

BIOMETRICS

<http://scgwww.epfl.ch/courses>

Dr. Andrzej Drygajlo, ELE 233

andrzej.drygajlo@epfl.ch

Speech Processing and Biometrics Group

Signal Processing Institute

Swiss Federal Institute of Technology Lausanne (EPFL)

National Center of Competence in Research (NCCR)

“Interactive Multimodal Information Management (IM)²”

IDIAP Research Institute, Martigny

School of Criminal Sciences

University of Lausanne

- Fundamentals of Biometrics
- Analysis, Modeling and Interpretation of Biometric Data
- **Leading Biometric Technology**
- Multimodal Biometrics
- **Biometric Standards**
- Small, Medium and Large Scale Biometric Systems
- Integration of biometrics with other existing technologies
- Behavioral Biometrics in Human-Machine Communication
- Securing Biometric Data and Systems
- Biometric Encryption
- **Biometric Applications**
- Privacy and Legal Issues

- Speaker Recognition
- Dynamic Signature
- Fingerprints
- Iris
- Retina
- Face
- **Others**
- Multimodal Biometrics



DNA



DNA



THAÏLANDE Un médecin prélève un échantillon d'ADN sur une victime non identifiée.

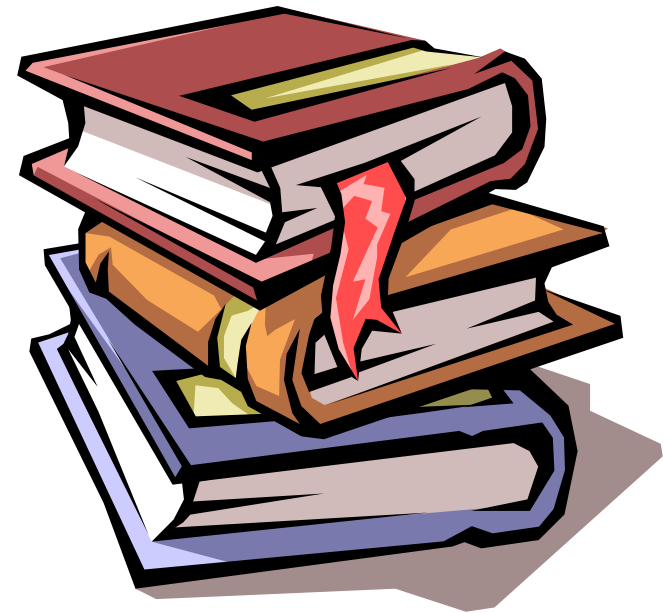


IDENTIFICATION Lorsque l'état du corps le permet, les légistes suisses relèvent les empreintes digitales.

Des médecins légistes suisses en Thaïlande

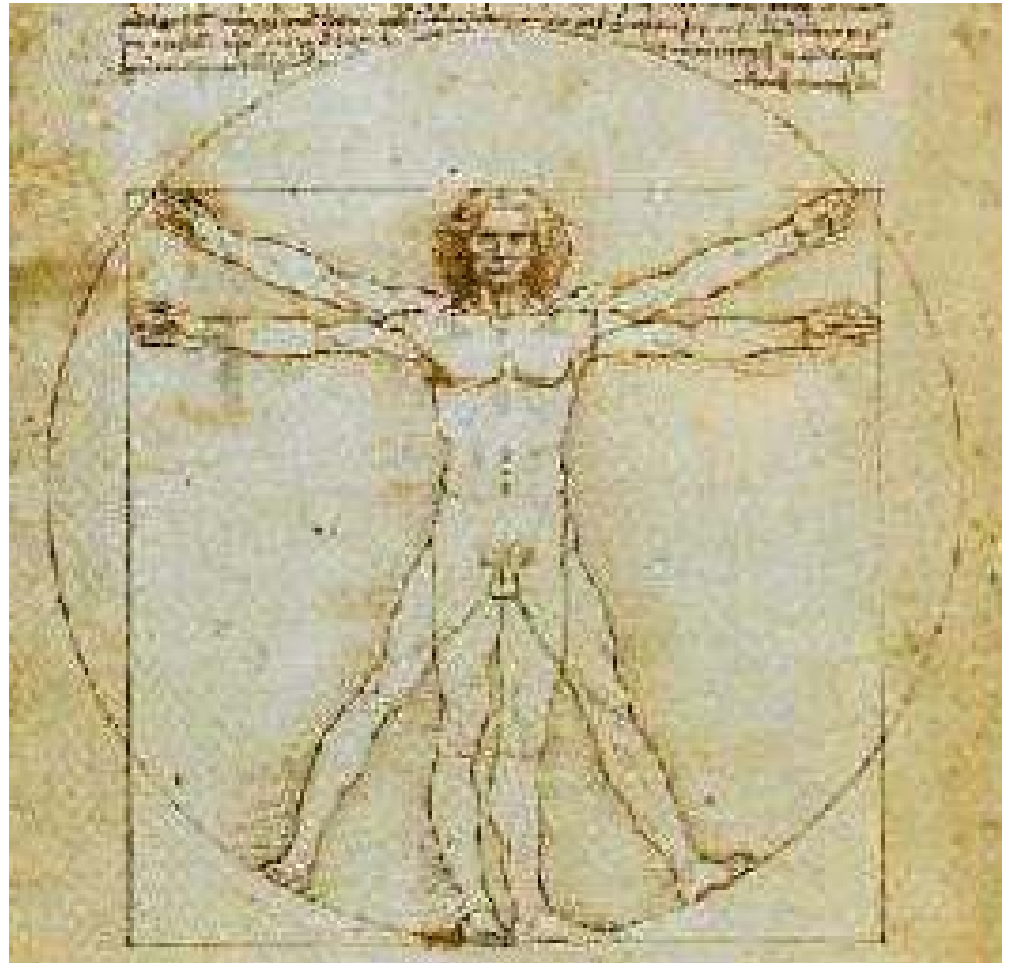
- **Biological traces**
 - **DNA (DeoxyriboNucleic Acid)**, blood, saliva, etc.
- **Biological (physiological) characteristics**
 - **fingerprints, eye irises and retinas**, hand palms and geometry, and **facial geometry**
- **Behavioral characteristics**
 - **dynamic signature**, gait, keystroke dynamics, lip motion
- **Combined**
 - **voice**

- N. Rudin, et al., “**DNA Based Identification**”, chapter 14 in A. Jain, R. Bolle, S. Pankanti, “**Biometrics: Personal Identification in Networked Society**”, Kluwer Academic Publishers, Norwell, 1999.
- J. M. Butler, “**Forensic DNA Typing**”, Academic Press, New York, 2001.
- R. Coquoz, “**Preuve par l’ADN**”, PPUR, Lausanne, 2003



- **Generalities**
- Chromosomes
- DNA (DeoxyriboNucleic Acid)
- DNA Components
- DNA for Human Identification
- Polymerase Chain Reaction (PCR)
- Short Tandem Repeats (STR)
- Capillary Electrophoresis
- Steps in DNA Analysis
- Applications
- DNA Instrumentation
- The Future of DNA Identification Technology

- **What to do?**
- **How?**
- **Why?**



How close are we to GATTACA?

10



<http://www.imdb.com/title/tt0119177/>

1997 movie with a futuristic story of a genetically imperfect man and his seemingly unobtainable goal to travel in space.

Gattaca Corp. is an aerospace firm in the future. During this time society analyzes your DNA and determines where you belong in life.

Ethan Hawke's character was born with a congenital heart condition which would cast him out of getting a chance to travel in space. So in turn he assumes the identity of an athlete named Jerome who has genes that would allow him to achieve his dream of space travel.

