

Search-Based Software Engineering

Evolutionary Algorithms - Part I

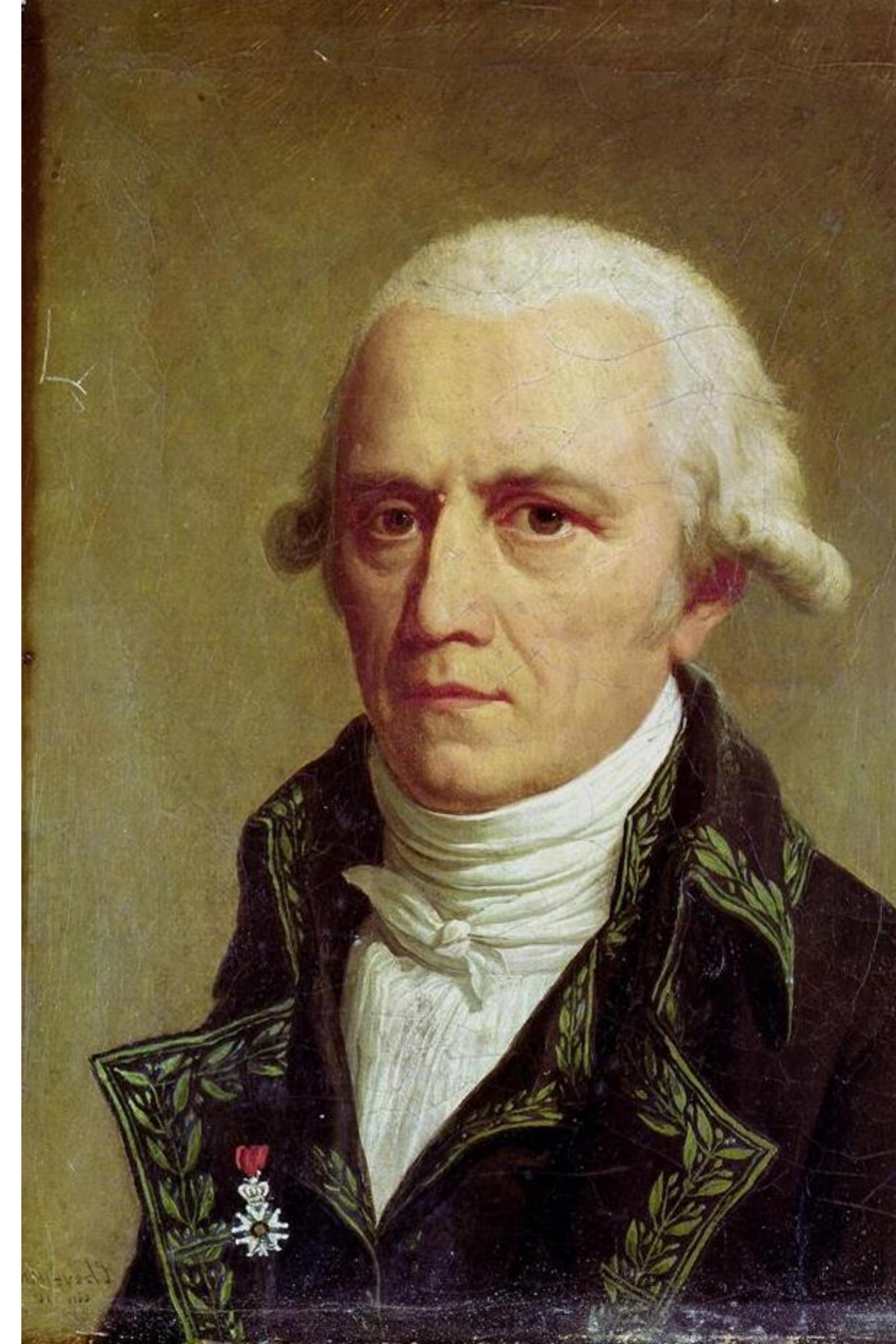
Gordon Fraser
Lehrstuhl für Software Engineering II

Contents

- What is Evolution?
- History of Evolutionary Computation
- Evolutionary Algorithms

