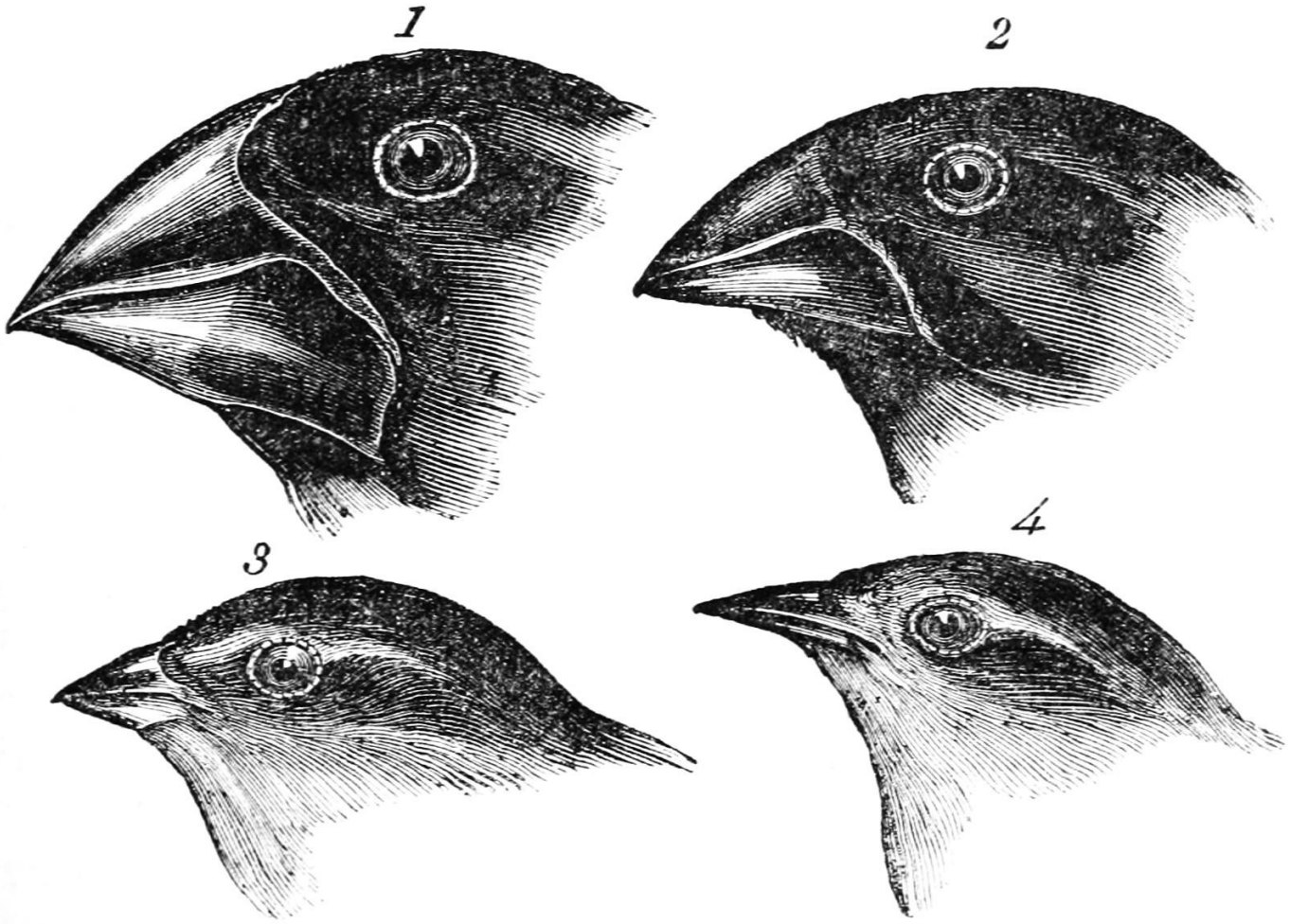
Evolutionary Computation

CMSC 326 Simulations

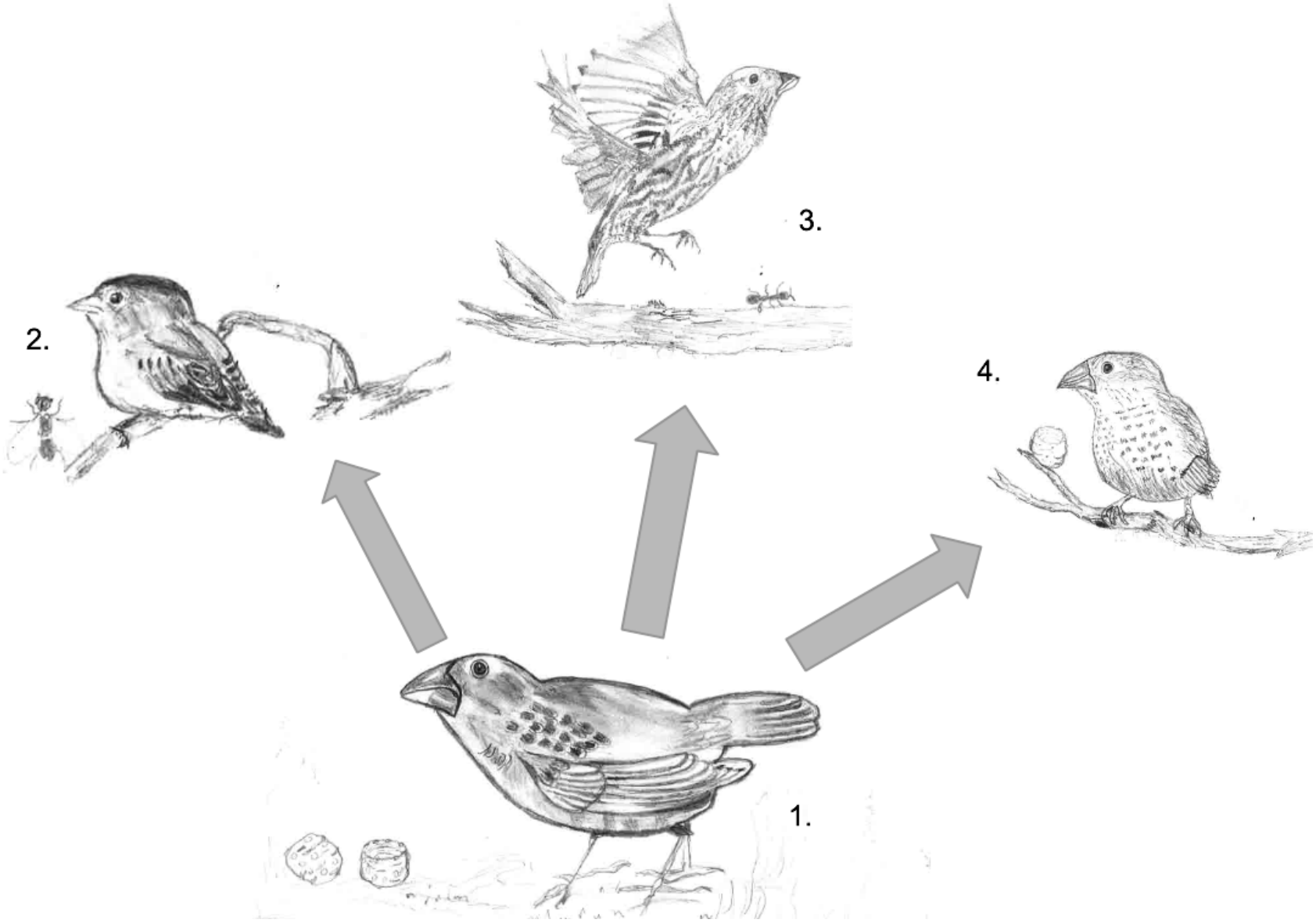
Darwin's Finches



1. Geospiza magnirostris.
3. Geospiza parvula.

2. Geospiza fortis.
4. Certhidea olivasea.

Darwin's Finches



Evolutionary Computing

Genetic Algorithms: developing code systems that evolve, which are inspired by the core principles of Darwinian evolutionary theory

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Genetic Algorithms: developing code systems that evolve, which are inspired by the core principles of Darwinian evolutionary theory

Ethical Note: We are only discussing the genetic modification of simulated creatures and code, not actual animals or organisms

How Genetic Algorithms Work

How can a population of creatures (a generic term for the elements of a simulation) evolve over a series of generations?