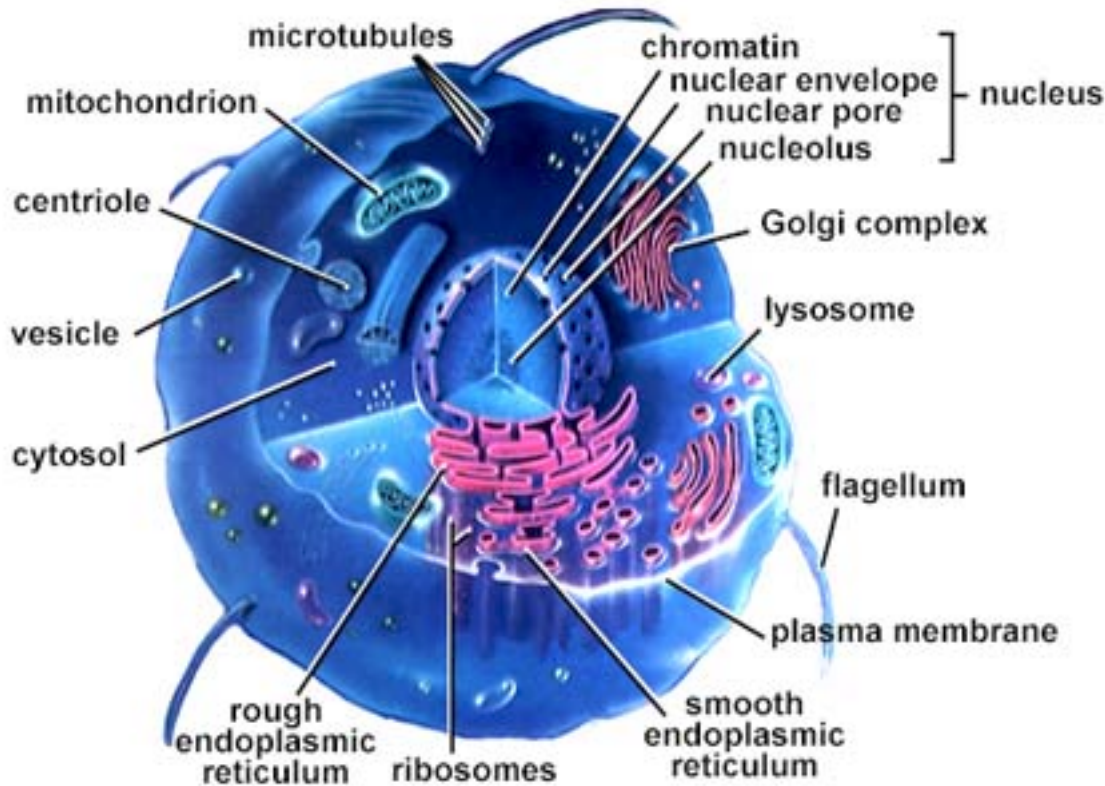
Hawke's character Vincent constantly passes genetic tests by diligently using samples of Jerome's hair, skin, blood and urine.

Entry to secure locations controlled by rapid genetic profiling

Ability to predict future health risks based on genetic testing

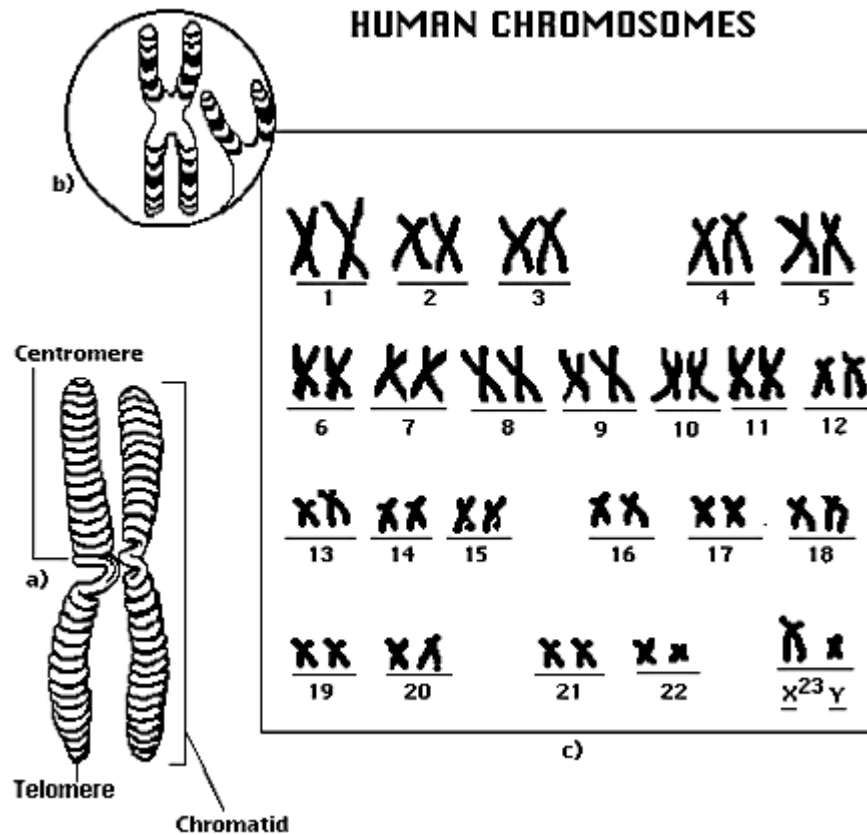
NOT THERE YET!

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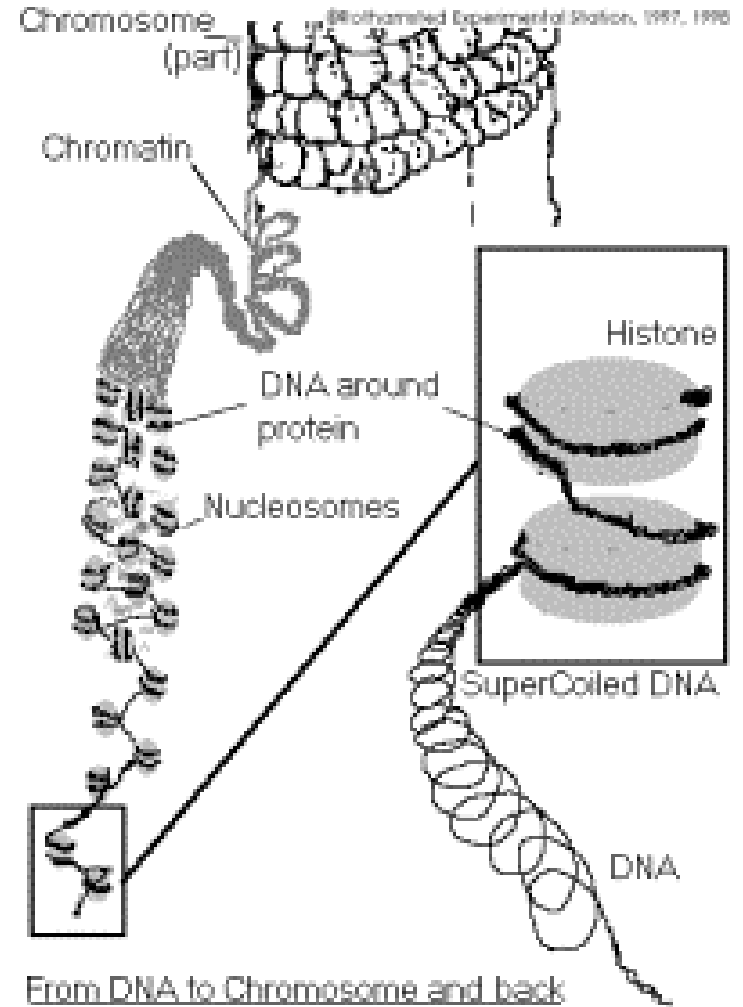
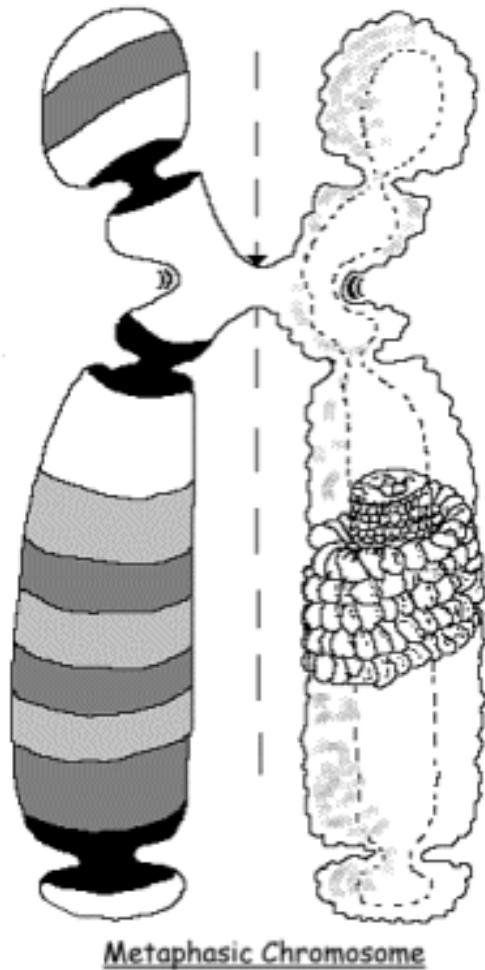
- There are about 100 trillion cells in the adult human body
- Most of them have a nucleus, or center, that contains thread-like bundles of chromosomes
- In these chromosomes are all of the instructions and genetic information needed to make a human being

