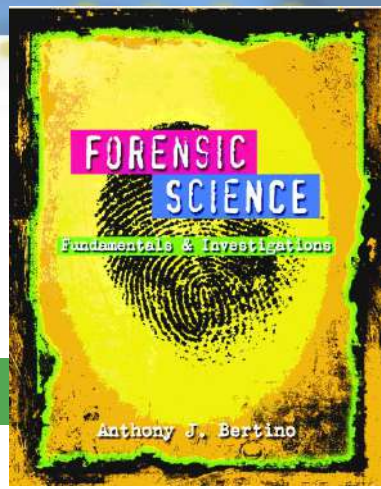
Chapter 7 *DNA Fingerprinting*

By the end of this chapter you will be able to:

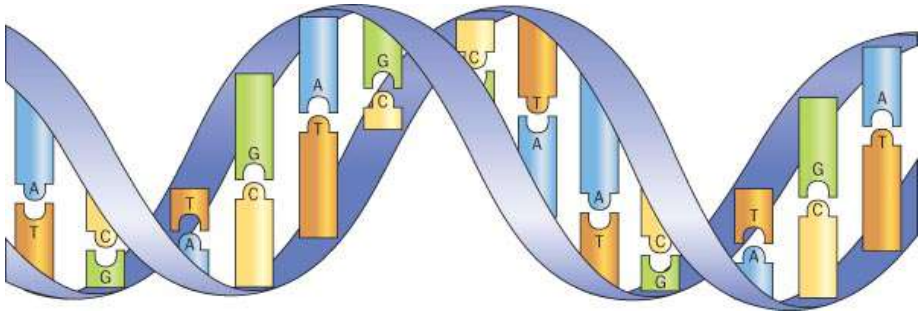


- Explain how crime scene evidence is collected and processed to obtain DNA
- Describe how radioactive probes are used in DNA fingerprinting
- Explain how DNA evidence is compared for matching
- Explain how to use DNA fingerprinting to identify DNA from a parent, child, other relative, or a non-related individual

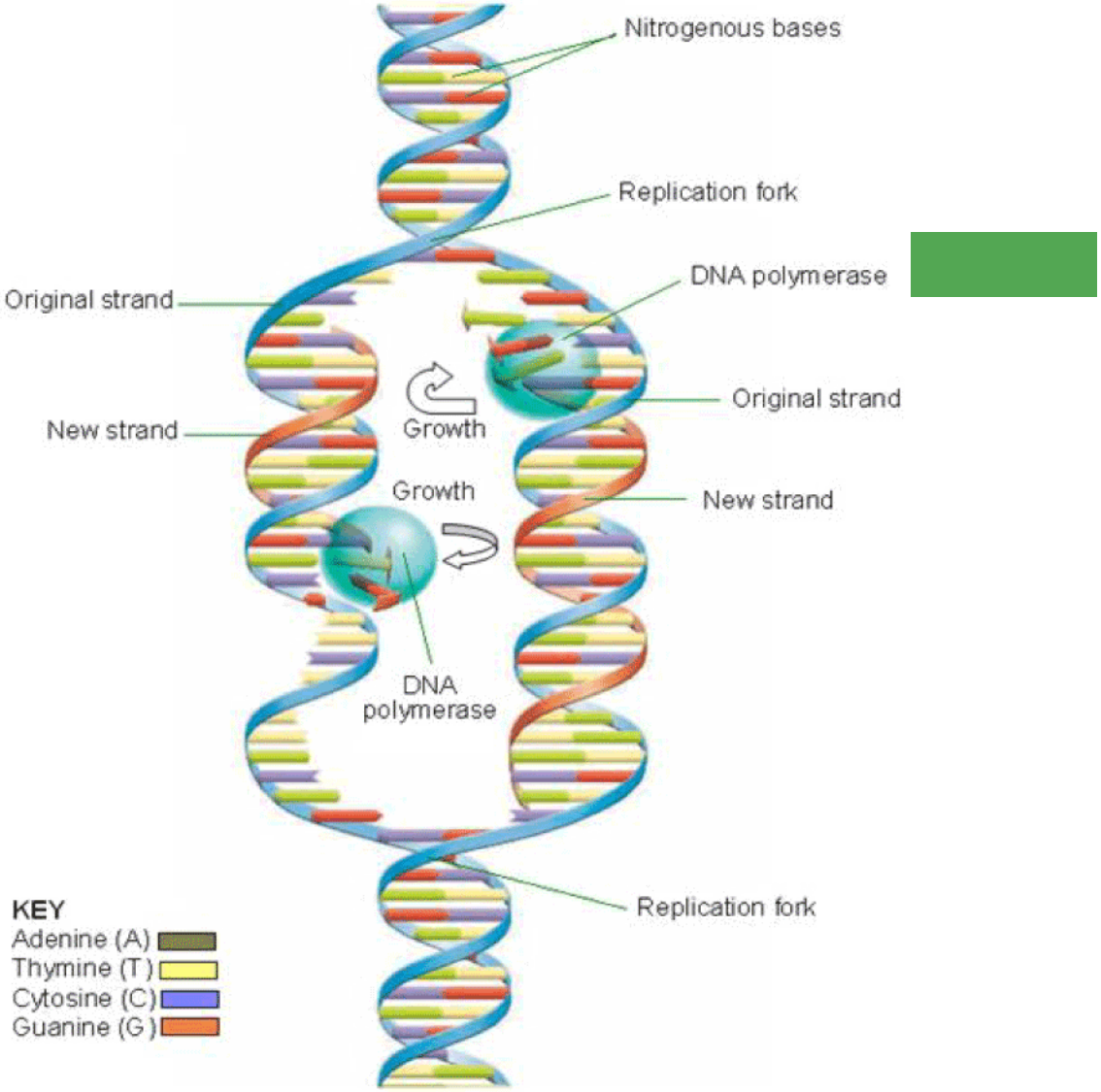
History of Biological Evidence in Forensics

