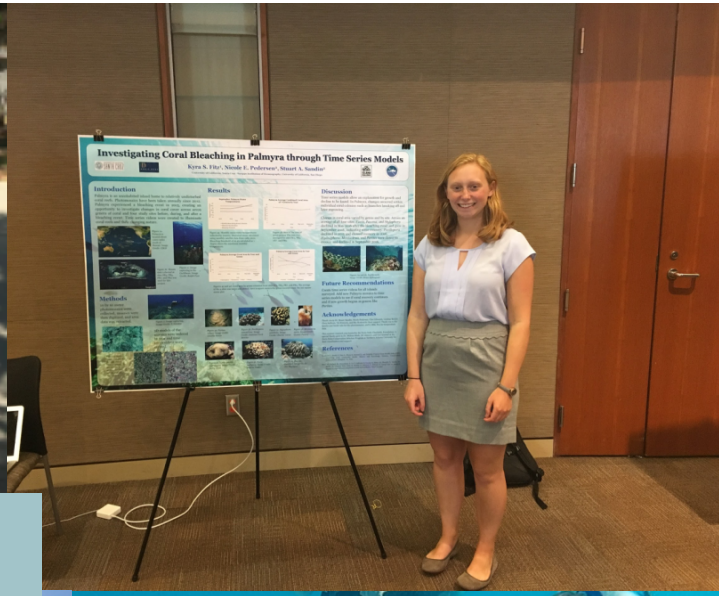
Using ‘Omics to Answer Your Biological Questions

Slides by: Amanda S. Ackiss

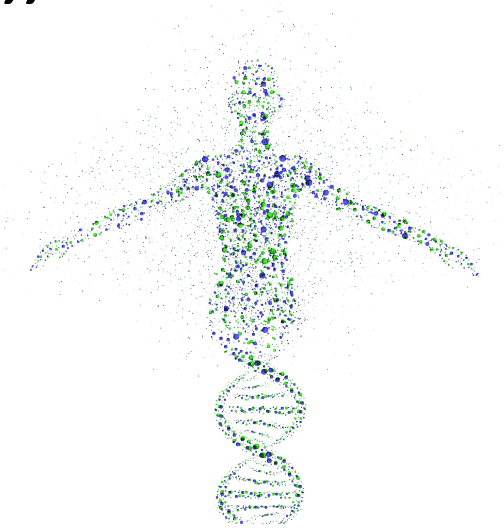
OLD DOMINION
UNIVERSITY


USTA
TENNIS ON CAMPUS


Investigating Coral Bleaching in Palmyra through Time Series Models
Introduction
Results
Discussion
Methods
Future Recommendations
Acknowledgements
References

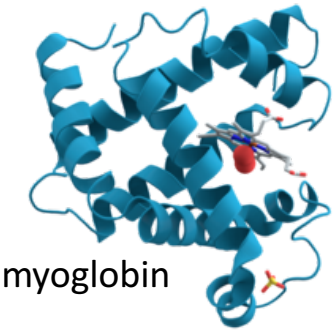
Kyra Fitz

What is “omics?”



- Genomics
  - The study of the structure, function, evolution and mapping of an organism’s genes (the **genome**)

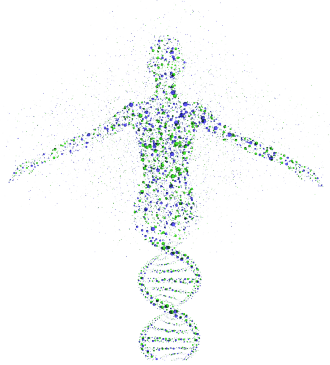
- Transcriptomics
  - The study of all the mRNA expressed (the **transcriptome**) from the genes in an organ or organism and their function



myoglobin

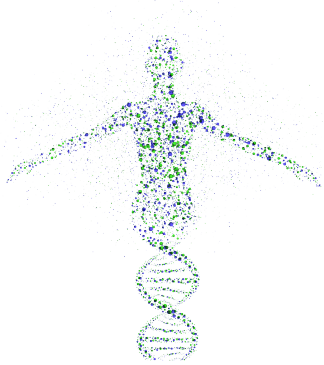
- Proteomics
  - The study of proteins that can be or are expressed by a cell, tissue, or organism (the **proteome**) and their function

Genomics

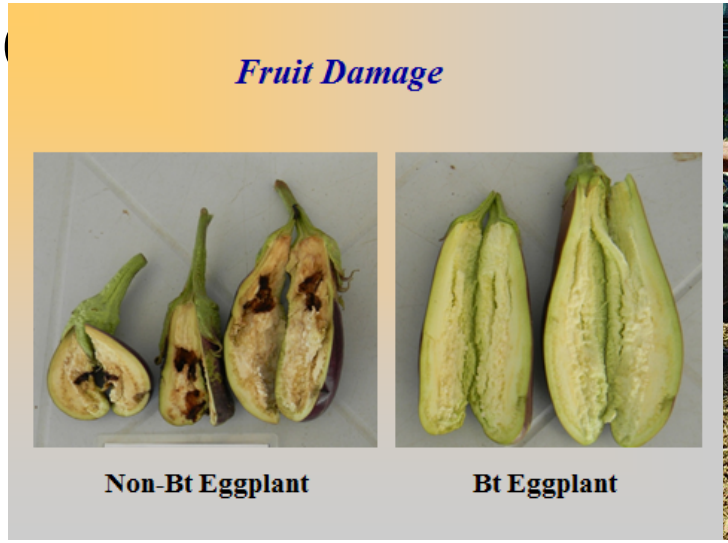


- Genetics vs Genomics
  - Genetics: the study of heredity, single genes, and their role in the way traits and conditions are passed from one generation to the next
  - Genomics: the study of the entirety of an organism's genes

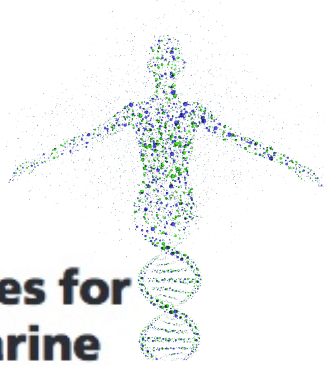
Genomics



- Applications:
  - Clinical and biomedical
    - Disease research & drug effects
  - Bioengineering
    - Creation of synthetic species
  -



Genomics



Genomic islands of divergence and their consequences for the resolution of spatial structure in an exploited marine fish

