21 September
University
Of Medical & Applied
Sciences

كلية التكنولوجيا الطبية

Bioinformatics and Computing Environments

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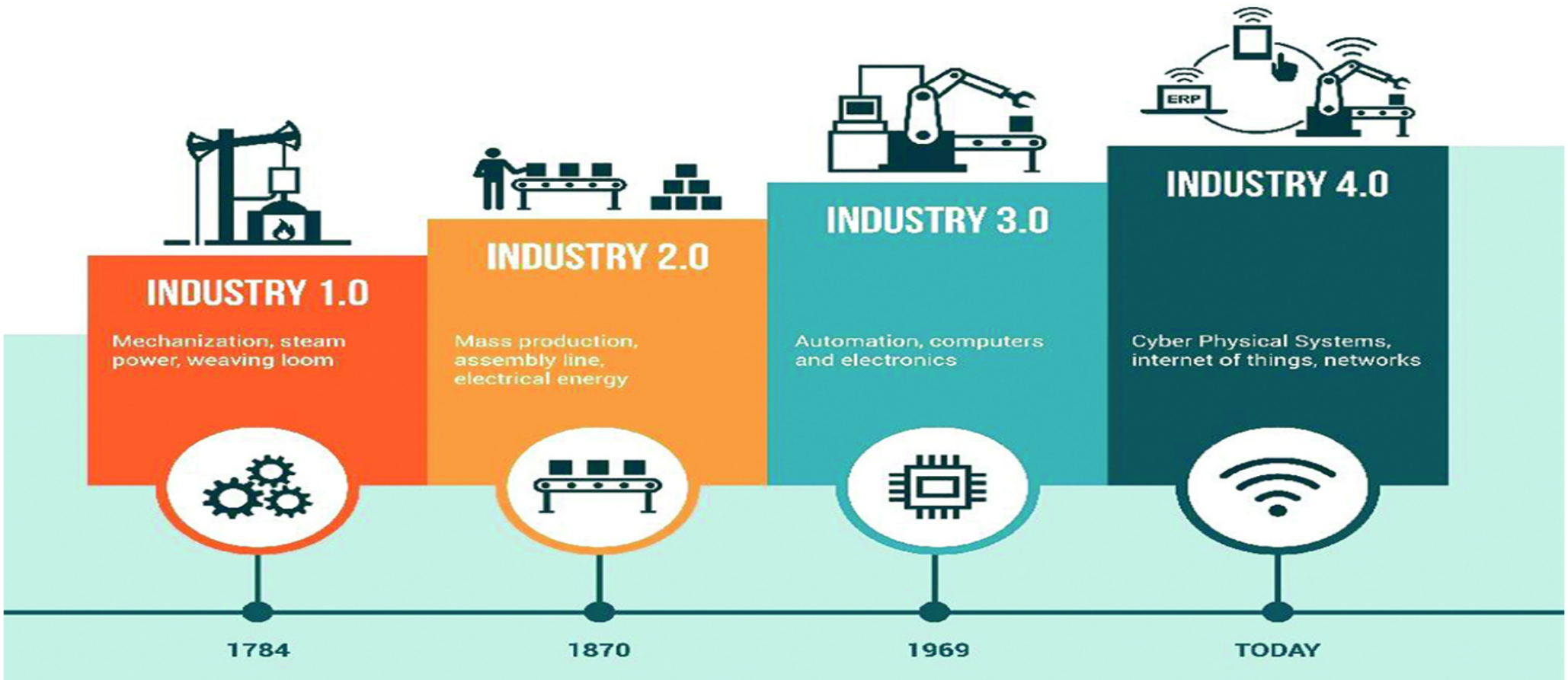
Dean of Medical Technology

Outline

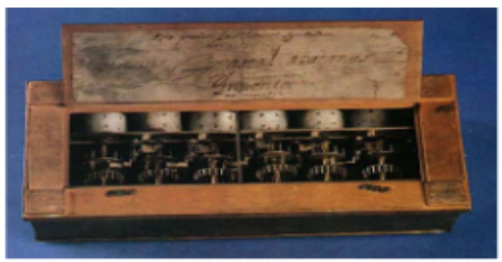
- History of Industrial Revolution
- Introduction to Bioinformatics
- Bioinformatics Tools
- Bioinformatics Applications
- Case Study

