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CSC 416

Wild Card GA Assignment

This assignment is intended to achieve better understanding of genetic algorithms, solving problems using evolutionary approaches, as well as practice coding in Common Lisp. Receiving a perfect result is not the main goal.

About the GA

The genetic algorithm developed in this assignment is intended to algorithmically compose music, specifically short melodies. It starts with a collection of randomly generated melodies, the score of a melody is based on how close its Krumhansl coefficient is from the desired manually entered coefficient, the melodies changes slightly each generation with intent to improve its score.

The Tasks

Task 1: Notes —----------

Demo

```
[1]> (load "melody-task-1.l")
;; Loading file melody-task-1.l ...
;; Loaded file melody-task-1.l
T
[2]> *note-limit*
20
[3]> (display (new-note))
MC
NIL
[4]> (display (new-note))
La
NIL
[5]> (display (list (new-note) (new-note) (new-note) (new-note) (new-note)))
Hg Mg Mg HD La
NIL
[6]> (display (list (new-note) (new-note) (new-note) (new-note) (new-note)))
HD Le Md Mc Lb
```

```
NIL
[7]> (display (new-notes))
Hg Ld Mc Ld He Ha Le Hb La Hg HE MA ME MG Mb La HB LG HF Mf
NIL
[8]> (display (new-notes))
LE Ld MF HF Lf LG Ld HE Ld MC LD Me HF He MG MF LF Hg LA Le
NIL
[9]> (display (new-notes))
ME Hd Ma Hb LC Hd HC LE HB MD Hb MD Mc Hb LG Hb LG HG LE MA
NIL
[10]> (display (new-notes))
LA LE Ha Le HF MB Lb Lg La Me Ha HF MG Mg HD Hb Mb Hb LB Ha
NIL
```

Code

```
; Since lisp is not case sensitive, I have to store them differently.
(setf *note-limit* 20)

(setf *notes-list* '(
      low-big-c mid-big-c high-big-c
      low-big-d mid-big-d high-big-d
      low-big-e mid-big-e high-big-e
      low-big-f mid-big-f high-big-f
      low-big-g mid-big-g high-big-g
      low-big-a mid-big-a high-big-a
      low-big-b mid-big-b high-big-b
      low-small-c mid-small-c high-small-c
      low-small-d mid-small-d high-small-d
      low-small-e mid-small-e high-small-e
      low-small-f mid-small-f high-small-f
      low-small-g mid-small-g high-small-g
      low-small-a mid-small-a high-small-a
      low-small-b mid-small-b high-small-b
      )
)

; A display method is needed to accommodate the upper and lower case needs
(defmethod display((notes list))
      (dotimes (i (length notes))
            (display (nth i notes))
            (format t " ")
      )
)

(defmethod display(note)
      (cond
            ((equal note 'low-big-c)
                  (format t "~A" 'LC)
            )
            ((equal note 'mid-big-c)
                  (format t "~A" 'MC)
            )
```

```
            ((equal note 'high-big-c)
                  (format t "~A" 'HC)
            )
            ((equal note 'low-big-d)
                  (format t "~A" 'LD)
            )
            ((equal note 'mid-big-d)
                  (format t "~A" 'MD)
            )
            ((equal note 'high-big-d)
                  (format t "~A" 'HD)
            )
            ((equal note 'low-big-e)
                  (format t "~A" 'LE)
            )
            ((equal note 'mid-big-e)
                  (format t "~A" 'ME)
            )
            ((equal note 'high-big-e)
                  (format t "~A" 'HE)
            )
            ((equal note 'low-big-f)
                  (format t "~A" 'LF)
            )
            ((equal note 'mid-big-f)
                  (format t "~A" 'MF)
            )
            ((equal note 'high-big-f)
                  (format t "~A" 'HF)
            )
            ((equal note 'low-big-g)
                  (format t "~A" 'LG)
            )
            ((equal note 'mid-big-g)
                  (format t "~A" 'MG)
            )
            ((equal note 'high-big-g)
                  (format t "~A" 'HG)
            )
            ((equal note 'low-big-a)
                  (format t "~A" 'LA)
            )
            ((equal note 'mid-big-a)
                  (format t "~A" 'MA)
            )
            ((equal note 'high-big-a)
                  (format t "~A" 'HA)
            )
            ((equal note 'low-big-b)
                  (format t "~A" 'LB)
            )
            ((equal note 'mid-big-b)
                  (format t "~A" 'MB)
            )
            ((equal note 'high-big-b)
                  (format t "~A" 'HB)
```

```
            )
            ((equal note 'low-small-c)
                  (format t "~A" '|Lc|)
            )
            ((equal note 'mid-small-c)
                  (format t "~A" '|Mc|)
            )
            ((equal note 'high-small-c)
                  (format t "~A" '|Hc|)
            )
            ((equal note 'low-small-d)
                  (format t "~A" '|Ld|)
            )
            ((equal note 'mid-small-d)
                  (format t "~A" '|Md|)
            )
            ((equal note 'high-small-d)
                  (format t "~A" '|Hd|)
            )
            ((equal note 'low-small-e)
                  (format t "~A" '|Le|)
            )
            ((equal note 'mid-small-e)
                  (format t "~A" '|Me|)
            )
            ((equal note 'high-small-e)
                  (format t "~A" '|He|)
            )
            ((equal note 'low-small-f)
                  (format t "~A" '|Lf|)
            )
            ((equal note 'mid-small-f)
                  (format t "~A" '|Mf|)
            )
            ((equal note 'high-small-f)
                  (format t "~A" '|Hf|)
            )
            ((equal note 'low-small-g)
                  (format t "~A" '|Lg|)
            )
            ((equal note 'mid-small-g)
                  (format t "~A" '|Mg|)
            )
            ((equal note 'high-small-g)
                  (format t "~A" '|Hg|)
            )
            ((equal note 'low-small-a)
                  (format t "~A" '|La|)
            )
            ((equal note 'mid-small-a)
                  (format t "~A" '|Ma|)
            )
            ((equal note 'high-small-a)
                  (format t "~A" '|Ha|)
            )
            ((equal note 'low-small-b)
```

```
                  (format t "~A" '|Lb|)
            )
            ((equal note 'mid-small-b)
                  (format t "~A" '|Mb|)
            )
            ((equal note 'high-small-b)
                  (format t "~A" '|Hb|)
            )
      )
)

(defmethod random-element((elements list))
      (nth (random (length elements)) elements)
)

(defmethod new-note()
      (random-element *notes-list*)
)

(defmethod new-notes()
      (generate-notes *note-limit*)
)

(defmethod generate-notes(number)
      (if (= number 0)
            (list)
            (cons (random-element *notes-list*) (generate-notes (- number
1)))
      )
)
```

Task 2: Mutation ----------

Demo

```
[]> (display (setf notes (new-notes)))
MC HA Le HE MA LC HG Le Hf Lb Hb HE LC He MA HE HA MG Hg MA
NIL
[]> (display (mutation notes))
MC HA Le HE MA LC HG Le Hf Lb Hb Ha LC He MA HE HA MG Hg MA
NIL
[]> (display notes)
MC HA Le HE MA LC HG Le Hf Lb Hb HE LC He MA HE HA MG Hg MA
NIL
[]> (display (mutation notes))
MC HA Le HE MA LC HG Le Hf Lb Hb HE LC He MA HE HA MG Hd MA
NIL
```

Code

```
(defmethod mutation((notes list) &aux position otherNotes)
      (setf position (random (length notes)))
      (setf otherNotes (other-elements *notes-list* (nth position notes)))
      (change-element notes (random-element otherNotes) position)
)

(defmethod other-elements((elements list) element)
      (remove element elements)
)

(defmethod change-element((elements list) element position &aux newElements)
      (setf newElements (copy-list elements))
      (setf (nth position newElements) element)
      newElements
)
```

Task 3: Crossover ----------

Demo

```
[]> (display (setf m (new-notes)))
HD Ha HE LF MA Hd Hf La Mc MG Lb MF Lb MD LG Lc HD LG LG LA
NIL
[]> (display (setf f (new-notes)))
HG MC MD MD MF LE Hf Ha HD Ld Mg HE HE La ME LB Ld Mg HA Lf
NIL
[]> (display (crossover m f))
HD Ha HE LF MA Hd Hf La Mc MG Lb MF HE La ME LB Ld Mg HA Lf
NIL
[]> (display (crossover m f))
HD Ha HE LF MA Hd Hf La Mc MG Lb MF Lb MD LG Lc HD LG LG Lf
NIL
[]> (display m)
HD Ha HE LF MA Hd Hf La Mc MG Lb MF Lb MD LG Lc HD LG LG LA
NIL
[]> (display f)
HG MC MD MD MF LE Hf Ha HD Ld Mg HE HE La ME LB Ld Mg HA Lf
NIL
```

Code

```
(defmethod crossover ((mother list) (father list) &aux position)
	(setf position (+ 1 (random (length mother))))
	(append (first-n mother position) (rest-n father position))
)

(defmethod first-n((l list) (pos number) &aux newPos)
	(setf newPos (- pos 1))
	(cond
		((>= newPos (length l))
			(first-n l newPos)
		)
		((>= newPos 0)
			(append (first-n l newPos) (list (nth newPos l)))
		)
		(t
			(list)
		)
	)
)

(defmethod rest-n((l list) (pos number))
	(cond
		((>= pos (length l))
			(list)
		)
		(t
			(append (list (nth pos l)) (rest-n l (+ pos 1)))
```

```
            )
      )
)
```

Task 4: Demo for Mutation and Crossover —----------

Demo

```
[]> (mutation-demo)
notes  = La Mc LC Ld HB Ld Le MB MD Hd Lg Hb Lg Hc HC MG LE Hc Ma Me
mutant = La Mc LC Ld HB Ld Le MB MD Hd Lg LF Lg Hc HC MG LE Hc Ma Me
notes  = La Mc LC Ld HB Ld Le MB MD Hd Lg Hb Lg Hc HC MG LE Hc Ma Me
mutant = Hb Mc LC Ld HB Ld Le MB MD Hd Lg Hb Lg Hc HC MG LE Hc Ma Me
notes  = La Mc LC Ld HB Ld Le MB MD Hd Lg Hb Lg Hc HC MG LE Hc Ma Me
mutant = La Mc LC Ld HB Ld Le MB MD Hd Lg La Lg Hc HC MG LE Hc Ma Me
notes  = La Mc LC Ld HB Ld Le MB MD Hd Lg Hb Lg Hc HC MG LE Hc Ma Me
mutant = La Mc LC Ld HB Ld Le MB MD Hd Lg Hb Lg Hc HC MG Lg Hc Ma Me
notes  = La Mc LC Ld HB Ld Le MB MD Hd Lg Hb Lg Hc HC MG LE Hc Ma Me
mutant = La Mc LC Ld HB LG Le MB MD Hd Lg Hb Lg Hc HC MG LE Hc Ma Me
notes  = La Mc LC Ld HB Ld Le MB MD Hd Lg Hb Lg Hc HC MG LE Hc Ma Me
mutant = Ha Mc LC Ld HB Ld Le MB MD Hd Lg Hb Lg Hc HC MG LE Hc Ma Me
notes  = La Mc LC Ld HB Ld Le MB MD Hd Lg Hb Lg Hc HC MG LE Hc Ma Me
mutant = La Mc LC Ld HB Ld Le MB MD Hd Lg Hb Lg HF HC MG LE Hc Ma Me
notes  = La Mc LC Ld HB Ld Le MB MD Hd Lg Hb Lg Hc HC MG LE Hc Ma Me
mutant = La Mc LC Ld HB Ld Le MB LD Hd Lg Hb Lg Hc HC MG LE Hc Ma Me
notes  = La Mc LC Ld HB Ld Le MB MD Hd Lg Hb Lg Hc HC MG LE Hc Ma Me
mutant = La Mc LC Ld HB Ld Le MB MD Hd Lg Hb Lg Hc HC MG LE Hc HF Me
notes  = La Mc LC Ld HB Ld Le MB MD Hd Lg Hb Lg Hc HC MG LE Hc Ma Me
mutant = La Mc LC Ld HB Ld Le MB MD Hd Lg Hb Lg Hc HC MG MF Hc Ma Me
NIL
[]> (crossover-demo)
mother    = Lb Lf Lf Ld Lc He HD LE Hb He Mc Hc MD HA MG MD LE Lg LB LA
offspring = Lb Lf Lg Mb MG Hc MB Lb HB HD LF Hb ME LC Lb HG HB Mg Md LA
father    = Ld Hg Lg Mb MG Hc MB Lb HB HD LF Hb ME LC Lb HG HB Mg Md LA
mother    = Lb Lf Lf Ld Lc He HD LE Hb He Mc Hc MD HA MG MD LE Lg LB LA
offspring = Lb Lf Lf Ld Lc He HD LE Hb He Mc Hc MD HA MG HG HB Mg Md LA
father    = Ld Hg Lg Mb MG Hc MB Lb HB HD LF Hb ME LC Lb HG HB Mg Md LA
mother    = Lb Lf Lf Ld Lc He HD LE Hb He Mc Hc MD HA MG MD LE Lg LB LA
offspring = Lb Lf Lg Mb MG Hc MB Lb HB HD LF Hb ME LC Lb HG HB Mg Md LA
father    = Ld Hg Lg Mb MG Hc MB Lb HB HD LF Hb ME LC Lb HG HB Mg Md LA
mother    = Lb Lf Lf Ld Lc He HD LE Hb He Mc Hc MD HA MG MD LE Lg LB LA
offspring = Lb Lf Lf Ld Lc He MB Lb HB HD LF Hb ME LC Lb HG HB Mg Md LA
father    = Ld Hg Lg Mb MG Hc MB Lb HB HD LF Hb ME LC Lb HG HB Mg Md LA
mother    = Lb Lf Lf Ld Lc He HD LE Hb He Mc Hc MD HA MG MD LE Lg LB LA
offspring = Lb Lf Lf Ld Lc He HD LE Hb He Mc Hb ME LC Lb HG HB Mg Md LA
father    = Ld Hg Lg Mb MG Hc MB Lb HB HD LF Hb ME LC Lb HG HB Mg Md LA
mother    = Lb Lf Lf Ld Lc He HD LE Hb He Mc Hc MD HA MG MD LE Lg LB LA
offspring = Lb Hg Lg Mb MG Hc MB Lb HB HD LF Hb ME LC Lb HG HB Mg Md LA
father    = Ld Hg Lg Mb MG Hc MB Lb HB HD LF Hb ME LC Lb HG HB Mg Md LA
mother    = Lb Lf Lf Ld Lc He HD LE Hb He Mc Hc MD HA MG MD LE Lg LB LA
```

```
offspring = Lb Lf Lf Ld Lc He HD LE Hb He Mc Hb ME LC Lb HG HB Mg Md LA
father    = Ld Hg Lg Mb MG Hc MB Lb HB HD LF Hb ME LC Lb HG HB Mg Md LA
mother    = Lb Lf Lf Ld Lc He HD LE Hb He Mc Hc MD HA MG MD LE Lg LB LA
offspring = Lb Lf Lf Ld Lc He MB Lb HB HD LF Hb ME LC Lb HG HB Mg Md LA
father    = Ld Hg Lg Mb MG Hc MB Lb HB HD LF Hb ME LC Lb HG HB Mg Md LA
mother    = Lb Lf Lf Ld Lc He HD LE Hb He Mc Hc MD HA MG MD LE Lg LB LA
offspring = Lb Lf Lf Ld Lc He HD LE Hb He Mc Hc MD HA MG MD HB Mg Md LA
father    = Ld Hg Lg Mb MG Hc MB Lb HB HD LF Hb ME LC Lb HG HB Mg Md LA
mother    = Lb Lf Lf Ld Lc He HD LE Hb He Mc Hc MD HA MG MD LE Lg LB LA
offspring = Lb Lf Lf Ld Lc He HD LE Hb He Mc Hc ME LC Lb HG HB Mg Md LA
father    = Ld Hg Lg Mb MG Hc MB Lb HB HD LF Hb ME LC Lb HG HB Mg Md LA
NIL
```

Code

```
; Note: The reason why I don't just display the variables outright
; because their representation is not easy on the eyes.
(defmethod mutation-demo (&aux notes mutant)
	(setf notes (new-notes))
	(dotimes (i 10)
		(format t "notes  = ")
		(display notes)
		(setf mutant (mutation notes))
		(format t "~%mutant = ")
		(display mutant)
		(format t "~%")
	)
	nil
)

(defmethod crossover-demo (&aux mother father offspring)
	(setf mother (new-notes))
	(setf father (new-notes))
	(dotimes (i 10)
		(setf offspring (crossover mother father))
		(format t "mother    = ")
		(display mother) (terpri)
		(format t "offspring = ")
		(display offspring) (terpri)
		(format t "father    = ")
		(display father) (terpri)
	)
	nil
)
```

Task 5: The Fitness Metric —----------

Demo

```
[]> (fitness-demo)
notes = La LB Ld He Lg HE MF Ld LF MA MF LE LC LB Mc Mb MG LD Mf LD
Krumhansl score: -0.3012427
Fitness test with desired coefficient -1.0: 30.124271
Fitness test with desired coefficient 0.00: 69.87573
Fitness test with desired coefficient +1.0: -30.124271
NIL
[]> (fitness-demo)
notes = Ld La HB HF HE Md Hg Lb HG HD Ma LE Hb LD Mb HD He Lg MD LF
Krumhansl score: -0.15778302
Fitness test with desired coefficient -1.0: 15.778303
Fitness test with desired coefficient 0.00: 84.221695
Fitness test with desired coefficient +1.0: -15.778303
NIL
[]> (fitness-demo)
notes = MB MB Le HA HD Lf Ld Lf Lb Mg Mg Lg MG Hf LD LD Hb LE Lc LF
Krumhansl score: -0.16962402
Fitness test with desired coefficient -1.0: 16.962402
Fitness test with desired coefficient 0.00: 83.0376
Fitness test with desired coefficient +1.0: -16.962397
NIL
```

Code

```
; Krumhansl stuff ----------------------------------------
; Returns the correlation coefficient of the set of notes
(defmethod krumhansl((notes list) &aux x-mean y-mean x-and-y-sum x-sum y-sum)
	(setf x-mean (get-x-mean notes))
	(setf y-mean (get-y-mean notes))
	(setf x-and-y-sum (get-x-and-y-summation notes x-mean y-mean))
	(setf x-sum (get-x-squared-summation notes x-mean))
	(setf y-sum (get-y-squared-summation notes y-mean))
	(/ x-and-y-sum (sqrt (* x-sum y-sum)))
)

(defun get-x-mean((notes list))
	(/ (length notes) 2.0)
)

(defun get-y-mean((notes list) &aux sum num)
	(setf sum 0.0)
	(setf num (length notes))
	(dotimes (i num)
		(setf sum (+ sum (position (nth i notes) *notes-list*)))
	)
	(/ sum num)
)

(defun get-x-squared-summation((notes list) x-mean &aux n sum i x)
	(setf n (length notes))
	(setf sum 0.0)
	(dotimes (a n)
		(setf i (+ a 1.0))
		(setf x (- i x-mean))
```

```
                (setf sum (+ sum (* x x)))
        )
        sum
)

(defun get-y-squared-summation((notes list) y-mean &aux n sum i y)
        (setf n (length notes))
        (setf sum 0.0)
        (dotimes (a n)
                (setf i (+ a 1.0))
                (setf y (- (position (nth a notes) *notes-list*) y-mean))
                (setf sum (+ sum (* y y)))
        )
        sum
)

(defun get-x-and-y-summation((notes list) x-mean y-mean &aux n sum i x y)
        (setf n (length notes))
        (setf sum 0.0)
        (dotimes (a n)
                (setf i (+ a 1.0))
                (setf x (- i x-mean))
                (setf y (- (position (nth a notes) *notes-list*) y-mean))
                (setf sum (+ sum (* x y)))
        )
        sum
)
; -------------------------------------------------------


; Fitness stuff-----------------------------------------------
; Fitness defined here does not guarantee good music,
; it's just what I think will be a good music

; Coefficient can only range from -1.0 to 1.0
; Remember to set the desired coefficient before calling the fitness function!
(setf desired-coefficient 0.0)

(defmethod *fitness*((notes list) &aux k-score distance score)
        (setf k-score (krumhansl notes))
        (setf distance (abs (- k-score desired-coefficient)))
        (setf score (* (- 1.00 distance) 100.00))
        score
)

(defmethod fitness-demo(&aux notes)
        (setf notes (new-notes))
        (format t "notes = ")
        (display notes)

        (format t "~%Krumhansl score: ~A~%" (krumhansl notes))
        (setf desired-coefficient -1.0)
        (format t "Fitness test with desired coefficient -1.0: ~A~%" (*fitness* notes))
        (setf desired-coefficient 0.0)
        (format t "Fitness test with desired coefficient 0.00: ~A~%" (*fitness* notes))
        (setf desired-coefficient 1.0)
        (format t "Fitness test with desired coefficient +1.0: ~A~%" (*fitness* notes))

        (setf desired-coefficient 0.0)
        nil
)
; -------------------------------------------------------------
```

Task 6: The Melody Class —----------

Demo

```
[]> (melody-demo)
Current desired coefficient: 0.0
0     HB LA LC MD Lf HE Hb Lf MG ME Mg HF LG MB La HD MG Mg ME Mf  83.980644
1     Mf MF La Hf LB LB Hd Ha Hd MG ME HG LF MB LC Hb MG LG HD HC  49.85646
2     Lc Lb Hc Hg Lg Mg Mf MG Hc LC Lf Hf LA Mg Lc LC LC LG MF La  57.92929
3     Ha Ma Mf Hd Mc HD Mg HC LC La HE LA LE HC MA LF MF LG Ha LA  62.33258
NIL
[]> (melody-demo)
Current desired coefficient: 0.0
0     MG MF Hb Lc Lb Hf Ma Hd MA MB HE LG HB Lg HB LC Hf Mg Hg Lg  91.51043
1     Me LC HD He Hg Me Lf Hg Mf MD Mg Hb LC ME Le HG LC Ld LE Lg  87.16642
2     MF MD LE He Le HD Hb HA LA Le MB LC Mc Me Hg LC HC Hc Mc Lf  84.045555
3     HE LA HG Me HC LC MD LE Lc Mc LC HD MD HF LG Lg HF LG Hf LC  87.04295
NIL
[]> (melody-demo)
Current desired coefficient: 0.0
0     Md MA Mg HG HE MC LB HG HD LE Mf HC LE LA Ha He HF MC HE MB  89.56614
1     Mb Hg LF MF HC La Le Mc LG Mf Ma Lg MC MC ME HB LB Ld Ha Hf  98.2544
2     HF MF Ma HD Ha Mc Hc HC HA ME Lc Ha Mg LC Mc Hf Lg Mf HD Ld  84.593025
3     Hc Hf Hb MA MF Hg Mc HG LA Md LG Lf Le LA Lg Le MD Hg Mb Lc  97.06804
NIL
```