- DNA fingerprinting
  - Also known as *DNA profiling*
  - Used with a high degree of accuracy
- Biological evidence is examined for the presence of inherited traits
- Some forensics laboratory techniques were originally developed for other purposes. Can you name any? *(originally developed as medical diagnosis or treatment)*

The Function and Structure of DNA



- DNA contains the genetic material of a cell
- Chromosomes are located in the cell nucleus
- Chromosomes contain long DNA strands wrapped around proteins

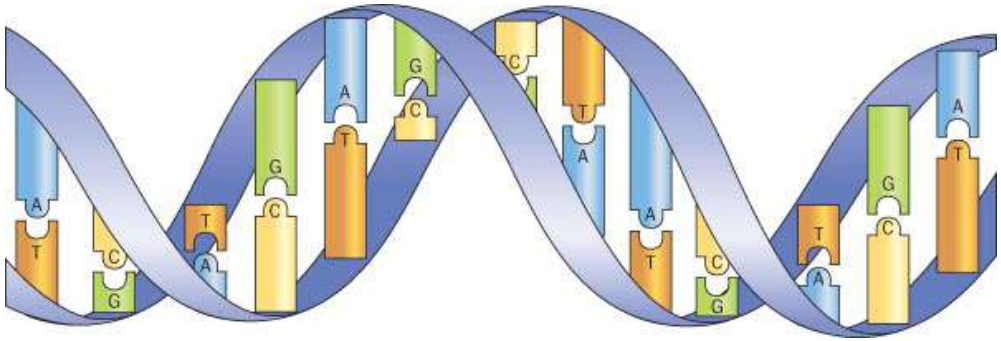

Nitrogenous bases
Replication fork
DNA polymerase
Original strand
Original strand
New strand
Growth
Growth
New strand
DNA
polymerase
Replication fork
KEY
Adenine (A)
Thymine (T)
Cytosine (C)
Guanine (G)

The Function and Structure of DNA

- *Nitrogenous Bases*—pairs of molecules that form the rungs of the DNA "ladder"
- Four types of Bases
  - A (adenine)
  - C (cytosine)
  - G (guanine)
  - T (thymine)

The Function and Structure of DNA

- Base-Pairing Rules
  - adenine (A) binds only with thymine(T)
  - Cytosine (C) binds only with guanine (G)



DNA Identification

- *Polymorphisms:* Non-coded DNA that contain unique patterns of repeated base sequences that that are unique to individuals
- *DNA Fingerprinting (Profiling)* isolates and analyzes polymorphisms
- DNA fingerprints appear as a pattern of bands on X-ray film.