History

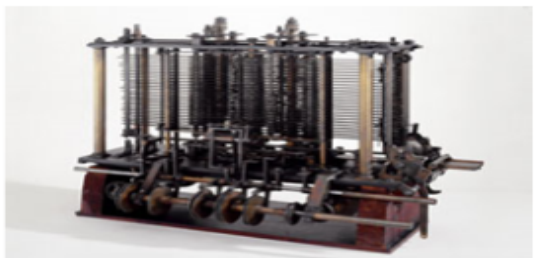

INDUSTRY 1.0
Mechanization, steam power, weaving loom
1784
INDUSTRY 2.0
Mass production, assembly line, electrical energy
1870
INDUSTRY 3.0
Automation, computers and electronics
1969
INDUSTRY 4.0
Cyber Physical Systems, internet of things, networks
ERP
TODAY

History (con)

- **Seeking to develop intelligent machine**

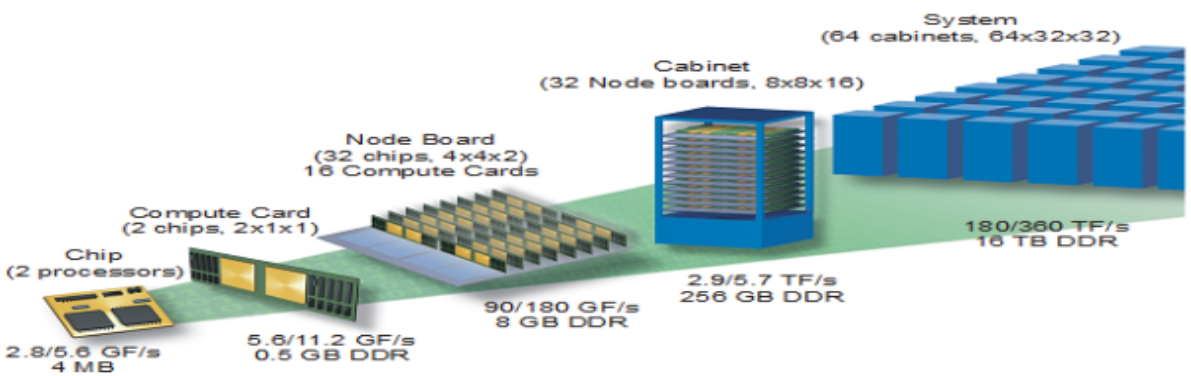


Blaise Pascal:1642



Charles Babbage:1833

ENIAC:1944

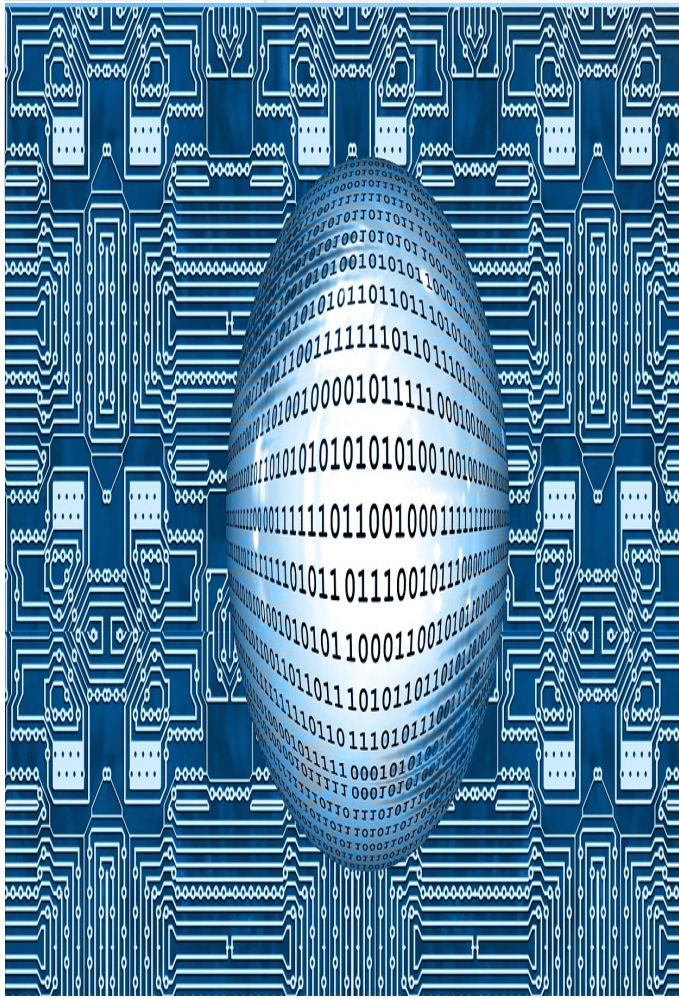


IBM: Blue Gene
A massively parallel supercomputer

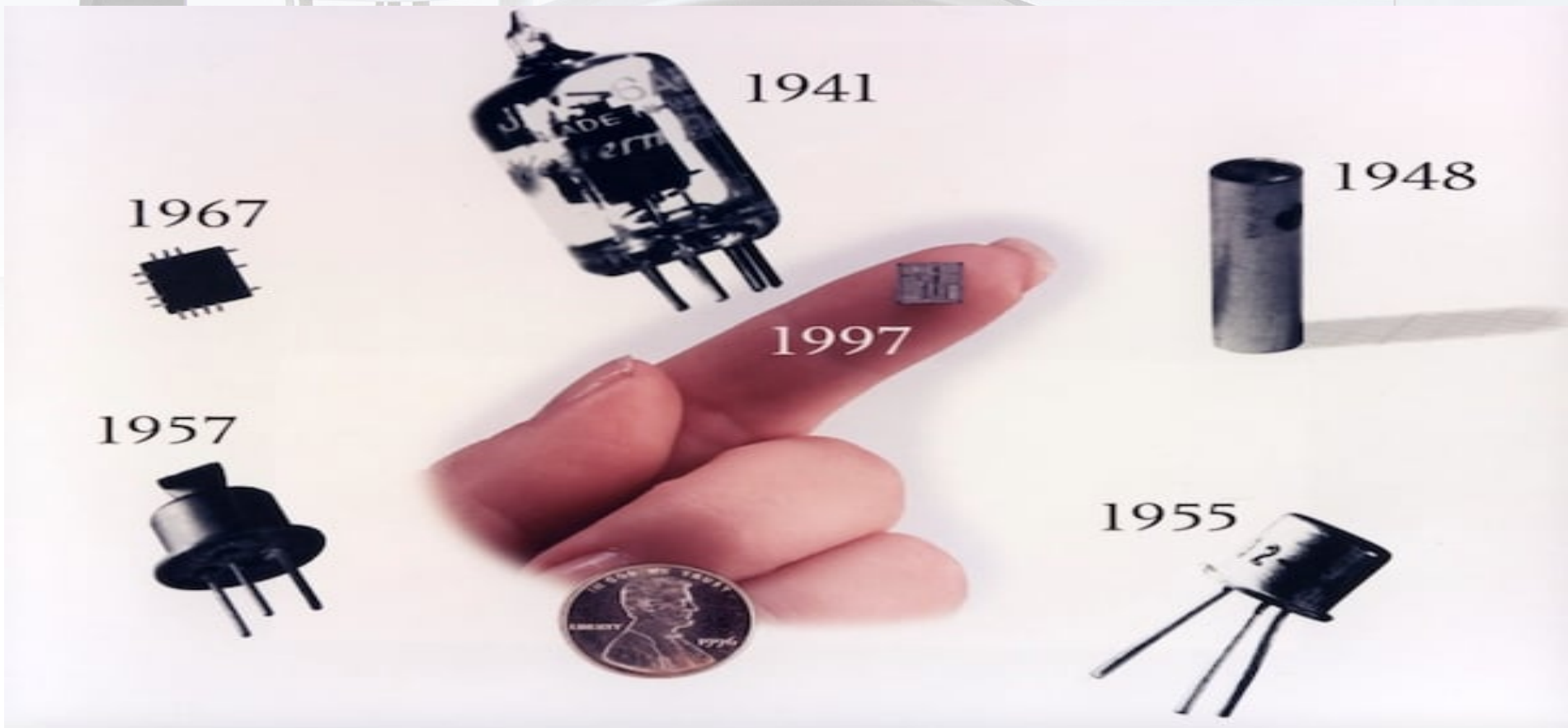
What is the language of computer

- 0s and 1s are the foundational language of computers. Known as "binary code," they are the means by which AI systems process information.