Code

```
(defclass melody ()
      (
            (notes :accessor melody-notes :initarg :notes)
            (fitness :accessor melody-fitness :initarg :fitness)
            (number :accessor melody-number :initarg :number)
      )
)

(defmethod random-melody(&aux notes)
      (setf notes (new-notes))
      (make-instance 'melody
            :notes notes
            :fitness (*fitness* notes)
            :number 0
      )
)

(defmethod new-melody((n number) (notes list))
      (make-instance 'melody
            :notes notes
            :fitness (*fitness* notes)
            :number n
      )
)
```

```
(defmethod display ((m melody) &aux m-num fitness)
      (setf n-num (melody-number m))
      (setf fitness (melody-fitness m))

      (format t "~A~A" n-num (filler n-num))
      (display (melody-notes m))
      (format t " ~A~A" fitness (filler fitness))
)

; copied from rbg-string assignment
( defmethod filler ( ( n number ) )
      ( cond
            ( ( < n 10 ) "     " )
            ( ( < n 100 ) "    " )
            ( ( < n 1000 ) "   " )
            ( ( < n 10000 ) "  " )
            ( ( < n 100000 ) " " )
      )
)

(defmethod melody-demo (&aux m0 m1 m2 m3)
      (format t "Current desired coefficient: ~A~%" desired-coefficient)
      (setf m0 (random-melody))
      (display m0) (terpri)
      (setf m1 (new-melody 1 (new-notes)))
      (display m1) (terpri)
      (setf m2 (new-melody 2 (new-notes)))
      (display m2) (terpri)
      (setf m3 (new-melody 3 (new-notes)))
      (display m3) (terpri)
      nil
)
```

Task 7: The Collection Class —----------

Demo

```
[]> (collection-demo)


Generation 0 collection ...
1     HC Ha Ma Ld MA Hc ME HF Hf HA HG Hc Ha MB LD Lb MF MD Hd HD  80.21537
2     Hf Mc Hc Mf Lc Le Le LE HG Md Ha MF MD Lf HB MA HB Lc Mf HD  70.49835
3     MD LD HE Lb MF He Ma Le Ma HC LE Hb HA HC HF Mf Lf Ma Lc Mg  69.587616
4     LA He MF Hd HC Ma He Mf LB La Lg Mc HA LD Ma MF La La MG Mf  84.98045
5     Hf Hc HG Ld Hd LD Mg LE Hf HC Mg La Mb Ld LD Ha HC He HB LC  85.807396
6     LE Mb Md HF Le Mg Ma Md HG HD HC He LE Mf Ha LE HG HE He Mc  86.33772
7     LF LC Lc MA Hg HA MG Hc Mf HB Lb HB Md Hc Le Hc HD Hg Ma HA  63.130524
8     Ha Le Hb LF MC Mb HA HF Hd LG LD Lg Me HD Mg Hb HD LF MG Md  80.304665
9     HA MG HF MG Hd LF Ma Ha Le MA Le Hd Lc Lg Ld La Lb ME Lf Le  60.585167
10    Ha LA Mc MB Hd Ld Lb Hd LC HC Md Mg Ha Mg HF HD ME Ha Hd HG  86.59623
11    Ha Ma La He MF HG Hg ME LA HD He LD Me Md Hd Hg MG MA HD MC  53.187134
12    Mg LA He Mf Md MB HF Lg MC HF MB Lf Lf LE Hg Mb Lb Hb LF Me  84.540085
13    Ma LC Ld Ma Hc MF Le He Lb Md LA LE LA HC Ld HG Hc ME La MF  75.61302
14    Lg Ld LG HD LA LG MF ME Hd Mg HB HC HE Ha La HD MF Hf MC MA  95.337494
15    Lb HF HD He Hb LF Lg HB LF ME Lb LB HF LB LB Md Md Ha He Lb  79.59485
16    Mg Mc LB Lb MG MA MF Ld Lb Ma LC HG HG MB Hd LA LE Hb La MF  89.57684
17    HF HA MD Lb MG LF La MD HC Mc HA MG LD LE HA MB LB Mg Hd MB  82.386246
18    Ha LD Lf Lg HG Hd Ha MC MG LF LC Mg Lb Hd Hg LB Lg Lb HG Lg  83.22788
19    Hd LD Lg HA HD HB Lc Le Hb MG Mb La Lf MG Hf He Le Hf LD Ma  75.2398
20    Lf Lc He LC Ma LE LE Md LG LC Ld Mf HG Lf Md HF Ha LB MD LG  91.77454
21    LA LC He Ha MA Mg Md HE Hf Le HB Mc Le Hb Hc MC MD Lc HC Mf  88.70414
22    Hg Mg Hb MF Hf LF LA Hd Lf Lc MG Mg HF LD LE HD MA HG Ma HB  61.752254
23    LB HB Mb Lb HF Mb HC MG ME MA Lf HF Mg MC Mf Mc HA MA LD Ma  86.14345
24    Le Mf HD Hg HF LB Md Le Lf Lc Lc Hd Ld Mc HG Lf Hc Hc Me HE  90.26736
25    HG Mc HB Lg MA Ld Mg LC Mb Me MD LC Mc HC Mc MG LF HE Me LE  68.43271
26    HA Mb Ma Ha He He He MB HF LG HD HG HC Hf Mf Hb Ld ME HC Hg  71.44269
27    Mf MB Mf Mf MC Ha La Mc MD Lf HG Mb HB Ha Hg Hc HC MC Ha Lb  98.67939
28    HF LE Hf Hb HF Mg La HB Lf HE LD LF HE MG He Hg Lg Mf Mc HC  96.97425
29    Le HC MA Lg LF HD HB Lc MA Hb Mb MF Me HA Lc LD HA Mb MD MB  96.151886
30    LE LB ME LG Mg Hf HC LD MC HA MA Mg LG HB MD Hf Hd Lg Ma Me  53.52991
31    LF Mg MB Ld MB Hb Hf MG LC Me Mg MF Mc Lf Md Hg Lb Hf LG Md  83.24165
32    HD LA Hg Mb Lb MD Hd MB HB Lg LB LC HC LG MD HD Ha Hg LC Lg  88.47031
33    LB MG LF MG Lb Mg Ma ME HD HA LG MC Md HD Ld LB Hg Hc Ma Lf  75.862625
34    Hf Lf Hg Md Lc Ma ME MC MD HG LB La Lg HB HF LA MA Ma LB HG  77.320404
35    HB Mc HB Hd HC MA Le MG Me Hf LG La Hf Hf HF He LC MF MA Ld  94.45012
36    Le Mg Mc He LG MC Lg LA Hb MD Lf Hd LB LA Hb MC LD Hg LB HG  80.96404
37    Le Ld HA Ld Ld Hb MB HF Ha LB LC HF ME Mf Hc LG He HC LA MG  63.188255
38    Md MG MB MD LA HF Mc LC Mc Me MA Ma LF MC Lf Lf HA Hf Hb Lc  60.077465
39    MA Mf LB LC Lf Hd ME Lc La LB Mb Hg LD HC Lc MG HB LG MC Hg  88.88263
40    Lb LD MF LC Le Mf HC Lb Hd MC LA HD Hd Ma Lf Lf LE Ld HE ME  97.44011
41    LE Ha LC Lf LD Md MD Md He MF Mb Le HA Ma MA LC HB Hg LC HA  98.09282
42    HA Lb HE La La Lc Mc HG Le LC La He Hd Hf Lc MD Lb Md HC La  94.578766
43    Mf MC MB HA Hd Hf LE La Lc MB Me HE Me Hb HD Le Lg HB Le Mc  82.10248
44    LE Le Le Ma LB ME MG Lg HD LF LE He Hb Lc Hb Le LC MD Hb Ha  81.76213
45    HA LB Mc La Me He La HG Lf Mc LC MA Le Me LF Mf MC MC Mc Mf  74.92604
46    Mg LD LG Hc HF LE Hb Mg Md LA Hg Ma HE Ma Lc Hc HB Hg Mf Me  68.30252
47    LA Md He HG LE LC He LD MD HB Me MD HD LC LF HG MG MB La Ld  92.76272
48    Hg MC ME LD Lf Ld Mb HD Mb MF Lc Mc MA Hg Hg Le LE HF ME Mb  89.145836
49    Hf LG LB Hf MA Hf Ha LB Ma Ha Mg HA MF Ld Lf Mc HG Hg LA LF  77.265236
50    Mb LD He Lf HG LE LE Mb Hd Mg LA MG HE Hg Ha MD MD Hg LA LE  83.16153
51    Ld Mg MC HC HA Hc Lg LF HF Hb LC Ma MC Lf HD Lf MD Lf HG Lg  92.13604
52    Ha HA Ld HF Lg HA Hg HF LG ME La Ma HF LF Hd MF HC Ld ME LA  62.725754
53    LF Hc MA ME Mg Hg Hc HE HB Hb MF Ma LB LB He Ha Hc Hb ME Lg  70.42016
54    MD MD Lg Lb HD HA Hb HD La LB MG MC LC MG LF MD Hg LA Ld LA  93.88633
55    ME Mc HF MB MB MD Hf Hd Ma Lg HG MA Mc HE LF LG LE Mb Le ME  98.02935
56    HE MA LG Md HF He Lf HD Me MG Lc Me He Me LF Md HB Mc LB HC  95.38452
57    Lb Mf LE Hb Mg MA HF MG Hd Hd Mf HD HC Mb LC He LD HC Mc Ld  65.115974
58    HC Ma Mc Ma Mb LF HB HF Lg LE Lg Ld LC Mg Lg HF Md Me Ma Lc  91.82657
59    MA Le Md HE LB Ha Lb Lg Mg MD HD Me MF MB ME LA Md He HG HG  77.37749
```

```
60    Ma Hf HD HA La ME He HB Ha Hf Ld HG HG Ha Md HC LA Lb HE Mg  91.40626
61    Mg Mg HA HE MA MD Le Lb Md He LF Ha Me ME MA MD HF HC MB HC  55.691563
62    ME Hb Hb La HD LA Me Hc Mb He Lg Hc Lf Lb ME MB Hf HD Md Ma  94.76463
63    MF Hf Ma MB Hd MA Hd Mf HG Lf MB MD Hc HB Ld HE Le Hc Lf HC  75.12497
64    MC LB HD Mg MD Mb Hd HE Ma MD Hc He Me LE Hc Ma Hg Mf HA Mg  60.304237
65    LG Lc Lc HC LA LD MC MB Hb MG MB HC Lf Ha HF Hb LF MF MF Mc  82.637825
66    LE He Hb Lg Ld HD Hc LC Hc Lf Ha Mb Lf LD Ha Hc MB Hc Me HF  99.33243
67    HB MC Hb Me La HD HF Hb La Mb Lg Hb LA LA LE LE Mf HC He MD  76.689896
68    Mg HB Hb LF MA Le ME HE HD Lb HG Mc LA HA MF Hc HA Lg LD HA  77.18958
69    Md Hc MC Hf Hf Lc Lg HD MG Ld Ha HG Lg Me Ha MA Lf HB Mc Lb  74.78621
70    LD Lc Hd HF Hc He HE LE Lg Hc HB Ma LE HD Ld Le HE HA Ld Hd  86.89533
71    Ha Ma Lg Lf Mb LB Mb Lf LC HF Mc MA MD LA Le Le Hg Lf La MF  69.7513
72    MD Le HA Hd MD Mc Mc MA MA MC LE LB LG Me LE Hg HD Mf Mg HB  75.55135
73    Hg Ld HE Ha HA Ma LD LB Le Lg HG Md LB MF LE HG MD HD MG MA  47.831367
74    Hd HG HF Mc Lb Hb Le Me HA Ma Mg Lc Ld Hb Mb La LE Hf Mg LB  85.752045
75    MA LG LA HE MG Ma LF Hb Hf Lf Hd HG HG Hf Mf MD Md HE Le MG  94.788864
76    MB Ha LA LC Md La LB La LE Lb LA HG MB LB Ha LD Ha HE MB Ld  94.75662
77    Mc Mb Me MA HD HC Md Hf Hf Hf Mf Mg Lc Lb Lb LC HF LG Ld Lf  96.4548
78    LB HC HB MC HC MA ME MD Hb Mf Lb Mc LF LB Md HD Mc Hc Lf LE  73.66604
79    HF HC Lb HD Md MC Me Lc Lf La Ma LA HC Mg Hd MB HD MA La Me  78.9534
80    HD MC ME Hb MA HB Hg Mc LD MC Hf Mf LA HG MD MC HE Ld HD LD  81.9031
81    Me LG Ha Mf HE LD Hc Mg Mf LC Ld MA Hg LC He LF Mf LB LA Le  92.67645
82    Mb La Hg La Me Ld Mg Le Le HG He Lb Le Mc Le Ma LE Hb HA Ma  72.00529
83    Lf Mg Mf Ld Md Me MC Mg Ld MG Hd LE HG Lf La HF HD He LF MG  57.896137
84    MD Md Hb LA LF Lc Le Lf Hb HG HB HF MA HA LF Hf Lg LF HB Ld  98.7519
85    HB Hd HG He Mb LA HB ME Lf Mg LB Mc MF ME Mf Hd HC LG Mb Lf  96.8253
86    Hf Mg HG Mb Hb LE Hf LD Mb MG Mf Mf MC He Mf HF Ld ME HD HF  56.580853
87    Lb HD Ld MB Ma MA ME Hg Hc Lb Mg Ma Hg Lg He Hd MC Hb HC Mg  96.981514
88    HD Mg HD LE LC MA Mc Le HB MD Hb MC Md MD Hb MA LF Lc HF HE  93.409454
89    Ld HF Lc HF MC Ld Me MD LB MC HD LA Ha He Mc Le Me Hf La Lg  45.909206
90    LD MB Lg LD LF Hd HA ME Mb HC Ha Ma LF LB Lb HC Ma Hb Mf Mc  63.15364
91    MB Md Lf HE Hb Hf LC MA MB MB HD LC Hf Lc MF Lb MC HE HG HA  74.77968
92    Hf Mf Lg HA Hc Lf HB HC Lc Hg Le MB HC Lc ME Ha HA MF Ha LG  74.204216
93    LD HF Hc MF MB Hd HE Ha MC Hf Mc Lf Lb MG Mg MA HA HA Le Le  64.52738
94    Mf HC Mf Lf Lf Le Ma Lf La LB HD Me Me Ha LA HF HB Lf HA Mf  89.39925
95    La Ha Lc MF Hf Lc LC Hf HF LF HB Ld HD Me He Le LE Lc MB Lf  85.41819
96    Ld MA MB Lf HB Mg La LE Mb MA Me Hf MC HD Mb Ma HF MG Md MG  85.120895
97    Ld MA Lf Ha MF Me MB LG HG Mb Hc MD Hc LE LC LB He Hb HB LC  79.001144
98    HB Lb MF Hd LB La MG MG HC HA Lb HF ME MB LF ME Lc Hg HF Me  87.611046
99    HE Lg Hg Hc Hb HA Hb LD Hb HG LA HC HC Md HF Md Lb Hg HC Lf  88.78372
100   LC Hd Md MD Hd Mb Ma HF Ld LB HG HE MD Hd Lf La HE Mf LG LC  91.6465
Average fitness = 80.58413


Sampling ...

The sample of melodies ...
16    Mg Mc LB Lb MG MA MF Ld Lb Ma LC HG HG MB Hd LA LE Hb La MF  89.57684
60    Ma Hf HD HA La ME He HB Ha Hf Ld HG HG Ha Md HC LA Lb HE Mg  91.40626
21    LA LC He Ha MA Mg Md HE Hf Le HB Mc Le Hb Hc MC MD Lc HC Mf  88.70414
83    Lf Mg Mf Ld Md Me MC Mg Ld MG Hd LE HG Lf La HF HD He LF MG  57.896137
73    Hg Ld HE Ha HA Ma LD LB Le Lg HG Md LB MF LE HG MD HD MG MA  47.831367
23    LB HB Mb Lb HF Mb HC MG ME MA Lf HF Mg MC Mf Mc HA MA LD Ma  86.14345
65    LG Lc Lc HC LA LD MC MB Hb MG MB HC Lf Ha HF Hb LF MF MF Mc  82.637825
4     LA He MF Hd HC Ma He Mf LB La Lg Mc HA LD Ma MF La La MG Mf  84.98045

The one with the best score ...
60    Ma Hf HD HA La ME He HB Ha Hf Ld HG HG Ha Md HC LA Lb HE Mg  91.40626


Sampling ...

The sample of melodies ...
4     LA He MF Hd HC Ma He Mf LB La Lg Mc HA LD Ma MF La La MG Mf  84.98045
31    LF Mg MB Ld MB Hb Hf MG LC Me Mg MF Mc Lf Md Hg Lb Hf LG Md  83.24165
32    HD LA Hg Mb Lb MD Hd MB HB Lg LB LC HC LG MD HD Ha Hg LC Lg  88.47031
7     LF LC Lc MA Hg HA MG Hc Mf HB Lb HB Md Hc Le Hc HD Hg Ma HA  63.130524
40    Lb LD MF LC Le Mf HC Lb Hd MC LA HD Hd Ma Lf Lf LE Ld HE ME  97.44011
87    Lb HD Ld MB Ma MA ME Hg Hc Lb Mg Ma Hg Lg He Hd MC Hb HC Mg  96.981514
37    Le Ld HA Ld Ld Hb MB HF Ha LB LC HF ME Mf Hc LG He HC LA MG  63.188255
```

```
36    Le Mg Mc He LG MC Lg LA Hb MD Lf Hd LB LA Hb MC LD Hg LB HG  80.96404

The one with the best score ...
40    Lb LD MF LC Le Mf HC Lb Hd MC LA HD Hd Ma Lf Lf LE Ld HE ME  97.44011


Sampling ...

The sample of melodies ...
85    HB Hd HG He Mb LA HB ME Lf Mg LB Mc MF ME Mf Hd HC LG Mb Lf  96.8253
76    MB Ha LA LC Md La LB La LE Lb LA HG MB LB Ha LD Ha HE MB Ld  94.75662
60    Ma Hf HD HA La ME He HB Ha Hf Ld HG HG Ha Md HC LA Lb HE Mg  91.40626
23    LB HB Mb Lb HF Mb HC MG ME MA Lf HF Mg MC Mf Mc HA MA LD Ma  86.14345
32    HD LA Hg Mb Lb MD Hd MB HB Lg LB LC HC LG MD HD Ha Hg LC Lg  88.47031
77    Mc Mb Me MA HD HC Md Hf Hf Hf Mf Mg Lc Lb Lb LC HF LG Ld Lf  96.4548
38    Md MG MB MD LA HF Mc LC Mc Me MA Ma LF MC Lf Lf HA Hf Hb Lc  60.077465
92    Hf Mf Lg HA Hc Lf HB HC Lc Hg Le MB HC Lc ME Ha HA MF Ha LG  74.204216

The one with the best score ...
85    HB Hd HG He Mb LA HB ME Lf Mg LB Mc MF ME Mf Hd HC LG Mb Lf  96.8253


NIL
```

Code

```
(defconstant *collection-size* 100)
(defconstant *selection-size* 8)

(defclass collection ()
        (
                (melodies :accessor collection-melodies :initarg :melodies)
                (generation :accessor collection-generation :initarg :generation :initform 0)
        )
)

(defmethod size((c collection))
        (length (collection-melodies c))
)

(defmethod display((c collection))
        (format t "~%~%Generation ~A collection ... ~%" (collection-generation c))
        (dolist (i (collection-melodies c))
                (display i) (terpri)
        )
)

(defmethod initial-collection(&aux melodies)
        (setf melodies ())
        (dotimes (i *collection-size*)
                (push (new-melody (+ i 1) (new-notes)) melodies)
        )
        (make-instance 'collection :melodies (reverse melodies))
)

(defmethod average((c collection) &aux sum melodies)
        (setf sum 0.00)
        (setf melodies (collection-melodies c))
        (dotimes (i *collection-size*)
                (setf sum (+ sum (melody-fitness (nth i melodies))))
        )
        (/ sum *collection-size*)
)

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

```
(defmethod select-melody((c collection) &aux candidates mfm)
	(setf candidates (select-candidates c))
	(setf mfm (most-fit-melody candidates))
	(if *select-demo* (select-demo-helper candidates mfm))
	mfm
)

(defmethod select-candidates((c collection) &aux melodies candidates ran)
	(setf melodies (collection-melodies c))
	(setf candidates (list))
	(dotimes (i *selection-size*)
		(setf ran (random *collection-size*))
		(push (nth ran melodies) candidates)
	)
	candidates
)

; Sometimes the fitness could end up been in the negatives
(defmethod most-fit-melody((candidates list) &aux best-score best-melody melody fitness)
	(setf best-melody (first candidates))
	(setf best-score (melody-fitness best-melody))

	(dotimes (i (length candidates))
		(setf melody (nth i candidates))
		(setf fitness (melody-fitness melody))
		(cond
			((>= fitness best-score)
				(setf best-score fitness)
				(setf best-melody melody)
			)
		)
	)
	best-melody
)

(defmethod select-demo-helper((candidates list) (best melody))
	(format t "The sample of melodies ... ~%")
	(dolist (c candidates)
		(display c)
		(terpri)
	)
	(format t "~%The one with the best score ... ~%")
	(display best)
	(terpri) (terpri)
	nil
)

(defmethod collection-demo(&aux c)
	(setf c (initial-collection))
	(display c)
	(format t "Average fitness = ~A~%~%~%" (average c))
	(setf *select-demo* t)
	(format t "Sampling ...~%~%")
	(select-melody c) (terpri)
	(format t "Sampling ...~%~%")
	(select-melody c) (terpri)
	(format t "Sampling ...~%~%")
	(select-melody c) (terpri)
	(setf *select-demo* nil)
	nil
)
```

Task 8: Incorporating Mutation —----------

Demo

