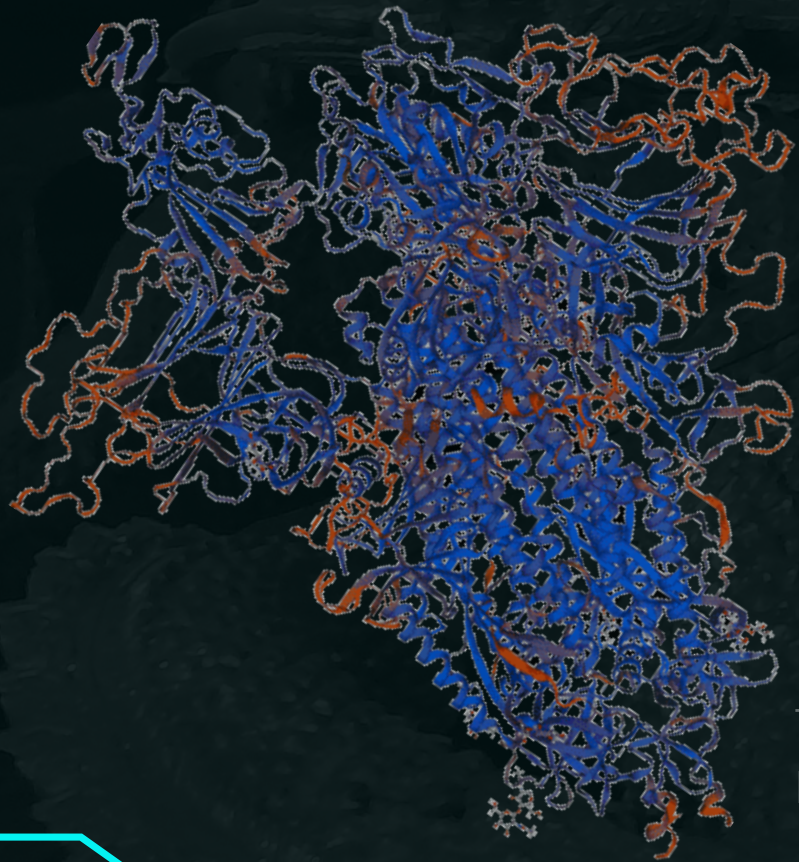


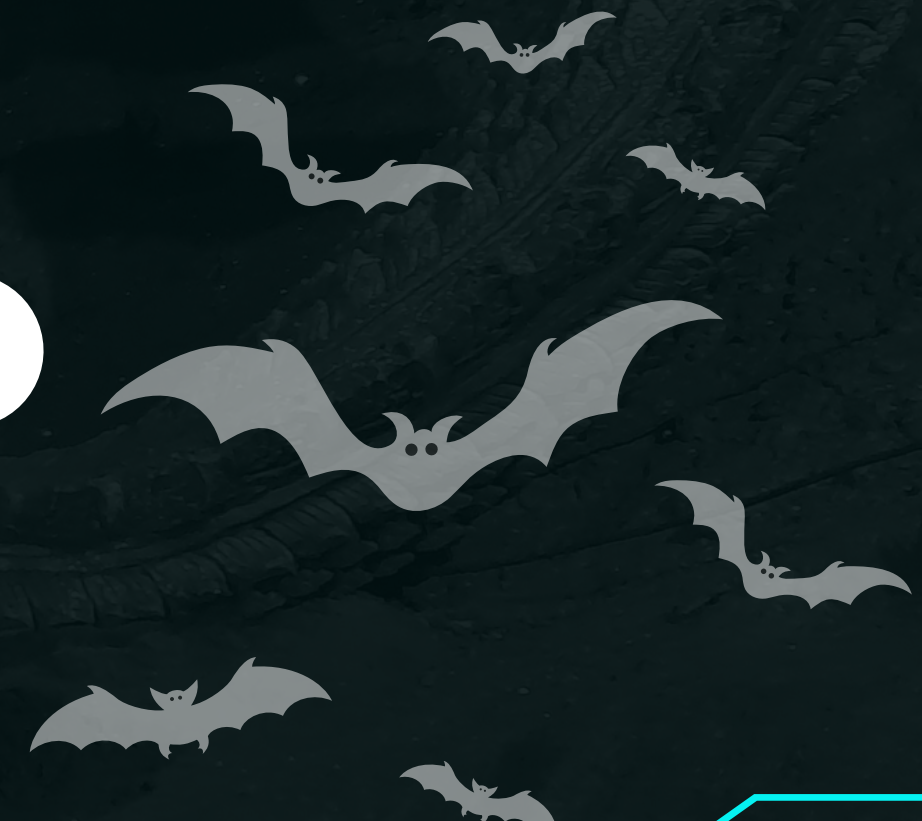
# Viral spread of **information pathogens**: the disputes around the origins of **SARS-CoV-2**



Trimeric Spike  
Protein

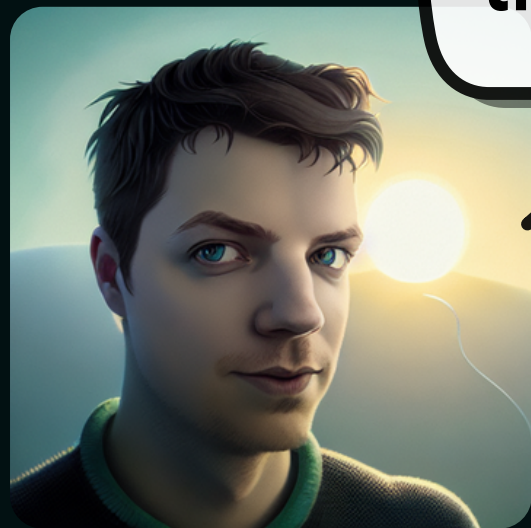
CDTS | COC Seminar, April 3rd 2023

Speaker:  
Philipp Markolin, PhD



# You can follow the presentation online

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Philipp Markolin, PhD

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# Table Of Content



*It is the responsibility of scientists never to suppress knowledge, no matter how awkward that knowledge is, no matter how it may bother those in power; we are not smart enough to decide which pieces of knowledge are permissible and which are not.*

—Carl Sagan

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Where did SARS-CoV-2 come from?

- Competing theories & uncertainties
- Infection Risk: Spillovers & lab leaks
- Genome: Artificial or natural?
- Epicenter: Market versus lab

03

New vulnerabilities and an ecosystem of falsehoods

- Asymmetries of the attention economy
- Discourse manipulators & velocity hackers
- Information pathogens & information cascades

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Concluding remarks



*Who will defend  
embattled scientists?*  
— Peter Hotez



01

# Science under pressure



# 01 Science under pressure

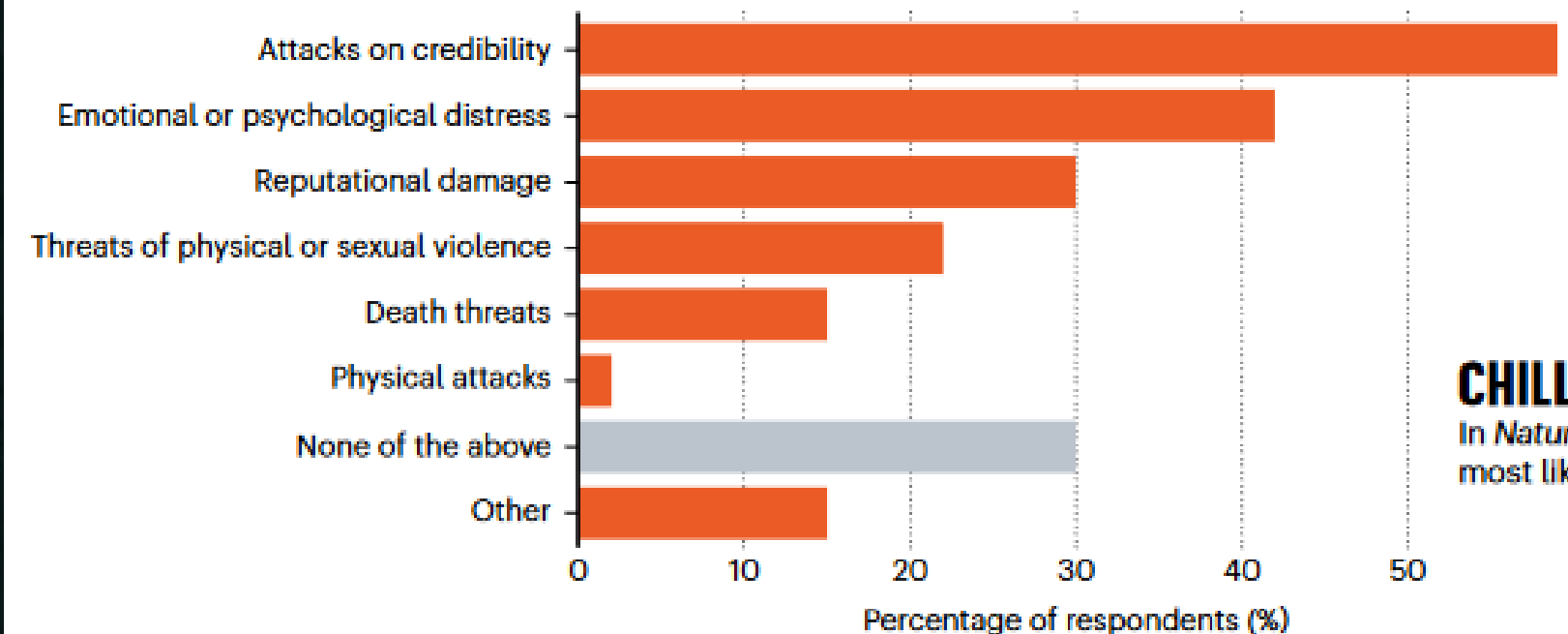
15% of surveyed scientists had received death threats for speaking publicly about Covid-19, almost 60% experienced attacks on their credibility



## NEGATIVE IMPACTS

In a *Nature* survey of scientists who have commented about COVID-19, 15% of 321 respondents said they had received death threats.

Question: Have you experienced any of the following negative impacts after speaking about COVID-19 to the media, or posting on social media? (You may select multiple options.)



AAMCNEWS

## Widespread distrust in science: Is the way we communicate to blame?

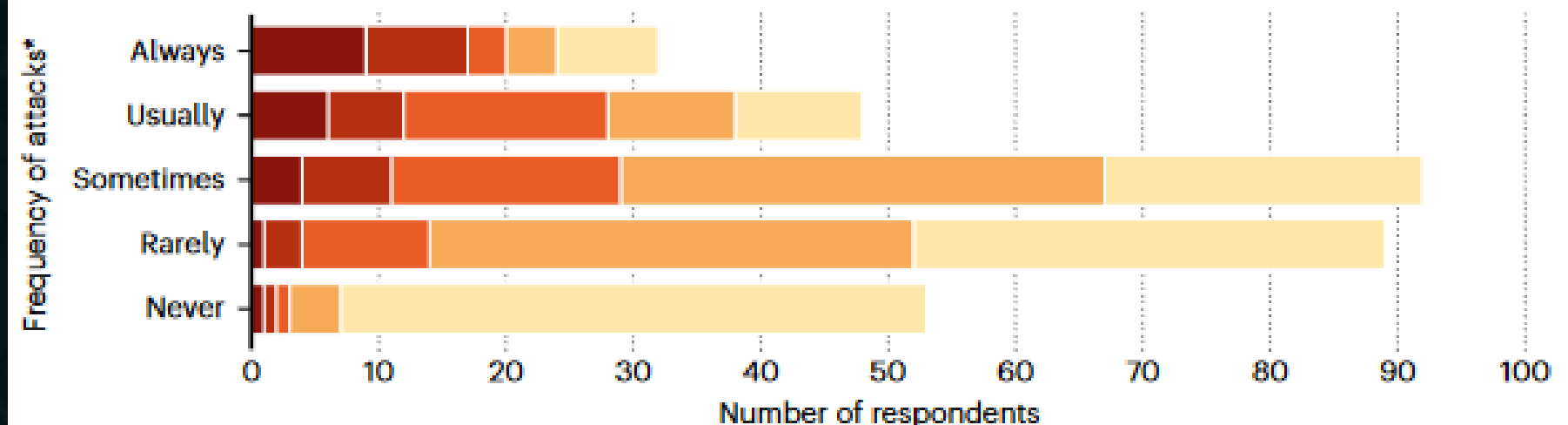
Researchers increasingly find their work misunderstood and misused, as the iterative nature of scientific discovery clashes with an explosion in public access to and interpretation of their work.

