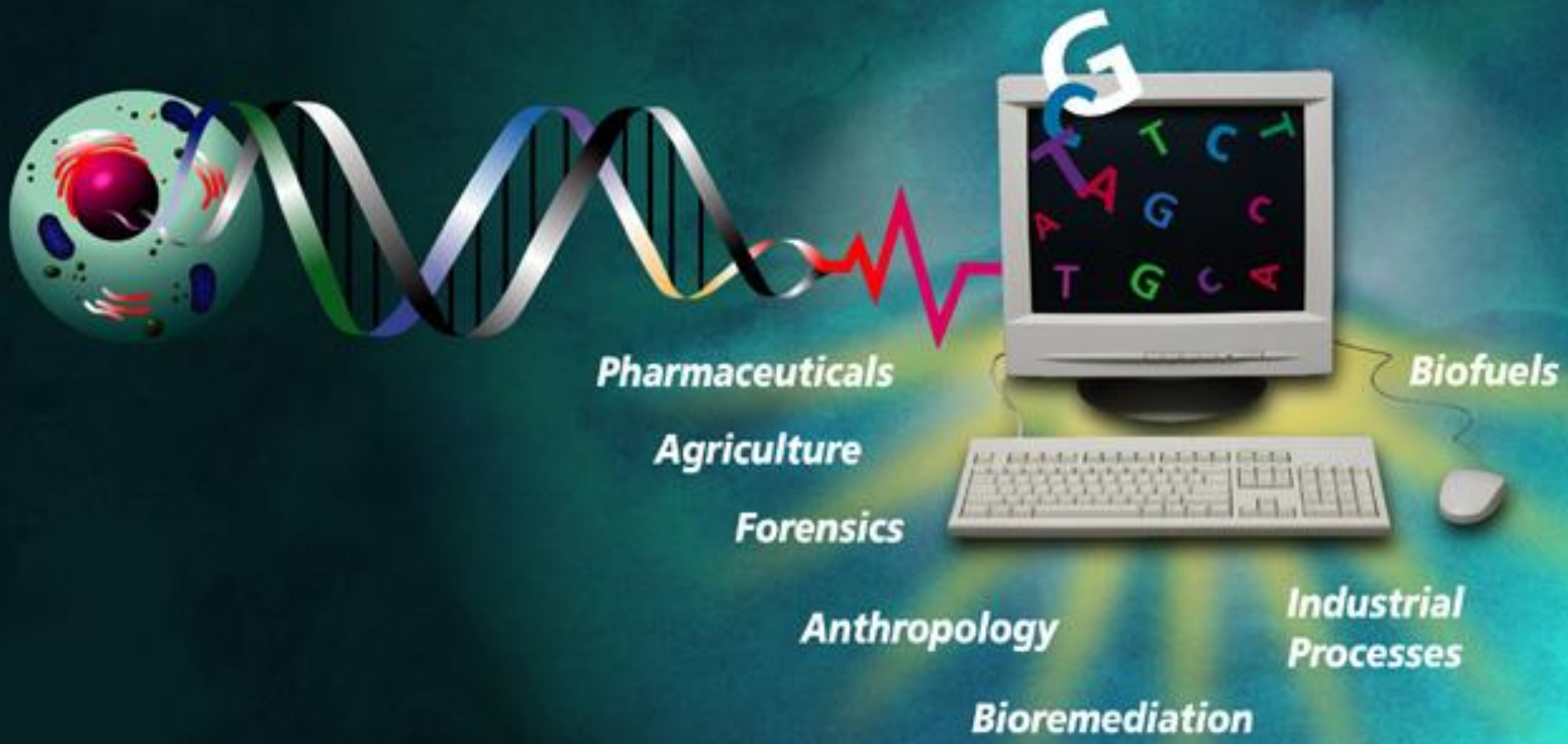
Genomics


Pharmaceuticals
Agriculture
Forensics
Anthropology
Bioremediation
Industrial Processes
Biofuels

Genetic science in this century will touch on all the aspects of our lives that we hold most dear; be it reproduction, nutrition or disease. In order to appreciate what these technologies will be able to deliver, what is hype and what is to be avoided, we need to be literate in exactly what genes do and how and why they do it.

