Introduction to Bioinformatics

biological data processes

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Outline

- ✓What is bioinformatics?
- ✓ Research area to manage and analyze biological data
- ✓New Science
- ✓Biological data
- ✓Bioinformatics Today
- ✓Bioinformatics Flow Chart
- ✓Computational approaches to biological questions
- ✓Bioinformatics Applications.
- ✓What can I do as computer science?
- ✓Bioinformatics Applications for Computer Science

BioInformatics Group

What is bioinformatics?

The combination of biology and information technology. It is a branch of science that deals with the computer based analysis of large biological data.

biological data= DNA, RNA and Protein Sequence

Information technology applied to the management and analysis of biological data statistical tools and algorithms to analyze and determine relationships between biological sets, such as macromolecular sequences and structures, etc…

What is bioinformatics (contd…)?

Bioinformatics use disciplines of computer science such as AI, neural networks, genetic algorithms, dynamic programming, pattern recognition, data mining, machine learning , algorithms to accelerate and enhance biological research.

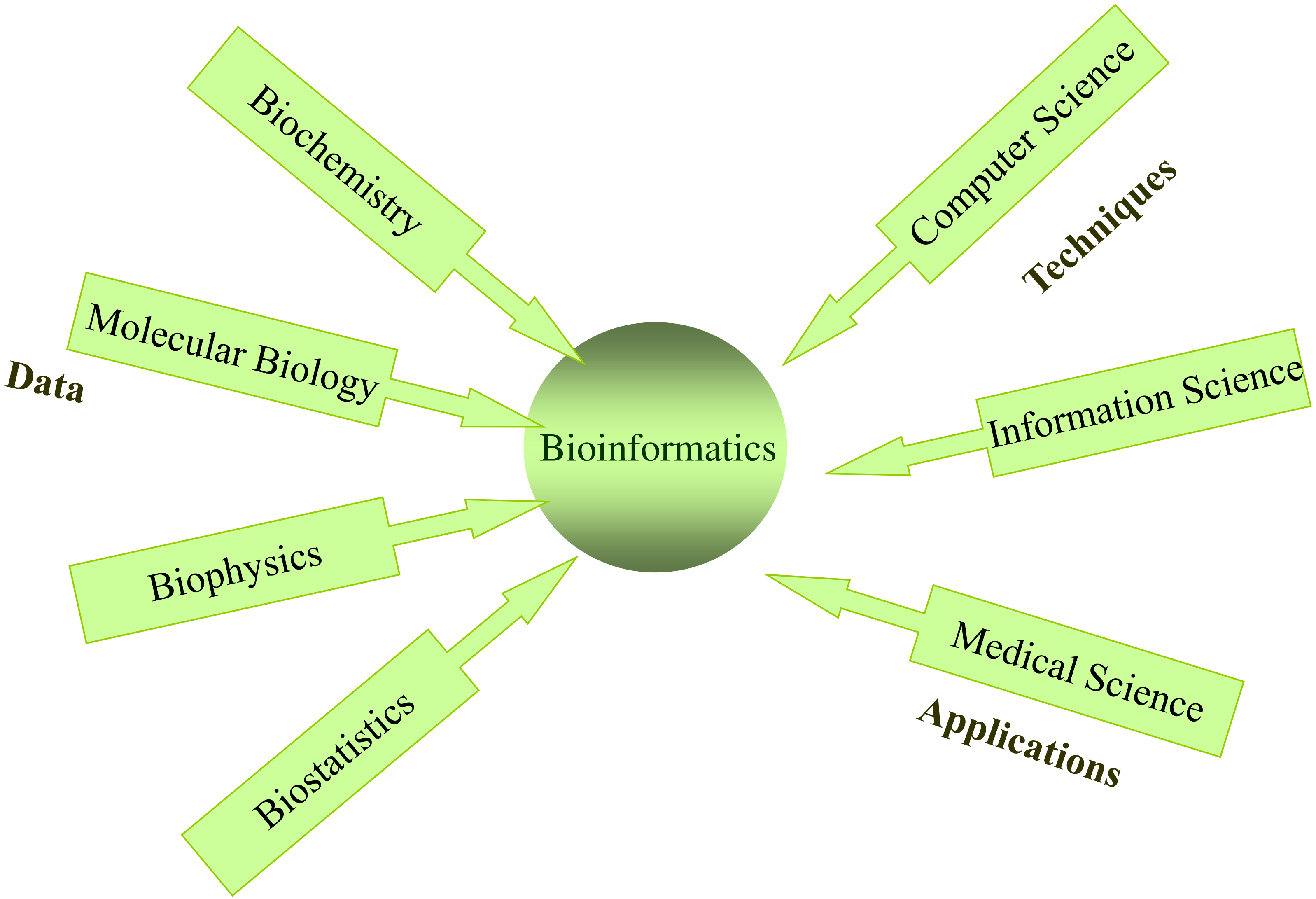
What is bioinformatics (contd...)?

