



*Pengantar*

# BIOINFORMATIKA

**UNTUK MEMAHAMI RISET  
DALAM BIDANG KOMPUTASI BIOLOGI**

Angga Aditya Permana, M.Kom

David Agustriawan, S. Kom., M.Sc., Ph.D.

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Semenjak Proyek genom manusia (Human Genome Project) yang berhasil dipetakan pada tahun 2003 dan perkembangan teknologi sekuensing yang semakin canggih seperti teknologi next-generation sequencing (NGS) yang bersifat "high throughput" yang dapat menghasilkan big data dalam bidang –omics (genomics, transcriptomics, epigenomics, proteomics, metabolomics dan lain sebagainya) untuk semua spesies yang melahirkan sebuah bidang ilmu Bioinformatika dimana keahlian dalam bidang komputasi biologi diperlukan untuk menganalisa dan menginterpretasikan ledakan big data dalam bidang –omics. Dengan demikian, diperlukan pemahan mengenai teknologi sekuensing bioinformatika yang dapat menghasilkan sekuens DNA/RNA/Protein dan lain sebagainya yang kemudian dapat dianalisa dengan statistik dan pemrograman (machine learning / deep learning) dalam bidang biologi komputasi untuk berbagai aspek kehidupan, seperti untuk mencari potensial Biomarker pada suatu penyakit seperti penyakit menular, penyakit kanker, penyakit yang diturunkan dan penyakit lainnya. Selain itu pengaplikasian data sekuens dari Teknologi sekuensing juga dapat digunakan dalam bidang forensik, desain obat, perikanan, pertanian dan lain sebagainya. Bidang ilmu Bioinformatika menjadi sangat populer di Indonesia semenjak adanya wabah pandemi virus Covid-19, dimana pemerintah dan pihak swasta menyiapkan teknologi sekuensing NGS yang dapat digunakan untuk mengetahui varian dari covid-19 pada populasi masyarakat di Indonesia. Selain itu, dari data sekuensing tersebut para peneliti juga dapat memanfaatkannya untuk pembuatan vaksin. Buku ini membahas mengenai sejarah, databases, teknologi, serta pengaplikasian data dan keahlian bioinformatika dalam berbagai bidang kehidupan secara umum. Buku ini juga membahas metode biologi komputasi (statistik, machine learning dan deep learning) untuk menganalisa data-data dari teknologi Bioinformatika. Dengan membaca buku ini diharapkan para pembaca dapat memahami bagaimana cara memahami riset dalam bidang biologi komputasi.



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## KATA PENGANTAR

Semenjak Proyek genom manusia (Human Genome Project) yang berhasil dipetakan pada tahun 2003 dan perkembangan teknologi sekuensing yang semakin canggih seperti teknologi next-generation sequencing (NGS) yang bersifat “high throughput” yang dapat menghasilkan big data dalam bidang -omics (genomics, transcriptomics, epigenomics, proteomics, metabolomics dan lain sebagainya) untuk semua spesies yang melahirkan sebuah bidang ilmu Bioinformatika dimana keahlian dalam bidang komputasi biologi diperlukan untuk menganalisa dan menginterpretasikan ledakan big data dalam bidang -omics. Dengan demikian, diperlukan pemahaman mengenai teknologi sekuensing bioinformatika yang dapat menghasilkan sekuens DNA/RNA/Protein dan lain sebagainya yang kemudian dapat dianalisa dengan statistik dan pemrograman (machine learning / deep learning) dalam bidang biologi komputasi untuk berbagai aspek kehidupan, seperti untuk mencari potensial Biomarker pada suatu penyakit seperti penyakit menular, penyakit kanker, penyakit yang diturunkan dan penyakit lainnya. Selain itu pengaplikasian data sekuens dari Teknologi sekuensing juga dapat digunakan dalam bidang forensik, desain obat, perikanan, pertanian dan lain sebagainya. Bidang ilmu Bioinformatika menjadi sangat populer di Indonesia semenjak adanya wabah pandemi virus Covid-19, dimana pemerintah dan pihak swasta menyiapkan teknologi sekuensing NGS yang dapat digunakan untuk mengetahui varian dari covid-19 pada populasi masyarakat di Indonesia. Selain itu, dari data sekuensing tersebut para peneliti juga dapat memanfaatkannya untuk pembuatan vaksin. Buku ini membahas mengenai sejarah, databases, teknologi, serta pengaplikasian data dan keahlian bioinformatika dalam berbagai bidang kehidupan secara umum. Buku ini juga membahas metode biologi komputasi (statistik, machine learning dan deep learning) untuk menganalisa data-data dari teknologi Bioinformatika. Dengan membaca buku ini diharapkan para pembaca dapat memahami bagaimana cara memahami riset dalam bidang biologi komputasi.