Baroness Susan Greenfield
President, Royal Institution
March 2002

Definitions

Genome

The complete DNA content of an organism

Genomics

The comprehensive study of whole sets of genes and their interactions rather than single genes or proteins

Timeline of Genetic Exploration

Scanning Life's Matrix – HHMI Holiday Lecture

Genomes Sizes

Organism	Genome Size (Bases)	Estimated Genes
Human (*Homo sapiens*)	3 billion	30,000
Laboratory mouse (*M. musculus*)	2.6 billion	30,000
Mustard weed (*A. thaliana*)	100 million	25,000
Roundworm (*C. elegans*)	97 million	19,000
Fruit fly (*D. melanogaster*)	137 million	13,000
Yeast (*S. cerevisiae*)	12.1 million	6,000
Bacterium (*E. coli*)	4.6 million	3,200
Human immunodeficiency virus (HIV)	9700	9

Genome Similarities

- 42% of genes discovered in *C. elegans* had some sort of match to genes in other organisms only distantly related
- 83% of *Drosophila* genes match those of other species
- The gene sequence is not a perfect match but functionality is maintained

Lessons from Human Genome

- Each of your cells had about 6 feet of DNA stuffed into it, but of that, less than 1 inch is devoted to genes.
- Genome size does not correlate with evolutionary status, nor is the number of genes proportionate with genome size.
- Repeat sequences that do not code for proteins make up at least 50% of the human genome – much more that in other organisms
- Number of human genes is 1/3 as great as previously thought
- Complexity lies not in gene number but in how gene parts are used to build different products, the thousands of chemical modifications to proteins, and various regulatory mechanisms

Chromosomes

Chromosome tour - video

Comparative Genomics

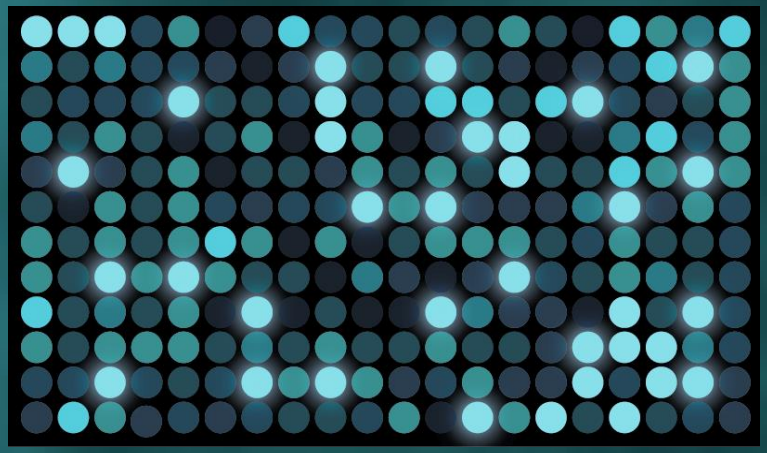
- Analysis and comparison of genomes from different species
- Gain a better understanding of how species have evolved
- Researchers look at many different features when comparing genomes:
  - sequence similarity
  - gene location
  - length and number of coding regions within genes
  - amount of noncoding DNA in each genome
  - highly conserved regions
- Involves the use of computer programs that can line up multiple genomes and look for regions of similarity among them

Functional Genomics

- Identification of the function of genes in a genome
- Attempt to determine the role of single nucleotide polymorphisms (SNPs) --single DNA base changes within the genome
- Figure out the role of noncoding regions and repeats in the genome.

The End of the Beginning:
The Birth of Bioinformatics

- Leading a shift from reductionism that characterized molecular biology and going towards a more holistic approach
- DNA chips allow us to view dynamic nature of genomes and expression of thousands of genes at a time
- Understand our genetic heritage - Evolution is an experimentalist who has been taking notes in genomes for 3.5 billion years



Tools of Bioinformatics

- **Gene prediction software**

  Analyze different reading frames, presence of stop codons, structural and regulatory sequences

- **Sequence alignment software**

  Determine similarity between sequences – BLAST (Basic Local Alignment Search Tool)

- **Molecular Phylogenetics**

  Construct gene trees based on sequence data

- **Molecular modeling and 3-D visualization**

  Determine protein structure and function – enter primary amino acid sequence and predict 3-D structure

Bioinformatics and the Internet

- **PubMed**
  Access to citations from biomedical literature
- **Entrez**
  Search and retrival system integrating all public databases
- **BLAST**
  Align sequences and search for similarities

Applications of Genomics and Bioinformatics

- **Medicine**
  Gene testing and gene therapy
  Pharmacogenomics - designer drugs

- **Agriculture**
  Disease, insect, and drought-resistant crops
  More nutritious produce

- **Bioarcheology and Anthropology**
  Evolution through germline mutations in lineages
  Migration of populations based on maternal genetic inheritance

Applications of Genomics and Bioinformatics

- **DNA Identification**

  Criminal forensics

  Paternity and other family relationships
  Match organ donors with recipients

- **Microbial Genomics**

  Rapidly detect and treat pathogens

  Monitor environments to detect pollutants
  Protect citizenry from biological and chemical warfare

Societal Concerns

- Privacy and confidentiality of genetic information
- Fairness in use of genetic information by insurers, employers, courts, and schools
- Fairness in access to advanced genomic technologies
- Conceptual and philosophical implications regarding human responsibility
- Health and environmental issues concerning gm foods and microbes
- Commercialization of products including property rights and accessibility of data and materials

We share 51% of our genes with yeast and 98% with chimpanzees - it is not genetics that makes us human.

Dr Tom Shakespeare
University of Newcastle