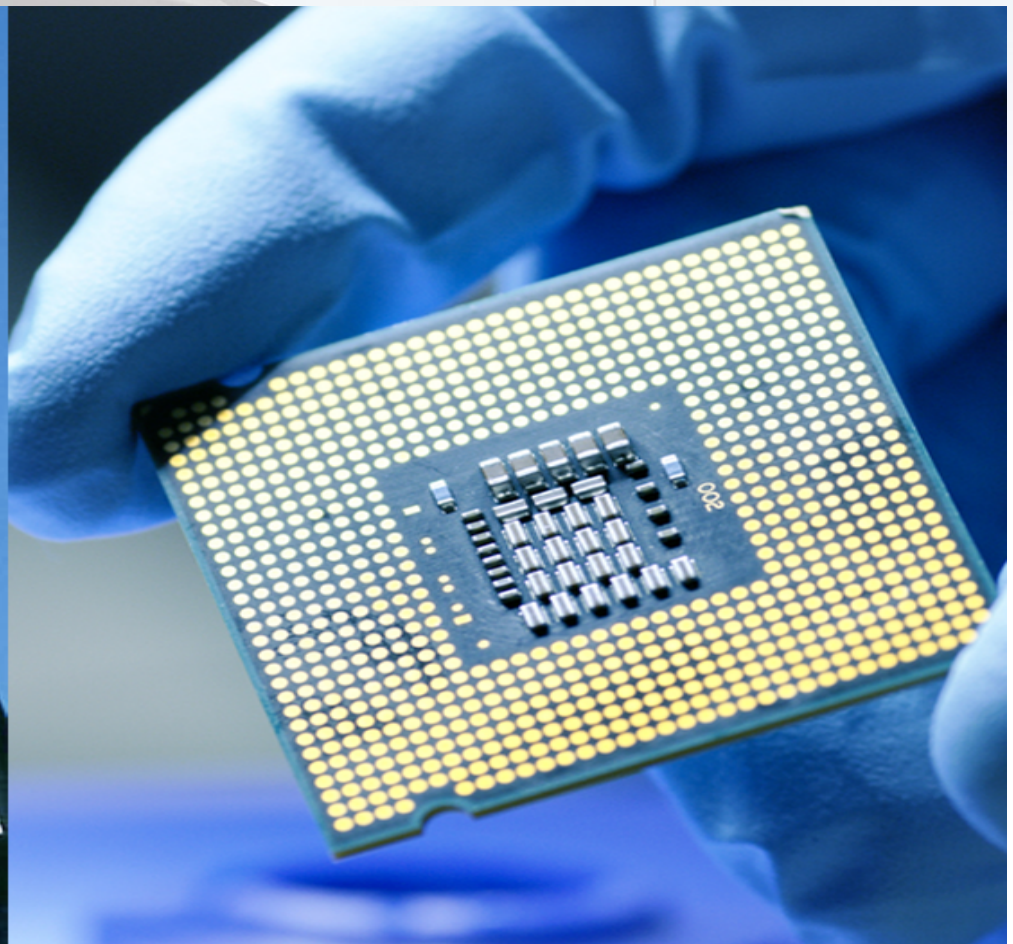
ASCII Character	Binary
A	01000001
B	01000010
C	01000011
D	01000100
E	01000101
F	01000110
G	01000111
H	01001000
I	01001001
J	01001010
K	01001011
L	01001100
M	01001101
N	01001110
O	01001111
P	01010000



