

Disease evolution



<http://www.youtube.com/watch?v=Rpj0emEGShQ>

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EEB464 Fall 2018

Learning objectives

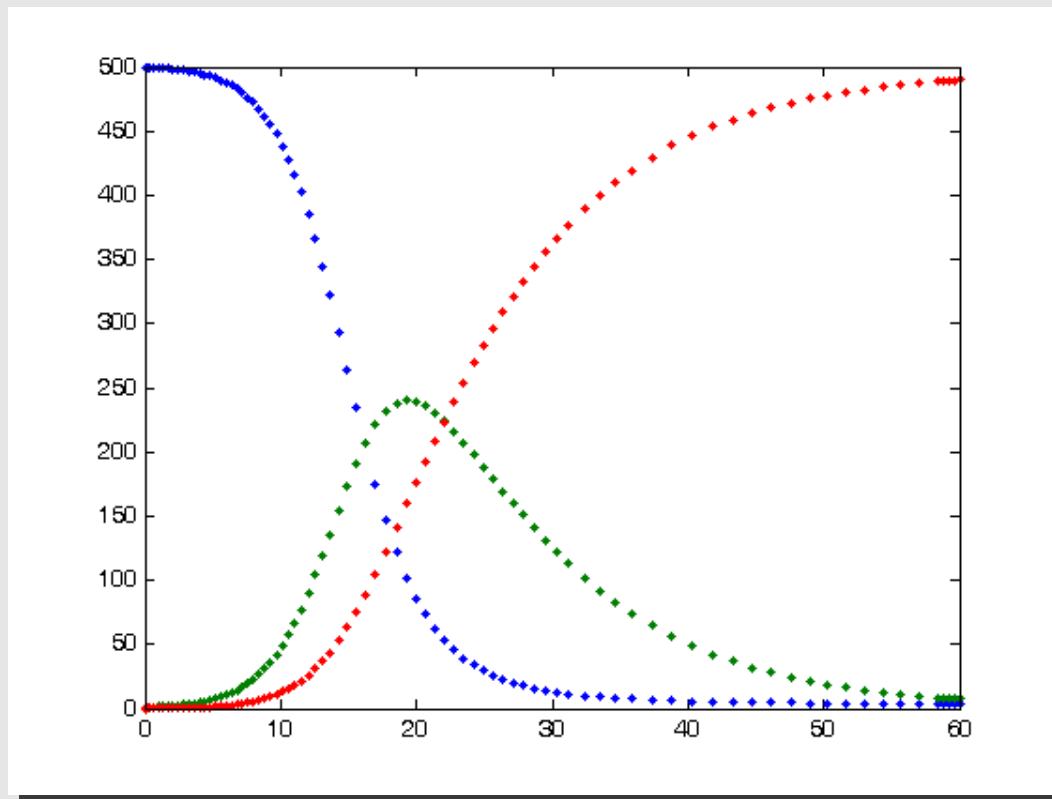
Connect ideas about symbiosis and game theory to disease evolution

Understand natural history of disease

Susceptible

Infectious

Recovered



Virus A	Virus B	Virus C
Kills host in a day	Kills host in a month	Kills host in a year

which disease will increase at the fastest rate?

Virus A	Virus B	Virus C
Kills host in a day	Kills host in a month	Kills host in a year
Each host infects 1 person on average	Each host infects 40 people on average	Each host infects 100 people on average

which disease will increase at the fastest rate?

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Kills host in a day	Kills host in a month	Kills host in a year	which disease will increase at the fastest rate?
Each host infects 1 person on average	Each host infects 40 people on average	Each host infects 100 people on average	
$1/1=1.0$	$40/30 = 1.3$	$100/365 = 0.3$	

Virulence: ability of an organism to cause disease

Virus A	Virus B	Virus C
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$1/1 = 1.0$	$40/30 = 1.3$	$100/365 = 0.3$

Why not just evolve to be less virulent?