## CHILLING EFFECT?

In *Nature's* survey, scientists who reported the highest frequency of trolling or personal attacks\* were also most likely to say that their experiences had greatly affected their readiness to give future media interviews.

Question: How much have your experiences with trolls and personal attacks affected your willingness to speak to the media in the future?

Legend: An enormous amount (dark red), A lot (red), A moderate amount (orange), A little (light orange), Not at all (yellow)



\*Respondents who answered the question: Have you experienced trolling or personal attacks after speaking about COVID-19 in the media?

Perspective | Published: 10 March 2022

## An epidemic of uncertainty: rumors, conspiracy theories and vaccine hesitancy

Ed Pertwee, Clarissa Simas & Heidi J. Larson

*Nature Medicine* 28, 456–459 (2022) | Cite this article

59k Accesses | 49 Citations | 435 Altmetric | Metrics

# The engineered bioweapon theory

*In 2020, conspiracy theories about a manmade bioweapon gained immediate traction*



## Was Coronavirus a Bioweapon? We Don't Know, but History Shows We Can't Trust China

By Michael Rubin

Washington Examiner

February 18, 2020



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TRENDING TRUMP | NASHVILLE SHOOTING

FOX NEWS FLASH · Published February 18, 2020 8:45pm EST

### Sen. Tom Cotton stands by startling theory on coronavirus origins: 'We need to be open to all possibilities'

THEWEEK MAGAZIN

HOME INDIA WORLD BUSINESS SPORTS SCI/TECH LEISURE ENTERTAIN



Research paper by Indian scientists on coronavirus fuels bioweapon theories



### CHINESE VIROLOGIST: THIS VIRUS CAME FROM

· TUCKER CARLSON tonight · #Tucker

Dr. Li-Meng Yan's interview on Tucker Carlson's show in September racked up at least 8.8 million views online. Facebook and Instagram flagged it as false information. Fox News

# Viral spread of the lab accident theory

*By spring-summer of 2021, the lab leak theory went mainstream*



**The Washington Post**  
*Democracy Dies in Darkness*

MEDIA

## The media called the ‘lab leak’ story a ‘conspiracy theory.’ Now it’s prompted corrections – and serious new reporting.

By [Paul Farhi](#) and [Jeremy Barr](#)  
June 10, 2021 at 11:10 a.m. EDT

**CNN** politics

## Senior Biden officials finding that Covid lab leak theory as credible as natural origins explanation

By [Natasha Bertrand](#), [Pamela Brown](#), [Katie Bo Williams](#) and [Zachary Cohen](#), CNN  
Published 6:18 PM EDT, Fri July 16, 2021


**VANITY FAIR**

## The Lab-Leak Theory: Inside the Fight to Uncover COVID-19’s Origins

Throughout 2020, the notion that the novel coronavirus leaked from a lab was off-limits. Those who dared to push for transparency say toxic politics and hidden agendas kept us in the dark.

## The origin of COVID: Did people or nature open Pandora’s box at Wuhan?

By Nicholas Wade | May 5, 2021



**Nicholas Wade**  
Nicholas Wade is a science writer, editor, and author who has worked on the staff of *Nature*, *Science*, and, for many years, the *New York Times*....  
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**Bulletin of the Atomic Scientists**

## Investigate the origins of COVID-19

[JESSE D. BLOOM](#), [YUJIA ALINA CHAN](#), [RALPH S. BARIC](#), [PAMELA J. BJORKMAN](#), [SARAH COBEY](#), [BENJAMIN E. DEVERMAN](#), [DAVID N. FISMAN](#), [RAVINDRA GUPTA](#), [AKIKO IWASAKI](#), [MARC LIPSITCH](#), [RUSLAN MEDZHITOV](#), [RICHARD A. NEHER](#), [RASMUS NIELSEN](#), [NICK PATTERSON](#), [TIM STEARNS](#), [ERIK VAN NIMWEGEN](#), [MICHAEL WOROBEY](#), AND [DAVID A. RELMAN](#)

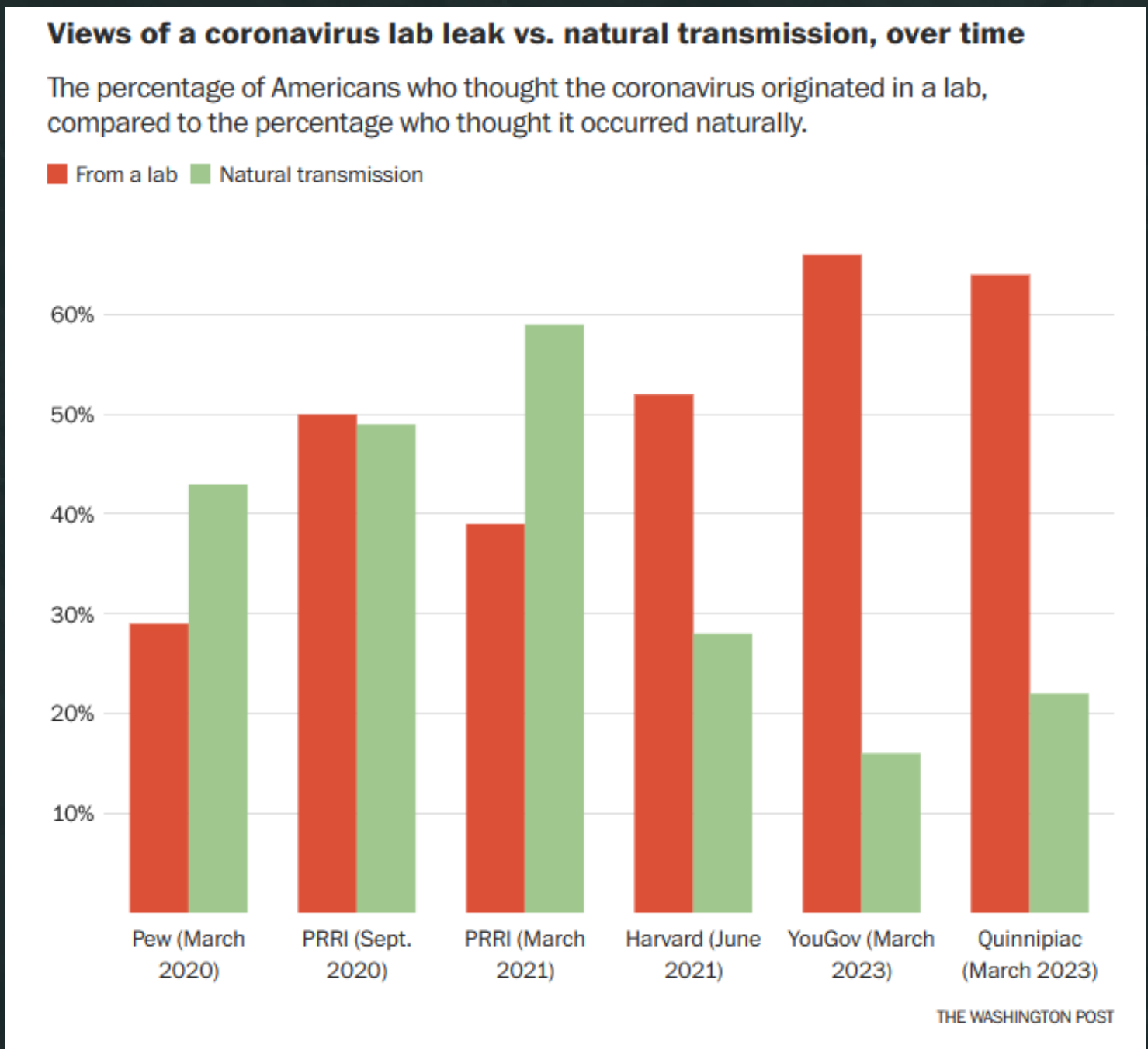
[fewer](#) [Authors Info & Affiliations](#)

**Science**

SCIENCE • 14 May 2021 • Vol 372, Issue 6543 • p. 694 • DOI: 10.1126/science.abj0016

# A contagious topic: Covid-19 origins

Recent pools find that 68% of Likely U.S. voters think it's likely that the COVID-19 virus originated in a Chinese laboratory, including 48% who say it's Very Likely



The Washington Post  
*Democracy Dies in Darkness*

## How the covid lab leak became the American public's predominant theory

Analysis by [Aaron Blake](#)  
Staff writer

March 16, 2023 at 3:33 p.m. EDT

News | Coronavirus pandemic



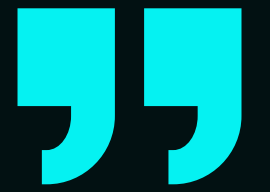
## Reports on COVID origin reignite conspiracy theories about virus

*FBI director, US Department of Energy say the coronavirus originated in a lab, but other US officials say there's no consensus.*



# A growing rift between science & society

Most virologists believe that SARS-CoV-2 emerged via *zoonotic spillover*. Can they be trusted?



Transmission electron micrograph of SARS-CoV-2 virus particles. Photo: Universal Images Group via Getty Images

BECOME A MEMBER

## LEAKED GRANT PROPOSAL DETAILS HIGH-RISK CORONAVIRUS RESEARCH

The proposal, rejected by U.S. military research describes the insertion of human-specific cleavage sites into SARS-related bat coronaviruses.

Sharon Lerner, Maia Hibbett  
September 23 2021, 8:16 p.m.

Bulletin of the Atomic Scientists

Doomsday Clock | Nuclear Risk | Climate Change | Disruptive Technologies | Biosecurity | Support Our Work



## The origin of COVID: Did people or nature open Pandora's box at Wuhan?

By Nicholas Wade | May 5, 2021



**Nicholas Wade**  
Nicholas Wade is a science writer, editor, and author who has worked on the staff of *Nature*, *Science*, and, for many years, the *New York Times*...

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## COVID-19 Origins: Investigating a "Complex and Grave Situation" Inside a Wuhan Lab

The Wuhan lab at the center of suspicions about the pandemic's onset was far more troubled than known, documents unearthed by a Senate team reveal. Tracing the evidence, Vanity Fair and ProPublica give the clearest view yet of a biocomplex in crisis.

## "This Shouldn't Happen": Inside the Virus-Hunting Nonprofit at the Center of the Lab-Leak Controversy

THE WALL STREET JOURNAL

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WSJ NEWS EXCLUSIVE | NATIONAL SECURITY

## Lab Leak Most Likely Origin of Covid-19 Pandemic, Energy Department Now Says

U.S. agency's revised assessment is based on new intelligence

*We live in a society  
exquisitely dependent on  
science and technology,  
in which hardly anyone  
knows anything about  
science and technology.*  
—Carl Sagan



# 02

Where did **SARS-CoV-2**  
come from?



# 02 Where did SARS-CoV-2 come from?

*Everybody loses by operating with bad definitions*



There are multiple theories subsumed under "zoonosis" vs "lab leak"

## Non-research related

- zoonotic spillover via intermediate host (susceptible animal) at a wildlife market in the city of Wuhan
- direct zoonotic spillover from animal reservoir (rhinolophus bats) or intermediate host (susceptible animal) in remote area and brought to Wuhan by animal handlers, smugglers, traders, tourists etc.