All cells of an organism contain the same DNA content (and the same genes) yet there is a variety of cell types.



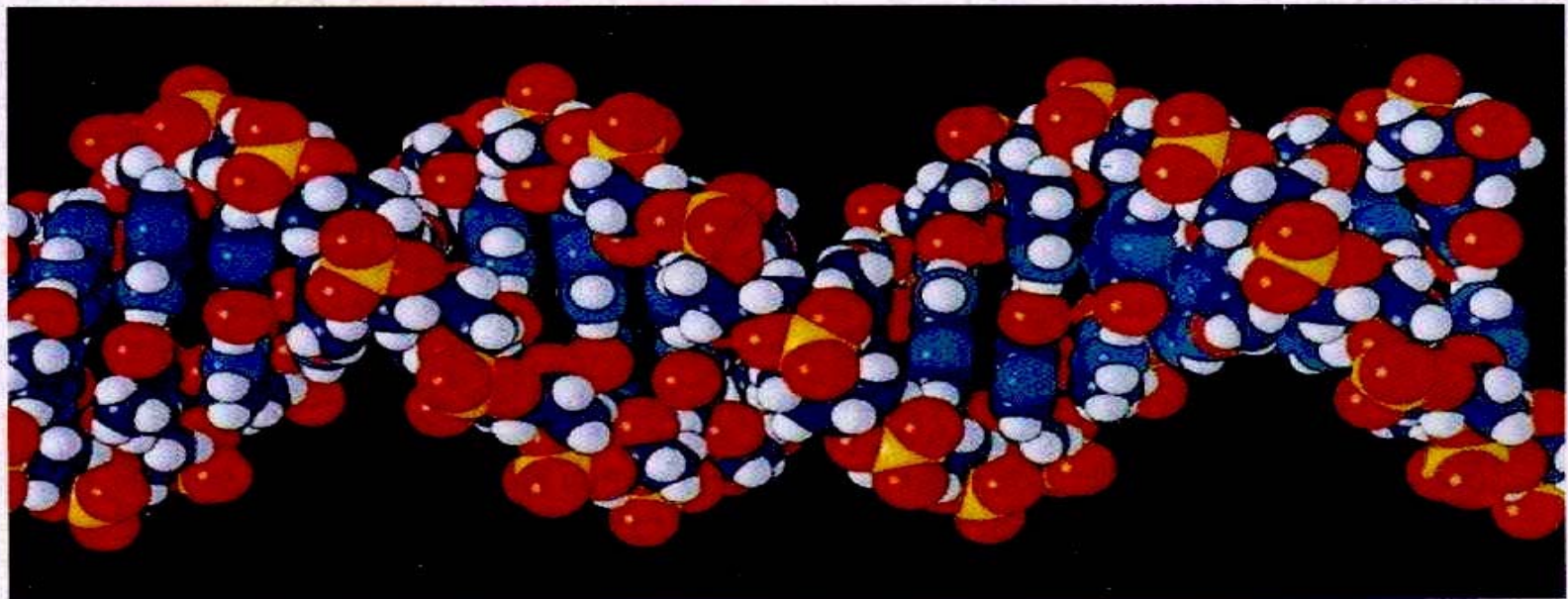
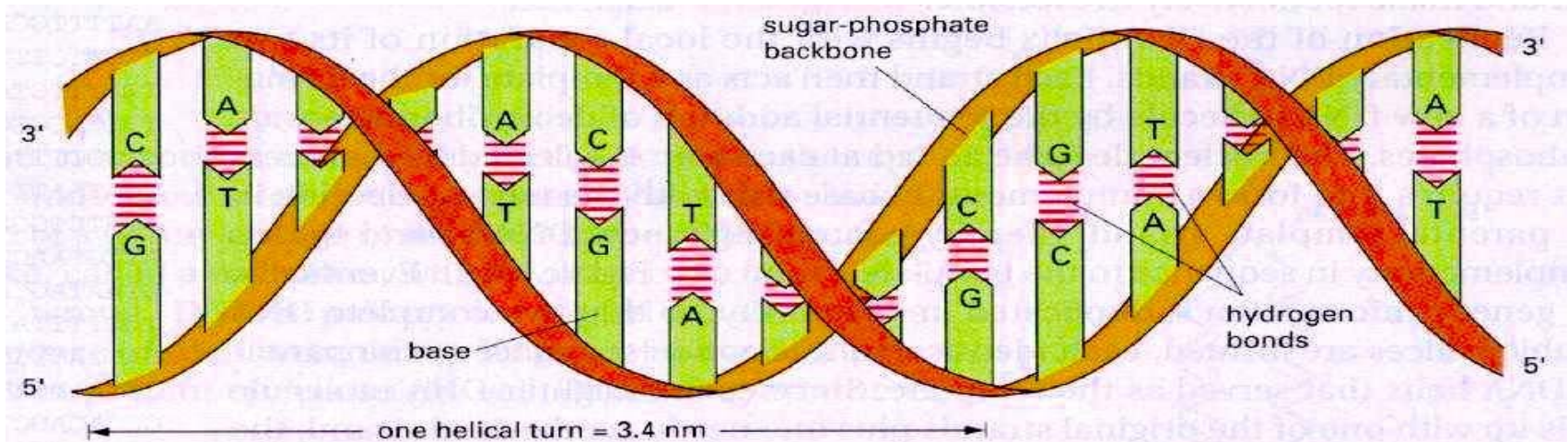
A chromosome is the visible state of genetic material during a phase of the division of the cell (metaphase). Humans have 23 pairs of chromosomes.

Within the chromosomes, are up to 100'000 paired genes, the fundamental units of heredity. Genes are made of **DeoxyriboNucleic Acid (DNA)**.



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DNA - The double helix



- The spiral staircase, the **double helix**, is the natural form in which DNA is found within the nucleus of the cells
- DNA is a polymer, i.e., a long string of simple repeating units.
- These repeating units are called **nucleotides** and are of four types:
 - Adenine (A)
 - Cytosine (C)
 - Guanine (G)
 - Thymine (T)
- Just as the order of the letters of the alphabet determines the information content of words, the order in which these four bases are strung together is what gives DNA its genetic information content.
- The complete DNA molecule consists of two of these strands of the four bases.

