Ebola Evolution

Zach Dumar & Audrey Simard

Itinerary

Background and Historical Context

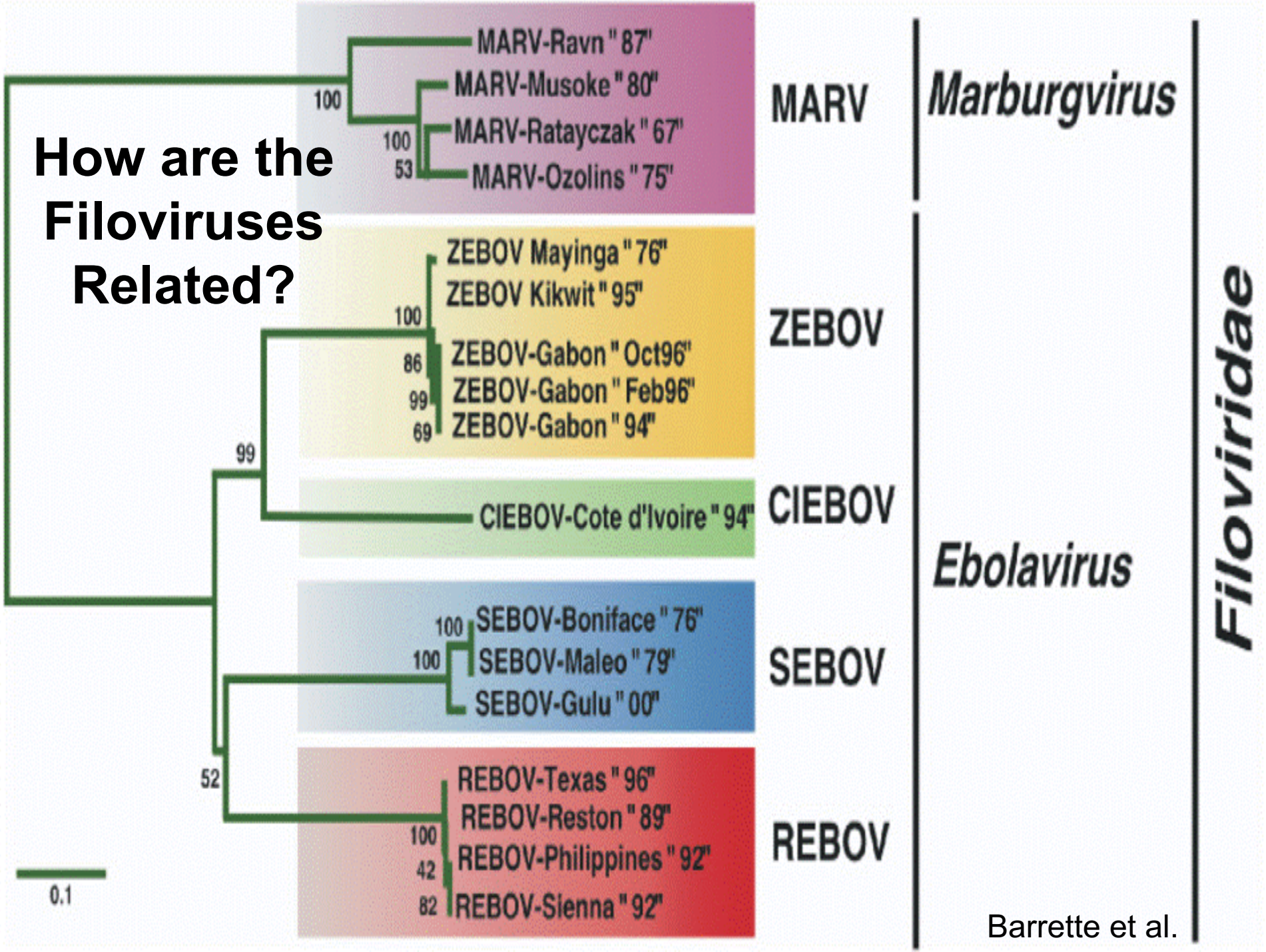
Next Gen Sequencing (NGS)

Primary Paper

What is Ebola?

What is Ebola?

How are the Filoviruses Related?



Barrette et al.

HOW IS EBOLA TRANSMITTED?

Infected fruit

Unprotected sex with infected individual

Infected bush meat

Contact with infected medical equipment

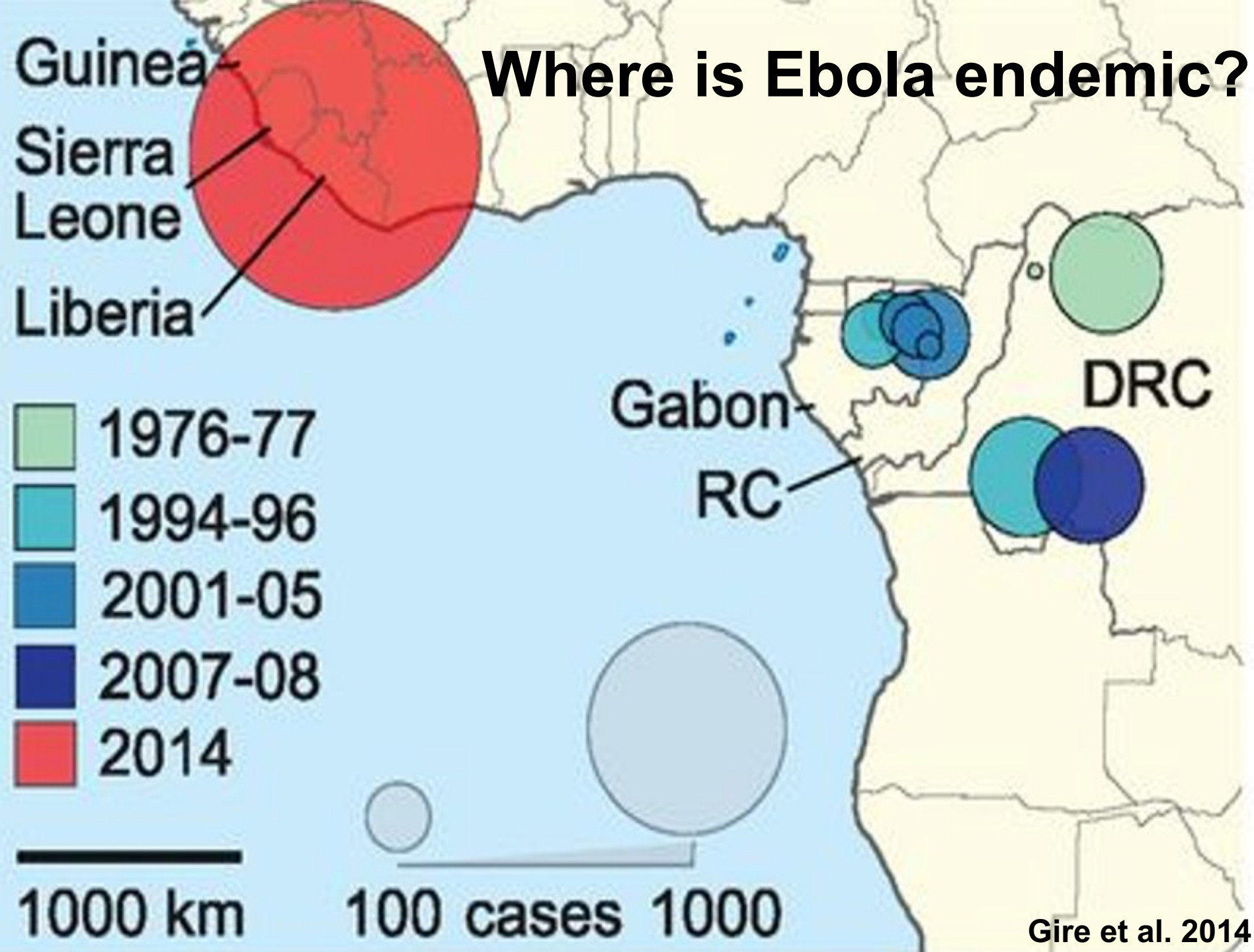
Infected stool/ urine

Contact with infected animal/ human

Infected blood

Contact with infected dead boady

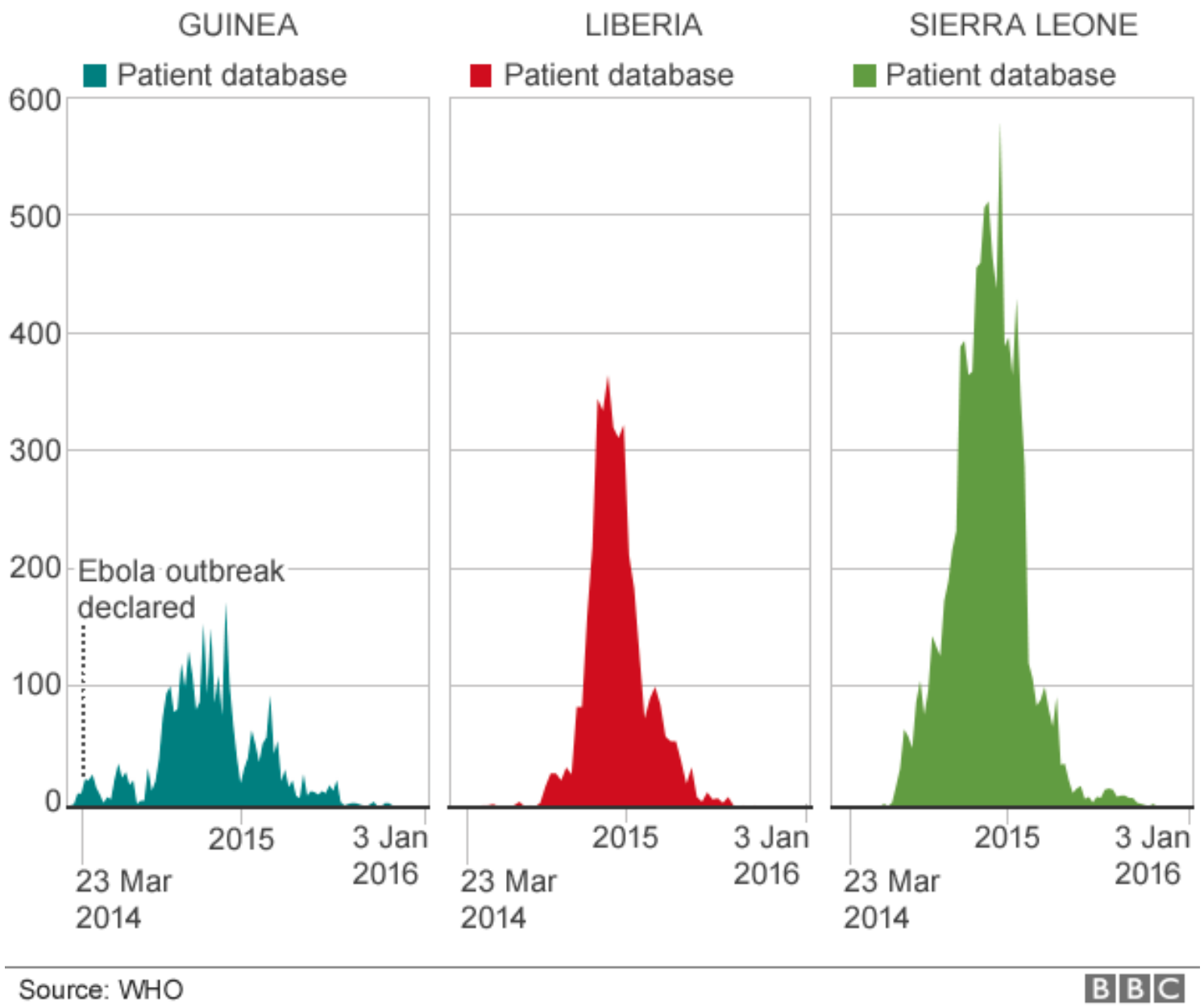
http://www.vige.co/wp-content/uploads/2014/10/Infographic_Medicine_043_How-is-Ebola-transmitted2.png


Where is Ebola endemic?
Guinea
Sierra Leone
Liberia
Gabon
RC
DRC
1976-77
1994-96
2001-05
2007-08
2014
1000 km
100 cases 1000
Gire et al. 2014

What makes Ebola so lethal?

