Lecture 1: Introductory Lecture

Dr. Sabah Sayed

Department of Computer Science

Faculty of Computers and Artificial Intelligence

Cairo University

Egypt

Grade Distribution

Midterm	15
4 Assignments	25
Lecture Participation	4

Syllabus

- Evolutionary Algorithms
  - Genetic Algorithms (GAs)
  - Genetic Programming
- Fuzzy Systems
- Artificial Neural Networks (ANNs)
  - Feed Forward Neural Networks (FFNNs)
  - Back Propagation Neural Networks (BPNNs)

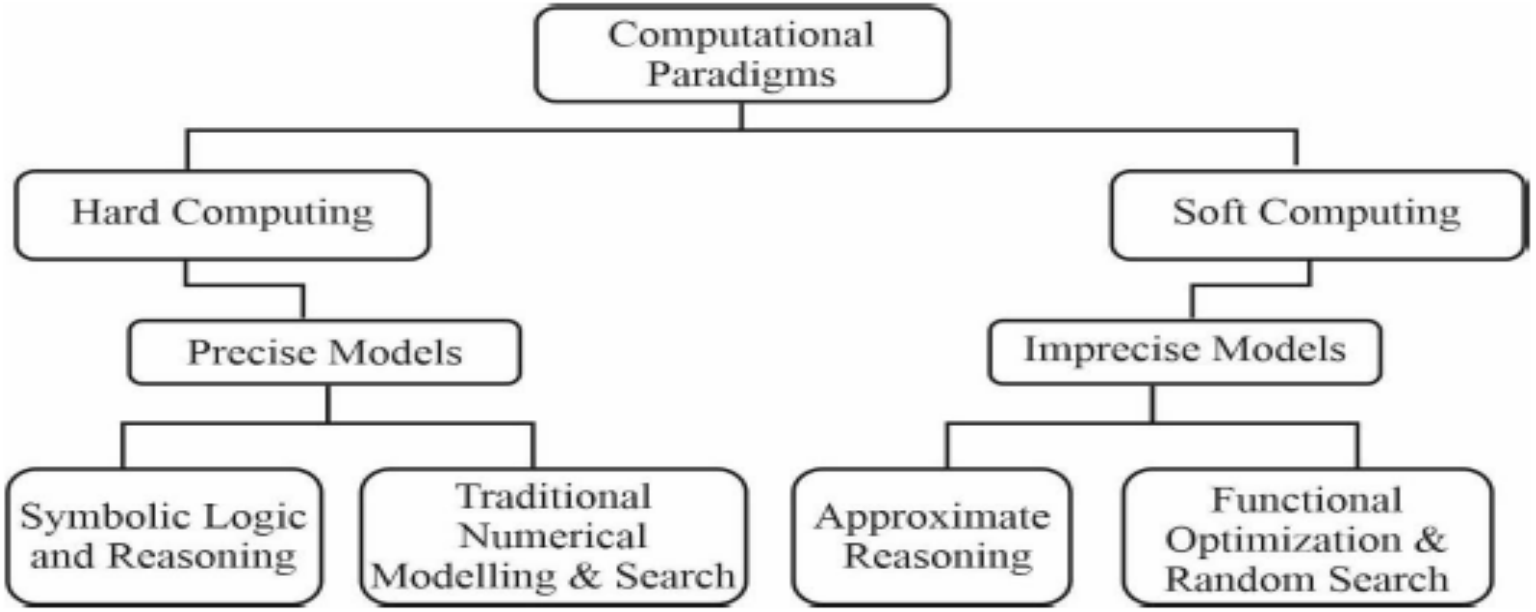
Textbooks

- "*An introduction to genetic algorithms for scientists and engineers*", David A. Coley, World Scientific, 1997, Har/Dis edition.

- "*An Introduction to Practical Neural Networks and Genetic Algorithms For Engineers and Scientists*", Christopher MacLeod.

- "*Computational Intelligence: Principles, Techniques, and Applications*", Amit Konar, Springer, 2005, 1st edition.