History of Transistors

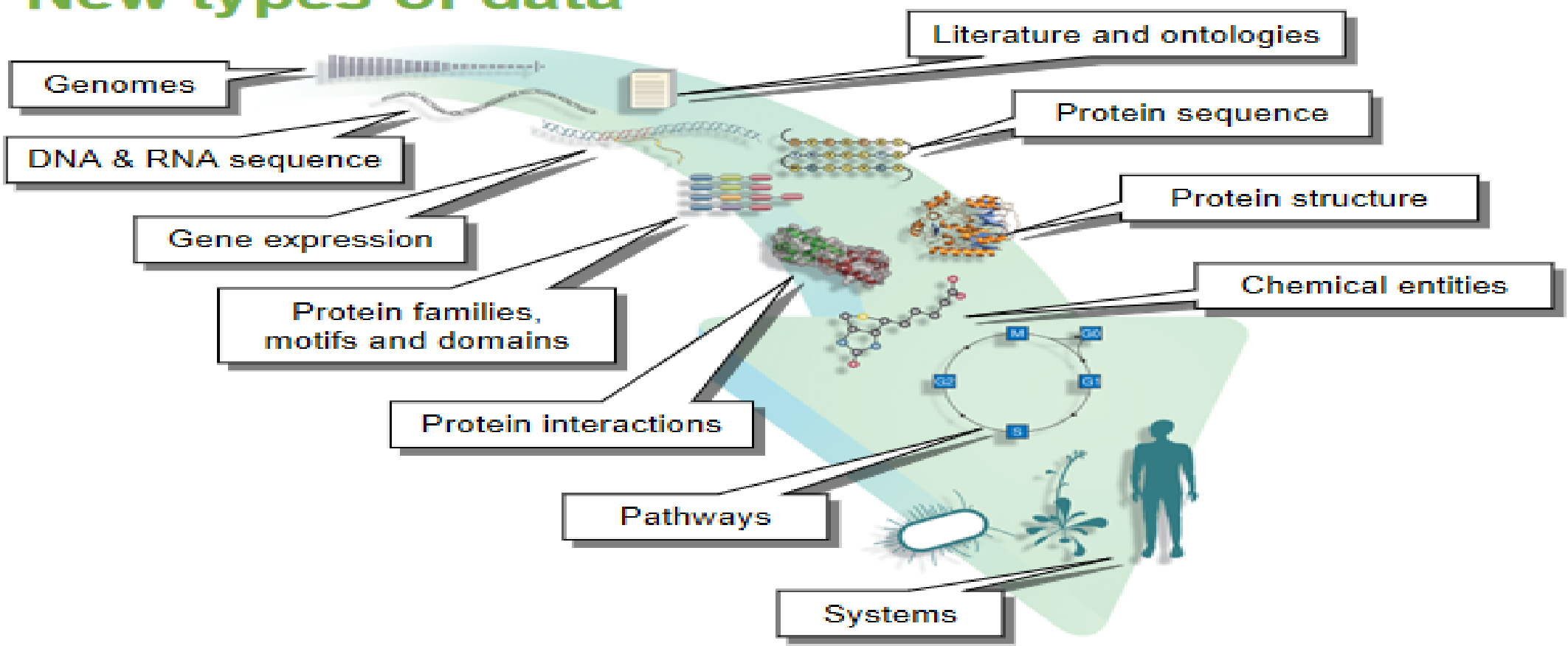



microelectronics group
A replica of the first transistor,
invented at Bell Labs,
December 23, 1947
Lucent Technologies
Bell Labs Innovations
50 Years and Counting...


002

- **iPhone 14 Pro** :16 billion transistors
- **Apple M2 Max**: 67 billion transistors

New types of data

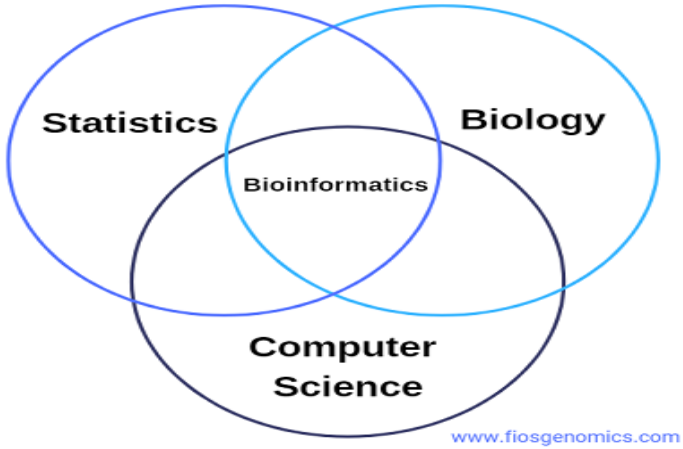


What is bioinformatics?

- **Bio-informatics**
- **Bio**: Biology, the study of life and living organisms
- **Informatics**: Information science

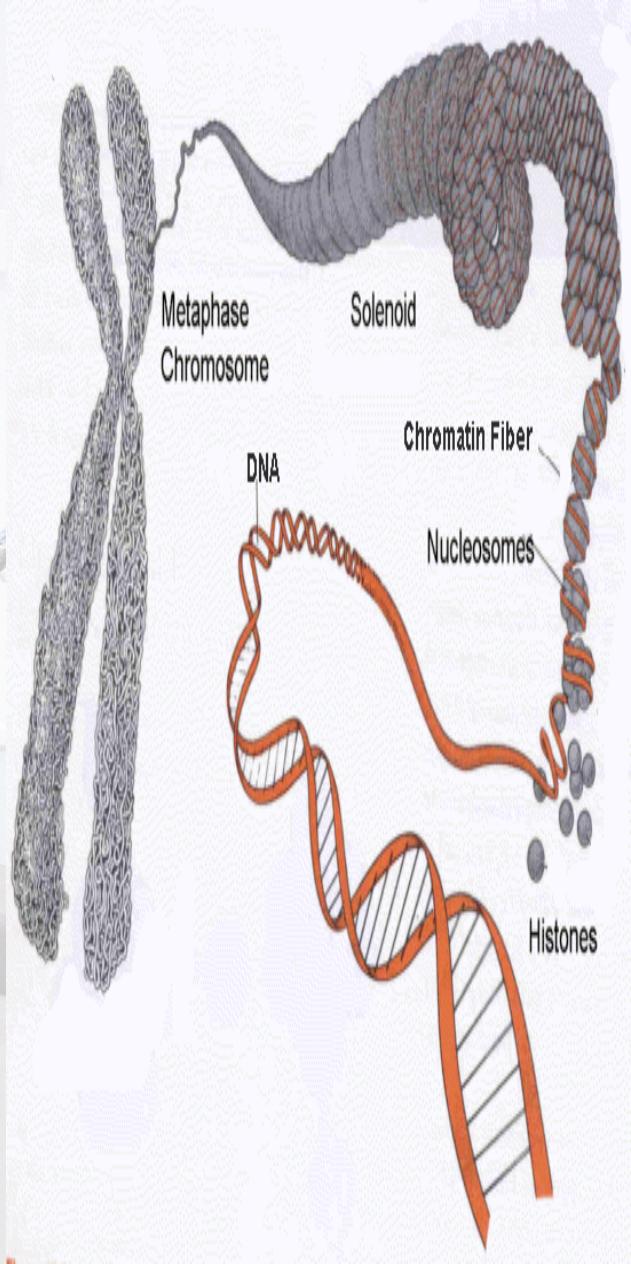
- Bioinformatics:

Application of computer science and information technology to the field of biology and medicine



Why we need bioinformatics?

- Why do we need computing methods to assist biomedical research?
  - Large data size
  - Difficult computational problems



Large data size

- Each adult human has 10^{13} -10^{14} cells (37.2 trillion cells)
- Most of them contain two copies of DNA with 3×10^{9} nucleotides (the “haploid genome”)
- If we represent DNA as a string with four letters, A, C, G and T…

CTCACCGTCGTAAATCTATGATCTGGCTTGGCCTGCAGTAGCTCT
TTCATTTCGGGCTTATCTAATGCTGACTGGTCGGTCCTGGCTAC
GCTCCAAAACGTACGTATTCGGGCCATCGAGGCTAGCGGCAC
TTCGAGCGATCTATCGGGAGCTTTGGCTATCGATCGGGCGATC
GATGCTGACGTACGTAGCGCGCGATCGAGCGCGGCTAGCTAG
CGGCATCGTAGCTACGTAGCTACGGCGCTATTTCGATCGAGTC
GTGTCTAGTCGGATATAGCTATGCATCTAGCTGAGGCATCTGAG
CGGATCGATGCTAGGGCGATCGGAGCTAGCTGAGCTAGCTAGC
TGAGCGCTAGCGAGCGTACGAGCGATCGAGCGAGTCTAGCGA
GCGATTCTAGCGATATACATTAGCCCGATCGTATGCTAGCTAGG
GCTAGCATGCGGATCTATCGAGCGGCTATCTGAGCGATTCGAT
CGAGCGATCTAGCGAGCTATCGATCGAGCCGG