Ian R. Bradbury,[1,2,3] Sophie Hubert,[4] Brent Higgins,[4] Sharen Bowman,[4] Tudor Borza,[4,5] Ian G. Paterson,[2] Paul V. R. Snelgrove,[3] Corey J. Morris,[1] Robert S. Gregory,[1] David Hardie,[2] Jeffrey A. Hutchings,[2] Daniel E. Ruzzante,[2] Christopher T. Taggart[6] and Paul Bentzen[2]

1 Fisheries and Oceans Canada, St. John's, NF, Canada
2 Department of Biology, Marine Gene Probe Laboratory, Dalhousie University Halifax, NS, Canada
3 Ocean Sciences Center and Biology Department, Memorial University of Newfoundland St. John's, NF, Canada
4 Atlantic Genome Center Halifax, NS, Canada
5 Department of Plant and Animal Sciences, Faculty of Agriculture, Dalhousie University Truro, NS, Canada
6 Department of Oceanography, Dalhousie University Halifax, NS, Canada

Complete Genome Sequence of the Marine Fish Pathogen *Vibrio anguillarum* Harboring the pJM1 Virulence Plasmid and Genomic Comparison with Other Virulent Strains of *V. anguillarum* and *V. ordalii*[▽†]

Hiroaki Naka,[1] Graciela M. Dias,[2] Cristiane C. Thompson,[3] Christopher Dubay,[1] Fabiano L. Thompson,[2] and Jorge H. Crosa[1]*

Department of Molecular Microbiology and Immunology, Oregon Health and Science University, Portland, Oregon 97239[1]; Institute of Biology, Federal University of Rio de Janeiro, UFRJ, Brazil[2]; and Laboratory of Molecular Genetics of Microorganisms, Oswaldo Cruz Institute, FIOCRUZ, Rio de Janeiro, Brazil[3]

Transcriptomics

- ‘Functional’ genomic approach
- Connects the genome to gene function
- Typically represents less than 5% of the **genome**
- The **transcriptome** is the precursor to the **proteome**

Transcriptomics

- Applications:
  - Clinical and biomedical
    - Examining the processes of cellular differentiation and carcinogenesis
    - Embryology and development
  - Biological and conservation sciences
    - Inferring phylogenetic relationships
    - Examining functional responses relative to biotic and abiotic stressors

Transcriptomics

Transcriptomics reveals tissue/organ-specific differences in gene expression in the starfish *Patiria pectinifera*

Chan-Hee Kim[a], Hye-Jin Go[a], Hye Young Oh[a], Yong Hun Jo[b], Maurice R. Elphick[c], Nam Gyu Park[a,*]

[a] *Department of Biotechnology, College of Fisheries Sciences, Pukyong National University, 45 Yongso-ro, Nam-gu, Busan 48513, Republic of Korea*
[b] *Division of Plant Biotechnology, Institute of Environmentally-Friendly Agriculture (IEFA), College of Agriculture and Life Sciences, Chonnam National University, Gwangju 500-757, Republic of Korea*
[c] *School of Biological and Chemical Sciences, Queen Mary University of London, London E1 4NS, UK*

Cellular stress responses to chronic heat shock and shell damage in temperate *Mya truncata*

Victoria A. Sleight[1,2] · Lloyd S. Peck[2] · Elisabeth A. Dyrynda[3] · Valerie J. Smith[4] · Melody S. Clark[2]

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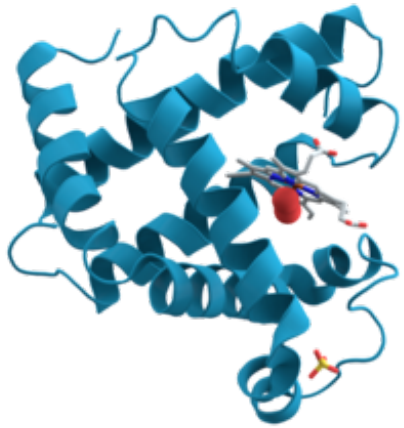
Proteomics

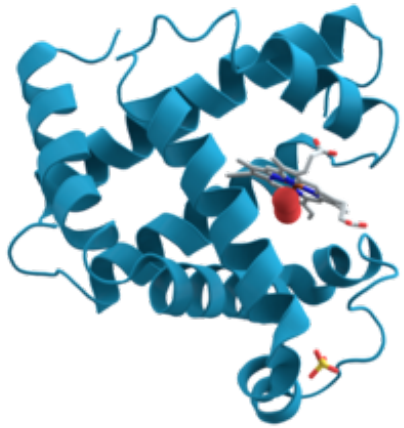


- protein + genome = *proteome*

- Why study the proteome?
  - mRNA is not always translated into protein
  - Relatively small changes in mRNA expression can produce large changes in the total amount of the corresponding protein present in the cell

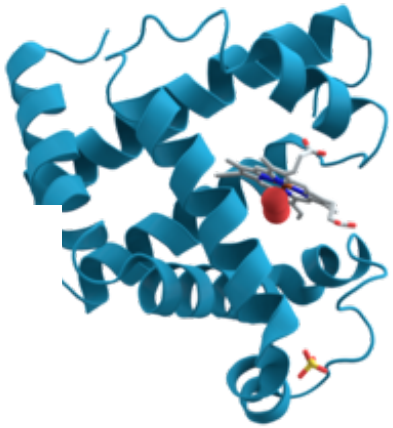
- Proteomics confirms the presence of the protein & provides a direct measure of the quantity present!