## DAFTAR ISI

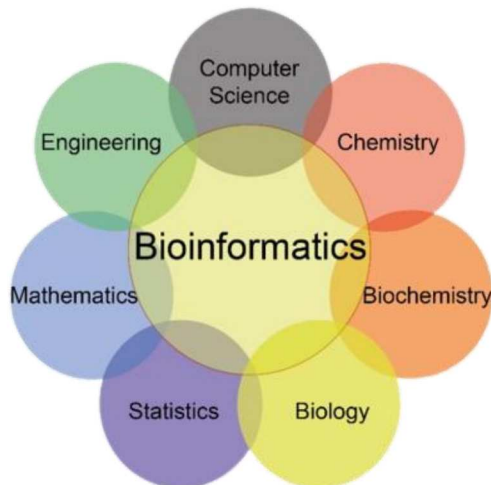
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# BAB

# 1

# BIOINFORMATIKA

## A. Pendahuluan



Gambar 1. 1. Bioinformatika  
Sumber : <https://imgbin.com/>

Bioinformatika adalah bidang ilmu yang memadukan biologi, ilmu komputer, matematika, teknik, kimia, biokimia, dan statistik untuk menganalisis dan memahami data biologis, terutama data genetik dan genomik. Dalam bidang ini, analisis sekuen genetik menjadi salah satu fokus utama. Ilmuwan bioinformatika menggunakan alat dan teknik komputasi untuk mengidentifikasi gen, menentukan struktur gen, dan

# BAB 2

## TEKNOLOGI NEXT- GENERATION SEQUENCING (NGS)

### A. Latar Belakang Teknologi NGS

Untuk melakukan riset atau proyek di bidang Bioinformatika ataupun membuka start up atau perusahaan Bioinformatika di Indonesia diperlukan pemahaman secara terperinci mengenai teknologi-teknologi Bioinformatika. Teknologi Bioinformatika dapat digunakan untuk menghasilkan atau memproduksi data -omics secara masif. Terminologi -omics merupakan sebuah bidang yang memungkinkan untuk mempelajari biologi sistem dari beberapa cabang ilmu, seperti genomik, transkriptomik, epigenomik, metagenomik dan lain sebagainya sehingga diharapkan dapat memberikan pemahaman yang lebih dalam terhadap biologi molekuler suatu sel.

Genomik adalah cabang ilmu yang mempelajari DNA termasuk deteksi variasi DNA/RNA dari suatu makhluk hidup dari berbagai spesies sedangkan transkriptomik mempelajari profil dan kuantifikasi ekspresi gen di beragam stadium dan kondisi (Olivier et al., 2019). Di sisi lain, proteomik mempelajari karakterisasi profil ekspresi protein suatu sel beserta jumlahnya pada sample yang spesifik. Metabolomik mempelajari molekul kecil yang dihasilkan dari lintasan metabolisme (metabolic pathway). Sedangkan untuk epigenomik, epitranskriptomik dan epiproteomik mempelajari modifikasi biokimia berupa proses-proses kimia yang ada di dalam tubuh makhluk hidup terhadap



# BAB 3

## APLIKASI NGS DI DALAM RISET DAN DIAGNOSTIK

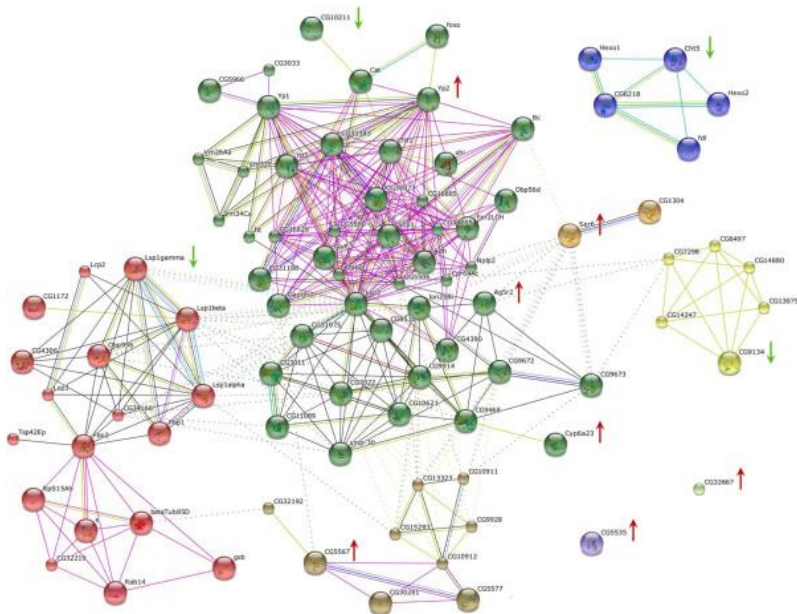
Teknologi NGS telah merevolusi bidang penelitian ilmiah dan genomika klinis karena teknologi tersebut memiliki kemampuan multiplexing yang berkecepatan tinggi. Keunggulan NGS dalam translation medicine tidak hanya terletak pada efisiensi multiplexing yang canggih tetapi juga pada alat bioinformatika yang cerdas yang digunakan untuk kurasi data diikuti oleh berbagai basis data referensi yang membantu peneliti, praktisi medis, dan perancang obat untuk memahami dasar genetik suatu penyakit.