Effect on virulence of: Change from horizontal to vertical transmission

HIV horizontal

Unprotected sex



Sharing needles



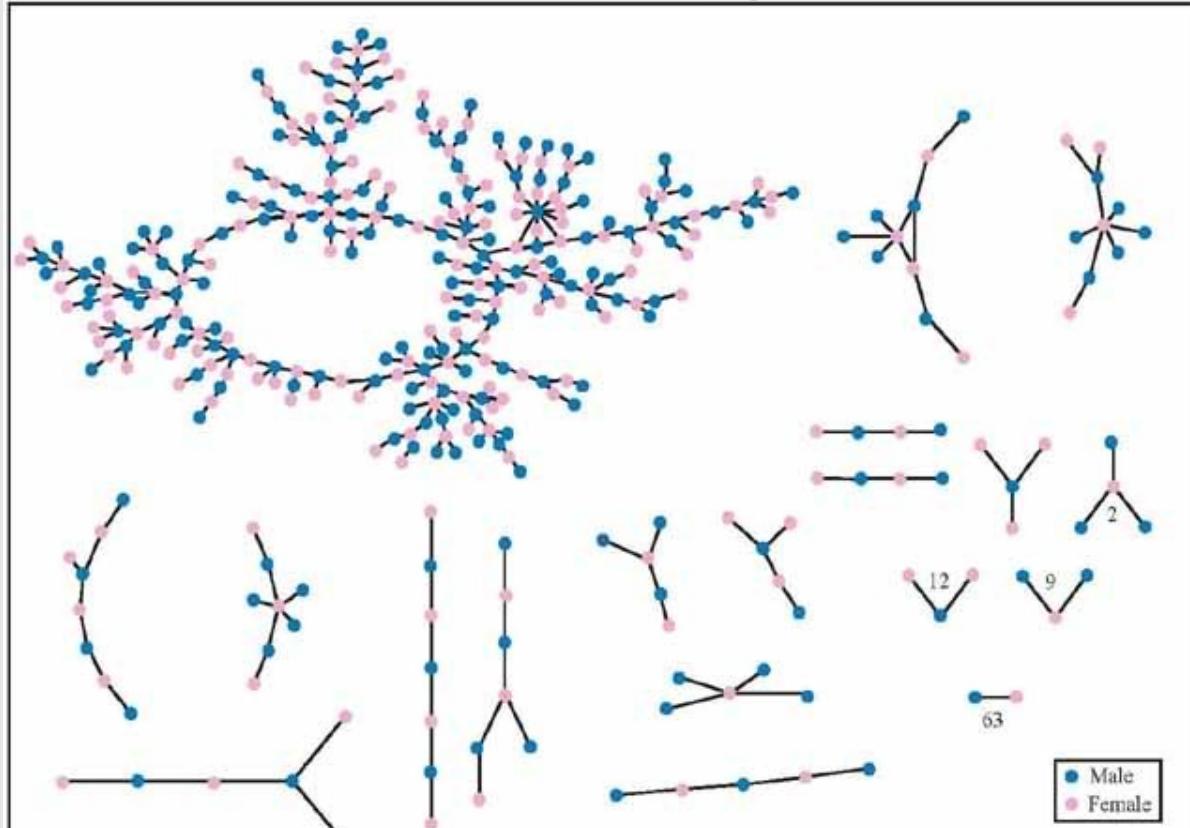
HIV vertical

From parent (typically mother)



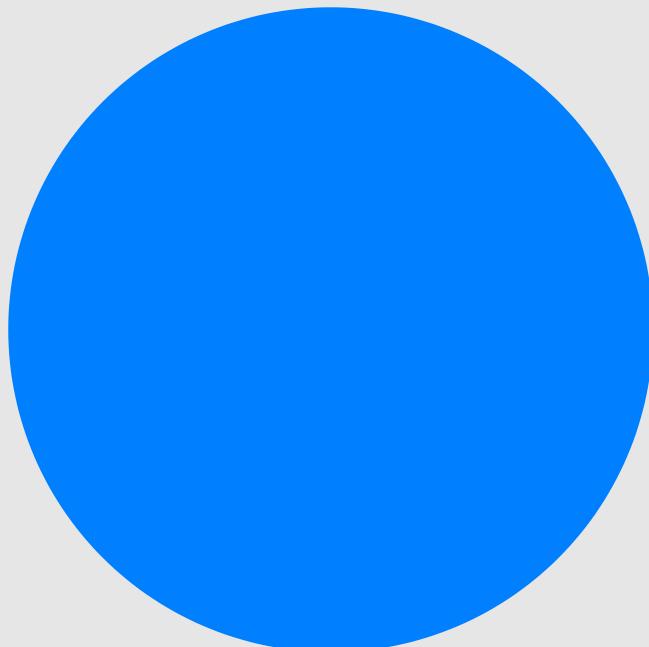
Effect on virulence of: Increased number of sexual partners

