Invasion of common reed (*Phragmites australis)* into North American Wetlands

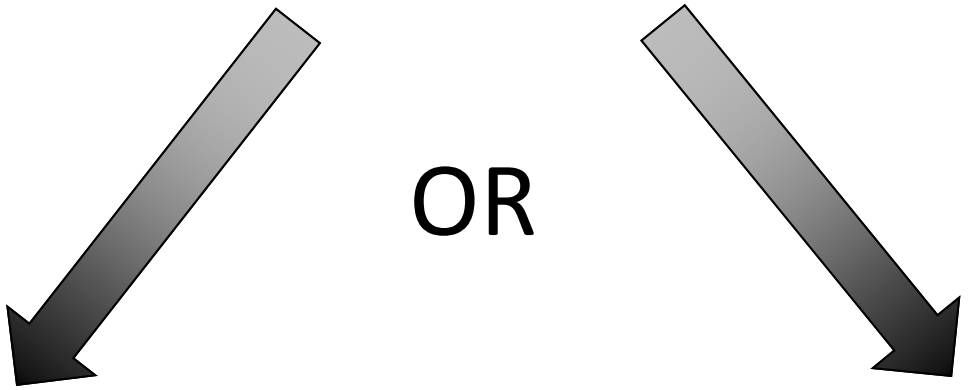
Introduced Species (Nonnative)

- Organisms released into an environment outside of their native geographic range

How are they introduced?

- Accidental
- Intentional

What happens after a nonnative species is introduced?



OR

- Never a threat to native species & never establish in the new environment

- Establish themselves & spread throughout an environment – called **invasive species**

Common Traits of Invasive Species

- High **fecundity** – production of many offspring each reproductive event
- Capable of **Asexual reproduction**
- Tolerant of broad range of environments

Common Environmental Conditions Facilitating Species Invasion

- Organisms associated with human activity (e.g., ornamental plants)
- Disturbance (natural or human induced)
  - Examples: Fire, volcanic eruption, flood, clear cutting forest habitat, etc.
- Lack of biotic limitations
  - Examples: No predators, no competition, no disease

Negative Effects of Invasive Species

- Loss of native species due to introduced pathogens, predators, competitors
  - Reduced **Species diversity** – the number of different types of species in an environment
- Modification of habitat structure – loss of function for native species
- Economic loss
  - Costs associated with eradication, damage to water flow structures (e.g., Zebra Mussels clog sewer pipes in many cities)

Case Study: *Phragmites australis*

- *Phragmites australis* (common reed) native species present in southwest U.S. for at least 40,000 years

- Records from 1800s indicate the plant was rare, but it has spread dramatically in past 150 years

- Now it is found throughout the U.S. and is recognized as an invasive or nuisance species


Photo: Reichart, LM

Saltonstall, 2002 & refs within


http://www.scienceteacherprogram.org/envsci/Vincent2006.html


http://badluckcity.wordpress.com/2011/08/10/phragmites/

Asexual Reproduction can occur via **rhizomes** – underground lateral stems that produce new plants genetically identical to parent plant

http://www.ksl.com/index.php?nid=148&sid=6754314

Recent explosion of *Phragmites* in N.A.

- Two varieties of *Phragmites* now co-occur in N.A.
  - Native and Nonnative
- Increase in *Phragmites* stands attributed to the nonnative variety (Saltonstall 2002)

Negative Effects of Nonnative *Phragmites* in N.A.

- Altered water flow along waterways
- Increased sedimentation and channelization in waterways
- Reduction in plant diversity
- Alters habitat used by variety of organisms: fish, birds, small mammals

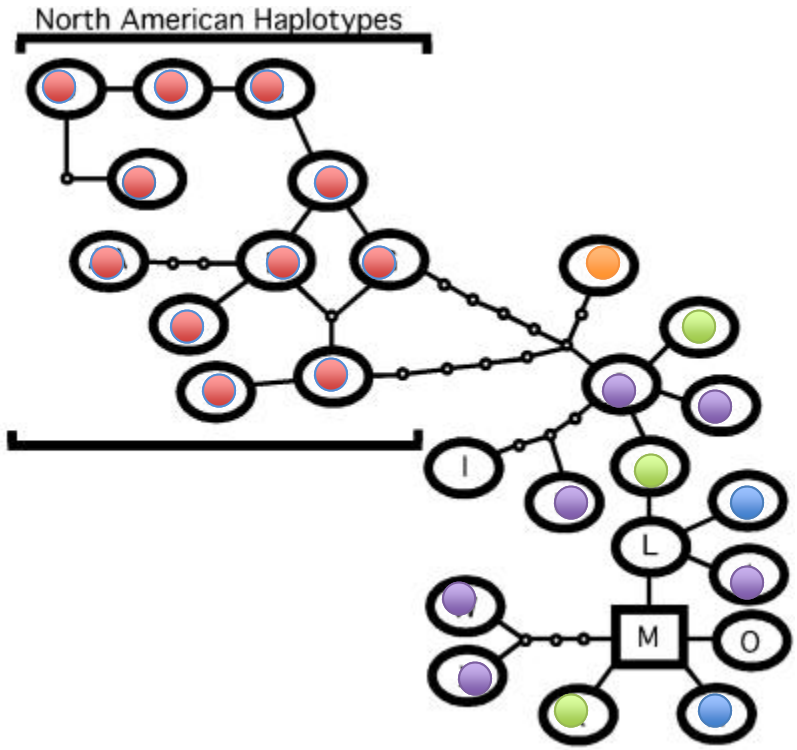
Recent explosion of *Phragmites* in N.A.