Computational Paradigm



Hard computing

- Hard computing is the conventional computing.
- Based on the principles of precision, certainty, and inflexibility.
- Requires mathematical model (precise models) to solve problems.
  - This model is further classified into symbolic logic and reasoning, and traditional numerical modelling and search methods.
  - The basic of traditional artificial intelligence is utilized by these methods.
- It consumes a lot of time to deal with real life problem which contains imprecise and uncertain information.
- Some problems cannot accommodate hard computing techniques:
  1. Recognition problems
  2. Mobile robot co-ordination, forecasting
  3. Combinatorial problems

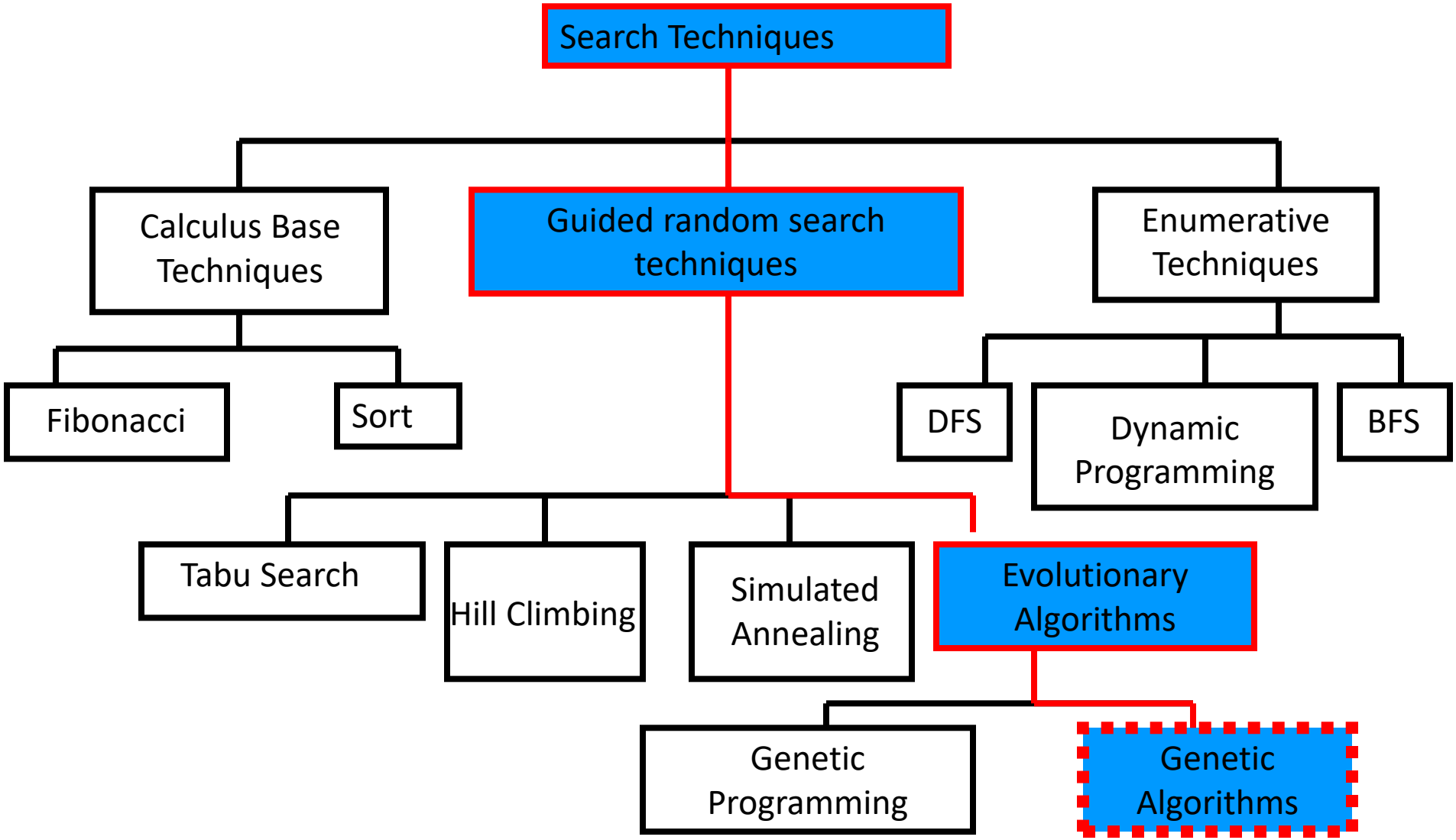
Soft Computing v/s Hard Computing

Hard Computing	Soft Computing
It uses precisely stated analytical model.	It is tolerant to imprecision, uncertainty, partial truth and approximation.
It is based on binary logic and crisp systems.	It is based on fuzzy logic and probabilistic reasoning.
It has features such as precision and categoricity.	It has features such as approximation and dispositionality.
It is deterministic in nature.	It is stochastic in nature.
It can work with exact input data.	It can work with ambiguous and noisy data.
It performs sequential computation.	It performs parallel computation.
It produces precise outcome.	It produces approximate outcome.