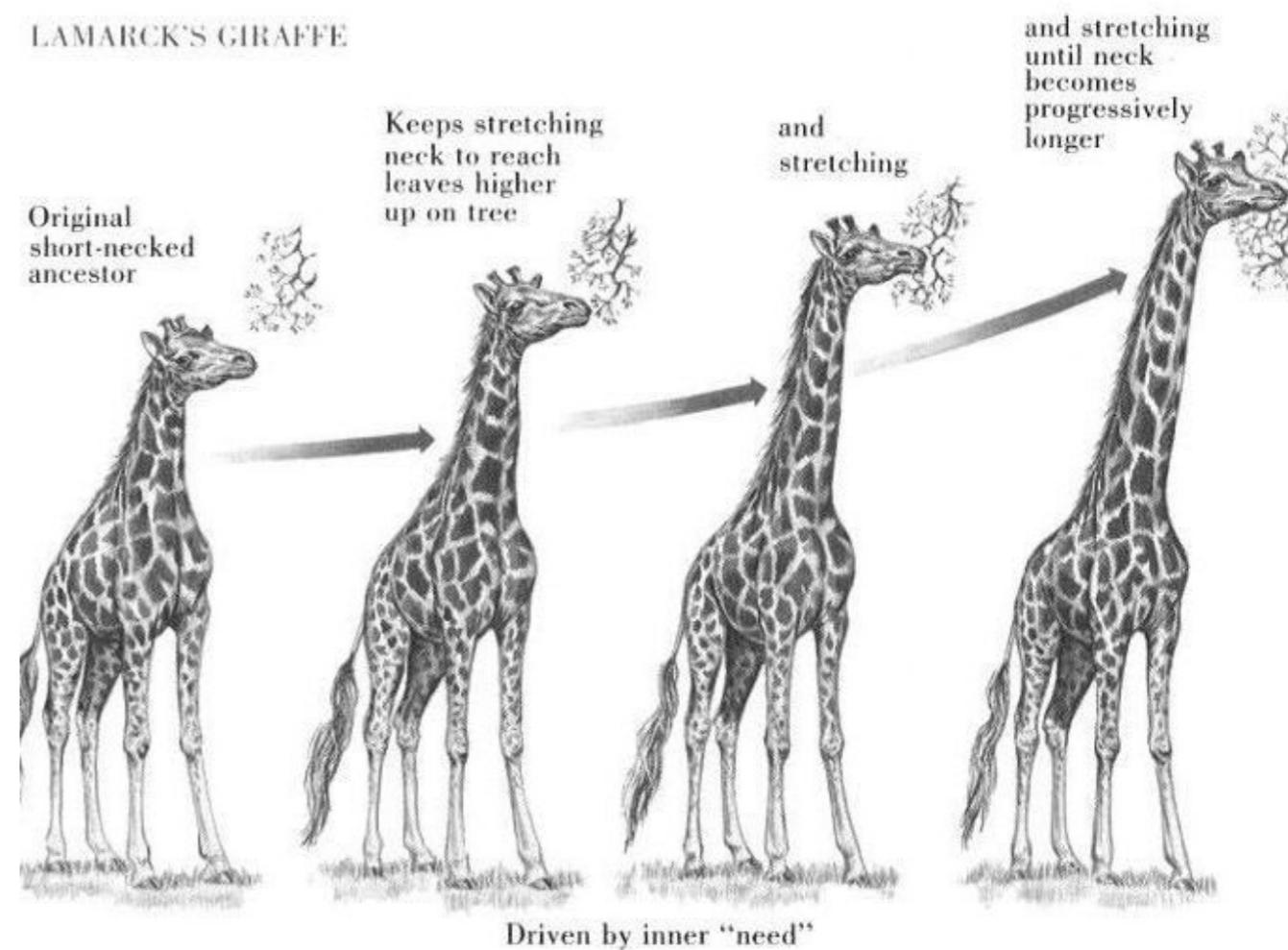
What is Evolution?