- Two varieties are difficult to distinguish by morphology

http://www.invasiveplants.net/phragmites/phrag/morph.htm#lightpic

Recent explosion of *Phragmites* in N.A.

- Two N.A. varieties distinguishable by genetic analysis
- **Haplotype:** combination of gene variants (alleles) that are inherited together



Haplotypes

North America:

A-H, S, Z, AA, I, M

Native Nonnative

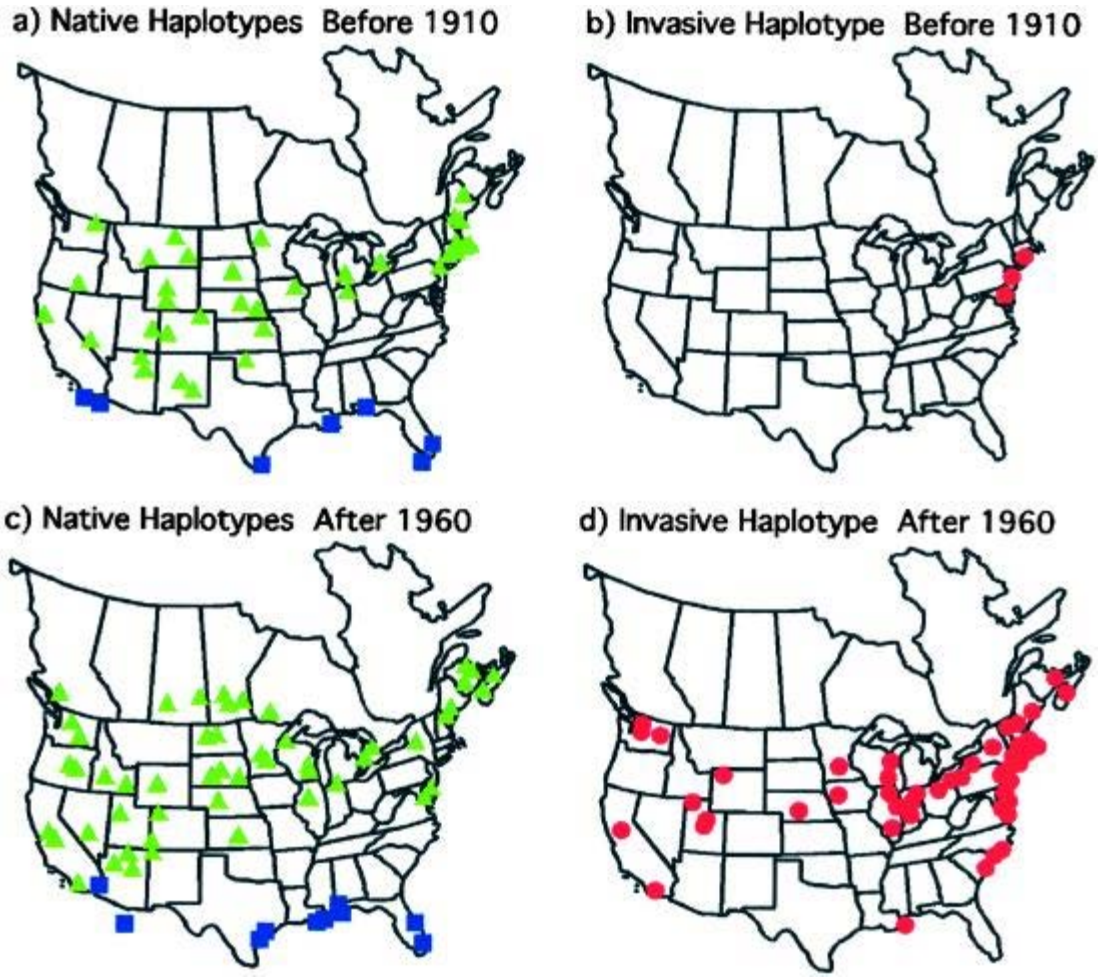
South America: I, Y

Europe: L, M, N, O, T

Asia/Australia: I, J, L, M, O, P, Q, U, W, X

Africa: K, M, R, V

Figure 1 (Saltonstall 2002)



