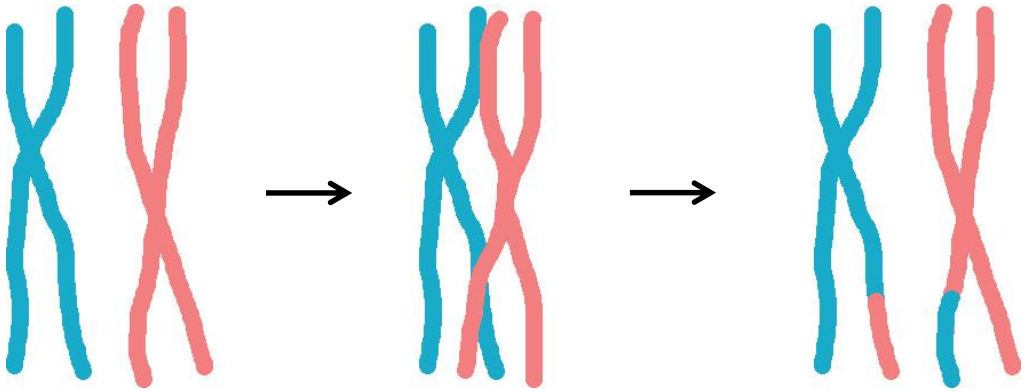
성신여자대학교

Algorithm

Yangjun Ahn
yangjunahn@sungshin.ac.kr
https://sites.google.com/sungshin.ac.kr/mhail

Evolution Process of Biology

- **Selection**
  - selection in relation to sex
- **Cross over**
  - At the very beginning of meiosis, two chromosomes exchange genetic material during sexual reproduction.



Evolution Process of Biology

- **Selection**
  - selection in relation to sex
- **Cross over**
  - At the very beginning of meiosis, two chromosomes exchange genetic material during sexual reproduction.
- **Mutation**
  - the possibility of evolution by natural selection.
- **Replacement**
  - Survival of the fitness

Genetic Algorithm: Pseudo Code

```
Initialize chromosome population
repeat{
        selection: father chromosome & mother chromosome;
        offspring : crossover father and mother chromosomes;
        offspring : mutation (offspring);
        if (offspring cost < the worst chromosome cost) {
                replacement;
        }
} until no progress;
return (the best chromosome in the population);
```

Example of Finding an Optimum by Using GA

$$\textit{Minimize} \quad f(\mathbf{x}) = x_1^2 + x_2^2 - 8x_1 - 8x_2$$

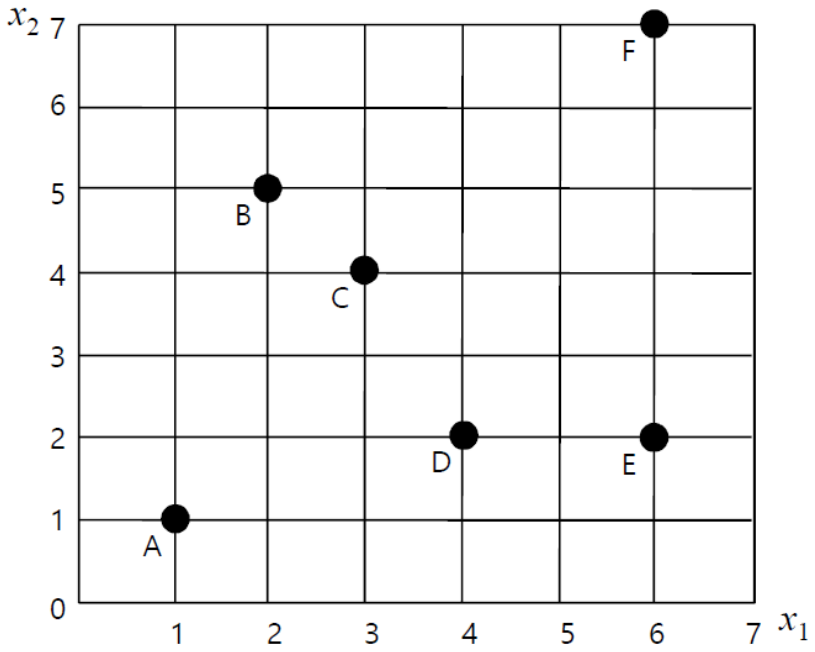
1st Generation Evaluation

A	(1 , 1)	-14
B	(2 , 5)	-27
C	(3 , 4)	-31
D	(4 , 2)	-28
E	(6 , 2)	-24
F	(6 , 7)	-19

Parents

(3 , 4)

(4 , 2)



Example of Finding an Optimum by Using GA

Minimize $f(\mathbf{x}) = x_1^2 + x_2^2 - 8x_1 - 8x_2$

1st Generation Evaluation

A	(1 , 1)	-14
B	(2 , 5)	-27
C	(3 , 4)	-31
D	(4 , 2)	-28
E	(6 , 2)	-24
F	(6 , 7)	-19

Parents

(3 , 4)

(4 , 2)

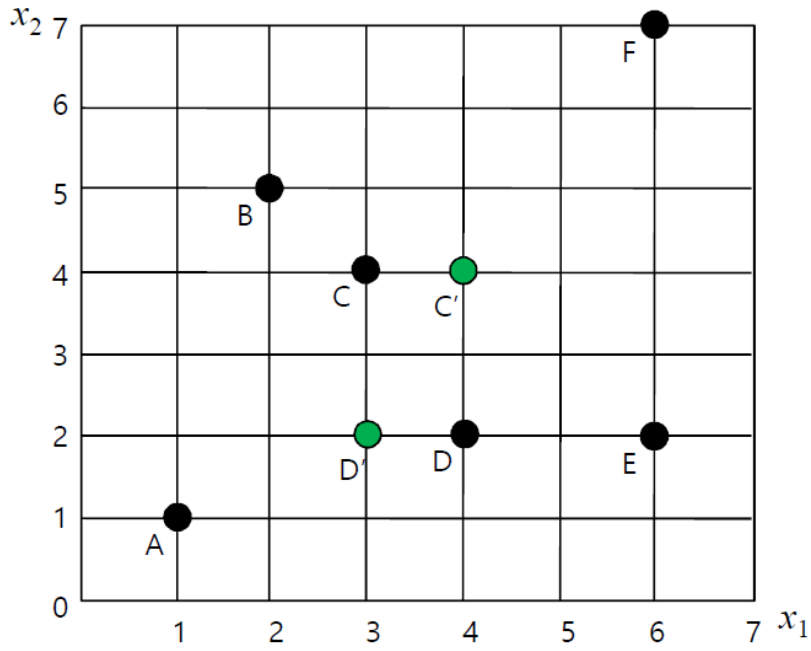
Crossover

Child

C' (3 , 2)