99.9% of human DNA sequences are the same for everyone, but some are different enough to tell one person from another. DNA fingerprinting uses repetitive sequences that are highly variable. There are 13 distinctly different markers for every person.

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DNA is essentially the molecule that holds all genetic information and 'instructions' for an organism. The human genome is composed of over 3 billion base pairs of information organized into 23 chromosomes. Genes are the regions of DNA that encode and regulate protein synthesis, though this involves just 1.5% of the entire genome. A significant amount of the human genome, approximately 75%, consists of estrogenic DNA, which contains regions that do not actually contain known gene sequences. About 50% of estrogenic DNA is made up of something called repetitive DNA, which is of particular use in forensic DNA analysis. Repetitive DNA is further sub-divided into tandem repeats (including satellite DNA, microsatellites and minisatellites) and interspersed repeats (SINE, LINE, LTR and Transposing). Tandem repeat DNA and the variation between them (polymorphisms) is the focus of many DNA profiling techniques. It is due to the number and location of these polymorphisms that every individual has unique DNA which produces a distinctive

Polymorphism is the presence of genetic variation within a population, upon which natural selection can operate. It is common in nature.

Examples include:

- the separation of most higher organisms into male and female sexes
- different blood types in humans

DNA Profile

Two types of repeating DNA sequences

- Variable Numbers of Tandem Repeats **(VNTR)**
  - The number of repeats varies from person to person
  - 9 to 80 bases in length
- Short Tandem Repeats **(STR)**
  - 2 to 5 bases in length
  - Shorter lengths make STRs easier to use than VNTRs
- VNTR and STR data are analyzed for
  - tissue matching
  - inheritance matching

DNA Profile Matching

- Tissue Matching
  - Two samples that have the same band pattern are from the same person
- Inheritance Matching
  - Each band in a child's NDA fingerprint must be present in at least one parent

DNA Population Databases

- **Population genetics:**
  - the study of gene variations among groups of individuals
  - Analyze the probability of a random person with the same alternative form of a gene (an allele)
- Examples
  - Identifying the suspect in a crime
  - Identifying an alleged father in a paternity case

Sources of DNA

- ***Biological* evidence:** examples include saliva, blood, skin, hair, seminal fluid
- ***Individual* evidence** is capable of identifying a specific person.
- Small amounts may be only ***trace* evidence**
- **Polymerase chain reaction** (PCR) technique generates multiple copies of DNA evidence

Collection and Preservation of DNA

1. Use disposable gloves and collection instruments
2. Avoid physical contact, talking, sneezing, and coughing in the evidence area
3. Air-dry evidence and put it into new paper bags or envelopes
4. Dry or freeze the evidence
5. Keep evidence cool and dry during transportation and storage

Preparing DNA Samples for Fingerprinting

1. DNA is mixed with special enzymes
2. Enzymes cut apart the DNA in specific places forming different sized fragments
3. DNA is separated within an agarose gel
4. An electric current is passed through the gel separating the fragments by size

Preparing DNA Samples for Fingerprinting

Extraction

1. Cells are isolated from biological evidence such as blood, saliva, urine, semen, and hair
2. The cells are disrupted to release the DNA from proteins and other cell components
3. The DNA can be extracted from the cell nucleus

Preparing DNA Samples for Fingerprinting

Amplification

- VNTR analyses—polymerase chain reaction (PCR) can be used to amplify the DNA that contains the VNTRs
- STR profiles—restriction enzymes are unnecessary; PCR allows the amplification of the strands with STR sequences