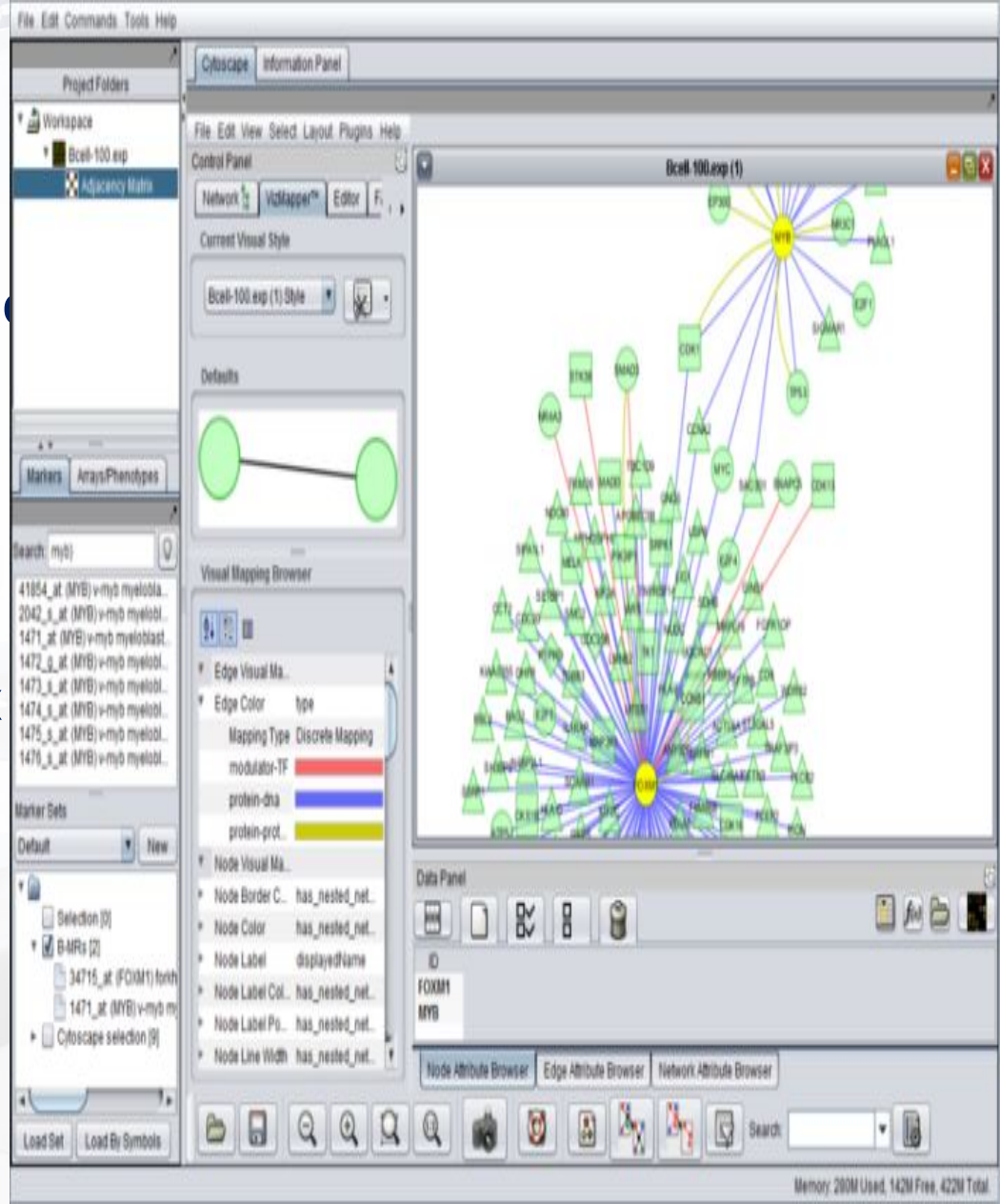
Large data size

- The last page contains about 500 characters
  - Need 6,000,000 pages to show the human genome
  - Printed in 130 books
- Humans have 20,000-25,000 genes that produce proteins
  - We want to study their pair-wise and higher-order relationships
  - About 3.1×10^8 pairs, 2.6×10^{12} triples, ...
- In humans, the total female diploid nuclear genome per cell extends for 6.37 Gigabase pairs (Gbp),
- Assuming a 3 billion letter human genome length and an average depth of coverage of 30×, we would have 90 billion letters, roughly occupying 90 gigabytes of disk space

Bioinformatics Tools

Here is the list of names of bioinformatic tools for different applications:

- geWorkbench
- BLAST
- BioPerl
- InterMine
- Biojava Bioinformatics Tool for Linux
- IGV Genomic Sequencing Tool
- GROMACS
- Taverna Workbench
- Clustal Omega



