EVOLUTION STRATEGIES

EVOLUTION STRATEGIES: IDEAS

CAUSE THE LIMITATON OF COMPUTATION OF THE TIME IT WAS THINKED AS SOMETHING SIMPLER

- Invented in the '60
- Some similarities with GA:
  - There is a population of solutions

    ⚠ NO CROSSOVER
  - There are offsprings derived from mutation
  - There is a selection process → SIMPLER AND BRUTAL: YOU CHOOSE 10 AND TRASH THE OTHERS

EVOLUTION STRATEGIES: IDEAS

- However, they have some key differences:
  - There is (usually) no crossover
  - The most used selection is truncated selection
  - Usually the individuals represent floating points values (which is also possible with GA)

ES PARAMETERS

YOU USE μ TO GENERETE

λ — Number of children that are generated

μ — Number of selected individuals

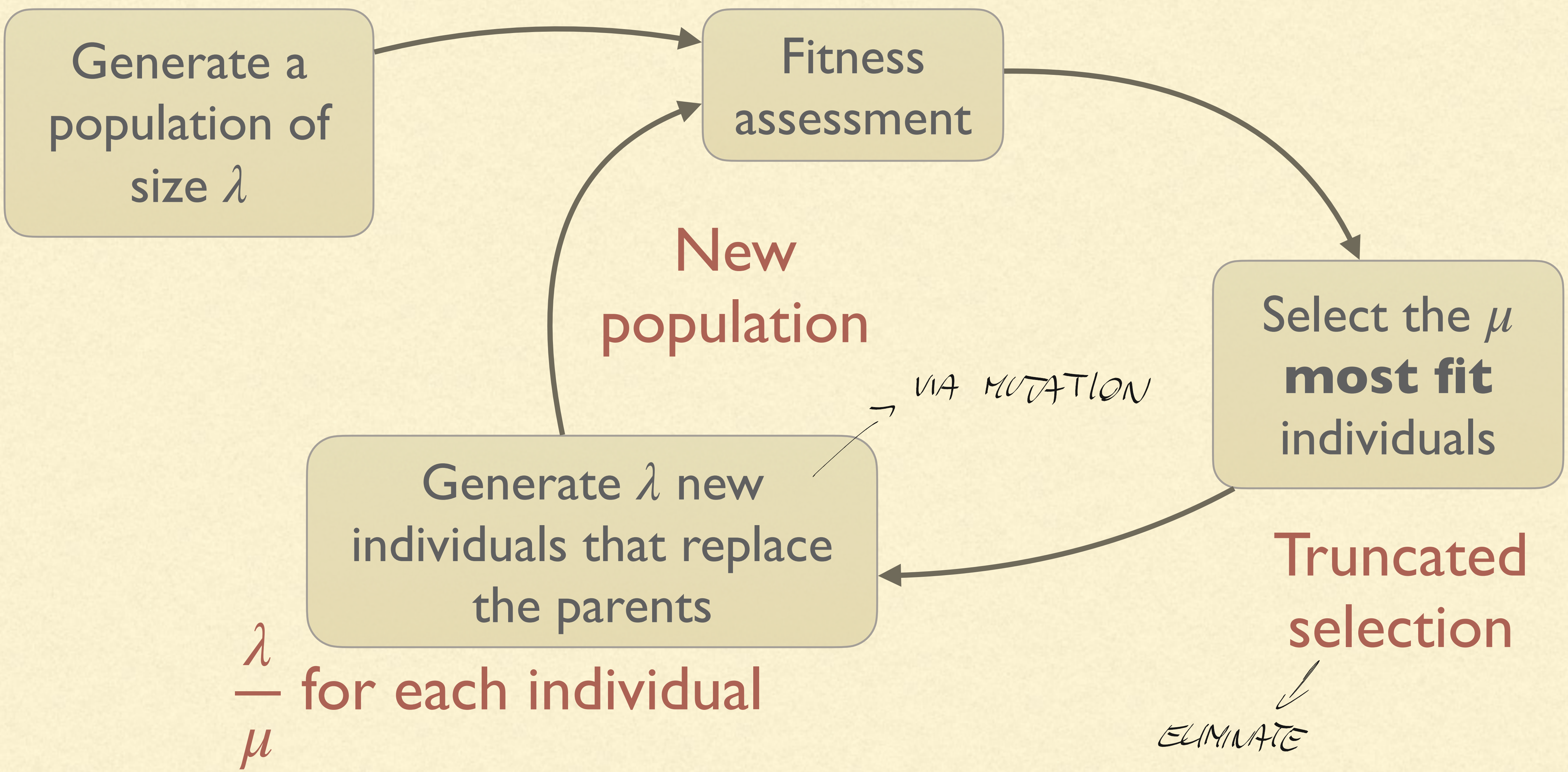
Two different kinds of ES:

$$(\mu, \lambda) - ES \qquad (\mu + \lambda) - ES$$

THE **ES** CYCLE

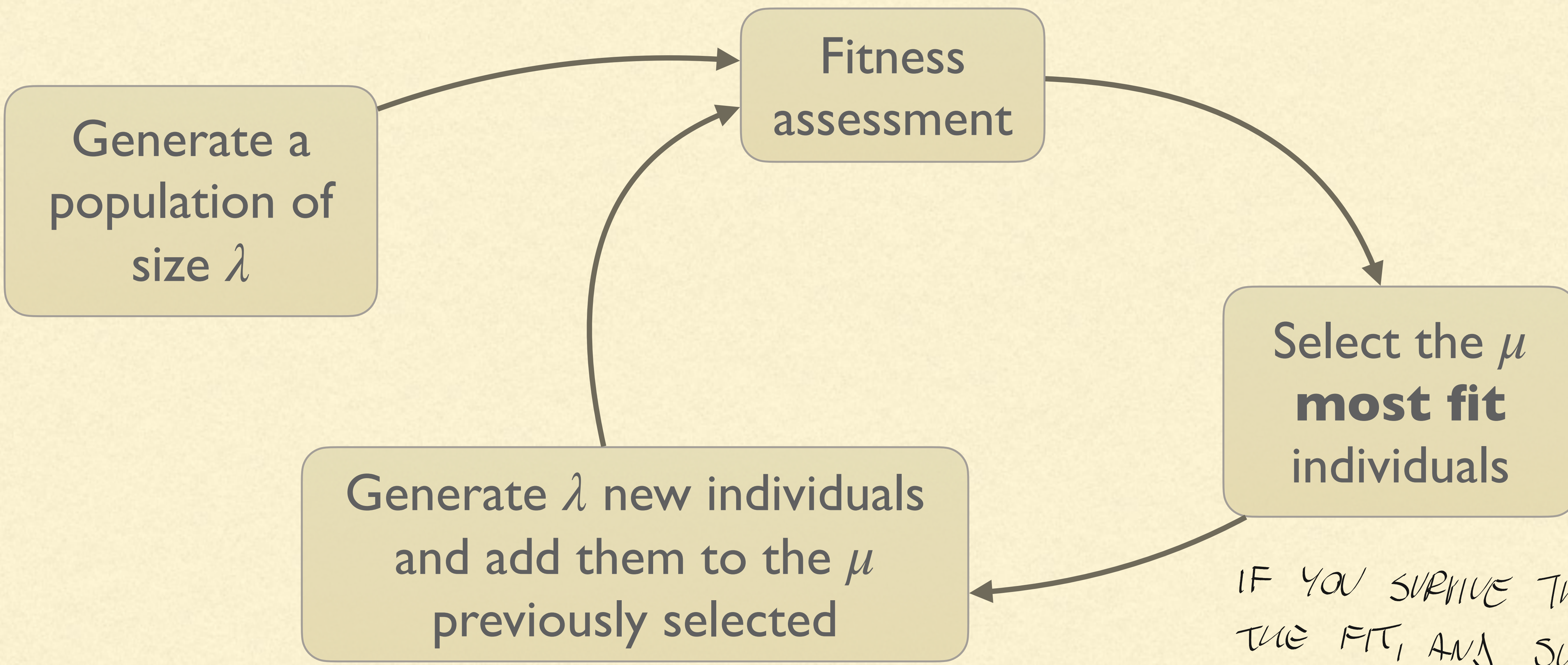
$(\mu, \lambda) - ES$

MORE SIMPLER CYCLE THAN THE ONE FOR GA



THE **ES** CYCLE

$(\mu + \lambda) - ES$



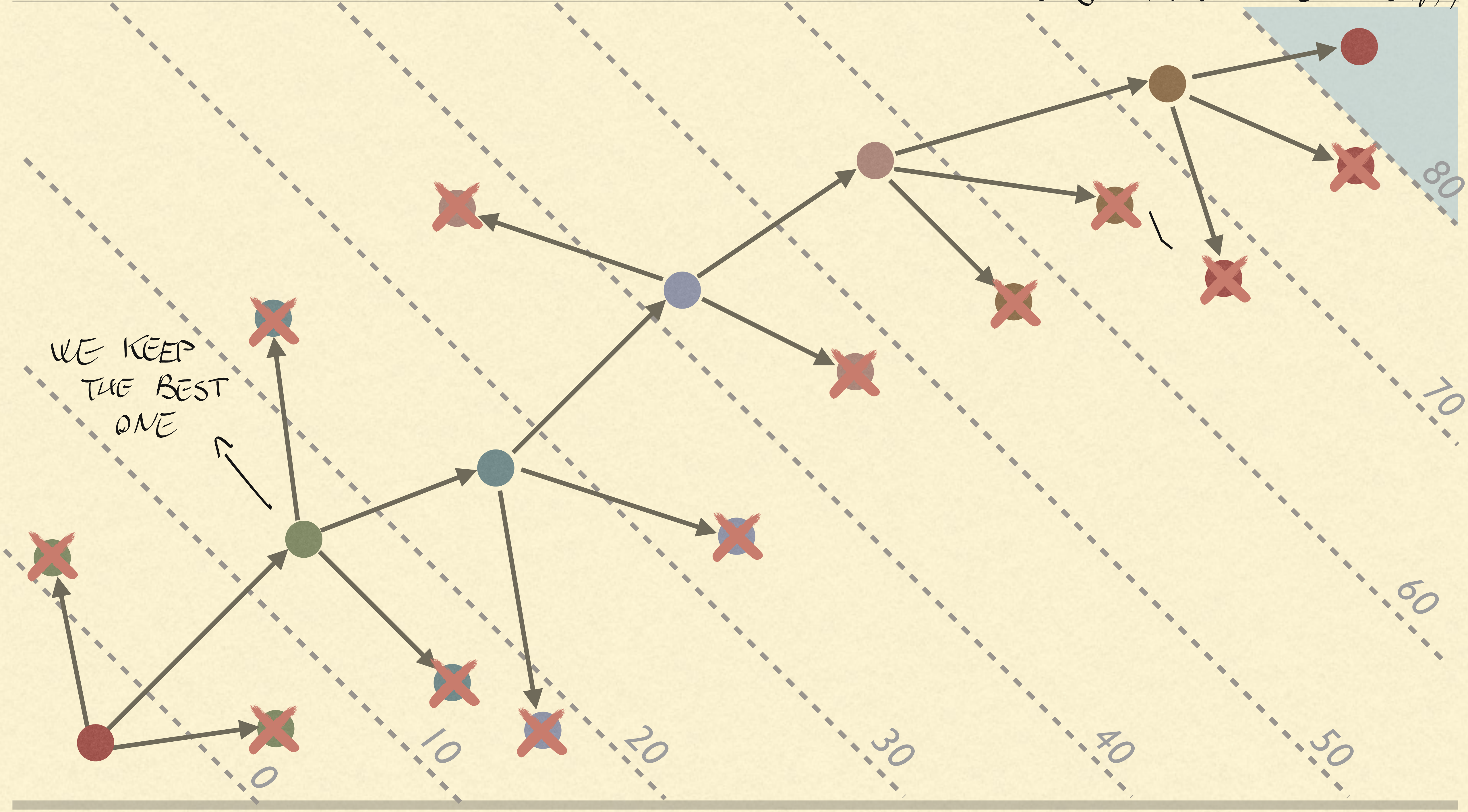
IF YOU SURVIVE THROW THE FIT, AND SUMMED TO YOUR CHILDREN IT'S SURE THAT YOU ARE GONNA SURVIVE

The parents are added together with the children to the new population

EXAMPLE OF (1,3) ES

⚠ A DOT IS A MUTATION OF THE FITTEST.
EACH POINT RAPPRESENT A CONFIGURATION THAT GET CLOSER AND CLOSER TO THE SOLUTION, THEY AREN'T ADDED GRADUALLY AS IT SEEMS FROM THE GRAPH

KEEP GENERATE



PROPERTIES OF A GOOD MUTATION OPERATOR

- **Reachability**: each area of the search space can be reached in a finite number of steps

  IF NOT, I COULD BE CUT OFF FROME THE BEST SOLUTION

- **Unbiasedness**: mutation should not use any information deriving from the fitness (that's the role of selection)