Proteomics



- Applications:
  - Clinical and biomedical
    - Biomarkers for diagnosing disease
  - Systems biology
    - Analysis of cellular systems
    - Cell-signaling cascades and gene regulatory networks
  - Conservation sciences
    - Examining functional responses relative to biotic and abiotic stressors

Proteomics



Exploring the Environmental Physiology of the Indo-Pacific Reef Coral *Seriatopora hystrix* with Differential Proteomics

Anderson B. Mayfield[1,2*], Yi-Jyun Chen[2], Chi-Yu Lu[3,4], Chii-Shiarng Chen[2,5,6]

[1]Khaled bin Sultan Living Oceans Foundation, USA
[2]Taiwan Coral Research Center, Taiwan
[3]Department of Biochemistry, College of Medicine, Kaohsiung Medical University, Taiwan
[4]Center for Research Resources and Development, Kaohsiung Medical University, Taiwan
[5]Department of Marine Biotechnology and Resources, National Sun Yat-Sen University, Taiwan
[6]Graduate Institute of Marine Biotechnology, National Dong-Hwa University, Taiwan
Email: *andersonblairmayfield@gmail.com

From Marine Venoms to Drugs: Efficiently Supported by a Combination of Transcriptomics and Proteomics

Bing Xie [1,†], Yu Huang [2,†], Kate Baumann [3,†], Bryan Grieg Fry [3,*] and Qiong Shi [2,4,*]

1 Venomics Research Group, BGI-Shenzhen, Shenzhen 518083, China; xiebing@genomics.cn
2 Shenzhen Key Lab of Marine Genomics, Guangdong Provincial Key Lab of Molecular Breeding in Marine Economic Animals, BGI, Shenzhen 518083, China; huangyu@genomics.cn
3 Venom Evolution Lab, School of Biological Sciences, University of Queensland, St. Lucia 4072, Australia; kate.baumann@uqconnect.edu.au
4 BGI Shenzhen Academy of Marine Sciences, BGI Fisheries, BGI, Shenzhen 518083, China
* Correspondence: bgfry@uq.edu.au (B.G.F.); shiqiong@genomics.cn (Q.S.); Tel.: +61-4-0019-3182 (B.G.F.); +86-755-3630-7807 (Q.S.)
† These authors contributed equally to this work.

Sequencing Methods

First and **Next Generation**

by Dr. Eric Garcia

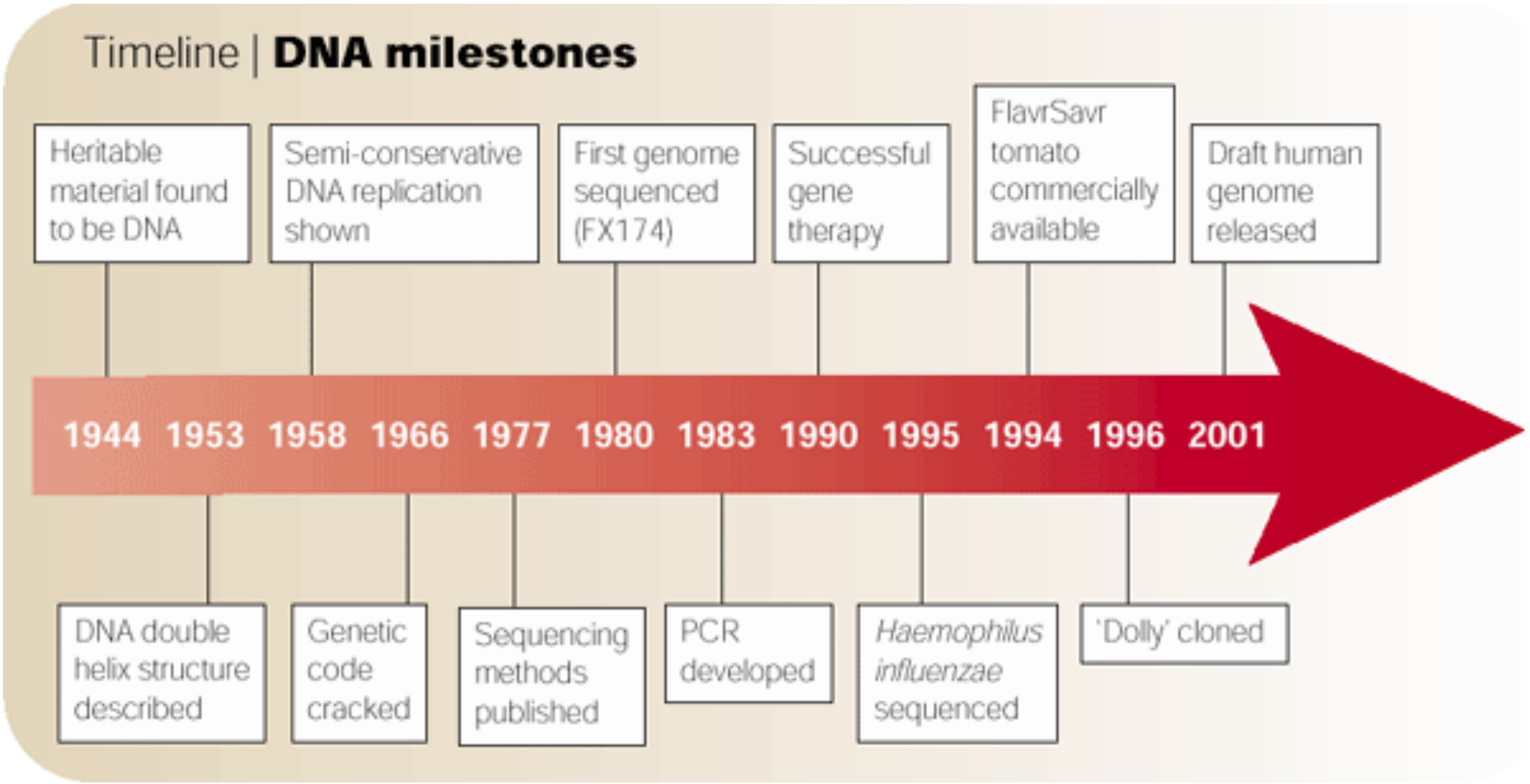
Outline

INTRO

- Timeline of technological advancements in genetics
  - Sanger sequencing
  - PCR
  - Next Gen

NEXT GENERATION

- Template preparation
- Sequencing

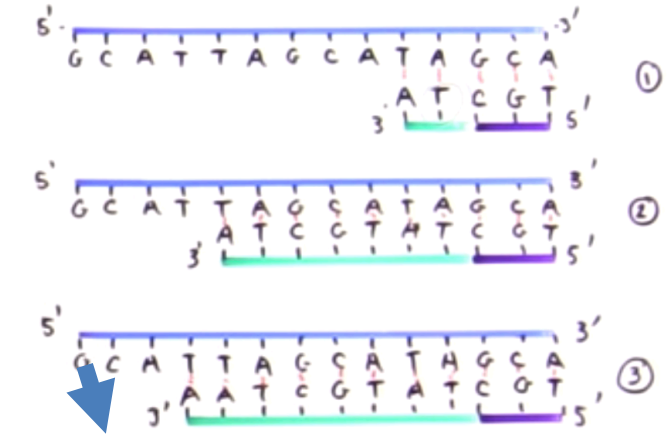

Timeline | DNA milestones
Heritable material found to be DNA
Semi-conservative DNA replication shown
First genome sequenced (FX174)
Successful gene therapy
FlavrSavr tomato commercially available
Draft human genome released
1944
1953
1958
1966
1977
1980
1983
1990
1995
1994
1996
2001
DNA double helix structure described
Genetic code cracked
Sequencing methods published
PCR developed
Haemophilus influenzae sequenced
'Dolly' cloned