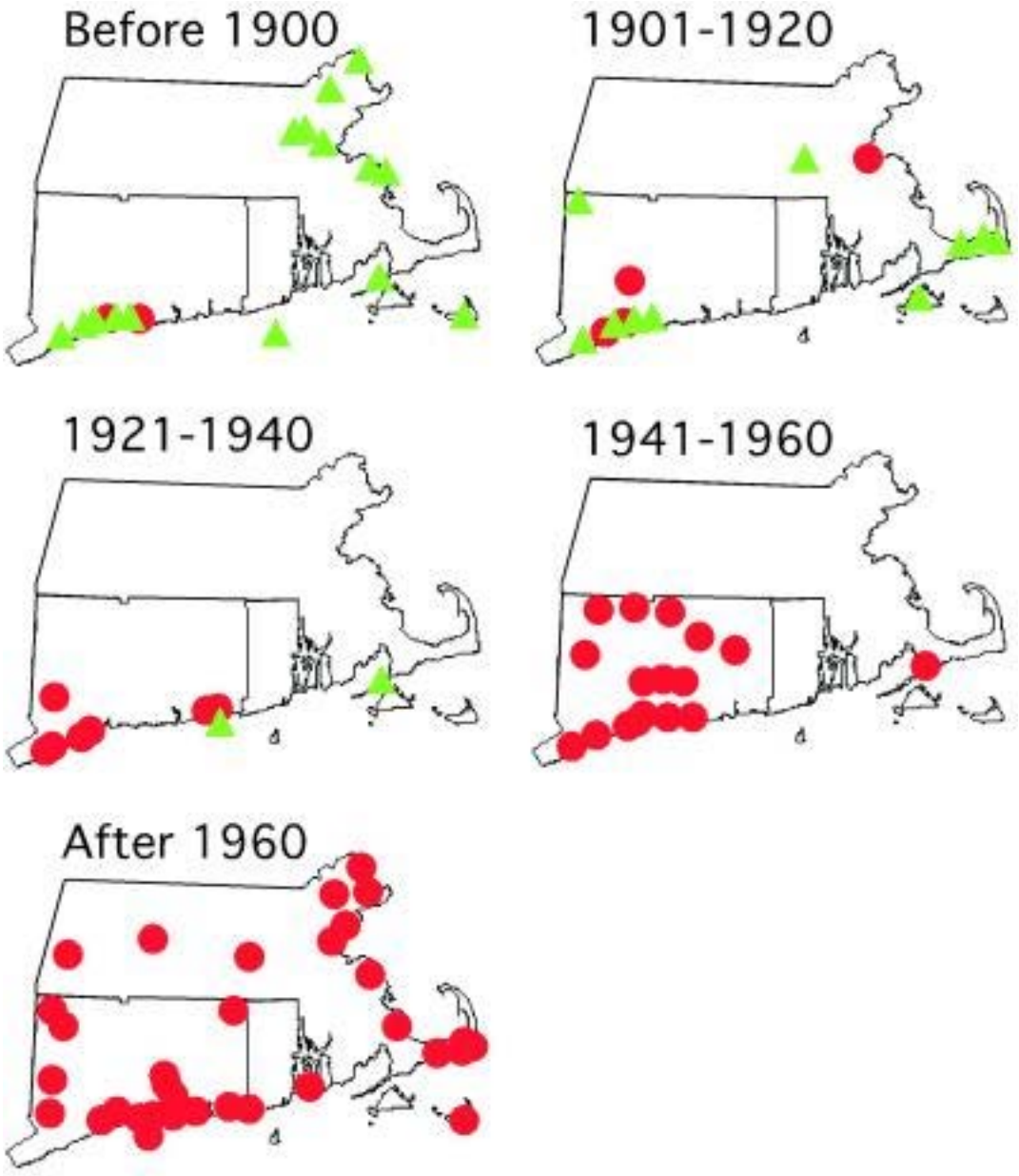
native haplotypes

haplotype I

nonnative haplotype M

- Primary nonnative haplotype is M

Figure 2, Saltonstall (2002)



native haplotypes

nonnative haplotype M

- Over time, nonnative haplotype M outcompetes native haplotypes

Figure 3, Saltonstall (2002)

Genetic Analyses to Distinguish Haplotypes

Two Methods

- DNA sequencing
- Restriction Fragment Length Polymorphism (RFLP)

DNA Sequencing

Fresh or Herbarium samples of *Phragmites*

↓

Extract DNA

↓

Use polymerase chain reaction (PCR) to amplify two non-coding chloroplast regions

↓

Sequence non-coding chloroplast regions

↓

Analyze the sequences

DNA Sequencing

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Analyze the sequences

DNA Sequencing

- **DNA extraction** – lyse cells from organisms to isolate genetic information

- **Polymerase chain reaction (PCR)**
  - Allows amplification of a small DNA fragment from a desired **genetic locus** (specific region or sequence of a chromosome)