The Structure of Romantic and Sexual Relations at "Jefferson High School"

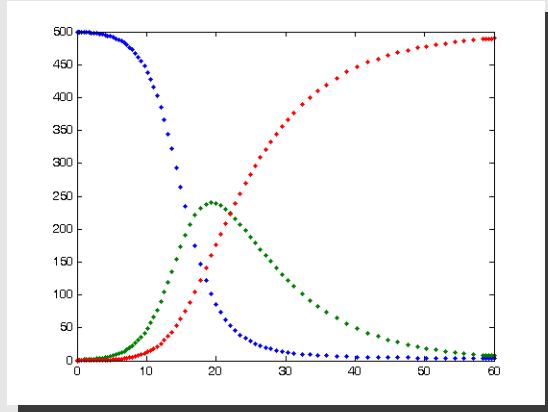
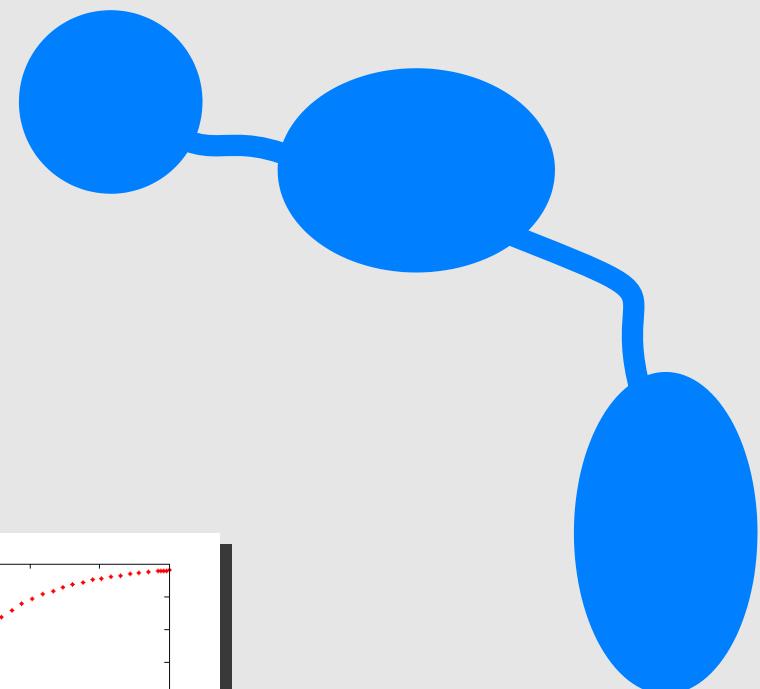