Jean Baptiste Lamarck

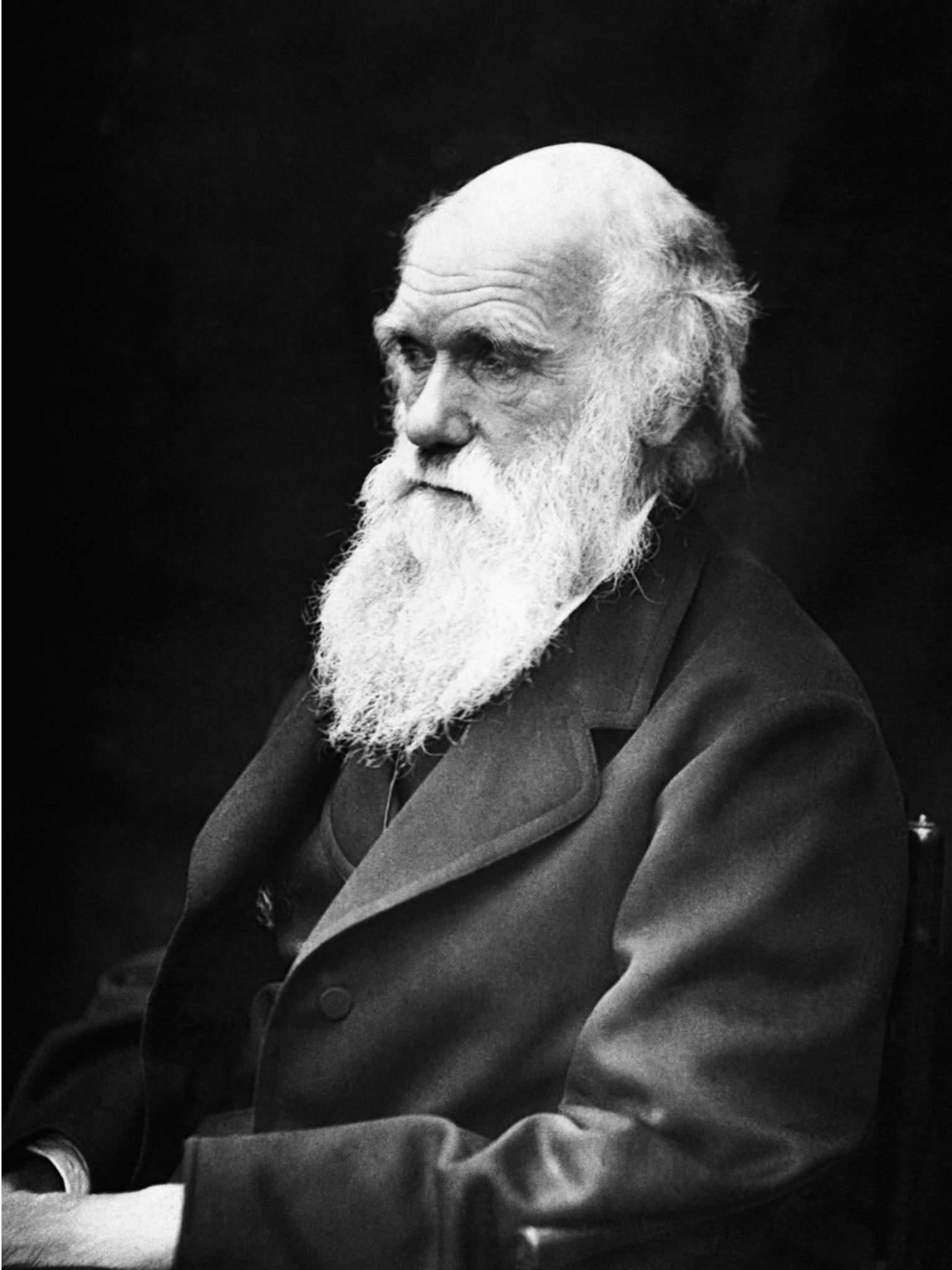


Lamarckism

- “Heritability of acquired characteristics”
- During lifetime, an organism will adapt to its environment and acquire certain traits.
- These traits are inherited to the offspring.
- Eventually, the species changes in the direction of adaptation.



Charles Darwin



Darwinism

- An attempt to theorise the emergence of species.
- If all offspring survived to reproduce the population would grow (fact).
- Despite periodic fluctuations, populations remain roughly the same size (fact).
- Resources are limited and are relatively stable over time (fact).
- A struggle for survival ensues (inference).
- Individuals in a population vary significantly from one another (fact).
- Much of this variation is heritable (fact).
- Individuals less suited to the environment are less likely to survive and less likely to reproduce; individuals more suited to the environment are more likely to survive and more likely to reproduce and leave their heritable traits to future generations, which produces the process of natural selection (inference).
- This slowly effected process results in populations changing to adapt to their environments, and ultimately, these variations accumulate over time to form new species (inference).