```
[]> (mutate-demo)
0     He HG Hb Lc Mf Ld Lf ME HG MG Ld HB Ma Ma MC LE LF Mg HE La  82.497025
0     He HG Hb Lc Mf Ld Lf ME HG MG Ld HB Ma Ma MC LE LF Mg Me La  94.62807
0     He HG Hb Lc Mf Ld Lf ME HG MG Ld LG Ma Ma MC LE LF Mg Me La  93.85264
0     He HG Hb Lc Mf Ld Lf ME HG MG Ld LG Ma Ma Le LE LF Mg Me La  97.35096
0     He HG Hb Lc Mf Ld Lf ME HG MG Ld LG Hd Ma Le LE LF Mg Me La  99.54052
0     He HG Hb Lc Mf Ld Lf ME HG MG HA LG Hd Ma Le LE LF Mg Me La  99.83426
0     He HG Hb Lc Mf Ld Lf ME HG MG HA LG Hd Ma Le LE La Mg Me La  85.10856
0     He HG Hb Lc Mf Ld Lf ME LC MG HA LG Hd Ma Le LE La Mg Me La  84.93415
0     Lb HG Hb Lc Mf Ld Lf ME LC MG HA LG Hd Ma Le LE La Mg Me La  92.43932
0     Lb HG Hb Lc Mf Ld Lf ME LC MG HA LG Hd Ma HC LE La Mg Me La  99.38898
0     Lb HG Hb Lc Me Ld Lf ME LC MG HA LG Hd Ma HC LE La Mg Me La  99.48754
0     Lb HG Hb Lc Me Ld Lf ME LD MG HA LG Hd Ma HC LE La Mg Me La  99.79083
0     Lb HG Hb Lc Me Lc Lf ME LD MG HA LG Hd Ma HC LE La Mg Me La  98.8497
0     Lb HG Hb Lc Me Lc Lf ME LD MG Mg LG Hd Ma HC LE La Mg Me La  98.28099
0     Lb HG Hb Lc Me Lc Lf ME Ld MG Mg LG Hd Ma HC LE La Mg Me La  99.51841
0     Lb HG Hb Lc Me Lc Lf ME Ld MG Mg LG Hd Hc HC LE La Mg Me La  95.757065
0     Lb HG Hb Lc Me Lc Lf ME Ld MG Mg LG LD Hc HC LE La Mg Me La  91.96615
0     Lb HG Hb Lc HE Lc Lf ME Ld MG Mg LG LD Hc HC LE La Mg Me La  99.7924
0     Lb HG Hb Lc HE Lc Lf ME Ld MG Mg LG LD Hc LC LE La Mg Me La  99.180336
0     Lb HG MB Lc HE Lc Lf ME Ld MG Mg LG LD Hc LC LE La Mg Me La  88.83103
0     Lb HG MB Lc HE Lc Lf ME Ld MG Mg LG LD Hc LC LE La MC Me La  93.26424
NIL
[]> (maybe-mutate-demo)
0     MF ME Ld Hc Mb LB Lb HG Me Le Lf Hf LA MC Lb Lc Mf Lf MA Hc  86.53708
0     MF ME Ld Hc Mb LB Lb HG Me Le Lf Hf LA MC Lb Lc Mf Lf MA Hc  86.53708
0     MF ME Ld Hc Mb LB Lb HG Me Le Hb Hf LA MC Lb Lc Mf Lf MA Hc  86.83717     *
0     MF ME Ld Hc Mb LB Lb HG Me Le Hb Hf LA MC Lb Lc Mf Mf MA Hc  86.29085     *
0     MF ME Ld Hc Mb LB Lb HG Me Le Hb Hf LA MC Lb Lc Lg Mf MA Hc  85.377106     *
0     MF ME Ld Hc Mb LB Lb HG Me Le Hb Hf LA MC Lb Lc Lg Mf MA Hc  85.377106
0     MF ME Ld Hc Mb LB Lb HG Me Le Hb Hf LA MC Lb Lc Mg Mf MA Hc  84.93281     *
0     MF ME Lb Hc Mb LB Lb HG Me Le Hb Hf LA MC Lb Lc Mg Mf MA Hc  93.809166     *
0     MF ME Lb Hc Mb LB Lb HG Me Le Hb Hf MC MC Lb Lc Mg Mf MA Hc  96.6594     *
0     MF ME Lb Hc Mb LB Lb HG Me Le Hb Hf MC MC Lb Lc Mg Mf MA Hc  96.6594
0     MF ME Lb Hc Mb LB Lb HG Me Le Hb Hf MC MC HC Lc Mg Mf MA Hc  92.23383     *
0     MF ME Lb Hc Mb MC Lb HG Me Le Hb Hf MC MC HC Lc Mg Mf MA Hc  97.44355     *
0     MF ME Lb Hc Mb MC Lb HG Me Le He Hf MC MC HC Lc Mg Mf MA Hc  96.934204     *
0     MF ME Lb Hc Mb MC Lb HG Me Le He Hf MC MC HC Lc Mg Mf MA Hc  96.934204
0     MF ME Lb Hc Mb MC Lb HG Me Le He Hf MC MC MF Lc Mg Mf MA Hc  99.25641     *
0     MF ME Lb Hc Mb MC Lb HG Me Le He Hf MC MC MF Lc La Mf MA Hc  99.86592     *
0     MF ME Lb Hc Mb MC Lb HG Me Le He Hf MC MC MF Lc La Mf La Hc  88.74353     *
0     MF ME Lb Hc Le MC Lb HG Me Le He Hf MC MC MF Lc La Mf La Hc  83.338295     *
0     MF ME Lb Hc Le MC Lb HG Me Le Hb Hf MC MC MF Lc La Mf La Hc  83.7037     *
0     MF ME Lb Hc Le MC Lb HG Me Le Hb Hf MC MC MF Lc La Mf La Hc  83.7037
0     MF ME Lb Hc Le MC Lb HG Me Mf Hb Hf MC MC MF Lc La Mf La Hc  83.95405     *
NIL
```

Code

```
(defmethod mutate((m melody) &aux notes)
      (setf notes (mutation (melody-notes m)))
      (make-instance 'melody
            :number (melody-number m)
            :notes notes
            :fitness (*fitness* notes)
      )
)
```

```
(defconstant *percent-mutate* 50)

(defmethod maybe-mutate((m melody))
      (if (<= (+ 1 (random 100)) *percent-mutate*)
            (mutate m)
            m
      )
)

(defmethod mutate-demo()
      (setf m (random-melody))
      (display m)
      (terpri)
      (dotimes(i 20)
            (setf m (mutate m))
            (display m)
            (terpri)
      )
)

(defmethod maybe-mutate-demo()
      (setf m (random-melody))
      (display m) (terpri)
      (dotimes(i 20)
            (setf new (maybe-mutate m))
            (display new)
            (if (not (equal new m)) (princ " *"))
            (terpri)
            (setf m new)
      )
      nil
)
```

Task 9: Copy —----------

Demo

```
[2]> (perform-copies-demo)
--------------------------------------------------------------------------



Generation 1 collection ...


--------------------------------------------------------------------------
The sample of melodies ...
43    MB Hd LA LE Hb La MF HF HA MD Lb MG LF La MD HC Mc HA MG LD  71.25988
5     Lb Hb HE LC He MA HE HA MG Hg MA Lg La LB Ld HD Ha HE LF MA  83.73853
51    Mc HG Lf Hc Hc Me HE HG Mc HB Lg MA Ld Mg LC Mb Me MD LC Mc  83.93815
27    LA Lg Le MD Hg Mb Lc HC Ha Ma Ld MA Hc ME HF Hf HA HG Hc Ha  95.36389
3     Hg Me HB HF Me HD LC Ld Md MD HF MF HD Ma HC LF Ma Hc Me Mf  92.984856
47    Lf Md HF Ha LB MD LG LA LC He Ha MA Mg Md HE Hf Le HB Mc Le  87.127754
17    MB LC Hb MG LG HD HC Lc Lb Hc Hg Lg Mg Mf MG Hc LC Lf Hf LA  80.16705
72    Me LF Mf MC MC Mc Mf Mg LD LG Hc HF LE Hb Mg Md LA Hg Ma HE  77.40676

The one with the best score ...
27    LA Lg Le MD Hg Mb Lc HC Ha Ma Ld MA Hc ME HF Hf HA HG Hc Ha  95.36389


Selected melody =
27    LA Lg Le MD Hg Mb Lc HC Ha Ma Ld MA Hc ME HF Hf HA HG Hc Ha  95.36389
Possibly mutated melody =
27    LA Lg Le MD Hg Mb Lc LC Ha Ma Ld MA Hc ME HF Hf HA HG Hc Ha  95.80172
Renumbered melody =
1     LA Lg Le MD Hg Mb Lc LC Ha Ma Ld MA Hc ME HF Hf HA HG Hc Ha  95.80172
--------------------------------------------------------------------------



Generation 1 collection ...
1     LA Lg Le MD Hg Mb Lc LC Ha Ma Ld MA Hc ME HF Hf HA HG Hc Ha  95.80172


--------------------------------------------------------------------------
The sample of melodies ...
3     Hg Me HB HF Me HD LC Ld Md MD HF MF HD Ma HC LF Ma Hc Me Mf  92.984856
47    Lf Md HF Ha LB MD LG LA LC He Ha MA Mg Md HE Hf Le HB Mc Le  87.127754
41    Ha La HD MF Hf MC MA Lb HF HD He Hb LF Lg HB LF ME Lb LB HF  88.885414
79    LF Hd MF HC Ld ME LA LF Hc MA ME Mg Hg Hc HE HB Hb MF Ma LB  59.661232
62    Hf HF He LC MF MA Ld Le Mg Mc He LG MC Lg LA Hb MD Lf Hd LB  90.10161
58    Lf Md Hg Lb Hf LG Md HD LA Hg Mb Lb MD Hd MB HB Lg LB LC HC  56.455673
58    Lf Md Hg Lb Hf LG Md HD LA Hg Mb Lb MD Hd MB HB Lg LB LC HC  56.455673
70    Hb HD Le Lg HB Le Mc LE Le Le Ma LB ME MG Lg HD LF LE He Hb  85.52377

The one with the best score ...
3     Hg Me HB HF Me HD LC Ld Md MD HF MF HD Ma HC LF Ma Hc Me Mf  92.984856


Selected melody =
3     Hg Me HB HF Me HD LC Ld Md MD HF MF HD Ma HC LF Ma Hc Me Mf  92.984856
Possibly mutated melody =
3     Hg Me HB HF Me HD LC Ld Md MD HF MF HD Ma HC LF Mg Hc Me Mf  94.273964
Renumbered melody =
2     Hg Me HB HF Me HD LC Ld Md MD HF MF HD Ma HC LF Mg Hc Me Mf  94.273964
--------------------------------------------------------------------------



Generation 1 collection ...
```

```
1     LA Lg Le MD Hg Mb Lc LC Ha Ma Ld MA Hc ME HF Hf HA HG Hc Ha  95.80172
2     Hg Me HB HF Me HD LC Ld Md MD HF MF HD Ma HC LF Mg Hc Me Mf  94.273964


--------------------------------------------------------------------------
The sample of melodies ...
52    HC Mc MG LF HE Me LE HA Mb Ma Ha He He He MB HF LG HD HG HC  97.2515
29    Lf HB MA HB Lc Mf HD MD LD HE Lb MF He Ma Le Ma HC LE Hb HA  91.008965
100   MF LE HG MD HD MG MA Hd HG HF Mc Lb Hb Le Me HA Ma Mg Lc Ld  31.607008
2     MA Lb HD Mc MG LB Hc MC Hf MC Mg LA Hg LG Lb Lf HG Le LD HA  96.98023
20    Lg HB LC Hf Mg Hg Lg Me LC HD He Hg Me Lf Hg Mf MD Mg Hb LC  98.448654
25    MC ME HB LB Ld Ha Hf HF MF Ma HD Ha Mc Hc HC HA ME Lc Ha Mg  76.683365
52    HC Mc MG LF HE Me LE HA Mb Ma Ha He He He MB HF LG HD HG HC  97.2515
53    Hf Mf Hb Ld ME HC Hg Mf MB Mf Mf MC Ha La Mc MD Lf HG Mb HB  90.80319

The one with the best score ...
20    Lg HB LC Hf Mg Hg Lg Me LC HD He Hg Me Lf Hg Mf MD Mg Hb LC  98.448654


Selected melody =
20    Lg HB LC Hf Mg Hg Lg Me LC HD He Hg Me Lf Hg Mf MD Mg Hb LC  98.448654
Possibly mutated melody =
20    Lg LA LC Hf Mg Hg Lg Me LC HD He Hg Me Lf Hg Mf MD Mg Hb LC  98.8704
Renumbered melody =
3     Lg LA LC Hf Mg Hg Lg Me LC HD He Hg Me Lf Hg Mf MD Mg Hb LC  98.8704
--------------------------------------------------------------------------



Generation 1 collection ...
1     LA Lg Le MD Hg Mb Lc LC Ha Ma Ld MA Hc ME HF Hf HA HG Hc Ha  95.80172
2     Hg Me HB HF Me HD LC Ld Md MD HF MF HD Ma HC LF Mg Hc Me Mf  94.273964
3     Lg LA LC Hf Mg Hg Lg Me LC HD He Hg Me Lf Hg Mf MD Mg Hb LC  98.8704


--------------------------------------------------------------------------
The sample of melodies ...
9     HD Mf Mc Ha Me MG HF Hd Hc Lb Lf Hd Hd HG HB LB LG Lb Lf Lf  84.03428
2     MA Lb HD Mc MG LB Hc MC Hf MC Mg LA Hg LG Lb Lf HG Le LD HA  96.98023
37    Mg HF HD ME Ha Hd HG Ha Ma La He MF HG Hg ME LA HD He LD Me  86.326004
2     MA Lb HD Mc MG LB Hc MC Hf MC Mg LA Hg LG Lb Lf HG Le LD HA  96.98023
38    Md Hd Hg MG MA HD MC Mg LA He Mf Md MB HF Lg MC HF MB Lf Lf  99.55451
41    Ha La HD MF Hf MC MA Lb HF HD He Hb LF Lg HB LF ME Lb LB HF  88.885414
63    LA Hb MC LD Hg LB HG Le Ld HA Ld Ld Hb MB HF Ha LB LC HF ME  85.84773
87    Ha Md HC LA Lb HE Mg Mg Mg HA HE MA MD Le Lb Md He LF Ha Me  93.61976

The one with the best score ...
38    Md Hd Hg MG MA HD MC Mg LA He Mf Md MB HF Lg MC HF MB Lf Lf  99.55451


Selected melody =
38    Md Hd Hg MG MA HD MC Mg LA He Mf Md MB HF Lg MC HF MB Lf Lf  99.55451
Possibly mutated melody =
38    Md Hd Hg MG MA HD MC Mg LA He Mf Md MB HF Lg MC HF MB Lf HF  85.76271
Renumbered melody =
4     Md Hd Hg MG MA HD MC Mg LA He Mf Md MB HF Lg MC HF MB Lf HF  85.76271
--------------------------------------------------------------------------



Generation 1 collection ...
1     LA Lg Le MD Hg Mb Lc LC Ha Ma Ld MA Hc ME HF Hf HA HG Hc Ha  95.80172
2     Hg Me HB HF Me HD LC Ld Md MD HF MF HD Ma HC LF Mg Hc Me Mf  94.273964
3     Lg LA LC Hf Mg Hg Lg Me LC HD He Hg Me Lf Hg Mf MD Mg Hb LC  98.8704
4     Md Hd Hg MG MA HD MC Mg LA He Mf Md MB HF Lg MC HF MB Lf HF  85.76271


--------------------------------------------------------------------------
The sample of melodies ...
62    Hf HF He LC MF MA Ld Le Mg Mc He LG MC Lg LA Hb MD Lf Hd LB  90.10161
```

```
89    Lb ME MB Hf HD Md Ma MF Hf Ma MB Hd MA Hd Mf HG Lf MB MD Hc  87.27544
43    MB Hd LA LE Hb La MF HF HA MD Lb MG LF La MD HC Mc HA MG LD  71.25988
15    Hf LD LD Hb LE Lc LF HB LA LC MD Lf HE Hb Lf MG ME Mg HF LG  94.975845
21    ME Le HG LC Ld LE Lg MF MD LE He Le HD Hb HA LA Le MB LC Mc  85.91931
51    Mc HG Lf Hc Hc Me HE HG Mc HB Lg MA Ld Mg LC Mb Me MD LC Mc  83.93815
12    MB MA Me La LA Hc Lc La LB Ld He Lg HE MF Ld LF MA MF LE LC  44.117252
55    MG He Hg Lg Mf Mc HC Le HC MA Lg LF HD HB Lc MA Hb Mb MF Me  99.23942

The one with the best score ...
55    MG He Hg Lg Mf Mc HC Le HC MA Lg LF HD HB Lc MA Hb Mb MF Me  99.23942


Selected melody =
55    MG He Hg Lg Mf Mc HC Le HC MA Lg LF HD HB Lc MA Hb Mb MF Me  99.23942
Possibly mutated melody =
55    MG He Hg Lg Mf Mc HC Le HC MA Lg LF HD HB Lc MA Hb Mb MF Me  99.23942
Renumbered melody =
5     MG He Hg Lg Mf Mc HC Le HC MA Lg LF HD HB Lc MA Hb Mb MF Me  99.23942
--------------------------------------------------------------------------------



Generation 1 collection ...
1     LA Lg Le MD Hg Mb Lc LC Ha Ma Ld MA Hc ME HF Hf HA HG Hc Ha  95.80172
2     Hg Me HB HF Me HD LC Ld Md MD HF MF HD Ma HC LF Mg Hc Me Mf  94.273964
3     Lg LA LC Hf Mg Hg Lg Me LC HD He Hg Me Lf Hg Mf MD Mg Hb LC  98.8704
4     Md Hd Hg MG MA HD MC Mg LA He Mf Md MB HF Lg MC HF MB Lf HF  85.76271
5     MG He Hg Lg Mf Mc HC Le HC MA Lg LF HD HB Lc MA Hb Mb MF Me  99.23942


--------------------------------------------------------------------------------
The sample of melodies ...
70    Hb HD Le Lg HB Le Mc LE Le Le Ma LB ME MG Lg HD LF LE He Hb  85.52377
52    HC Mc MG LF HE Me LE HA Mb Ma Ha He He He MB HF LG HD HG HC  97.2515
87    Ha Md HC LA Lb HE Mg Mg Mg HA HE MA MD Le Lb Md He LF Ha Me  93.61976
98    LA Le Le Hg Lf La MF MD Le HA Hd MD Mc Mc MA MA MC LE LB LG  49.14659
7     LE Hf Ha HD Ld Mg HE HE La ME LB Ld Mg HA Lf Ma Hf La Mc LC  89.20475
5     Lb Hb HE LC He MA HE HA MG Hg MA Lg La LB Ld HD Ha HE LF MA  83.73853
35    HD Mg Hb HD LF MG Md HA MG HF MG Hd LF Ma Ha Le MA Le Hd Lc  75.899345
98    LA Le Le Hg Lf La MF MD Le HA Hd MD Mc Mc MA MA MC LE LB LG  49.14659

The one with the best score ...
52    HC Mc MG LF HE Me LE HA Mb Ma Ha He He He MB HF LG HD HG HC  97.2515


Selected melody =
52    HC Mc MG LF HE Me LE HA Mb Ma Ha He He He MB HF LG HD HG HC  97.2515
Possibly mutated melody =
52    HC Mc MG LF HE Me LE HA Mg Ma Ha He He He MB HF LG HD HG HC  97.81502
Renumbered melody =
6     HC Mc MG LF HE Me LE HA Mg Ma Ha He He He MB HF LG HD HG HC  97.81502
--------------------------------------------------------------------------------



Generation 1 collection ...
1     LA Lg Le MD Hg Mb Lc LC Ha Ma Ld MA Hc ME HF Hf HA HG Hc Ha  95.80172
2     Hg Me HB HF Me HD LC Ld Md MD HF MF HD Ma HC LF Mg Hc Me Mf  94.273964
3     Lg LA LC Hf Mg Hg Lg Me LC HD He Hg Me Lf Hg Mf MD Mg Hb LC  98.8704
4     Md Hd Hg MG MA HD MC Mg LA He Mf Md MB HF Lg MC HF MB Lf HF  85.76271
5     MG He Hg Lg Mf Mc HC Le HC MA Lg LF HD HB Lc MA Hb Mb MF Me  99.23942
6     HC Mc MG LF HE Me LE HA Mg Ma Ha He He He MB HF LG HD HG HC  97.81502


--------------------------------------------------------------------------------
The sample of melodies ...
35    HD Mg Hb HD LF MG Md HA MG HF MG Hd LF Ma Ha Le MA Le Hd Lc  75.899345
28    MB LD Lb MF MD Hd HD Hf Mc Hc Mf Lc Le Le LE HG Md Ha MF MD  97.02919
71    Lc Hb Le LC MD Hb Ha HA LB Mc La Me He La HG Lf Mc LC MA Le  89.46673
45    Hd Hg LB Lg Lb HG Lg Hd LD Lg HA HD HB Lc Le Hb MG Mb La Lf  93.00907
```

```
69    Hf Lc MD Lb Md HC La Mf MC MB HA Hd Hf LE La Lc MB Me HE Me  97.51705
79    LF Hd MF HC Ld ME LA LF Hc MA ME Mg Hg Hc HE HB Hb MF Ma LB  59.661232
35    HD Mg Hb HD LF MG Md HA MG HF MG Hd LF Ma Ha Le MA Le Hd Lc  75.899345
53    Hf Mf Hb Ld ME HC Hg Mf MB Mf Mf MC Ha La Mc MD Lf HG Mb HB  90.80319

The one with the best score ...
69    Hf Lc MD Lb Md HC La Mf MC MB HA Hd Hf LE La Lc MB Me HE Me  97.51705


Selected melody =
69    Hf Lc MD Lb Md HC La Mf MC MB HA Hd Hf LE La Lc MB Me HE Me  97.51705
Possibly mutated melody =
69    Hf Lc MD Lb Md HC La Mf MC MB HA MB Hf LE La Lc MB Me HE Me  96.72933
Renumbered melody =
7     Hf Lc MD Lb Md HC La Mf MC MB HA MB Hf LE La Lc MB Me HE Me  96.72933
--------------------------------------------------------------------------------



Generation 1 collection ...
1     LA Lg Le MD Hg Mb Lc LC Ha Ma Ld MA Hc ME HF Hf HA HG Hc Ha  95.80172
2     Hg Me HB HF Me HD LC Ld Md MD HF MF HD Ma HC LF Mg Hc Me Mf  94.273964
3     Lg LA LC Hf Mg Hg Lg Me LC HD He Hg Me Lf Hg Mf MD Mg Hb LC  98.8704
4     Md Hd Hg MG MA HD MC Mg LA He Mf Md MB HF Lg MC HF MB Lf HF  85.76271
5     MG He Hg Lg Mf Mc HC Le HC MA Lg LF HD HB Lc MA Hb Mb MF Me  99.23942
6     HC Mc MG LF HE Me LE HA Mg Ma Ha He He He MB HF LG HD HG HC  97.81502
7     Hf Lc MD Lb Md HC La Mf MC MB HA MB Hf LE La Lc MB Me HE Me  96.72933


--------------------------------------------------------------------------------
The sample of melodies ...
70    Hb HD Le Lg HB Le Mc LE Le Le Ma LB ME MG Lg HD LF LE He Hb  85.52377
42    LB LB Md Md Ha He Lb Mg Mc LB Lb MG MA MF Ld Lb Ma LC HG HG  72.74234
69    Hf Lc MD Lb Md HC La Mf MC MB HA Hd Hf LE La Lc MB Me HE Me  97.51705
76    Ld Lf Mc HG Hg LA LF Mb LD He Lf HG LE LE Mb Hd Mg LA MG HE  82.45592
27    LA Lg Le MD Hg Mb Lc HC Ha Ma Ld MA Hc ME HF Hf HA HG Hc Ha  95.36389
56    HA Lc LD HA Mb MD MB LE LB ME LG Mg Hf HC LD MC HA MA Mg LG  98.00585
36    Lg Ld La Lb ME Lf Le Ha LA Mc MB Hd Ld Lb Hd LC HC Md Mg Ha  83.118
38    Md Hd Hg MG MA HD MC Mg LA He Mf Md MB HF Lg MC HF MB Lf Lf  99.55451

The one with the best score ...
38    Md Hd Hg MG MA HD MC Mg LA He Mf Md MB HF Lg MC HF MB Lf Lf  99.55451


Selected melody =
38    Md Hd Hg MG MA HD MC Mg LA He Mf Md MB HF Lg MC HF MB Lf Lf  99.55451
Possibly mutated melody =
38    Md Hd Hg MG MA HD MC Mg LA He Mf Md MB HF Lg MC HF MB Lf Lf  99.55451
Renumbered melody =
8     Md Hd Hg MG MA HD MC Mg LA He Mf Md MB HF Lg MC HF MB Lf Lf  99.55451
--------------------------------------------------------------------------------