Proyek-proyek sekuensing genom pada suatu populasi yang berbeda seperti 1000 G, ExAC, ESP6500, UK 100 K, Indigenome, dan gnomAD telah menghasilkan jumlah data yang sangat besar dalam NGS (Jain et al., 2021). Di antara basis data populasi referensi, gnomAD adalah basis data terbesar dan paling banyak digunakan yang dihasilkan dari data sekuensing yang diselaraskan yang mencakup data sekuensing eksom dan genom dari 140.000 manusia. Data tersebut telah banyak digunakan sebagai sumber daya untuk memperkirakan frekuensi alel dalam penyakit langka, penemuan gen penyakit, dan efek biologis variasi (Karczewski et al., 2020). Temuan tersebut telah dijadikan acuan untuk pembuatan basis pengetahuan dan pada gilirannya panel sekuensing besar dan kecil untuk aplikasi utama dalam penelitian klinis dan diagnostic (Lu et al., n.d.). Panel - panel gen menemukan aplikasi utama mereka dalam penelitian klinis terutama dalam bidang genetika kanker.

# BAB 4

## PROJEK BIOINFORMATIKA

### A. Protein - Protein Interaction



Gambar 4. 1. Protein-Protein Interaction  
Sumber : (Sagri et al., 2014)

Interaksi Protein-Protein (PPI) adalah fenomena penting dalam biologi molekuler di mana dua atau lebih protein berinteraksi dalam sel atau organisme. PPI adalah fondasi dari sebagian besar proses biologis, memungkinkan protein untuk bekerja sama atau memengaruhi satu sama lain dalam

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## TENTANG PENULIS



**Angga Aditya Permana, M.Kom**  
Dosen Program Studi Informatika  
Fakultas Teknik dan Informatika  
Universitas Multimedia Nusantara

Angga Aditya Permana (lahir pada Desember 1989 di Jakarta) seorang dosen full time di bidang Computer Science pada Universitas Multimedia Nusantara sejak tahun 2021, fokus penelitian pada kriptografi, steganografi serta keamanan computer, namun pada tahun 2021 sedang mendalami topik bioinformatika dan network science. Angga juga memiliki hobi yaitu touring dan juga bermain bulutangkis, saat ini sedang menjadi mahasiswa program doctoral pada IPB University. Memulai karir pertama kali sebagai Network Enginner tahun 2011 dan memulai profesinya sebagai dosen pada 2013 di kampus swasta yang ada di Jakarta, pernah juga mengajar di kampus negeri yang berada di Jakarta dan Tangerang, juga pernah di undang menjadi dosen tamu untuk mengenalkan Bioinformatika di kampus negeri di Jakarta. Terimakasih.



**David Agustriawan, S. Kom., M.Sc., Ph.D.**

Dosen Program Studi Informatika

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David Agustriawan adalah dosen tetap pada Program Studi Informatika, Universitas Multimedia Nusantara sejak tanggal 1 Agustus 2023, sebelumnya menjadi dosen prodi Bioinformatika dan sekaligus bertugas sebagai kepala prodi sejak tahun 2017 sampai tahun 2023 pada Indonesia International Institute for Life Sciences (i3L), dan sebelumnya juga pernah bekerja sebagai dosen tetap di prodi Teknik Informatika pada Universitas Amikom Yogyakarta pada tahun 2008 - 2009. Selama menjadi dosen pada Prodi Informatika dan Bioinformatika David lebih banyak fokus pada mata kuliah pemrograman dan database dengan riset yang berkaitan dengan data analisis pada dunia kesehatan. David menyelesaikan pendidikan S1 pada Jurusan Teknik Informatika Universitas Amikom Yogyakarta Indonesia dan melanjutkan S2 dan S3 pada Jurusan Bioinformatics and Medical Engineering di Asia University Taiwan, fokus penelitian saat ini yaitu pada topik-topik berikut: bioinformatika, medical informatics, cancer epigenetics, deep learning pada data -omics dan memiliki antusias yang tinggi untuk mempelajari topik-topik baru di dunia IT dan Bioinformatika seperti Big data, AWS, software development dan lain sebagainya.