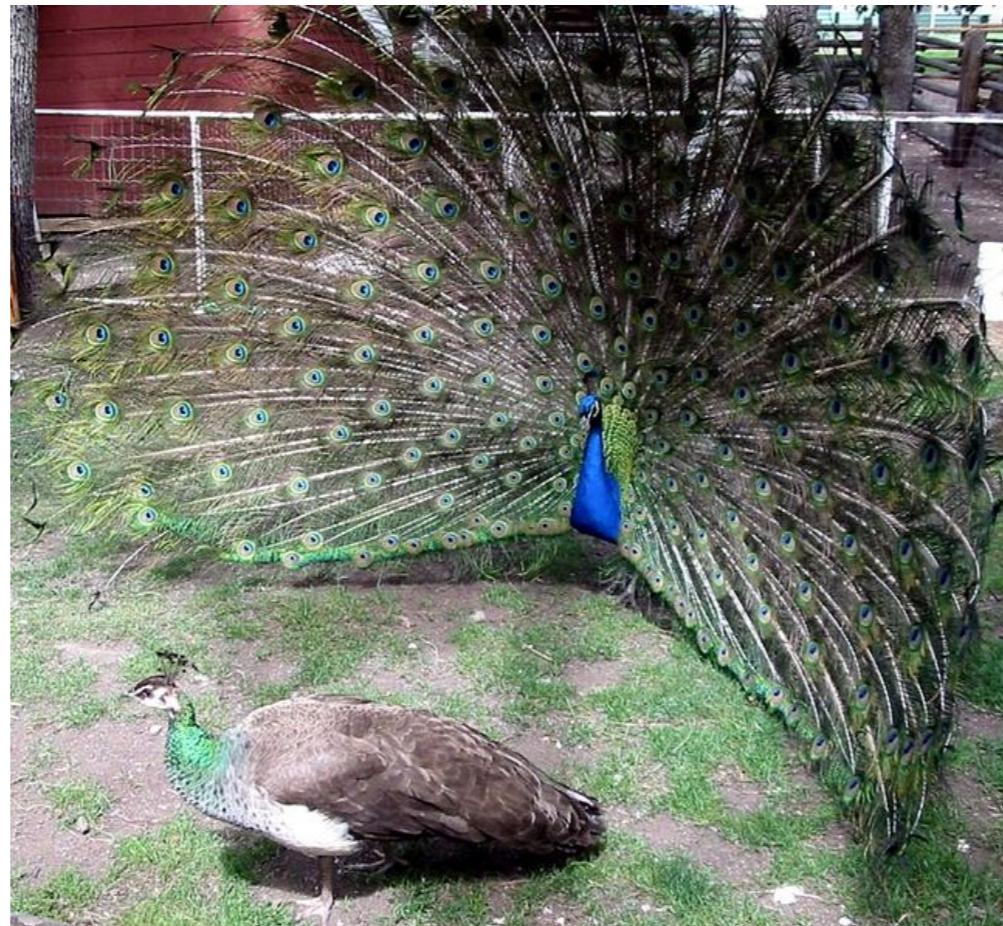
Traditional peppered moth



Peppered moth during industrial revolution

Evolutionary Pressure

- Also known as selection pressure: Anything that affects the reproductive success rate exerts evolutionary pressure.
- One critical link in Darwinian evolution: fitter individuals are assumed to have better reproductive success rate.





Gregor Mendel

Mendelism

- Hereditary “unit” (he called them “factors”, now we know them as “genes”)
- Explained the mechanism of inheritance.



Genetics

- Each **gene** encodes a different trait of individual
 - An **allele** is a concrete value a gene can have
- **Chromosome:** A sequence of genes
- **Genome:** Complete genetic information of a living being
- **Genotype:** Genetic encoding of an individual; that part of the genetic material that determines a specific characteristic of an individual
- **Phenotype:** The characteristic manifested by a specific genotype.