Effect on virulence of: Spatial structure

Unstructured



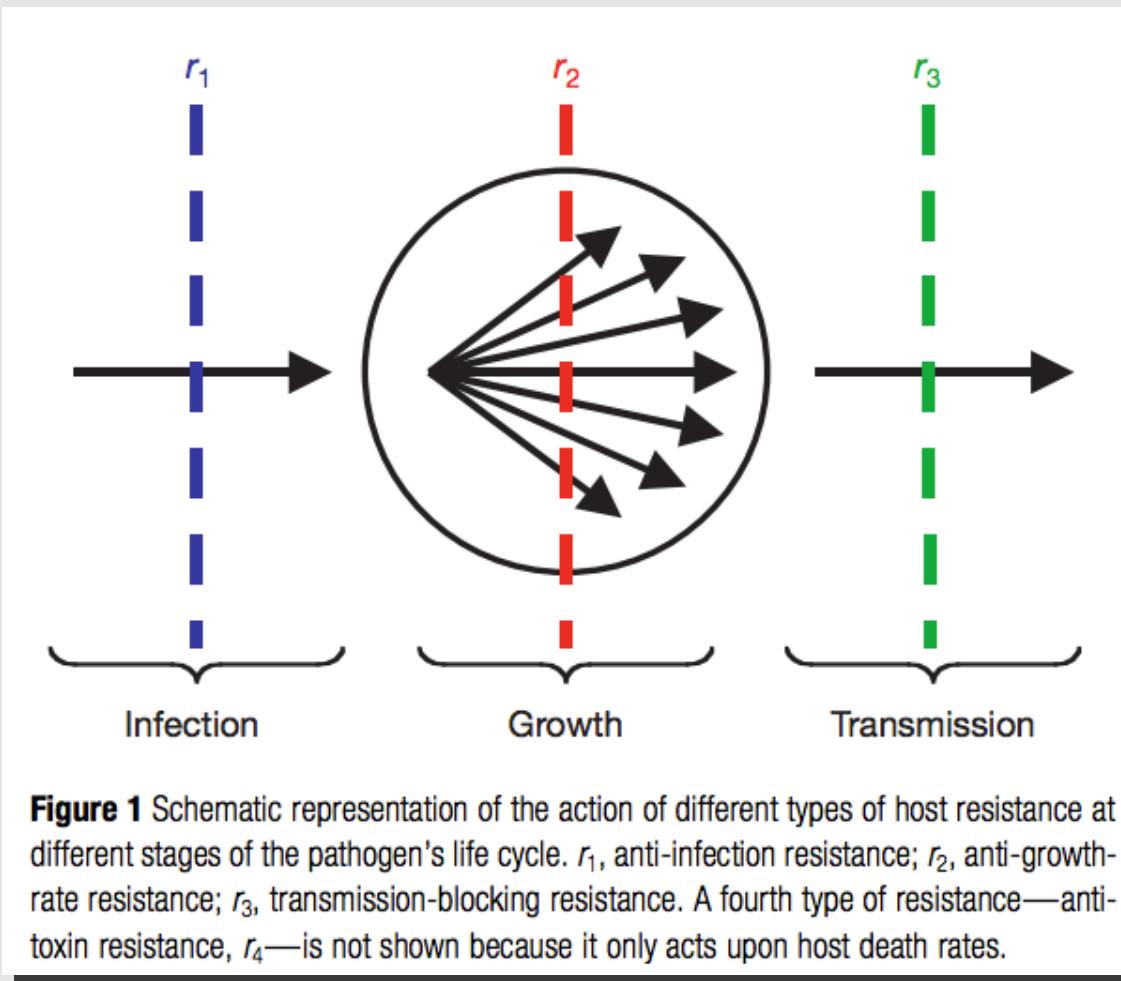
Structured



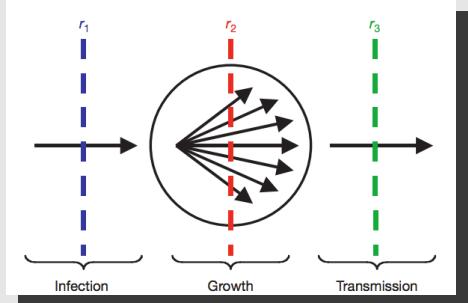
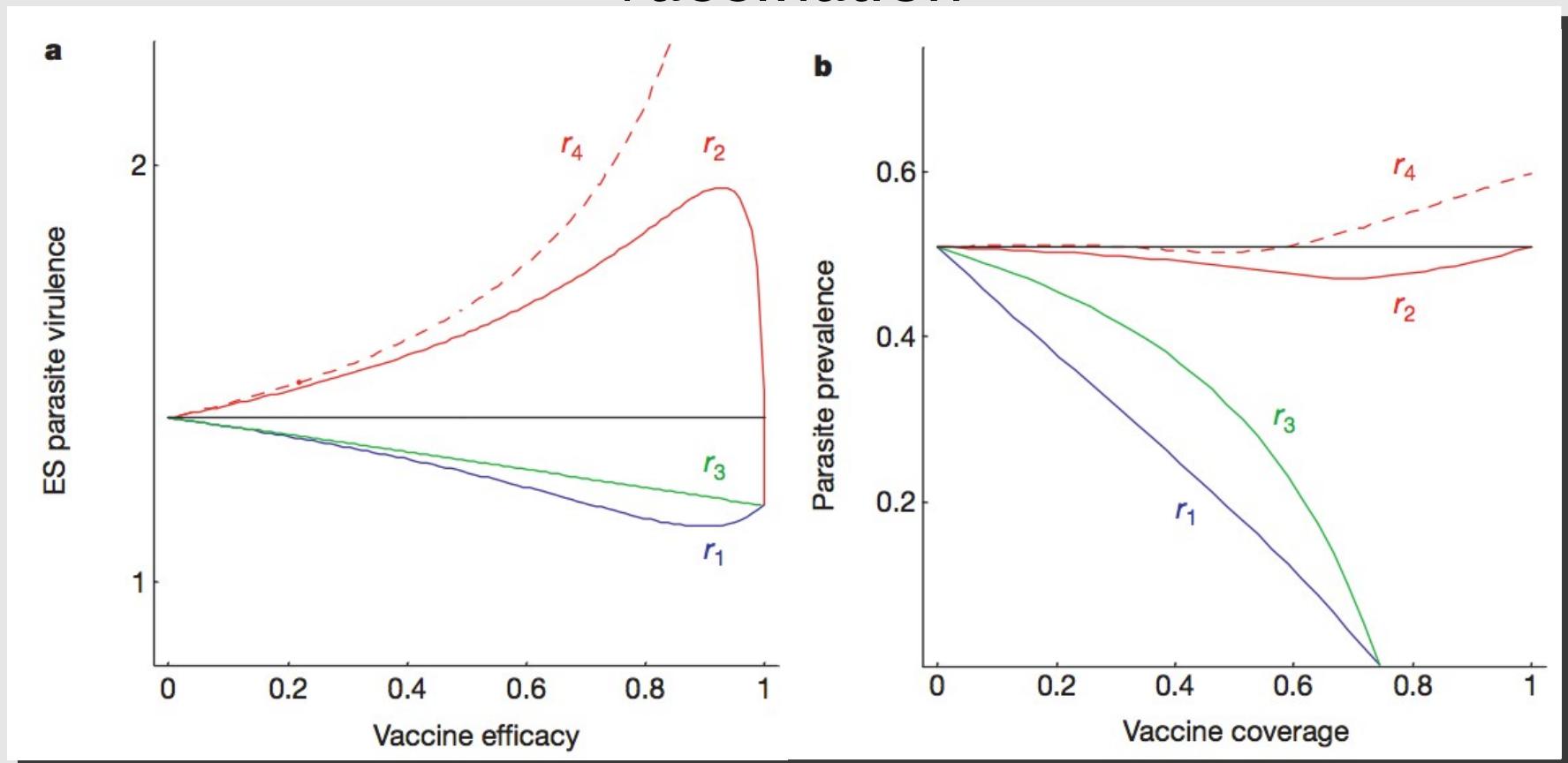
Effect on virulence of: Vaccination



Effect on virulence of: Vaccination

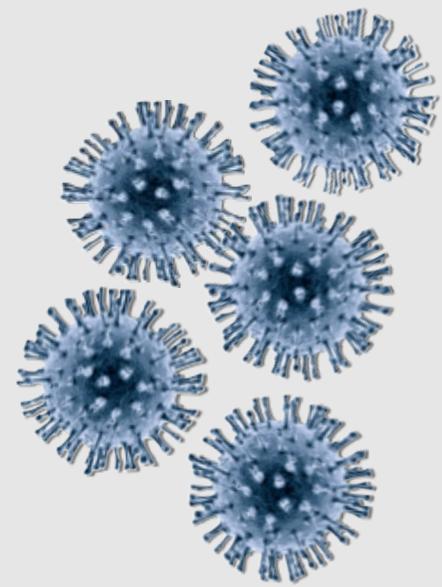
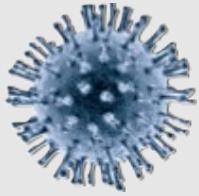