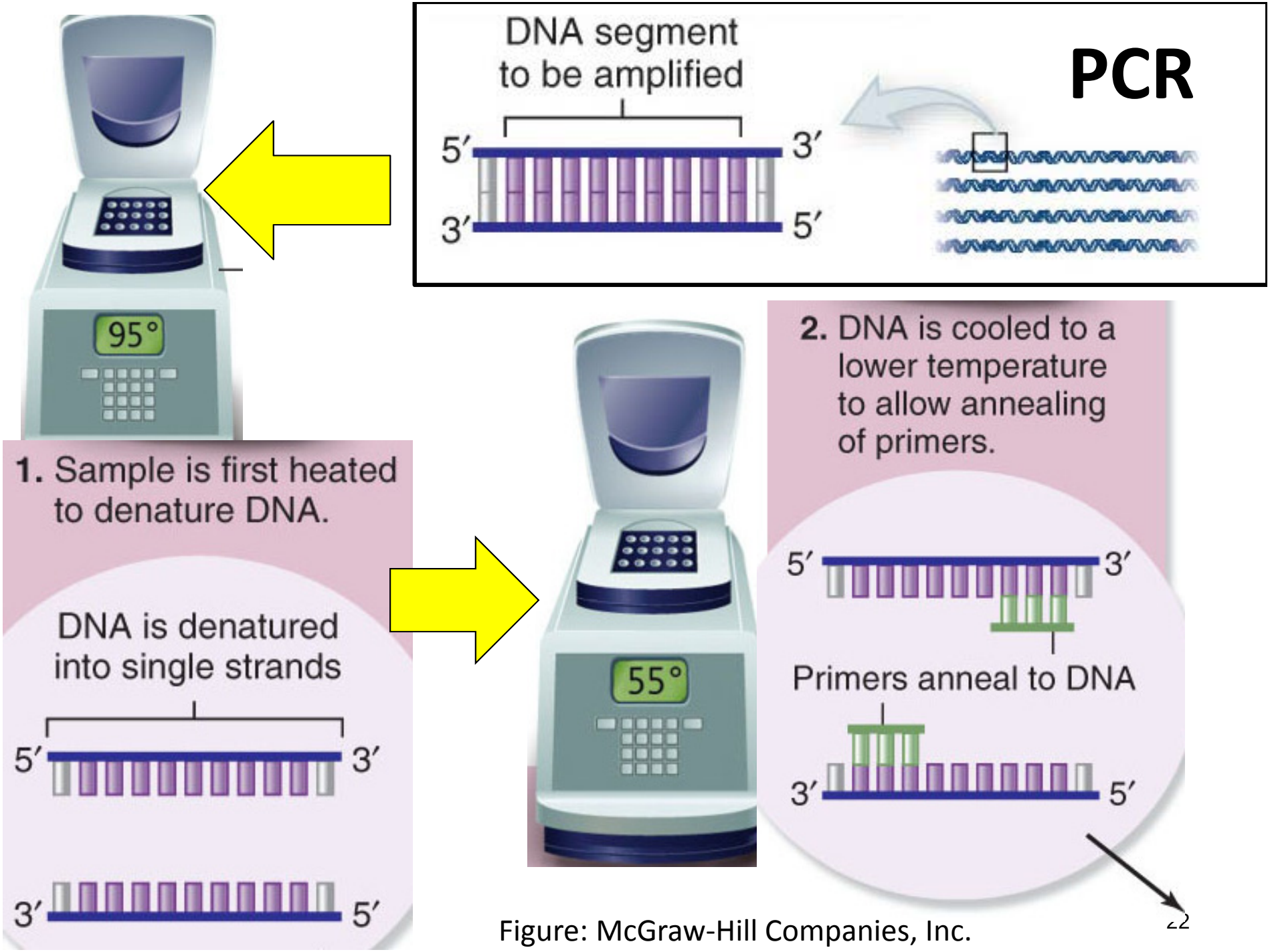
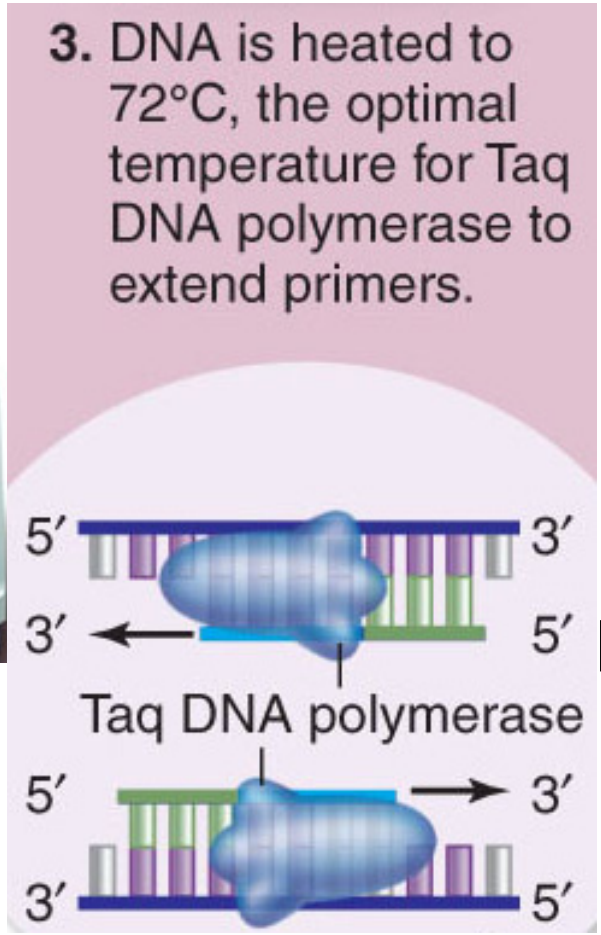