Time

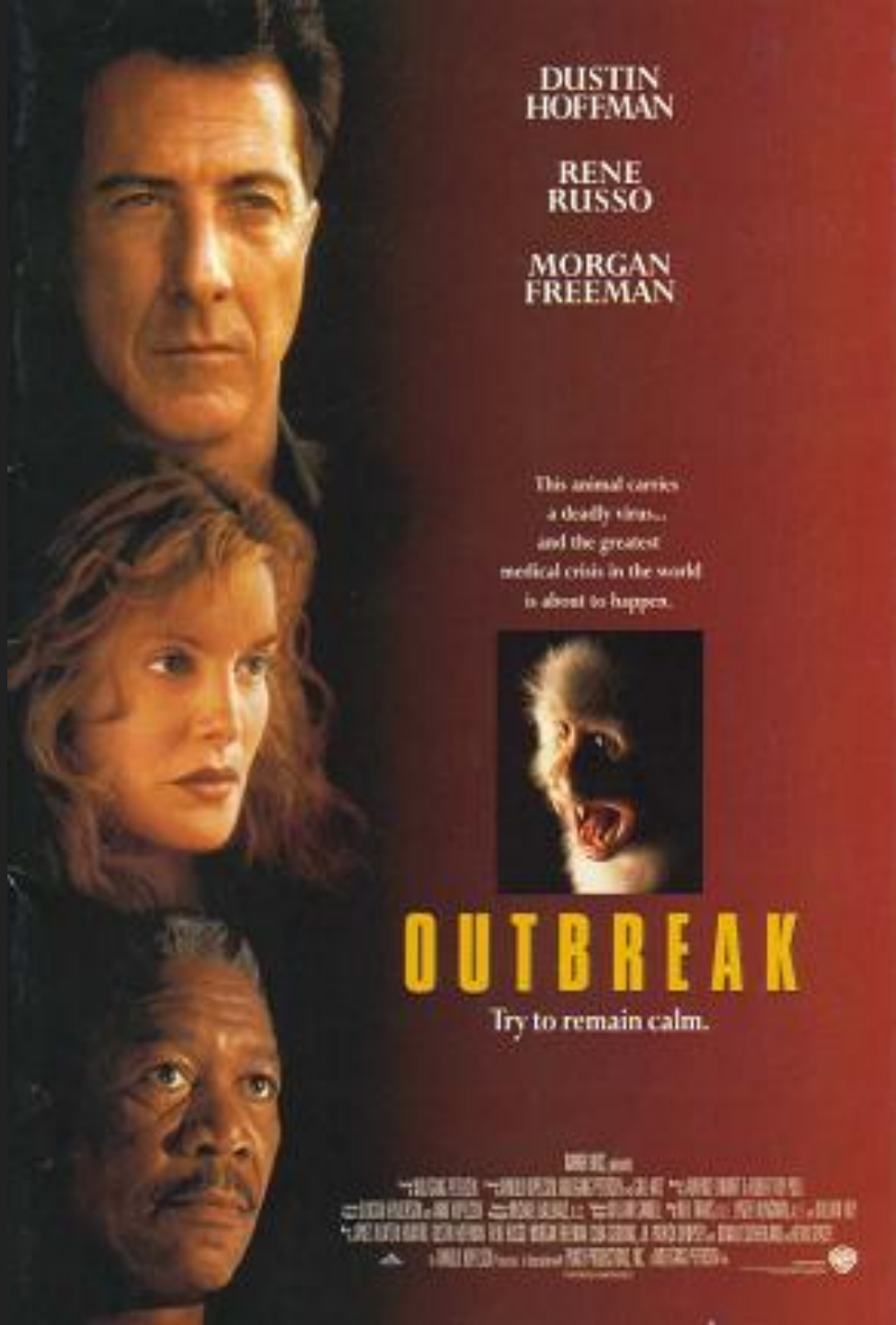
What Impact does Ebola have?



Fun Fact!

The film was released on March 10th, 1995.

On April 4th, 1995 the second Ebola outbreak occurred in Congo (Zaire).



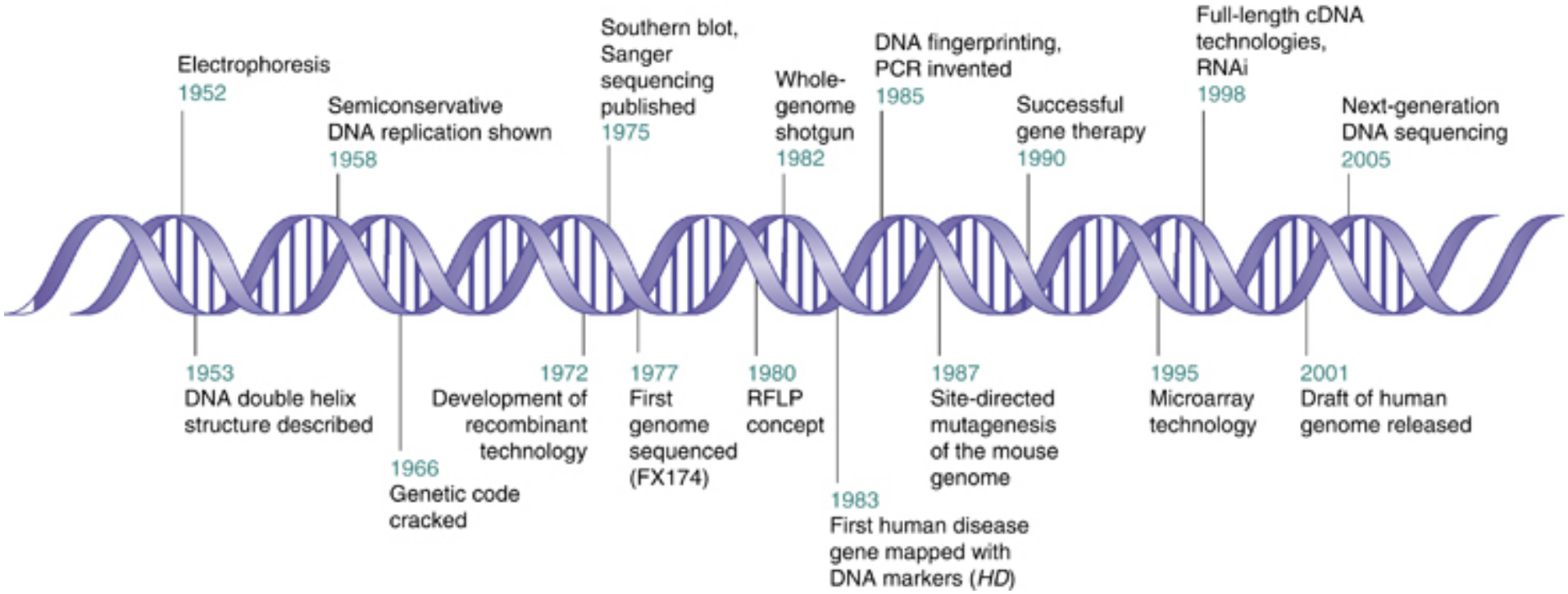
Itinerary

Background and Historical Context

Next Gen Sequencing

Primary Paper

How far have we come in genomic tech?



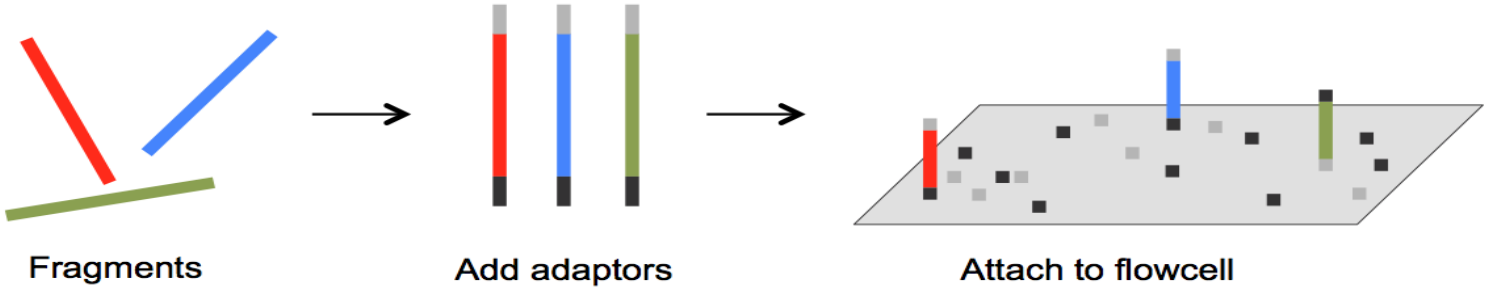
What is Next Gen Sequencing?