How Genetic Algorithms Work

Three core principles of Darwinian evolution:

Heredity: A mechanism that allows parent creatures in one generation to pass their traits down to child creatures in the next generation

How Genetic Algorithms Work

Three core principles of Darwinian evolution:

Variation: Need a variety of traits present in the population of creatures or a means to introduce variation for evolution to take place

How Genetic Algorithms Work

Three core principles of Darwinian evolution:

Selection: A mechanism by which some creatures have the opportunity to be parents and pass on their genetic information, while others don’t

Commonly referred to as survival of the fittest

How Genetic Algorithms Work

Step 1: Population Creation

Step 2: Selection

Step 3: Reproduction

Step 4: Repetition

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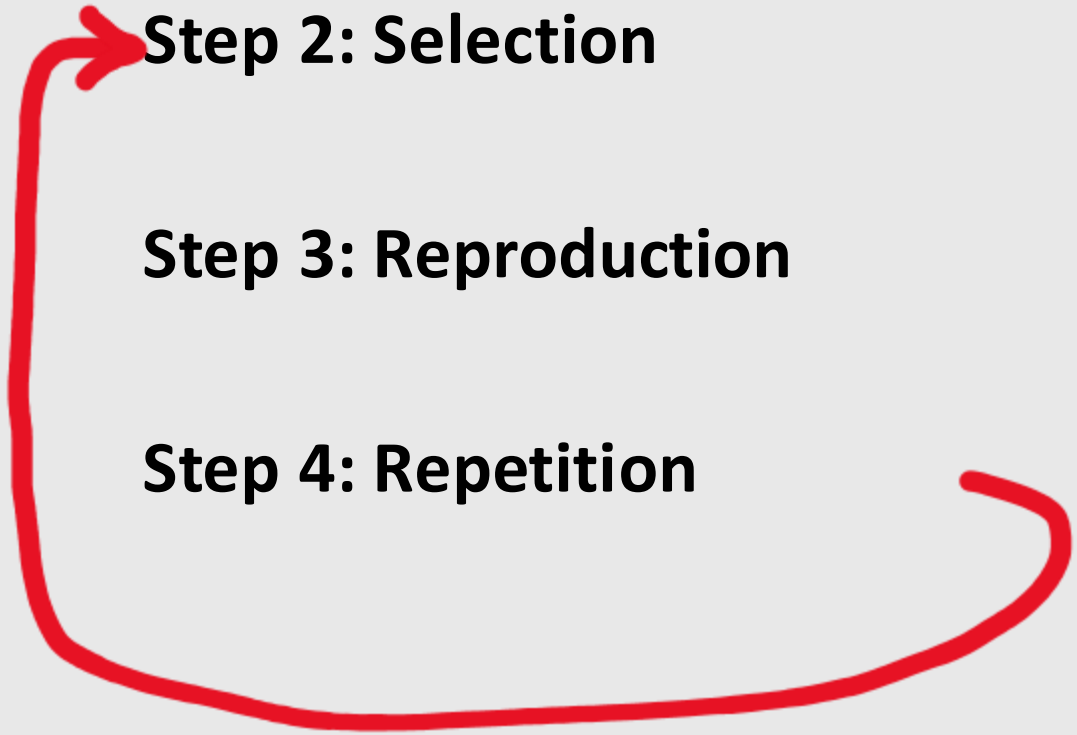

How Genetic Algorithms Work

Step 1: Population Creation

Create a population of N creatures or elements, each with randomly generated DNA

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Create a population of N creatures or elements, each with randomly generated DNA

Genotype: The actual genetic code — the particular sequence of molecules in the DNA

Phenotype: the expression of that data

How Genetic Algorithms Work

Genotype	Phenotype
0	
127	
255	

Same Genotype	Different Phenotype (Line Length)
0	
127	
255	

We do this all the time in graphics programming, taking values (the genotype)
and interpreting them in a visual way (the phenotype)

How Genetic Algorithms Work

Step 2: Selection

Evaluating the population and determining which members are fit to be selected as parents for the next generation

How Genetic Algorithms Work

Step 2: Selection

The process of selection can be divided into two steps:

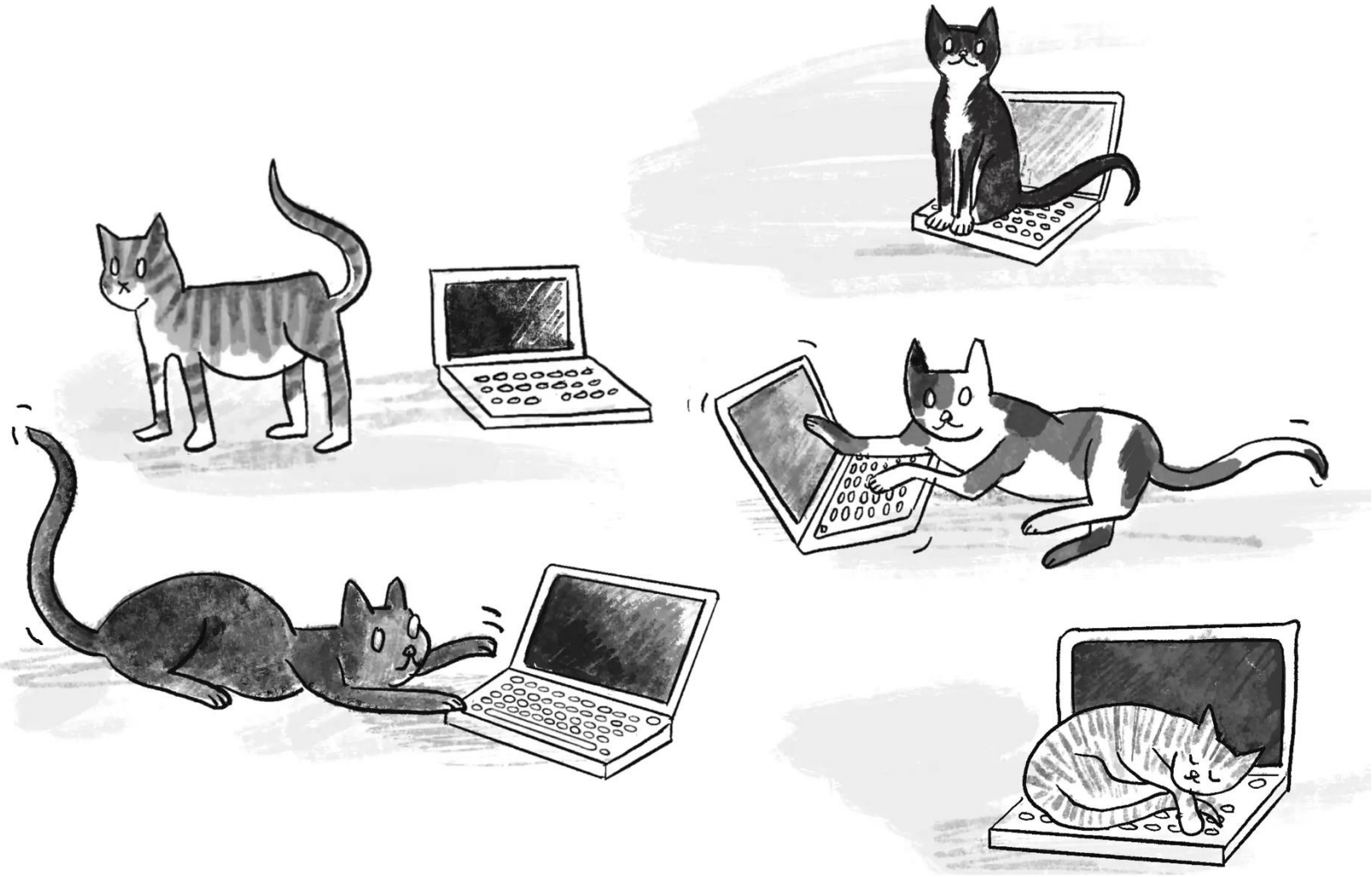
1. Evaluate fitness
2. Create a mating pool

How Genetic Algorithms Work

1. Evaluate fitness

Fitness function: a function that produces a numeric score to describe the fitness of a given element of the population

Example: Typing Cats



1. Evaluate Fitness

Say that we're trying to evolve the phrase **cat**

Fitness = the number of correct characters

DNA	Fitness
car	2
hut	1
box	0

2. Create a Mating Pool

Elitist Method: Select the two members of the population who scored the highest

Element	Fitness
A	3
B	4
C	0.5
D	1
E	1.5

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Probabilistic Method: selection is based on probabilities rather than deterministically