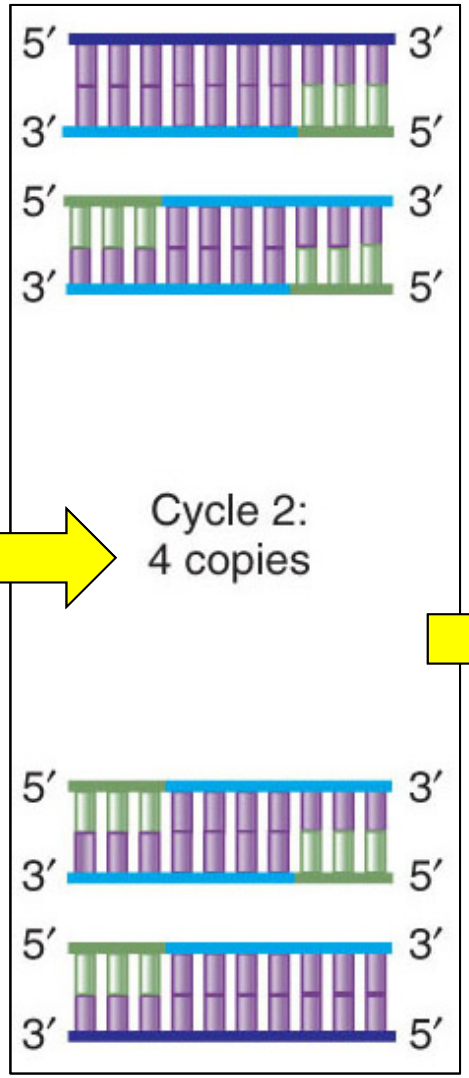
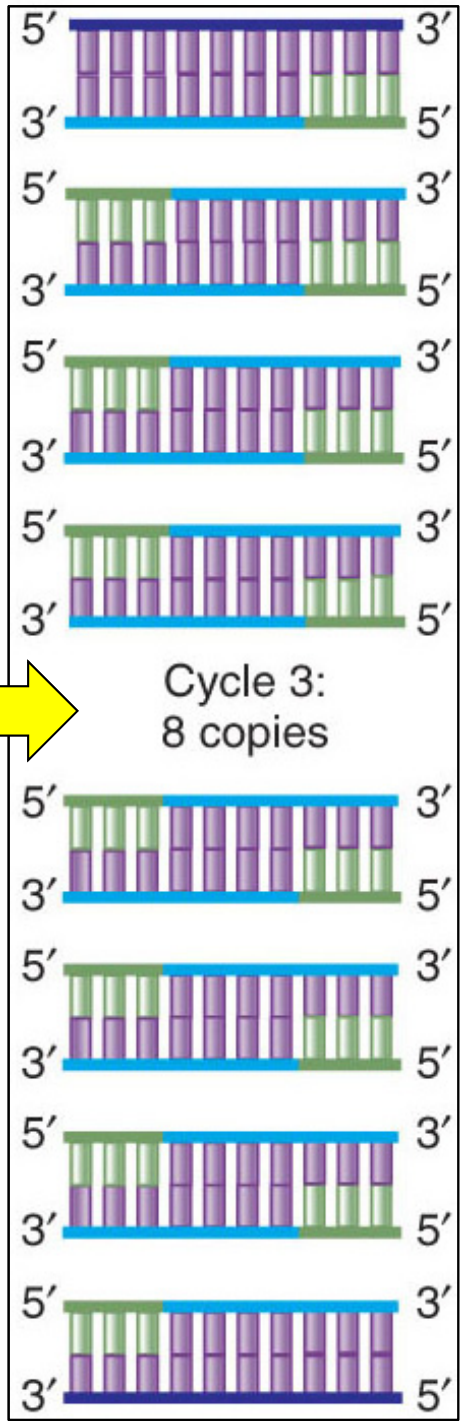