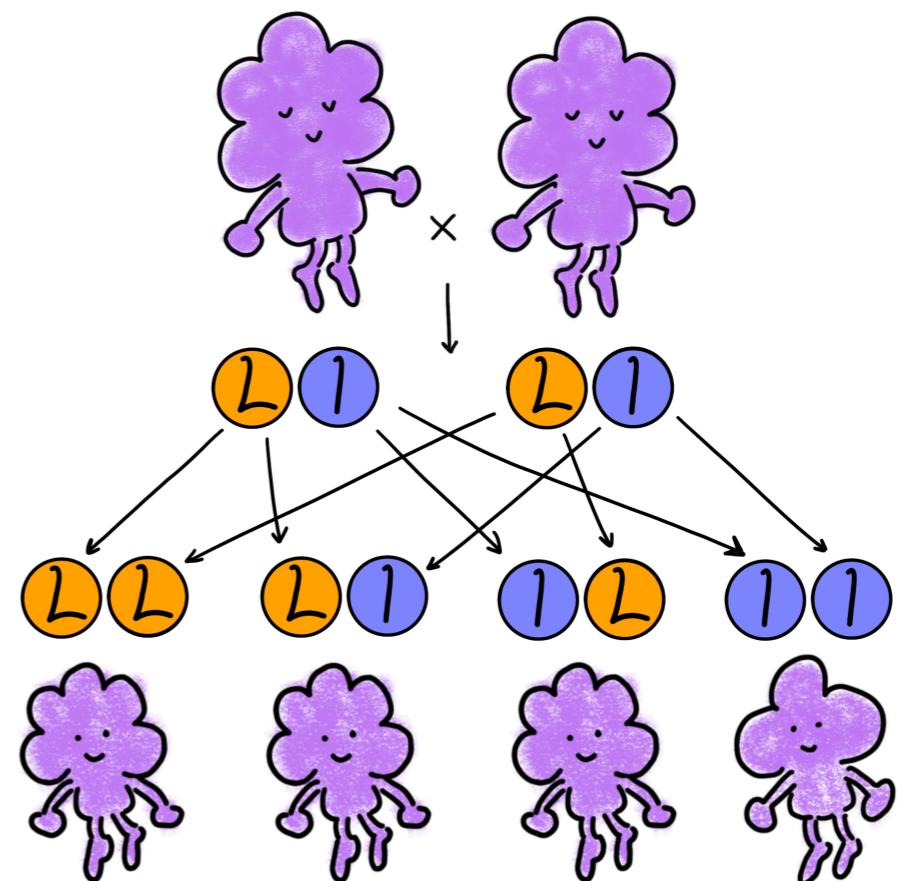
Law of Dominance

- Recessive alleles will be masked by dominant alleles.
- Little evidence that tongue-rolling is a dominant Mendelian trait though.
 - Martin, N. G. No evidence for a genetic basis of tongue rolling or hand clasping. *J. Hered.* 66: 179-180, 1975



