

# Genetic Algorithms

Jean-Louis Dessalles  
Telecom ParisTech

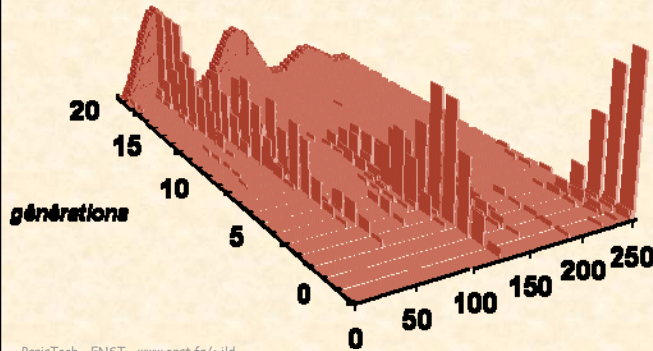
nov.-23

ParisTech - ENST - [www.enst.fr/~jld](http://www.enst.fr/~jld)

## Genetic Algorithms

History


- Population of "solutions"
- Binary coding
- Best individuals are selected to reproduce



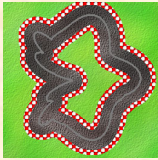
The 3D bar chart illustrates the population size over 250 generations. The vertical axis is labeled 'générations' with values 0, 5, 10, 15, and 20. The horizontal axis represents generations from 0 to 250. The population starts at approximately 15 individuals at generation 0, fluctuates, and generally increases over time, reaching a peak of about 20 individuals around generation 250.

ParisTech - ENST - [www.enst.fr/~jld](http://www.enst.fr/~jld)

3



Robbie Jameson & Emmanuel Pellereau  
(IC 2003)

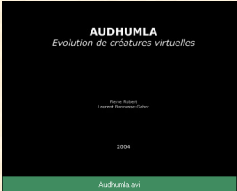
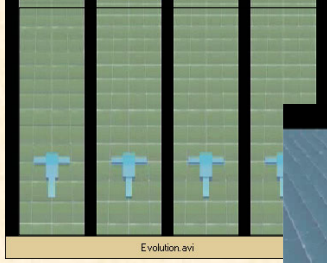
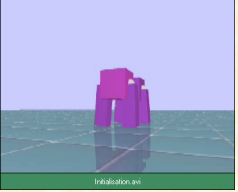
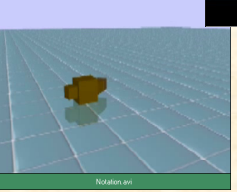
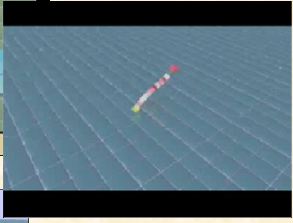


daytona

- Information available to the "pilot":
  - Current speed
  - Local vision
- The pilot acts on:
  - Brake/Accelerator
  - Steering wheel

ParisTech - ENST - [www.enst.fr/~jld](http://www.enst.fr/~jld)

**Emergence of adapted behaviour** **AUDHUMLA (2004)**  
Pierre Robert  
Laurent Bonnasse-Gahot

Optima  
Prey  
Snakes

ParisTech - ENST - [www.enst.fr/~jld](http://www.enst.fr/~jld)

5

## Emergence of a communication code

- Expérience de G. Werner et M. Dyer
- Émergence de catégories sémantiques
- Effet Baldwin

Evolve

ParisTech - ENST - [www.enst.fr/~jld](http://www.enst.fr/~jld)

6

## Genetic Algorithms

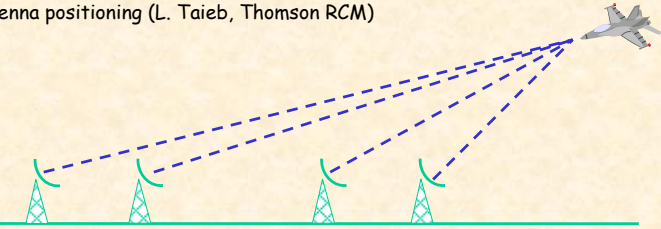
- Some applications
- History
  - Ch. Darwin, G. Mendel, J. Holland
- Two didactic examples
  - Binary sum
  - Labyrinth
- Important concepts
  - Selection, crossover, mutations, phenotype
  - Punctuated equilibria
  - Implicite parallelism
  - Schemata
- Genetic programming