Generation 1 collection ...
1     LA Lg Le MD Hg Mb Lc LC Ha Ma Ld MA Hc ME HF Hf HA HG Hc Ha  95.80172
2     Hg Me HB HF Me HD LC Ld Md MD HF MF HD Ma HC LF Mg Hc Me Mf  94.273964
3     Lg LA LC Hf Mg Hg Lg Me LC HD He Hg Me Lf Hg Mf MD Mg Hb LC  98.8704
4     Md Hd Hg MG MA HD MC Mg LA He Mf Md MB HF Lg MC HF MB Lf HF  85.76271
5     MG He Hg Lg Mf Mc HC Le HC MA Lg LF HD HB Lc MA Hb Mb MF Me  99.23942
6     HC Mc MG LF HE Me LE HA Mg Ma Ha He He He MB HF LG HD HG HC  97.81502
7     Hf Lc MD Lb Md HC La Mf MC MB HA MB Hf LE La Lc MB Me HE Me  96.72933
8     Md Hd Hg MG MA HD MC Mg LA He Mf Md MB HF Lg MC HF MB Lf Lf  99.55451


--------------------------------------------------------------------------------
The sample of melodies ...
6     Hd Hf La Mc MG Lb MF Lb MD LG Lc HD LG LG LA HG MC MD MD MF  32.344532
24    LA Ha He HF MC HE MB Mb Hg LF MF HC La Le Mc LG Mf Ma Lg MC  92.99984
30    HC HF Mf Lf Ma Lc Mg LA He MF Hd HC Ma He Mf LB La Lg Mc HA  81.26757
```

```
33    Mf Ha LE HG HE He Mc LF LC Lc MA Hg HA MG Hc Mf HB Lb HB Md  82.44589
70    Hb HD Le Lg HB Le Mc LE Le Le Ma LB ME MG Lg HD LF LE He Hb  85.52377
57    HB MD Hf Hd Lg Ma Me LF Mg MB Ld MB Hb Hf MG LC Me Mg MF Mc  90.88416
13    LB Mc Mb MG LD Mf LD Ld La HB HF HE Md Hg Lb HG HD Ma LE Hb  88.57585
94    LA LE LE Mf HC He MD Mg HB Hb LF MA Le ME HE HD Lb HG Mc LA  89.815895

The one with the best score ...
24    LA Ha He HF MC HE MB Mb Hg LF MF HC La Le Mc LG Mf Ma Lg MC  92.99984


Selected melody =
24    LA Ha He HF MC HE MB Mb Hg LF MF HC La Le Mc LG Mf Ma Lg MC  92.99984
Possibly mutated melody =
24    LA Ha He HF MC HE MB Mb He LF MF HC La Le Mc LG Mf Ma Lg MC  92.258354
Renumbered melody =
9     LA Ha He HF MC HE MB Mb He LF MF HC La Le Mc LG Mf Ma Lg MC  92.258354
--------------------------------------------------------------------------------



Generation 1 collection ...
1     LA Lg Le MD Hg Mb Lc LC Ha Ma Ld MA Hc ME HF Hf HA HG Hc Ha  95.80172
2     Hg Me HB HF Me HD LC Ld Md MD HF MF HD Ma HC LF Mg Hc Me Mf  94.273964
3     Lg LA LC Hf Mg Hg Lg Me LC HD He Hg Me Lf Hg Mf MD Mg Hb LC  98.8704
4     Md Hd Hg MG MA HD MC Mg LA He Mf Md MB HF Lg MC HF MB Lf HF  85.76271
5     MG He Hg Lg Mf Mc HC Le HC MA Lg LF HD HB Lc MA Hb Mb MF Me  99.23942
6     HC Mc MG LF HE Me LE HA Mg Ma Ha He He He MB HF LG HD HG HC  97.81502
7     Hf Lc MD Lb Md HC La Mf MC MB HA MB Hf LE La Lc MB Me HE Me  96.72933
8     Md Hd Hg MG MA HD MC Mg LA He Mf Md MB HF Lg MC HF MB Lf Lf  99.55451
9     LA Ha He HF MC HE MB Mb He LF MF HC La Le Mc LG Mf Ma Lg MC  92.258354


--------------------------------------------------------------------------------
The sample of melodies ...
56    HA Lc LD HA Mb MD MB LE LB ME LG Mg Hf HC LD MC HA MA Mg LG  98.00585
41    Ha La HD MF Hf MC MA Lb HF HD He Hb LF Lg HB LF ME Lb LB HF  88.885414
11    Mb MG Hc MB Lb HB HD LF Hb ME LC Lb HG HB Mg Md LA HD MA Lg  89.267944
59    LG MD HD Ha Hg LC Lg LB MG LF MG Lb Mg Ma ME HD HA LG MC Md  98.398384
22    Me Hg LC HC Hc Mc Lf HE LA HG Me HC LC MD LE Lc Mc LC HD MD  57.600212
64    Mf Hc LG He HC LA MG Md MG MB MD LA HF Mc LC Mc Me MA Ma LF  97.13516
79    LF Hd MF HC Ld ME LA LF Hc MA ME Mg Hg Hc HE HB Hb MF Ma LB  59.661232
37    Mg HF HD ME Ha Hd HG Ha Ma La He MF HG Hg ME LA HD He LD Me  86.326004

The one with the best score ...
59    LG MD HD Ha Hg LC Lg LB MG LF MG Lb Mg Ma ME HD HA LG MC Md  98.398384


Selected melody =
59    LG MD HD Ha Hg LC Lg LB MG LF MG Lb Mg Ma ME HD HA LG MC Md  98.398384
Possibly mutated melody =
59    LF MD HD Ha Hg LC Lg LB MG LF MG Lb Mg Ma ME HD HA LG MC Md  99.74013
Renumbered melody =
10    LF MD HD Ha Hg LC Lg LB MG LF MG Lb Mg Ma ME HD HA LG MC Md  99.74013
--------------------------------------------------------------------------------



Generation 1 collection ...
1     LA Lg Le MD Hg Mb Lc LC Ha Ma Ld MA Hc ME HF Hf HA HG Hc Ha  95.80172
2     Hg Me HB HF Me HD LC Ld Md MD HF MF HD Ma HC LF Mg Hc Me Mf  94.273964
3     Lg LA LC Hf Mg Hg Lg Me LC HD He Hg Me Lf Hg Mf MD Mg Hb LC  98.8704
4     Md Hd Hg MG MA HD MC Mg LA He Mf Md MB HF Lg MC HF MB Lf HF  85.76271
5     MG He Hg Lg Mf Mc HC Le HC MA Lg LF HD HB Lc MA Hb Mb MF Me  99.23942
6     HC Mc MG LF HE Me LE HA Mg Ma Ha He He He MB HF LG HD HG HC  97.81502
7     Hf Lc MD Lb Md HC La Mf MC MB HA MB Hf LE La Lc MB Me HE Me  96.72933
8     Md Hd Hg MG MA HD MC Mg LA He Mf Md MB HF Lg MC HF MB Lf Lf  99.55451
9     LA Ha He HF MC HE MB Mb He LF MF HC La Le Mc LG Mf Ma Lg MC  92.258354
10    LF MD HD Ha Hg LC Lg LB MG LF MG Lb Mg Ma ME HD HA LG MC Md  99.74013
```

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

Code

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

(defconstant *percent-copy* 40)

(defmethod perform-copies((original collection) (new collection))
	(dotimes (i (number-of-copies))
		(perform-one-copy original new)
	)
)

(defmethod number-of-copies()
	(* (/ *percent-copy* 100) *collection-size*)
)

; An melody have a chance to mutate before been copied into next generation
(defmethod perform-one-copy((original collection) (new collection) &aux m mm nm)
	(setf m (select-melody original))
	(setf mm (maybe-mutate m))
	(setf nm (new-melody (+ 1 (size new)) (melody-notes mm)))
	(setf
		(collection-melodies new)
		(append (collection-melodies new) (list nm))
	)
	(if *copy-demo* (copy-demo-helper m mm nm))
	nil
)

(defmethod copy-demo-helper((selected melody) (mutant melody) (new melody))
	(terpri)
	(format t "Selected melody = ~%")
	(display selected) (terpri)
	(format t "Possibly mutated melody = ~%")
	(display mutant) (terpri)
	(format t "Renumbered melody = ~%")
	(display new) (terpri)
	nil
)

(defmethod empty-collection((original collection) &aux new)
	(make-instance 'collection
		:melodies (list)
		:generation (+ 1 (collection-generation original))
	)
)

(defmethod perform-copies-demo(&aux old new)
	(setf old (initial-collection))
	(setf new (empty-collection old))
	(format t
"--------------------------------------------------------------------------~%~%")
	(display new)
	(format t
"~%~%--------------------------------------------------------------------------~%")
	(setf *select-demo* t)
	(setf *copy-demo* t)
	(dotimes(i 10)
		(perform-one-copy old new)
		(format t
"--------------------------------------------------------------------------~%~%")
```

```
               (display new)
               (format t
"~%~%----------------------------------------------------------------------------~%")
       )
       (setf *select-demo* nil)
       (setf *copy-demo* nil)
       nil
)
```