## Research related

- deliberate release or accidental leak of a secret bioweapon
- risky GoF research & accidental infection of a lab worker
- standard viral culture or serial passaging & accidental containment breach
- unnoticed infection during field research & brought to Wuhan

# 02 Where did SARS-CoV-2 come from?

*Everybody loses by operating with bad definitions*



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market emergence

heated-up or engineered virus

natural virus brought into lab



## Research related

~~grifters & nutjobs~~

- ~~deliberate release or accidental leak of a secret bioweapon~~

- risky GoF research & accidental infection of a lab worker

- standard viral isolation & culture or serial passaging & accidental containment breach

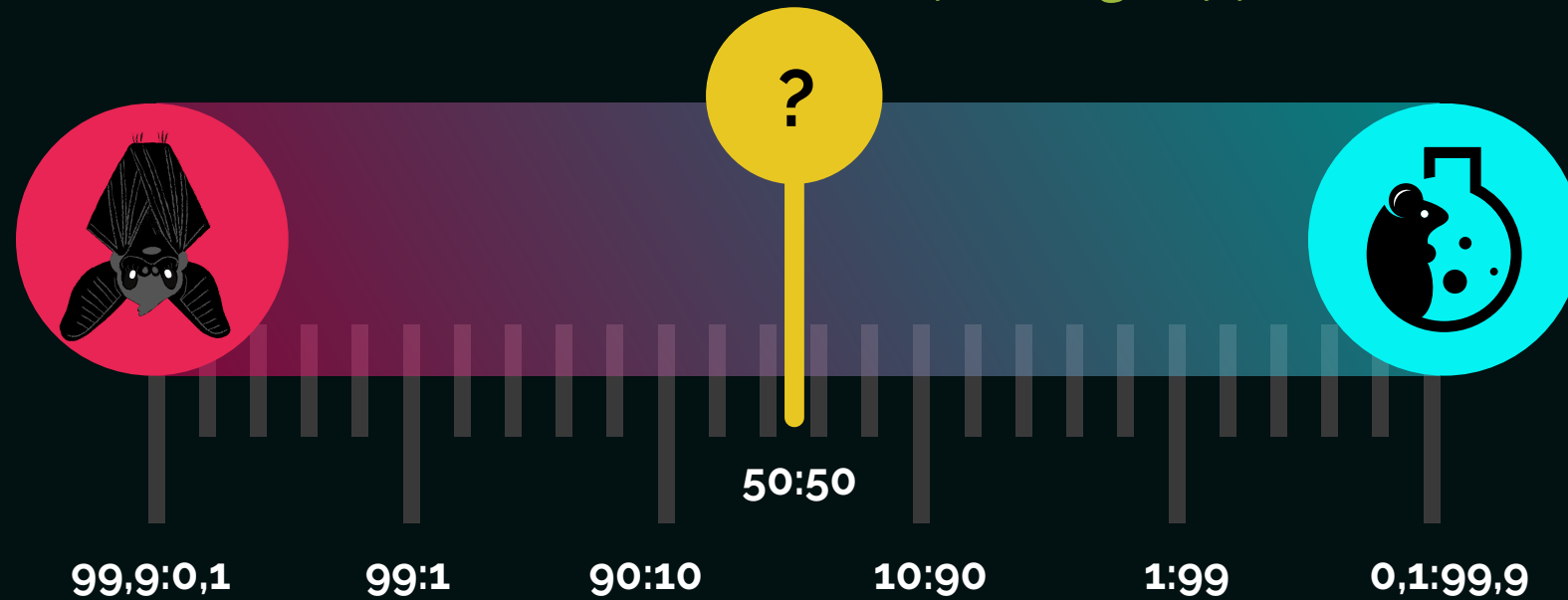
- unnoticed infection during field research & brought to Wuhan

# How can evidence reduce uncertainty?



*In the absence of clear scientific proof, or direct and compelling evidence, scientists use a Bayesian probability framework to assess the **likelihood of competing hypotheses**.*

How well does my hypothesis explain (all!) the relevant data compared to competing hypotheses?



*One might describe science as a Bayesian effort that tries to **approximate what is most likely 'true/real'** given the current evidence while **updating when new evidence comes in***

## Question A

What are the a priori likelihoods of zoonotic spillover from an animal reservoir vs. a lab leak causing **human infection**?

## Question B

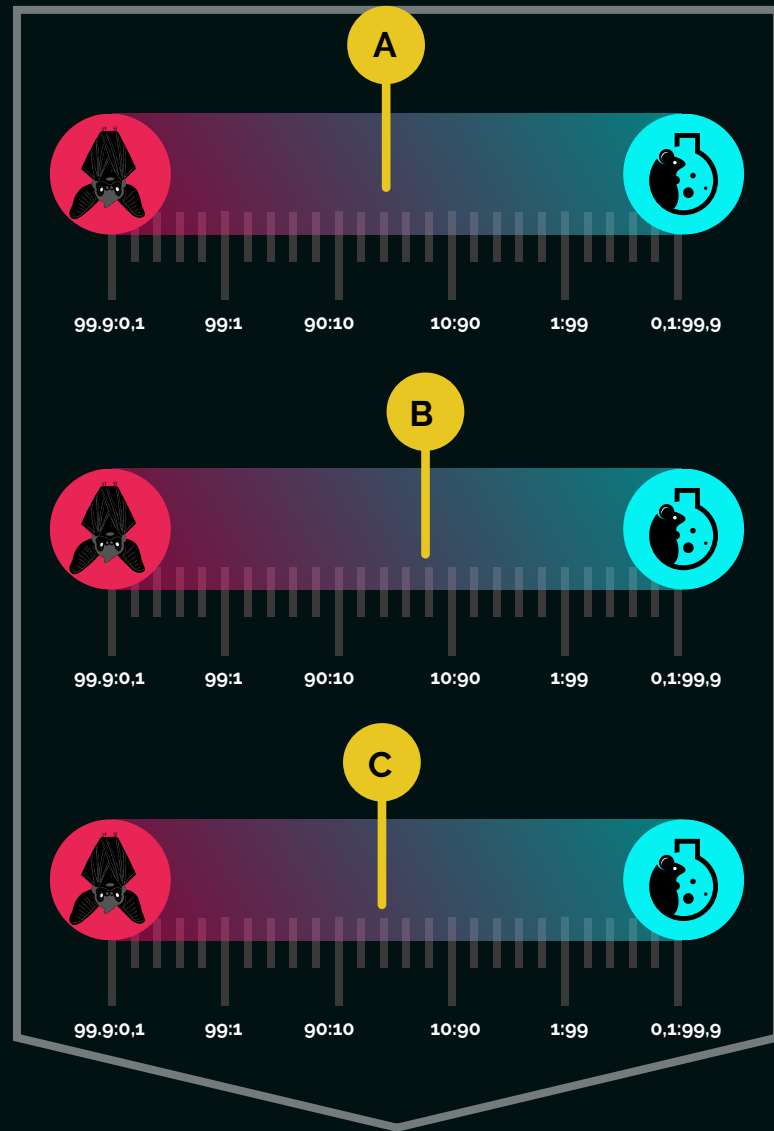
What are the likelihoods that the **genetic sequences found in the viral genome** of SARS-CoV-2 could arise in nature vs. culture or engineering in a lab?

## Question C

What are the likelihoods of a **SARS-related virus to start a pandemic at a wildlife market in Wuhan** (a city that also houses a CoV research lab) compared to all other places in the world?

# As evidence accumulates, uncertainties shrink

## Knowledge & evidence base in Jan 2020



*"I had never expected this kind of thing to happen in Wuhan, in central China. Could they have come from our lab?"*

*--- Zheng-Li Shi's first thoughts, December 30, 2019*

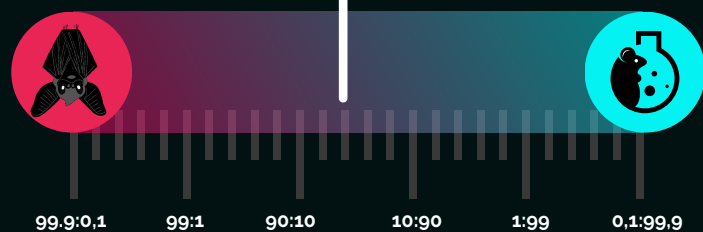
*"He said there's this furin cleavage site between the S1 and S2 junctions," ... "There are two restriction sites, BamHI, around it. And that section, between the restriction sites, looks like it has reduced variation."*

*--- Edward Holmes about K.G Andersen observations, January 31, 2020*

*"[...] this series of coincidences, what you know of the lab in Wuhan, how much could be in nature – accidental release or natural event? I am 70:30 or 60:40."*

*--- Jeremy Farrar to Anthony Fauci, February 2, 2020*

Uncertainty: 



# How common do humans get infected through lab leaks?

## Labs

Lab-acquired infections occur frequently, most with bacteria [*Brucella*, *meningococcus*] or when handling blood [*Hepatitis*, *HIV*] (**Singh K, OUP Public Health Colleciton, 2009**) Infections from high biosafety labs with potential pandemic pathogens (incl. bacteria) happen rarely (220 infections in last 35 years) (**Wurtz et al., Eur J Clin Micro Inf, 2016**) No epidemic has ever been caused by the leak of a novel virus (**Holmes et al., Cell, 2021**)

*It is dubious whether an uncharacterized virus would ever serve as the basis for genetic engineering.*