ParisTech - ENST - [www.enst.fr/~jld](http://www.enst.fr/~jld)

7

## Some applications of genetic algorithms

- **Optimisation problems**
  - Antenna positioning (L. Taieb, Thomson RCM)



- **Ill-defined problems**
  - ex: emergence of a communication code

W-D


ParisTech - ENST - [www.enst.fr/~jld](http://www.enst.fr/~jld)

8

## Some applications of genetic algorithms

- Oil flow optimization in a pipe-line (Goldberg 1989)
- Jet engine turbine (General Electric)
- Protein structure prediction (Schulze & Kremer 1992)
- Message routing in telephone or data networks (Cox, Davis & Qiu)
- Antenna positioning (L. Taieb, Thomson RCM)
- Méga-Joule laser (CEA): phase blade profile optimization

[http://neo.lcc.uma.es/TutorialEA/semEC/cap03/cap\\_3.html](http://neo.lcc.uma.es/TutorialEA/semEC/cap03/cap_3.html)

 **Genetic Algorithms**

ParisTech - ENST - [www.enst.fr/~jld](http://www.enst.fr/~jld)

## History

### Evolution

- ◉ Jean-Baptiste Lamarck (1801): How species get transformed
- ◉ Charles Darwin (1859): Natural selection and blind diversity generation (variations)

### Genetics

- ◉ Gregor Mendel (1873): heredity is digital

### Genetic Algorithms

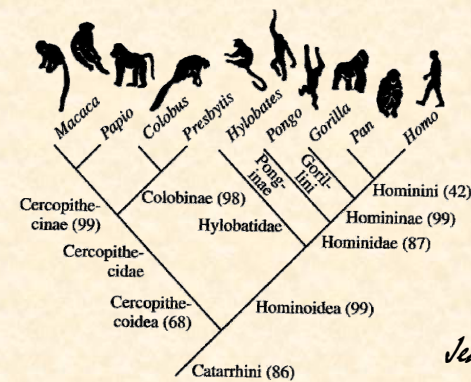
- ◉ Francis Crick & James Watson (1953): discovery of DNA structure
- ◉ John Holland (1965): concept of schema and implicate parallelism
- ◉ David Goldberg (1989): popularization

ParisTech - ENST - [www.enst.fr/~jld](http://www.enst.fr/~jld)