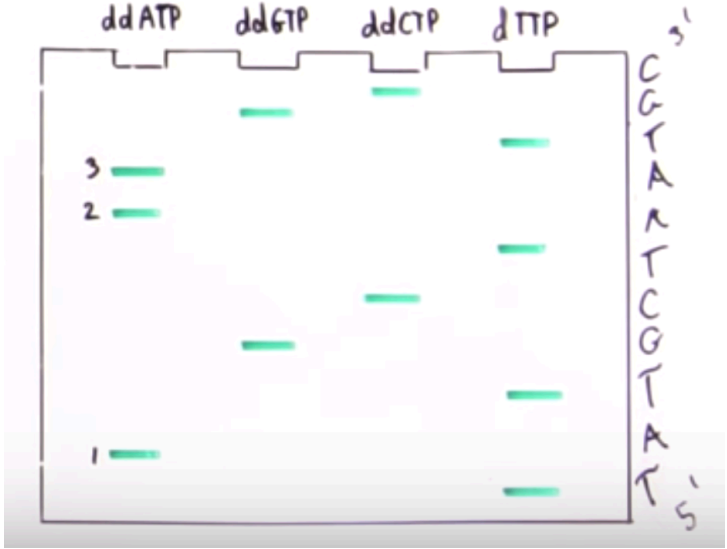
Baxter 2003

Sanger Sequencing

- Developed in 1977 by Frederick Sanger

1. Denature DNA
2. Mix template with:
   - Primer
   - Polymerase
   - All 4 dNTP
   - Then add only **ONE type of** ddNTP
3. Repeat this with the other 3 ddNTP
4. Gel reactions in diff. lanes