Task 10: Crossover ----------

Demo

```
[3]> (perform-crossover-demo)
------------------------------------------------------------------------



Generation 1 collection ...


------------------------------------------------------------------------
The sample of melodies ...
24    LE LF Mg HE La Mg Mc Hb MF MA MB MA Ma LC Lf MD Lf LB MF Mg  98.13321
53    Lf Ha MD MF MC MB LE MA La Mc Lb Ld HB HB HB LD Hf Md HG Md  91.207756
14    LG LD HF Hc MF MB Hd HE Ha MC Hf Mc Lf Lb MG Mg MA HA HA Le  63.467228
90    Hc LC LE HF HF LA HA MA Lc HB Ma HG LA Hf MA HG He HG HF MF  77.93891
89    Lg Mc La MD Hb MC MC Lc MA Ha Hd HC Hb Mc Ha La Lf Lg HA Hb  73.970055
79    Hd HC MA MA HG HG Lf LG Md HB MD HD LB LF Mg He Mf La ME La  63.065403
20    Me HE Lg Hg Hc Hb HA Hb LD Hb HG LA HC HC Md HF Md Lb Hg HC  80.1471
6     Ld HB Hd HG He Mb LA HB ME Lf Mg LB Mc MF ME Mf Hd HC LG Mb  87.809006

The one with the best score ...
24    LE LF Mg HE La Mg Mc Hb MF MA MB MA Ma LC Lf MD Lf LB MF Mg  98.13321

The sample of melodies ...
25    HB Mc LE LE Lb Mc He HF LB Hf HF HB Mc Hc LE La MF LC Lc HC  77.02449
55    ME LE MC Hf Hc Hg Ma LA HF MB LG LB Hb HA HA ME Hc Hd HB MB  84.05478
73    Md MD LA Lc Hd Mb LE MA MD LE MB HC HD LB LG Lc Hf HG Ld Me  89.277435
77    Ma MB Hb LC Hf HD LA Mg LD MA Le LB Hg Hg Ha HG MB MD LA HE  78.928444
22    LC Hg Me HC HC Lf LC HF Mf MC LC Hf Lg Ld Md Me Lg Lg Lb LG  60.353123
58    MF Hb Me La Mg Mb Hb Hc Ld Hf HB Le HE HB Md LC Hf Hg MB ME  58.690487
29    MA HB He La La Me Mc Lc MD LC Hc HB Ma MB MA Hd Hf HG He ME  83.674835
93    HB LD Md LF Lc MF MA Hc LE Lb HD Lc Lg Lb HG Md LA MG Hd He  68.05278

The one with the best score ...
73    Md MD LA Lc Hd Mb LE MA MD LE MB HC HD LB LG Lc Hf HG Ld Me  89.277435

Selected mother =
24    LE LF Mg HE La Mg Mc Hb MF MA MB MA Ma LC Lf MD Lf LB MF Mg  98.13321
Selected father =
73    Md MD LA Lc Hd Mb LE MA MD LE MB HC HD LB LG Lc Hf HG Ld Me  89.277435
The crossover =
0     LE LF Mg HE La Mg Mc Hb MF MA MB MA Ma LB LG Lc Hf HG Ld Me  87.9506
The possibly mutated individual =
0     LE LF Mg HE La Mg Mc Hb MF MA MB MA Ma LB LG Lc Hf HG Ld Me  87.9506
The renumbered individual =
1     LE LF Mg HE La Mg Mc Hb MF MA MB MA Ma LB LG Lc Hf HG Ld Me  87.9506
------------------------------------------------------------------------
```

```
Generation 1 collection ...
1     LE LF Mg HE La Mg Mc Hb MF MA MB MA Ma LB LG Lc Hf HG Ld Me  87.9506


------------------------------------------------------------------------
The sample of melodies ...
59    Hd Mb Hc MD Mc MF Mf Lb LB LF HA Hb Hd Mb Ld MA HB Le HC Hc  88.5102
89    Lg Mc La MD Hb MC MC Lc MA Ha Hd HC Hb Mc Ha La Lf Lg HA Hb  73.970055
87    Ld HD Lg Hg Mg HG HF He Ha LA Le LE Le LE Md Hg LD HD HG HC  60.4002
53    Lf Ha MD MF MC MB LE MA La Mc Lb Ld HB HB HB LD Hf Md HG Md  91.207756
74    Lg Mb Mc MG HC Me MA LG MA LG Ld LC Mc LF HG HB Lc Le He LF  81.326
56    HD Ld HA Lc LB Me La Lg Mf Mb Lc HG MB MG Le Ld Lf He Mf MB  77.38781
7     Lf Hf Mg HG Mb Hb LE Hf LD Mb MG Mf Mf MC He Mf HF Ld ME HD  58.474308
37    MB Hg HC Lc Ld LA HC HF Ma Lg MG HD HG Mc MC MB He MD MC Le  83.74582

The one with the best score ...
53    Lf Ha MD MF MC MB LE MA La Mc Lb Ld HB HB HB LD Hf Md HG Md  91.207756

The sample of melodies ...
9     Mg HD Mg HD LE LC MA Mc Le HB MD Hb MC Md MD Hb MA LF Lc HF  99.73252
98    Hg LC Mf HF Lb HB LA Lc Mb HC HA Ld Le Le Hg HB Hc LB Lg Lg  80.57887
39    HC Lb Ha MB HD MG Mf HE Hf HB Lg Hc LD Ma LA MG La HA Mg MG  95.08551
13    HA Hf Mf Lg HA Hc Lf HB HC Lc Hg Le MB HC Lc ME Ha HA MF Ha  85.599724
88    HG LC HB LG Mb Md HG Me Mb MF HB La LC MG Me Me Lf LD He LC  98.36678
25    HB Mc LE LE Lb Mc He HF LB Hf HF HB Mc Hc LE La MF LC Lc HC  77.02449
32    Lb Hf Hd Hg MF Md HB HE Lb Lg Lg HB MG MF Mc LB Ha ME Me Hc  72.51414
96    MC MA MD HA HG HA HF Le Hf LD Ha Ma HD Lg La Me MF MG MD Ma  68.07982

The one with the best score ...
9     Mg HD Mg HD LE LC MA Mc Le HB MD Hb MC Md MD Hb MA LF Lc HF  99.73252

Selected mother =
53    Lf Ha MD MF MC MB LE MA La Mc Lb Ld HB HB HB LD Hf Md HG Md  91.207756
Selected father =
9     Mg HD Mg HD LE LC MA Mc Le HB MD Hb MC Md MD Hb MA LF Lc HF  99.73252
The crossover =
0     Lf Ha MD MF MC MB LE MA Le HB MD Hb MC Md MD Hb MA LF Lc HF  96.33785
The possibly mutated individual =
0     Lf Ha MD MF MC MB LE MA Le HB MD Hb MC Md MD Mb MA LF Lc HF  95.93553
The renumbered individual =
2     Lf Ha MD MF MC MB LE MA Le HB MD Hb MC Md MD Mb MA LF Lc HF  95.93553
------------------------------------------------------------------------



Generation 1 collection ...
1     LE LF Mg HE La Mg Mc Hb MF MA MB MA Ma LB LG Lc Hf HG Ld Me  87.9506
2     Lf Ha MD MF MC MB LE MA Le HB MD Hb MC Md MD Mb MA LF Lc HF  95.93553


------------------------------------------------------------------------
The sample of melodies ...
48    Le La Mg Hg HF MC HD MB HC Hd Hd LD ME La Mg MB LB Hd La LF  95.22227
76    HC ME HE Ma Mf HD Hg HC Hf Le HA He HA MF MD Hf Ld HE LB Hg  81.32276
44    MF HB HG Me LD Me Hb HD Md Ma Ld MF Le HG LC Mc LG Mf Mb Lc  84.5831
37    MB Hg HC Lc Ld LA HC HF Ma Lg MG HD HG Mc MC MB He MD MC Le  83.74582
47    LG HB Ma MA Mc MC He MD MD ME LB Me Hb Lb HA LE MC LB Mb LC  98.01929
73    Md MD LA Lc Hd Mb LE MA MD LE MB HC HD LB LG Lc Hf HG Ld Me  89.277435
93    HB LD Md LF Lc MF MA Hc LE Lb HD Lc Lg Lb HG Md LA MG Hd He  68.05278
99    Hd La Hc Ld MB Hb MC Ha LC LD MB Lf Mc Lb HD Hc MC Ha LG HG  77.55381

The one with the best score ...
47    LG HB Ma MA Mc MC He MD MD ME LB Me Hb Lb HA LE MC LB Mb LC  98.01929

The sample of melodies ...
27    Lc Mf Lf MA Hc Hd LG Mb HG Lg Hg MG Lf Hd Hc MF He HG HF LC  59.70608
56    HD Ld HA Lc LB Me La Lg Mf Mb Lc HG MB MG Le Ld Lf He Mf MB  77.38781
29    MA HB He La La Me Mc Lc MD LC Hc HB Ma MB MA Hd Hf HG He ME  83.674835
62    LD ME LG HD LE HA HA Mc MC LE Mg He LB Lf HD LG LD HG Lc Hb  57.212032
84    MD LE Hc Hf HE Md Hg Hg MC HC HB Me Ma Ha LC Me Mc Le HF Mg  76.36496
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80    HG LD HE HA Ha MA La Lb Ha Le Ld Mf HD Hd Hd MF Hc Hd LA La  81.146164
84    MD LE Hc Hf HE Md Hg Hg MC HC HB Me Ma Ha LC Me Mc Le HF Mg  76.36496
17    Lf Ld MA MB Lf HB Mg La LE Mb MA Me Hf MC HD Mb Ma HF MG Md  86.81746

The one with the best score ...
17    Lf Ld MA MB Lf HB Mg La LE Mb MA Me Hf MC HD Mb Ma HF MG Md  86.81746

Selected mother =
47    LG HB Ma MA Mc MC He MD MD ME LB Me Hb Lb HA LE MC LB Mb LC  98.01929
Selected father =
17    Lf Ld MA MB Lf HB Mg La LE Mb MA Me Hf MC HD Mb Ma HF MG Md  86.81746
The crossover =
0     LG HB Ma MA Mc MC He MD MD ME LB Me Hb Lb HA Mb Ma HF MG Md  76.3929
The possibly mutated individual =
0     LG HB Ma MA Mc HG He MD MD ME LB Me Hb Lb HA Mb Ma HF MG Md  79.18022
The renumbered individual =
3     LG HB Ma MA Mc HG He MD MD ME LB Me Hb Lb HA Mb Ma HF MG Md  79.18022
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Generation 1 collection ...
1     LE LF Mg HE La Mg Mc Hb MF MA MB MA Ma LB LG Lc Hf HG Ld Me  87.9506
2     Lf Ha MD MF MC MB LE MA Le HB MD Hb MC Md MD Mb MA LF Lc HF  95.93553
3     LG HB Ma MA Mc HG He MD MD ME LB Me Hb Lb HA Mb Ma HF MG Md  79.18022


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The sample of melodies ...
49    Ma HE HA LD LC He LG Le ME Mf LF MF MF La HC LD Hg Hg Hg Mc  76.26218
54    MC Hd MF HA Mf HC Hd HC LG Ma Mc MF Mb Mf Ha Hc Hb LB He MB  56.025387
68    Le Le Lf MF LD Ld ME Mc HC HA HA Le Lg LG Mc ME HC HB MC Lb  89.274826
23    Lc Mb HF MC HC He HG Hb Lc Mf Ld Lf ME HG MG Ld HB Ma Ma MC  94.704605
48    Le La Mg Hg HF MC HD MB HC Hd Hd LD ME La Mg MB LB Hd La LF  95.22227
54    MC Hd MF HA Mf HC Hd HC LG Ma Mc MF Mb Mf Ha Hc Hb LB He MB  56.025387
14    LG LD HF Hc MF MB Hd HE Ha MC Hf Mc Lf Lb MG Mg MA HA HA Le  63.467228
78    Lf Mb LD LA Mg MC ME HF LF Md Mb MA HG LD HE MC Mg Hg Lb Mf  86.04615

The one with the best score ...
48    Le La Mg Hg HF MC HD MB HC Hd Hd LD ME La Mg MB LB Hd La LF  95.22227

The sample of melodies ...
91    Hd Le Le ME MA Lb Hf LB Lf HC Lg La MG Lf MF MF MC LF LA HD  53.277325
68    Le Le Lf MF LD Ld ME Mc HC HA HA Le Lg LG Mc ME HC HB MC Lb  89.274826
12    Mc MB Md Lf HE Hb Hf LC MA MB MB HD LC Hf Lc MF Lb MC HE HG  72.61465
100   LE ME LE Ma HC Mc HE HB Me Hf Hb Hc HB MG Mb Mc He HA HE LG  77.70107
85    HB Ld LG Hc HD Hg ME MD Mb Hg Me LG Lf Lc Mg LA Hb HG MA LD  98.43111
59    Hd Mb Hc MD Mc MF Mf Lb LB LF HA Hb Hd Mb Ld MA HB Le HC Hc  88.5102
36    HC MB MG Ld HD HD HC La HE Lb HD Lb HC LD Lc HE LF HF HE LG  94.60578
88    HG LC HB LG Mb Md HG Me Mb MF HB La LC MG Me Me Lf LD He LC  98.36678

The one with the best score ...
85    HB Ld LG Hc HD Hg ME MD Mb Hg Me LG Lf Lc Mg LA Hb HG MA LD  98.43111

Selected mother =
48    Le La Mg Hg HF MC HD MB HC Hd Hd LD ME La Mg MB LB Hd La LF  95.22227
Selected father =
85    HB Ld LG Hc HD Hg ME MD Mb Hg Me LG Lf Lc Mg LA Hb HG MA LD  98.43111
The crossover =
0     Le La Mg Hg HF MC HD MB HC Hd Hd LD ME La Mg LA Hb HG MA LD  83.126465
The possibly mutated individual =
0     Le La Mb Hg HF MC HD MB HC Hd Hd LD ME La Mg LA Hb HG MA LD  80.75127
The renumbered individual =
4     Le La Mb Hg HF MC HD MB HC Hd Hd LD ME La Mg LA Hb HG MA LD  80.75127
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Generation 1 collection ...
1     LE LF Mg HE La Mg Mc Hb MF MA MB MA Ma LB LG Lc Hf HG Ld Me  87.9506
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2     Lf Ha MD MF MC MB LE MA Le HB MD Hb MC Md MD Mb MA LF Lc HF  95.93553
3     LG HB Ma MA Mc HG He MD MD ME LB Me Hb Lb HA Mb Ma HF MG Md  79.18022
4     Le La Mb Hg HF MC HD MB HC Hd Hd LD ME La Mg LA Hb HG MA LD  80.75127


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The sample of melodies ...
6     Ld HB Hd HG He Mb LA HB ME Lf Mg LB Mc MF ME Mf Hd HC LG Mb  87.809006
60    Lf Mc Me Mg La Hg Lb Lb He Lb La Ha MD Lf Hd Ha LB Mc Hf LA  67.641365
33    LA MB LE Hb Mg ME Me MG LB HC LD MA Hd HE MG Lb ME Mb LC Ha  93.22627
18    MG Ld MA Lf Ha MF Me MB LG HG Mb Hc MD Hc LE LC LB He Hb HB  98.32108
100   LE ME LE Ma HC Mc HE HB Me Hf Hb Hc HB MG Mb Mc He HA HE LG  77.70107
26    Ld HE LA He La MF ME Ld Hc Mb LB Lb HG Me Le Lf Hf LA MC Lb  84.11561
64    Mf Mc Ha LA HA MD MA LF MD Hf HA Le HF Le LE Hc ME Md HF LF  70.25951
79    Hd HC MA MA HG HG Lf LG Md HB MD HD LB LF Mg He Mf La ME La  63.065403

The one with the best score ...
18    MG Ld MA Lf Ha MF Me MB LG HG Mb Hc MD Hc LE LC LB He Hb HB  98.32108

The sample of melodies ...
37    MB Hg HC Lc Ld LA HC HF Ma Lg MG HD HG Mc MC MB He MD MC Le  83.74582
39    HC Lb Ha MB HD MG Mf HE Hf HB Lg Hc LD Ma LA MG La HA Mg MG  95.08551
85    HB Ld LG Hc HD Hg ME MD Mb Hg Me LG Lf Lc Mg LA Hb HG MA LD  98.43111
4     Ma Lf Mg Mf Ld Md Me MC Mg Ld MG Hd LE HG Lf La HF HD He LF  54.18744
35    La LC HC LA LC LF LC LB HG HE Hc LD HD Mf Me MD ME LA Hb Me  66.01547
23    Lc Mb HF MC HC He HG Hb Lc Mf Ld Lf ME HG MG Ld HB Ma Ma MC  94.704605
57    HD Lg HC MC La Le HB Mg Hf Mb La La HA LA MA Mg Lb HB Mg MG  75.647484
24    LE LF Mg HE La Mg Mc Hb MF MA MB MA Ma LC Lf MD Lf LB MF Mg  98.13321

The one with the best score ...
85    HB Ld LG Hc HD Hg ME MD Mb Hg Me LG Lf Lc Mg LA Hb HG MA LD  98.43111

Selected mother =
18    MG Ld MA Lf Ha MF Me MB LG HG Mb Hc MD Hc LE LC LB He Hb HB  98.32108
Selected father =
85    HB Ld LG Hc HD Hg ME MD Mb Hg Me LG Lf Lc Mg LA Hb HG MA LD  98.43111
The crossover =
0     MG Ld MA Lf Ha MF Me MB LG HG Mb Hc MD Hc LE LC Hb HG MA LD  73.73393
The possibly mutated individual =
0     MG Ld MA Lf Ha MF Me MB LG HG Mb Hc MD Hc LE LC Hb HG MA LD  73.73393
The renumbered individual =
5     MG Ld MA Lf Ha MF Me MB LG HG Mb Hc MD Hc LE LC Hb HG MA LD  73.73393
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Generation 1 collection ...
1     LE LF Mg HE La Mg Mc Hb MF MA MB MA Ma LB LG Lc Hf HG Ld Me  87.9506
2     Lf Ha MD MF MC MB LE MA Le HB MD Hb MC Md MD Mb MA LF Lc HF  95.93553
3     LG HB Ma MA Mc HG He MD MD ME LB Me Hb Lb HA Mb Ma HF MG Md  79.18022
4     Le La Mb Hg HF MC HD MB HC Hd Hd LD ME La Mg LA Hb HG MA LD  80.75127
5     MG Ld MA Lf Ha MF Me MB LG HG Mb Hc MD Hc LE LC Hb HG MA LD  73.73393


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The sample of melodies ...
17    Lf Ld MA MB Lf HB Mg La LE Mb MA Me Hf MC HD Mb Ma HF MG Md  86.81746
54    MC Hd MF HA Mf HC Hd HC LG Ma Mc MF Mb Mf Ha Hc Hb LB He MB  56.025387
80    HG LD HE HA Ha MA La Lb Ha Le Ld Mf HD Hd Hd MF Hc Hd LA La  81.146164
52    HA Hf LC Lf HA MB HC Hc MB Le Me Lc HB Le Hf HA LA HB Ld He  75.31686
71    MD Ma Mg Hf Ld Mf Lg Lc MF LA Lf LG Hc MF HF LA MF LC HF Lf  54.294205
4     Ma Lf Mg Mf Ld Md Me MC Mg Ld MG Hd LE HG Lf La HF HD He LF  54.18744
22    LC Hg Me HC HC Lf LC HF Mf MC LC Hf Lg Ld Md Me Lg Lg Lb LG  60.353123
10    HE Ld HF Lc HF MC Ld Me MD LB MC HD LA Ha He Mc Le Me Hf La  46.635933

The one with the best score ...
17    Lf Ld MA MB Lf HB Mg La LE Mb MA Me Hf MC HD Mb Ma HF MG Md  86.81746

The sample of melodies ...
71    MD Ma Mg Hf Ld Mf Lg Lc MF LA Lf LG Hc MF HF LA MF LC HF Lf  54.294205
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64    Mf Mc Ha LA HA MD MA LF MD Hf HA Le HF Le LE Hc ME Md HF LF  70.25951
3     Le Mb La Hg La Me Ld Mg Le Le HG He Lb Le Mc Le Ma LE Hb HA  65.4321
90    Hc LC LE HF HF LA HA MA Lc HB Ma HG LA Hf MA HG He HG HF MF  77.93891
83    Lb HE HB Me Ha LD HE HD HD MC LA MD LB Me MF HG HC Mg Lb HD  92.35827
37    MB Hg HC Lc Ld LA HC HF Ma Lg MG HD HG Mc MC MB He MD MC Le  83.74582
97    Mb HC HF HF Hf HE Ha Ha HB MF HB Hf LA Ma HA La HA MB HC Hc  97.29652
71    MD Ma Mg Hf Ld Mf Lg Lc MF LA Lf LG Hc MF HF LA MF LC HF Lf  54.294205

The one with the best score ...
97    Mb HC HF HF Hf HE Ha Ha HB MF HB Hf LA Ma HA La HA MB HC Hc  97.29652

Selected mother =
17    Lf Ld MA MB Lf HB Mg La LE Mb MA Me Hf MC HD Mb Ma HF MG Md  86.81746
Selected father =
97    Mb HC HF HF Hf HE Ha Ha HB MF HB Hf LA Ma HA La HA MB HC Hc  97.29652
The crossover =
0     Lf Ld MA MB Lf HB Mg La LE Mb MA Me LA Ma HA La HA MB HC Hc  79.162506
The possibly mutated individual =
0     Lf LB MA MB Lf HB Mg La LE Mb MA Me LA Ma HA La HA MB HC Hc  83.59077
The renumbered individual =
6     Lf LB MA MB Lf HB Mg La LE Mb MA Me LA Ma HA La HA MB HC Hc  83.59077
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Generation 1 collection ...
1     LE LF Mg HE La Mg Mc Hb MF MA MB MA Ma LB LG Lc Hf HG Ld Me  87.9506
2     Lf Ha MD MF MC MB LE MA Le HB MD Hb MC Md MD Mb MA LF Lc HF  95.93553
3     LG HB Ma MA Mc HG He MD MD ME LB Me Hb Lb HA Mb Ma HF MG Md  79.18022
4     Le La Mb Hg HF MC HD MB HC Hd Hd LD ME La Mg LA Hb HG MA LD  80.75127
5     MG Ld MA Lf Ha MF Me MB LG HG Mb Hc MD Hc LE LC Hb HG MA LD  73.73393
6     Lf LB MA MB Lf HB Mg La LE Mb MA Me LA Ma HA La HA MB HC Hc  83.59077


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The sample of melodies ...
54    MC Hd MF HA Mf HC Hd HC LG Ma Mc MF Mb Mf Ha Hc Hb LB He MB  56.025387
98    Hg LC Mf HF Lb HB LA Lc Mb HC HA Ld Le Le Hg HB Hc LB Lg Lg  80.57887
85    HB Ld LG Hc HD Hg ME MD Mb Hg Me LG Lf Lc Mg LA Hb HG MA LD  98.43111
24    LE LF Mg HE La Mg Mc Hb MF MA MB MA Ma LC Lf MD Lf LB MF Mg  98.13321
76    HC ME HE Ma Mf HD Hg HC Hf Le HA He HA MF MD Hf Ld HE LB Hg  81.32276
78    Lf Mb LD LA Mg MC ME HF LF Md Mb MA HG LD HE MC Mg Hg Lb Mf  86.04615
11    Lg LD MB Lg LD LF Hd HA ME Mb HC Ha Ma LF LB Lb HC Ma Hb Mf  70.385925
40    Mc MD LB MB Lb Ld Md MG Ma Le Mc He Hg Hc Ha MG HE Ha Lb LC  91.054985

The one with the best score ...
85    HB Ld LG Hc HD Hg ME MD Mb Hg Me LG Lf Lc Mg LA Hb HG MA LD  98.43111

The sample of melodies ...
7     Lf Hf Mg HG Mb Hb LE Hf LD Mb MG Mf Mf MC He Mf HF Ld ME HD  58.474308
36    HC MB MG Ld HD HD HC La HE Lb HD Lb HC LD Lc HE LF HF HE LG  94.60578
61    Hg Md LC Lf Ma MB Hc MD MD MB MG HC Mb Hc Lg LD MD HB HB Hc  84.9015
38    HA LC HA Hg HD MF HE Hd ME Lb HE HC Ma ME Hf HG ME Hb Hd MD  84.041466
73    Md MD LA Lc Hd Mb LE MA MD LE MB HC HD LB LG Lc Hf HG Ld Me  89.277435
78    Lf Mb LD LA Mg MC ME HF LF Md Mb MA HG LD HE MC Mg Hg Lb Mf  86.04615
36    HC MB MG Ld HD HD HC La HE Lb HD Lb HC LD Lc HE LF HF HE LG  94.60578
24    LE LF Mg HE La Mg Mc Hb MF MA MB MA Ma LC Lf MD Lf LB MF Mg  98.13321

The one with the best score ...
24    LE LF Mg HE La Mg Mc Hb MF MA MB MA Ma LC Lf MD Lf LB MF Mg  98.13321

Selected mother =
85    HB Ld LG Hc HD Hg ME MD Mb Hg Me LG Lf Lc Mg LA Hb HG MA LD  98.43111
Selected father =
24    LE LF Mg HE La Mg Mc Hb MF MA MB MA Ma LC Lf MD Lf LB MF Mg  98.13321
The crossover =
0     HB Ld LG Hc HD Hg ME MD Mb Hg Me LG Lf Lc Mg LA Hb HG MF Mg  80.352486
The possibly mutated individual =
0     HB Ld LG Hc HD Hg ME MD Mb Hg Le LG Lf Lc Mg LA Hb HG MF Mg  80.35099
The renumbered individual =
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7     HB Ld LG Hc HD Hg ME MD Mb Hg Le LG Lf Lc Mg LA Hb HG MF Mg  80.35099
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Generation 1 collection ...
1     LE LF Mg HE La Mg Mc Hb MF MA MB MA Ma LB LG Lc Hf HG Ld Me  87.9506
2     Lf Ha MD MF MC MB LE MA Le HB MD Hb MC Md MD Mb MA LF Lc HF  95.93553
3     LG HB Ma MA Mc HG He MD MD ME LB Me Hb Lb HA Mb Ma HF MG Md  79.18022
4     Le La Mb Hg HF MC HD MB HC Hd Hd LD ME La Mg LA Hb HG MA LD  80.75127
5     MG Ld MA Lf Ha MF Me MB LG HG Mb Hc MD Hc LE LC Hb HG MA LD  73.73393
6     Lf LB MA MB Lf HB Mg La LE Mb MA Me LA Ma HA La HA MB HC Hc  83.59077
7     HB Ld LG Hc HD Hg ME MD Mb Hg Le LG Lf Lc Mg LA Hb HG MF Mg  80.35099


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The sample of melodies ...
82    La LG Le HB MA Mf HF MF LB LE HE Ld MB La LA LB MB Ha LD HE  82.33663
33    LA MB LE Hb Mg ME Me MG LB HC LD MA Hd HE MG Lb ME Mb LC Ha  93.22627
63    MC Mf Hd Me HE MF Ma HB LA Mf Mb MG MD Mb Ha Lc HG Lf Mg Me  71.735504
69    LA LF HE Mc La Hg Mc Le MD Ld Hd MB HB LF LE Lf Hg MB He Hf  74.26958
82    La LG Le HB MA Mf HF MF LB LE HE Ld MB La LA LB MB Ha LD HE  82.33663
71    MD Ma Mg Hf Ld Mf Lg Lc MF LA Lf LG Hc MF HF LA MF LC HF Lf  54.294205
44    MF HB HG Me LD Me Hb HD Md Ma Ld MF Le HG LC Mc LG Mf Mb Lc  84.5831
42    Hc He LE HC MA Hg Ld Md LD HE MA Mc La MB HG Me LA Mf Lc He  75.81539

The one with the best score ...
33    LA MB LE Hb Mg ME Me MG LB HC LD MA Hd HE MG Lb ME Mb LC Ha  93.22627

The sample of melodies ...
46    Mb Lg He Hb Lc Hf Md Lf Lg LB Lc LA LC He Lg Lb Le Lb Ma ME  77.70499
7     Lf Hf Mg HG Mb Hb LE Hf LD Mb MG Mf Mf MC He Mf HF Ld ME HD  58.474308
61    Hg Md LC Lf Ma MB Hc MD MD MB MG HC Mb Hc Lg LD MD HB HB Hc  84.9015
59    Hd Mb Hc MD Mc MF Mf Lb LB LF HA Hb Hd Mb Ld MA HB Le HC Hc  88.5102
6     Ld HB Hd HG He Mb LA HB ME Lf Mg LB Mc MF ME Mf Hd HC LG Mb  87.809006
70    HG Hd Lc HB MB Ld Mg La HE Hc LG HE Me Me Md HB MC Hd Lc MC  73.82904
22    LC Hg Me HC HC Lf LC HF Mf MC LC Hf Lg Ld Md Me Lg Lg Lb LG  60.353123
41    LE Md Mg MD MC Mb Ma Mf Le HE LE Hg Lg MA Mb Hb MC Hc Lb LF  87.56977

The one with the best score ...
59    Hd Mb Hc MD Mc MF Mf Lb LB LF HA Hb Hd Mb Ld MA HB Le HC Hc  88.5102

Selected mother =
33    LA MB LE Hb Mg ME Me MG LB HC LD MA Hd HE MG Lb ME Mb LC Ha  93.22627
Selected father =
59    Hd Mb Hc MD Mc MF Mf Lb LB LF HA Hb Hd Mb Ld MA HB Le HC Hc  88.5102
The crossover =
0     LA MB LE Hb Mg ME Me MG LB HC LD MA Hd Mb Ld MA HB Le HC Hc  99.84859
The possibly mutated individual =
0     LA MB LE Hb Mg ME Me MG LB HC LD MA Hd Mb Ld La HB Le HC Hc  91.914734
The renumbered individual =
8     LA MB LE Hb Mg ME Me MG LB HC LD MA Hd Mb Ld La HB Le HC Hc  91.914734
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Generation 1 collection ...
1     LE LF Mg HE La Mg Mc Hb MF MA MB MA Ma LB LG Lc Hf HG Ld Me  87.9506
2     Lf Ha MD MF MC MB LE MA Le HB MD Hb MC Md MD Mb MA LF Lc HF  95.93553
3     LG HB Ma MA Mc HG He MD MD ME LB Me Hb Lb HA Mb Ma HF MG Md  79.18022
4     Le La Mb Hg HF MC HD MB HC Hd Hd LD ME La Mg LA Hb HG MA LD  80.75127
5     MG Ld MA Lf Ha MF Me MB LG HG Mb Hc MD Hc LE LC Hb HG MA LD  73.73393
6     Lf LB MA MB Lf HB Mg La LE Mb MA Me LA Ma HA La HA MB HC Hc  83.59077
7     HB Ld LG Hc HD Hg ME MD Mb Hg Le LG Lf Lc Mg LA Hb HG MF Mg  80.35099
8     LA MB LE Hb Mg ME Me MG LB HC LD MA Hd Mb Ld La HB Le HC Hc  91.914734


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The sample of melodies ...
17    Lf Ld MA MB Lf HB Mg La LE Mb MA Me Hf MC HD Mb Ma HF MG Md  86.81746
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43    HE HC Mc Le HC MC MG LE Mf HG LE LF LC Le HF Lc LF Ld Ld He  63.13591
53    Lf Ha MD MF MC MB LE MA La Mc Lb Ld HB HB HB LD Hf Md HG Md  91.207756
49    Ma HE HA LD LC He LG Le ME Mf LF MF MF La HC LD Hg Hg Hg Mc  76.26218
52    HA Hf LC Lf HA MB HC Hc MB Le Me Lc HB Le Hf HA LA HB Ld He  75.31686
87    Ld HD Lg Hg Mg HG HF He Ha LA Le LE Le LE Md Hg LD HD HG HC  60.4002
93    HB LD Md LF Lc MF MA Hc LE Lb HD Lc Lg Lb HG Md LA MG Hd He  68.05278
89    Lg Mc La MD Hb MC MC Lc MA Ha Hd HC Hb Mc Ha La Lf Lg HA Hb  73.970055

The one with the best score ...
53    Lf Ha MD MF MC MB LE MA La Mc Lb Ld HB HB HB LD Hf Md HG Md  91.207756

The sample of melodies ...
72    HF MF Hg HC Le Mg Mf Mc MA MC LE Hb Ha MA Mf Hc Hf Hd Hb Hg  57.779514
72    HF MF Hg HC Le Mg Mf Mc MA MC LE Hb Ha MA Mf Hc Hf Hd Hb Hg  57.779514
25    HB Mc LE LE Lb Mc He HF LB Hf HF HB Mc Hc LE La MF LC Lc HC  77.02449
44    MF HB HG Me LD Me Hb HD Md Ma Ld MF Le HG LC Mc LG Mf Mb Lc  84.5831
3     Le Mb La Hg La Me Ld Mg Le Le HG He Lb Le Mc Le Ma LE Hb HA  65.4321
88    HG LC HB LG Mb Md HG Me Mb MF HB La LC MG Me Me Lf LD He LC  98.36678
5     MG MD Md Hb LA LF Lc Le Lf Hb HG HB HF MA HA LF Hf Lg LF HB  97.73623
96    MC MA MD HA HG HA HF Le Hf LD Ha Ma HD Lg La Me MF MG MD Ma  68.07982

The one with the best score ...
88    HG LC HB LG Mb Md HG Me Mb MF HB La LC MG Me Me Lf LD He LC  98.36678

Selected mother =
53    Lf Ha MD MF MC MB LE MA La Mc Lb Ld HB HB HB LD Hf Md HG Md  91.207756
Selected father =
88    HG LC HB LG Mb Md HG Me Mb MF HB La LC MG Me Me Lf LD He LC  98.36678
The crossover =
0     Lf Ha MD LG Mb Md HG Me Mb MF HB La LC MG Me Me Lf LD He LC  75.009346
The possibly mutated individual =
0     Lf Ha MD LG Mb Md HG Me Mb MF HB La LC MG Me Me Lf LD He LC  75.009346
The renumbered individual =
9     Lf Ha MD LG Mb Md HG Me Mb MF HB La LC MG Me Me Lf LD He LC  75.009346
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Generation 1 collection ...
1     LE LF Mg HE La Mg Mc Hb MF MA MB MA Ma LB LG Lc Hf HG Ld Me  87.9506
2     Lf Ha MD MF MC MB LE MA Le HB MD Hb MC Md MD Mb MA LF Lc HF  95.93553
3     LG HB Ma MA Mc HG He MD MD ME LB Me Hb Lb HA Mb Ma HF MG Md  79.18022
4     Le La Mb Hg HF MC HD MB HC Hd Hd LD ME La Mg LA Hb HG MA LD  80.75127
5     MG Ld MA Lf Ha MF Me MB LG HG Mb Hc MD Hc LE LC Hb HG MA LD  73.73393
6     Lf LB MA MB Lf HB Mg La LE Mb MA Me LA Ma HA La HA MB HC Hc  83.59077
7     HB Ld LG Hc HD Hg ME MD Mb Hg Le LG Lf Lc Mg LA Hb HG MF Mg  80.35099
8     LA MB LE Hb Mg ME Me MG LB HC LD MA Hd Mb Ld La HB Le HC Hc  91.914734
9     Lf Ha MD LG Mb Md HG Me Mb MF HB La LC MG Me Me Lf LD He LC  75.009346


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The sample of melodies ...
41    LE Md Mg MD MC Mb Ma Mf Le HE LE Hg Lg MA Mb Hb MC Hc Lb LF  87.56977
67    HG MA HF LC Hg Hb Me HC Hc LE HG Hd Ld Lf He Me Hg MG Hc Hg  63.519276
87    Ld HD Lg Hg Mg HG HF He Ha LA Le LE Le LE Md Hg LD HD HG HC  60.4002
69    LA LF HE Mc La Hg Mc Le MD Ld Hd MB HB LF LE Lf Hg MB He Hf  74.26958
39    HC Lb Ha MB HD MG Mf HE Hf HB Lg Hc LD Ma LA MG La HA Mg MG  95.08551
63    MC Mf Hd Me HE MF Ma HB LA Mf Mb MG MD Mb Ha Lc HG Lf Mg Me  71.735504
36    HC MB MG Ld HD HD HC La HE Lb HD Lb HC LD Lc HE LF HF HE LG  94.60578
42    Hc He LE HC MA Hg Ld Md LD HE MA Mc La MB HG Me LA Mf Lc He  75.81539

The one with the best score ...
39    HC Lb Ha MB HD MG Mf HE Hf HB Lg Hc LD Ma LA MG La HA Mg MG  95.08551

The sample of melodies ...
8     HF Lb HD Ld MB Ma MA ME Hg Hc Lb Mg Ma Hg Lg He Hd MC Hb HC  93.448425
93    HB LD Md LF Lc MF MA Hc LE Lb HD Lc Lg Lb HG Md LA MG Hd He  68.05278
45    LC Hg Hf Mg Mg MD HE ME Hc LA LF Ld HE LE Hc Mb ME La Le HE  98.30529
25    HB Mc LE LE Lb Mc He HF LB Hf HF HB Mc Hc LE La MF LC Lc HC  77.02449
67    HG MA HF LC Hg Hb Me HC Hc LE HG Hd Ld Lf He Me Hg MG Hc Hg  63.519276
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13    HA Hf Mf Lg HA Hc Lf HB HC Lc Hg Le MB HC Lc ME Ha HA MF Ha  85.599724
57    HD Lg HC MC La Le HB Mg Hf Mb La La HA LA MA Mg Lb HB Mg MG  75.647484
28    Ha ME Me LB La LB LD HE MF La LA Lb HE MD Mc LA LB HB LC He  80.82026

The one with the best score ...
45    LC Hg Hf Mg Mg MD HE ME Hc LA LF Ld HE LE Hc Mb ME La Le HE  98.30529

Selected mother =
39    HC Lb Ha MB HD MG Mf HE Hf HB Lg Hc LD Ma LA MG La HA Mg MG  95.08551
Selected father =
45    LC Hg Hf Mg Mg MD HE ME Hc LA LF Ld HE LE Hc Mb ME La Le HE  98.30529
The crossover =
0     HC Lb Ha MB HD MG Mf HE Hf HB Lg Hc LD Ma LA MG ME La Le HE  94.240364
The possibly mutated individual =
0     HC Lb Ha MB HD MG Mf HE HF HB Lg Hc LD Ma LA MG ME La Le HE  96.37473
The renumbered individual =
10    HC Lb Ha MB HD MG Mf HE HF HB Lg Hc LD Ma LA MG ME La Le HE  96.37473
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Generation 1 collection ...
1     LE LF Mg HE La Mg Mc Hb MF MA MB MA Ma LB LG Lc Hf HG Ld Me  87.9506
2     Lf Ha MD MF MC MB LE MA Le HB MD Hb MC Md MD Mb MA LF Lc HF  95.93553
3     LG HB Ma MA Mc HG He MD MD ME LB Me Hb Lb HA Mb Ma HF MG Md  79.18022
4     Le La Mb Hg HF MC HD MB HC Hd Hd LD ME La Mg LA Hb HG MA LD  80.75127
5     MG Ld MA Lf Ha MF Me MB LG HG Mb Hc MD Hc LE LC Hb HG MA LD  73.73393
6     Lf LB MA MB Lf HB Mg La LE Mb MA Me LA Ma HA La HA MB HC Hc  83.59077
7     HB Ld LG Hc HD Hg ME MD Mb Hg Le LG Lf Lc Mg LA Hb HG MF Mg  80.35099
8     LA MB LE Hb Mg ME Me MG LB HC LD MA Hd Mb Ld La HB Le HC Hc  91.914734
9     Lf Ha MD LG Mb Md HG Me Mb MF HB La LC MG Me Me Lf LD He LC  75.009346
10    HC Lb Ha MB HD MG Mf HE HF HB Lg Hc LD Ma LA MG ME La Le HE  96.37473


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NIL
```