Why to Study Soft computing?

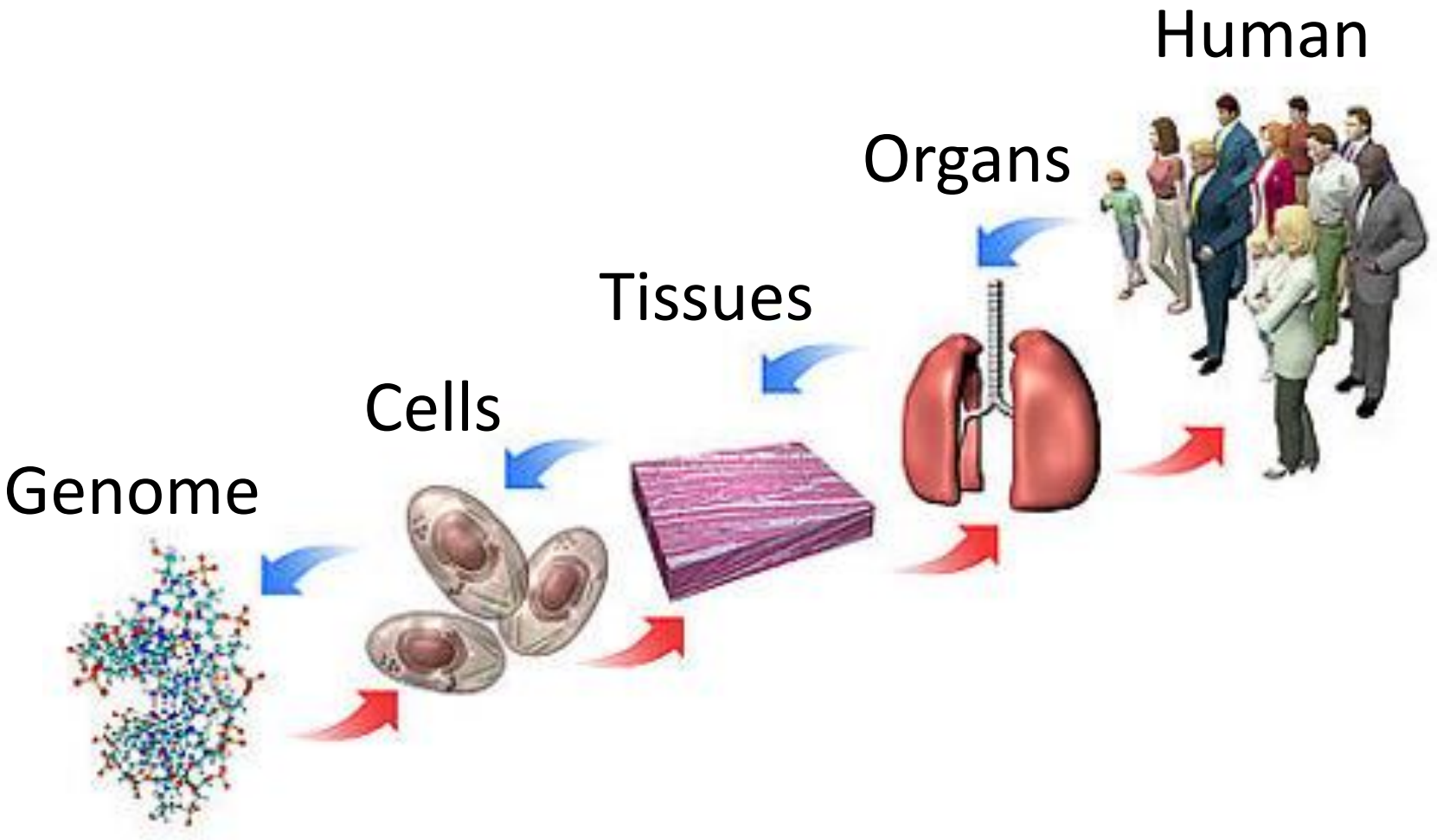
- Till now, you have studied how to develop efficient algorithms/databases that can be processed by computers to solve day-life problems.
- Unfortunately, this is not sufficient to solve all kinds of problems, especially problems involving huge ***runtime***.
- Throughout this course, you will learn about how scientists have overcome this by developing new algorithms inspired from:
  - The natural evolution in ecological systems
  - The training and learning activities of the human brain
  - The immune system of the living creatures.
  - … etc