Figure: McGraw-Hill Companies, Inc.

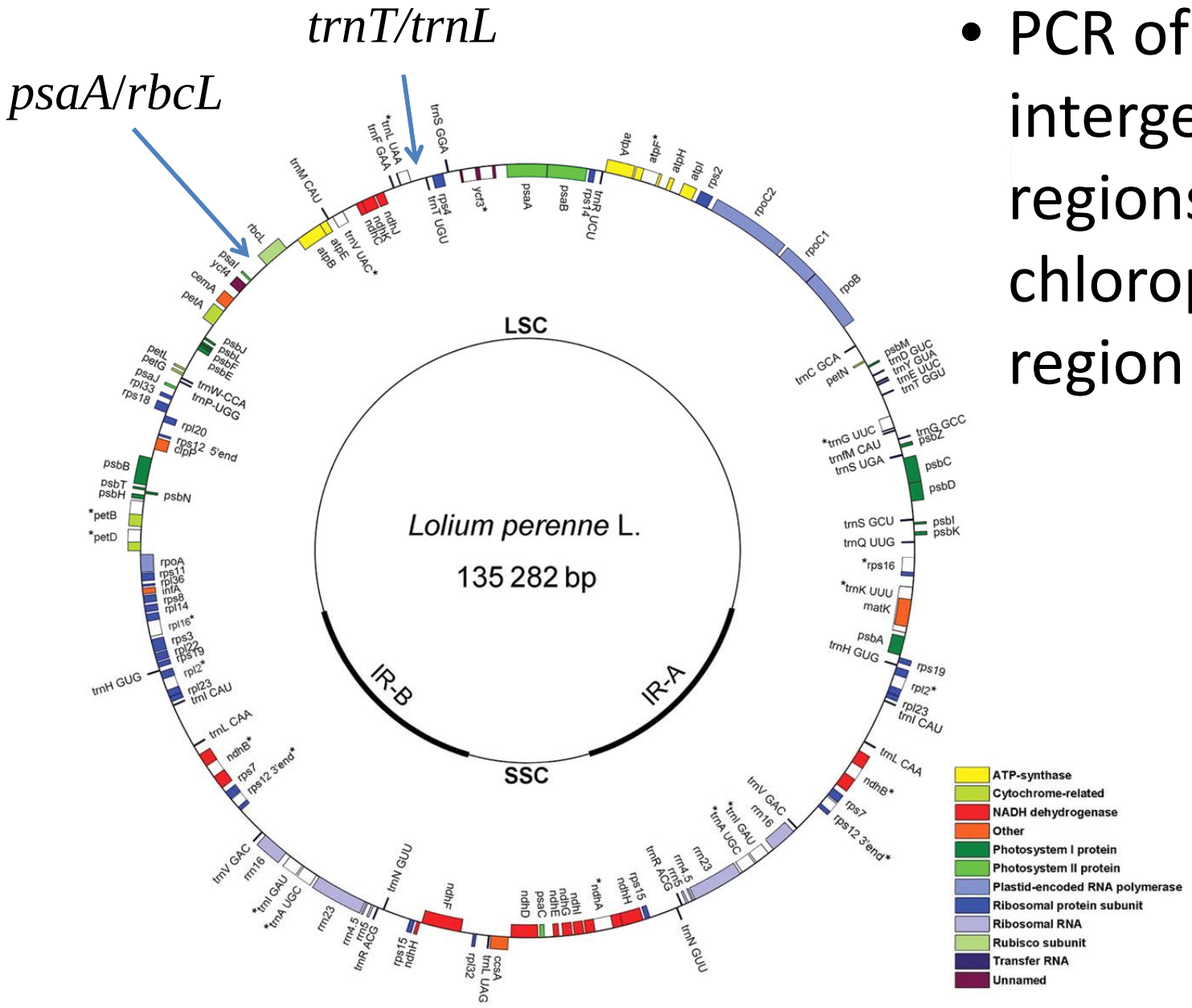






After 20 cycles, a single fragment produces over one million (2^{20}) copies!

Figure: McGraw-Hill Companies, Inc.



- PCR of two intergenic regions of chloroplast region

Diekmann et al. 2009

DNA Sequencing

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Analyze the sequences

Sequencing Basics

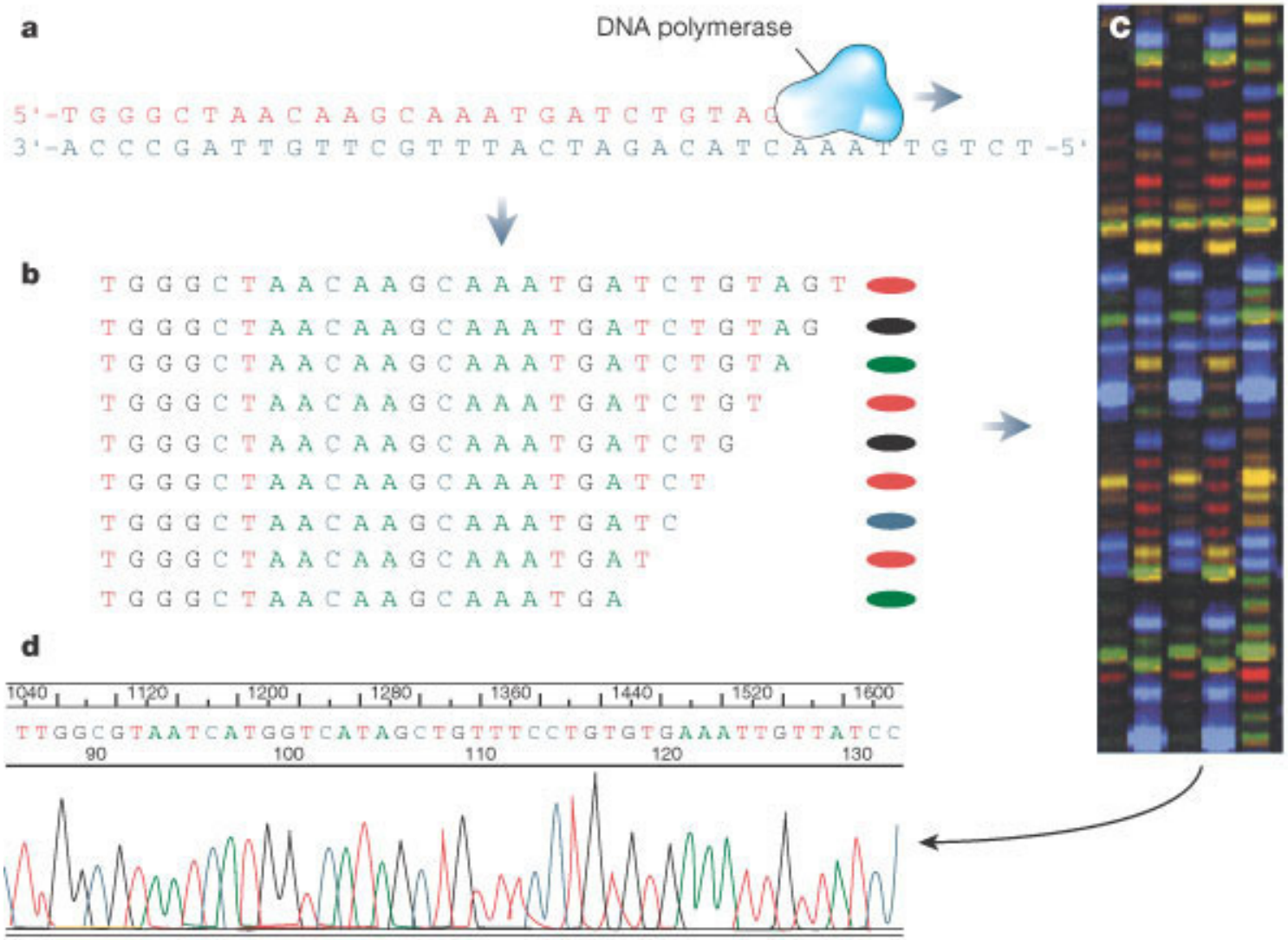

Figure 6; Hood and Galas; Nature: 421 (2003)

MORE

DNA Sequencing

Fresh or Herbarium samples of *Phragmites*

↓

Extract DNA

↓

Use polymerase chain reaction (PCR) to amplify two non-coding chloroplast regions