Code

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

(defconstant *percent-crossover* 60)

(defmethod perform-crossover((old collection) (new collection))
       (dotimes (i (number-of-crossovers))
              (perform-one-crossover old new)
       )
)

(defmethod number-of-crossovers()
       (* (/ *percent-crossover* 100) *collection-size*)
)

(defmethod perform-one-crossover((old collection) (new collection))
       (let (mother father m mm new-m)
              (setf mother (select-melody old))
              (setf father (select-melody old))
              (setf m (crossover mother father))
              (setf mm (maybe-mutate m))
              (setf new-m (new-melody (+ 1 (size new)) (melody-notes mm)))
              (setf
                     (collection-melodies new)
                     (append (collection-melodies new) (list new-m))
              )
              (if *crossover-demo* (crossover-demo-helper mother father m mm new-m))
```

```
        )
        nil
)

(defmethod crossover-demo-helper((mother melody) (father melody) (m melody) (mm melody)
(new-m melody))
        (format t "Selected mother = ~%")
        (display mother)
        (terpri)
        (format t "Selected father = ~%")
        (display father)
        (terpri)
        (format t "The crossover = ~%")
        (display m)
        (terpri)
        (format t "The possibly mutated individual = ~%")
        (display mm)
        (terpri)
        (format t "The renumbered individual = ~%")
        (display new-m)
        (terpri)
)

(defmethod crossover((mother melody) (father melody) &aux m-notes f-notes new-notes)
        (setf m-notes (melody-notes mother))
        (setf f-notes (melody-notes father))
        (setf new-notes (crossover m-notes f-notes))
        (new-melody 0 new-notes)
)

(defmethod perform-crossover-demo(&aux old new)
        (setf old (initial-collection))
        (setf new (empty-collection old))
        (format t
"--------------------------------------------------------------------------------~%~%")
        (display new)
        (format t
"~%~%--------------------------------------------------------------------------------~%")
        (setf *select-demo* t)
        (setf *crossover-demo* t)
        (dotimes(i 10)
                (perform-one-crossover old new)
                (format t
"--------------------------------------------------------------------------------~%~%")
                (display new)
                (format t
"~%~%--------------------------------------------------------------------------------~%")
        )
        (setf *select-demo* nil)
        (setf *crossover-demo* nil)
        nil
)
```

Task 11: The GA —----------

Demo

```
[]> (ga)
Initial collection: (desired coefficient: 0)



Generation 0 collection ...
```

1	Mg	MD	LE	He	Hd	Lf	Hb	HA	Hg	Mb	HB	LD	LG	LA	LF	LD	LA	HG	Hg	HC	69.61909
2	Le	Lg	LG	Hf	HF	Ha	MA	Lg	Md	Hd	Le	Hc	Hb	Lf	LA	LB	HD	Mb	Hg	ME	88.92085
3	HE	MG	HE	HE	Lb	MF	LC	La	MF	Lc	HB	Hd	LG	Lg	Hc	Md	Ha	Me	Mc	Mf	45.97128
4	Hf	HE	Le	LB	Lf	Le	HF	Mb	LF	HG	Hb	LD	MF	Lf	Mb	Mf	ME	Mf	Ha	LA	92.13388
5	Lb	ME	Mb	Lg	LE	MD	Hg	MA	Lg	Le	Md	Mf	LE	Md	HB	Mg	Mb	MD	Mb	MG	98.07114
6	Hc	MG	Hf	Mf	MC	HE	Hc	Mc	Lg	Ma	HF	Hb	LB	HF	ME	LF	LB	HC	MA	HD	65.09554
7	He	ME	HB	Hb	HC	Lc	Ld	LA	ME	Mf	LG	MC	He	La	Lb	Lb	Lg	MD	MD	LC	91.96832
8	Le	Hf	MC	Lf	Ld	MF	ME	LD	LG	Ha	MB	LG	MB	Ld	Lb	Ld	Le	LG	MF	LE	91.969246
9	MB	Md	LC	MG	MA	LF	MD	MC	MB	LE	LF	MA	HC	Ha	LE	Ha	HB	Mc	Hf	La	52.80589
10	MB	Lc	LG	Ha	He	Mf	MD	Md	Mf	Lg	Mb	Lb	Le	Me	Hd	LC	HE	HD	Hb	MD	80.151115
11	Lb	HC	HG	LG	MC	MD	Me	Md	Mf	Lb	LG	Lg	La	Ma	Hb	Mg	HF	Le	MG	MF	80.18261
12	Mb	Hf	Ma	Mc	HG	Me	LF	Hg	Hc	Hf	HF	Hg	LF	Me	Mg	Me	Lf	Hf	Mf	Hc	95.990005
13	LA	Mg	Hb	MG	Hc	MD	Lc	LE	LG	MD	Hb	MD	MG	Ma	He	HE	HD	LB	HC	MF	70.47974
14	HB	Mc	HF	MD	La	Hg	Hf	MC	LD	MB	MC	Hd	HE	MB	Ld	Hc	La	Mf	LF	LE	99.34527
15	ME	HG	Lc	He	ME	Hb	HF	LC	HF	HD	Ma	MB	Mc	Hg	MG	Me	ME	MA	Ha	ME	87.180984
16	LD	LC	Hc	LA	Md	Hg	MG	LG	HB	HF	HA	Md	HC	HF	LA	MC	MF	Lg	Ha	Mg	68.55532
17	HA	HB	HG	Ha	Me	He	Lg	HG	Ha	Ma	Ha	MD	LB	Lg	Mc	He	Ha	HF	LB	MA	90.36265
18	Me	Hd	Me	MD	Lg	LD	Mc	Hb	Hf	Hg	HD	HD	MD	Md	Ld	Mb	Mg	MF	HE	Mb	98.93291
19	LE	LA	Lb	MF	HE	MF	La	Hd	HG	Hg	Lf	ME	Lf	HC	Ma	LA	Lc	La	Hg	Mb	60.590477
20	LC	LF	Lc	Lg	Mg	Mc	LF	Mb	LC	LA	Ha	Hd	Mb	Lc	HA	Lb	Lg	Le	LE	Hd	75.37505
21	LC	MB	La	Lf	Mb	LB	Hc	HC	Ma	LE	La	LG	Md	MF	ME	Me	LB	MG	Lc	Lf	94.565544
22	Lf	HB	MA	Me	Lf	Hc	Lc	MG	Lb	He	Ha	Ld	LC	Hd	Ha	La	Mc	Hg	HF	Mc	98.377716
23	He	Lf	Lb	Ma	ME	LA	Lb	Lg	MA	Ma	Hf	LF	HF	MA	Md	MC	LC	HA	HB	LF	43.436104
24	Ld	HA	Ha	MA	Mg	Lg	LC	HF	HF	MC	Mg	MD	Lc	MG	Ld	HG	LE	Lf	LC	Hc	74.25588
25	Mb	Ma	LB	MG	LG	LF	HG	LB	La	Lf	Mb	Lb	Lg	Me	Lg	Lg	HG	HB	Hg	HF	96.14183
26	LG	MF	HB	Mg	MF	HD	Mg	Mg	Hb	LB	Mf	Ha	LD	LF	Lb	Me	Lb	Lb	MF	LF	84.72256
27	Lc	Mb	LD	Me	La	Ha	MD	Ld	HD	Hc	LG	HF	La	Hc	Me	Mg	LG	LB	LC	MC	68.07308
28	Ma	MG	Ld	Mg	LC	LB	MA	La	Mb	Mc	Mb	Ma	Ld	He	Mg	Ma	LB	HF	Lg	Ma	79.4531
29	Me	LF	ME	Mb	Mf	Mc	HE	Le	MD	MB	HE	LA	MF	MG	LA	Hg	Ma	LB	Ma	Hg	74.36563
30	Mb	MA	Le	LF	Lc	MC	Mb	Hf	Hg	HE	Lf	Ha	Hf	LG	Md	LG	Mf	Me	Mg	Hd	88.74451
31	HF	MB	Md	MB	Hf	MB	Hb	ME	LC	Hc	HF	Lb	Mc	MC	LA	MB	Lc	Hf	Ma	Lc	86.63606
32	Ma	MC	Hf	Lf	HF	Le	Mb	He	MC	HE	LA	Lg	ME	HB	ME	HE	Hd	MD	MF	HE	57.437706
33	MD	MD	MG	Le	MD	Lf	Ha	MB	HE	Me	ME	MD	LE	Le	LC	HD	MG	Md	LE	La	92.558205
34	HD	Hd	La	HE	LG	Md	MD	MB	MC	LC	HE	Hc	Hf	HB	ME	LA	Ma	Lb	Lb	Le	60.24779
35	LG	HE	ME	Mc	Ha	Ma	LG	MA	He	Ma	LG	HA	LG	Hf	LA	La	HA	Hf	Mc	Hg	66.61286
36	ME	Ma	He	HG	Hd	HB	Md	Lb	HA	HE	Ma	Ha	Hc	Me	HC	MF	Md	He	La	Hd	92.77724
37	HA	La	ME	Hg	ME	Ma	He	MF	Hb	Hg	ME	Hc	Me	LF	Hb	MB	MA	Mg	Hd	Hf	88.64865
38	MF	LG	La	Ma	He	HD	HC	Ma	Hf	LD	Ma	La	HB	HF	Hf	LF	Hf	LG	Lb	HB	91.010376
39	HA	Lc	He	LC	Ma	HE	MA	Hb	Lg	HC	Le	Le	MF	Ha	LC	LC	MD	Mf	LA	Md	89.02922
40	HA	HB	Mg	HD	Mf	MC	Mf	Md	LD	ME	Lg	Ha	LE	Lc	Lg	HE	HF	Mb	Ma	ME	91.19244
41	Hd	MF	Lf	HE	MG	LE	Lf	La	LA	Mb	MA	Mc	LF	MA	Md	LE	Mc	Lf	HB	HA	98.27013
42	Md	MA	HD	Lc	HD	LF	Md	Mc	Lb	Ha	HB	LD	Hg	LA	Md	Ha	Hb	Lb	Me	HC	69.18225
43	Mb	MD	Mb	Lb	Mb	Ma	Hd	Mc	He	Hf	LF	La	MB	LC	MB	Ld	ME	Lg	LC	Mb	64.91476
44	LG	Hf	Hd	LG	MG	HB	LG	Hf	Hb	LB	MB	MA	Mb	LF	HF	Hf	MA	MC	LB	LA	82.159546
45	LB	HC	Lc	HD	LA	Lf	Lf	Lg	HE	La	Lf	LC	Mf	MF	LD	Me	HC	Ma	HG	Ma	83.79226
46	Md	Hg	Mc	MF	HA	Lg	LA	LE	HD	MD	Lf	LF	HC	LF	HF	Hf	MB	Mb	Lb	LG	94.60195
47	Lf	Lb	MC	Ma	MB	Lg	MD	LA	LC	Mf	MA	LB	Lg	Mg	HF	MD	Hb	LF	Lf	HA	91.71466
48	LA	Hd	HG	Hg	Me	ME	LD	ME	Mb	MD	La	LE	Mg	Ld	Le	Hf	LE	Mg	LG	Ha	81.14157
49	MF	Mb	MG	LE	Mg	Ma	Me	HA	Lg	He	Ld	HG	LE	HG	He	Md	Ma	MF	Hb	HF	99.70181
50	Hf	LD	Hf	MD	LA	Md	LE	He	Ha	Le	LB	La	Le	Lf	HA	Hc	Hg	LA	MD	Hf	87.46975
51	HG	Lf	Le	HG	Le	Mb	Le	MD	HA	Le	La	Lg	Hc	Mb	HD	HC	HA	Hg	LE	Ld	85.03609
52	Mg	MF	Ma	Me	Lb	Mc	Hf	Lf	HG	Hc	Ld	Lg	MB	Lb	Hg	LC	La	HA	HC	LF	61.32808
53	LC	MF	Hg	ME	Ma	ME	Lg	Ld	Mg	He	Mg	HG	Md	HB	HE	LF	HG	Md	Hb	LF	92.91988
54	Mb	HA	HB	Mf	Mb	LB	Le	Mf	Ha	Hd	HD	LC	Lb	HE	HB	Lc	Ld	MA	HD	LA	54.34761
55	MC	LF	MF	Me	Lc	Mc	HF	LB	Ha	LB	Mc	LA	HD	HC	HB	Le	MG	MG	Mg	Me	71.85657
56	Mf	LF	HD	MB	Hf	Ha	LE	HC	Mc	Mc	Mb	Mb	HF	MB	Hc	Mb	Hf	Ld	Lb	HB	67.70701
57	Lb	Mc	LB	Mg	LD	Md	Lc	LF	Hd	Mc	LC	ME	HF	HC	LC	Hc	Mc	MA	Lb	Mg	92.93998
58	LB	Mc	Mf	HA	LC	Mg	Mf	MF	LD	ME	HD	Lc	Hg	LG	Ld	Hd	MG	HC	LC	Hc	79.85615
59	LE	HB	MG	He	LG	MD	La	Mg	Hf	Hf	HA	LB	MB	Mc	HE	LE	LE	HF	Lf	Hb	90.61043
60	LF	Lc	Lg	HB	HA	Md	Hd	Mg	LG	MC	MB	LD	HG	Mc	Lf	Hg	LG	Hc	LC	Lc	88.28058
61	Ld	LD	LA	Md	Ma	LG	Lg	MD	Hf	Hd	MF	HE	HG	HC	Hb	Lb	LF	Md	HB	Le	88.68879
62	Le	Lf	LB	Mb	LE	LE	Lf	MG	MG	Lc	LA	Hc	Ha	Mg	HG	LE	Mb	MC	MD	LB	77.98738
63	La	HD	Hc	Lg	La	LD	La	MA	He	Lg	HF	HB	MF	MF	HG	Le	Hc	Lb	Hc	Le	99.3657
64	HE	Ld	Hg	Hb	Ha	Md	Ha	Mg	Hg	HB	HG	LB	HA	Hg	ME	HD	LB	Lg	Mc	LE	59.47553
65	HB	LF	LA	Md	Ma	Ld	LF	LG	LD	Ld	Lg	HG	LF	LC	HC	MD	Mf	LC	Hg	LG	83.26391
66	Mg	Lg	La	MF	Hf	Hg	Mf	MF	HF	Me	LF	Ld	HD	MC	MA	Hd	LC	Mg	HF	La	67.319405
67	HC	Ma	Lg	La	Le	LD	Hb	Hb	Mb	Ha	Hg	ME	HC	LC	Lf	Lg	Md	Mf	LA	HG	82.23362
68	MG	MA	Hg	HB	LB	MD	HE	MG	La	Hc	MA	La	HC	Mc	Ha	LF	Hg	HE	Lb	HF	86.06687
69	Hf	Lc	HG	Md	Hd	La	Md	Hf	La	LA	HE	Hf	He	Lc	HB	LA	HF	MG	Mf	LA	65.73439
70	LG	Lb	HC	MA	MB	HD	HC	Lg	Ma	MG	Ld	MA	Le	HD	LE	Hd	Ld	MA	Lc	Lc	91.83494

```
71    HC Lf HC MG LF Ma MD LD LA MA MB ME Lf LE MG Mb LA LF Hg Me  65.566956
72    LD He Me LC LF HC MF LF HC LB Mg Ha Ld ME HD Mf Mf LG HC Lf  77.323296
73    ME MD Ma MC MF Mc Mb Hf Ma HA Hd Me MG MB Md LB ME HG Ha Md  81.2329
74    HF Mb Md LE Mc Me MG LC LC HD MA Lb MB MC MA HG HA Md Mg Md  90.86262
75    Lg Mb HB LC Ha HD HA HG HF He HC La HG Hb HF Me Mc Lb Hd Lb  80.117455
76    LF HG LF He Md Md Hd Me La Mf Hg LE HB HC LF Ha Le Lg Mb LF  82.068794
77    Ld MA Hg Ha He MA MG HE MG Lb MD HA HB Md LF MB LC MA LA MC  49.35932
78    Lc ME Lg MG Ld HD He HD Me MD Mb Mc HF Hf HB Ld Ha HA LD MF  99.54647
79    MF HD HB MF Ma Hg MF Lf LD Lf HE LF Lg Lg LA HD Lb Hd Lc MD  90.68602
80    HB HC Mb Hg HG He Md ME Ld MF HD Hg Lc Hb Mb Ld MC LA Me Lg  90.03653
81    Me He Hg Ha Mc HC LG LF LF LD HG HF Ha Hf Lb HB He HF Me MB  98.08484
82    Ma Hd LD Lf HC La LG He Md He LD HA HG LE Lg Hf Ld HG Hd LD  84.46077
83    LE Lc HE Hf La LA HD La HC LF Mg Mc MG Mf HE LA Ha Mc Ma HA  77.331055
84    Lc Md ME Me MB Hg He LB Le Le MB LD Me Me HA HD Lf Mc Md LA  88.98484
85    La Lb La Hg LE MD Lc HB Hd Ma Mb MF Hb Me Hg HF Lc Ld HA Ld  80.31186
86    MC Ma Hd LF HG MA HC LA Mb Ha LF Mc MD LB Mb LE Mb MD LB LE  98.318665
87    HC Ha MG Ld MA He Lc Mb HF MD Mf HC HC LC Md Hf Hf Lg Lf Hb  74.23536
88    HF MA HF Mb Ma HA HA Me LA Hc Mb Ld Hd Hd He Lf LD Me LC Lc  92.77784
89    HC HG HG MC Lb LB LA MG MD MG He Hd Mg ME HB La He HE MB Ld  64.93298
90    HB Lc Md HE He Lg Mf HF LC LG LD LD Mg Lf LG HC Hf Ld HF La  98.07161
91    LD Mb Hc LB Hb ME LA HD Hd Lc Hd LB La HF HD LB HC ME HF Hg  82.36817
92    He LD HE HD He ME Mf MB He Lf MC Mb Ha LA He HA Lg Mg Mc Ld  62.11254
93    Lc He HA HC MG MF Hg MC Md Mf HF LF ME Ma LA HD MG He He MB  91.27572
94    He Mb Ma LE Hb La Hf MA Le Ma MB LE Ha HA Lb Hb Hc HE MD Mb  77.8625
95    LG LB MB Lc MG Lg Ha LG Ha Ha LG HA HA Hc MD LB Lc Hd Mg Md  88.838264
96    HD Mg MC Mf Mc LA HF LE MB HD Hb Le Lf Ha Hd Hc MB Ha LE HE  83.96591
97    LC Ld MA Mf Hb HC Lg La Hc Lb Mf Lb MG LC HD MB HB MB Le MC  82.47777
98    Hc LD LE Hf HF LF LD Hd He HE LE Lg LE LA Lf HD MF HF HE Me  96.4661
99    Hb LC Ld He Lc Mg Lc HD Ha Mc Ma LC HG Ha LA Ha MA Me HE Mf  97.22239
100   Mg MG LF Mg MF Hg MF MB HC LA Md Le MC Mg MF Lb Me HE LD Le  95.06529
Average fitness of collection 0 = 81.83755

The desired coefficient is -1.0
Average fitness of collection 1 = 1.1313193
Average fitness of collection 2 = 17.2508
Average fitness of collection 3 = 36.760025
Average fitness of collection 4 = 51.82773
Average fitness of collection 5 = 65.06218
Average fitness of collection 6 = 72.58917
Average fitness of collection 7 = 76.88396
Average fitness of collection 8 = 80.0033
Average fitness of collection 9 = 83.60434
Average fitness of collection 10 = 88.0541
Average fitness of collection 11 = 89.61039
Average fitness of collection 12 = 91.567245
Average fitness of collection 13 = 91.55886
Average fitness of collection 14 = 91.831055
Average fitness of collection 15 = 92.48584
Average fitness of collection 16 = 92.82018
Average fitness of collection 17 = 93.64781
Average fitness of collection 18 = 93.541824
Average fitness of collection 19 = 93.728806
Average fitness of collection 20 = 94.791016
Average fitness of collection 21 = 94.98518
Average fitness of collection 22 = 94.535164
Average fitness of collection 23 = 95.130554
Average fitness of collection 24 = 94.98642
Average fitness of collection 25 = 95.654144



Generation 25 collection ...
1     Mb Mb Mb Lg Mg Mg Me Lf HG Mc Ld HG MA MF HD MF MD MD MD LC  96.51711
2     Mb Mb Mb Lg Hg Mg Me Lf Me Hc Ld HG MA MF HD MD MD MD LC  97.61846
3     Mb Mb Mb Lg Hg Mg Me Lf Md HB Hf HG MA MF HD HC MD MD MD LC  95.847115
4     Mb Mb Mb Lg Mg Mg Me Lf Me Le Ld HG MA MF HD MD MD MD MD LC  97.32699
5     Mb Mb Mb Lg Mg Mg Me Lf Me LB Ld HG MA MF HD MD MD HD HE LC  96.770645
6     Mb Mb Mb Lg Mg Mg Me Lf Me HB Lc HG MA MF HD HC MD MD MD LC  97.63926
7     Mb Mb Mb Lg Mg Mg Me Lf Me Le Ld HG MA MF HD MF MD MD MD LC  97.4415
8     Mb Mb Mb Lg Hg Mg Me Lf Me Le Ld HG MA MF HD MF MD MD MD LC  97.44163
```