9

## Evolution

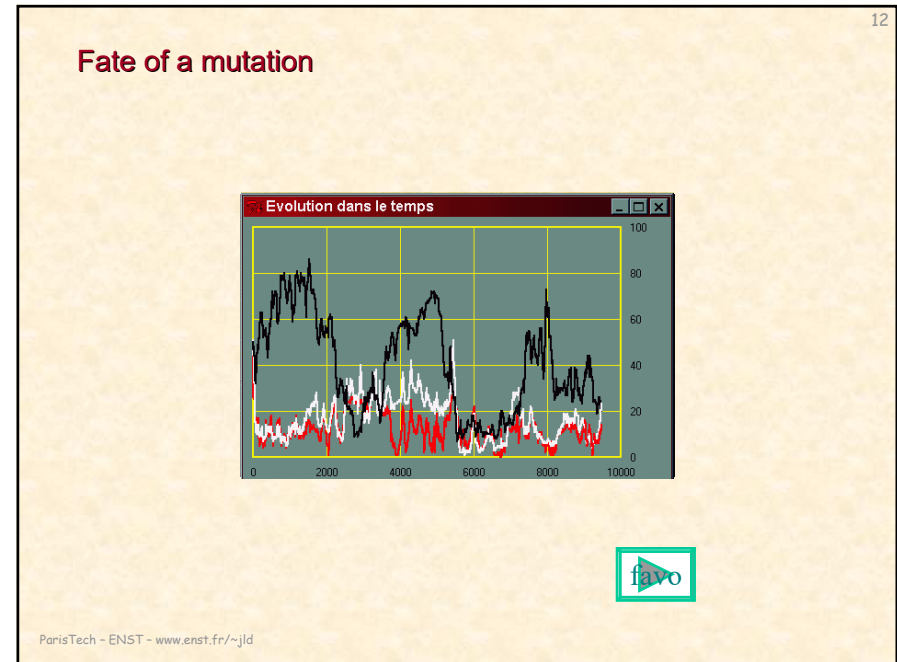
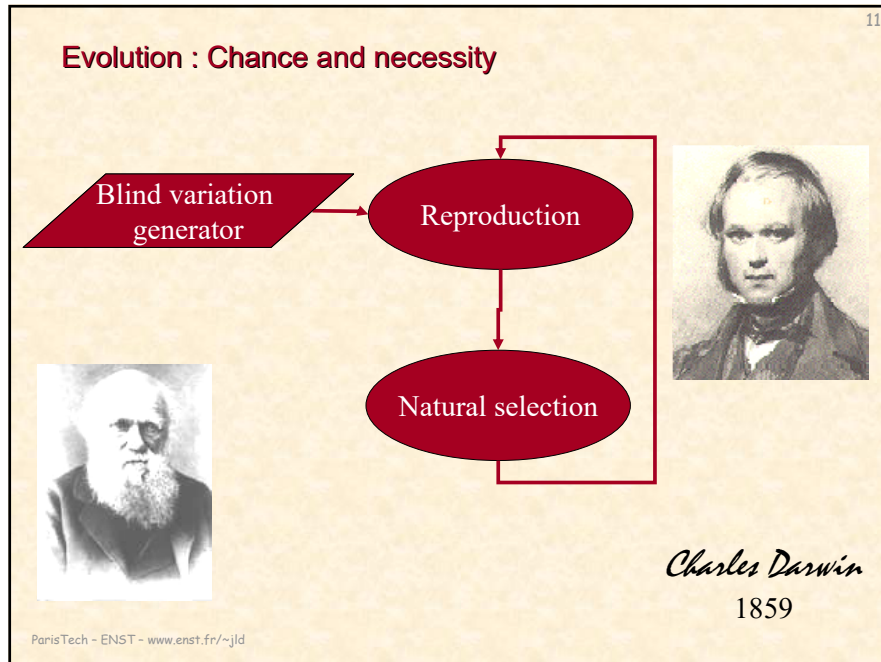
1809



*Jean-Baptiste Lamarck*

ParisTech - ENST - [www.enst.fr/~jld](http://www.enst.fr/~jld)

10



13

## THE ORIGIN OF SPECIES

by Charles Darwin  
1859

[...] we clearly see that the nature of the conditions is of subordinate importance in comparison with the nature of the organism in determining each particular form of variation;- perhaps of not more importance than the nature of the spark, by which a mass of combustible matter is ignited, has in determining the nature of the flames.

The evidence that accidental mutilations can be inherited is at present not decisive; but the remarkable cases observed by Brown-Sequard in guinea-pigs, of the inherited effects of operations, should make us cautious in denying this tendency.

For peculiar habits confined to the workers or sterile females, however long they might be followed, could not possibly affect the males and fertile females, which alone leave descendants. I am surprised that no one has hitherto advanced this demonstrative case of neuter insects, against the well-known doctrine of inherited habit, as advanced by Lamarck.

ParisTech - ENST - www.enst.fr/~jld

14

**phénotype** 3 1  
**génotype** 1 AA 2 Aa 1 aa

**Heredity: a digital phenomenon**

1873

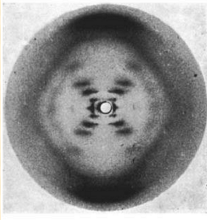
*Gregor Mendel*

ParisTech - ENST - www.enst.fr/~jld

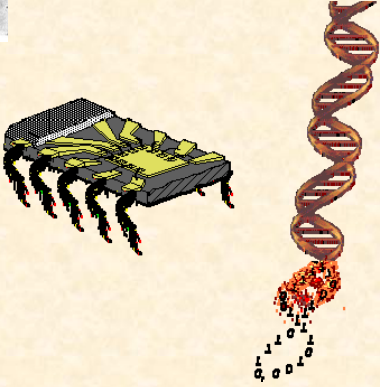
15

## Genomes

Francis Crick  
James Watson  
Rosalind Franklin  
(1953)



Aids virus : 9718 b.p.  
Bacteria:  $5 \cdot 10^6$  b.p.  
humans:  $3,3 \cdot 10^9$  b.p.