PACIFIC BIOSCIENCES®

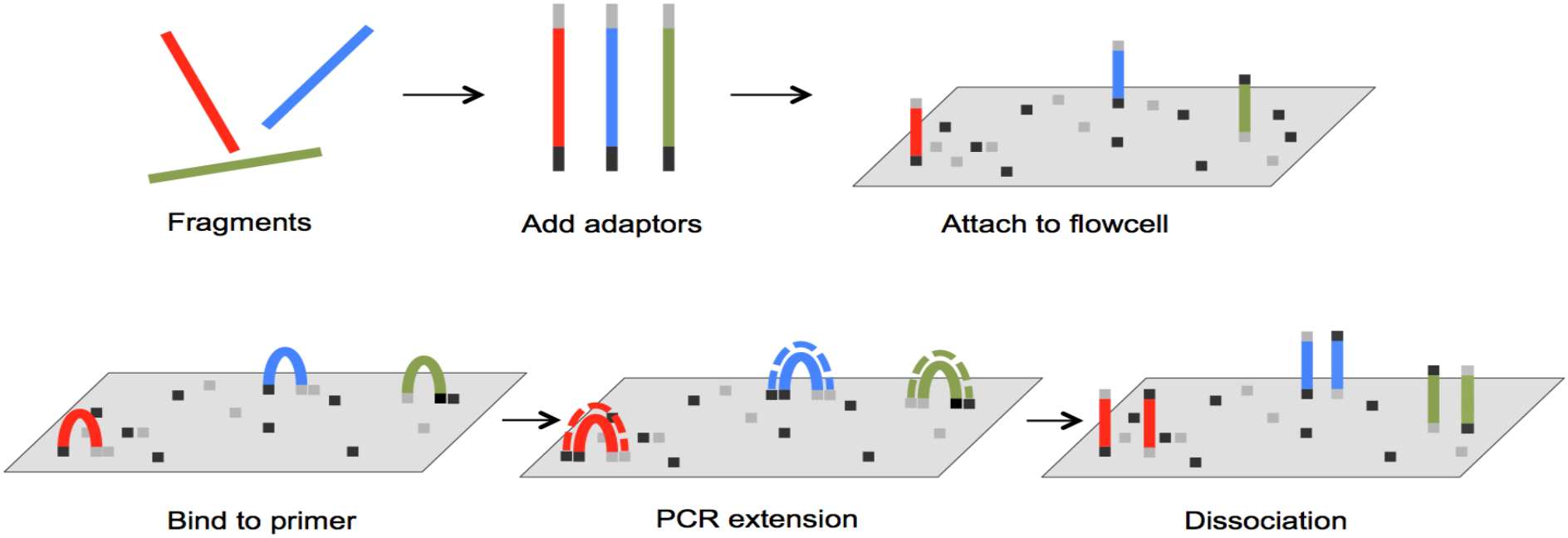
illumina®

Agilent Technologies

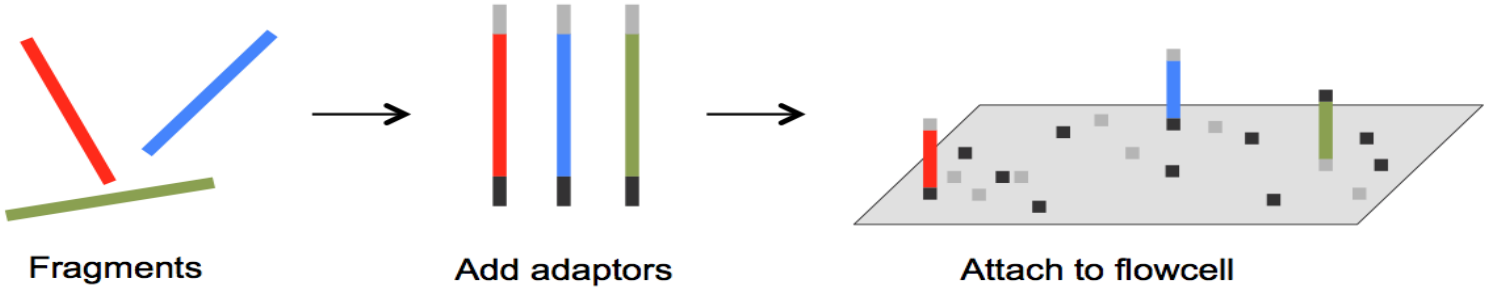
Part 1: What is Illumina sequencing?

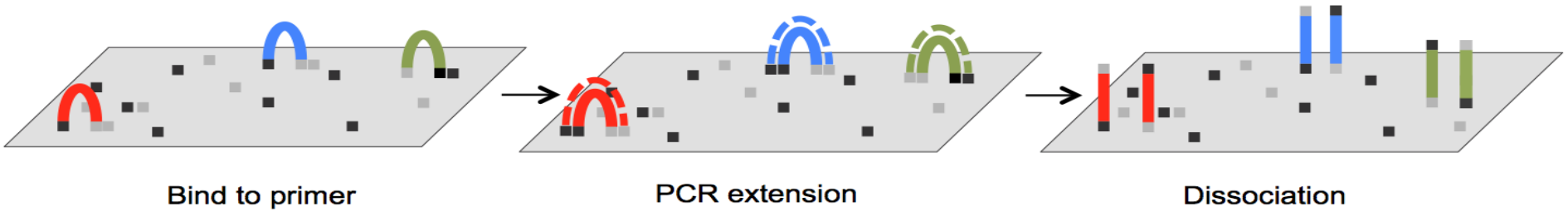


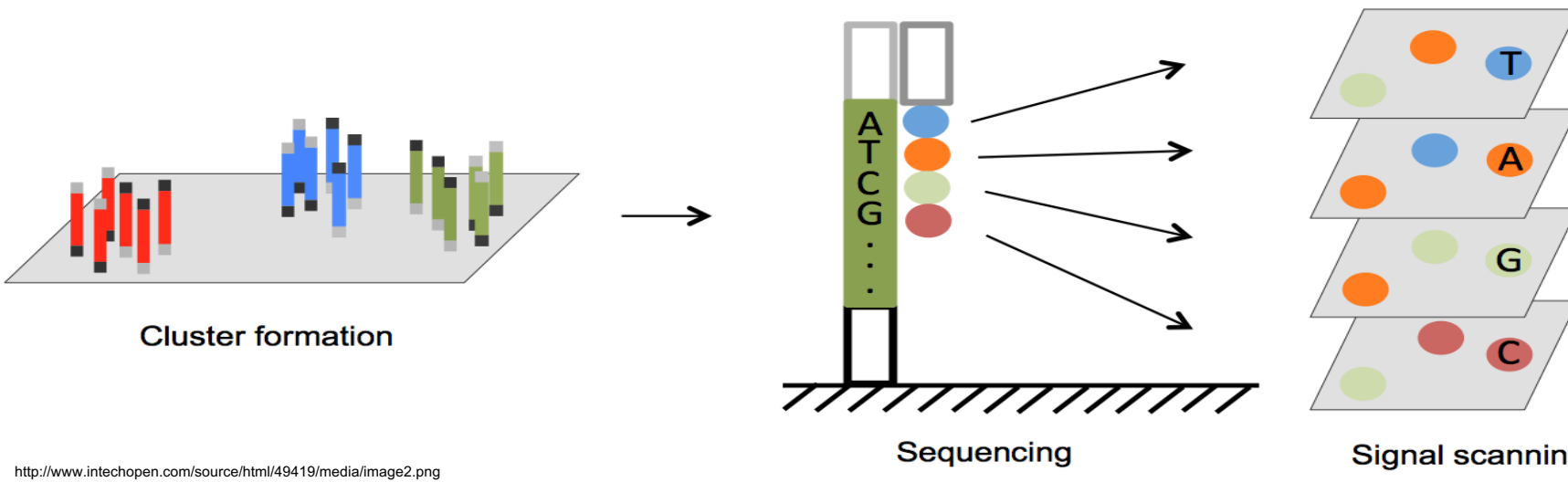
Part 2: What is Illumina sequencing?



Part 3: What is Illumina sequencing?

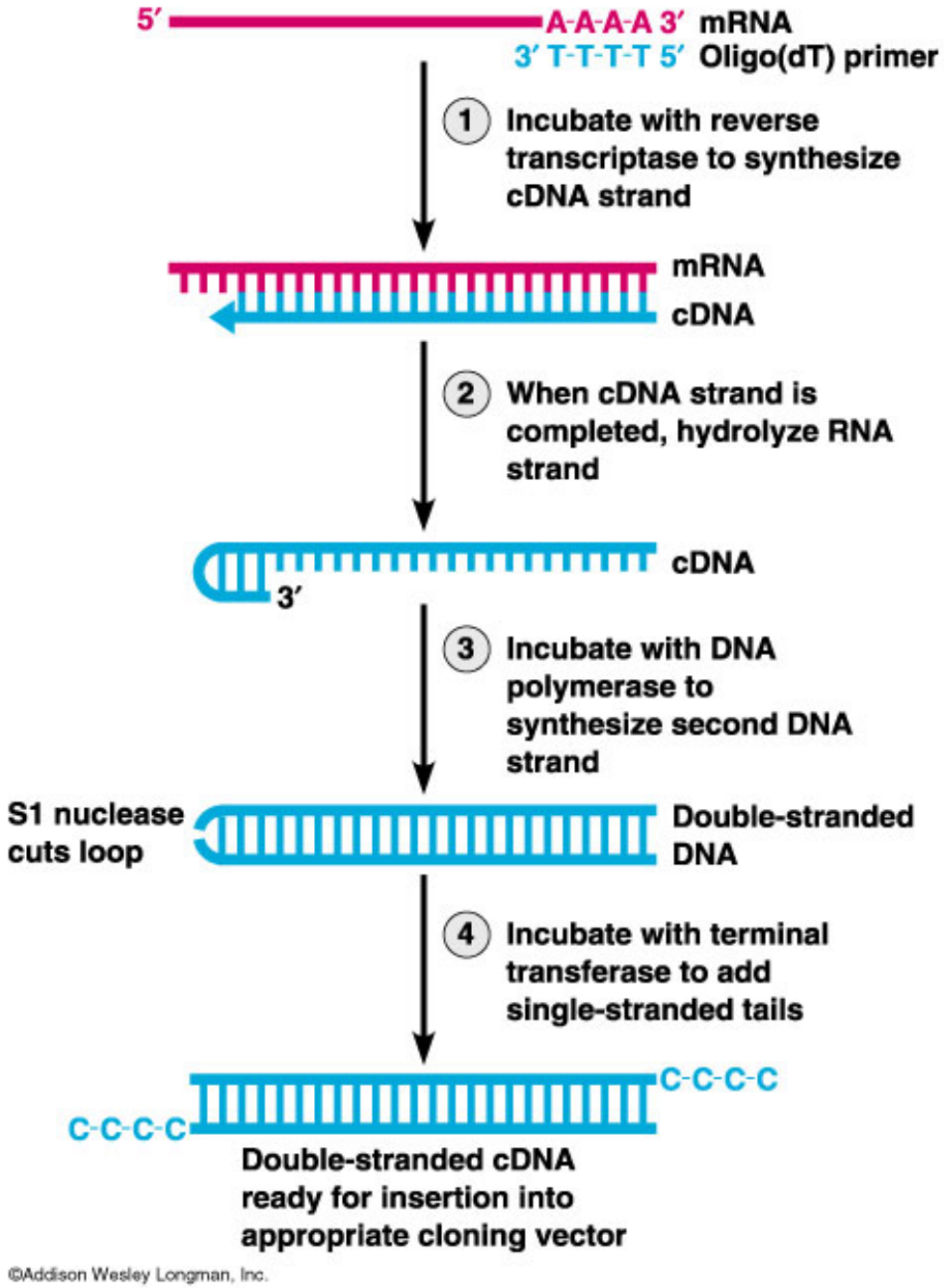






http://www.intechopen.com/source/html/49419/media/image2.png

How are cDNA Libraries constructed?