```
9     Mb Mb Mb Lg Mg Mg Me Lf Me HB Lc HG MA MF LG MD MD MD MD LC  98.08788
10    Mb Mb Mb Lg Mg Mg Me Lf Me HB Lc HG LB MF HD MD MD MD MD LC  97.708725
11    Mb Mb Mb Lg Hg Mg Me Lf Me HB Lc HG MA MF LA MD MD MD MD LC  97.80681
12    Mb Mb Mb Lg Mg Mg Me Lf Me Le Ld HG MA MF HE MF MD MD MD LC  97.77318
13    Mb Mb Hb Lc Hg Mg Me Lf Me Le Ld HG MA MF HD MD MD MD MD LC  94.31105
14    Mb Mb Mb Lg Mg Mg Me Lf Me Le Ld HG MA MF LE MF MD MD MD LC  97.57501
15    Mb Mb Mb Lg Mg Mg Me Lf Me Mc Ld HG MA MF HD He MD MD MD LC  91.990486
16    HD Mb Mb Lg Hf Mg Me Lf Me HB Lc HG MA MF HD MD MD MD MD LC  79.062706
17    Mb Mb Mb Lg Mg MA Me Lf Me Le Ld HG MA MF HE MF MD MD MD LC  94.48696
18    LD Mb Mb Lg Mg Mg Me Lf Me Le Ld HG MA MF LE MF MD MD MD LC  75.92947
19    Mb Mb Mb Lg Mg Mg Me Lf Me HB Lc HG MA MF HD HC MD HF MD LC  96.686714
20    Mb Mb Mb Lg Hg Lg Me Lf Me HB Lc HG MA MF HD MD MD MD MD LC  97.87877
21    Mb Mb Mb Lg Hg Mg Me Lf LC HB Lc HG MA MF HD MD MD MD MD LC  91.38766
22    Mb Mb Mb Lg Hg Mg Me Lf Me HB Lc HG MA MF Md HC MD MD MD LC  94.97603
23    Mb Mb Mb Lg Mg Mg Me Hc Me Ld Ld HG MA MF HD MF MD MD MD LC  97.62348
24    Mb Mb Mb Lg Mg Mg Me Lf Me Le Ld LA MA MF HD MF MD HG MD LC  96.09178
25    Mb Mb Mb Lg Mg Mg Me Lf Me HB Lc LC MA MF HD HC MD MD MD LC  94.58271
26    Mb Mb Mb Lg Hf Mg Me Lf Me HB Lc HG MA MF HD MD MD MD MD LC  97.804276
27    Mb Mb Mb Lg Mg Mg Me Lf Me Hc Ld HG MA MF HD MF MD MD MD LC  97.725105
28    Mb Mb Mb Lg Mg Mg Me Lf Me Ld Ld HG MA MF HD MF MD MD MD LC  97.692024
29    Mb Mb Mb Lg Mg Mg Me Lf Me HB Lc HG MA MF HD HC MD MD MD LC  97.63926
30    Mb Mb Hb Ha Mg Mg Me Lf Me Le Ld HG MA MF HD MF MD MD MD LC  97.63643
31    Mb Hf Mb Lg Mg Mg Me Lf Me HB Lc HG MA MF HD MD MD MD MD LC  96.85073
32    Mb Ha Mb Lg Mg Mg Me Lf Me Le Ld HG MA MF Ld MF MD MD MD LC  95.46175
33    Mb Mb Mb Lg Hg Mg Me Lf Me HB Lc HG MA MF LF HC MD MD MD LC  97.87892
34    Mb Mb Mb Lg Mg Mg Me Lf Me Le Ld HG MA MF HD MF MD MD MD LC  97.4415
35    Mb Mb Mb Mg Hg Mg Me Lf Me HB Lc HG MA MF HD MD MD MD MD LC  97.899666
36    Mb Mb Mb Lg Hg Mg Me Lf Me Le Ld HG LB MF HD MF MD MD MD LC  97.35336
37    Mb Mb Mb Lg Mg Mg Me Lf Me Le Ld LA MA MF HD MF MD MD MD LC  97.52612
38    Mb Mb Mb Lg Mg Mg Me Lf Me Ld Ld HG MA MF HD MD MD MD MD LC  97.586975
39    Mb Mb Mb Lg Mg Mg Me Lf MB HB Lc HG MA MF HD MD MD MD MD LC  97.75819
40    Mb Mb Mb Lg Hg Mg Me Lf Me HB Lc HG MA Lc HD MD MD MD MD LC  96.90264
41    Md Mb Mb Lg Hg Mg Me Lf Me HB Lc HG MA MF LF HC MD MD MD LC  93.60105
42    Mb Mb Mb Lg Hg Mg Me Lf LC HB Lc HG MA MF HD MD MD MD MD LC  91.38766
43    Mb Mb Mb Lg Mg Mg Me Lf Me HB Lc HG Ha MF LF HC MD MD MD LC  91.31575
44    Mb Mb Mb Lg Hg Mg Me Lf Me Le Ld HG MA MF HD HC MD MD MD LC  97.1131
45    Mb Mb Mb Lg Hf Mg Me Lf Me HB Lc HG MA MF HD MD MD MD MD LC  97.804276
46    Mb Mb Mb Lg Hg Mg Me Lf Md HB Lc HG MA MF HD HC MD MD MD LC  97.813126
47    Mb Mb Mb Lg Hg Mg Me Lf Me HB Lc HG MA MF HD MD MD MD MD ME  96.76509
48    Mb Mb Mb Lg Hg Mg Me Lf Me MC Lc HG MA MF HD MD MD MD MD LC  92.923096
49    Mb Mb Mb Lg Hg Mg Me Lf Me HB Lc HG MA MF HD HC MD MD MD LC  97.624504
50    Mb Mb Mb Lg Mg Mg Me Lf Me HB Lc HG MA MF HD MD MD MD MD LC  97.84184
51    Mb Mb Mb Lg Hg Mg Me Lf Me HB Lc HG MA MF MG MD MD MD MD LC  98.00864
52    Mb Mb Mb Lg Mg Mg Me Lf Me Le Ld HG MA MF HE MF MD Mc MD LC  93.30497
53    Mb Mb Mb Lg Hg Mg Me Lf Me HB Lc HG MA MF LF HC LC MD MD LC  97.619095
54    Mb Mb Mb Lg Hg Mg Me Lf MC HB Lc HG MA MF HD MF MD MD MD LC  91.56385
55    Mb Mb Mb Lg Hg Mg Me Lf Me HB Lc HG MA MF HD MD MD MD MD LC  97.8255
56    Mb Mb Mb Lg Hg Mg Me Lf Me HB Lc HG MA MF HD MD MD MD MD LC  97.8255
57    Mb Mb Mb Lg Hg Mg Me Lf Me HB Lc HG MA MF HD MD Lf MD MD LC  89.832565
58    Mb Mb Mb Lg Mg Mg Me Lf Me Mc Ld HG MA MF HD HC MD MD ME LC  96.9924
59    Mb Mb Mb Lg Mg Mg Me Lf Me Mc Ld HG MA MF HD MF MD MD MD LC  97.73272
60    Mb Mb Mb Lg Hg Mg Me Lf Me LB Ld HG MA MF HD MD MD MD MD LC  97.44017
61    Mb Mb Mb Lg Mg Mg Me Lf Me Ld Ld HG MA MF HD MF HB MD MD LC  95.08939
62    Mb Mb Mb Lg Mg Mg Me Lf Me Lg Ld HG MA MF HD MD MD MD MD LC  96.184654
63    Mb Mb Mb Lg Mg Mg Me Lf Me Le Ld HG MA MF HD MF MD MD MD LC  97.4415
64    Mb Mb Mb Lg MA Mg Me Lf Me Le Lc HG MA MF HD MD MD MD MD LC  93.42826
65    Mb Mb Hb Ha Mg Mg Me Lf Me Le Ld HG MA MF HD MF Ld MD MD LC  93.53926
66    Mb Mb Mb Lg Mg Mg Me Lf Me Lf Lc HG MA MF LF HC MD MD MD LC  97.12815
67    Mb Mb LC Lg Hf Mg Me Lf Me HB Lc HG MA MF HD MD MD MD MD LC  79.398254
68    Mb Mb Mb Lg Mg Mg Me Lf Me Ld Ld HG MA MF HD MD MD MD MD LC  97.586975
69    Mb Mb Mb Lg Hf Mg Me Lf Me HB Lc HG MA MF HD MD MD MD MD LC  97.804276
70    Mb Mb Mb Lg Mg Mg Me Lf Me Hd Lc HG MA MF HD MF MD MD MD LC  97.75616
71    Mb Mb Mb Lg Mg Mg Me Lf Me Le Ld HG MA MF HE Mg MD MD MD LC  89.2487
72    Mb Mb Mb Lg Hg Mg Me Lf Md HB Lc HG MA MF HD HC MD LG MD LC  96.610245
73    Mb Mb Mb Lg Hf Mg Me Lf He HB Lc HG MA MF HD HC MD MD MD LC  97.48336
74    Mb Mb Mb Lg Hg Mg Me Lf Md HB Lc HG MA MF HD HC MD MD MD LC  97.813126
75    Mb Mb Mb Lg Hg Mg Me Lf Me HB Lc HG MA HE HD HC MD MD MD LC  97.49039
76    Mb Mb Mb Lg Mg Mg LG Lf Me HB Lc HG MA MF HD MD MD MD MD LC  94.306274
77    Mb Mb Mb Lg Hg Mg Me Lf Me HB Lc HG MA MF HD MD MD MD MD LC  97.8255
78    Mb Mb Mb Lg Hg Mg Me Lf Md HB Lc HG MA MF HD HC MD MD MD LC  97.813126
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79    Mb Mb Mb Lg Hg Mg Me Lf Me HB Lc HG MA MF Hc MD MD MD MD LC  95.95909
80    Mb Mb Mb Lg Mg Mg Me Lf Me Le Ld HG MA MF LE MF MD MD MD LC  97.57501
81    Mb Mb Mb Lg Hg Mg Me Lf Me HB Lc HG MA MF Le HC MD MD MD LC  94.16586
82    Mb Mb Mb Lg Mg Mg Me Lf Me Mc Ld HG MA MF HD MF MD MD MD LC  97.73272
83    Mb Mb Mb Lg Hg Mg Me Lf Me HB Lc LA MA HE HD HC MD MD MD LC  97.54262
84    Mb Mb Mb Lg Mg Mg Me Lf Me HB Lc HG MA MF LF HC MD MD MD LC  97.89478
85    Mb Mb Mb Lg Mg Mg Me Lf Me HB Lc HG MA MF HD MD MD MD MD LC  97.84184
86    Mb Mb Mb Lg Hg Mg Me Lf Me HB Lc HG MA MF HD MD MD MD MD LC  97.8255
87    Mb Mb Mb Lg Mg Mg Me Lf Me Le Ld HG MA MF HE MF MD MD MD LC  97.77318
88    Mg Mb Mb Lg Hg Mg Me Lf Me HB Lc HG MA MF HD MF MD MD MD LC  96.88043
89    Mb Mb Mb Lg Mg Mg Me Lf Me Ld Ld HG MA MF HD MD MD MD MD LC  97.586975
90    Mb Mb Mb Lg Hg Mg Me Lf Me HB Lc HG MA MF HD MD MD MD MD LC  97.8255
91    Mb Mb Mb Lg Mg Mg Me Lf Me HB Lc HG MA MF HD HC MD MD MD LC  97.63926
92    Mb Lg Mb Lg Hf Mg Me Lf Me Ld Ld HG MA MF HD MD MD MD MD LC  96.6989
93    Mb Mb Mb Lg Mg Mg Me Lf Me Le Ld HG MA MF HE MF MD MD MD MB  92.40101
94    Mb Mb Mb Lg Mg Mg Me Lf Me Mc Ld HG MA MF HD MF MD MD MD LC  97.73272
95    Mb Mb Mb Lg Hg Mg Me Lf Me HB Lc HG MA MF HD HC MD MD Mf LC  85.551994
96    Mb Mb Mb Lg Hg MC Me Lf Me HB Lc HG MA MF HD HC MD MD MD LC  86.90141
97    Mb Mb Mb Lg Hg Mg Me Lf Me HB Lc HG MA MF Mg HC MD MD MD LC  90.64191
98    Mb Mb Mb Lg Hg Mg Me Lf Me Le Ld HG MA MF LE MF MD MD MD LC  97.57449
99    Mb Mb Mb Lg Mg Mg Me Lf Me Le Ld Mc MA MF HE MF MD MD MD LC  97.78836
100   Mb Mb Mb Lg Hg Mg Me Lf Me HB Lc HG MA MF LF HC MD MD MD LC  97.87892
Average fitness of collection 25 = 95.654144

The desired coefficient is -0.5
Average fitness of collection 26 = 54.71227
Average fitness of collection 27 = 65.627396
Average fitness of collection 28 = 78.624916
Average fitness of collection 29 = 91.39442
Average fitness of collection 30 = 95.37776
Average fitness of collection 31 = 96.34588
Average fitness of collection 32 = 96.32502
Average fitness of collection 33 = 95.853905
Average fitness of collection 34 = 95.41604
Average fitness of collection 35 = 95.26887
Average fitness of collection 36 = 95.33974
Average fitness of collection 37 = 95.93662
Average fitness of collection 38 = 95.98762
Average fitness of collection 39 = 96.8244
Average fitness of collection 40 = 98.02407
Average fitness of collection 41 = 97.38925
Average fitness of collection 42 = 97.82581
Average fitness of collection 43 = 98.00991
Average fitness of collection 44 = 97.95245
Average fitness of collection 45 = 96.92051
Average fitness of collection 46 = 97.02479
Average fitness of collection 47 = 97.69167
Average fitness of collection 48 = 96.60293
Average fitness of collection 49 = 97.898964
Average fitness of collection 50 = 97.642265



Generation 50 collection ...
1     HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
2     HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
3     HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
4     HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
5     HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD Lf Hg  86.71289
6     HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA Hc HD MD LG MD MD Hg  97.65292
7     HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
8     HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
9     HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
10    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
11    HC Mb Mb Lg Hg Mg Le Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.8864
12    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
13    HC Mb Mb Lg Hg Mg La Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.555466
14    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
15    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
16    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
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17    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
18    HC Mb Mb Lg Hg Mg Me MD HC HB Lc MG MA MF HD MD LG MD MD Hg  95.26892
19    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MG LG MD MD Hg  98.18171
20    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
21    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD LD  80.3872
22    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG LD MF HD MD LG MD MD Hg  99.61795
23    HC Mb Mb Lg Hg Mg Me Mf Mb HB Lc MG MA MF HD MD LG MD MD Hg  96.69338
24    HC Mb Mb Lg Hg Mg Me Mf LG HB Lc MG MA MF HD MD LG MD MD Hg  97.179825
25    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD LE Hg  99.30656
26    HC Mb Mb Lg Hg Mg Me Mf Hc HB Lc MG MA MF HD MD LG MD MD Hg  95.60826
27    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA LC HD MD LG MD MD Hg  99.680016
28    HC Mb Mb Lg Hg Hc Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  98.20956
29    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
30    HC Mb Mb Lg Ma Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.74876
31    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG Hc MD Hg  92.340576
32    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD Lc MD MD Hg  96.6315
33    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD Md Hg  89.87995
34    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA Ma HD MD LG MD MD Hg  92.91504
35    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD HA LG MD MD Hg  97.0098
36    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
37    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Lc  89.416824
38    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc HE MA MF HD MD LG MD MD Hg  99.88135
39    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
40    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA LG HD MD LG MD MD Hg  99.78448
41    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LB MD MD Hg  97.87279
42    HC Mb Mb Mb Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  98.72353
43    HC Mb Mb Lg Hg Mg Me Mf HC HA Lc MG MA MF HD MD LG MD MD Hg  99.86829
44    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
45    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
46    HC Mb Mb Lg Hg Mg Me HB HC HB Lc MG MA MF HD MD LG MD MD Hg  99.18759
47    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
48    HC Ma Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.14795
49    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
50    HC Mb Mb Lg Mf Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.336334
51    HC Mb Mb Lg Hg Mg Me Mf HC Mc Lc MG MA MF HD MD LG MD MD Hg  99.97739
52    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD HB MD MD Hg  97.05773
53    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
54    Me Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  81.72101
55    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
56    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
57    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HB MD LG MD MD Hg  97.12685
58    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
59    HC Mb Mb Lg Hg Mg Me Mf HA HB Lc MG MA MF HD MD LG MD MD Hg  96.24258
60    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
61    HC Mb Mb Lg Hg Mg Me Mf LB HB Lc MG MA MF HD MD LG MD MD Hg  96.09874
62    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc Mc MA MF HD MD LG MD MD Hg  99.40279
63    HC Mb Mb Lg Hg Mg Me Mf HC HB Lb MG MA MF HD MD LG MD MD Hg  97.14218
64    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
65    HC Mb Mb Lg Hg Mg Ma Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.554565
66    HC Mb Mb Lg Lg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.695274
67    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
68    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
69    HC HF Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  86.268555
70    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hd  92.9417
71    Hf Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  79.95326
72    HC Mb Mb Lg Hg Mg Me Lc HC HB Lc MG MA MF HD MD LG MD MD Hg  99.32822
73    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
74    HF Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  92.65776
75    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
76    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD Lc LG MD MD Hg  95.621254
77    HC Mb Mb Lg Hg Mg Mg Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.5923
78    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LB MD MD Hg  97.87279
79    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD La  99.1789
80    HC Mb Mb Lg MG Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  93.63496
81    HC Mb Mb Lg Hg Mg Hf Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.67757
82    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
83    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
84    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF MA MD LG MD MD Hg  98.194244
85    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD HB Hg  92.81407
86    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
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87    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
88    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
89    HC Mb Mb Lg Hg Mg Me Mf Hc HB Lc MG MA MF HD MD LG MD MD Hg  95.60826
90    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
91    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
92    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
93    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG Hg MF HD MD LG MD MD Hg  95.66712
94    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
95    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
96    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
97    HC Mb Mb Lg HE Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  91.36193
98    HC Mb Mb Lg Hg HA Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  96.53718
99    HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg  99.99971
100   HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD LA LG MD MD Hg  97.623535
Average fitness of collection 50 = 97.642265

The desired coefficient is 0.0
Average fitness of collection 51 = 50.515083
Average fitness of collection 52 = 58.720646
Average fitness of collection 53 = 69.72038
Average fitness of collection 54 = 83.85598
Average fitness of collection 55 = 92.84152
Average fitness of collection 56 = 94.273964
Average fitness of collection 57 = 94.88044
Average fitness of collection 58 = 94.73302
Average fitness of collection 59 = 95.30019
Average fitness of collection 60 = 97.413086
Average fitness of collection 61 = 96.47124
Average fitness of collection 62 = 97.48357
Average fitness of collection 63 = 98.56348
Average fitness of collection 64 = 97.44609
Average fitness of collection 65 = 97.76413
Average fitness of collection 66 = 96.5776
Average fitness of collection 67 = 97.399925
Average fitness of collection 68 = 97.08028
Average fitness of collection 69 = 97.55155
Average fitness of collection 70 = 98.01392
Average fitness of collection 71 = 97.97668
Average fitness of collection 72 = 97.8225
Average fitness of collection 73 = 97.34591
Average fitness of collection 74 = 96.47493
Average fitness of collection 75 = 96.130104



Generation 75 collection ...
1     HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
2     HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
3     HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MC MF Hf MA LG La MD Hg  97.566696
4     HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG LF MF Hf MA LG La MD Hg  98.80683
5     HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
6     HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
7     HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
8     HC LC Mb Lg Hg Mg Me Md MC ME Lc MG MA MF Hf MA LG La MD Hg  99.54025
9     HC LC Mb Lg Hg Mg Me Md MA Mc Lc MG MA MF Hf MA LG La MD Hg  98.351395
10    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
11    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
12    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
13    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD ME  81.8857
14    HC Me Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  82.79038
15    HC LC Mb Lg Hg Mg Me Md MC Lc Lc MG MA MF Hf MA LG La MD Hg  100.0
16    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
17    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
18    HC LC Mb Lg Hg Hf Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.42261
19    HC LC Mb Lg Hf Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  98.90844
20    HC LG Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  92.67503
21    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG LE MF Hf MA LG La MD Hg  98.328514
22    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA Hb La MD Hg  87.85297
23    HC LC Mb Lg Hg Mg Ld Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.08386
24    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
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25    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf Mb LG La MD Hg  91.536316
26    HC LC Mb Hb Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  96.59132
27    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
28    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
29    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
30    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
31    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La Ha Hg  80.427864
32    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
33    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
34    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG LB MF Hf MA LG La MD Hg  99.695915
35    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
36    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
37    Md LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  84.352936
38    HC LC Mb Lg Hg Mb Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  98.19824
39    MF LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  94.64373
40    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf LF LG La MD Hg  97.41481
41    Ha LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  76.47987
42    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG Ha MF Hf MA LG La MD Hg  96.45846
43    HC Ld Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  85.161736
44    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
45    HC Ha Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  77.47505
46    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
47    HC LC Mb Lg Hg Mg Me MF MC Mc Lc MG MA MF Hf MA LG La MD Hg  97.53765
48    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
49    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
50    HC LC Mb Lg Hg Mg Me Md MC Mc Mc MG MA MF Hf MA LG La MD Hg  100.0
51    HC LC Me Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  93.64309
52    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
53    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
54    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
55    La LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  77.57823
56    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
57    HC LC Mb Lg Hg Mg Me Md MC Mc Hg MG MA MF Hf MA LG La MD Hg  99.57413
58    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
59    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La HE Hg  97.699486
60    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
61    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
62    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
63    HC LC Mb Md Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  96.4542
64    HC LC Mb Lg Hg Mg Me Md Le Mc Lc MG MA MF Hf MA LG La MD Hg  97.16574
65    HC LC Mb Lg Hg LC Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  90.01418
66    HC LC Mb Lb Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  97.40755
67    HC LC HG Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  86.10613
68    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La Md Hg  87.44318
69    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Lb MA LG La MD Hg  97.97209
70    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
71    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG Hf MF Hf MA LG La MD Hg  97.37321
72    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
73    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
74    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA Mc Hf MA LG La MD Hg  97.14903
75    HC LC LA Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  86.61912
76    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
77    HC Ma Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  77.960144
78    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Lf MA LG La MD Hg  99.35547
79    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
80    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
81    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf Ld LG La MD Hg  97.06049
82    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG LB MD Hg  90.509636
83    HC LC Mb Lg Hg Mg HE Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  95.37735
84    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf LD LG La MD Hg  95.343124
85    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF LC MA LG La MD Hg  90.6127
86    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
87    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG MA MD Hg  89.478386
88    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
89    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
90    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf Mb LG La MD Hg  91.536316
91    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
92    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
93    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
94    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
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95    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
96    HC LC Mb Lg Hg Mg Me Md MC Mc LD MG MA MF Hf MA LG La MD Hg  99.38682
97    HC LC Mb Lg Hg Mg Me La MC Mc Lc MG MA MF Hf MA LG La MD Hg  98.169495
98    HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  99.96629
99    HC LC Mb MC Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG La MD Hg  86.39632
100   HC LC Mb Lg Hg Mg Me Md MC Mc Lc MG MA MF Hf MA LG HA MD Hg  89.99198
Average fitness of collection 75 = 96.130104