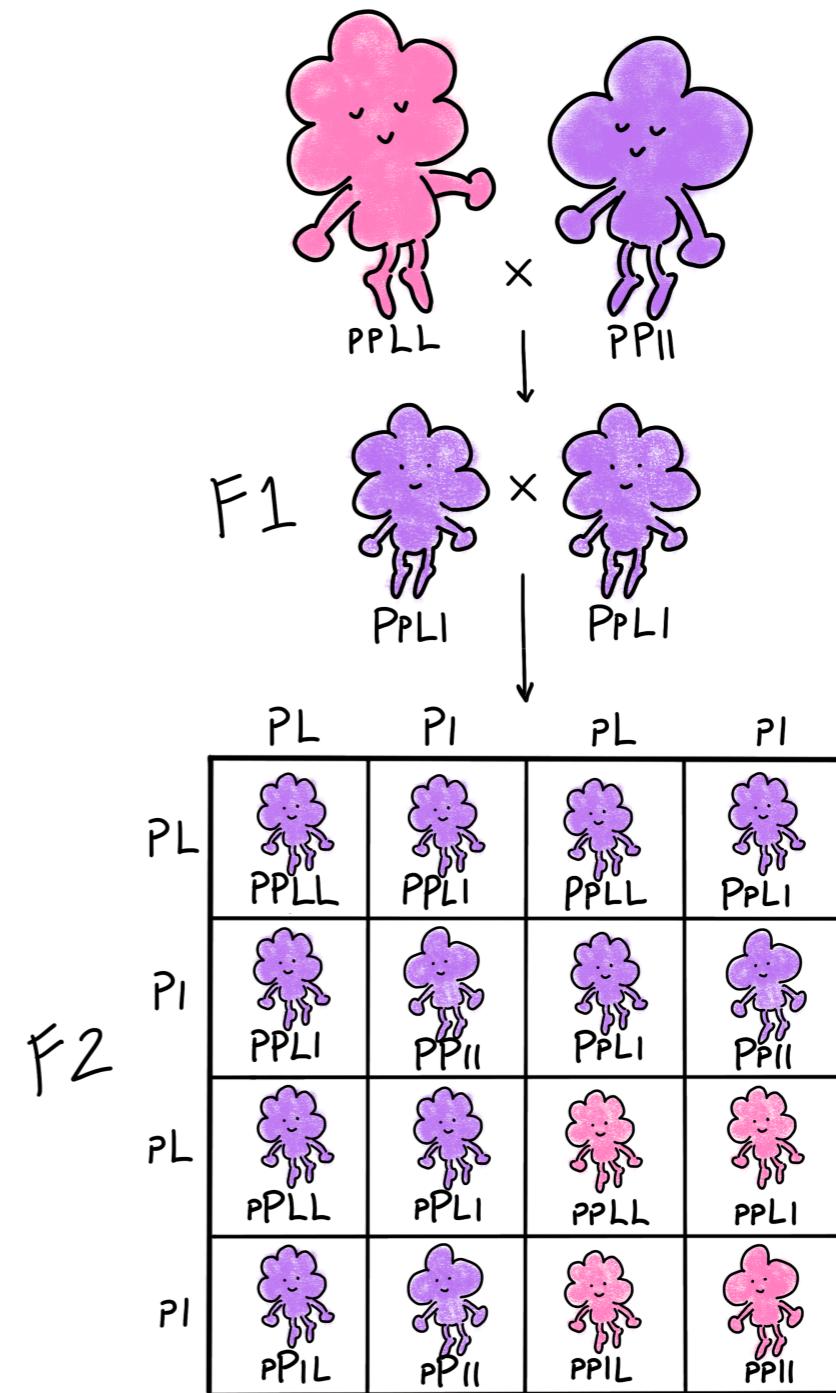
Law of Segregation

- Individuals contain a pair of alleles. During reproduction, the pair is separated; a child inherits one of these alleles, randomly chosen.



Law of Independent Assortment

- Informally: separate genes for separate traits are passed independently from parents to offsprings.
- Colour and hair style are independent; any combination is possible