**...ATTGCCAGGCTTAGTCCATAGAGCCGC...
...TAACGGTCCGAATCAGGTATCTCGGCG...**

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Four nucleotide types:

Adenine
Guanine
Cytosine
Thymine

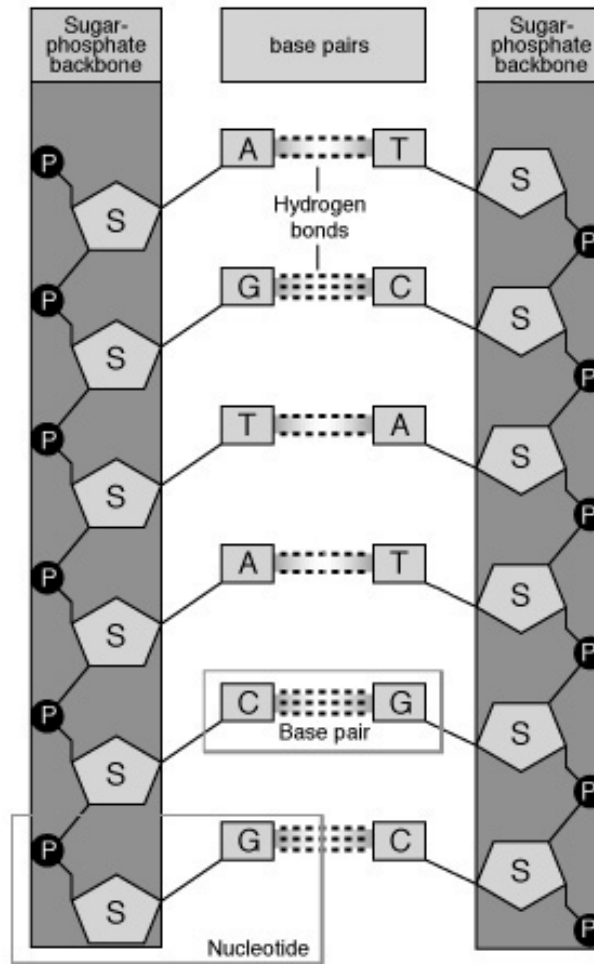
Hydrogen bonds

(electrostatic connection):

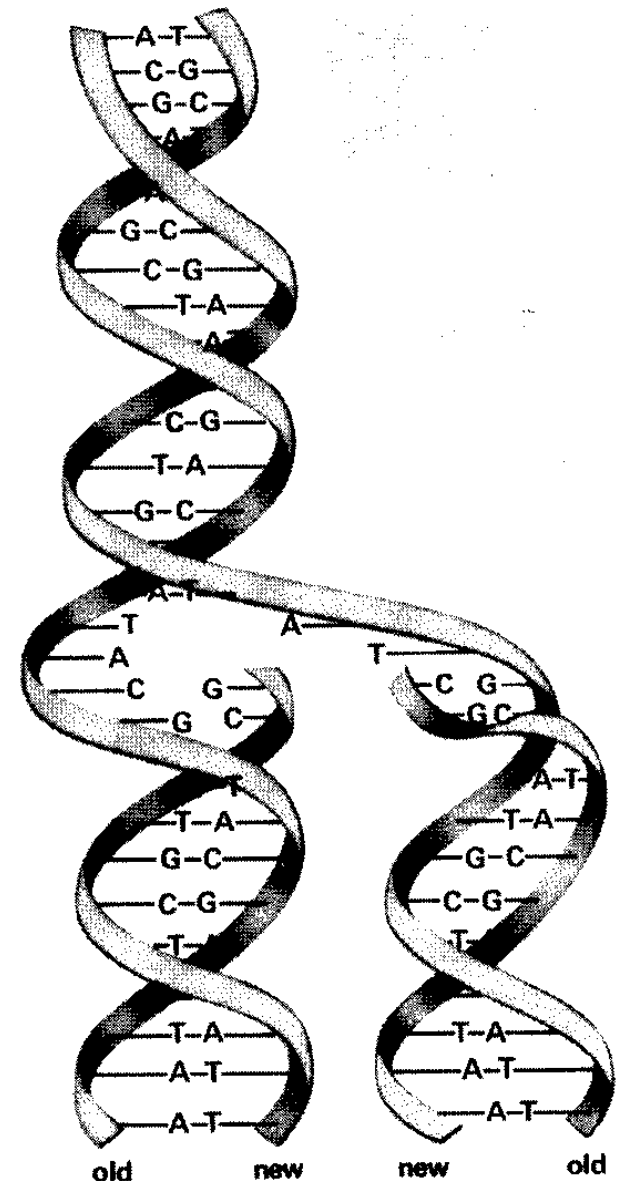
A-T
C-G

A always is across from or paired with T and G always is paired with C

C-G are the base pairs that are the unit of measurement in determining the size of a given segment of DNA



- This structure suggests a natural mechanism for the **duplication** or **replication** of the DNA molecule, as occurs during cell division
- Within the chromosomes, are up to 100'000 paired genes, the fundamental units of heredity
- Each gene can have different versions (as many as 100 or more in rare cases) called alleles, but most are the same from person to person



Information Storage

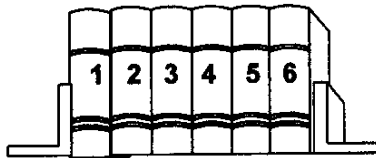
Paternity blood testing has come a long way since the judge had the bailiff hold the baby up next to the alleged father prior to reaching the verdict. Blood typing was discovered almost a century ago, but the revolution in paternity testing did not start until the 1970s, with the widespread application of HLA testing. DNA testing completes the revolution in parentage testing and kinship analysis because it removes the need to report ambiguous results.

Biological characteristics including the HLA
Solving genetic cases involving identical twins
DNA, the master code of life, codes for every
feature of an organism