Biologists
collect molecular data:
DNA & Protein sequences,
gene expression, etc.

Bioinformaticians
Study biological questions by
analyzing molecular data

Computer scientists
(+Mathematicians, Statisticians, etc.)
Develop tools, software's, algorithms
to store and analyze the data.

Research area to manage and analyze biological data



New Science

Most of the biologists don’t know computer science. Most computer scientists don’t know biology.

… There is a new science ----------------→ Bioinformatics

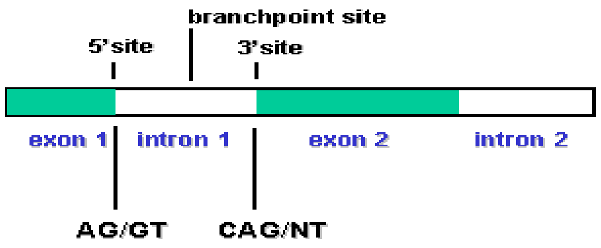
Biological data comes in many forms:

- Sequence
  - DNA and protein sequence
- Structure
  - RNA Secondary structure, protein secondary and 3D structure
- Graphs
  - Biological networks

Bioinformatics Today

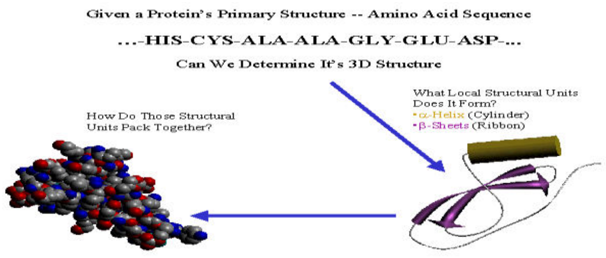
Sequence analysis

- Sequence alignment
- Structure and function prediction
- Gene finding



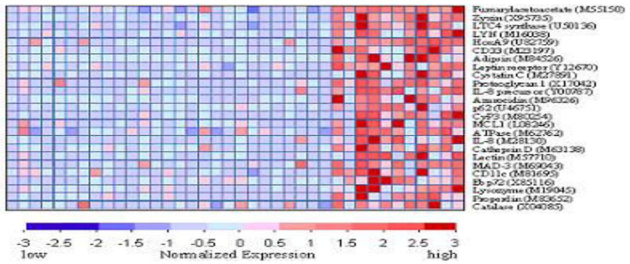
Structure analysis

- Protein structure comparison
- Protein structure prediction
- RNA structure modeling



Expression analysis

- Gene expression analysis
- Gene clustering



Bioinformatics Flow Chart

1. Sequencing

↓

1a. Analysis of nucleic acid(DNA,RNA) seq.