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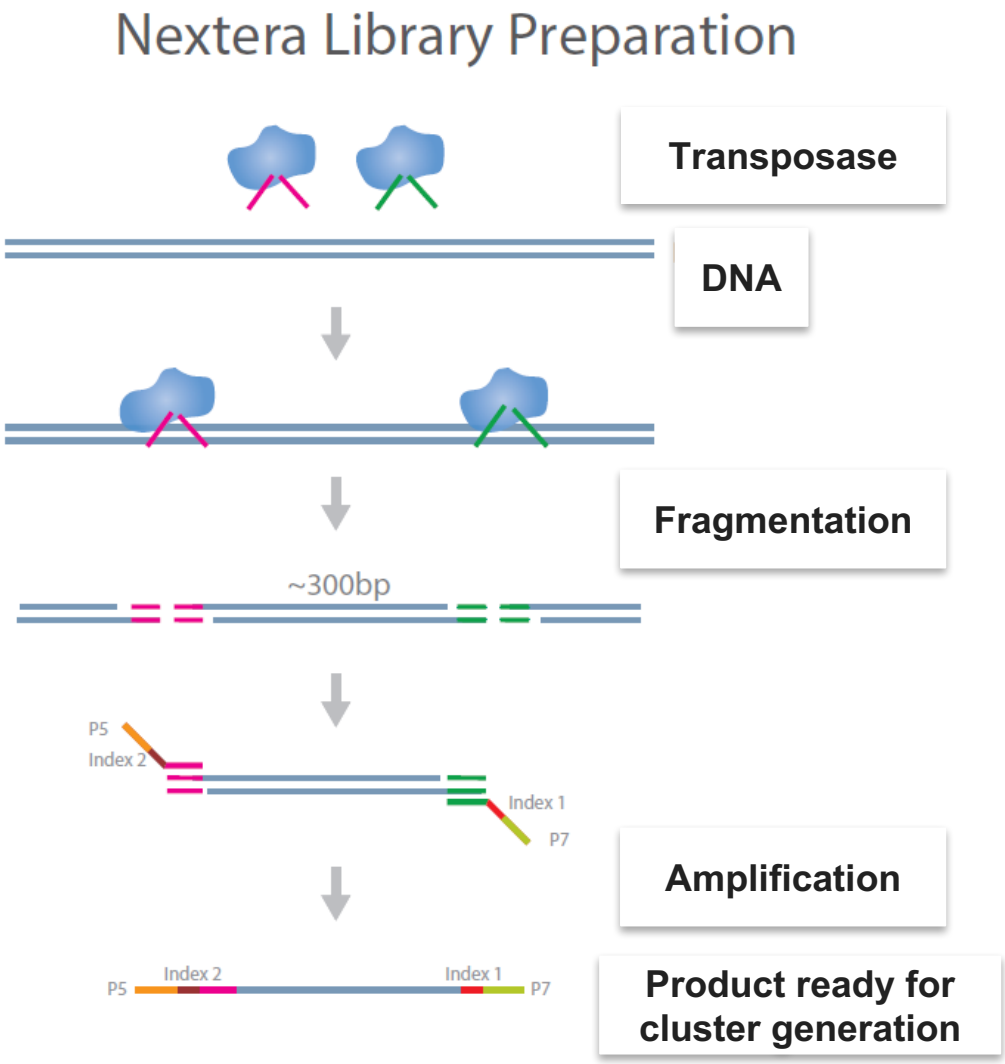
How are Nextera libraries made?



What other NGS options are there?

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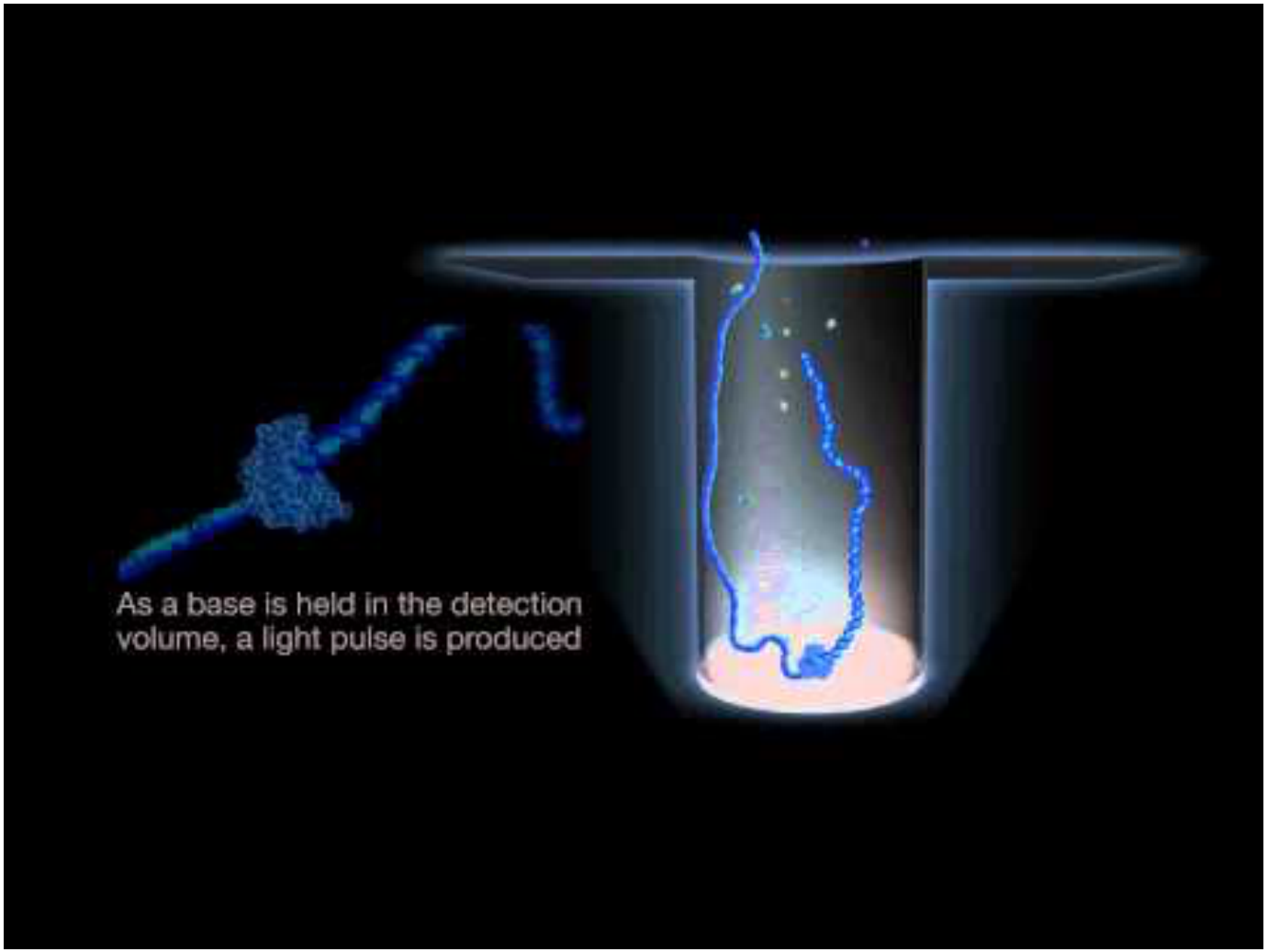


https://www.youtube.com/watch?v=NHCJ8PtYCFc

Sciencexpress

Genomic surveillance elucidates Ebola virus origin and transmission during the 2014 outbreak

Stephen K. Gire,[1,2*] Augustine Goba,[3*†] Kristian G. Andersen,[1,2*†] Rachel S. G. Sealfon,[2,4*] Daniel J. Park,[2*] Lansana Kanneh,[3] Simbirie Jalloh,[3] Mambu Momoh,[3,5] Mohamed Fullah,[3,5‡] Gytis Dudas,[6] Shirlee Wohl,[1,2,7] Lina M. Moses,[8] Nathan L. Yozwiak,[1,2] Sarah Winnicki,[1,2] Christian B. Matranga,[2] Christine M. Malboeuf,[2] James Qu,[2] Adrianne D. Gladden,[2] Stephen F. Schaffner,[1,2] Xiao Yang,[2] Pan-Pan Jiang,[1,2] Mahan Nekoui,[1,2] Andres Colubri,[1] Moinya Ruth Coomber,[3] Mbalu Fonnie,[3‡] Alex Moigboi,[3‡] Michael Gbakie,[3] Fatima K. Kamara,[3] Veronica Tucker,[3] Edwin Konuwa,[3] Sidiki Saffa,[3] Josephine Sellu,[3] Abdul Azziz Jalloh,[3] Alice Kovoma,[3‡] James Koninga,[3] Ibrahim Mustapha,[3] Kandeh Kargbo,[3] Momoh Foday,[3] Mohamed Yillah,[3] Franklyn Kanneh,[3] Willie Robert,[3] James L. B. Massally,[3] Sinéad B. Chapman,[2] James Bochicchio,[2] Cheryl Murphy,[2] Chad Nusbaum,[2] Sarah Young,[2] Bruce W. Birren,[2] Donald S. Grant,[3] John S. Scheiffelin,[8] Eric S. Lander,[2,7,9] Christian Happi,[10] Sahr M. Gevao,[11] Andreas Gnirke,[2§] Andrew Rambaut,[6,12,13§] Robert F. Garry,[8§] S. Humarr Khan,[3‡§] Pardis C. Sabeti[1,2†§]

Fig 1: How was NGS used?

D

	# Total	# Patients	% Coverage	x Coverage
Batch 1	15	12	99.77%	555 [16-23,042]
Batch 2	84	66	99.91%	2,186 [6-18,623]
Combined	99	78	99.88%	2,048 [6-23,042]
Replication	140	78	99.39%	2,109 [8-17,537]

What catalyzed the 2014 Ebola Outbreak?

RIP

Traditional Healer
Sierra Leone
Feb. 2014

What catalyzed the 2014 Ebola Outbreak?

RIP

Traditional Healer
Sierra Leone
Feb. 2014

+13=

What catalyzed the 2014 Ebola Outbreak?

RIP

Traditional Healer Sierra Leone Feb. 2014

+13=

Jan. 2014 -2016

Fig. 3a: What is the genealogy of ebola outbreaks?