Effect on virulence of: Vaccination



Blue = anti-infection vaccine
 Green = transmission-blocking vaccine
 Red solid = anti-growth rate vaccine (slow parasite growth)
 Red dashed = anti-toxin immunity (make parasite less harmful w/o affecting transmission and growth rates)

Effect on virulence of: Number of innocula



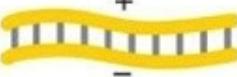
How do we then get pandemics?



<http://www.christinatonges.com>

SUMMARY TABLE 35.2 The Diversity of Viral Genomes

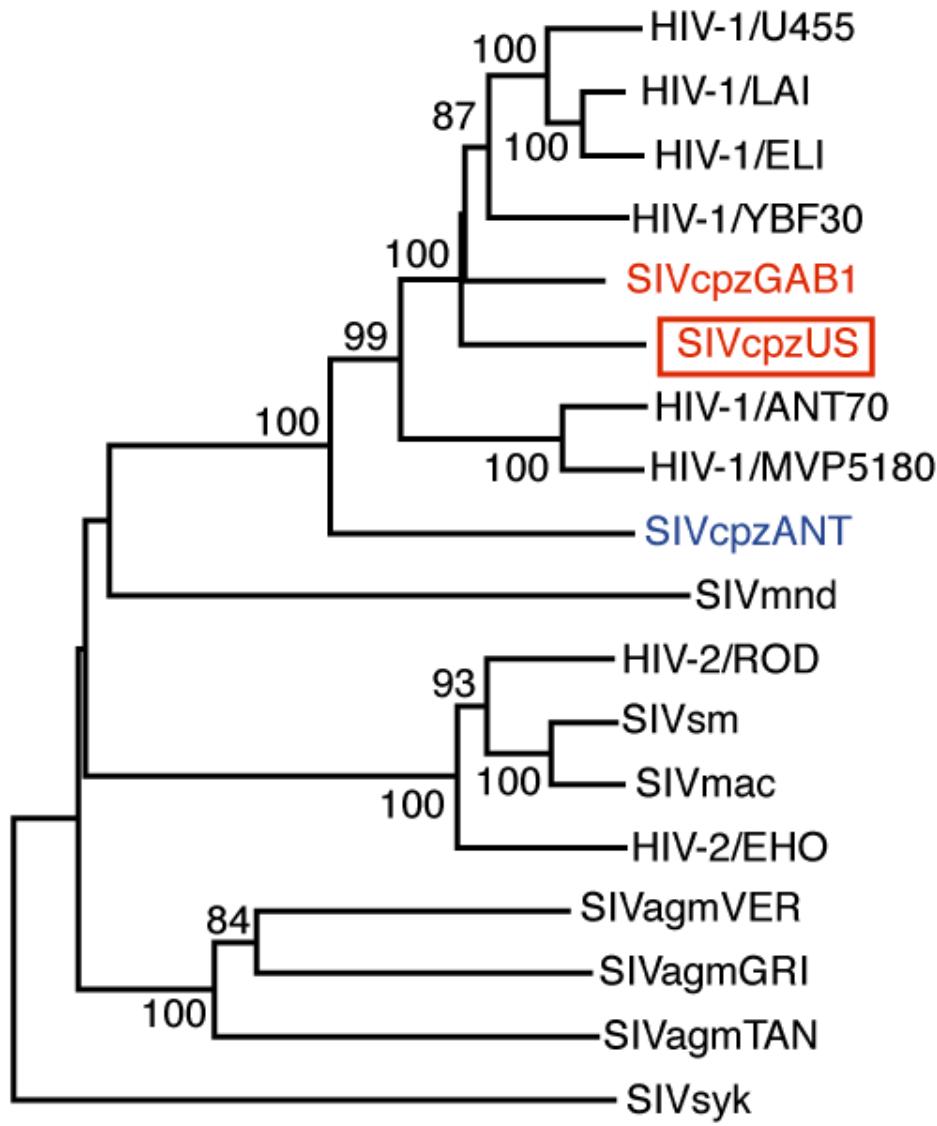
Key: ss = single stranded; ds = double stranded; (+) = positive sense (genome sequence is the same as viral mRNA); (-) = negative sense (genome sequence is complementary to viral mRNA)