ParisTech - ENST - [www.enst.fr/~jld](http://www.enst.fr/~jld)

16

## Genetic algorithms: a biological metaphore for engineers

- Evolution through natural selection is an optimizer
- It is an efficient optimizer (rapidity)
  - Concept of schema: John Holland 1965



John Holland

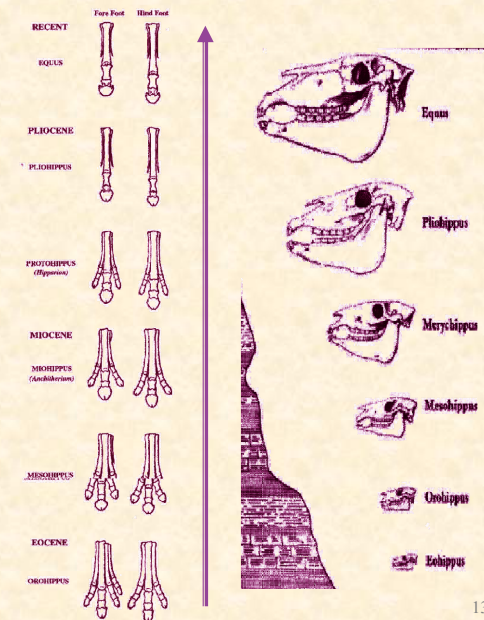
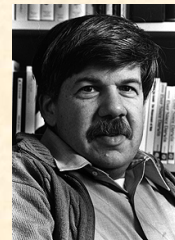
ParisTech - ENST - [www.enst.fr/~jld](http://www.enst.fr/~jld)



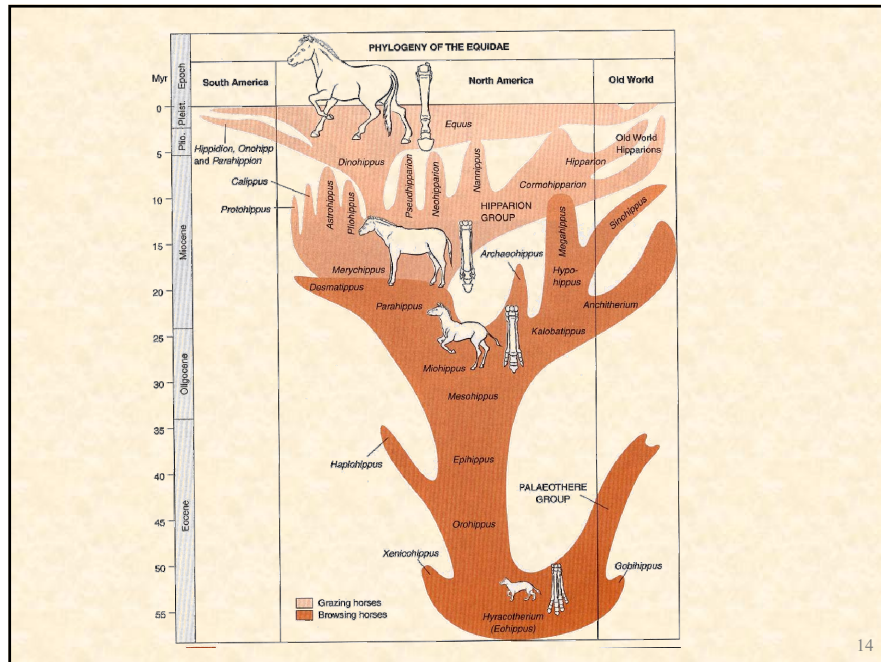
- **Long term evolution follows trends (e.g. larger brains during hominisation, or size increase throughout horses' ancestry)**
  - A. Always true
  - B. Not always true
  - C. Never true.