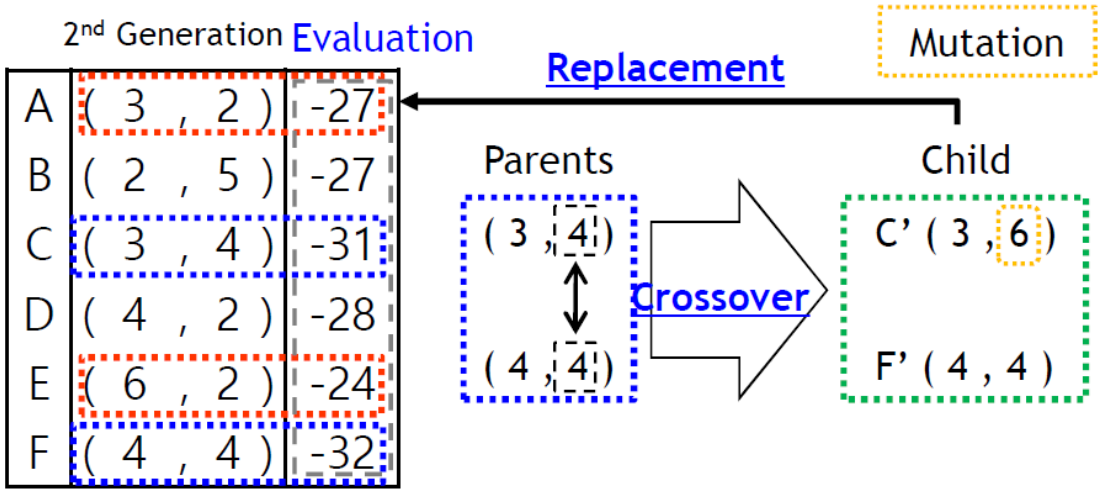
D' (4 , 4)

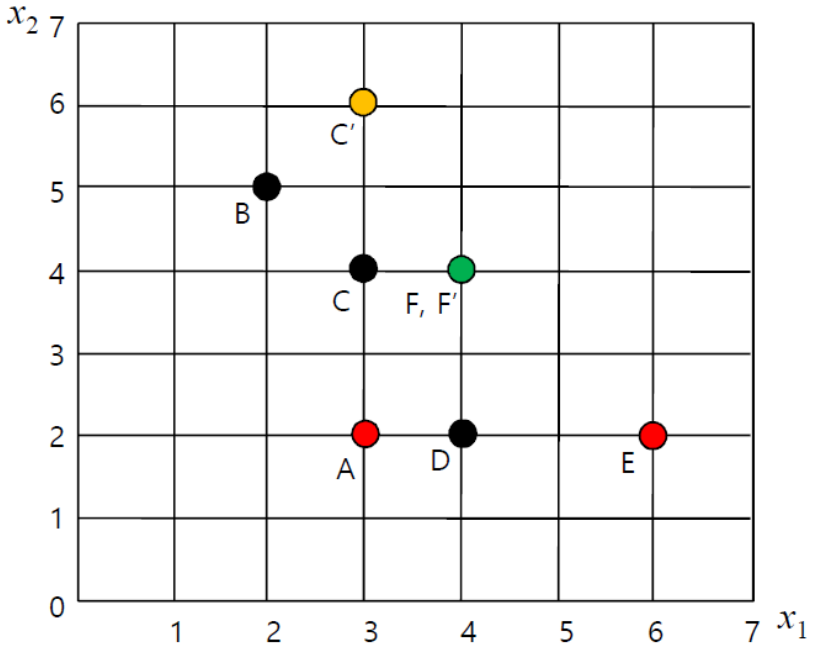
Replacement



Example of Finding an Optimum by Using GA

$$\textit{Minimize} \quad f(\mathbf{x}) = x_1^2 + x_2^2 - 8x_1 - 8x_2$$





성신여자대학교

Example of Finding an Optimum by Using GA

$$\textit{Minimize} \quad f(\mathbf{x}) = x_1^2 + x_2^2 - 8x_1 - 8x_2$$

3rd Generation Evaluation

A	(3 , 6)	-27
B	(2 , 5)	-27
C	(3 , 4)	-31
D	(4 , 2)	-28
E	(4 , 4)	-32
F	(4 , 4)	-32

Replacement

Parents

(4 , 4)

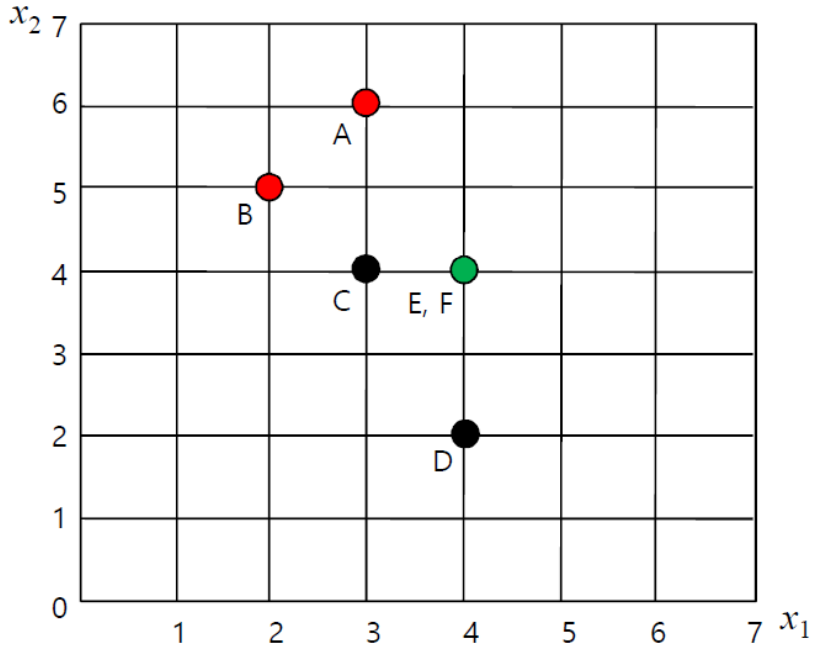
(4 , 4)