  WHY? BECAUSE YOU COULD GET STUCK IN A AREA OF THE SPACE DUE TO THE ALGORYTH BECOMING GREADY

- **Scalability**: the "strength" of the mutation should be adaptable to the specific fitness landscape/search space (e.g., by deciding how much the mutation changes an individual)

  IT'S LIKE SETTING A LEARNING RATE OF AN ALGORITHM

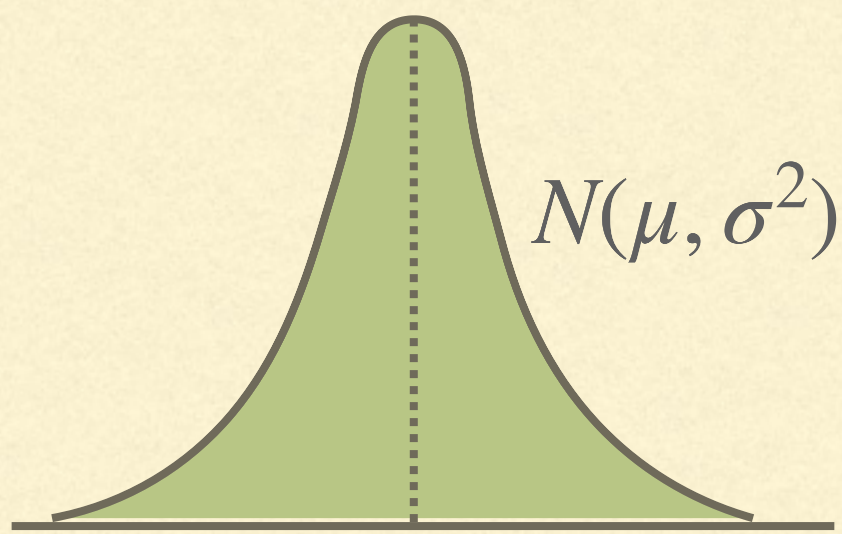
MUTATION

For binary values: the same as GA

In the case of real values the mutation is usually performed by adding a gaussian noise to the coordinates

Gaussian

$$x_i +$$



$\mu = 0$ seems natural, but how to select the variance?

OR YOU GUESS IT
OR ...

SELF-ADAPTIVITY IN ES

YOU DON'T WANT TO MOVE TO FAR AWAY BETWEEN EACH STEP. BUT, IF YOU NOTICE DURING THE EXECUTION THAT IT'S EASYIER IF YOU MOVE FAR, WHY NOT DO IT

- It is common do have self-adaptive ES, where a series of parameters (e.g., the variance) are modified during the evolution
- You can think of every individual of being a pair $\langle x, s \rangle$ where x is the actual solution and s a set of parameters of the operators used for mutation
- In some cases s itself is modified as part of the evolutionary process with the same operators it controls

ONE-FIFTH RULE

- An empirical rule for self-adaptation of the variance of the mutation operator
- Introduced by Info Rechenberg in the 70s
- If less than 1/5 of the children are fitter than their parents then decrease the variance → YOU HAVE TO REDUCE THE SPACE EXPLORED AND PERFORM A BETTER SEARCH
- If more than 1/5 of the children are fitter than their parents then increase the variance → INCRESE THE SPACE EXPLORED SO THE CHILDREN CAN HAVE MORE SPACE TO EXPLORE

ONE-FIFTH RULE

- Two parameters, $k \in \mathbb{N}$ and $c \in (0,1]$ (usually $0.817 < c < 1$)
- p_S is the probability of having a successful mutation
- Every k generations:
  - If $p_S > 1/5$ then set $\sigma = \sigma/c$
  - If $p_S < 1/5$ then set $\sigma = \sigma \cdot c$
  - Otherwise leave σ unchanged

ES WITH RECOMBINATION

- It is possible to extend ES with a recombination step (in addition to mutation) using ρ parents
- The notations are $(\mu/\rho, \lambda)$-ES and $(\mu/\rho + \lambda)$+ES

THEY EXIST BUT ARE NOT VERY COMMON BECAUSE PRATICALLY IT'S GA

- It means that to generate each of the λ children, ρ individuals are randomly selected (without reinsertion) from the population of size μ

ES WITH RECOMBINATION

- Two main kinds of recombination:
  - **Discrete/dominant recombination**: for each position select randomly from one of the ρ individuals
  - **Intermediate recombination**: given the values $x_{1,j}, x_{2,j}, \ldots, x_{\rho,j}$ for each position j of the parents the offspring will contain the average $\frac{1}{\rho}\sum_{i=1}^{\rho} x_{i,j}$ of all that values