R R R R R R R R R R R R R R R R R R R R R G) 24
54 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
55 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
56 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
57 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
58 (R R R R R R R R R R R R R R R R R R B R R R R R R) 24
59 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
60 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
61 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
62 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
63 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
64 (R R R R R R R R R R R R R R R R R B R R R R R R R) 24
65 (R R R R R R R R R R R R R R R R R R R B R R R R R) 24
66 (R R R R R R R R R R R R B R R R R R R R R R R R R) 24
67 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
68 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25

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69 (R R R R R R R R R R R R R R R R R R R R R R R R B) 24
70 (R R R R R R R R R R R R G R R R R R R R R R R R R) 24
71 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
72 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
73 (R R R R R R R R R R R R R R R R B R R R R R R R R) 24
74 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
75 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
76 (R R G R R R R R R R R R R R R R R R R R R R R R R) 24
77 (R R R R R R R R R R R B R R R R R R R R R R R R R) 24
78 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
79 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
80 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
81 (R R R R R R R R G R R R R R R R R R R R R R R R R) 24
82 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
83 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
84 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
85 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
86 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
87 (R R R R R R R R R R R R R R R R R R R R B R R R R) 24
88 (R R R R R R R R R R R R B R R R R R R R R R R R R) 24
89 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
90 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
91 (R R R R R B R R R R R R R R R R R R R R R R R R R) 24
92 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
93 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
94 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
95 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
96 (R R R R R R R R R R R R R R R R R R B R R R R R R) 24
97 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
98 (R R R R R R R R R R R B R R R R R R R R R R R R R) 24
99 (B R R R R R R R R R R R R R R R R R R R R R R R R) 24
100 (R R R R R R R R R R R R R R R R R R R R R B R R R) 24
average fitness of populatioon 50 = 24.59

THE WORLD IS GREEN


Generation 50 population ...
1 (R R R R R R R R R R R R R R R R R R B R R R R R R) 24
2 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
3 (R R R R R R R R R R R R R R R R R R R R R R R R B) 24
4 (R R R R R R R R R R G R R R R R R R R R R R R R R) 24
5 (R R R R R R R R R R R R R G R R R R R R R R R R R) 24
6 (R R R R R R R R G R R R R R R R R R R R R R R R R) 24
7 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
8 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
9 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
10 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
11 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
12 (R R R R R R R R R R R R R R R R R R R R R R R R B) 24
13 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
14 (R R R R R R R R R R R R R R R R R R R R B R R R R) 24
15 (R R G R R R R R R R R R R R R R R R R R R R R R R) 24
16 (R R R R R R R R R R R R R R R R R R R R R R B R R) 24
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17 (R R B R R R R R R R R R R R R R R R R R R R R R R) 24
18 (R R R R R R R R R R R R R R R R R G R R R R R R R) 24
19 (R R G R R R R R R R R R R R R R R R R R R R R R R) 24
20 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
21 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
22 (R G R R R R R R R R R R R R R R R R R R R R R R R) 24
23 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
24 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
25 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
26 (R R R R R R R R R R R R R R R R R R R R R R R B R) 24
27 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
28 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
29 (R R R R R R R R R R R R R R R G R R R R R R R R R) 24
30 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
31 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
32 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
33 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
34 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
35 (R R R R R R R R R R R R R R R R B R R R R R R R R) 24
36 (R R R R R R R R R G R R R R R R R R R R R R R R R) 24
37 (R R R R R R R B R R R R R R R R R R R R R R R R R) 24
38 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
39 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
40 (R R R R R R R R R R B R R G R R R R R R R R R R R) 23
41 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
42 (R R R R R R R R G R R R R R R R R R R R R R R R R) 24
43 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
44 (R R R R R R R R R R R R R R R R R R R R R B R R R) 24
45 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
46 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
47 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
48 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
49 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
50 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
51 (R R R R R R R R R R R R R R R R R R R G R R R R R) 24
52 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
53 (R R R R R R R R R R R R R R R R R R R R R R R R G) 24
54 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
55 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
56 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
57 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
58 (R R R R R R R R R R R R R R R R R R B R R R R R R) 24
59 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
60 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
61 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
62 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
63 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
64 (R R R R R R R R R R R R R R R R R B R R R R R R R) 24
65 (R R R R R R R R R R R R R R R R R R R B R R R R R) 24
66 (R R R R R R R R R R R R R B R R R R R R R R R R R) 24
67 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
68 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
69 (R R R R R R R R R R R R R R R R R R R R R R R R B) 24
70 (R R R R R R R R R R R R G R R R R R R R R R R R R) 24

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71 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
72 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
73 (R R R R R R R R R R R R R R R R B R R R R R R R R) 24
74 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
75 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
76 (R R G R R R R R R R R R R R R R R R R R R R R R R) 24
77 (R R R R R R R R R R R B R R R R R R R R R R R R R) 24
78 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
79 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
80 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
81 (R R R R R R R R G R R R R R R R R R R R R R R R R) 24
82 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
83 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
84 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
85 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
86 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
87 (R R R R R R R R R R R R R R R R R R R R B R R R R) 24
88 (R R R R R R R R R R R R B R R R R R R R R R R R R) 24
89 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
90 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
91 (R R R R R B R R R R R R R R R R R R R R R R R R R) 24
92 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
93 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
94 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
95 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
96 (R R R R R R R R R R R R R R R R R R B R R R R R R) 24
97 (R R R R R R R R R R R R R R R R R R R R R R R R R) 25
98 (R R R R R R R R R R R B R R R R R R R R R R R R R) 24
99 (B R R R R R R R R R R R R R R R R R R R R R R R R) 24
100 (R R R R R R R R R R R R R R R R R R R R R B R R R) 24
average fitness of populatioon 50 = 0.16