Crossover

Child

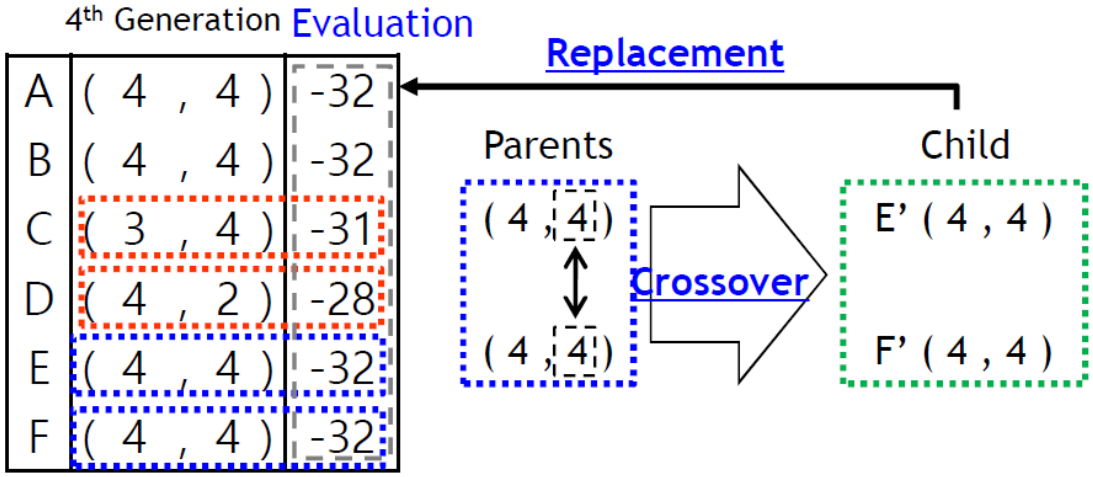
E' (4 , 4)

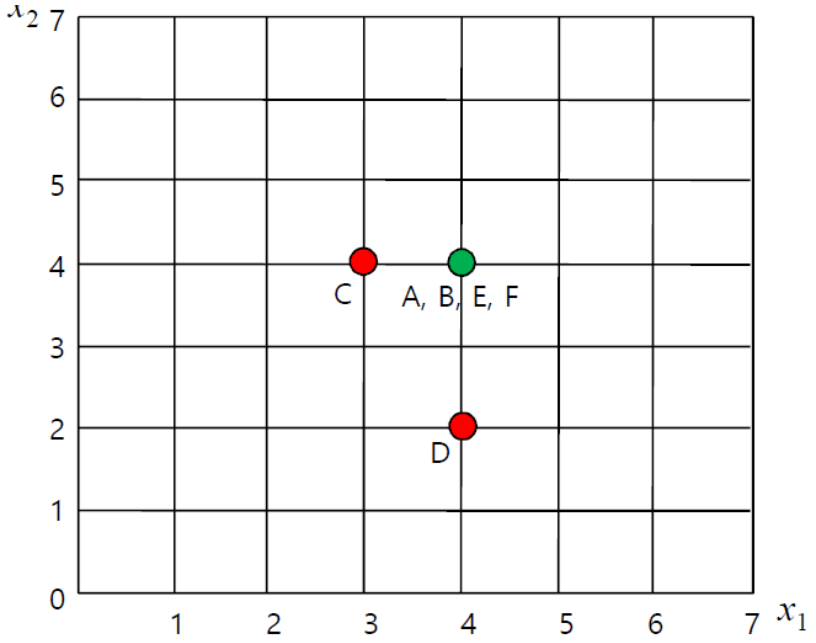
F' (4 , 4)