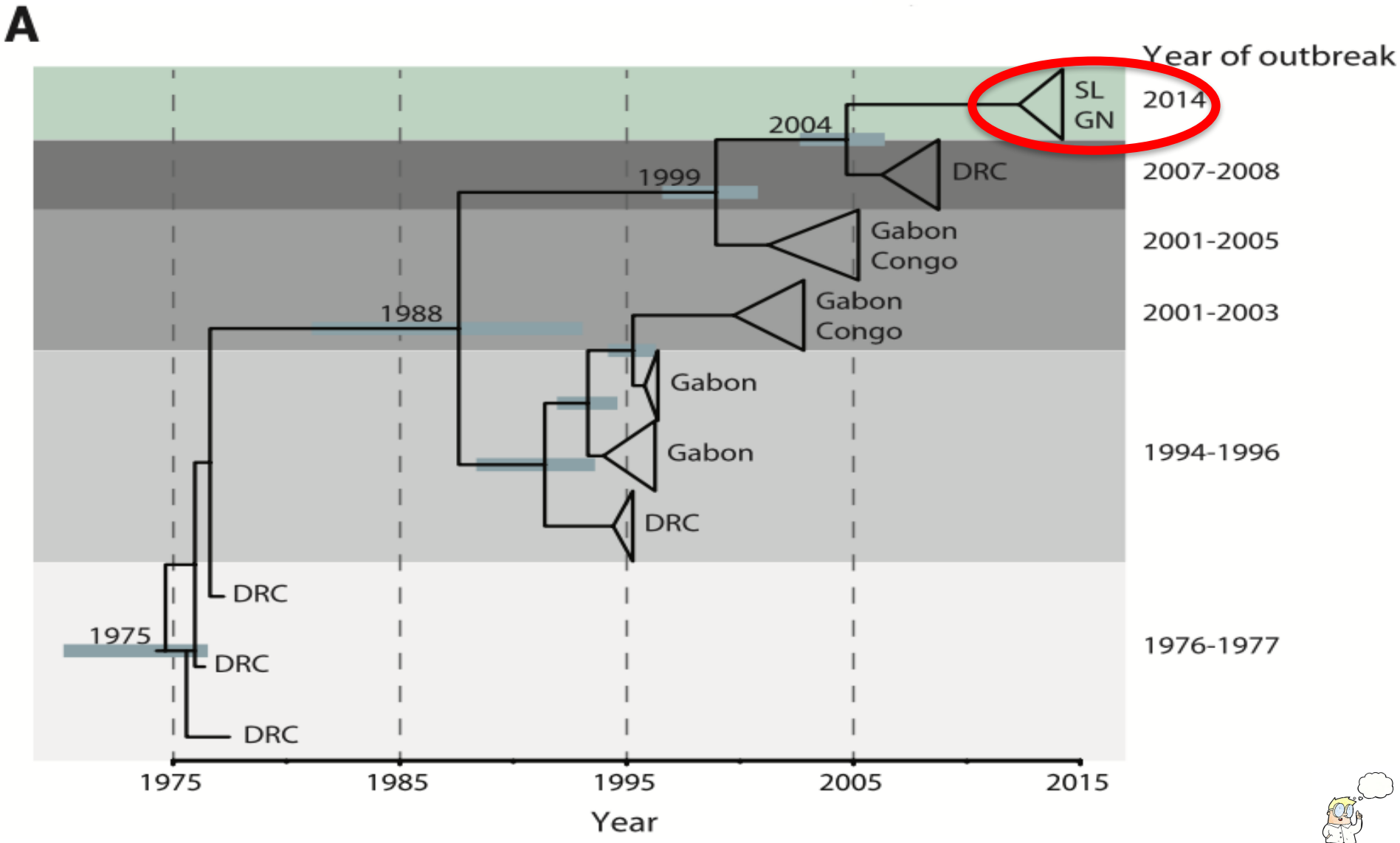


Fig. 3b: What is the genealogy of the 2014 Outbreak?

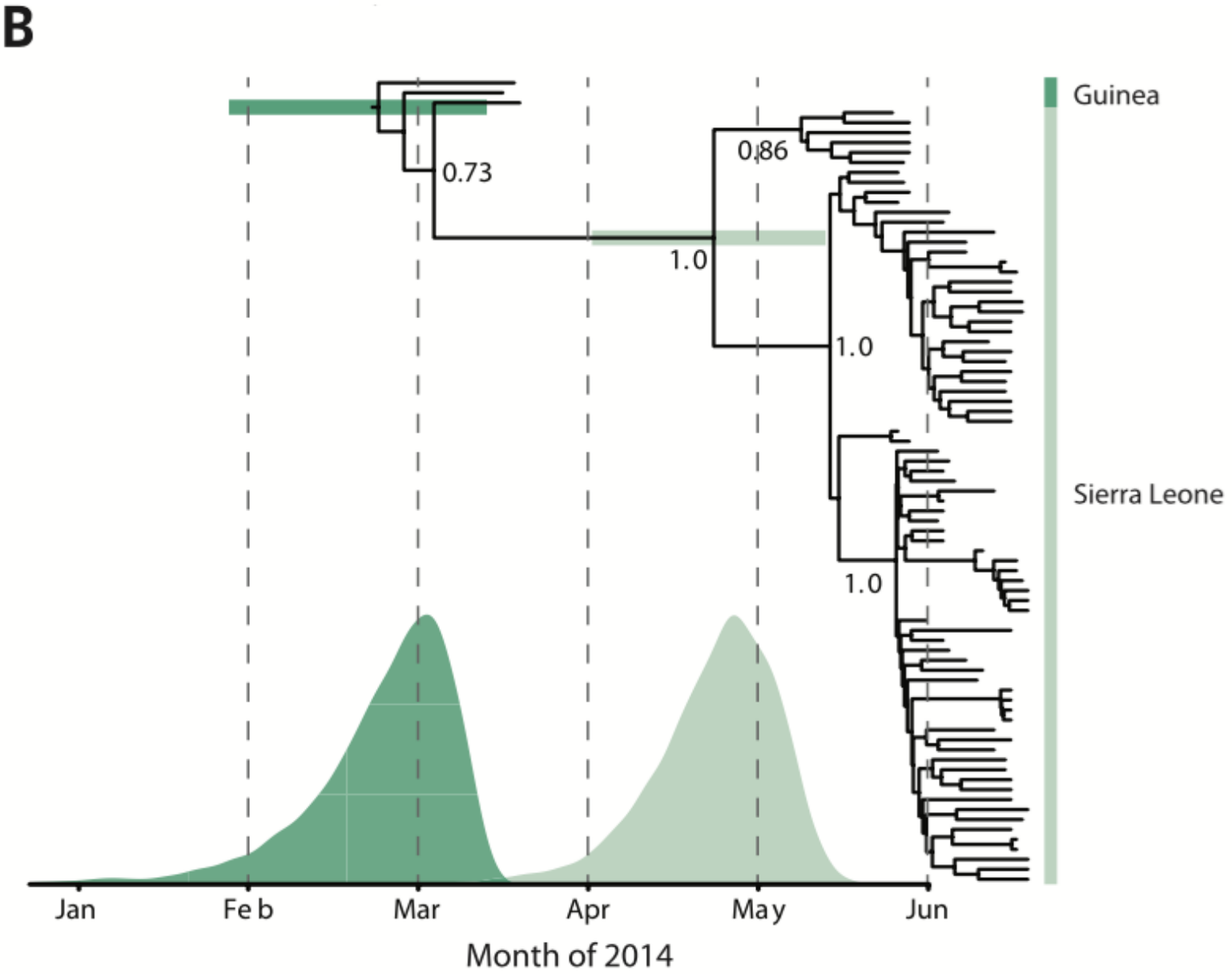


Fig. S3A: Were there pathogenic relationships?

A

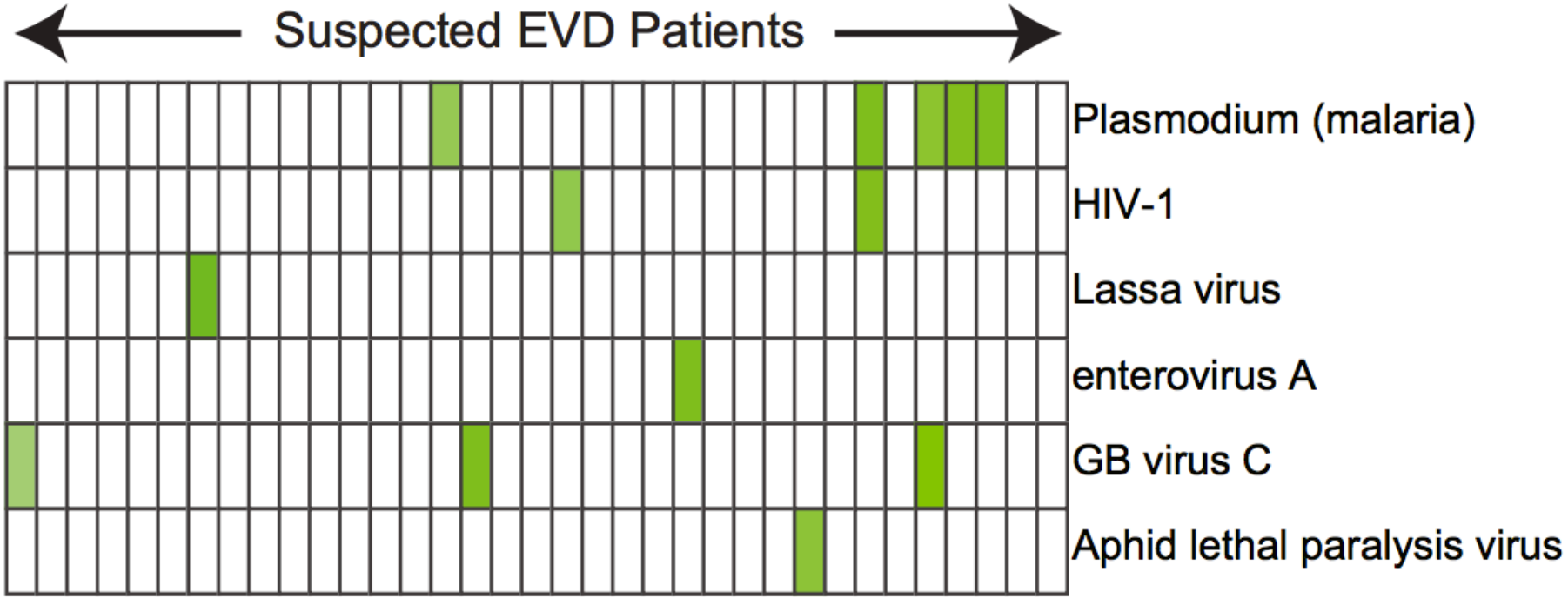


Fig. S3B: Were there pathogenic relationships?

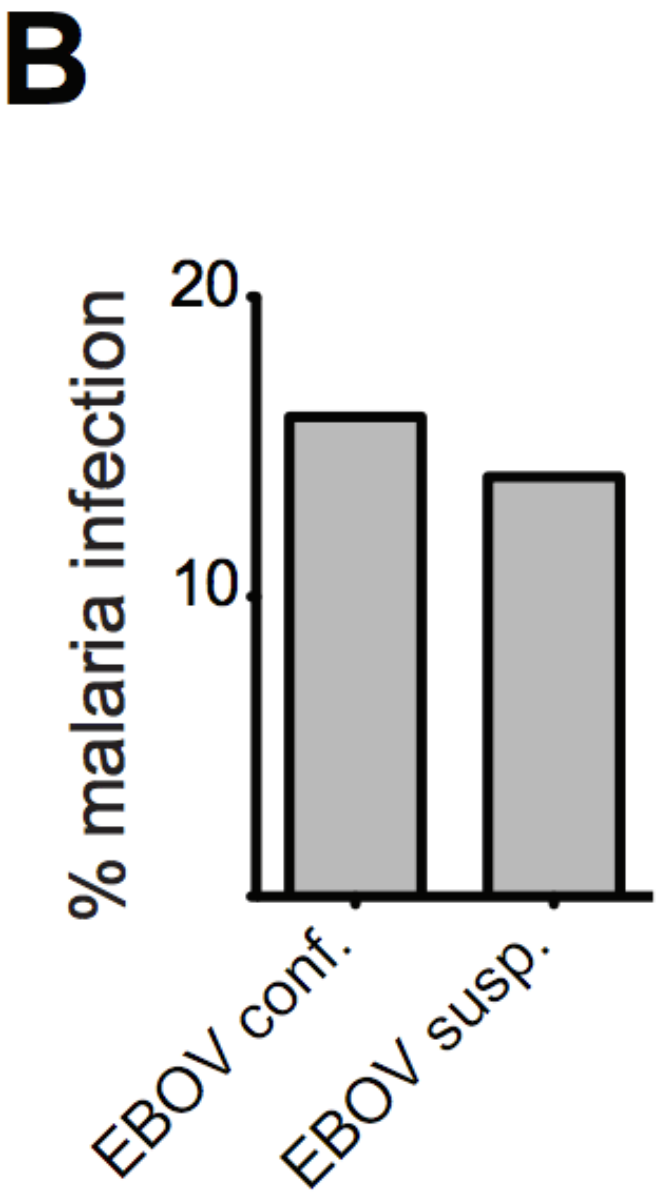


Fig. 4: How genetically diverse was the 2014 ebola outbreak?