12

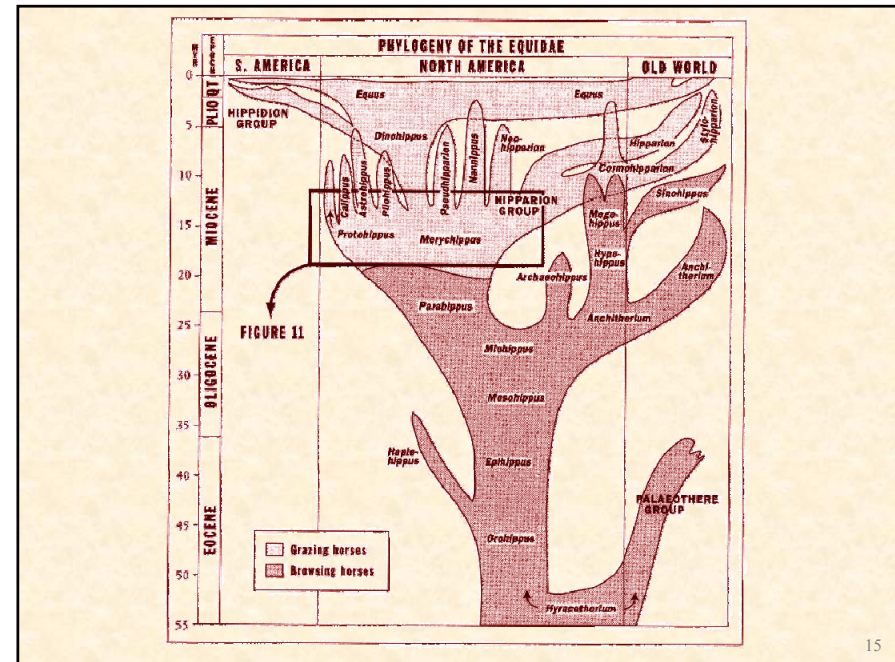
## Evolution: a directed process ?



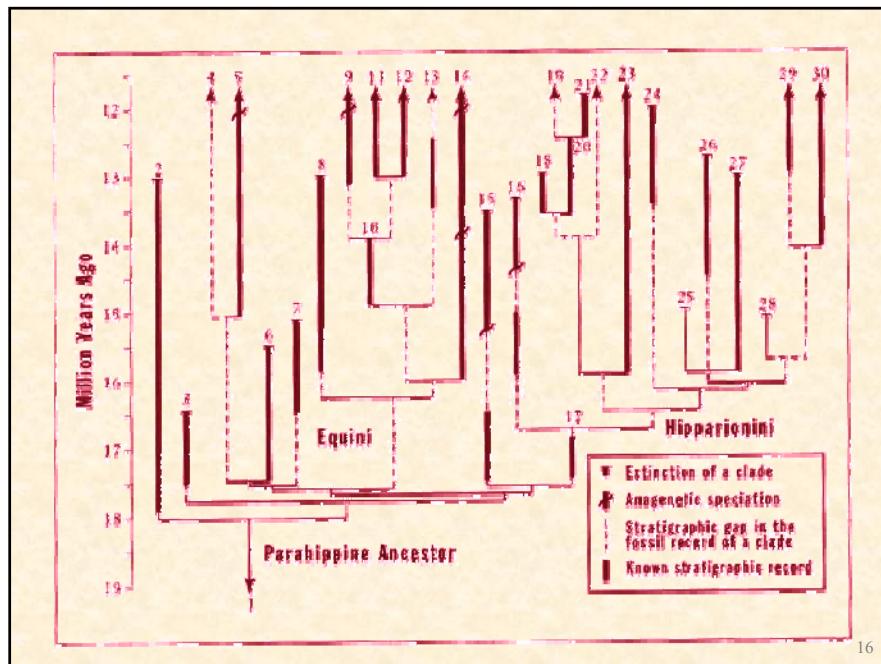
13



14

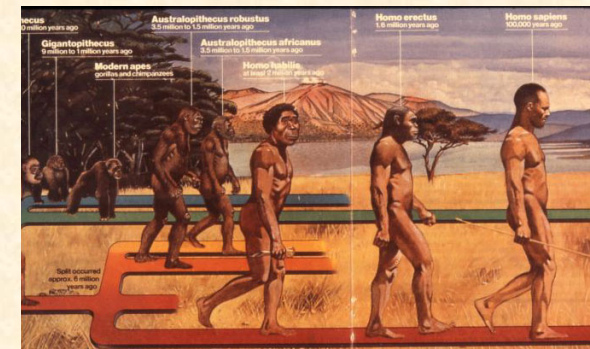


15



16

### Evolution: a directed process ?



Evolution through natural selection has no inertia

17