Example of Finding an Optimum by Using GA

Minimize $f(\mathbf{x}) = x_1^2 + x_2^2 - 8x_1 - 8x_2$

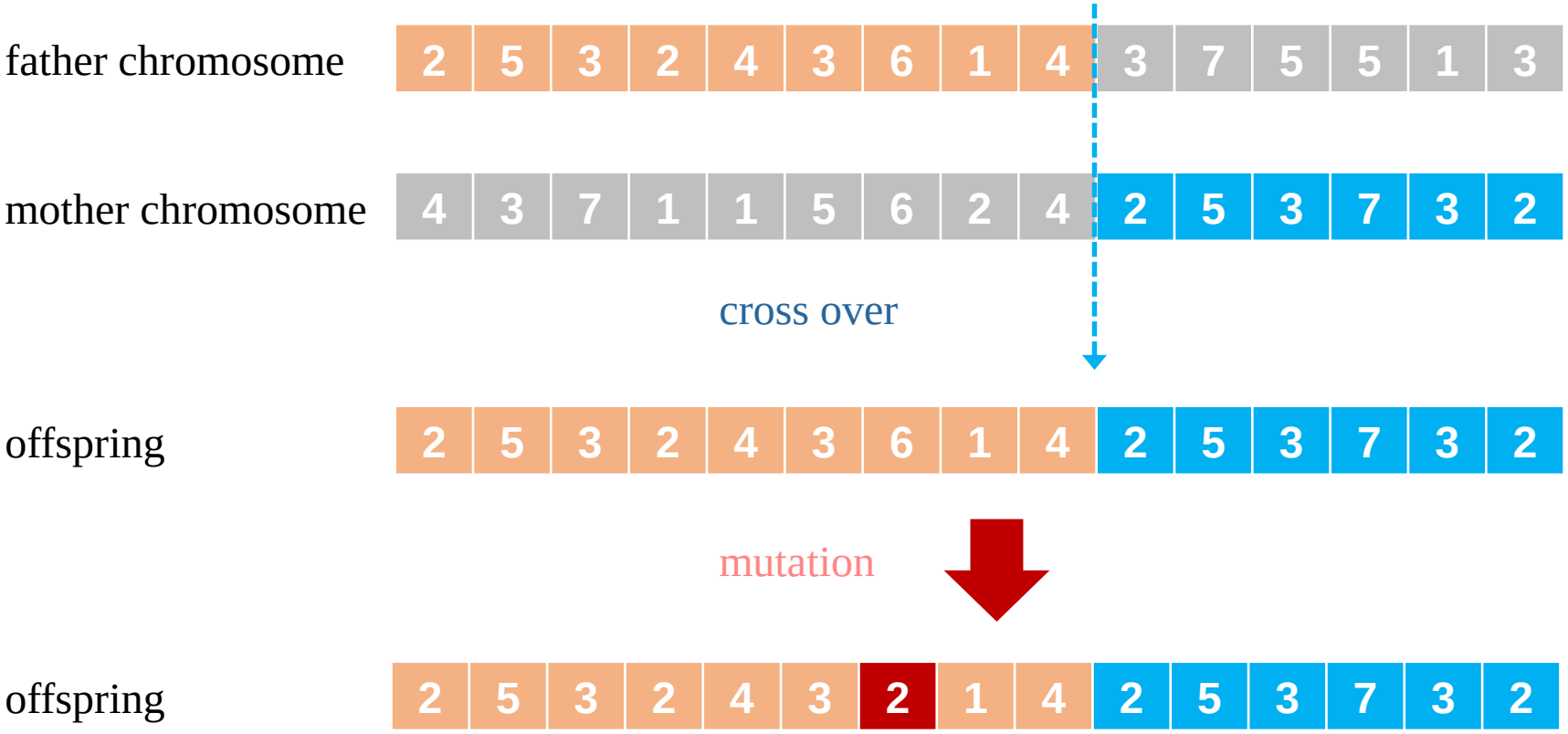




성신여자대학교

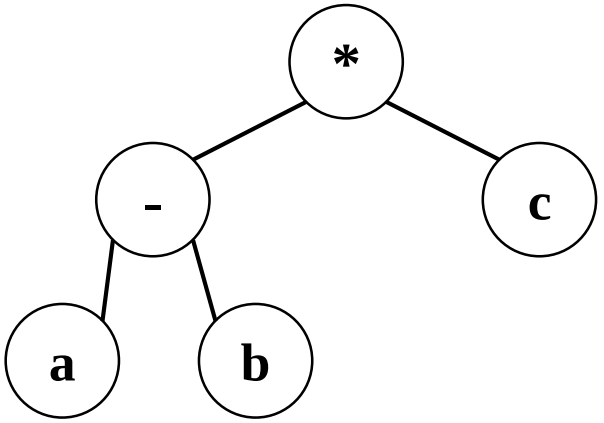
Example of Application: Uber

- **Cross over and mutation**
  - Uber's car assignment example (15 customers and 7 cars)



Genetic Programming (GP)

- **The computer program creates a program (in 1985, John Koza).**
- **A program has been developed since March.**
  - Three expression is implemented in C++.
  - Genetic algorithm has been verified and applied.



: Tree expression: *f* = (a–b) x c

operators	+, –, x, /, >, <, =
functions	exp, pow, log, ln, sin, cos, tan, sinh, cosh, tanh
number of variables	799
number of branches	1,000

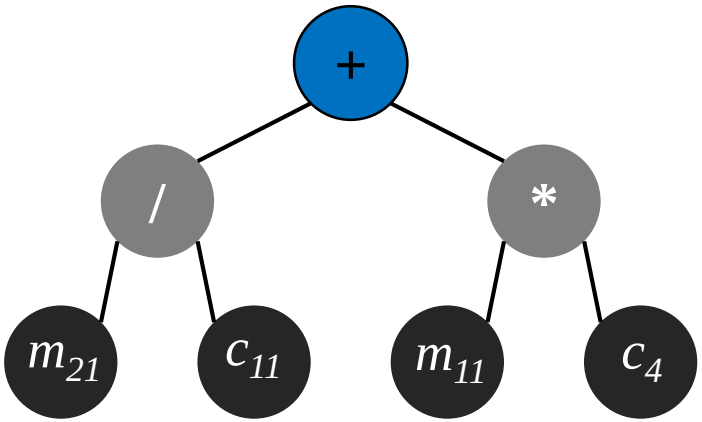
Genetic Programming

initialize population;
evaluate;
repeat{
    Selection;
    Crossover;
    Mutation;
    Replacement;
} until no progress;

Genetic Programming

initialize population;
evaluate;
repeat{
    Selection;
    Crossover;
    Mutation;
    Replacement;
} until no progress;

Chromosome Expression & Evaluation

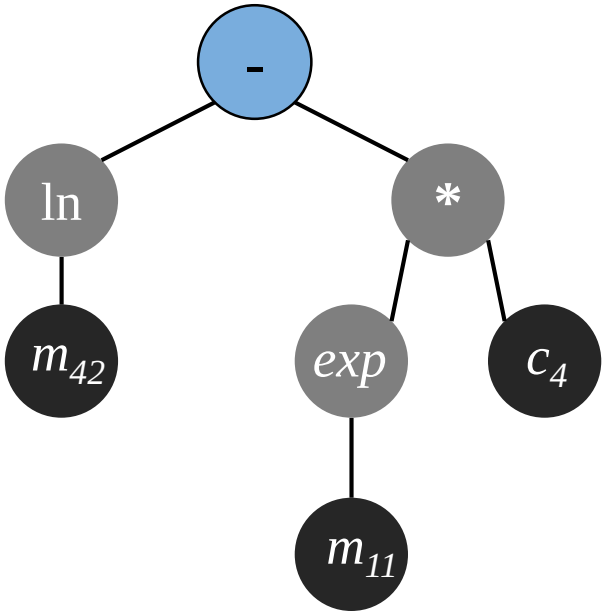


$$C_P = \left[\frac{m_{21}}{c_{11}}\right] + \left[m_{11} \times c_4\right]$$

$$\text{cost} = \frac{1}{n}\sum_i \left[C_{P,EXP,i} - C_{P,GA,i}\right]^2$$

superior

inferior



$$C_P = \left[\log\left(m_{42}\right)\right] - \left[\left\{\exp\left(m_{11}\right)\right\} \times c_4\right]$$