Organization of Information

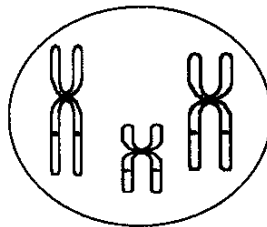
Location of Information

Language



Volumes in a Set of Encyclopedias

Genetics



23 Pairs of Chromosomes in a Cell

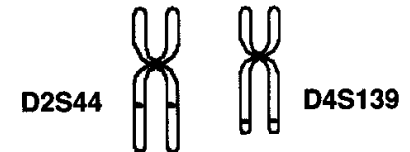
Printed Information

Volume, Page, Line



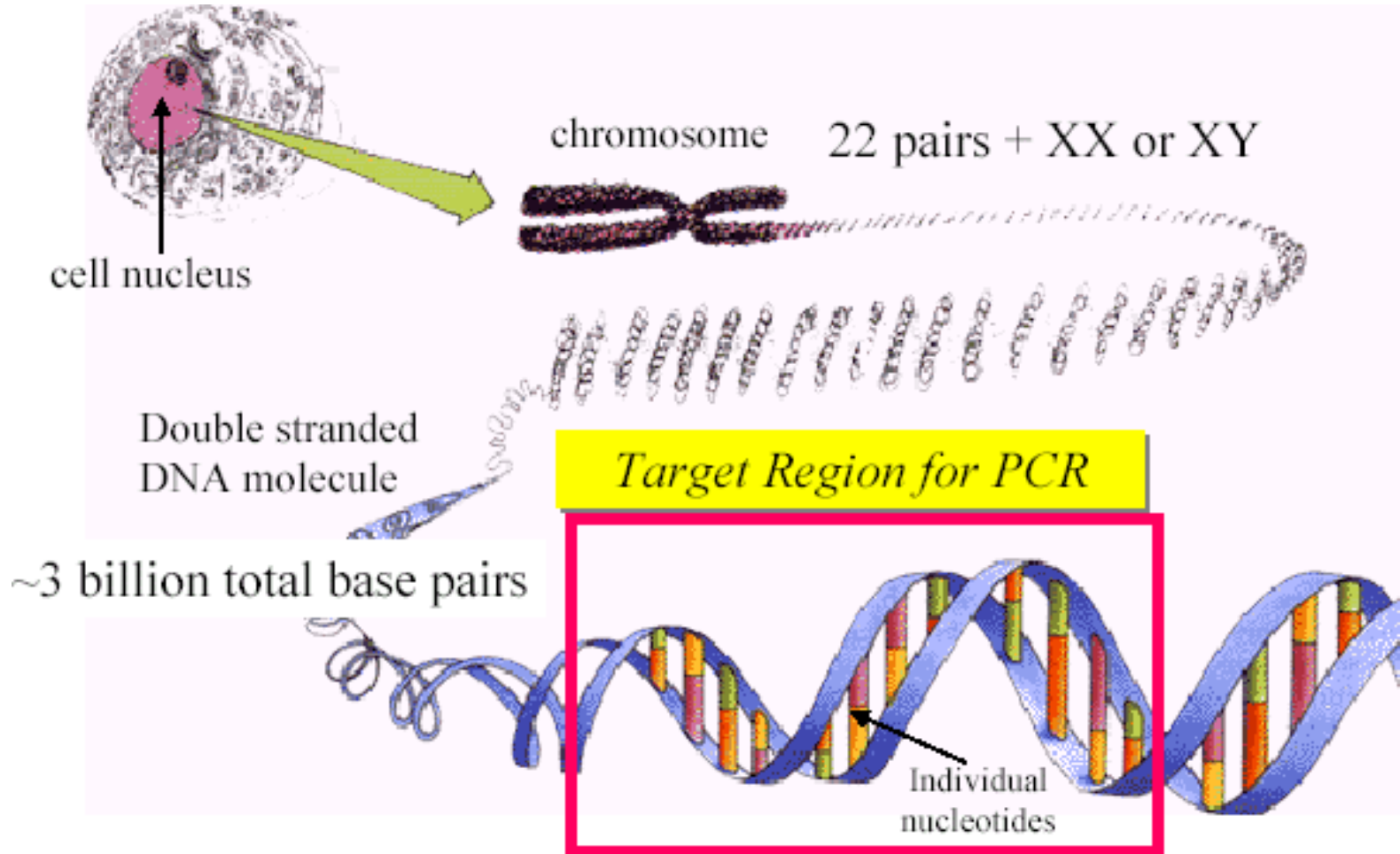
Cellular Information

Chromosome, Locus



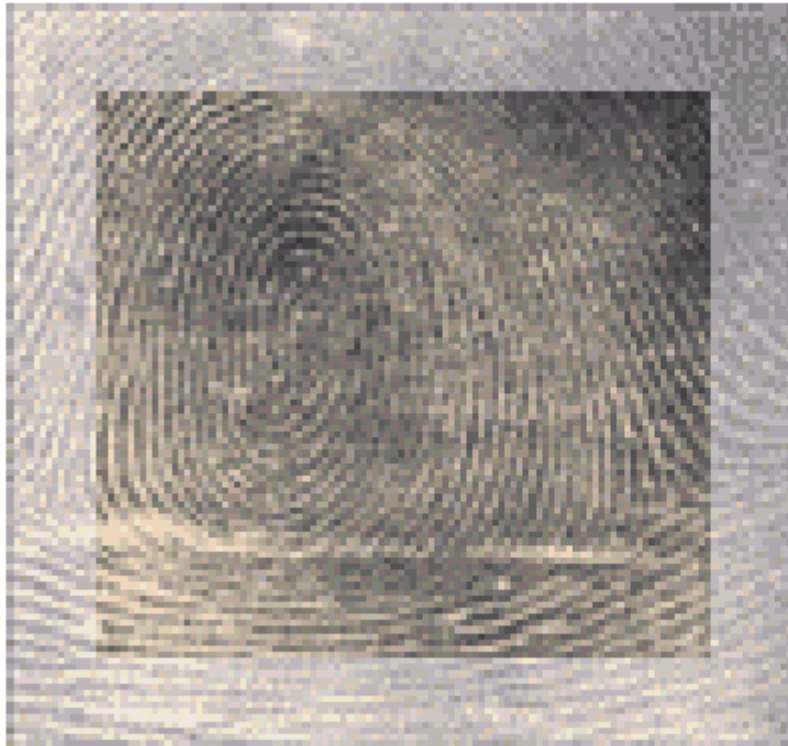
D4S139 – 139th DNA probe mapped to chromosome 4

- Each person has a unique DNA profile
- Each person's DNA is the same in every cell
- An individual's DNA profile remains the same throughout life
- Most DNA is the same from person to person
- Some DNA varies from person to person

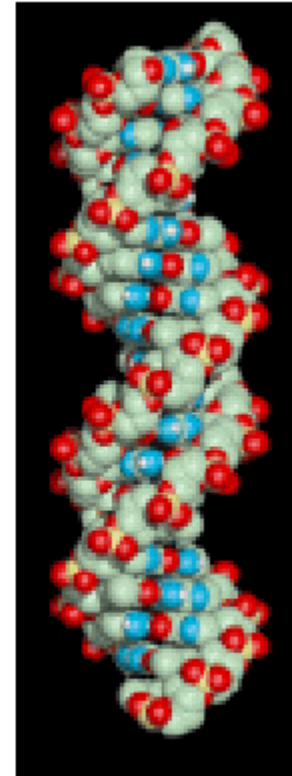


PCR – Polymerase Chain Reaction

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Fingerprints have been used since 1901



DNA since 1986

- Length Variation

short tandem repeats (**STRs**)

CTAGTCGT(**GATA**)(**GATA**)(**GATA**)GCGATCGT

- Sequence Variation

single nucleotide polymorphisms (**SNPs**)

insertions/deletions

GCTAGTCGATGCTC(**G/A**)GCGTATGCTGTAGC

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PCR polymerase chain reaction – method of amplifying a specific region of the genome – go from 1 to over a billion copies in about 2 hours

Locus region of the genome being examined

Allele the state of the genetic variation being examined
(**STRs** = number of repeat units)
(**SNPs** = base sequence at the site)

Chromosomes are paired so...

Homozygous – Alleles are identical on each chromosome

Heterozygous - Alleles differ on each on each chromosome

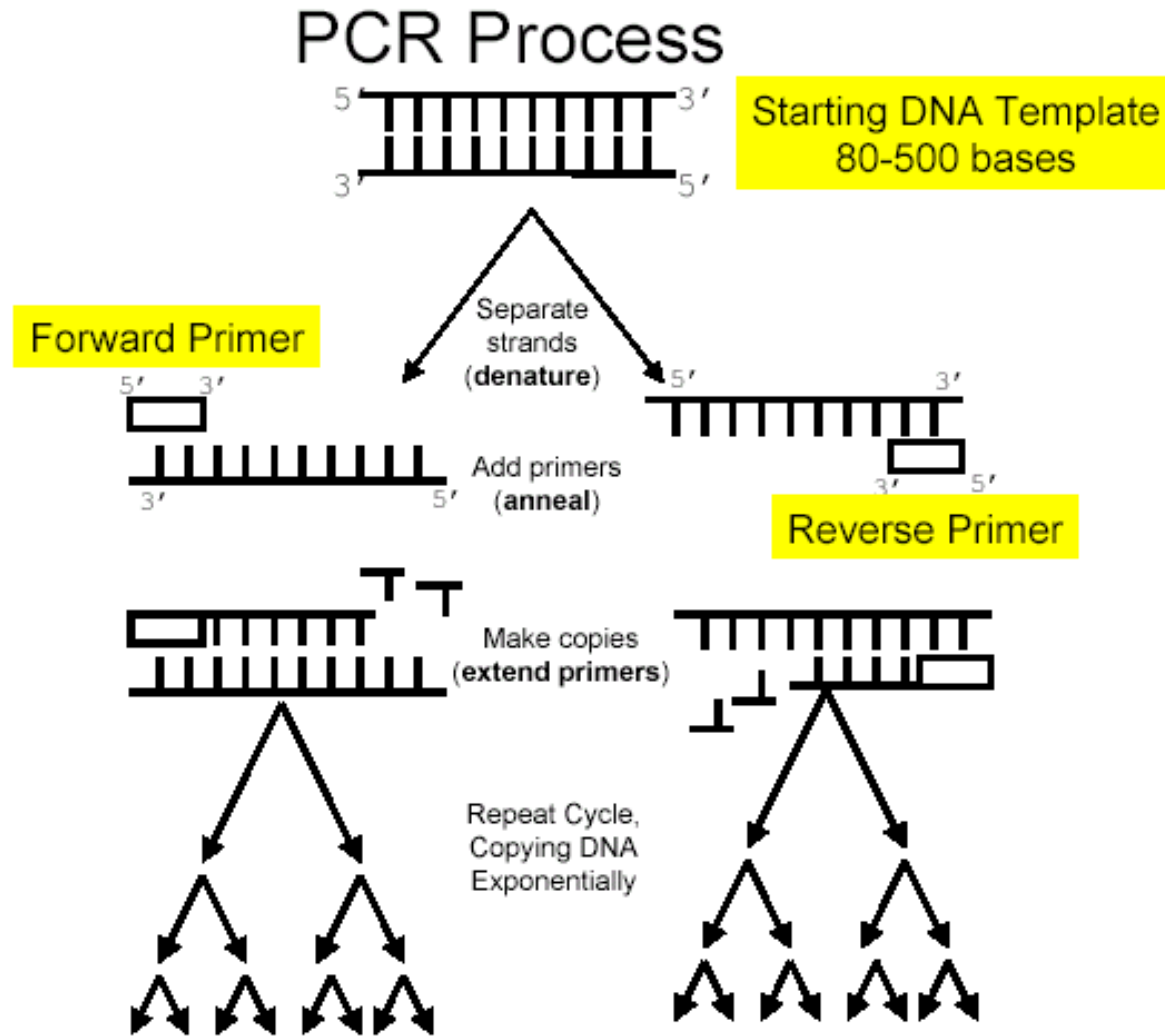
Recommended Web page for more details on PCR:

T.A. Brown, “Genomes” BIOS Scientific Publishers, Second Edition 2002

<http://www.ncbi.nlm.nih.gov/books/bv.fcgi?rid=genomes.section.6064>

<http://www.ncbi.nlm.nih.gov/books/bv.fcgi?rid=genomes.section.6217>

Polymerase Chain Reaction (PCR)



PCR : Polymerase Chain Reaction

30 - 40 cycles of 3 steps :

Step 1 : denaturation

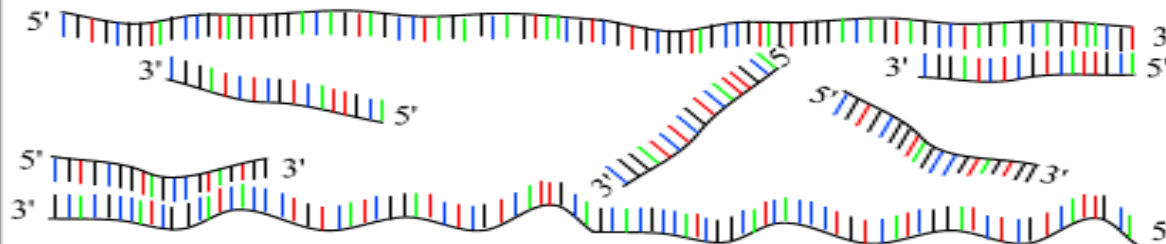
1 minut 94 °C



Step 2 : annealing

45 seconds 54 °C

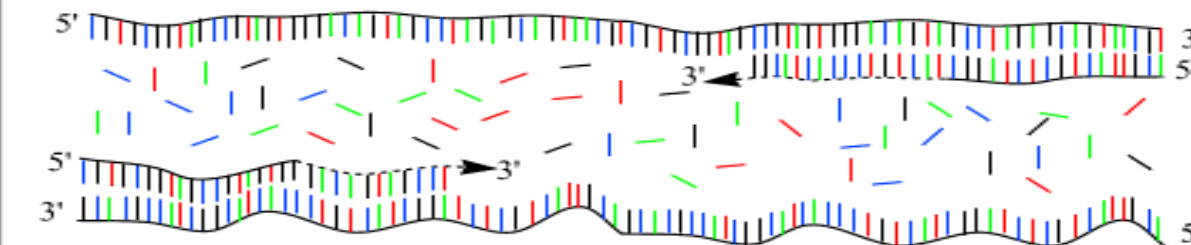
forward and reverse primers !!!



Step 3 : extension

2 minutes 72 °C

only dNTP's



(Andy Vierstraete 1999)

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- Length Variation

short tandem repeats (STRs)

CTAGTCGT(GATA)(GATA)(GATA)GCGATCGT

- Sequence Variation

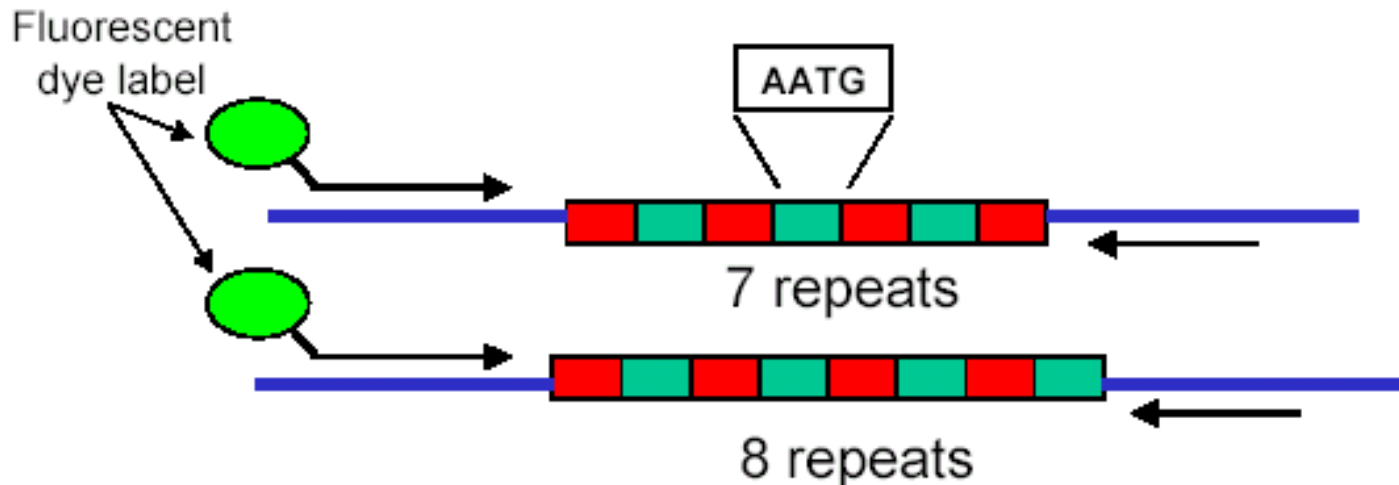
single nucleotide polymorphisms (SNPs)

insertions/deletions

GCTAGTCGATGCTC(G/A)GCGTATGCTGTAGC

Short Tandem Repeats (STR)