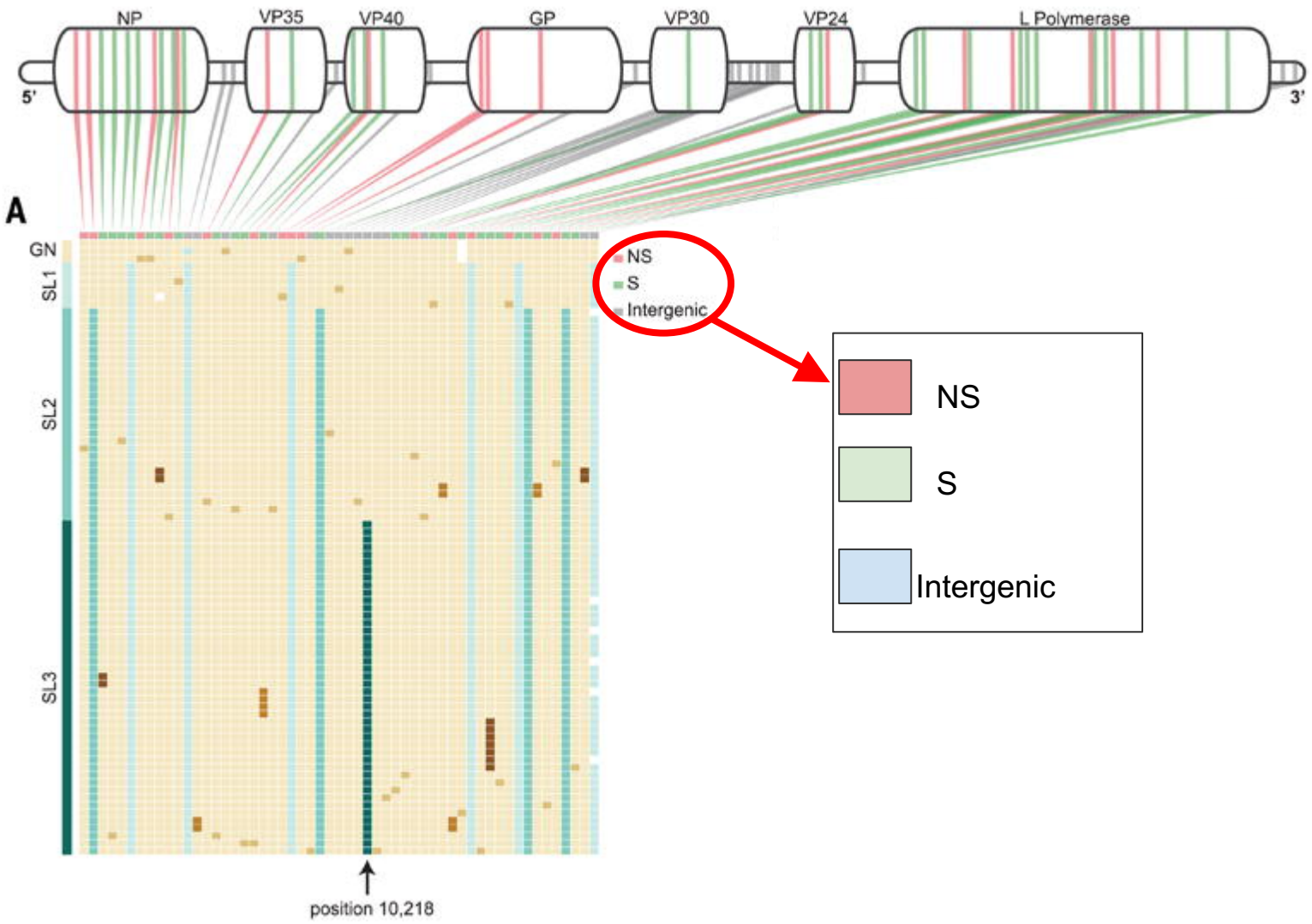
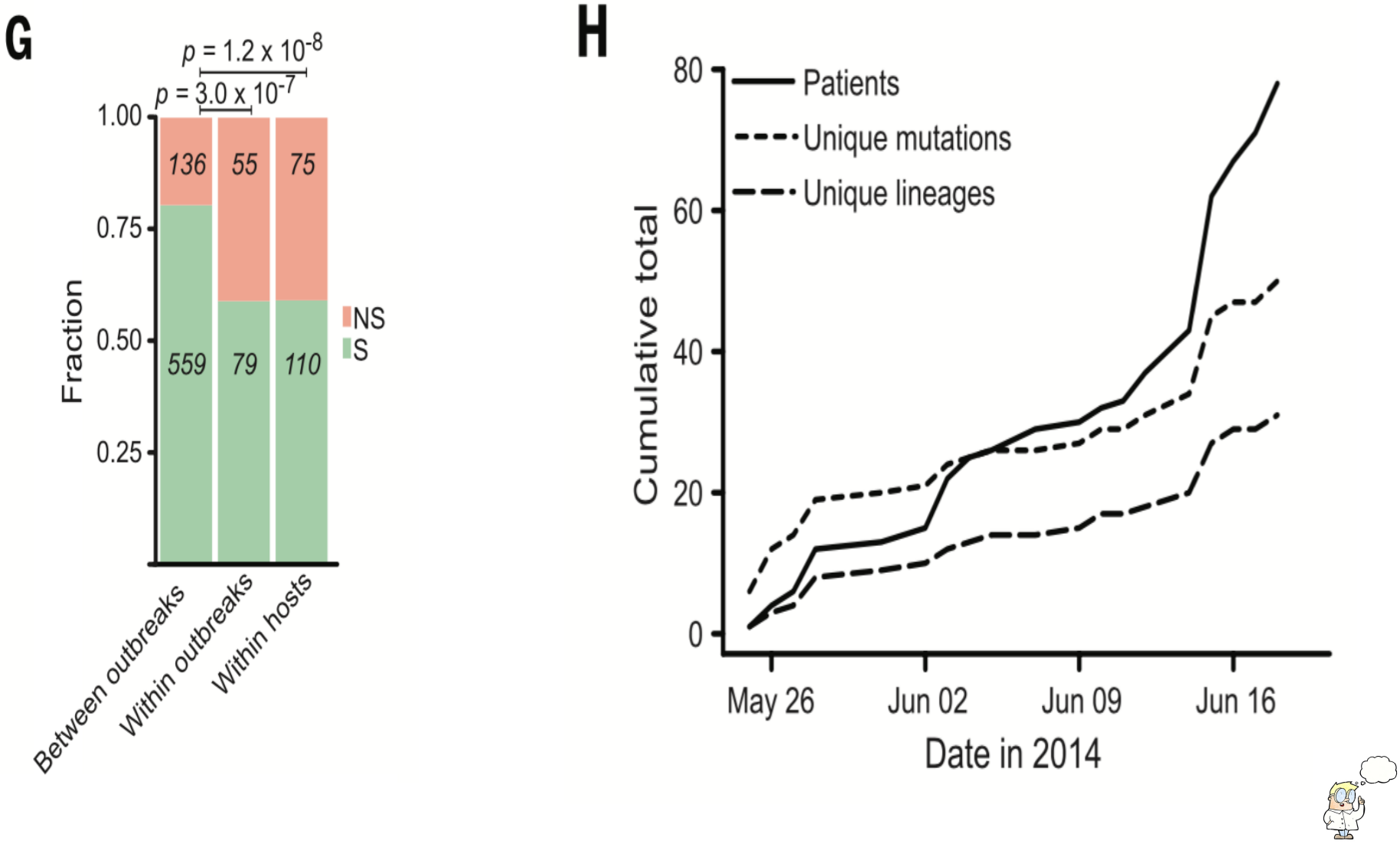


Fig 4: Did the Ebola virus evolve during the 2014 outbreak?



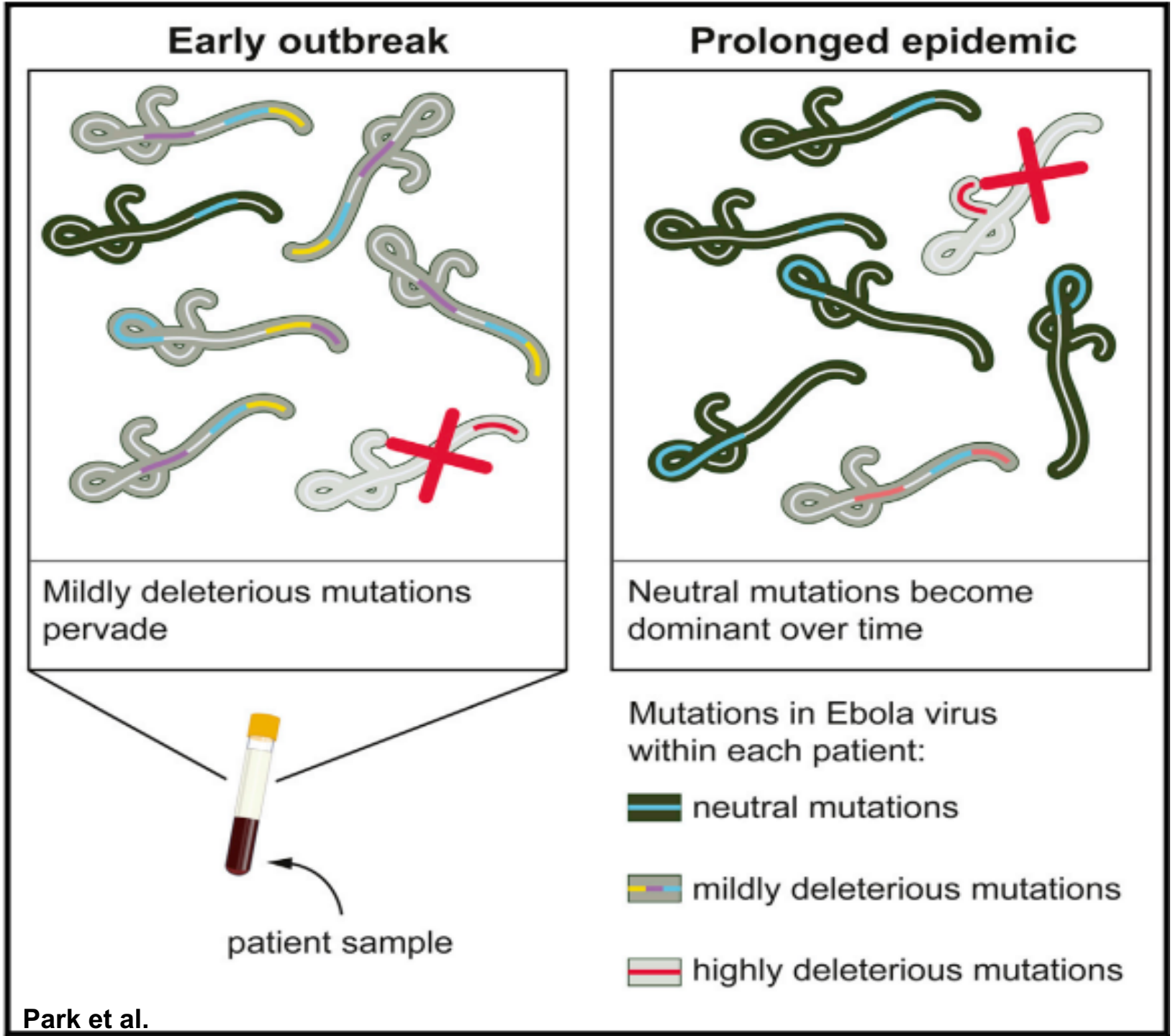
Cell

Article

Ebola Virus Epidemiology, Transmission, and Evolution during Seven Months in Sierra Leone