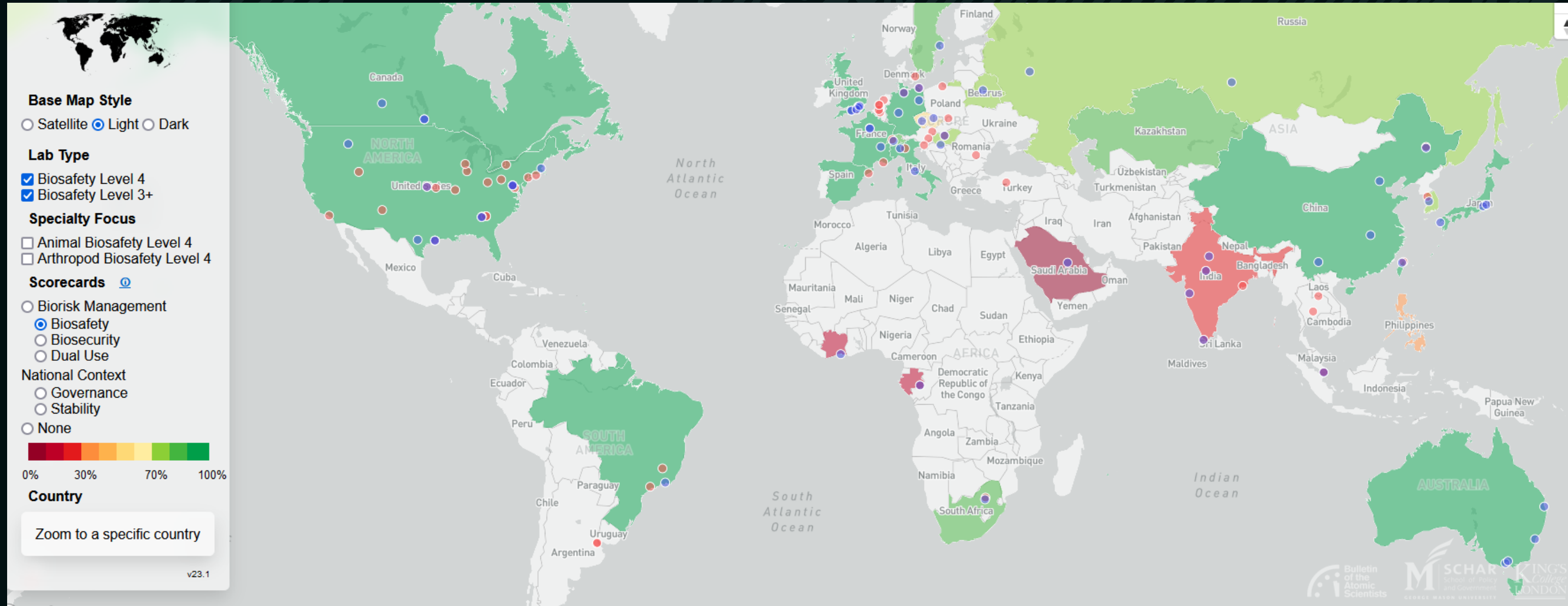
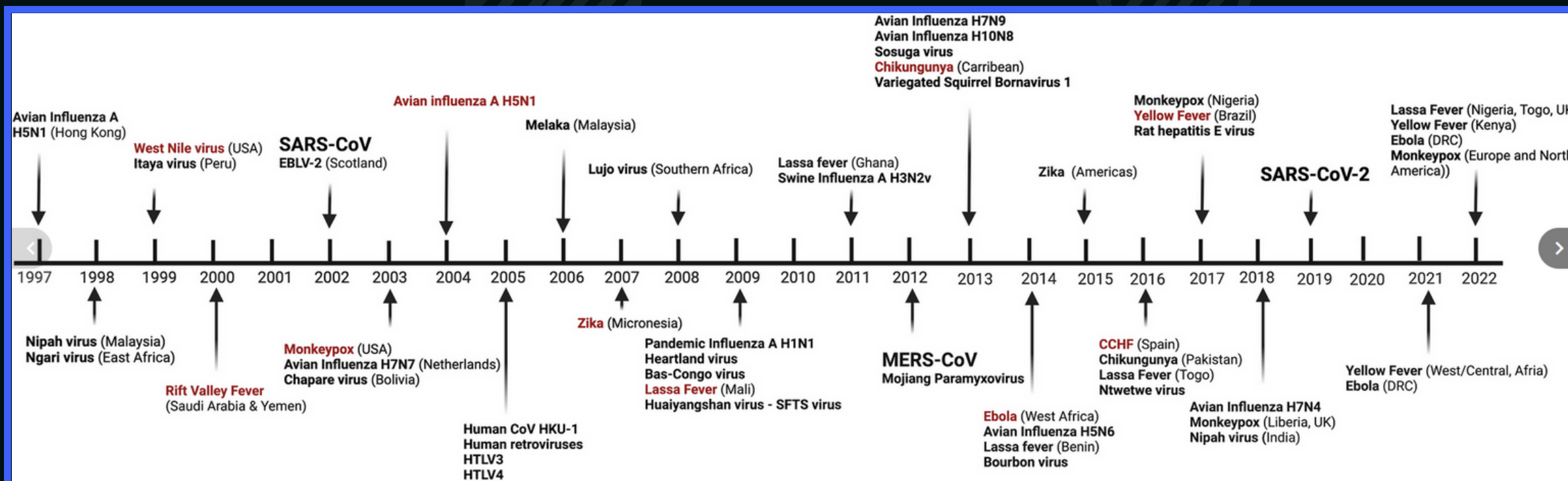


Figure: <https://www.globalbiolabs.org/map>, as of March 2023

# Have unknown CoVs entered humans civilization before?

## History

Zoonotic coronaviruses are common and have caused pandemics before (**Cui et al., Nature Reviews Microbiology, 2018**). SC2 shows many parallels to SARS-1 outbreak, including wildlife trade, time of year and Hubei farms link (**Shi et al., Virus Research, 2007**). All previous pandemics with an unknown pathogen were caused by zoonotic spillovers, which are common and present danger (**Keusch et al, PNAS, 2022**)



Keusch et al, PNAS, 2022

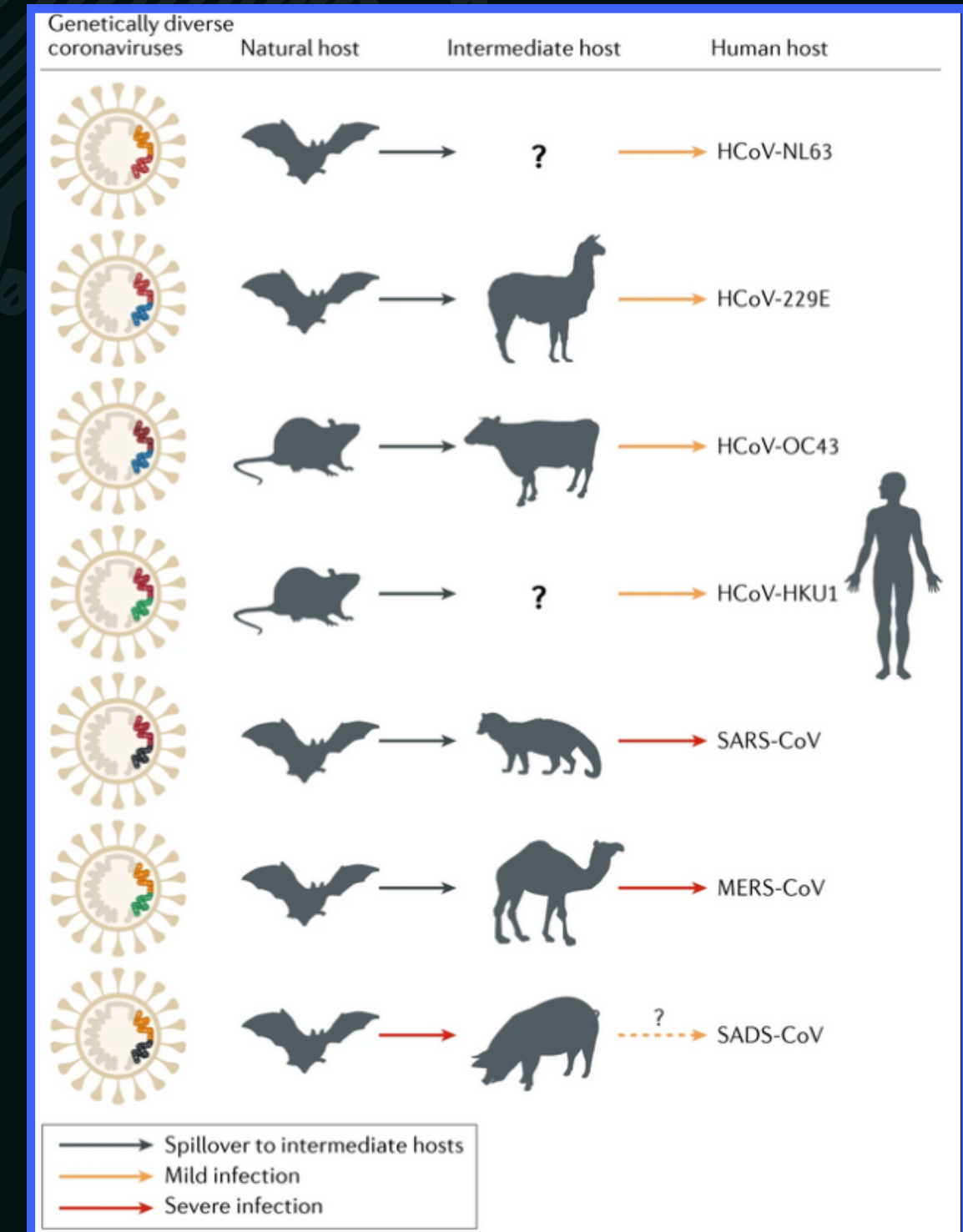


Figure: Cui et al., Nature reviews microbiology, 2022



# How diverse and widespread are SARS-related CoVs and how often do they spill over?

## Hotspots

Bats & other animals carrying SC2r viruses have a wide range and are found in China (Zhou et al, Cell, 2021), Laos, Thailand (Wacharapluesadee et al, Nature communications, 2021) and other countries in South East Asia. Models suggest >60.000 CoV spillovers per year (Sanchez et al, Nature Communication, 2021). Animal handlers have high immunity against unknown Sarbecoviruses (Evans et al, ISID, 2023)