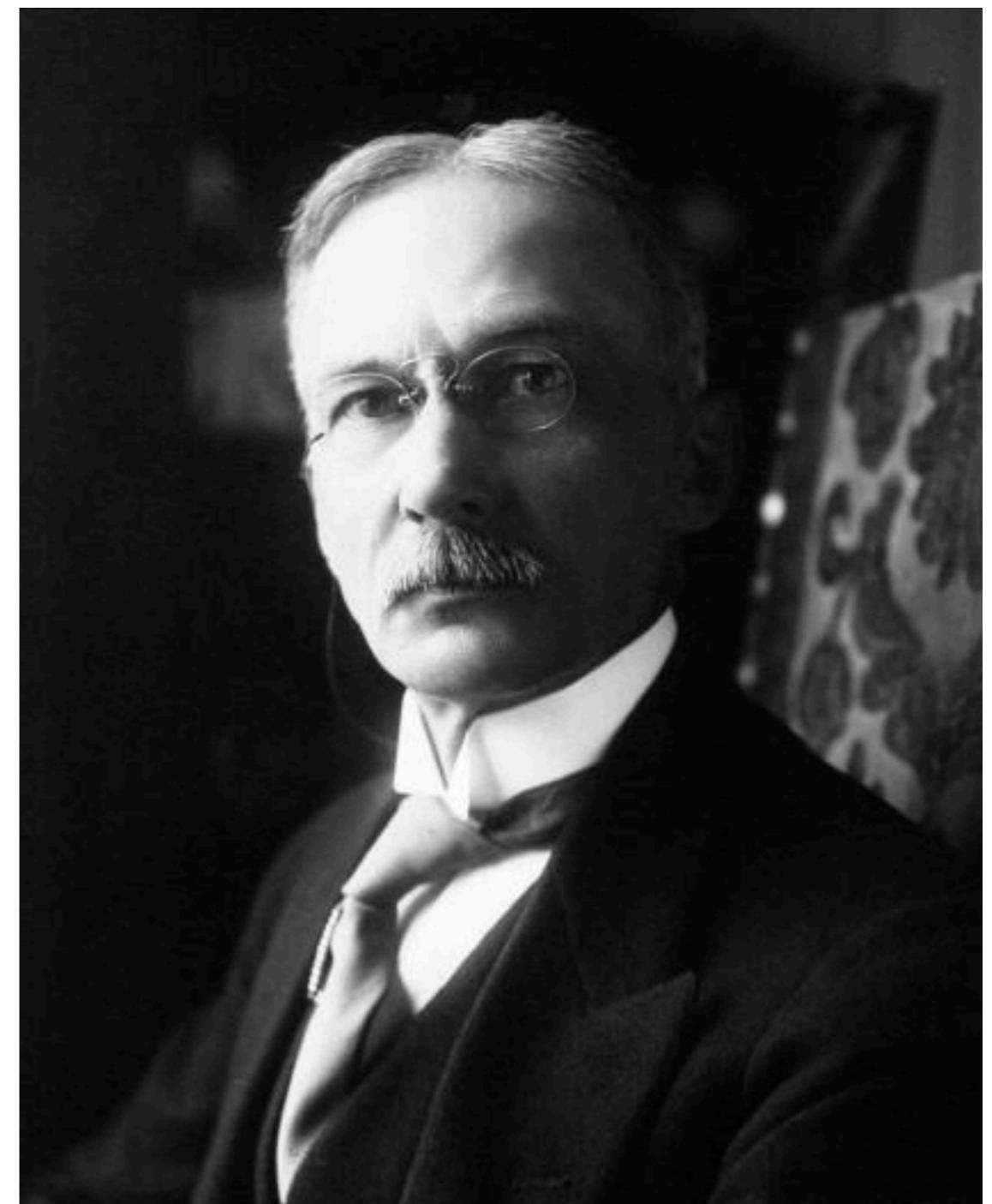
Hugo de Vries

Mutation

- Occasionally some of the genetic material changes very slightly during reproduction
- Mutationism: Before Darwin, biologists commonly believed in saltationism, the possibility of large evolutionary jumps, including immediate speciation.
- This means that the child might have genetic material information not inherited from either parent
- This can be
 - catastrophic: offspring is not viable (most likely)
 - neutral: new feature not influences fitness
 - advantageous: strong new feature occurs

Baldwin effect: A trait acquired through learning is replaced by genetic traits through natural selection over generations