33

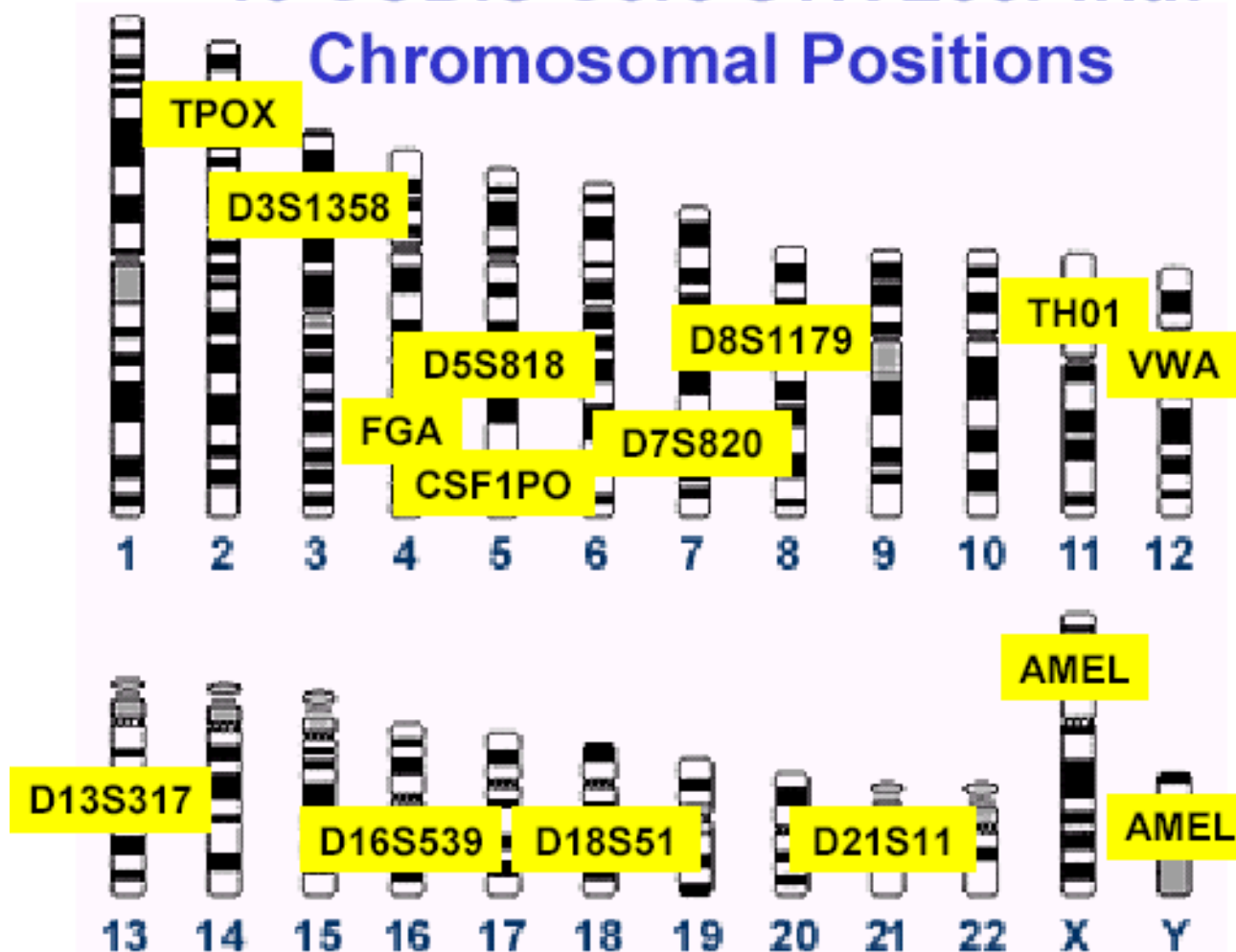


the repeat region is variable between samples while the flanking regions where PCR primers bind are constant

Homozygote = both alleles are the same length

Heterozygote = alleles differ and can be resolved from one another

13 CODIS Core STR Loci with Chromosomal Positions





NIST
National
Institute of
Standards
and Technology

STRBase

Short Tandem Repeat DNA
Internet Database

... working with industry to develop and apply technology, measurements and standards

General Information

- Intro to STRs
(downloadable PowerPoint)
- STR Fact Sheets**
- Sequence Information
- Multiplex STR Kits
- Variant Allele Reports

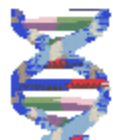
Forensic Interest Data

- FBI CODIS Core Loci
- DAB Standards
- NIST SRM 2391
- Published PCR Primers
- Y-Chromosome STRs
- Population Data
- Validation Studies

Supplemental Info

- Reference List
- Technology Review
- Addresses for Scientists
- Links to Other Web Sites

Standardized
information formats

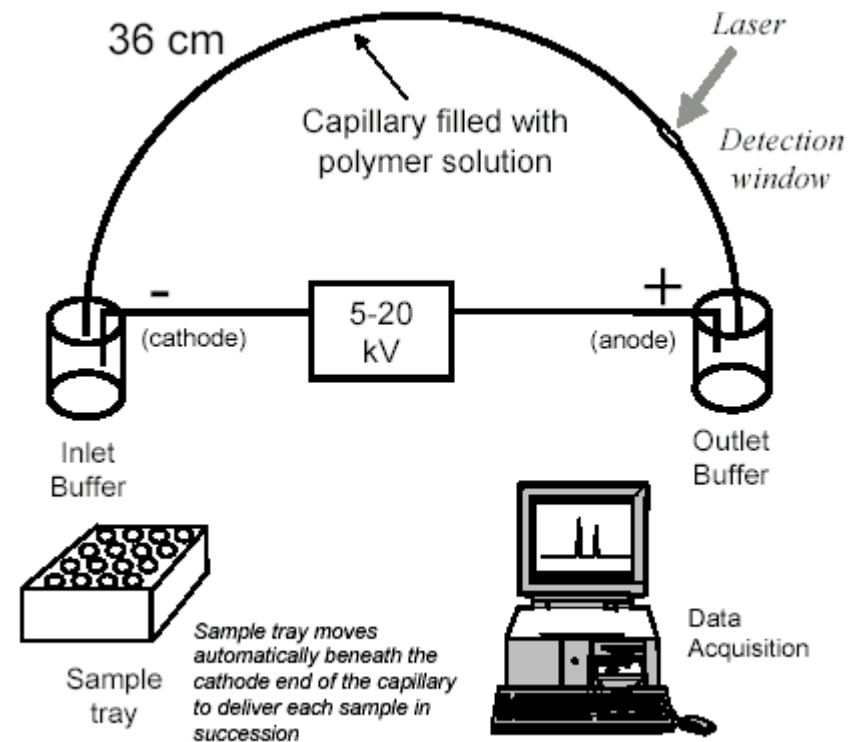
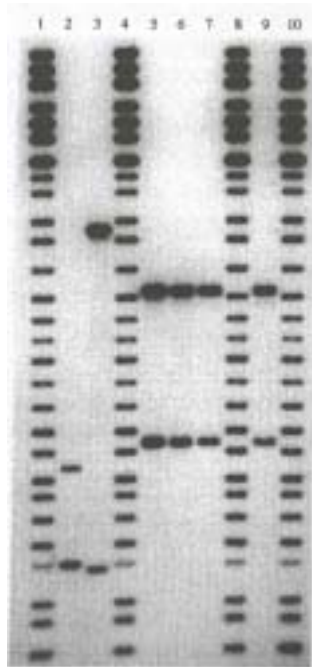
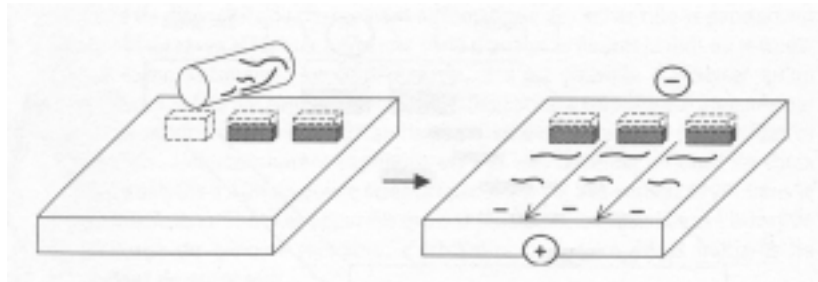