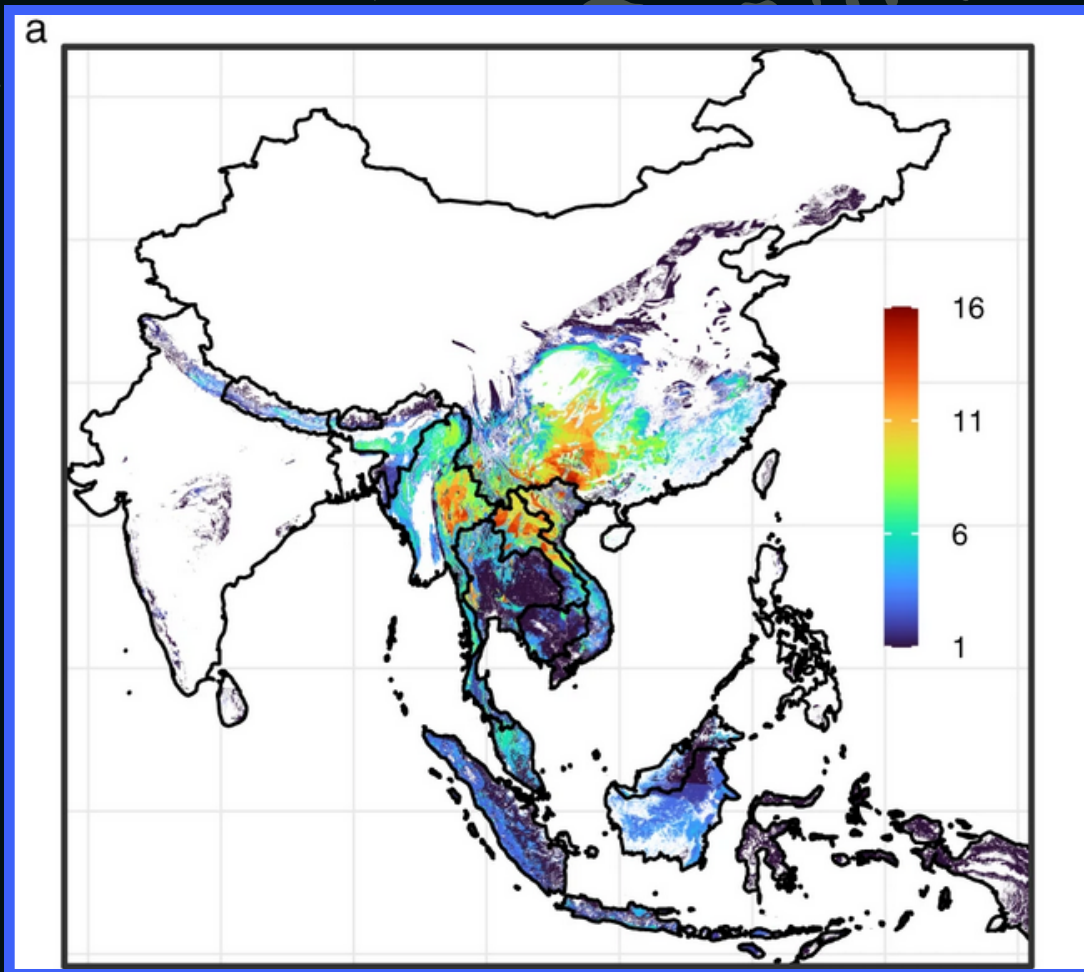


Figure: Sanchez et al., Nature communication, 2021

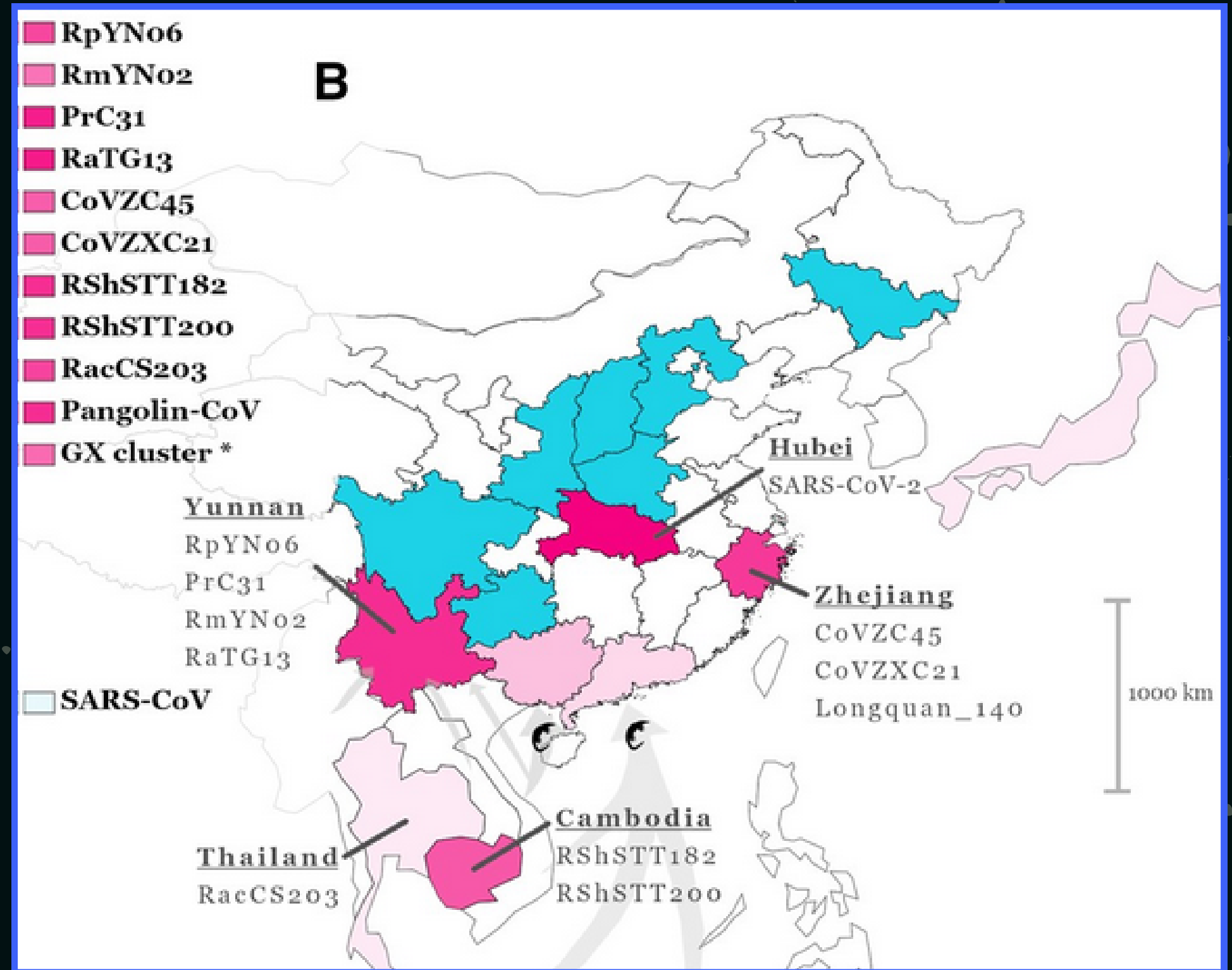


Figure: Lytras et al., Genome Biology & Evolution, 2022

# Conclusion Question A

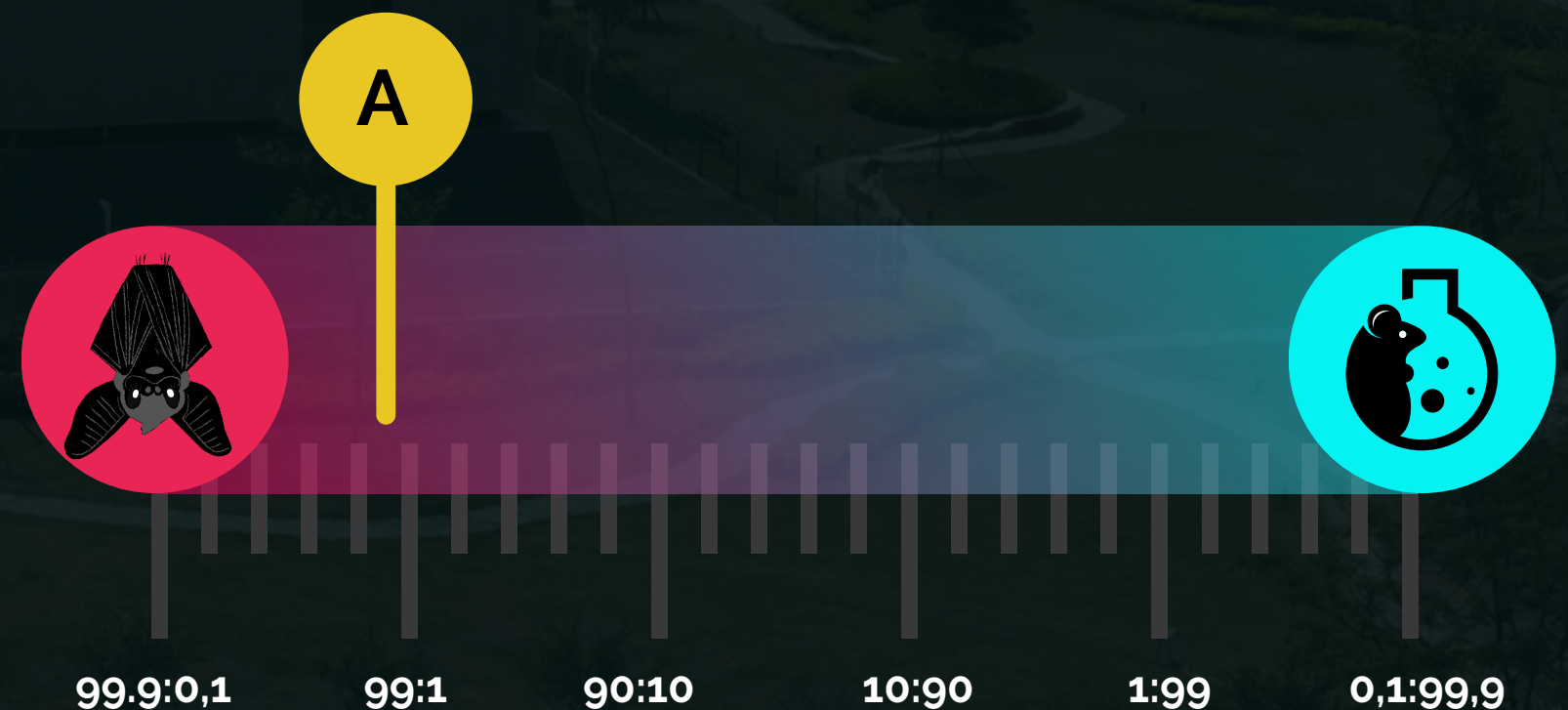
## Summary

- Research activities involving dangerous pathogens can lead to accidental infections or 'leaks' of that pathogen
- lab leaks first require that the labs are in possession of that pathogen
- All previous human-infecting CoVs have had a zoonotic origin, from SARS to MERS & including the four endemic HCoV strains
- Putting the estimates from bat numbers, geographic range, serological surveys, and human encounters together shines a devastating light on the vast opportunities for zoonosis we offer these viruses

*BUT: This only matters if there is no additional info & if SARS-CoV-2 is indeed a natural virus...*



A priori, the first infections with a novel CoV are orders of magnitude less likely to occur inside than outside of labs



# Was the viral genome 'backbone' created?

## Recombination

The genome of SARS-CoV-2 is like a jigsaw puzzle with 27 pieces. All elements of its genome are found in nature (Zhou et al., Cell, 2021 & Temman et al., Nature, 2022) and the virus could have only come about through recombination in nature (on top of normal evolution & selection mechanism) (Lytras et al., Genome Biol Evol. 2022)