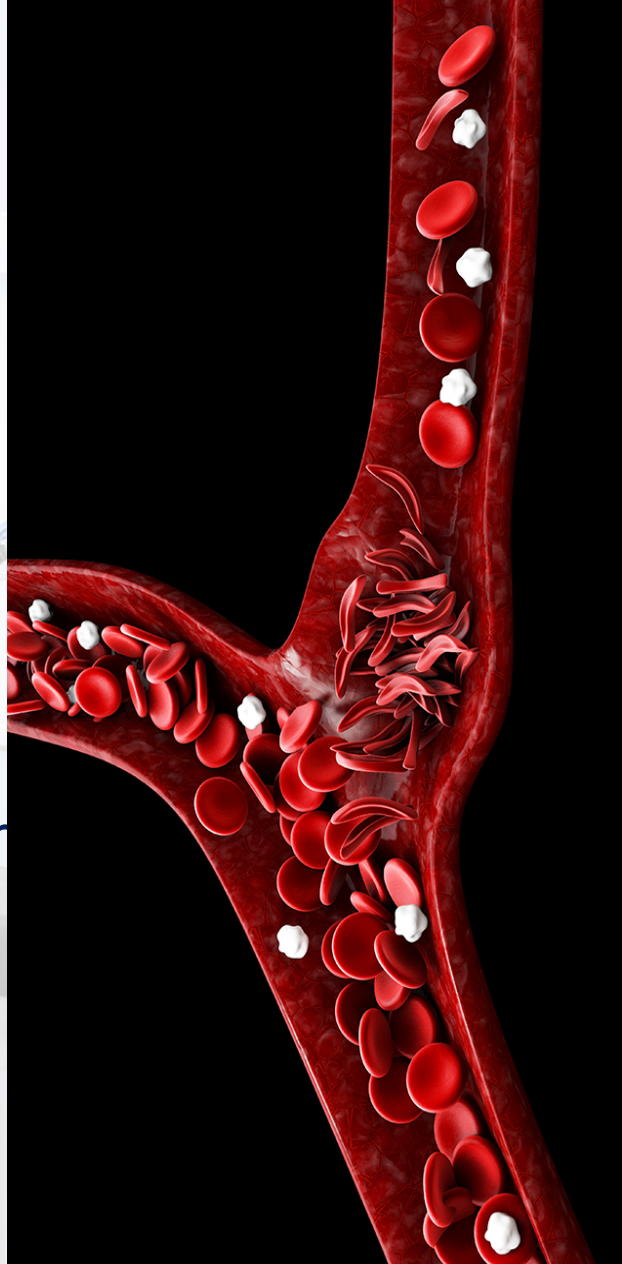
Bioinformatics Applicatio

- Drug Discovery
- Preventive Medicine
- Biofuels
- Plant Modelling
- Gene Therapy
- Waste Clean-up
- Climate Change
- Stem Cell Therapy
- Alternative Energy Sources
- Microbial Genome
- Crop Improvement
- Nutrition Quality
- Bio-weapon Development
- Forensic Science
- Veterinary Sciences
- Antibiotic Resistance
- Evolutionary Studies
- Insect Resistance

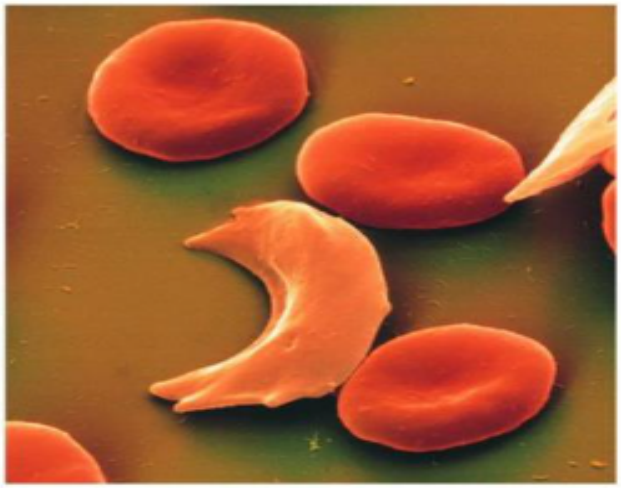
Case study: Sickle-cell

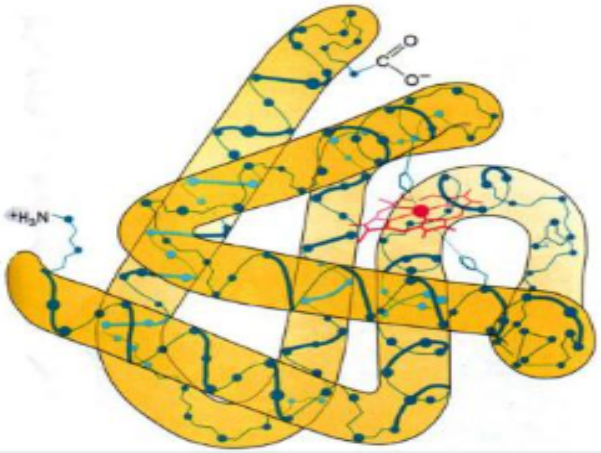
- Normal red blood cells are round and flexible, able to carry oxygen and travel through blood vessels
- People with Sickle-cell Anemia have red blood cells that look like a sickle and get stuck in blood vessels

- What went wrong?
  - Hemoglobin molecules, which are responsible for carrying oxygen, form a long chain in affected people
  - Why? There is a mutation in one of the hemoglobin genes on chromosome 11



Case study: Sickle-cell





Normal Cells

CAA	GTA	AAC	ATA	GGA	CTT	CTT	DNA
GUU	CAU	UUG	UAU	CCU	GAA	GAA	mRNA
val	his	leu	thr	pro	glu	glu	Protein

Sickle Cells

CAA	GTA	AAC	ATA	GGA	CAT	CTT	DNA
GUU	CAU	UUG	UAU	CCU	GUA	GAA	mRNA
val	his	leu	thr	pro	val	glu	Protein

Red blood cells undergo sickling due to a single base change in the DNA of the beta-globin gene. This base change in DNA changes one residue in the protein`

Thank you