Preparing DNA Samples for Fingerprinting

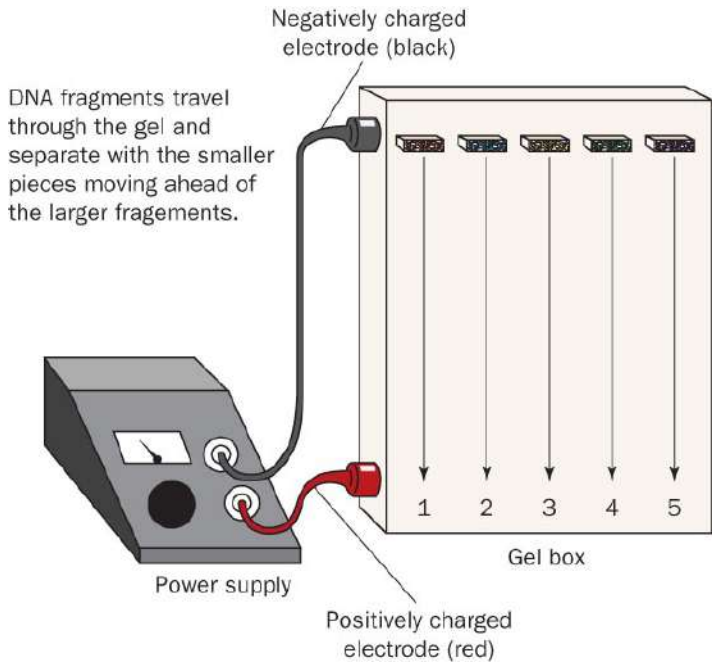
Loading the gels

Electrophoresis

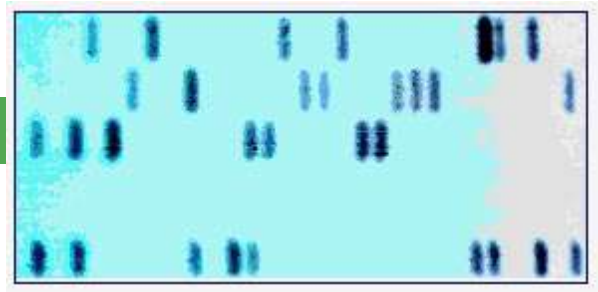
- DNA samples are placed in gels through which electronic currents are passed
- DNA fragments line up in bands along the length of each gel

Electrophoresis

- An electrophoresis apparatus running five sample of DNA
- Arrows show the movement of the negatively charged DNA fragments through the gel matrix



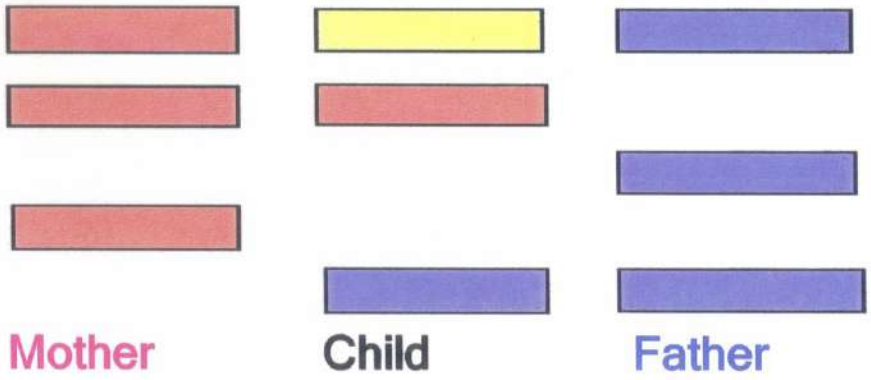
Probes



- DNA probes
  - identify the unique sequences in a person's DNA
  - are made up of different synthetic sequences of DNA bases complimentary to the DNA strand
  - bind to complimentary bases in the strand (see the fragmentary DNA bands above)
- In most criminal cases, 6 to 8 probes are used

Analysis of DNA Fingerprints and Applications

Bands and widths are significant in matching samples of DNA



Analysis of DNA Fingerprints and Applications

- DNA fingerprinting can
  - match crime scene DNA with a suspect
  - determine maternity, paternity, or match to another relative
  - eliminate a suspect
  - free a falsely imprisoned individual
  - identify human remains

. . . . . Summary . . . .

- DNA contains the information needed for replication in a sequence of nitrogenous bases.
- DNA analysis allows even a small sample of tissue to be identified with a single individual.
- DNA contains, in non-coding regions called *junk DNA,* many repeated sequences that vary in number between individuals.
- These differences between individuals can be used to produce a DNA fingerprint for an individual.

Summary

- Polymerase chain reaction (PCR) for DNA amplification has largely eliminated the problem resulting from the tiny samples usually available.
- DNA evidence must be collected carefully to avoid contamination with other DNA.
- DNA analysis involves extraction, electrophoresis, and visualization.
- DNA profiles are kept by police agencies in electronic databases.