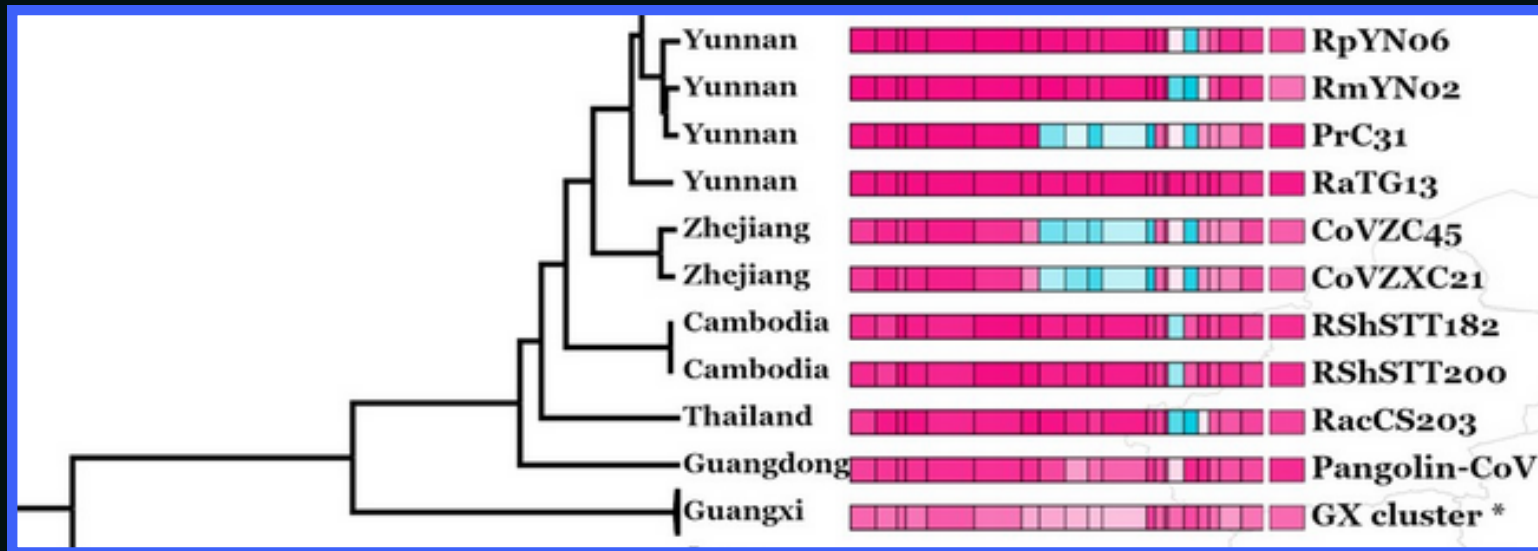


Figure: Lytras et al., Genome Biology & Evolution, 2022

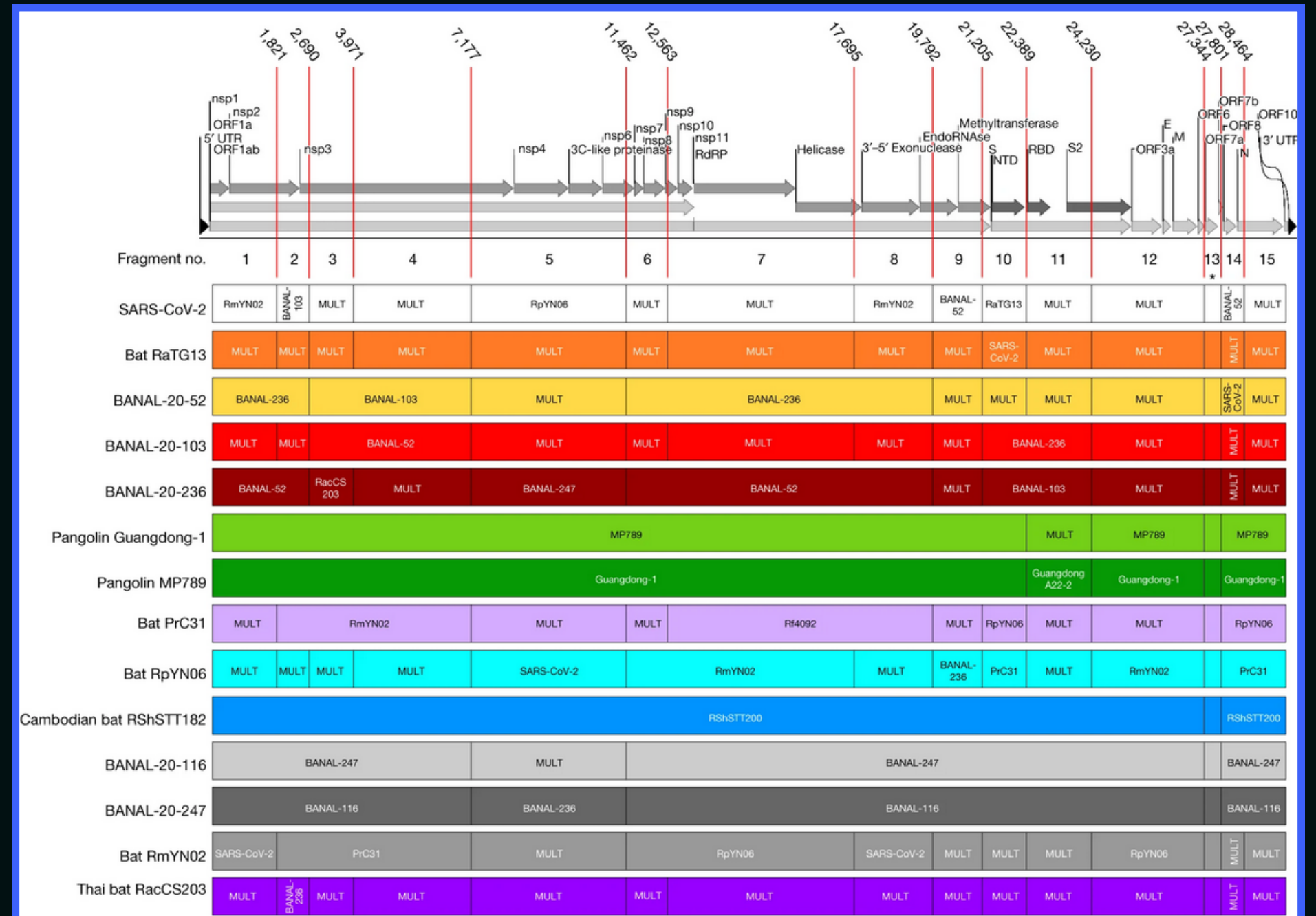


Figure: Temman et al., Nature, 2022

# Was the receptor-binding domain (RBD) optimized for human ACE2?

## RBD binding

SC2 uses different amino acids to bind to hACE2 than SARS-1, but the same AA interactions have been found in CoVs from pangolins and in bats in Laos (Andersen et al., Nature medicine, 2020 & Temman et al., Nature, 2022) The RBD has seen significant changes and adaptations in human populations over time, it is also a generalist virus (see for example: Otto et al., Current Biology, 2021 or Holmes et al., Cell, 2021, ...)

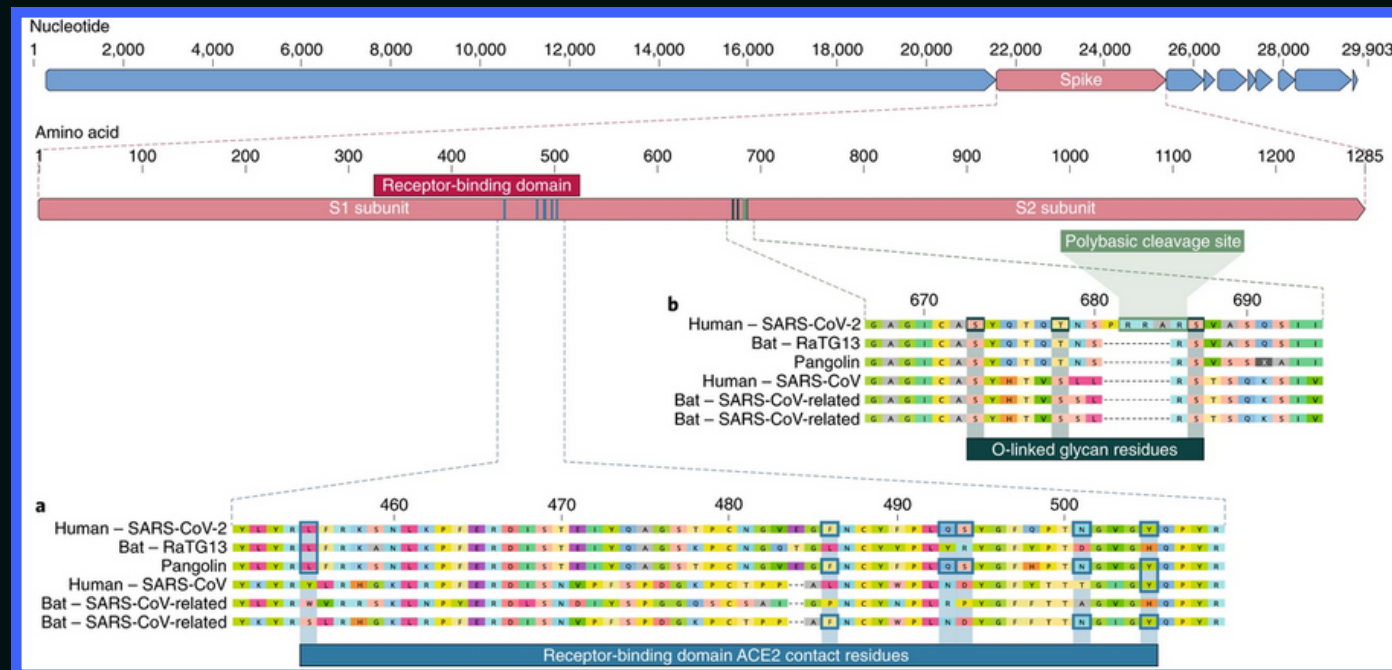


Figure: Andersen et al., Nature Medicine, 2020

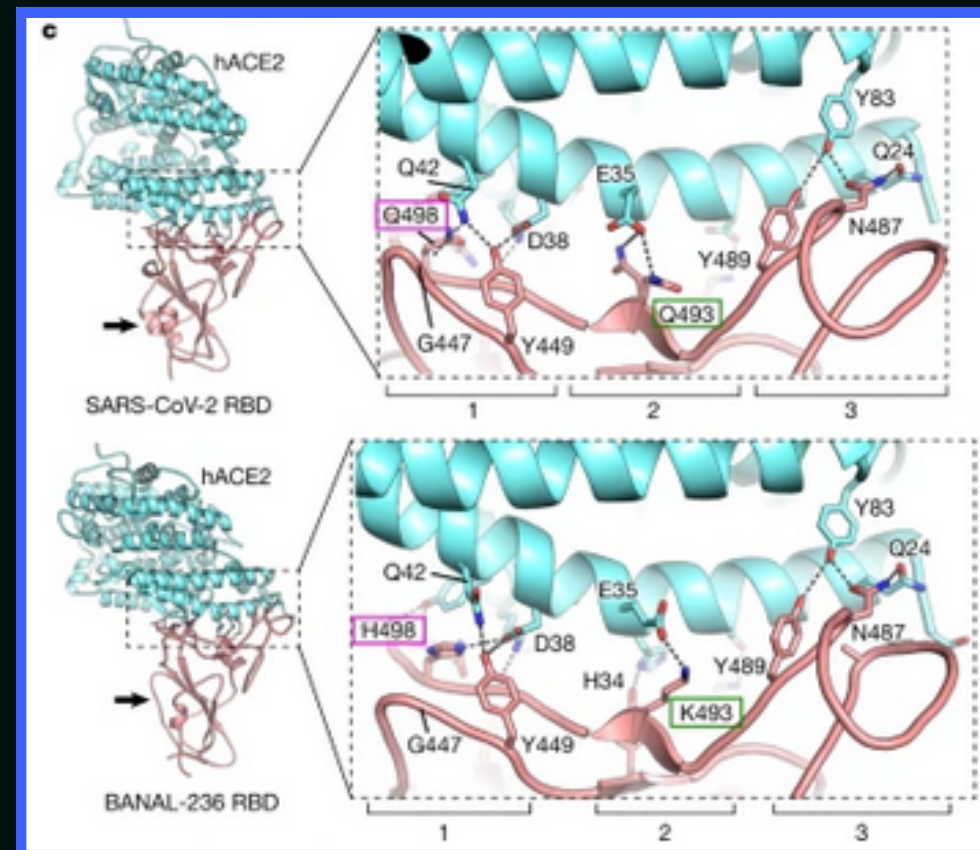


Figure: Temman et al., Nature, 2022

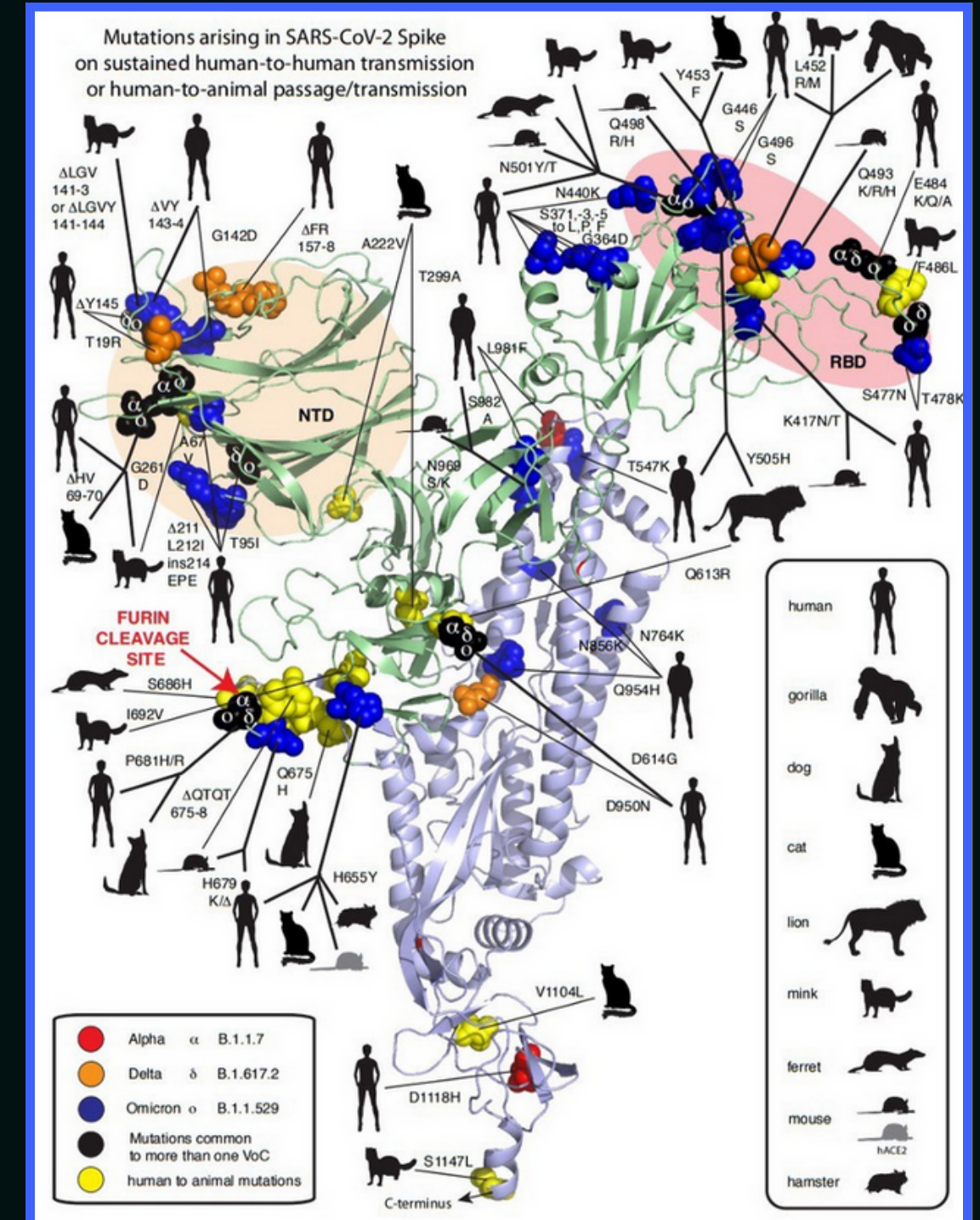


Figure: Professor Robert F. Garry, Virological, 2022

# Was the Furin cleavage site (FCS) artificially inserted?

## FCS origin

FCS motifs have been introduced to CoVs in the past (**Folly et al., Virology, 2006**) No other sarbecovirus with functional FCS at S1/S2 site has yet been found, but FCS are observed in the wider beta-CoV family (**Wu Y. et al, Stem Cell Research, 2021**) and multiple likely pathway exists to acquire FCS in nature (**Sanders et al., Communications Biology, 2022**). The FCS motif in SC2 is suboptimal, out of frame, has a unusual proline spacer and was almost certainly not engineered (**Garry RF, PNAS, 2022**), it also bears hallmarks of evolutionary pressures. (**Andersen et al., Nature medicine, 2020 & Vu et al., PNAS, 2022**)