↓

Sequence non-coding chloroplast regions

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Analyze the sequences

Sequence Analysis

- Compare new sequences with DNA sequences from known haplotypes
  - to identify a possible matching haplotype for sequences of unknown identity

Genetic Analyses to Distinguish Haplotypes

Two Methods

- DNA sequencing
- Restriction Fragment Length Polymorphism (RFLP)

RFLP

- Use **restriction enzymes** to cleave DNA at specific sequences

RFLP

Fresh or Herbarium samples of *Phragmites*

↓

Extract DNA

↓

Use polymerase chain reaction (PCR) to amplify two non-coding chloroplast regions

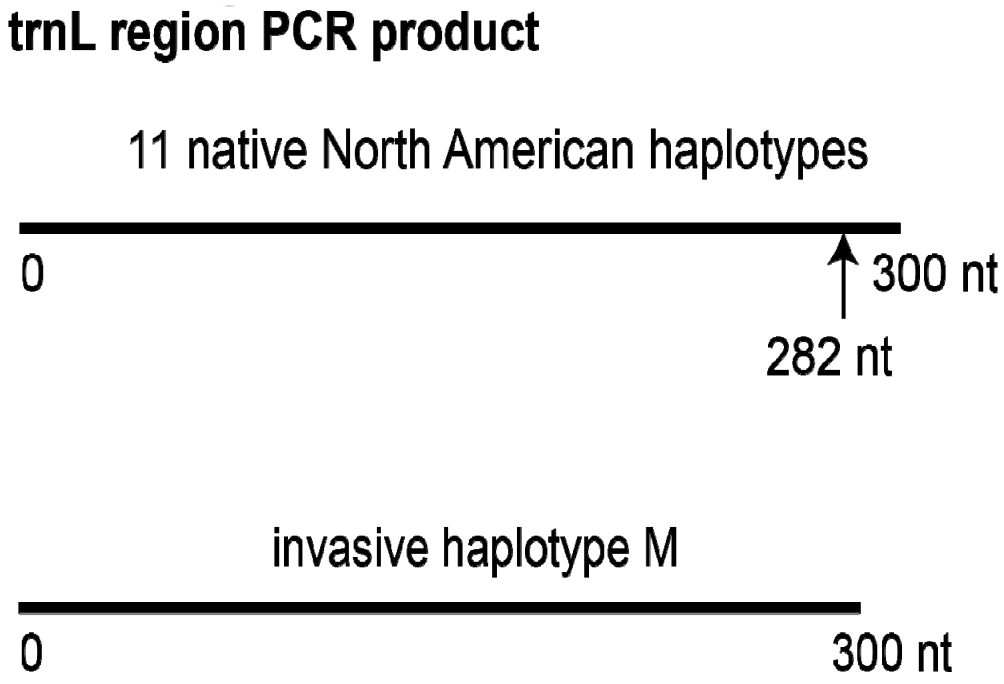
↓

Use restriction enzymes to cut PCR products from non-coding chloroplast regions

↓

Visualize PCR products after cutting with enzymes

RFLP: Example Restriction Enzyme



One cut site – Native Haplotypes

No cut sites – Nonnative Haplotype M

RFLP

Fresh or Herbarium samples of *Phragmites*

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Use restriction enzymes to cut PCR products from non-coding chloroplast regions

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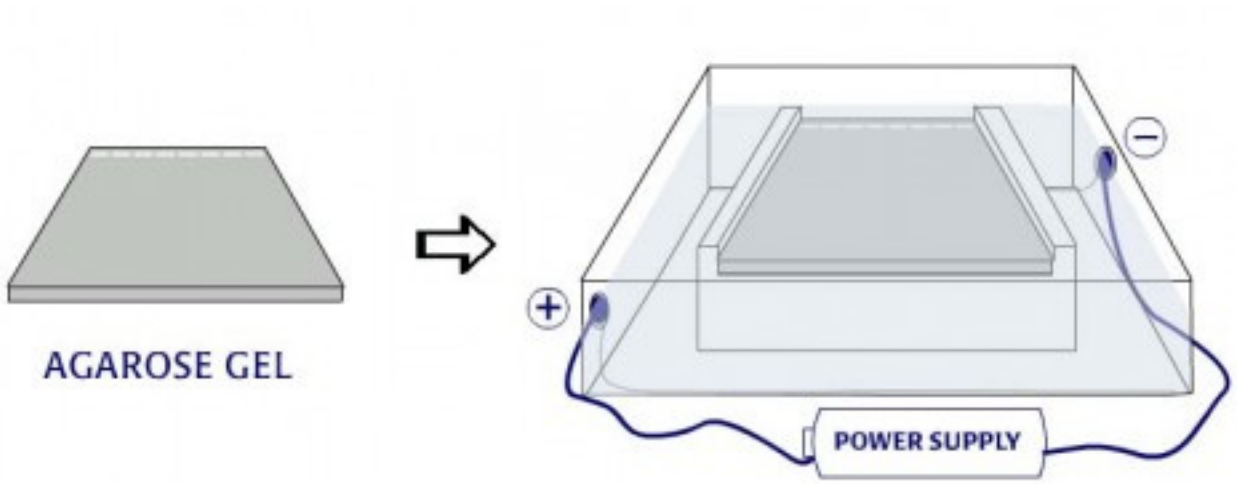
Visualize PCR products after cutting with enzymes