Sanger Sequencing

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   - Primer
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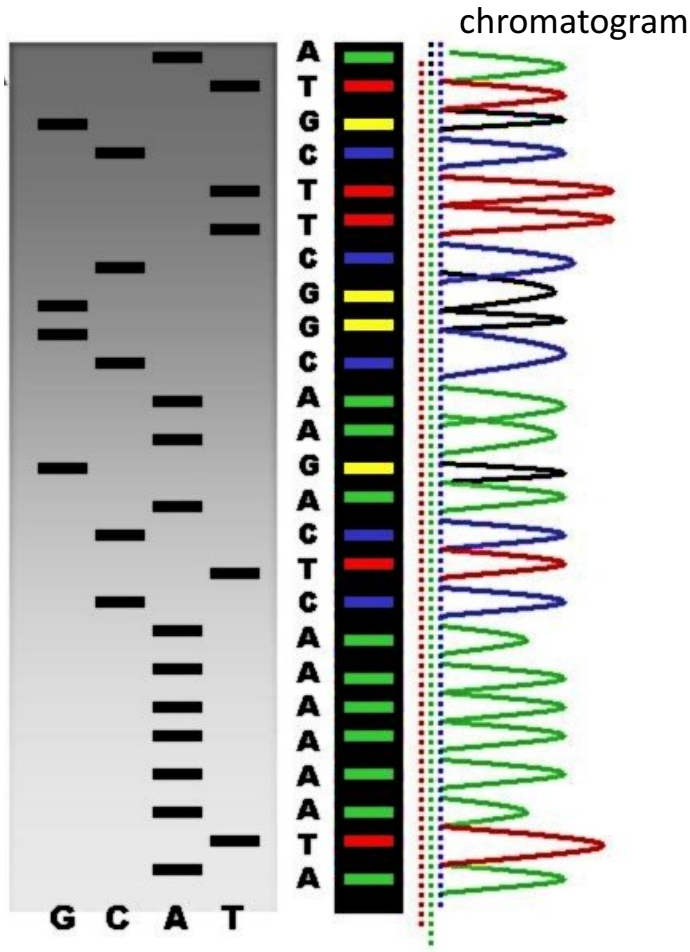
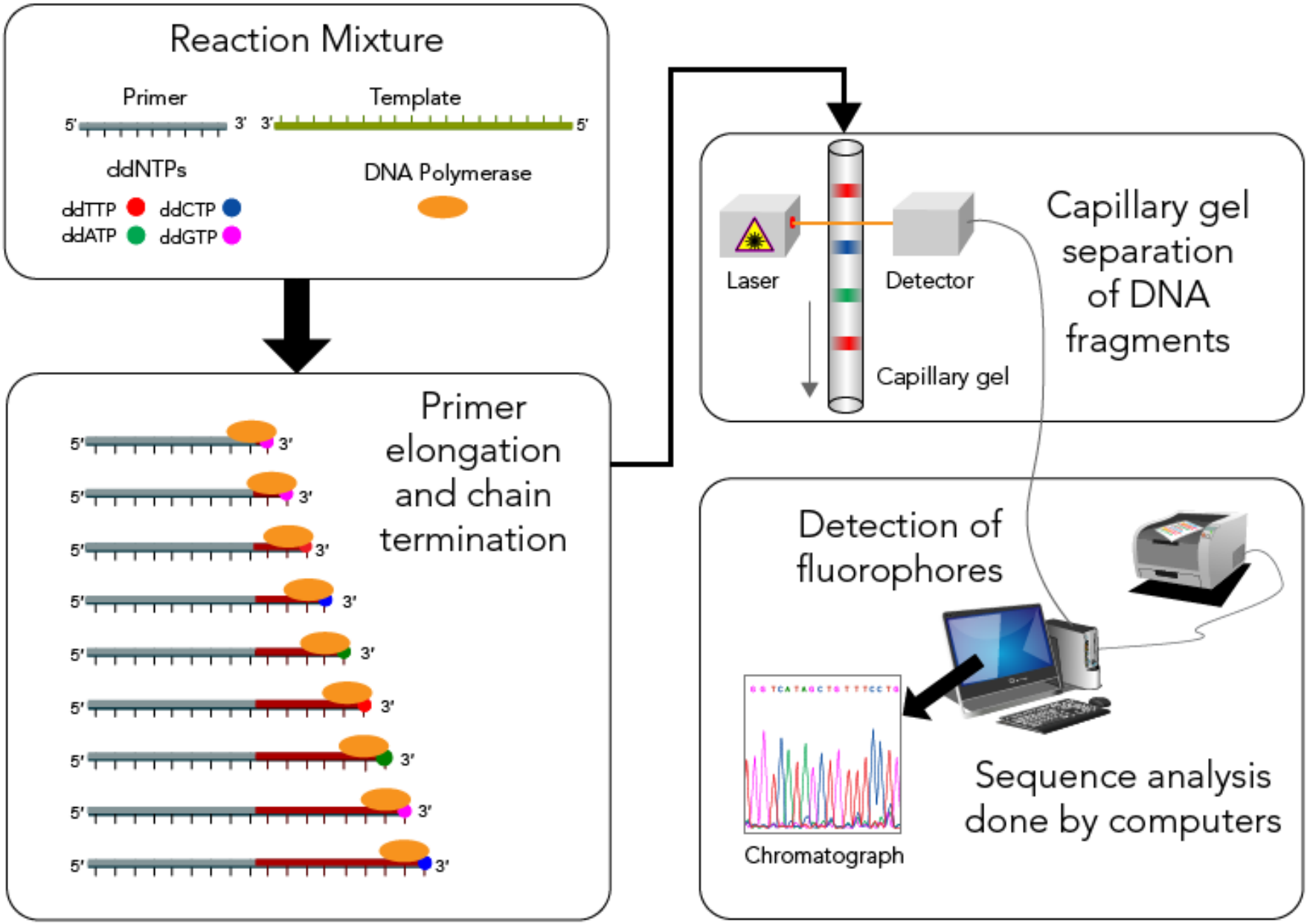
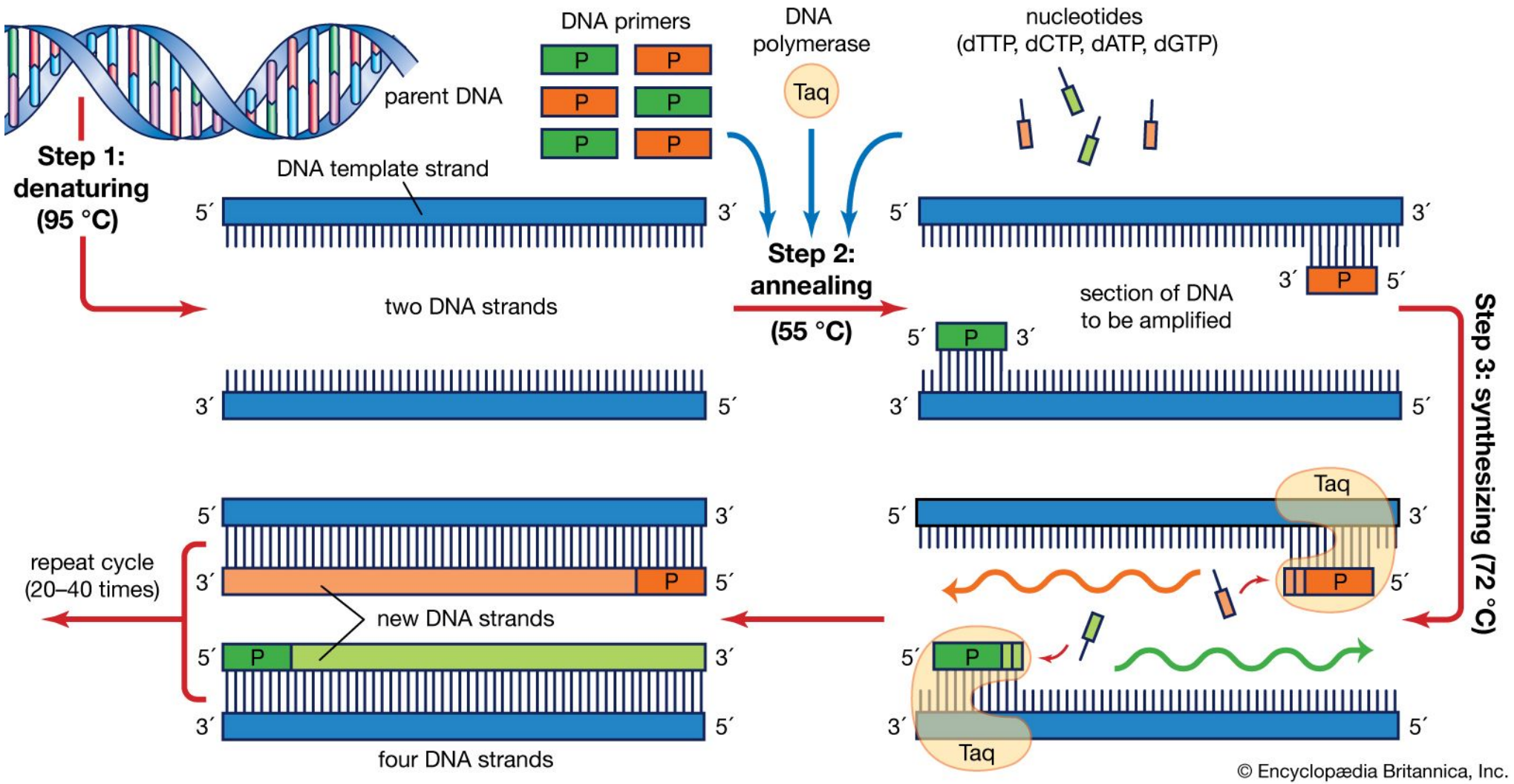
   - Then add only **ONE type of** ddNTP
3. Repeat this with the other 3 ddNTP
4. Gel reactions in diff. lanes
5. Expose to X-ray