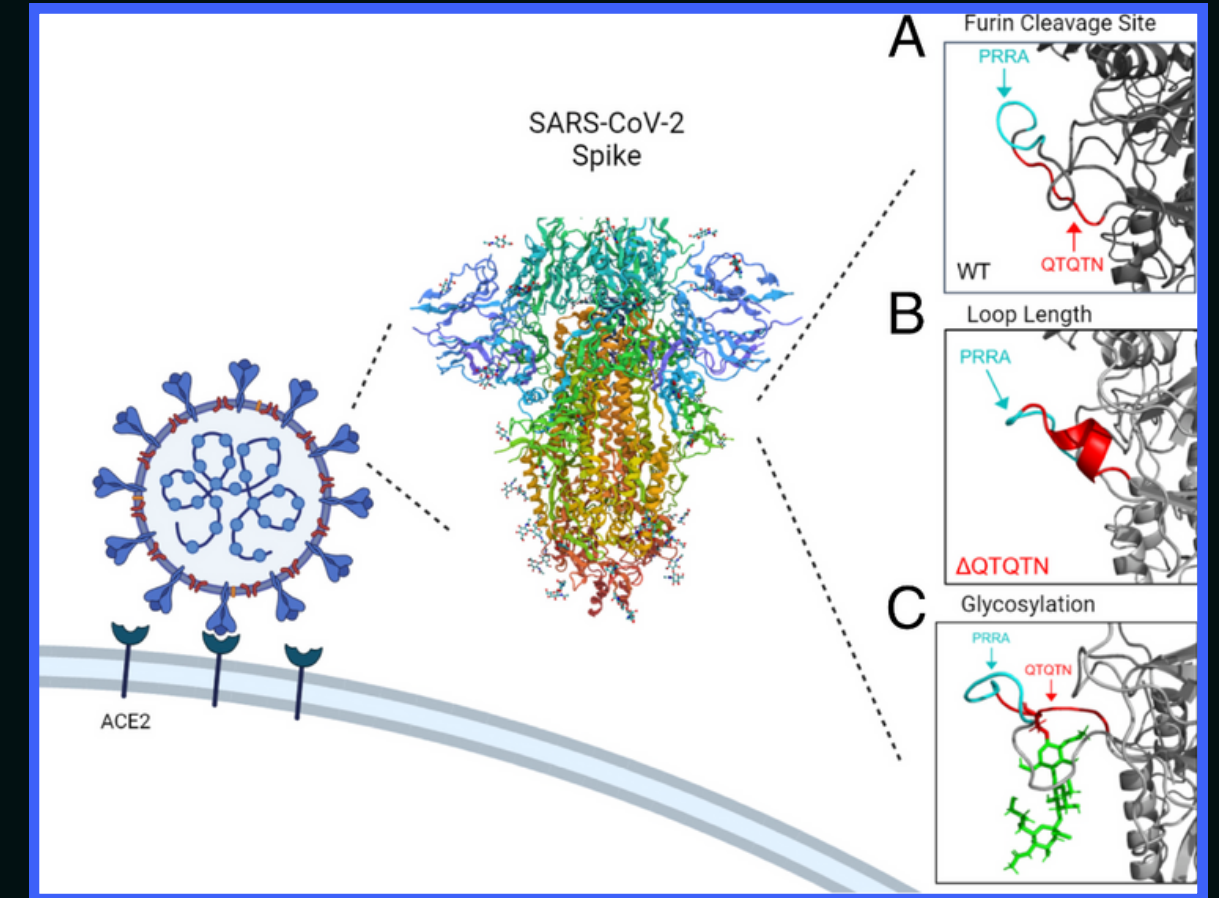


Figure: Vu et al., PNAS, 2022

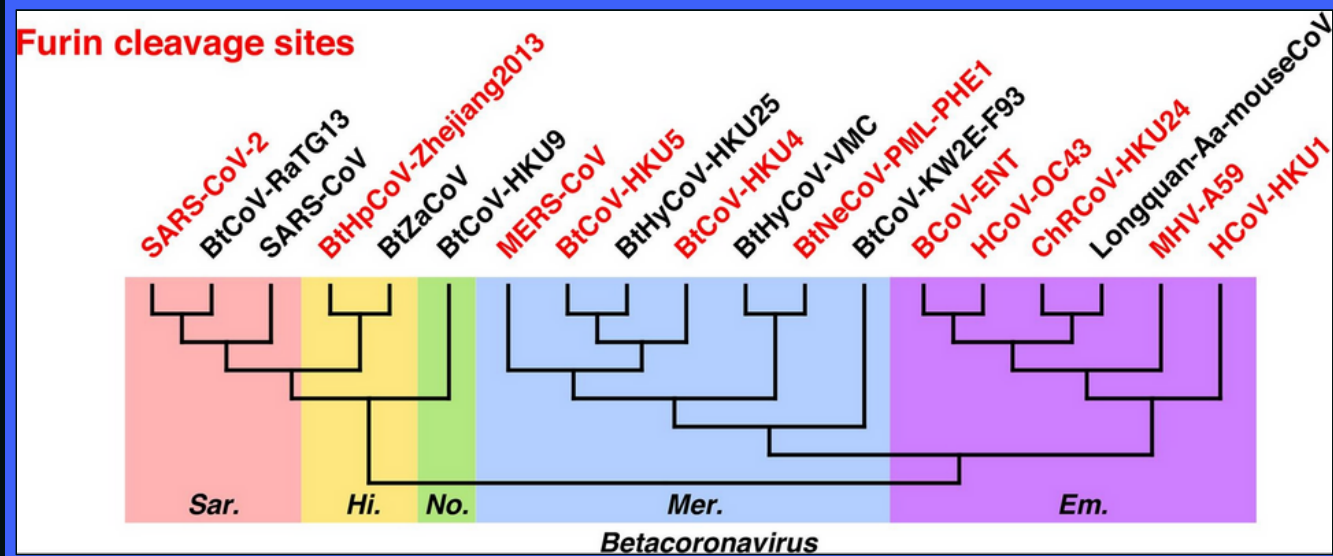


Figure: Wu Y. et al, Stem Cell Research, 2021

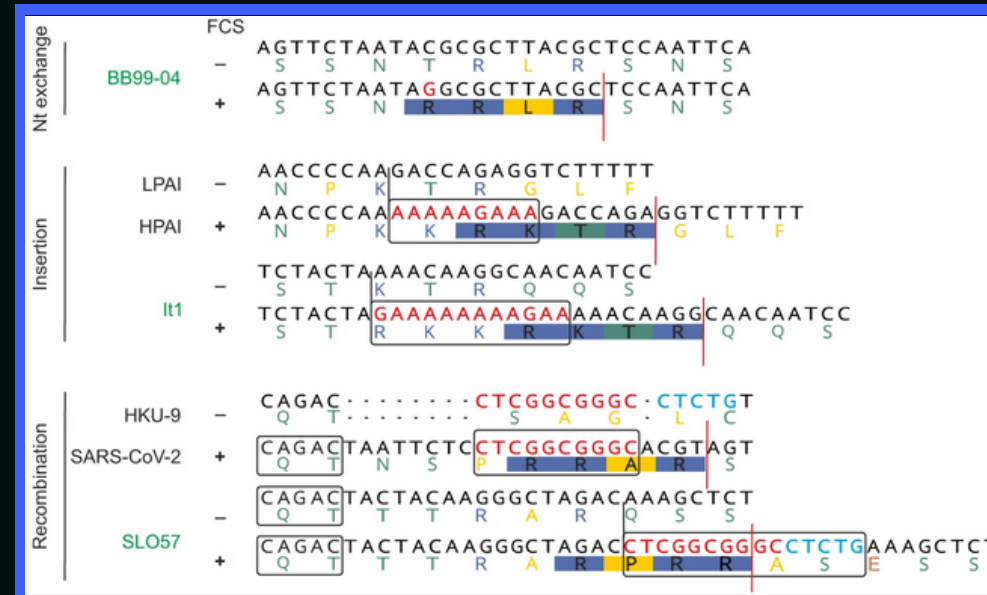


Figure: Sanders et al., Communications Biology, 2022

**B. nucleotide alignment (ENaC vs. SARS-CoV-2 and BANAL-20-52)**

	H/N	G/S	A/P	R	R	A	R	S	V	A	S	S/Q
human ENaC	705	cac	ggg	gcc	cgu	cga	gcc	cgu	agc	gug	gcc	ucc agc 740
SARS-CoV-2 Spike	23597	aau	u	cu	ccu	cgg	cgg	gca	cgu	agu	gua	gcu agu caa 23632
BANAL-20-52 Spike	23546	aau	u						ca	cgu	agu	gug gcc agu caa 23569