Daniel J. Park,[1,21,*] Gytis Dudas,[2,21] Shirlee Wohl,[1,3,21] Augustine Goba,[4,21] Shannon L.M. Whitmer,[5,21] Kristian G. Andersen,[6] Rachel S. Sealfon,[1,7] Jason T. Ladner,[8] Jeffrey R. Kugelman,[8] Christian B. Matranga,[1] Sarah M. Winnicki,[1,3] James Qu, Stephen K. Gire,[1,3] Adrianne Gladden-Young,[1] Simbirie Jalloh,[4] Dolo Nosamiefan,[1] Nathan L. Yozwiak,[1,3] Lina M. Moses,[3] Pan-Pan Jiang,[1,3] Aaron E. Lin,[1,3] Stephen F. Schaffner,[1,3] Brian Bird,[5] Jonathan Towner,[5] Mambu Mamoh,[4] Michael Gbakie,[4] Lansana Kanneh,[4] David Kargbo,[4] James L.B. Massally,[4] Fatima K. Kamara,[4] Edwin Konuwa,[4] Josephine Sellu,[4] Abdul A. Jalloh,[4] Ibrahim Mustapha,[4] Momoh Foday,[4] Mohamed Yillah,[4] Bobbie R. Erickson,[5] Tara Sealy,[5] Dianna Blau,[5] Christopher Paddock,[5] Aaron Brault,[5] Brian Amman,[5] Jane Basile,[5] Scott Bearden,[5] Jessica Belser,[5] Eric Bergeron,[5] Shelley Campbell,[5] Ayan Chakrabarti,[5] Kimberly Dodd,[5] Mike Flint,[5] Aridth Gibbons,[5] Christin Goodman,[5] John Klena,[5] Laura McMullan,[5] Laura Morgan,[5] Brandy Russell,[5] Johanna Salzer,[5] Angela Sanchez,[5] David Wang,[5] Irwin Jungreis,[7] Christopher Tomkins-Tinch,[1] Andrey Kislyuk,[10] Michael F. Lin,[10] Sinead Chapman,[1] Bronwyn MacInnis,[1] Ashley Matthews,[1,3] James Bochicchio,[1] Lisa E. Hensley,[11] Jens H. Kuhn,[11] Chad Nusbaum,[1] John S. Schieffelin,[9] Bruce W. Birren,[1] Marc Forget,[12] Stuart T. Nichol,[5] Gustavo F. Palacios,[8] Daouda Ndiaye,[13] Christian Happi,[14] Sahr M. Gevao,[15] Mohamed A. Vandi,[16] Brima Kargbo,[16] Edward C. Holmes,[17] Trevor Bedford,[18] Andreas Gnirke,[1] Ute Ströher,[5,22] Andrew Rambaut,[2,19,20,22,*] Robert F. Garry,[9,22] and Pardis C. Sabeti[1,3,22,*]

June 2015

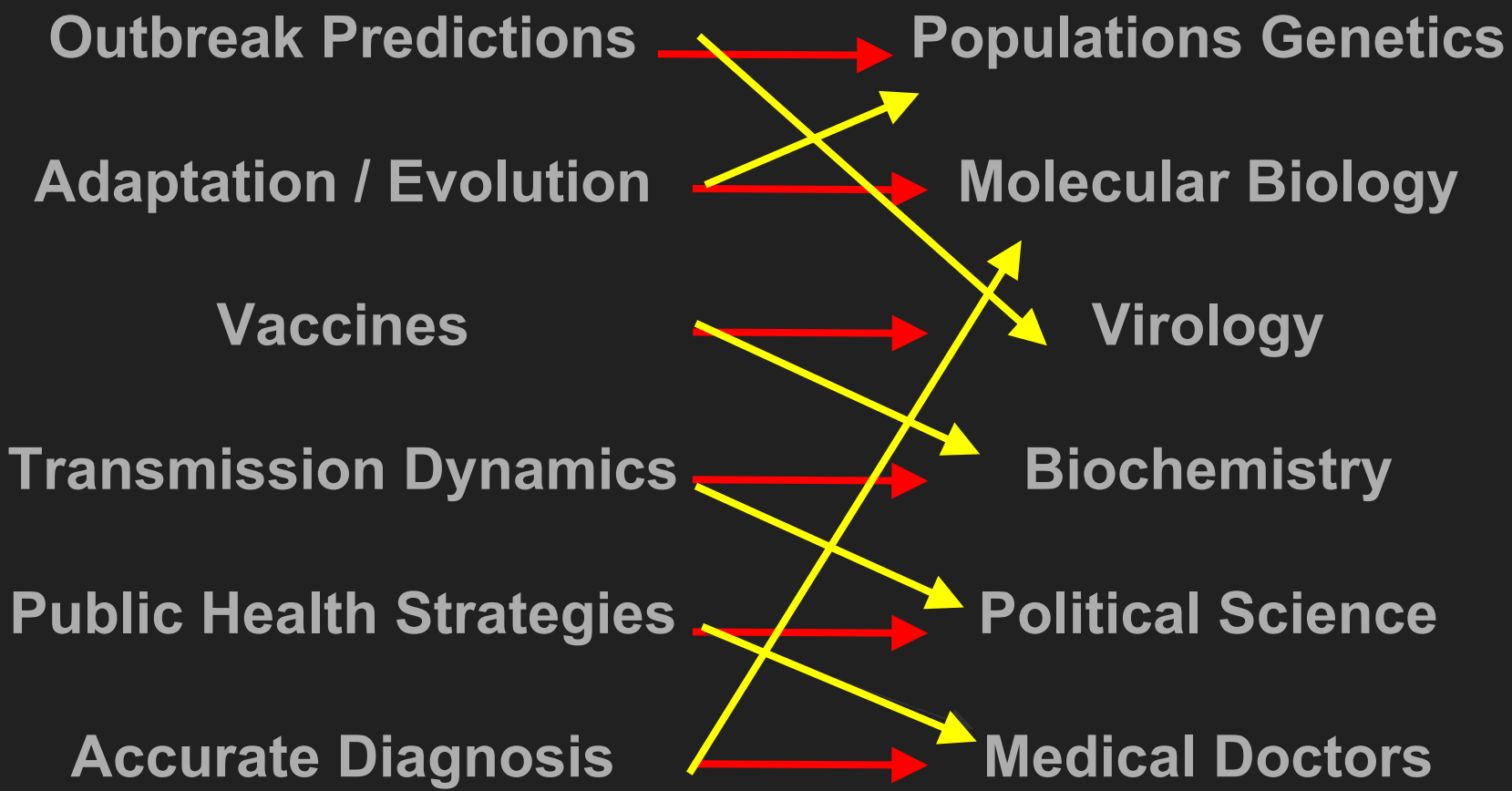

Early outbreak
Prolonged epidemic
Mildly deleterious mutations pervade
Neutral mutations become dominant over time
patient sample
Mutations in Ebola virus within each patient:
neutral mutations
mildly deleterious mutations
highly deleterious mutations

Park et al.

Why is this important?

Outbreak Predictions	→	Populations Genetics
Adaptation / Evolution	→	Molecular Biology
Vaccines	→	Virology
Transmission Dynamics	→	Biochemistry
Public Health Strategies	→	Political Science
Accurate Diagnosis	→	Medical Doctors

Why is this important?



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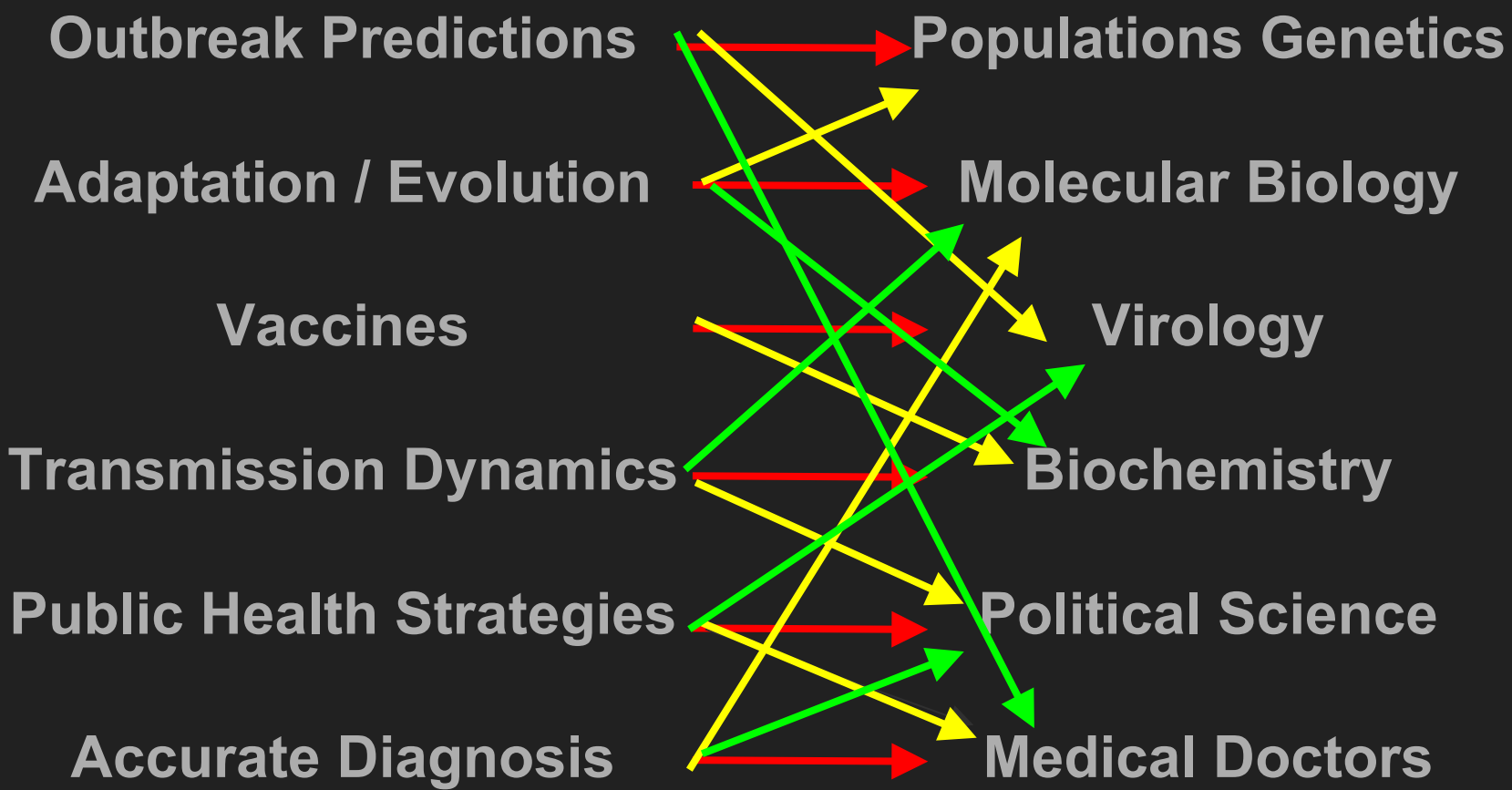


In Memoriam

Mohamed Fullah † **Mbalu Fonnie †** **Alex Moigboi †**

Alice Kovoma † **S. Humarr Khan †**

What's Next?