$$\text{cost} = \frac{1}{n}\sum_i \left[C_{P,EXP,i} - C_{P,GA,i}\right]^2$$

Genetic Algorithm

initialize population;
evaluate;
repeat{
    Selection;
    Crossover;
    Mutation;
    Replacement;
} until no progress;

Roulette Wheel Selection

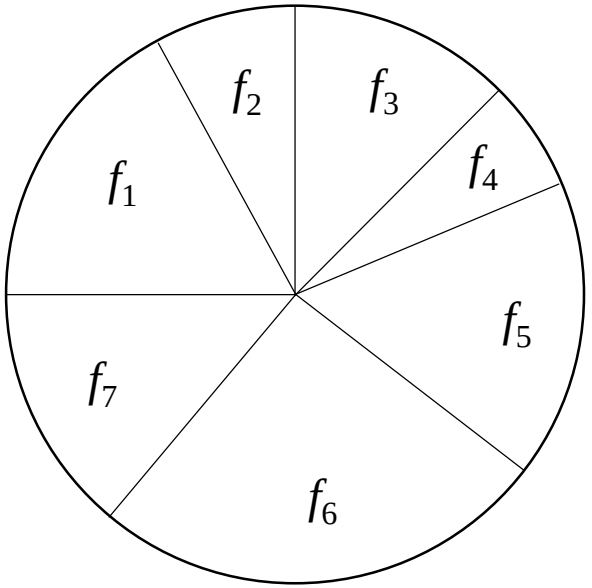
- **Roulette wheel selection**
  - $f_i = (C_w - C_i) + (C_w - C_b) / (k - 1),\ k > 1$

C_w : cost of the worst chromosome

C_b : cost of the best chromosome

C_i : cost of i th chromosome

k : the selection pressure



Pseudo Code

```
point = rand(0, sum f_i);
sum = 0.0;
for i = 0 to n – 1 {
        sum = sum + f_i;
        if (dart < sum) return i;
}
```

성신여자대학교

Tournament Selection

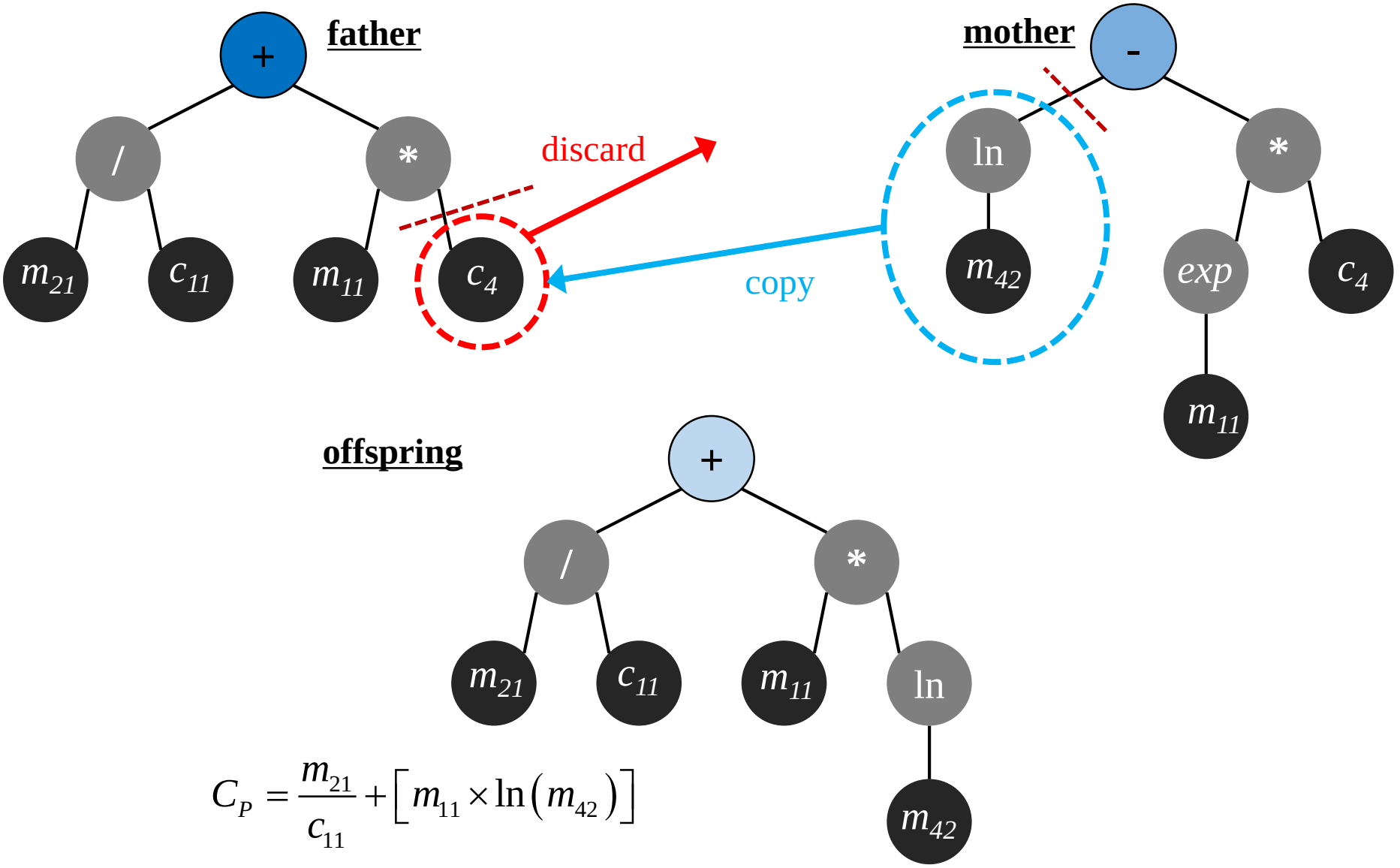
Pseudo Code

```
t = 0.7;
r = rand(0, 1);
for i = 0 to 1 {
      chromosome1 = rand(0, number of chromosomes);
      chromosome2 = rand(0, number of chromosomes);
     if (t > r) {
            if (cost of chromosome 1 > cost of chromosome 2) parent[i] = chromosome 1;
            else father = chromosome 2;
     }
     else {
            if (cost of chromosome 1 > cost of chromosome 2) parent[i] = chromosome 2;
            else father = chromosome 1;
     }
}
```