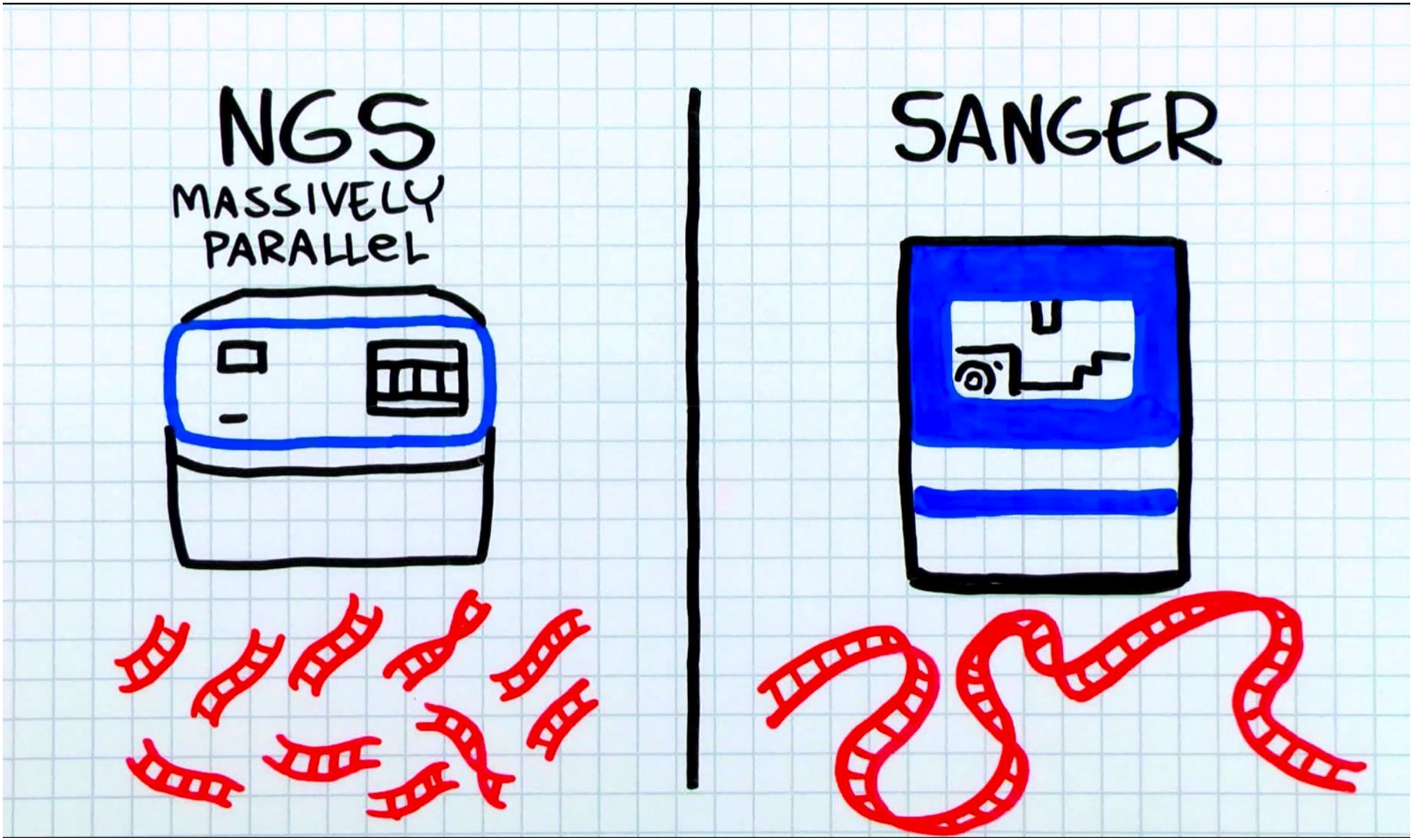


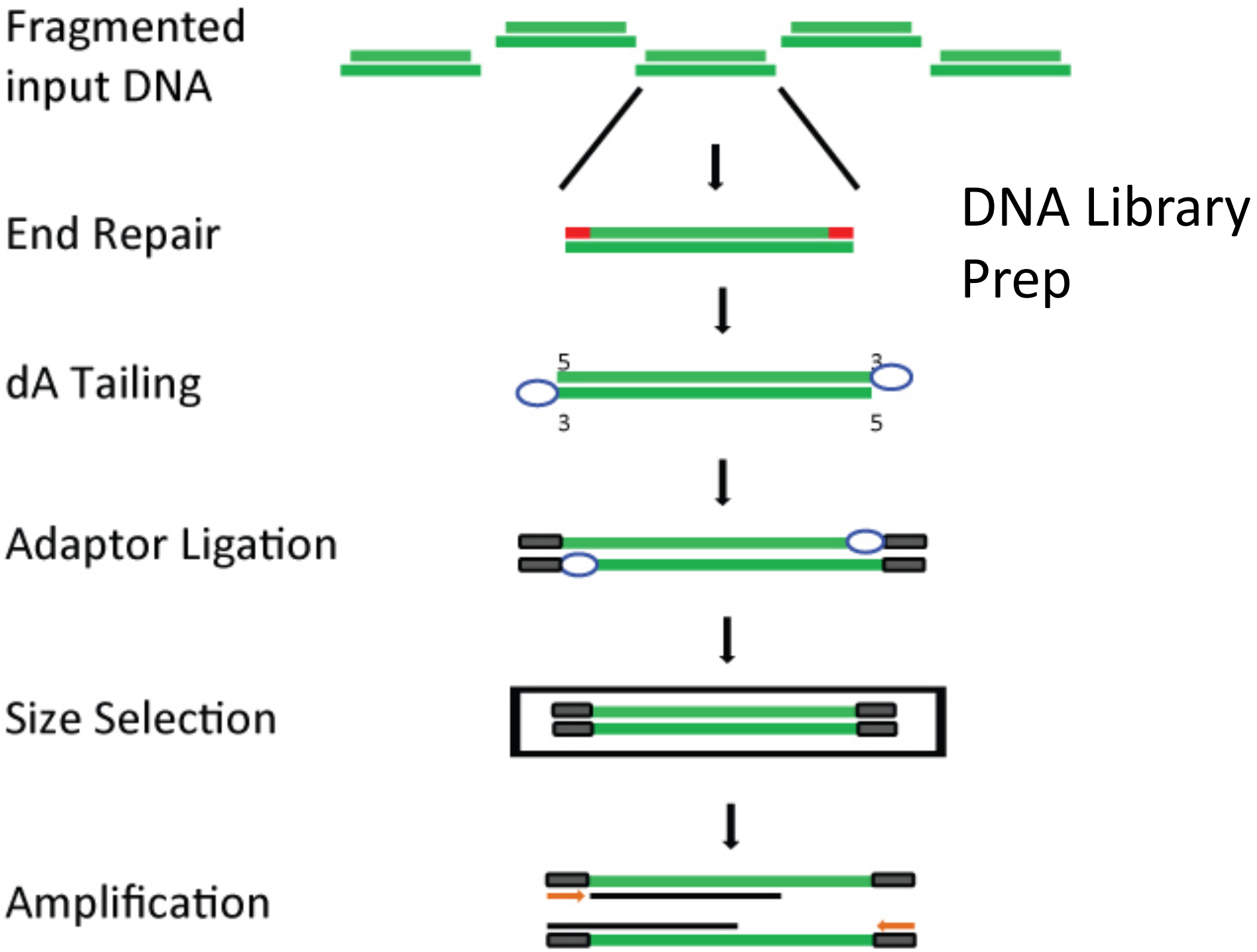
PCR

Developed by Mullis 1985



Next Generation Sequencing




Fragmented input DNA
End Repair
dA Tailing
5
3
3
5
Adaptor Ligation
Size Selection
Amplification
DNA Library Prep

Sequencing technologies — the next generation

- Template preparation
  - Different types of preparations
  - Different types of loading platforms