THE LANCET

Articles

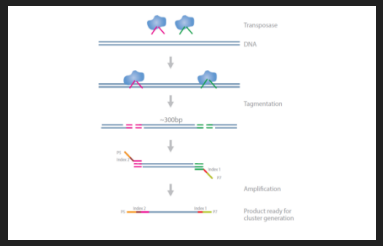
Efficacy and effectiveness of an rVSV-vectored vaccine in preventing Ebola virus disease: final results from the Guinea ring vaccination, open-label, cluster-randomised trial (Ebola Ça Suffit!)

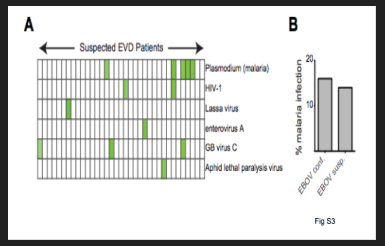
Dr Ana Maria Henao-Restrepo, MD, Anton Camacho, PhD, Prof Ira M Longini, PhD, Conall H Watson, MFPH, Prof W John Edmunds, PhD, Prof Matthias Egger, PhD, Miles W Carroll, PhD, Natalie E Dean, PhD, Ibrahima Diatta, MSc, Moussa Doumbia, MD, Bertrand Draguez, MD, Sophie Duraffour, PhD, Godwin Enwere, FWACP, Rebecca Grais, PhD, Stephan Gunther, MD, Pierre-Stéphane Gsell, PhD, Stefanie Hossmann, MSc, Sara Viksmoen Watle, MD, Prof Mandy Kader Kondé, PhD, Sakoba Kéïta, MD, Souleymane Kone, MSc, Eewa Kuisma, PhD, Prof Myron M Levine, MD, Sema Mandal, MD, Thomas Mauget, MBA, Gunnstein Norheim, PhD, Ximena Riveros, MSc, Aboubacar Soumah, MD, Sven Trelle, MD, Andrea S Vicari, PhD, Prof John-Arne Røttingen, MD†, Marie-Paule Kieny, PhD†

† Contributed equally

Published: 22 December 2016

Summary





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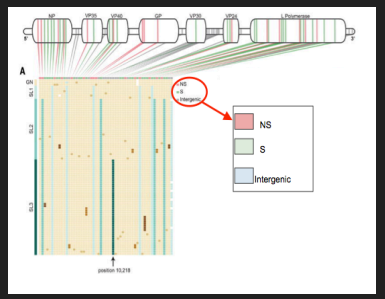
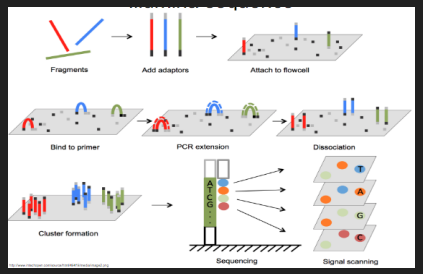
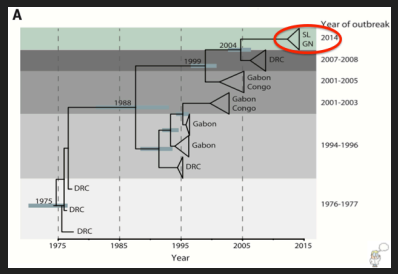
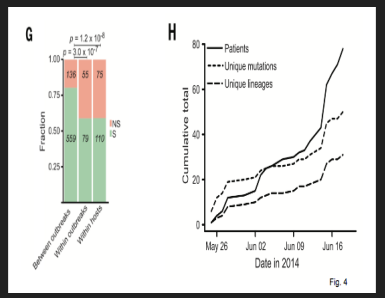
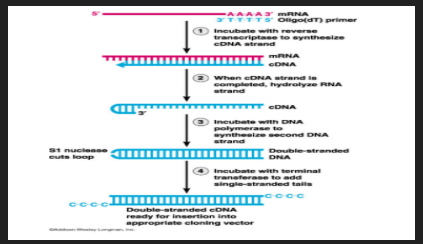
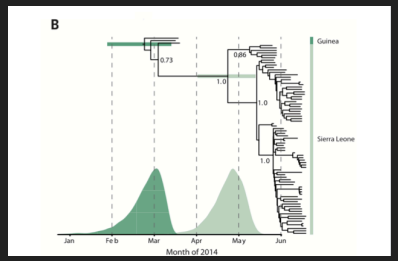


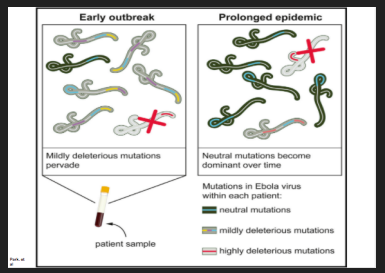












References:

Barrette, R. W., L. Z. Xu, J. M. Rowland, and M. T. McIntosh. 2011. Current perspectives on the phylogeny of Filoviridae. *Infection Genetics and Evolution* 11 (7):1514-1519.

Falasca, L., C. Agrati, N. Petrosillo, A. Di Caro, M. R. Capobianchi, G. Ippolito, and M. Piacentini. 2015. "Molecular mechanisms of Ebola virus pathogenesis: focus on cell death." *Cell Death and Differentiation* 22 (8):1250-1259.

Gire, S.K., Goba, A., Andersen, K.G., Sealfon, R.S.G., Park, D.J., Kanneh, L., Jalloh, S., Momoh, M., Fullah, M., Dudas, G., et al. (2014). Genomic surveillance elucidates Ebola virus origin and transmission during the 2014 outbreak. Science 345, 1369-1372.

Misasi, J., and Sullivan, N.J. (2014). Camouflage and Misdirection: The Full-On Assault of Ebola Virus Disease. Cell 159, 477-486.

Munroe, D. J., and T. J. R. Harris. 2010. "Third-generation sequencing fireworks at Marco Island." *Nature Biotechnology* 28 (5):426-428.

References continued:

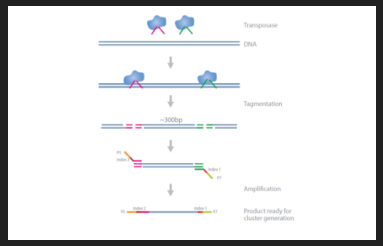
Munroe, D. J., and T. J. R. Harris. 2010. "Third-generation sequencing fireworks at Marco Island." *Nature Biotechnology* 28 (5):426-428.

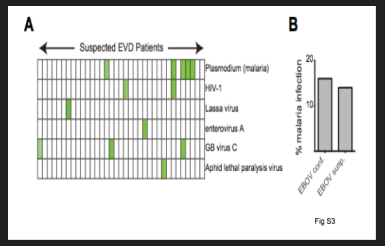
Shendure, J., and Ji, H.L. (2008). Next-generation DNA sequencing. Nature Biotechnology 26, 1135-1145.

World Health Organization: Photos

Thank You

Questions?





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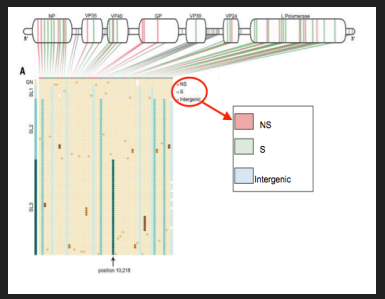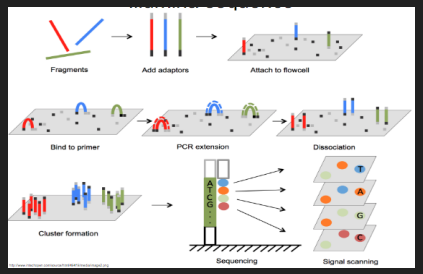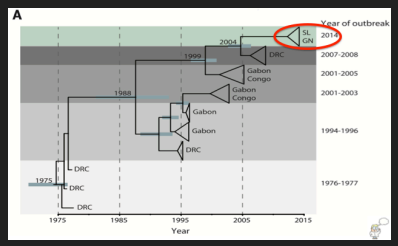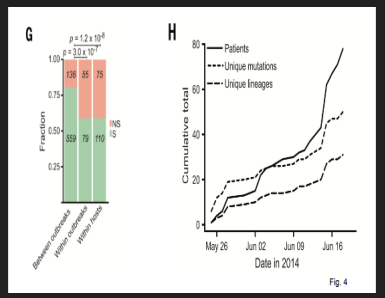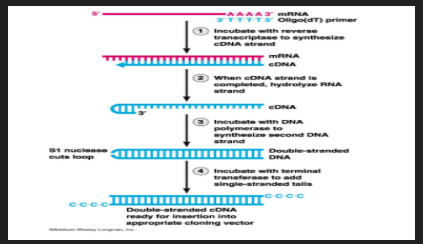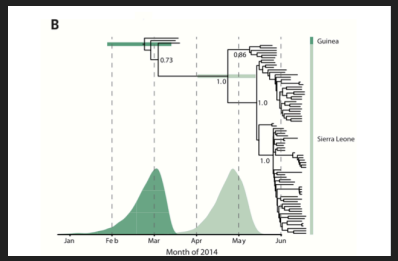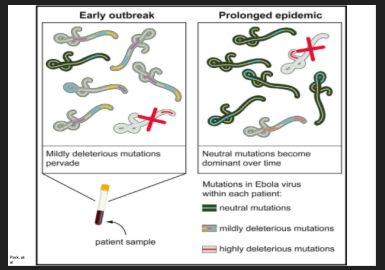
	# Total	# Patients	% Coverage	x Coverage
Batch 1	15	12	99.77%	555 [16-23,042]
Batch 2	84	66	99.91%	2,186 [6-18,623]
Combined	99	78	99.88%	2,048 [6-23,042]
Replication	140	78	99.39%	2,109 [8-17,537]