Genetic Algorithm

initialize population;
evaluate;
repeat{
    Selection;
    Crossover;
    Mutation;
    Replacement;
} until no progress;

Cross Over



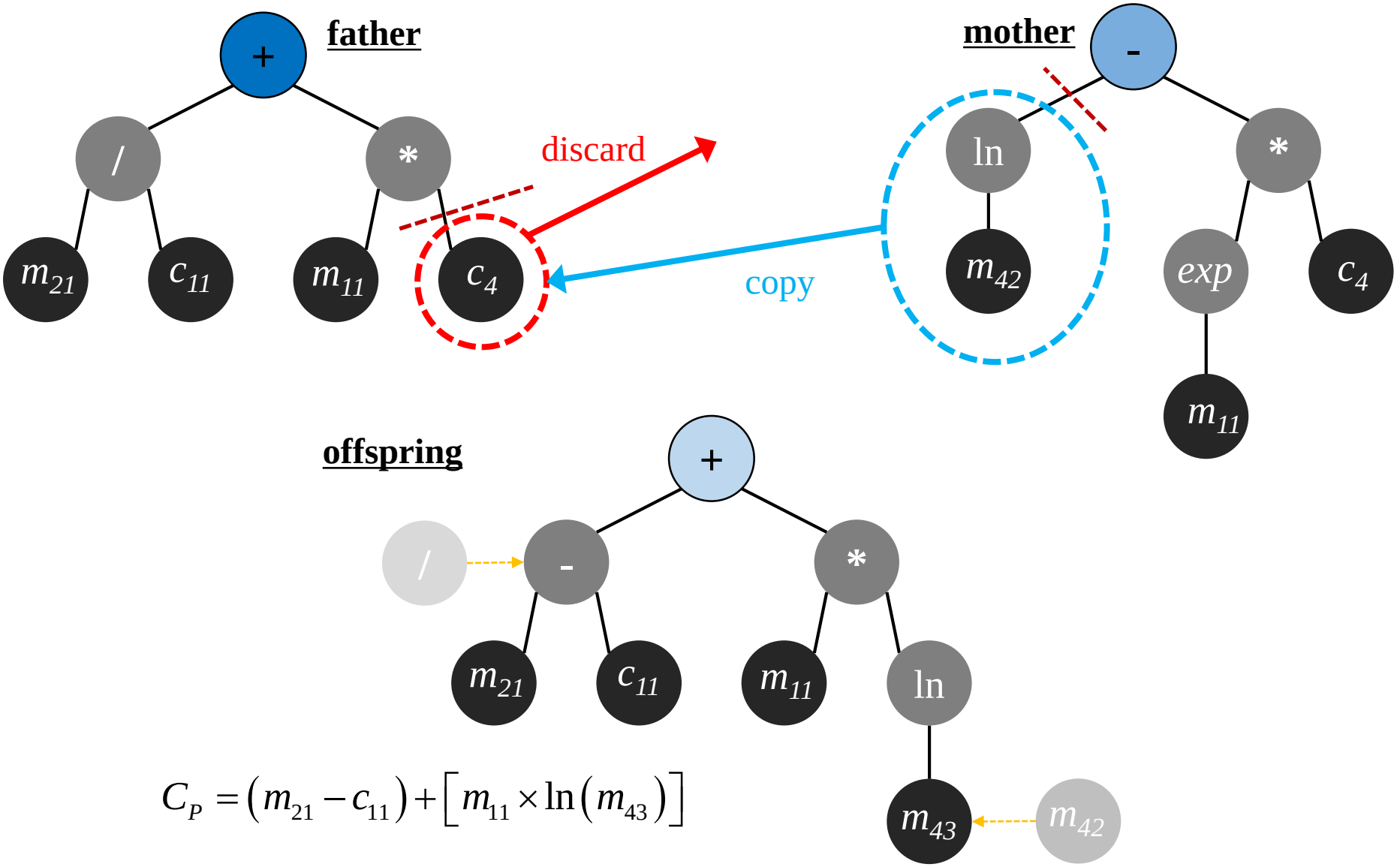
$$C_P = \frac{m_{21}}{c_{11}} + \left[m_{11} \times \ln\left(m_{42} \right) \right]$$

Genetic Algorithm

- **Pseudo code**

initialize population;
evaluate;
repeat{
    Selection;
    Crossover;
    Mutation;
    Replacement;
} until no progress;