<http://www.cstl.nist.gov/biotech/strbase>

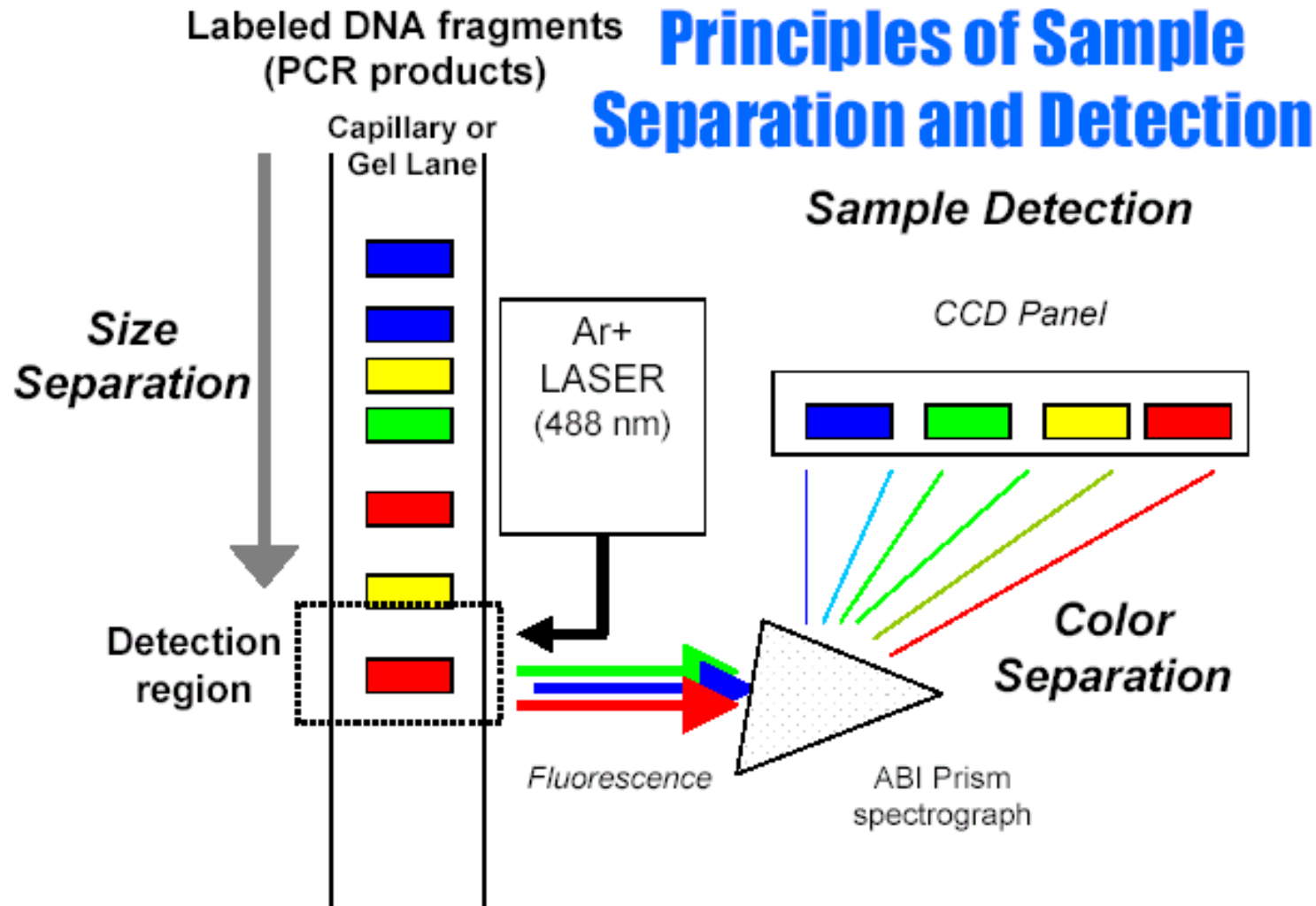
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- Focus solely on STR regions
- Since these repeat regions are usually bounded by specific **restriction enzyme** sites, it is possible to cut out the segment of the chromosome
- **Restriction enzymes** – a class of enzymes obtained from microorganisms that cut the DNA strands at specific four to twelve base pair (bp) sequences
- **Capillary Electrophoresis**
 - Generally used for separating ions, which move at different speeds when the voltage is applied depending on their size and charge. The solutes are seen as peaks as they pass through the detector
 - Area of each peak is proportional to their concentration
 - Produces a chart mapping a person's exact genetic makeup

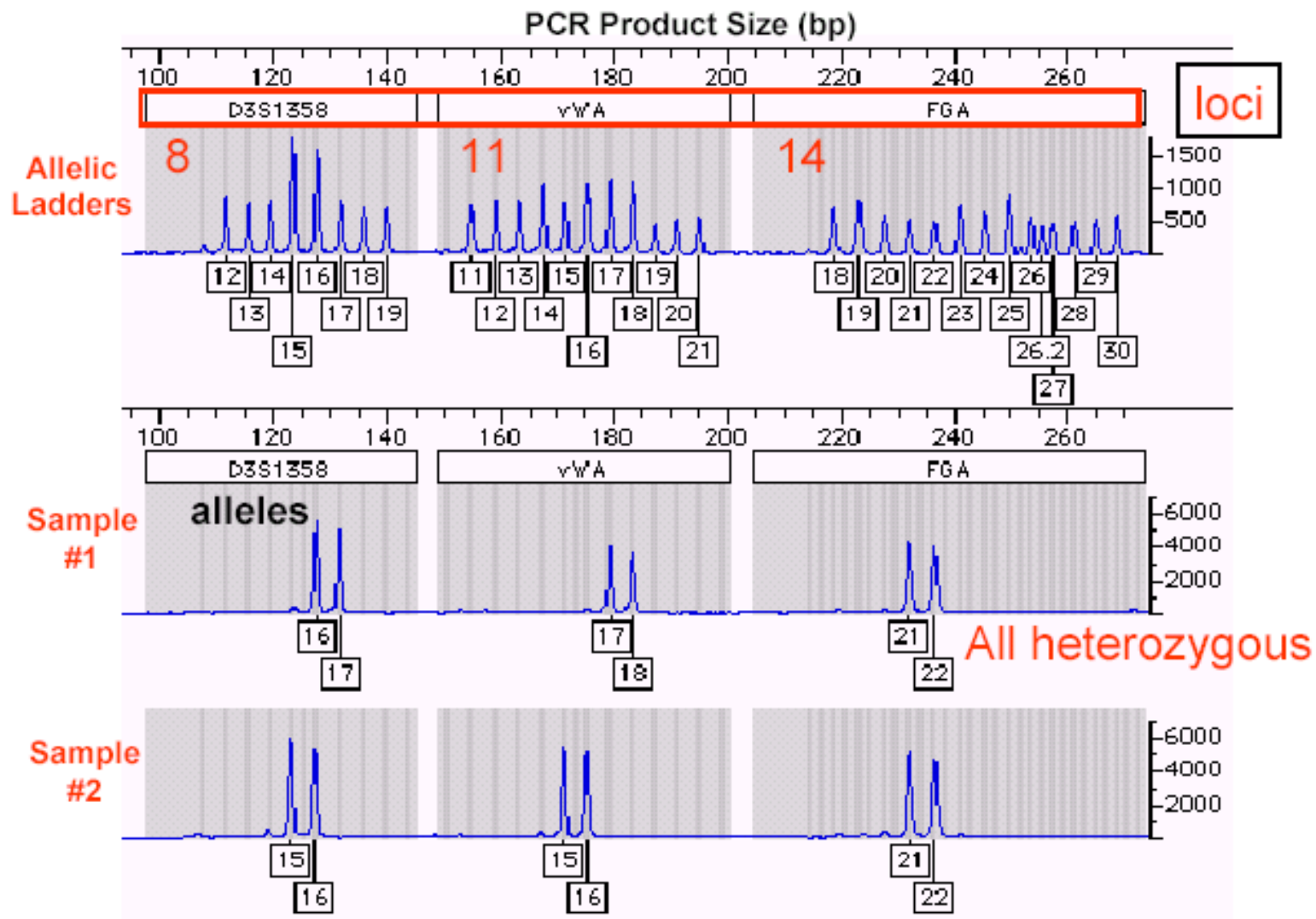
Capillary Electrophoresis System



Butler, J.M. (2001) *Forensic DNA Typing*, Figure 9.3, ©Academic Press



Comparison



Example: Two Suspects