- Sequencing
  - By CTR
  - By ligation
  - By Single-nucleotide addition
  - Real Time Sequencing

Template Preparation

– Clonally amplified templates

Requires ↑ DNA (20x more)

PCR

Immobilizing:

1.- BEADS, chemically crosslinked to glass surface

2.- CLUSTERS, covalently attached (adaptors)

• Single DNA molecule Template ↓

Requires DNA

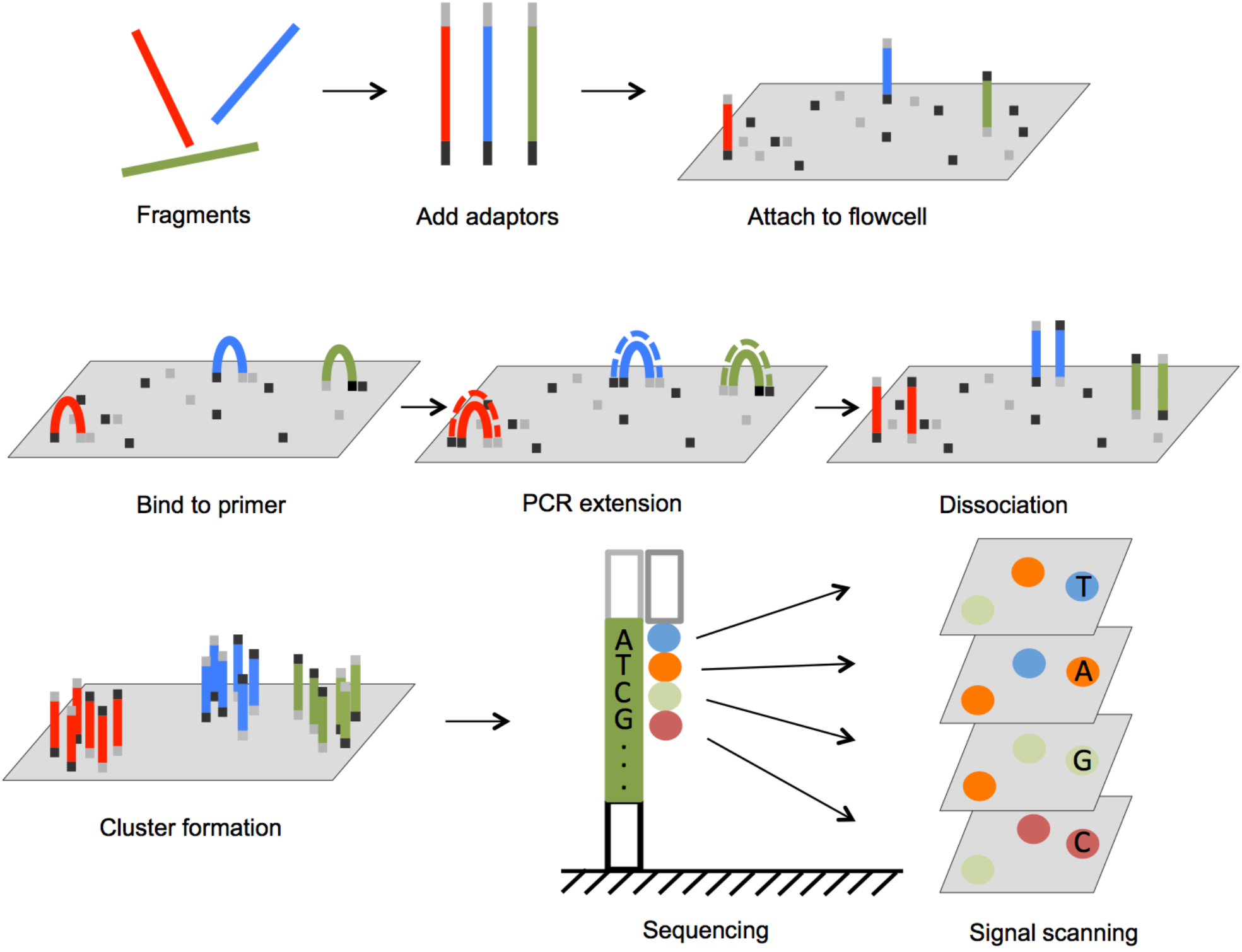
No PCR

Immobilizing:

1.- templates

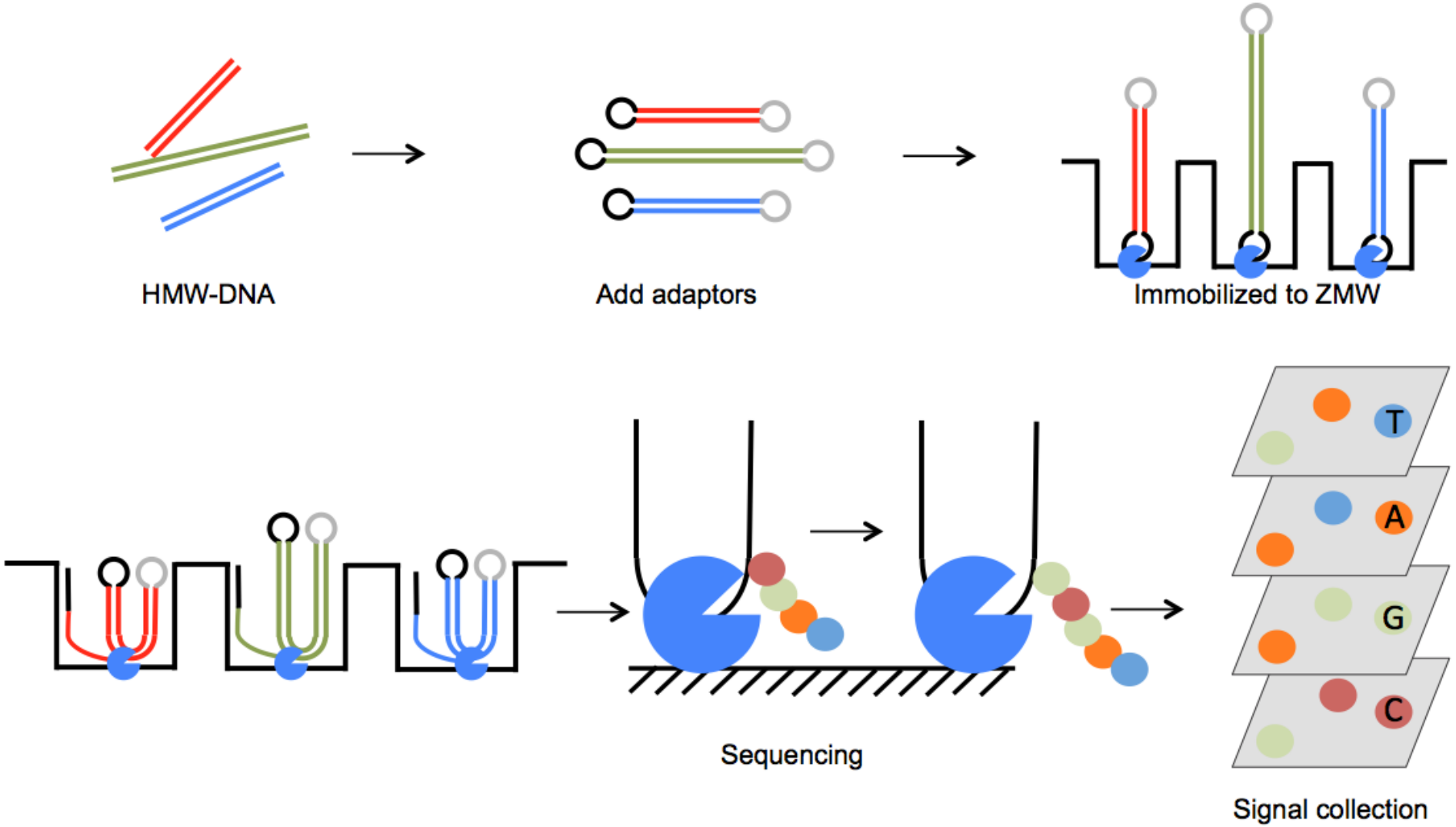
2.- primer

3.- polymerase

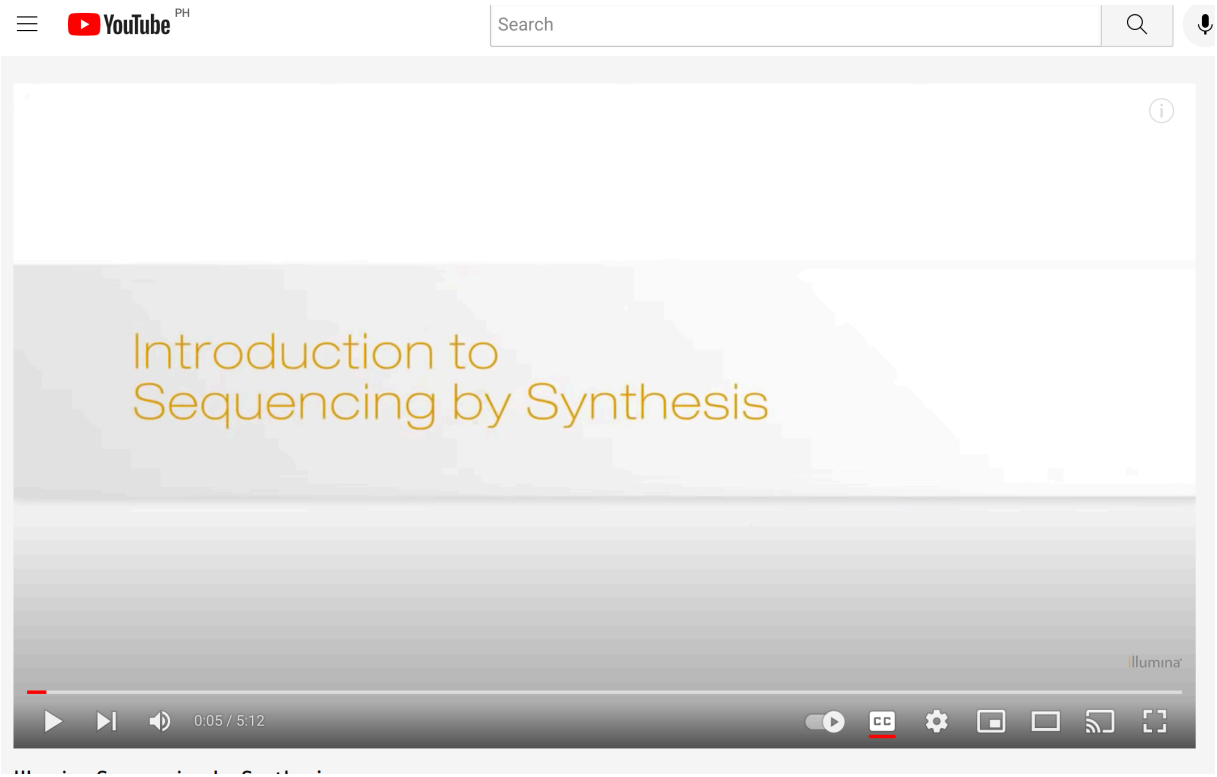

Fragments
Add adaptors
Attach to flowcell
Bind to primer
PCR extension
Dissociation
Cluster formation
ATCG...
Sequencing
T
A
G
C
Signal scanning

Single DNA Molecule Template- PacBio

Immobilizing polymerases = longer reads (1000s to 10,000s bps)



Illumina Online Resources



https://www.youtube.com/watch?v=fCd6B5HRaZ8&t=