Analysis of PCR Products

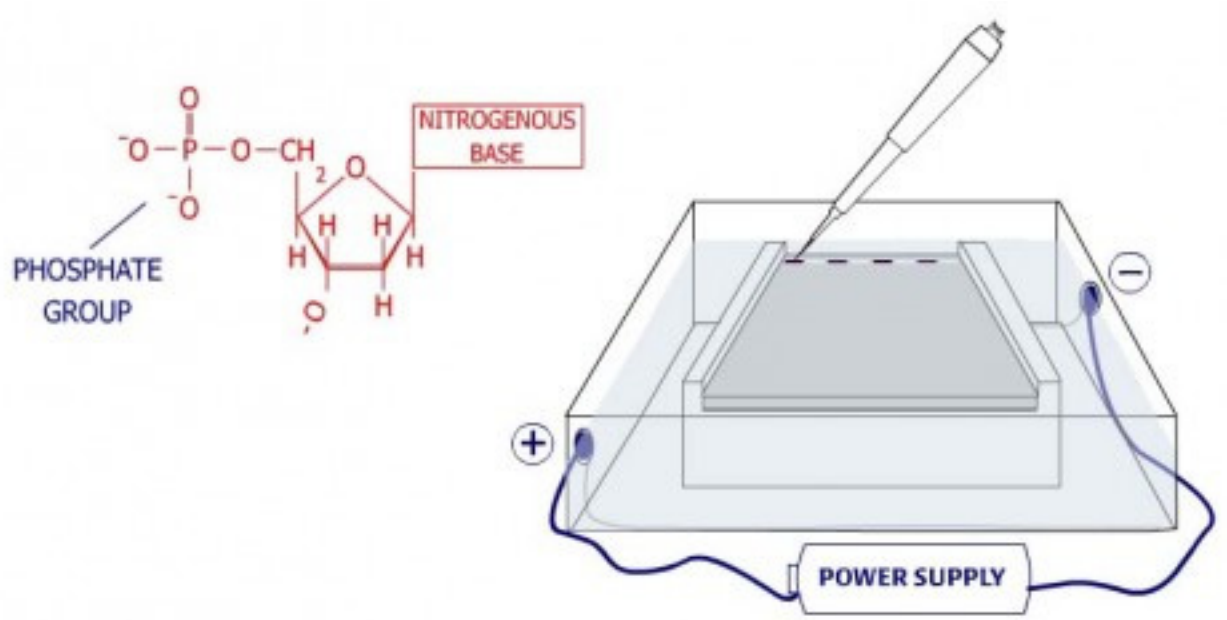
- Gel electrophoresis



http://irfanchemist.wordpress.com/2009/03/05/gel-electrophoresis/

Analysis of PCR Products

- Gel electrophoresis



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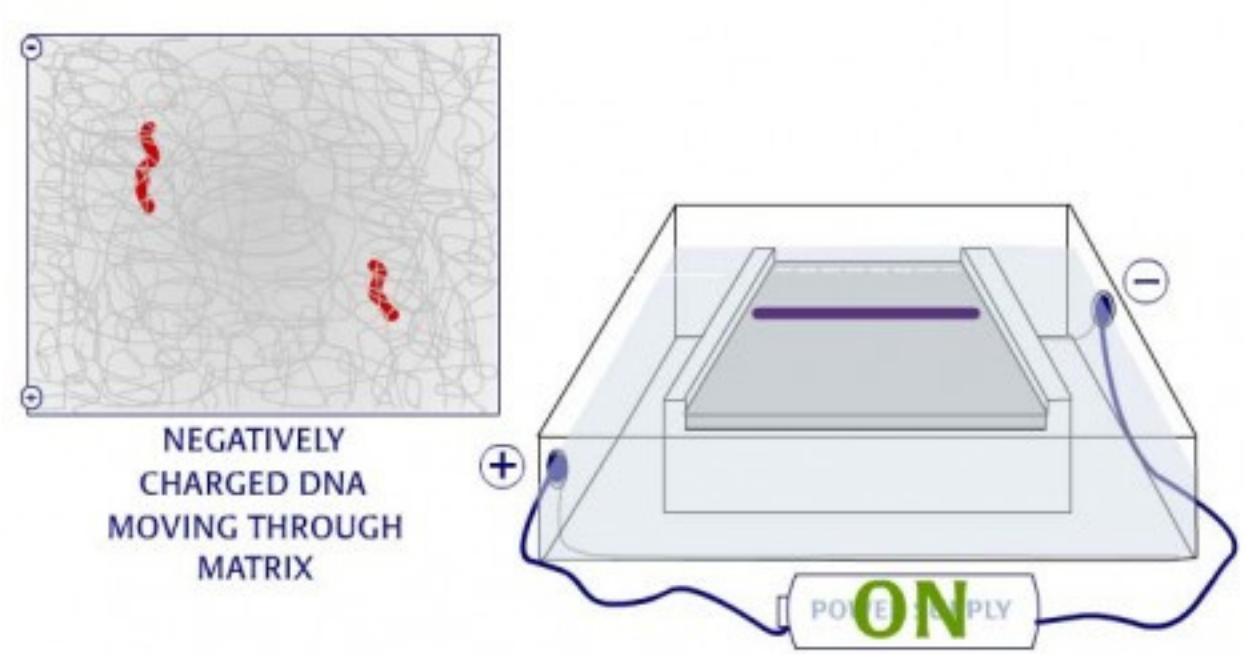
Analysis of PCR Products

- Gel electrophoresis



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RFLP: Example Gel Electrophoresis