James Mark Baldwin





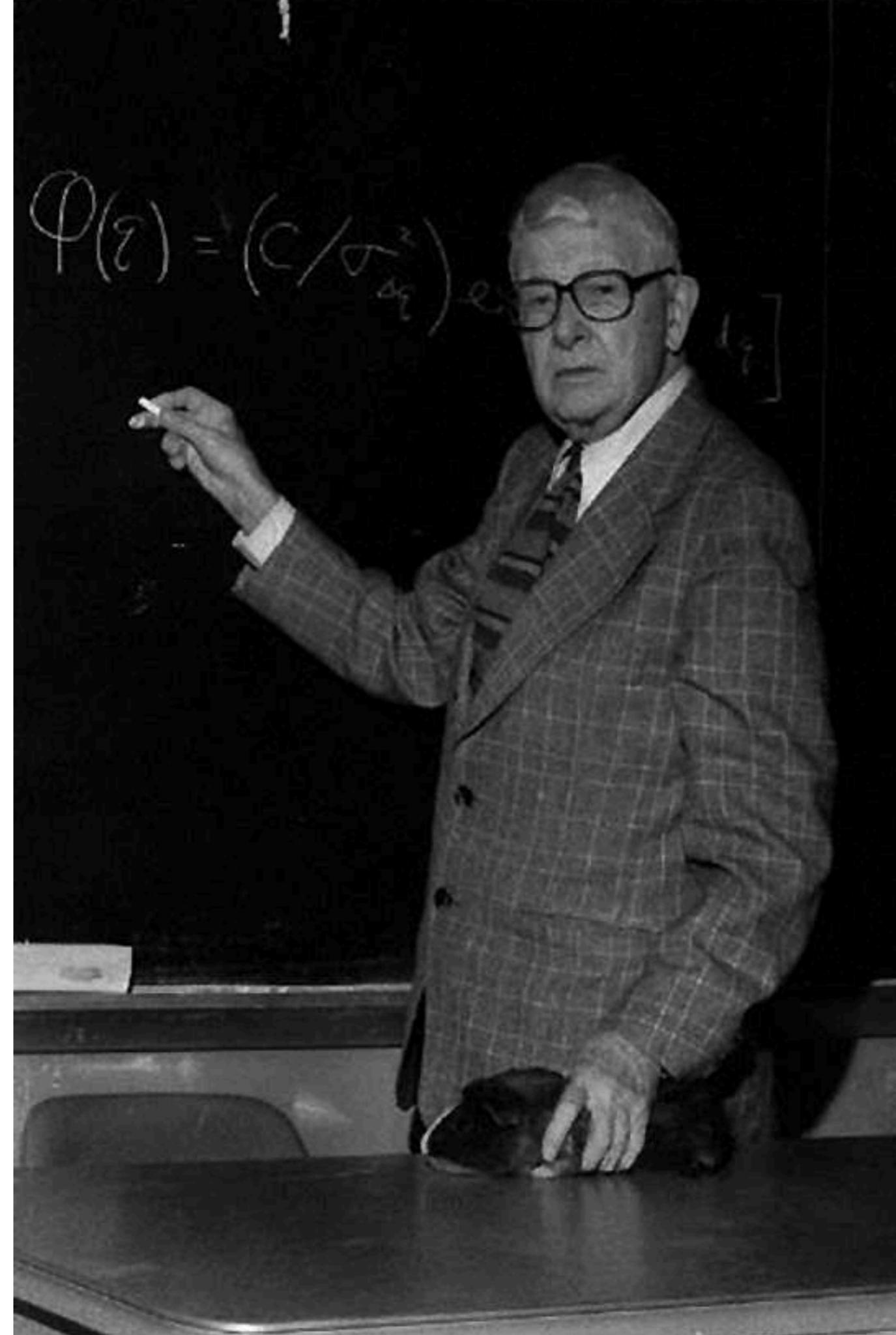
Dmitri Beljajew

Lyssenkoism



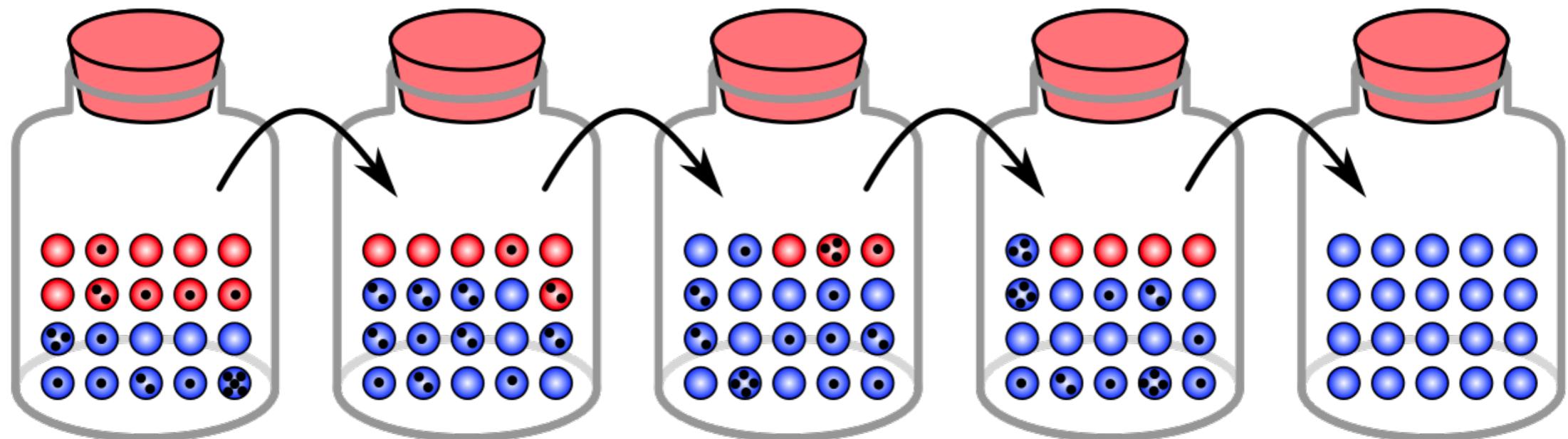
На совещании передовиков урожайности по зерну, трактористов и машинистов молотилок с руководителями партии и правительства. Товарищи Сталин, Андреев, Микоян и Косиор слушают речь академика Т. Д. Лысенко.
Снимок сделан в Кремле 29 октября 1935 года. Фото М. Калашникова и Н. Чулкова.

Sewall Wright



Genetic Drift

- Nature does not select, it merely samples randomly, resulting in frequency of specific alleles.
 - A much more neutral view on evolution.
 - Fixation: Alleles can get lost, and the alleles for all genes are fixed



Richard Dawkins



Memetics

- Meme: An idea, behaviour, or style that spreads from person to person within a culture
- “Conveys the idea of a unit of cultural transmission, or a unit of imitation”
 - Dawkins. *The Selfish Gene*.



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History

- 1948, Turing proposes “genetical or evolutionary search”
- 1962, Bremermann optimisation through evolution and recombination
- 1964, Rechenberg introduces **evolution strategies**
- 1965, Fogel, Owens and Walsh introduce **evolutionary programming**
- 1975, Holland introduces **genetic algorithms**
- 1992, Koza introduces **genetic programming**

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