Genome	Example(s)	Host	Result of Infection	Notes
(+)-ssRNA		TMV	Tobacco plants	Tobacco mosaic disease (leaf wilting) TMV was the first RNA virus to be discovered.
(-)-ssRNA		Influenza	Many mammal and bird species	Influenza The negative-sense ssRNA viruses transcribe their genomes to mRNA via RNA replicase.
dsRNA		Phytopivirus	Rice, corn, and other crop species	Dwarfing Double-stranded RNA viruses are transmitted from plant to plant by insects. Many can also replicate in their insect hosts.
ssRNA that requires reverse transcription for replication		Rous sarcoma virus	Chickens	Sarcoma (cancer of connective tissue) These are called retroviruses. Rous sarcoma virus was identified as a cancer-causing agent in 1911—decades before any virus was seen.
ssDNA—can be (+), (-), or (+) and (-)		φX174	Bacteria	Death of host cell The genome for φX174 is circular and was the first complete genome ever sequenced.
dsDNA that is replicated through an RNA intermediate		Hepatitis B virus	Humans	Hepatitis These are called “reversiviruses.”
dsDNA that is replicated by DNA polymerase		Baculovirus Smallpox Bacteriophage	Insects Humans Bacteria	Death Smallpox Death These include the largest viruses in terms of genome size and overall size.

Origins of virus

Origins of a particular virus (SARS, HIV, flu)

Origins of viruses as a biological entity

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Origins of viruses as a biological entity