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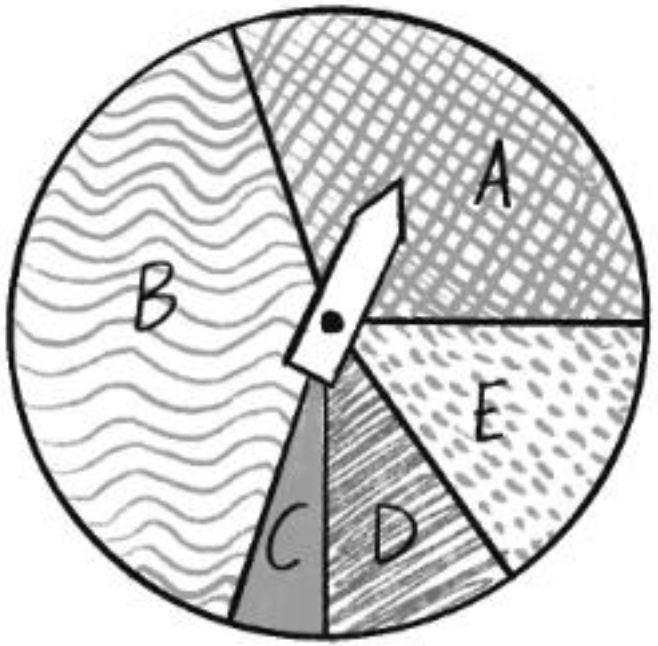
The first step is to **normalize** all the scores

Element	Fitness	Normalized Fitness	Expressed as a Percentage
A	3	0.3	30%
B	4	0.4	40%
C	0.5	0.05	5%
D	1	0.1	10%
E	1.5	0.15	15%

2. Create a Mating Pool



Fitness roulette:

Element	Fitness	Normalized Fitness	Expressed as a Percentage
A	3	0.3	30%
B	4	0.4	40%
C	0.5	0.05	5%
D	1	0.1	10%
E	1.5	0.15	15%

2. Create a Mating Pool

Fitness roulette unlike with the **elitist** method, even the lowest-scoring element has at least some chance of passing its information to the next generation