Classes of Search Techniques

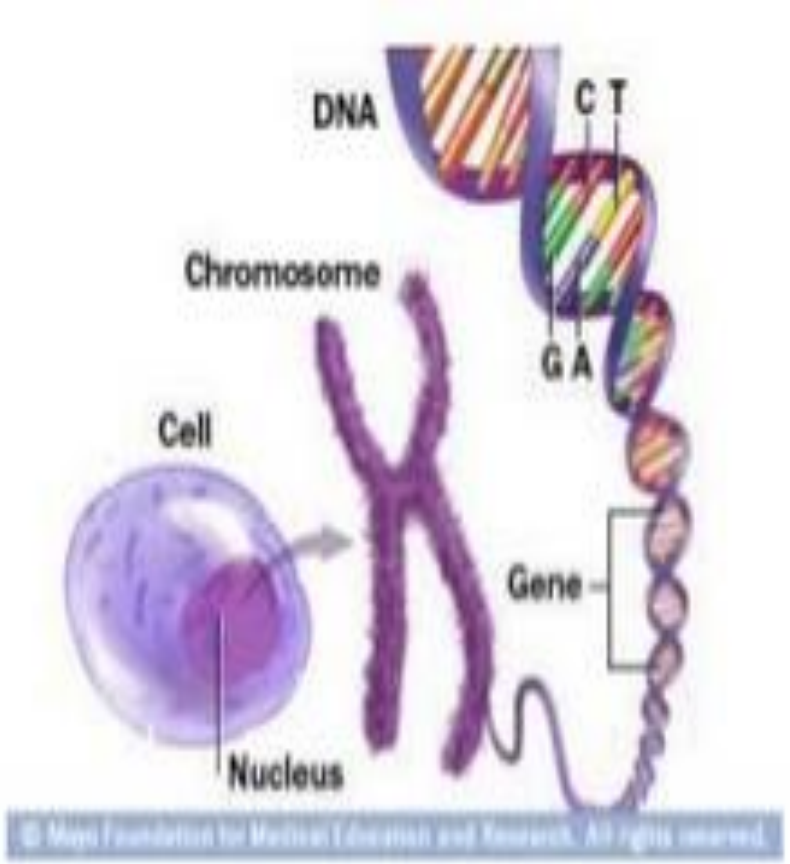


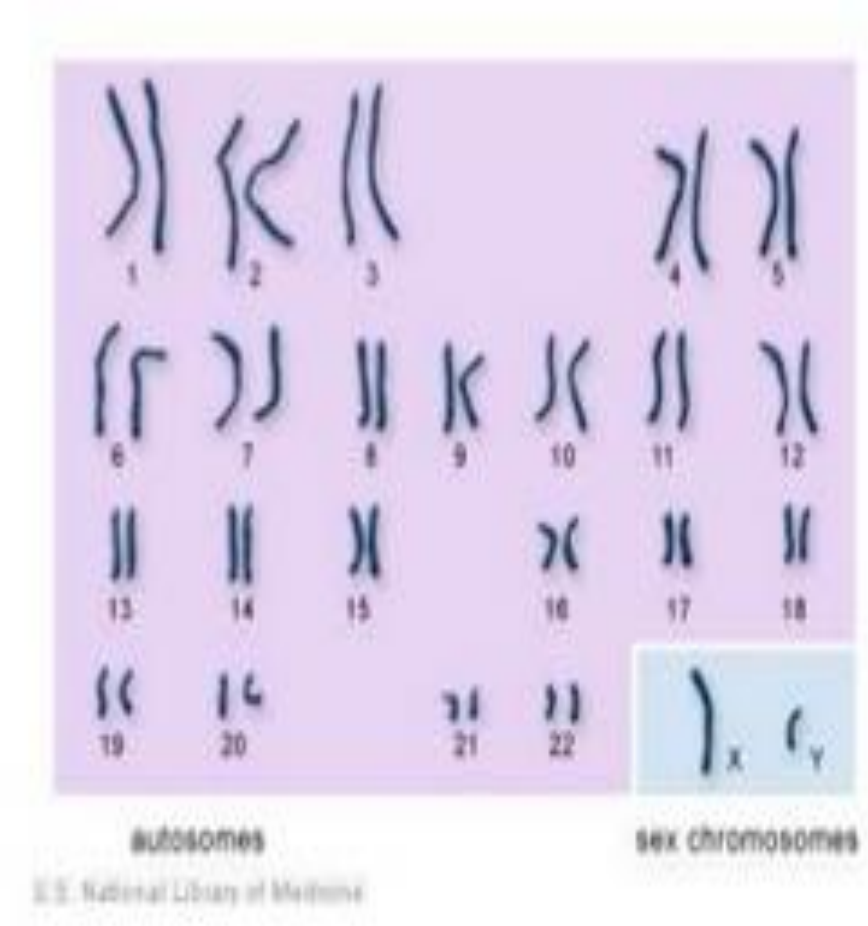
Questions?