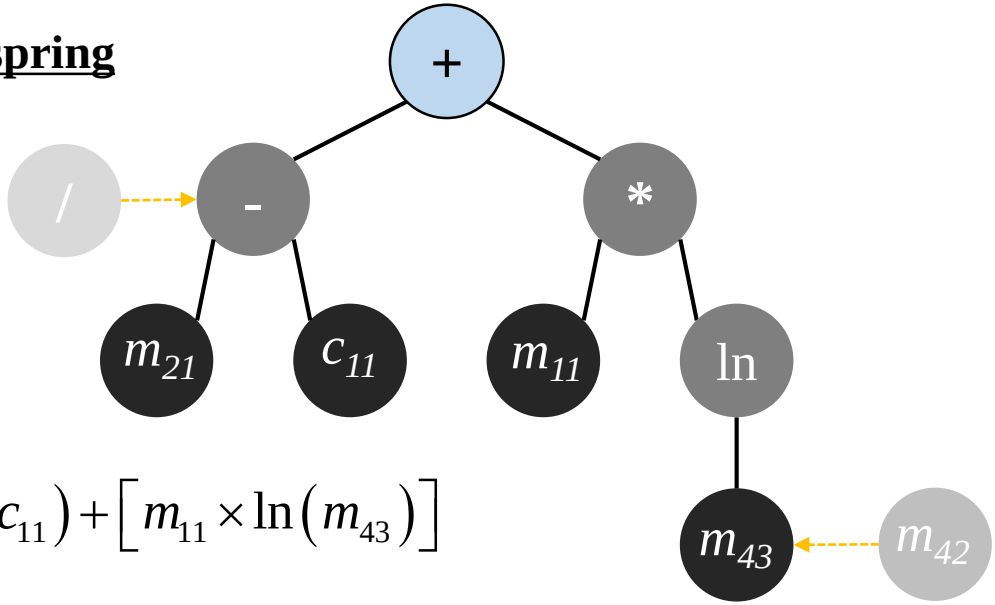
Mutation



$$C_P = \left(m_{21} - c_{11}\right) + \left[m_{11} \times \ln\left(m_{43}\right)\right]$$

Atrophy

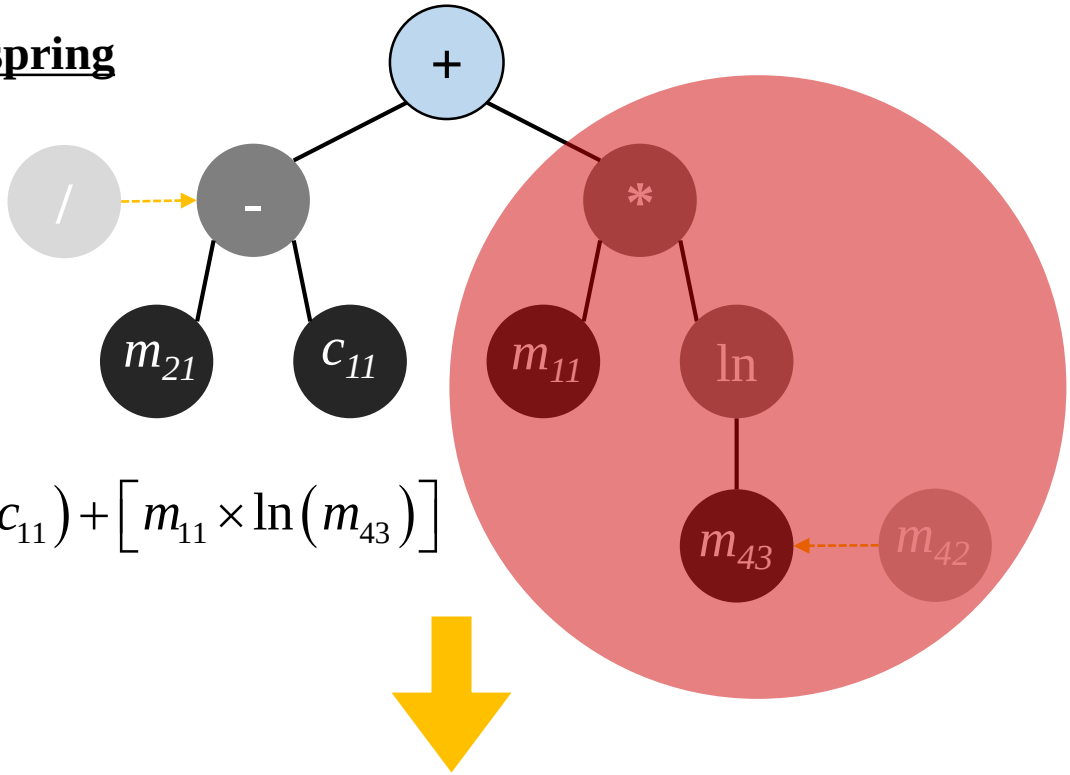
offspring



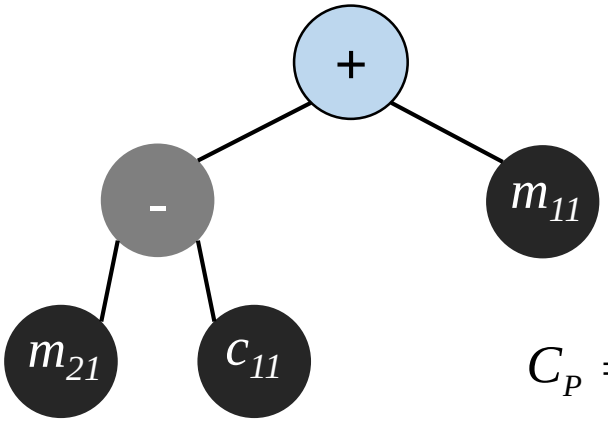
$$C_P = \left(m_{21} - c_{11}\right) + \left[m_{11} \times \ln\left(m_{43}\right)\right]$$

Atrophy

offspring



$$C_P = \left(m_{21} - c_{11}\right) + \left[m_{11} \times \ln\left(m_{43}\right)\right]$$

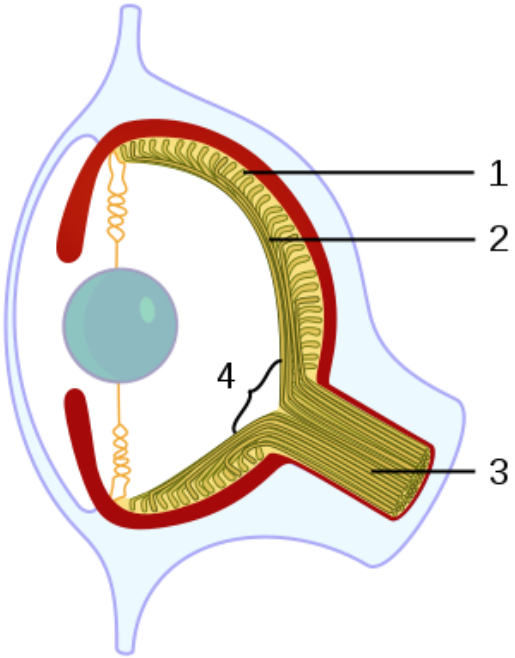


$$C_P = \left(m_{21} - c_{11}\right) + \left[m_{11} \times \ln\left(m_{43}\right)\right]$$