↓

2. Analysis of protein seq.

↓

3. Molecular structure prediction

↓

4. molecular interaction

↓

5. Gene & Protein expression data

↓

7. Drug Design

Computational approaches to biological questions

Biological question	Computational approach
• Understanding one genome	• String and graph based algorithms for sequence assembly
• Understanding many genomes	• Comparing multiple genomes using trees and hidden markov models
• Identifying causal genes for a disease	• Clustering\ etc..

Bioinformatics Applications

Some Simple Bioinformatics Applications

- Identify a gene in a genome
- Mutation location
- ORF
- Motif
- Predict function of unknown genes/proteins
- Retrieve/compare gene sequences (Alignments)

Bioinformatics Applications (contd ...)

1

How do we identify a gene in a genome?

A gene is characterized by several features (promoter, ORF…)

Bioinformatics Applications (contd …)

Q: Where are the genes in this genome?

1

CCACACCACACCCACACACCCACACACCACACCACACACCACACCACACCCACACACACACATCCTAACACTACCCTAACACAGCCCTAATCTAACCCTGGCCAACCTGTCTCTCAACTT
CGTTACCCTGTCCCATTCAACCATACCACTCCGAACCACCATCCATCCCTCTACTTACTACCACTCACCCACCGTTACCCTCCAATTACCCATATCCAACCCACTGCCACTTACCCTACCATT T
CACCATACTGTTCTTCTACCCACCATATTGAAACGCTAACAAATGATCGTAAATAACACACACGTGCTTACCCTACCACTTTATACCACCACCACATGCCATACTCACCCTCACTTGTATACT
CTACAGTATATACCATCTCAAACTTACCCTACTCTCAGATTCCACTTCACTCCATGGCCCATCTCTCACTGAATCAGTACCAAATGCACTCACATCATTATGCACGGCACTTGCCTCAGCGG T
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TCCCCACAAAAATCACCTAAACATAAAAATATTCTACTTTTCAACAATAATACATAAACATATTGGCTTGTGGTAGCAACACTATCATGGTATCACTAACGTAAAAGTTCCTCAATATTGCA
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GCAGCGACTCATTTTTATTTAAGGACAAAGGTTGCGAAGCCGCACATTTCCAATTTCATTGTTGTTTATTGGACATACACTGTTAGCTTTATTACCGTCCACGTTTTTCTAGCACCATATACTTACCACTCCATTTATGAATCAG
TACCAAATGCA

whole genome…

Where are the genes in this genome?

Answer

1

CCACACCACACCCACACACCCACACACCACACCACACACCACACCACACCCACACACACACATCCTAACACTACCCTAACACAGCCCTAATCTAACCCTGGCCAACCTGTCTCTCAACTTACCCTCCATTACCCTGCCTCCACTC
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TGCTAACCGCAATATCCTAAAAGCATAACTGATGCATCTTTAATCTTGTATGTGACACTACTCATACG … TGATAGGTACGTTATTTAATAGGATCTATAACGAAATGTCAAATAATTT
TACGGTAATATAACTTATCAGCGGCGTATACTAAAACGGACGTTACGATATTGTCTCACTTCATCTTA … AACCCCTCAGCTTTATTTCTAGTTACAGTTACACAAAAAACTATGCCA

Protein coding sequence

ACCCAGAAATCTTGATATTTTACGTGTCAAAAAATGAGGGTCTCTAAATGAGAGTTTGGTACCATGACTTGTAACTCGCACTGCCCTGATCTGCAATCTTGTTCTTAGAAGTGACGCATATTCTATACGGCCCGACGCGACGCG
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AATATGTCACATCACTGTCGTAACACTCTTTATTCACCGAGCAATAATACGGTAGTGGCTCAAACTCATGCGGGTGCTATGATACAATTATATCTTATTTCCATTCCCAT**ATGCTAACCGCAATATCCTAAAAGCATAACTGATGC**
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Bioinformatics Applications (contd …)