The desired coefficient is 0.5
Average fitness of collection 76 = 50.022655
Average fitness of collection 77 = 59.604626
Average fitness of collection 78 = 73.16172
Average fitness of collection 79 = 89.443695
Average fitness of collection 80 = 96.4118
Average fitness of collection 81 = 96.233475
Average fitness of collection 82 = 96.92636
Average fitness of collection 83 = 97.58872
Average fitness of collection 84 = 97.74162
Average fitness of collection 85 = 97.57928
Average fitness of collection 86 = 97.238
Average fitness of collection 87 = 97.22656
Average fitness of collection 88 = 97.128204
Average fitness of collection 89 = 97.123474
Average fitness of collection 90 = 96.97908
Average fitness of collection 91 = 97.13042
Average fitness of collection 92 = 97.59637
Average fitness of collection 93 = 96.37327
Average fitness of collection 94 = 97.32686
Average fitness of collection 95 = 96.95823
Average fitness of collection 96 = 97.33381
Average fitness of collection 97 = 96.056595
Average fitness of collection 98 = 97.726906
Average fitness of collection 99 = 97.64083
Average fitness of collection 100 = 97.90628



Generation 100 collection ...
1     HC LC LB Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  95.41811
2     HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG HA Lb Hg  92.50825
3     HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
4     HC LC ME LA HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  90.193405
5     HC LC ME Lg HC Mg Me Lc MC HF LB MG MA MF Hf MA LG La Lb Hg  99.97664
6     HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
7     HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
8     HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
9     HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
10    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf HC LG La Lb Hg  93.14875
11    HC LC ME Lg MG Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  97.77065
12    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
13    HC LC ME Lg HC Mg Me Lc MC HF Lb MG MA MF Hf MA LG La Lb Hg  97.84422
14    HC LC ME Lg HC Mg Me Lc MC Hg Ld MG MA MF Hf MA LG La Lb Hg  97.87847
15    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
16    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La MF Hg  85.54227
17    HC LC ME Lg HC Mg Me HD MC HF Ld MG MA MF Hf MA LG La Lb Hg  98.59735
18    HC LC ME Lg HC Mg Le Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.635445
19    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
20    HC LC Lg Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  86.655846
21    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
22    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
23    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
24    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
25    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hd MA LG La Lb Hg  99.12836
26    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
27    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
28    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
29    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
30    HC LC ME Lg HC HC Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  90.20228
31    HC LC ME Lg HA Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  96.49094
32    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf Mb LG La Lb Hg  94.56987
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33    HC LC ME Lg HC He Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  97.44493
34    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
35    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF La MA LG La Lb Hg  99.7212
36    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
37    HC LC Mg Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  86.00793
38    HC LC ME Lg HC Mg Me Lc MC HF Ld MG LE MF Hf MA LG La Lb Hg  97.26809
39    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
40    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
41    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
42    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
43    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG Mg Lb Hg  99.47952
44    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
45    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf LE LG La Lb Hg  95.293106
46    HC Mg ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  81.349625
47    MF LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  96.34135
48    HC LC ME Lg HC Mg Me Lc MC MG Ld MG MA MF Hf MA LG La Lb Hg  99.872116
49    HC LC ME Lg HC Mg Me Lc MC HF Ld MG Ma MF Hf MA LG La Lb Hg  98.82513
50    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG Ma Lb Hg  99.77442
51    HC LC Mg Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  86.00793
52    Hd LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  86.04287
53    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
54    HC MC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.69457
55    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
56    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
57    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
58    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
59    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
60    HC LC ME Lg HC Mg Lc Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  97.67971
61    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
62    HC LC ME Lg HC Hg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.452194
63    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
64    HC LC ME Lg HC Mg Me Lc MC HF ME MG MA MF Hf MA LG La Lb Hg  98.75271
65    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
66    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
67    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
68    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
69    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
70    HC LC ME Lg HC Mg Me Lc MC HF Ld LE MA MF Hf MA LG La Lb Hg  98.37779
71    HC LC ME Lg HC Mg Me Lc MC HF Ld MG HB MF Hf MA LG La Lb Hg  99.29154
72    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
73    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
74    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
75    HC LC ME Lg HC Mg Me Lc MC HF Ha MG MA MF Hf MA LG La Lb Hg  98.06395
76    HC LC ME Lg HC Mg Me Lc MC LF Ld MG MA MF Hf MA LG La Lb Hg  99.80216
77    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
78    HC LC ME MF HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  88.43739
79    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
80    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
81    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
82    HC LC ME Lg HC Mg Me Lc HD HF Ld MG MA MF Hf MA LG La Lb Hg  99.438705
83    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA Lg La Lb Hg  92.055695
84    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
85    HC LC ME Lg HC Mg Me Hc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.555504
86    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
87    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
88    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
89    MC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.62849
90    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf LB LG La Lb Hg  99.21648
91    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
92    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
93    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
94    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
95    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
96    HC LC ME Lg Md Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  93.22775
97    HC LC ME Lg HC Mg Me Lc MC HF Me MG MA MF Hf MA LG La Lb Hg  99.68893
98    HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  99.99252
99    HC LC Le Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg  90.41807
100   HC LC ME Lg HC Mg Me Lc MC HF Ld LB MA MF Hf MA LG La Lb Hg  99.25402
Average fitness of collection 100 = 97.90628
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The desired coefficient is 1.0
Average fitness of collection 101 = 49.670364
Average fitness of collection 102 = 52.75566
Average fitness of collection 103 = 57.583637
Average fitness of collection 104 = 62.49627
Average fitness of collection 105 = 70.963196
Average fitness of collection 106 = 77.75294
Average fitness of collection 107 = 79.82784
Average fitness of collection 108 = 82.41262
Average fitness of collection 109 = 85.33479
Average fitness of collection 110 = 87.14166
Average fitness of collection 111 = 88.39252
Average fitness of collection 112 = 89.726036
Average fitness of collection 113 = 89.30752
Average fitness of collection 114 = 91.24933
Average fitness of collection 115 = 91.55712
Average fitness of collection 116 = 91.44284
Average fitness of collection 117 = 92.52823
Average fitness of collection 118 = 93.55841
Average fitness of collection 119 = 93.40017
Average fitness of collection 120 = 94.16703
Average fitness of collection 121 = 94.798225
Average fitness of collection 122 = 93.76548
Average fitness of collection 123 = 95.337166
Average fitness of collection 124 = 95.724014
Average fitness of collection 125 = 95.97605



Generation 125 collection ...
1     HC LC MC MC HC HE LE MF MF MB HB HB Hd Md Ld Mg Lg La Lb Mb  97.71978
2     HC LC MC MC HC HE LE MF MF MB HB HB HB Md Ld Mg Lg La Lb Mb  97.62048
3     HC LC MC MC HC HE LE MF MF MB HB HB Hd Md Ld Mg Lg La Lb Mb  97.71978
4     HC LC MC MC HC HE LE MF MF MB HB HB HB Md Ld Mg Lg La Lb Mb  97.62048
5     HC LC MC MC HC HE LE MF MF MB HB HB HB Md Ld Mg Lg La Lb Mb  97.62048
6     HC LC MC MC HC HE LE MF MF MB HB HB HB Md Ld Mg Lg La Lb Mb  97.62048
7     HC LC LC MC La HE LE MF MF MB HB HB HB Md Ld Mg Lg La Lb Mb  85.12076
8     HC LC MC MC HC HE LE MF MF MB Md HB Hd Md Ld Mg Lg La Lb Mb  97.27523
9     HC LC MC Hd HC HE LE MF MF MB HB HB Hd Mc Ld Mg Lg La Lb Mb  90.11038
10    HC LC MC MC HC HE LE MF MF MB HB HB HB Md LE Mg Lg La Lb Mb  91.480865
11    HC LC MC MC HC HE LE MF MF Me HB HB HB Md Ld Mg Lg La Lb Mb  95.95895
12    HC LC MC MC HC HE LE MF MF MB HB HB HB Md Ld Mg Lg La Lb Mb  97.62048
13    HC LC MC MC HC HE LE MF MF MB HB HB Hd Mc Ld Mg Lg La Lb Mb  97.51148
14    HC LC MC MC HC HE LE MF MF MB HB HB Hd Mc Ld Mg Lg La Lb Lg  96.8651
15    HC LC MC MC HC HE LE MF MF MB HB HB HB Md Ld Mg Lg La Lb Ha  97.57088
16    HC LC MC MC HC HE LE MF MF MB MA HB Hd Mc Ld Mg Lg La Lb Mb  97.43159
17    HC LC MC MC HC HE LE MF MF MB HB HB Ld Md Ld Mg Lg La Lb Mb  97.78784
18    HC LC MC MC HC HE LE MF MF MB HB HF Hd Mc Ld Mg Lg La Lb Mb  96.189926
19    HC LC MC MC HC HE LE MF MF MB HB HB Hd Md Ld Mg Lg La Lb Mb  97.71978
20    HC LC MC MC HC HE LE MF MF MB HB HB HB Md Ld Mg Hb La Lb Mb  96.90387
21    HC LC MC MC HC HE LE MF MF MB HB HB HB Md Ld Mg Lg La Lb Mb  97.62048
22    HC LC MC MC HC HE LE MF MF MB HB HB HB Md Ld Mg Lg La Lb Mb  97.62048
23    HC LC MC MC HC HE LE MF MF LA Ld HB Mc Md Ld MA Lg La Lb Mb  94.88982
24    HC LC MC MC HC HE LE MF MF LA Ld HB HB Md Ld Mg Lg Hg Lb Mb  97.34214
25    HC LC MC MC HC HE LE MF MF MB HB HB HB Md Ld Mg Lg La Lb Mb  97.62048
26    HC LC MC MC HC Le LE MF MF MB HB HB HB Md Ld Mg Lg La Lb Mb  92.35334
27    HC LC MC MC HC HE LE MF MF MB HB HB HB Md Ld Mg Lg La Lb Mb  97.62048
28    HC LC LC MC HC HE LE MF MF MB HB HB Hd Mc Ld Mg Lg La Lb Mb  97.53386
29    HF LC MC MC HC HE LE MF MF MB HB HB Hd Md Ld Mg Lg La Lb Mb  94.99102
30    HC LC MC MC HC HE Mb MF MF MB HB HB HB Md Ld Mg Lg La Lb Mb  86.267944
31    HC LC MC MC LC HE LE MF MF MB HB HB Hd Md Ld Mg Lg La Lb Mb  97.535446
32    HC LC MC MC HC HE LE MF Lc MB HB HB HB Md Ld Mg Lg La Lb Mb  97.235985
33    HC LC MC MC HC HE LE MF MF MB HB Mg Hd Mc Ld Mg Lg La Lb Mb  95.60129
34    HC LC MC MC HC HE LE MF MF LA Ld HB Mc Md Ld Mg Lg La Lb Mb  97.4754
35    HC LC MC MC HC HE LE MF MF MB HB HB LB Md Ld Mg Lg La Lb Mb  97.382614
36    HC LC MC MC HC HE LE MF MF MB HB HB HB Md Ld Mg Lg La Lb Mb  97.62048
37    HC LC LC MC HC HE LE MF MF MB HE HB Hd Mc Ld Mg Lg La Lb Mb  96.12053
38    HC LC MC HA HC HE LE MF MF MB HB HB Hd Mc Ld Mg Lg La Lb Mb  94.69731
39    HC LC MC MC HC HE LE MF MF MB HB HB Hd Md Ld Mg Lg La Lb Mb  97.71978
40    HC LC MC MC HC HE LE MF MF MB HB HB HB Md Ld Mg Lg La Lb Mb  97.62048
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41    HC LC MC MC HC Mg LE MF MF MB HB HB HB Md Ld Mg Lg La Lb Mb  88.301605
42    HC LC MC MC LD HE LE MF MF MB HB HB Hd Mc Ld Mg Lg La Lb Mb  97.56698
43    HC LC MC MC HC HE LE MF MF MB HB HB Hd Md Ld Mg Lg La Lb Mb  97.71978
44    HC LC MC MC HC HE LE MF MF MB HB HB Hd Mc Ld Mg Lg La Lb Mb  97.51148
45    HC LC LC MC HC HE LE MF MF MB HB Lg HB Md Ld Mg Lg La Lb Mb  95.9504
46    HC LC MC MC HC HE LE MF MF MB HB HB Hd Mc Ld Mg Lg La Lb Mb  97.51148
47    HC LC MC MC HC HE LE MF MF MB HB HB HB Md Ld Mg Lg La Lb Mb  97.62048
48    HC LC MC MC HC HE LE MF MF MB HB HB HB Md Ld Mg Lg La Lb Hg  97.31813
49    HC LC MC MC HC HE LE MF MF LA Ld HB HB Md Ld Mg MG La Lb Mb  92.10609
50    HC LC MC MC HC HE LE MF MF MB HB HB Hb Md Ld Mg Lg La Lb Mb  94.37793
51    HC LC MC MC HC HE LE MF MF MB HB HB HB Md Ld Mg Lg La Lb Mb  97.62048
52    HC LC MC MC HC HE LE MF MF MB HB HB Hd Mc Ld Hb Lg La Lb Mb  96.39513
53    HC LC MC MC HC HE LE Hc MF MB HB HB Hd Mc Ld Mg Lg La Lb Mb  95.93687
54    HC LC MC MC HC HE LE MF MF MB HB HB Hd Mc Ld Mg Lg La Lb Mb  97.51148
55    HC LC MC MC HC HE LE MF MF MB HB HB HB Md Ld Mg Lg La Lb MB  91.74016
56    HC LC MC MC HC HE LE MF MF MB HB HB Hd Md Ld Mg Lg La Lb Mb  97.71978
57    HC LC MC MC HC HE LE MF MF MB HB HB HB Md Ld Mg Lg La Lb Mb  97.62048
58    HC LC MC MC HC HE LE MF MF MB HB HB Hb Mc Ld Mg Lg La Lb Mb  94.09077
59    HC LC MC MC HC HE LE MF MF MB HB HB HB Md Ld Mg Lg La Lb Mb  97.62048
60    HC LC Lc MC HC HE LE MF MF MB HB HB Hd Md Ld Mg Lg La Lb Mb  91.886
61    HC LC MC MC HC HE LE MF MF MB HB HB HB Md Ld Mg Lg Lb Lb Mb  97.46626
62    HC LC MC MC HC HE LE MF MF MB HB HB HB Md Ld Mg Le La Lb Mb  97.17813
63    HC LC MC MC HC HE LE MF MF MB HB HB HB Md Ld HC Lg La Lb Mb  87.31448
64    HC LC MC MC HC HE LE MF MF MB HB HB Hd Md Ld Mg Lg La Lb Mb  97.71978
65    HC LC MC MC HC HE LE MF MF LA Ld HB HB Md Ld Mg Lg La Lb Mb  97.339775
66    HC LC MC MC HC HE LE MF MF MB HB HB Hd Mc Ld Mg Lg La Lb Mb  97.51148
67    HC LC MC MC HC HE LE MF MF MB HB HB HB Md Ld Mg Lg La Lb Mb  97.62048
68    HC LC MC MC HC HE LE MF MF MB HB HB HB Md Ld Mg Lg La Lb Mb  97.62048
69    HC LC MC MC HC HE LE MF MF MB HB HB Hd Md Ld Mg Lg La Lb Mb  97.71978
70    HC LC LC MC HC HE LE MF MF MB HB HB HB Md Ld Mg Lg La Lb Mb  97.644585
71    HC LC MC MC HC HE LE MF MF MB HB HB HB Md Ld Mg Lg La Lb Mb  97.62048
72    HC LC MC MC HC HE LE MF MF MB HB Hb Hd Mc Ld Mg Lg La Lb Mb  93.1248
73    HC LC LC MC HC HE LE MF MF MB HB HB HB Md Ld Mg Lg La Lb Mb  97.644585
74    HC LC MC MC HC HE LE MF MF MB HB HB HB Md Ld Mg Lg La Lb Mb  97.62048
75    LB LC MC MC HC HE LE MF MF LA HB HB Hd Md Ld Mg Lg La Lb Mb  91.32591
76    HC LC MC MC HC HE LE MF MF MB HB HB Hd Mc Ld Mg Lg La Lb Mb  97.51148
77    HC LC MC MC HC HE LE MF MF MB HB HB Hd Mc Ld Mg Lg La Lb Mb  97.51148
78    HC LC MC MC HD HE LE MF MF MB HB HB Hd Mc Ld Mg Lg La Lb Mb  97.606285
79    HC LC MC MC HC HE LE MF MF MB Lc HB Hd Mc Ld Hf Lg La Lb Mb  97.58951
80    HC LC MC MC HC HE LE HF MF MB HB HB Hd Md Ld Mg Lg La Lb Mb  97.755554
81    HC LC MC MC HC Mf LE MF MF MB HB HB Hd Md Ld Mg Lg La Lb Mb  90.48707
82    HC LC MC MC HC HE LE MF MF MB Hb HB HB Md Ld Mg Lg La Lb Mb  91.85397
83    HC LC MC MC HC HE LE MF MF MB HB HB HB Md Ld Mg Lg La Lb Mb  97.62048
84    HC LC MC MC HC HE LE MF MF MB HB HB HB Md Ld Mg Lg La Lb Mb  97.62048
85    HC LC MC MC HC HE LE MF MF MB HB HB Hd Mc Ld Mg Lg La Lb Mb  97.51148
86    HC LC MC MC HC HE LE MF MF MB HB HB HB Md Ld Mg Lg La Mb Mb  97.57477
87    HC LC MC MC HC HE LE MF MF LG Lc HB Hd Mc Ld Lg Lg La Lb Mb  97.393326
88    Ma LC MC MC HC HE LE MF MF MB HB HB Hd Mc Ld Mg Lg La Lb Mb  75.51096
89    HC LC LC MC HC HE LE MF MF MB HB HB Hd Md Ld Mg Lg La Lb Mb  97.73927
90    HC LC MC MC HC HE LE MF MF MB HB HB Hd Md Ld Mg Lg La Lb Mb  97.71978
91    HC LC MC MC HC HE LE MF MF MB HB HB HB Md Hb Mg Lg La Lb Mb  96.151115
92    HC LC MC Md HC HE LE MF MF MB HB HB HB Md Ld Mg Lg La Lb Mb  90.719124
93    HC LC MC MC HC HE LE MF MF MB HB HB Hd Md Ld Mg Lg La Lb Mb  97.71978
94    HC LC LC MC HC HE LE MF MF MB HB HB Hd Mc Ld Mg Lg La Lb Mb  97.53386
95    HC LC MC MC HC HE LE MF MF MB HB HB Hd Mc Ld Mg Lg La Lb Mb  97.51148
96    HC LC MC MC HC HE LE MF MF MB HB HB HB Md Ld Mg Lg La Lb Mb  97.62048
97    HC LC MC MC HC HE LE MF MF MB HB HB HB Md Ld Mg Lg La Lb Mb  97.62048
98    HC LC MC MC HC HE LE MF MF MB HB HB HB Md Ld Mg Lg La Lb Mb  97.62048
99    HC LC MC MC HC HE LE MF MF MB HB HB Hd Mc Ld Mg Lg La Lb Mb  97.51148
100   HC LC MC MC HC HE LE MF LB MB HB HB HB Md Ld Mg Lg La Lb Mb  97.65301
Average fitness of collection 125 = 95.97605

NIL
```

Code

```
(defmethod next-generation((old collection) &aux new)
      (setf new (empty-collection old))
      (perform-copies old new)
      (perform-crossover old new)
      new
)

(defconstant *number-of-generations* 25)

(defmethod ga (&aux c)
      (setf desired-coefficient 0.0)
      (setf c (initial-collection))
      (format t "Initial collection: (desired coefficient: 0) ~%~%")
      (summarize c)

      (setf desired-coefficient -1.0)
      (setf c (evolve c))

      (setf desired-coefficient -0.5)
      (setf c (evolve c))

      (setf desired-coefficient 0.0)
      (setf c (evolve c))

      (setf desired-coefficient 0.5)
      (setf c (evolve c))

      (setf desired-coefficient 1.0)
      (setf c (evolve c))

      nil
)

(defmethod evolve((c collection))
      (format t "The desired coefficient is ~A~%" desired-coefficient)
      (dotimes(i *number-of-generations*)
            (setf c (next-generation c))
            (check-average c)
      )
      (terpri)
      (summarize c)
      c
)

(defmethod summarize((c collection))
      (display c)
      (check-average c)
      (terpri)
)

(defmethod check-average((c collection))
      (format t "Average fitness of collection ~A = ~A~%"
            (collection-generation c)
            (average c)
```

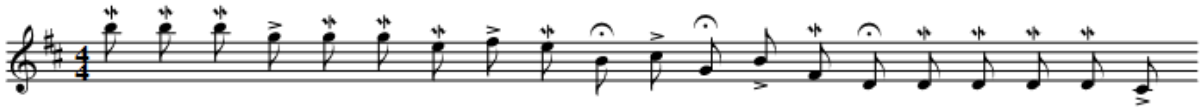
```
            )
)
```

Behavior of the GA

The fitness metric measures how close the melody's Krumhansl coefficient is from the set desired one, as a result the desired coefficient determines the goal shape that the melody is adapting towards.

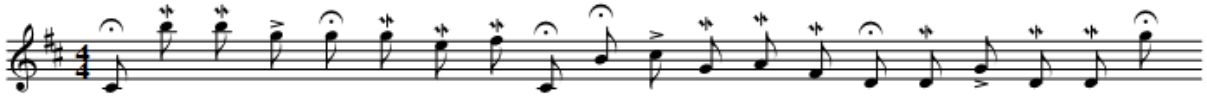
An example from 25th generation, desired coefficient of -1.0
10 Mb Mb Mb Lg Mg Mg Me Lf Me HB Lc HG LB MF HD MD MD MD MD LC 97.708725

Demo



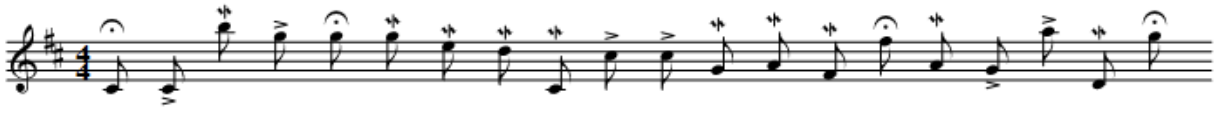
An example from 50th generation, desired coefficient of -0.5
1 HC Mb Mb Lg Hg Mg Me Mf HC HB Lc MG MA MF HD MD LG MD MD Hg 99.99971

Demo



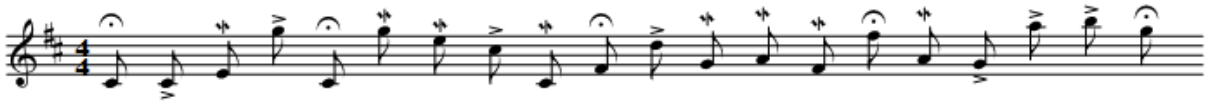
An example from 75th generation, desired coefficient of 0.0
15 HC LC Mb Lg Hg Mg Me Md MC Lc Lc MG MA MF Hf MA LG La MD Hg 100.0

Demo



An example from 100th generation, desired coefficient of 0.5
6 HC LC ME Lg HC Mg Me Lc MC HF Ld MG MA MF Hf MA LG La Lb Hg 99.99252

Demo



An example from 125th generation, desired coefficient of 1.0
17 HC LC MC MC HC HE LE MF MF MB HB HB Ld Md Ld Mg Lg La Lb Mb 97.78784

Demo