average fitness of populatioon 51 = 1.03
average fitness of populatioon 52 = 2.11
average fitness of populatioon 53 = 3.76
average fitness of populatioon 54 = 5.58
average fitness of populatioon 55 = 7.91
average fitness of populatioon 56 = 9.69
average fitness of populatioon 57 = 11.09
average fitness of populatioon 58 = 12.36
average fitness of populatioon 59 = 13.85
average fitness of populatioon 60 = 15.31
average fitness of populatioon 61 = 16.65
average fitness of populatioon 62 = 17.72
average fitness of populatioon 63 = 18.72
average fitness of populatioon 64 = 19.78
average fitness of populatioon 65 = 20.89
average fitness of populatioon 66 = 21.69
average fitness of populatioon 67 = 22.16
average fitness of populatioon 68 = 22.62
average fitness of populatioon 69 = 23.21
average fitness of populatioon 70 = 23.52
average fitness of populatioon 71 = 23.86
average fitness of populatioon 72 = 24.34
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average fitness of populatioon 73 = 24.54
average fitness of populatioon 74 = 24.51
average fitness of populatioon 75 = 24.58

Generation 75 population ...
1 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
2 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
3 (G G G G G G G G G B G G G G G G G G G G G G G G G) 24
4 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
5 (G G G G G G G G G G R G G G G G G G G G G G G G G) 24
6 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
7 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
8 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
9 (G G G G G G G G G G G G R G G G G G G G G G G G G) 24
10 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
11 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
12 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
13 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
14 (G G G R G G G G G G G G G G G G G G G G G G G G G) 24
15 (B G G G G G G G G G G G G G G G G G G G G G G G G) 24
16 (G G G R G G G G G G G G G G G G G G G G G G G G G) 24
17 (G G G G G G G G G G G G G G G G G G G R G G G G G) 24
18 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
19 (B G G G G G G G G G G G G G G G G G G G G G G G G) 24
20 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
21 (G G G G G G G G G G B G G G G G G G G G G G G G G) 24
22 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
23 (G B G G G G G G G G G G G G G G G G G G G G G G G) 24
24 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
25 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
26 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
27 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
28 (G G G G G G G G G G G G G G G G G G G G G G R G G) 24
29 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
30 (G G G G G G G R G G G G G G G G G G G G G G G G G) 24
31 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
32 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
33 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
34 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
35 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
36 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
37 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
38 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
39 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
40 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
41 (G G G B G G G G G G G G G G G G G G G G G G G G G) 24
42 (G G G G G G G G G G G G G G G G R G G G G G G G G) 24
43 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
44 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
45 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
46 (G G G G G G R G G G G G G G G G G G G G G G G G G) 24
47 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
48 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
49 (G G G G G G G G G G G G G G G G G G G B G G G G G) 24
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50 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
51 (G G G G G G G R G G G G G G G G G G G G G G G G G) 24
52 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
53 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
54 (G G G G R G G G G G G G G G G G G G G G G G G G G) 24
55 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
56 (G G G G G G G G G G G G G G R G G G G G G G G G G) 24
57 (G G G G G G G G G G G G G G G G G G B G G G G G G) 24
58 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
59 (G G G G G G G G G G G G G G G G G G G B G G G G G) 24
60 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
61 (B G G G G G G G G G G G G G G G G G G G G G G G G) 24
62 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
63 (G G G G G B G G G G G G G G G G G G G G G G G G G) 24
64 (G G G G G G G R G G G G G G G G G G G G G G G G G) 24
65 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
66 (G G G G G G G G G G G G G G G G B G G G G G G G G) 24
67 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
68 (G G G G G G G G R G G G G G G G G G G G G G G G G) 24
69 (G G G G G G G G B G G G G G G G G G G G G G G G G) 24
70 (G G B G G G G G G G G G G G G G G G G G G G G G G) 24
71 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
72 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
73 (G G G G G G G G G G G G G G G G G G G G G G G G B) 24
74 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
75 (G R G G G G G G G G G G G G G G G G G G G G G G G) 24
76 (G G G G G G G G G G G G G G G G G G G B G G G G G) 24
77 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
78 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
79 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
80 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
81 (G G G G G G G G G G G G G G G G G G G G B G G G G) 24
82 (G G G G G G G G R G G G G G G G G G G G G G G G G) 24
83 (G G G G G G G G G B G G G G G G G G G G G G G G G) 24
84 (G G G G G G G G G G G G G G G G G G G B G G G G G) 24
85 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
86 (G G G G G G G G G G G G G G G G G G G G G B G G G) 24
87 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
88 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
89 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
90 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
91 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
92 (G G G G G G G G G G G G G G G G G G G R G G G G G) 24
93 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
94 (G G G G G G G G B G G G G G G G G G G G G G G G G) 24
95 (G B G G G G G G G G G G G G G G G G G G G G G G G) 24
96 (G G G G G G G G G R G G G G G G G G G G G G G G G) 24
97 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
98 (G G G G G G G B G G G G G G G G G G G G G G G G G) 24
99 (G G G G G G G G G G G G G G G G G G G G G G G G G) 25
100 (G G G G G G G G G G G G G G G G G G R G G G G G G) 24
average fitness of populatioon 75 = 24.58

NIL
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[43> (bye)
Bye.
bash-3.2$
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