Element	DNA
A	to be or not to go
B	to be or not to pi
C	purrrrrrrrrrrrr be

How Genetic Algorithms Work

Step 3: Reproduction

Create the population’s next generation

How Genetic Algorithms Work

Step 3: Reproduction

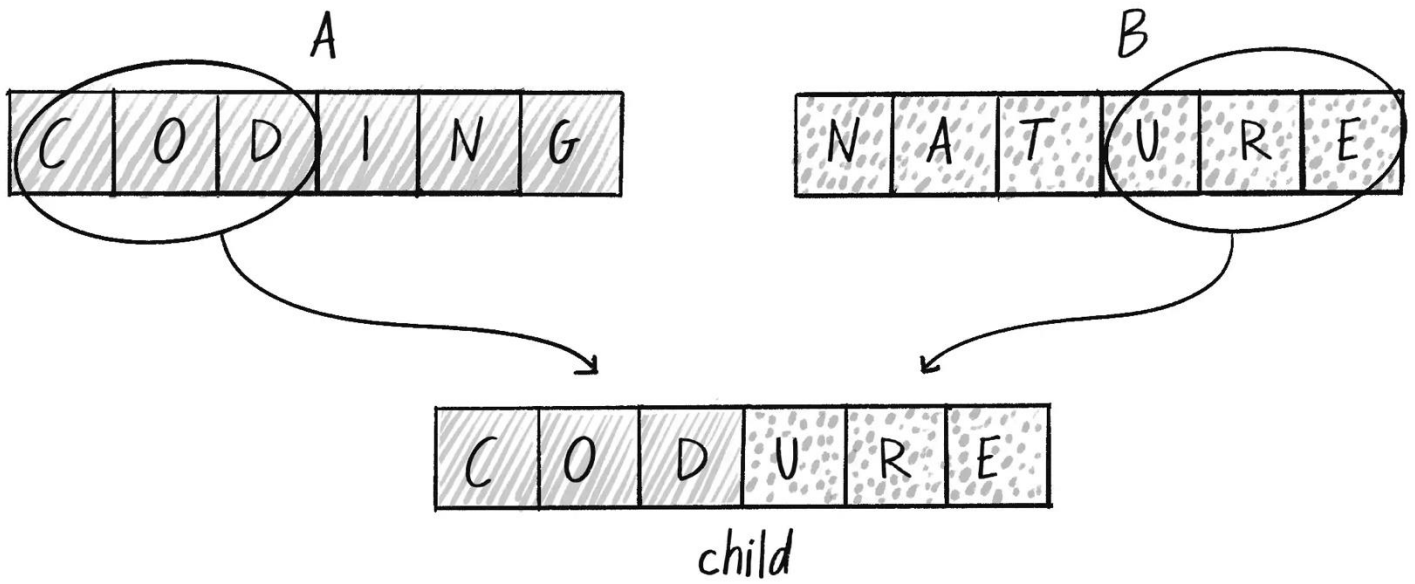
Create the population's next generation

Standard approach is to pick two parents and create a child according to two steps:

1. Crossover
2. Mutation

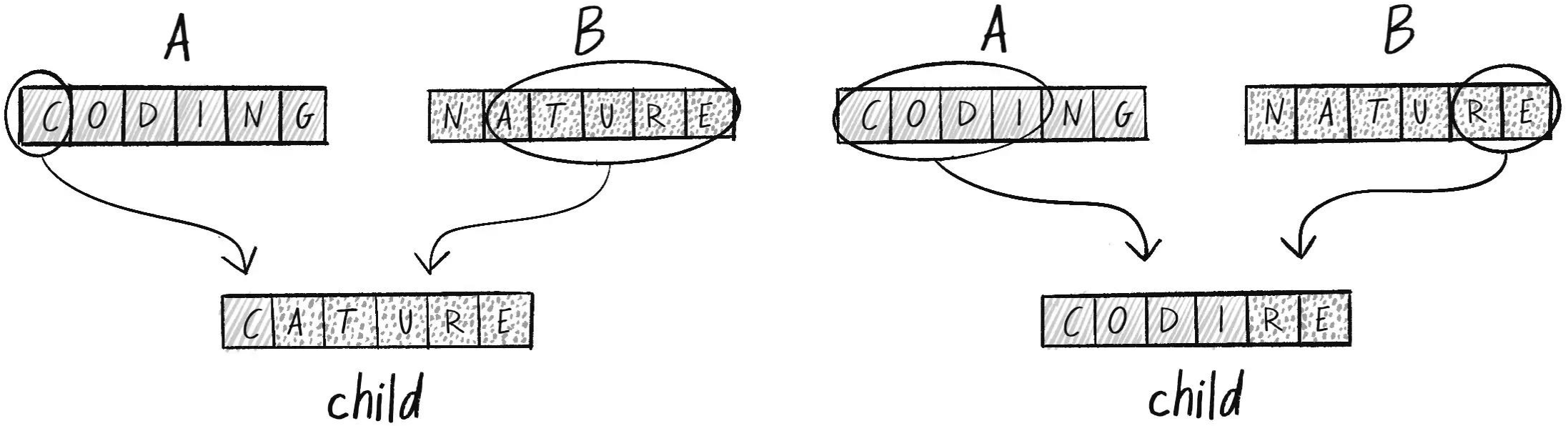
Crossover

Parent A	coding
Parent B	nature



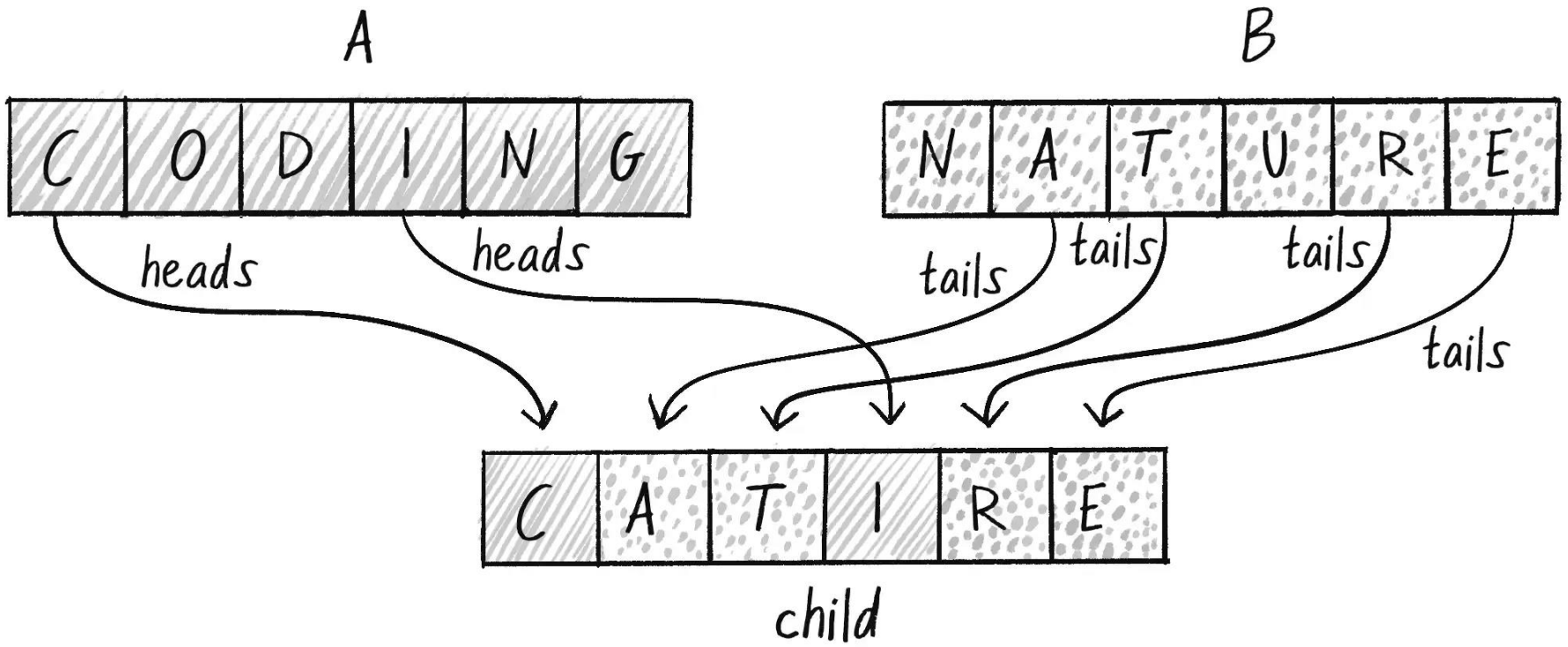
Crossover

Parent A	coding
Parent B	nature



Crossover

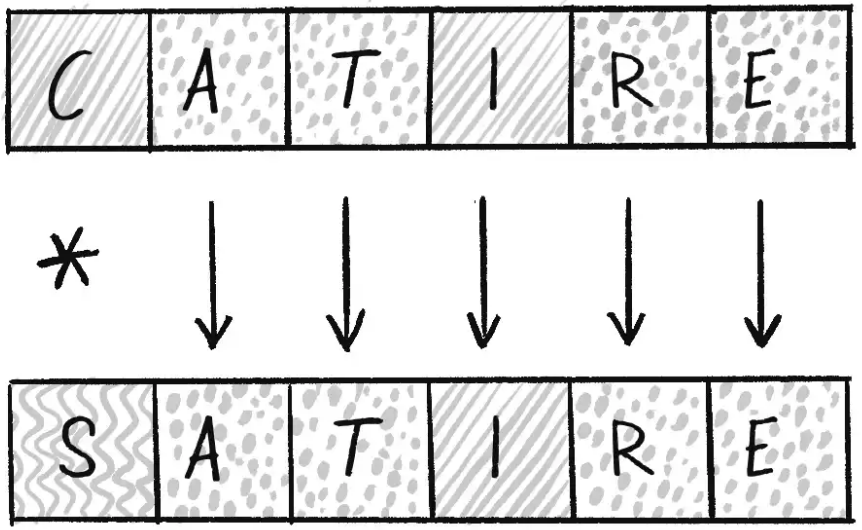
Parent A	coding
Parent B	nature



Mutation

Mutation is described in terms of a *rate*

A given GA might have a mutation rate of 5 percent, or 1 percent, or 0.1 percent



How Genetic Algorithms Work

Step 4: Repetition

New population of children becomes the current population

Process returns to step 2 and starts all over again, evaluating the fitness of each element, selecting parents, and producing another generation of children