Three hypotheses

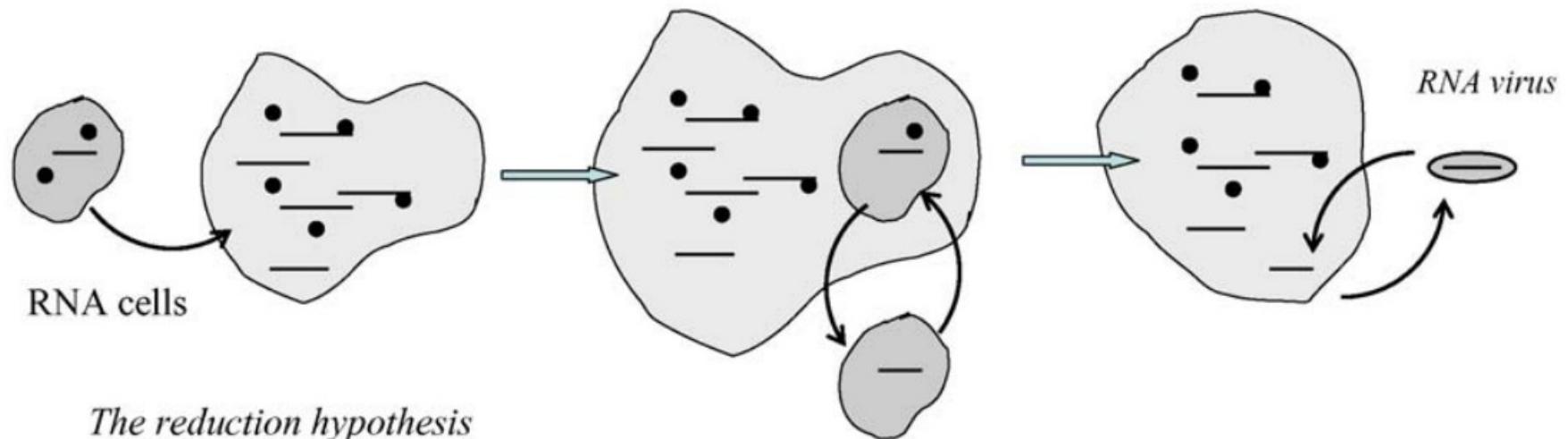
Virus-first

Reduction

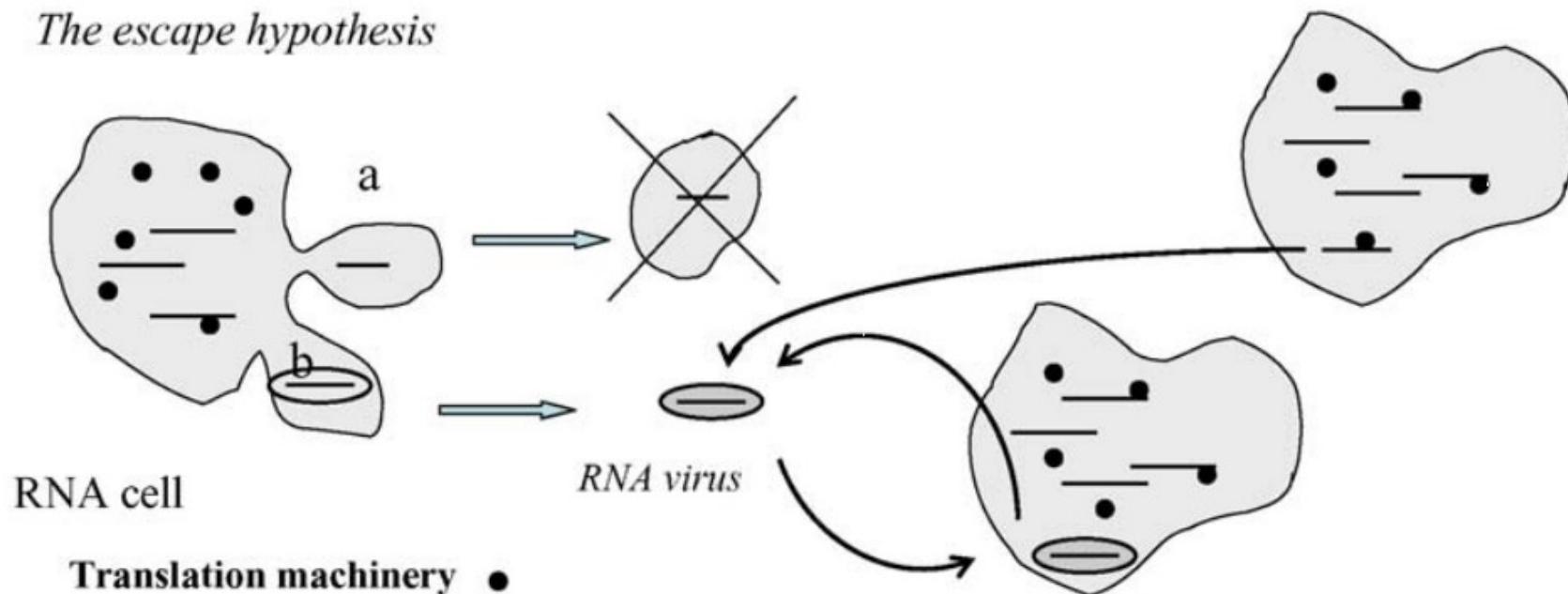
Escape

Virus-first: Viruses evolve, use the prebiotic soup for replication, later parasitize cells

Not favored: requires ribosomes (protein synthesis for coats), other complex structures, need Darwinian evolution for that



The escape hypothesis



Transposons



McGraw-Hill. <https://www.youtube.com/watch?v=uI8BmgqN2YY> (it's less than 2 minutes long. It *feels* longer, but it's worth it.



- Cows (Bovine spongiform encephalopathy, aka “mad cow”)
- Sheep (Scrapie)
- Mink
- Cats
- Deer (chronic wasting disease)
- Humans (kuru; variant Creutzfeldt-Jakob Disease (vCJD))