Human Body

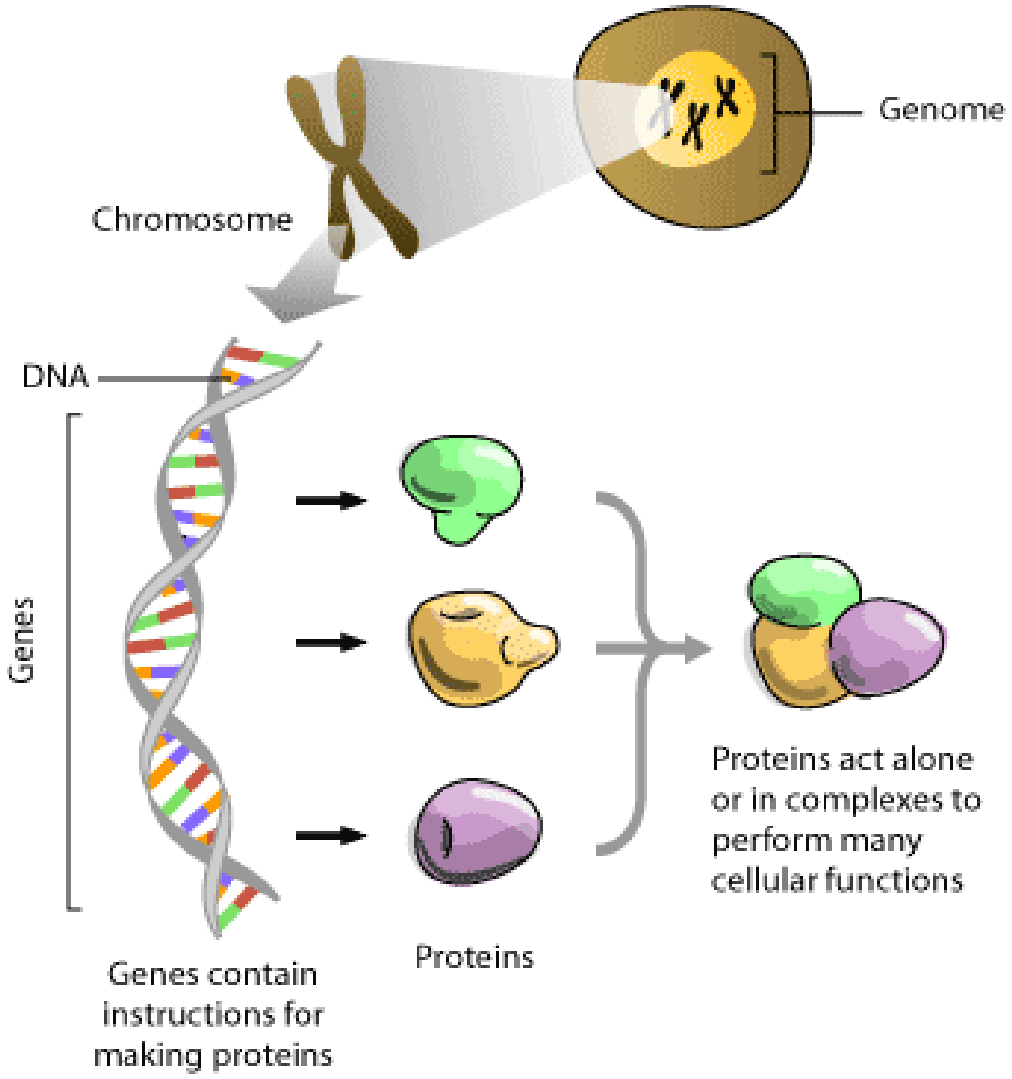


Cell .. Genome .. *Chromosomes* .. DNA .. *Genes*

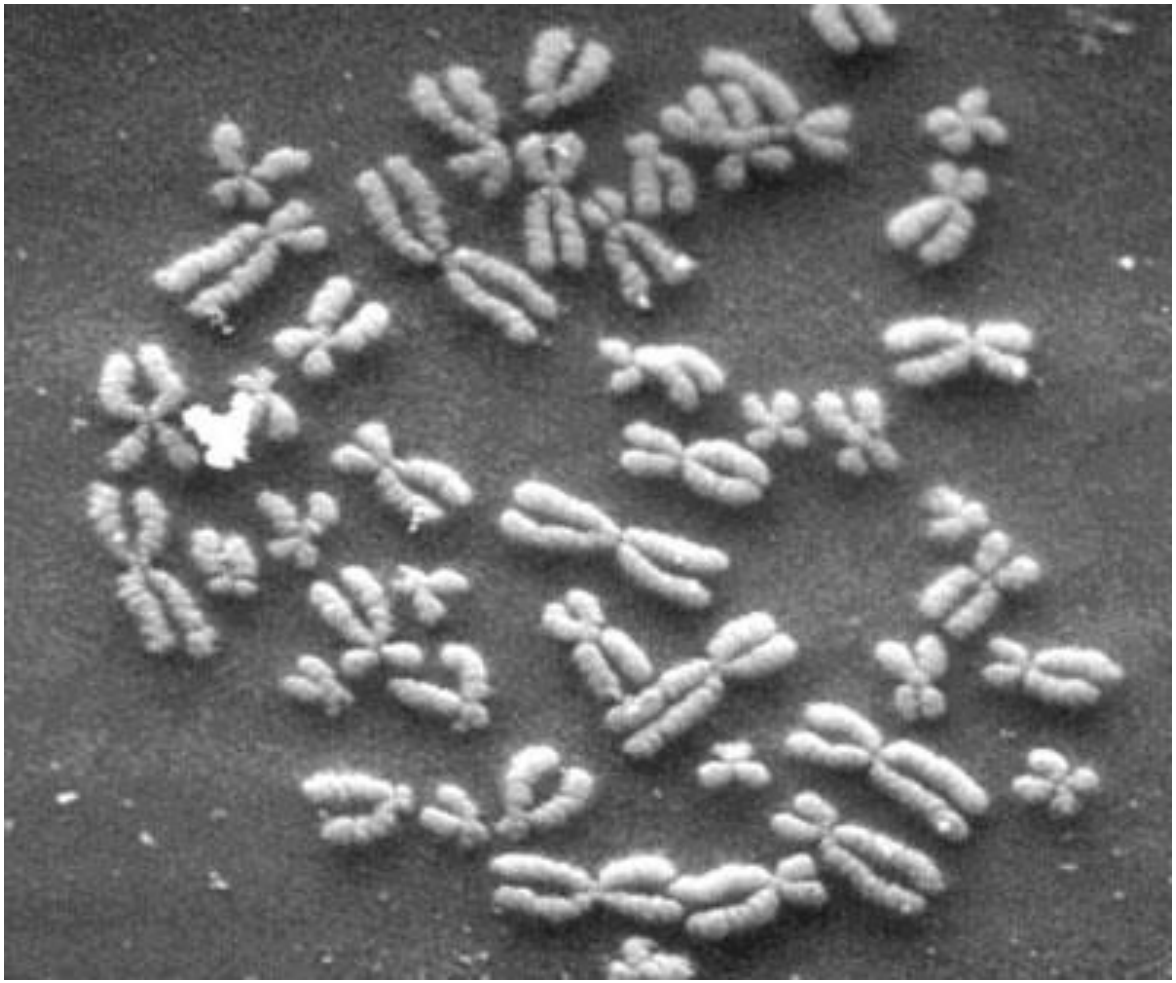




Genome


Genome
Chromosome
DNA
Genes
Genes contain instructions for making proteins
Proteins
Proteins act alone or in complexes to perform many cellular functions