Healthy Individual 2

>gi|28302128|ref|NM_000518.4| Homo sapiens hemoglobin, beta (HBB), mRNA

ACATTTGCTTCTGACACAACTGTGTTCACTAGCAACCTCAAACAGACACCATGGTGCATCTGACTCCTGA
GGAGAAGTCTGCCGTTACTGCCCTGTGGGGCAAGGTGAACGTGGATGAAGTTGGTGGTGAGGCCCTGGGC
AGGCTGCTGGTGGTCTACCCTTGGACCCAGAGGTTCTTTGAGTCCTTTGGGGATCTGTCCACTCCTGATG
CTGTTATGGGCAACCCTAAGGTGAAGGCTCATGGCAAGAAAGTGCTCGGTGCCTTTAGTGATGGCCTGGC
TCACCTGGACAACCTCAAGGGCACCTTTGCCACACTGAGTGAGCTGCACTGTGACAAGCTGCACGTGGAT
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CCCCACCAGTGCAGGCTGCCTATCAGAAAGTGGTGGCTGGTGTGGCTAATGCCCTGGCCCACAAGTATCA
CTAAGCTCGCTTTCTTGCTGTCCAATTTCTATTAAAGGTTCCTTTGTTCCCTAAGTCCAACTACTAAACT
GGGGGATATTATGAAGGGCCTTGAGCATCTGGATTCTGCCTAATAAAAAACATTTATTTTCATTGC

>gi|4504349|ref|NP_000509.1| beta globin [Homo sapiens]

MVHLTPEEKSAVTALWGKVNVDEVGGEALGRLLVVYPWTQRFFESFGDLSTPDAVMGNPKVKAHGKKVLG
AFSDGLAHLDNLKGTFATLSELHCDKLHVDPENFRLLGNVLVCVLAHHFGKEFTPPVQAAYQKVVAGVAN
ALAHKYH

Bioinformatics Applications (contd …)

Diseased Individual (Mutation)

2

>gi|28302128|ref|NM_000518.4| Homo sapiens hemoglobin, beta (HBB), mRNA

ACATTTGCTTCTGACACAACTGTGTTCACTAGCAACCTCAAACAGACACCATGGTGCATCTGACTCCTGA

GGTGAAGTCTGCCGTTACTGCCCTGTGGGGCAAGGTGAACGTGGATGAAGTTGGTGGTGAGGCCCTGGGC

AGGCTGCTGGTGGTCTACCCTTGGACCCAGAGGTTCTTTGAGTCCTTTGGGGATCTGTCCACTCCTGATG

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CCTGAGAACTTCAGGCTCCTGGGCAACGTGCTGGTCTGTGTGCTGGCCCATCACTTTGGCAAAGAATTCA

CCCCACCAGTGCAGGCTGCCTATCAGAAAGTGGTGGCTGGTGTGGCTAATGCCCTGGCCCACAAGTATCA

CTAAGCTCGCTTTCTTGCTGTCCAATTTCTATTAAAGGTTCCTTTGTTCCCTAAGTCCAACTACTAAACT

GGGGGATATTATGAAGGGCCTTGAGCATCTGGATTCTGCCTAATAAAAAACATTTATTTTCATTGC

>gi|4504349|ref|NP_000509.1| beta globin [Homo sapiens]

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AFSDGLAHLDNLKGTFATLSELHCDKLHVDPENFRLLGNVLVCVLAHHFGKEFTPPVQAAYQKVVAGVAN

ALAHKYH

Random Sample

whole Data

3

atgaccgggatactgataccgtatttggcctaggcgtacacattagataaacgtatgaagtacgttagactcggcgc

acccctatttttgagcagatttagtgacctggaaaaaaatttgagtacaaacttttccgaatactgggcataag

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Implanting Motif AAAAAAAGGGGGGG

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acccctattttttgagcagatttagtgacctggaaaaaaaatttgagtacaaaacttttccgaataAAAAAAAAGGGGGGGa