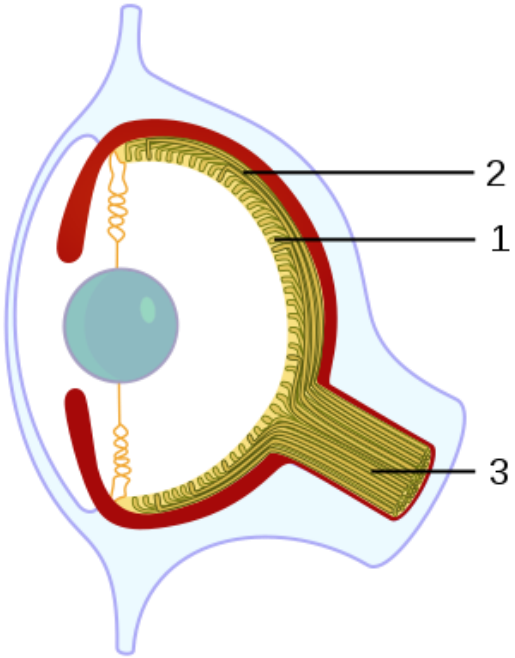
Verification Case II: Results

- **GA is very vulnerable to the local optimization.**
- **Schema cannot be automatically purified *or* simplified.**

*



Vertebrate

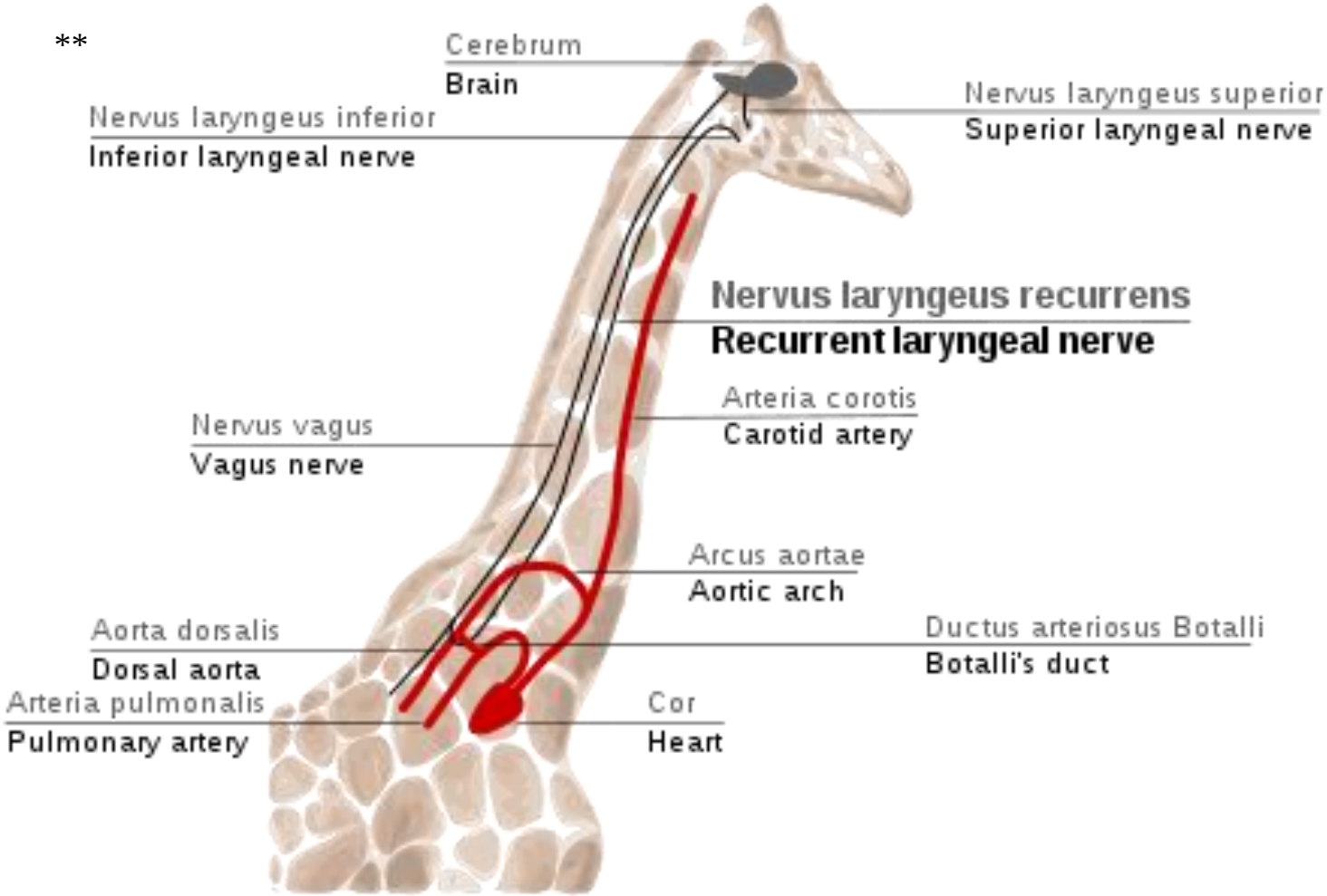


Octopus

* https://en.wikipedia.org/wiki/Blind_spot_(vision)

Verification Case II: Results

- **GA is very vulnerable to the local optimization.**
- **Schema cannot be automatically purified *or* simplified.**



** https://rationalwiki.org/wiki/File:GiraffaRecurrEn.svg