Human Chromosomes Under Microscope



Evolution in the real world

- Each cell of a living thing contains ***chromosomes*** - strings of *DNA*
- Each chromosome contains a set of ***genes*** - blocks of DNA
- Each gene determines some aspect of the organism (like eye colour)
- A collection of genes is sometimes called a ***genotype***
- A collection of aspects (like eye colour) is sometimes called a ***phenotype***
- Reproduction involves ***recombination*** of genes from parents and then small amounts of ***mutation*** (errors) in copying
- The ***fitness*** of an organism is how much it can reproduce before it dies
- Evolution based on “survival of the fittest”

Motivation

- Suppose you have a problem with some search space
- You don’t know how to solve it
- What can you do?
- Can you use a computer to somehow find a solution for you?
- This would be nice! Can it be done?

A dumb solution = Random Search

A "*blind generate and test*" algorithm:

Repeat

- Generate a random possible solution
- Test the solution and see how good it is

Until reaching a solution that is good enough

Can we use this dumb idea?

- Sometimes - yes:
  - if there are only a few possible solutions
  - and you have enough time
  - then such a method *could* be used
- For most problems - no:
  - many possible solutions
  - with no time to try them all
  - so this method *can not* be used

A “less-dumb” idea (**GA**)

Generate a *set* of random solutions

Repeat

- Test each solution in the set (rank them)
- Remove some bad solutions from set
- Duplicate some good solutions
- Make small changes to some of them

Until reaching a solution that is good enough

Genetic Algorithms - History

- A class of *Evolutionary optimization* algorithms
- Inspired from ***(Biological) Evolution Process***
  - Uses concepts of ‘‘Natural Selection’’ and ‘‘Genetic Inheritance’’
- Pioneered by ***John Holland*** (University of Michigan) in the 1970’s
- Got popular in the late 1980’s
- Can be used to solve a variety of problems that are not easy to solve using traditional techniques

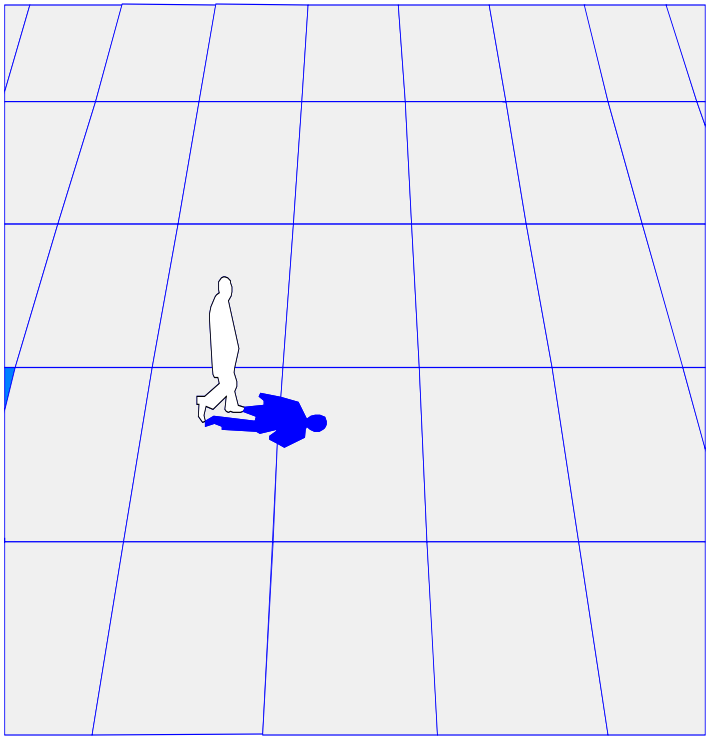
Genetic Algorithms - History

- "Evolutionary Computing" was introduced in the 1960s by **I. Rechenberg**.

- John Holland wrote the first book on Genetic Algorithms 'Adaptation in Natural and Artificial Systems' in 1975.

- In 1992 **John Koza** used genetic algorithm to evolve programs to perform certain tasks. He called his method "Genetic Programming".

Genetic Algorithms - History



"Genetic Algorithms are good at taking large, potentially huge search spaces and navigating them, looking for optimal combinations of things, solutions you might not otherwise find in a lifetime."

- Salvatore Mangano

Computer Design, May 1995

Genetic Algorithms - History

- ***John Holland*** developed Genetic Algorithms:
  - To understand the adaptive processes of natural systems
  - To design artificial systems software that retains the robustness of natural systems