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Where is the Implanted Motif?

atgaccgggatactgataaaaaaaaggggggggcgtacacattagataaacgtatgaagtacgttagactcggcgccgccg

acccctattttttgagcagatttagtgacctggaaaaaaaatttgagtacaaaacttttccgaataaaaaaaaaggggggga

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ctggtgagcaacgacagattcttacgtgcattagctcgcttccggggatctaatagcacgaagcttaaaaaaaaaggggggga

Implanting Motif AAAAAAGGGGGG with Four Mutations 3

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ctggtgagcaacgacagattcttacgtgcattagctcgcttccggggatctaatagcacgaagcttActAAAAAGGaGcGGa

What can I do as computer science?

In the beginning should be proficient in one of the programming languages that can be programmed : Matlab is the easiest of the programming languages because it has contain functions (tools) that can be use. We may need a language that deals with databases as (Foxpro,Oracl ,..).

The programmer can do the following:

- Bioinformatics use certain training of computer science such as AI, neural networks, genetic algorithms, dynamic programming to accelerate and enhance biological research.

What can I do as computer science (contd…)?

- One of the most basic operations in bioinformatics involves searching for similarities, or homologies, between a newly sequenced piece of DNA and another sequenced DNA segments from various organisms can be use computer techniques to solve this operations.

- Correspondingly, there is a need to think about changes in hardware and software configurations of the present day computers, as they would very soon become redundant. Watch for days in near future when a multi-processor computer would be available for the price of a personal computer…

What can I do as computer science (contd…)?

the programmer can do the following (specific)

- ✓ Detection of the location of mutations depending on the **neural network (genetic programming).**
- ✓ **Statistic** pattern (codon) in a sequence .
- ✓ Distinguish patterns (**recognize**)   for different sequence .
- ✓ Comparison of two or more sequences based on **neural networks.**
- ✓ Sequence alignment based on **artificial intelligence.**

What can I do as computer science (contd…)?

- ✓ Design an **integrated** system to handle a different database (fast and ease)
- ✓
- ✓ Comparison of two different amino acid structures (**image processing**)
- ✓ **Design** protein and nucleic acid structural
- ✓ **Image processing** for output microarray
- ✓ **Simulation** protein-protein interaction.
- ✓ Etc……

Some Simple Bioinformatics Applications (Research's) for Computer Science

Bioinformatics Applications (Research's) for Computer Science

DNA Sequence Assembly using Particle Swarm Optimization

Ravi Shankar Verma
National Institute of Technology
Raipur, India

Vikas Singh
ABV- Indian Institute of Information Technology and management, Gwalior, India

Sanjay Kumar
National Institute of Technology
Raipur, India

AI

Applications of artificial intelligence in bioinformatics: A review

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A Genetic Algorithm Approach to Solving DNA Fragment Assembly Problem

Shu-Cherng Fang,[*,†] Yong Wang, and Jie Zhong

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Bioinformatics Applications (Research's) for Computer Science

Data and text mining

Bioimage informatics: a new area of engineering biology

Hanchuan Peng
Janelia Farm Research Campus, Howard Hughes Medical Institute, Ashburn, Virginia, USA

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Image processing

The role of Digital Image Processing and pattern recognition in the Bioinformatics."

Dr. Evelio Luis Báez Pérez, Centro de Bioplantas,Universidad de Ciego de Avila

Bioinformatics Applications (Research's) for Computer Science

International Journal of Computer Science & Information Technology (IJCSIT) Vol 3, No 4, August 2011

DNA Lossless Differential Compression Algorithm Based on Similarity of Genomic Sequence Database

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Big Data in Bioinformatics & the Era of Cloud Computing

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Data management

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Aspects of DNA Cryptography

Calina Popovici

Security

Good Practice in (Pseudo) Random Number Generation for Bioinformatics Applications

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Using Cloning Technique for hiding secret message

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Thanks

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