12 inserted nucleotides

Figure: Garry RF, PNAS, 2022

# Conclusion Question B

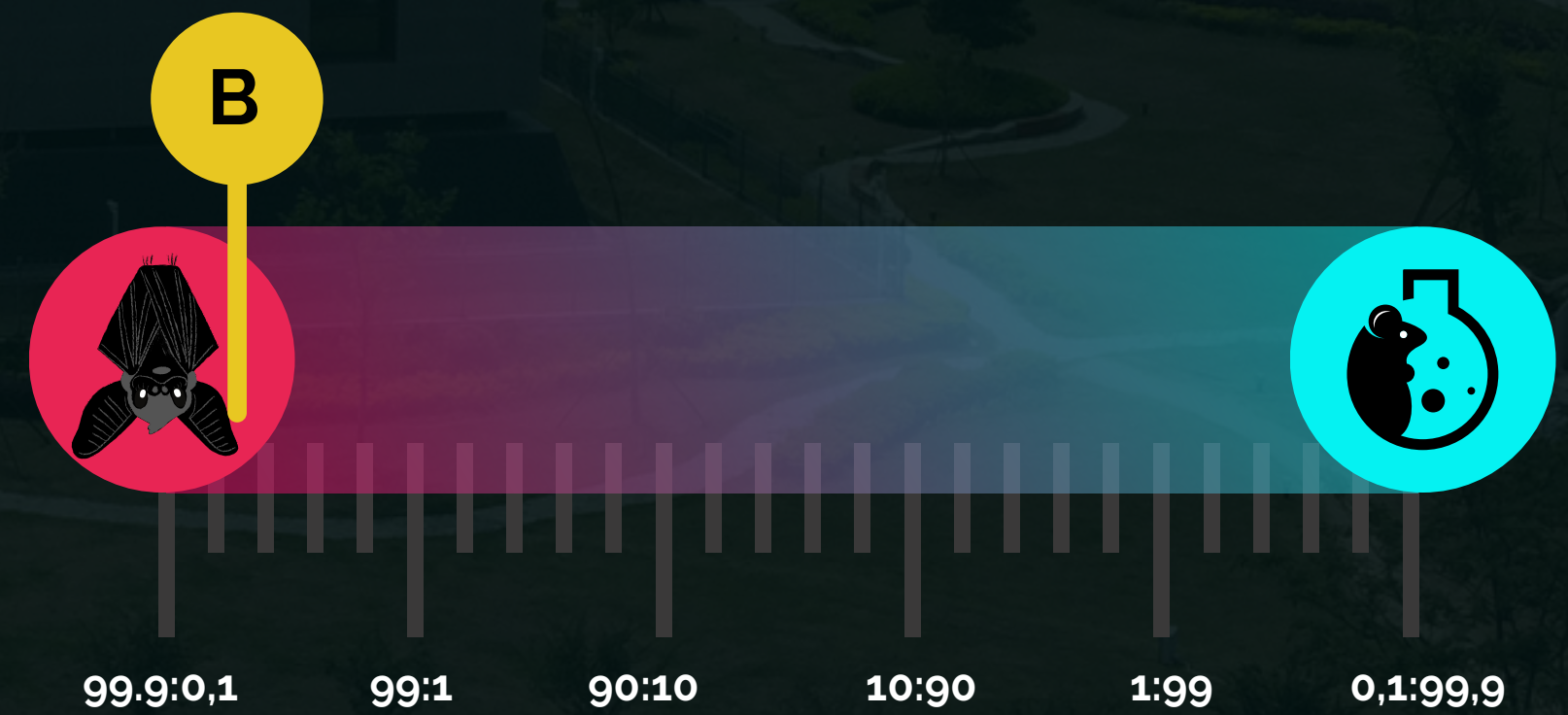
## Summary

- The evolutionary history of recombination makes it clear that the SARS-CoV-2 genome overall came about by natural processes, not genetic engineering
- features like RBD or FCS that might have been introduced or optimized to 'heat up' a natural bat COV show no hallmarks of being artificial
- RBDs in nature (pangolins & bats) have been found that are almost identical and capable of infecting human cells from the get go
- The occurrence of a FCS in sarbeco family is unusual, but not impossible. Multiple natural explanations are on offer. Lab origin of this particular FCS motif is highly implausible.

*BUT: A novel, natural CoV could still have leaked from a lab that collected hundreds of such unknown CoV*



SARS-CoV-2 is a natural, not engineered virus that almost certainly was not manipulated in any shape



# When did the first infection happen and what is the recent history of the virus?

## Phylogeny

Phylogenetic analysis showed that there were two separate lineages (Rambaut et al, Nature Microbiology, 2020) from the start of the outbreak, polytomies & lack of transitional genomes indicating multiple introductions from an animal population (Pekar et al., Science, 2022) A single spillover (e.g from a lab leak) would die out 70% of the time by itself. (Pekar et al., Science, 2021)

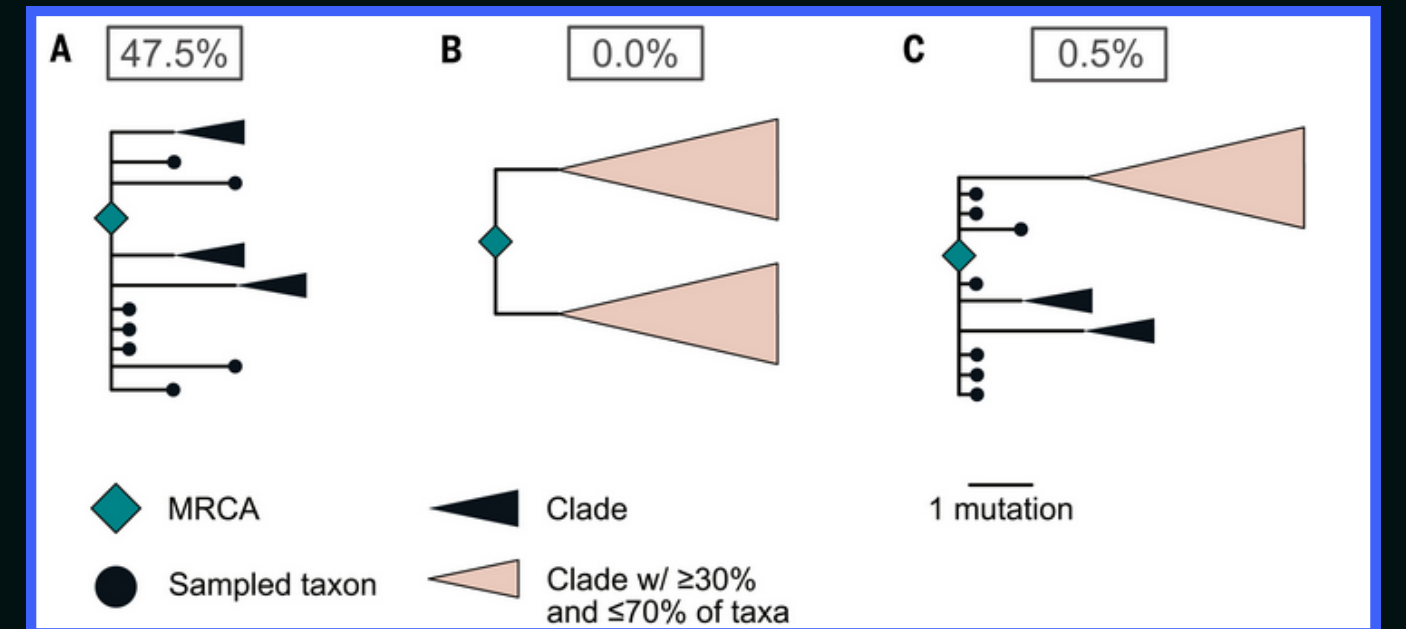
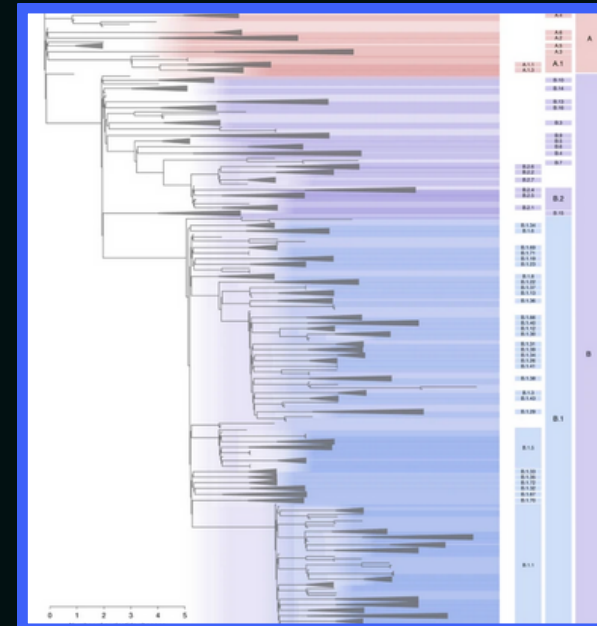
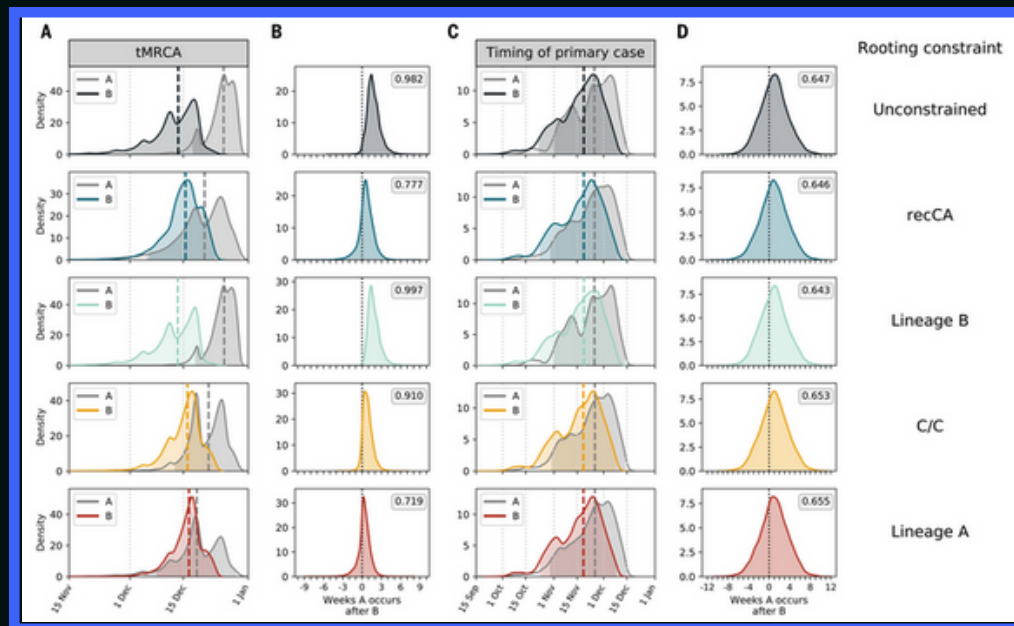
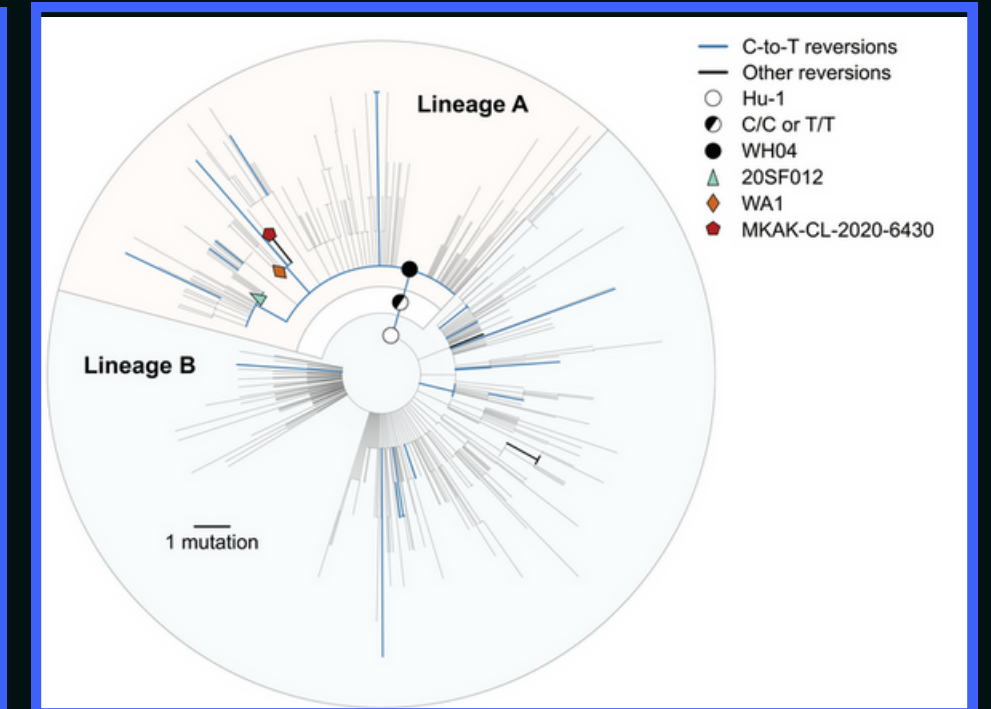
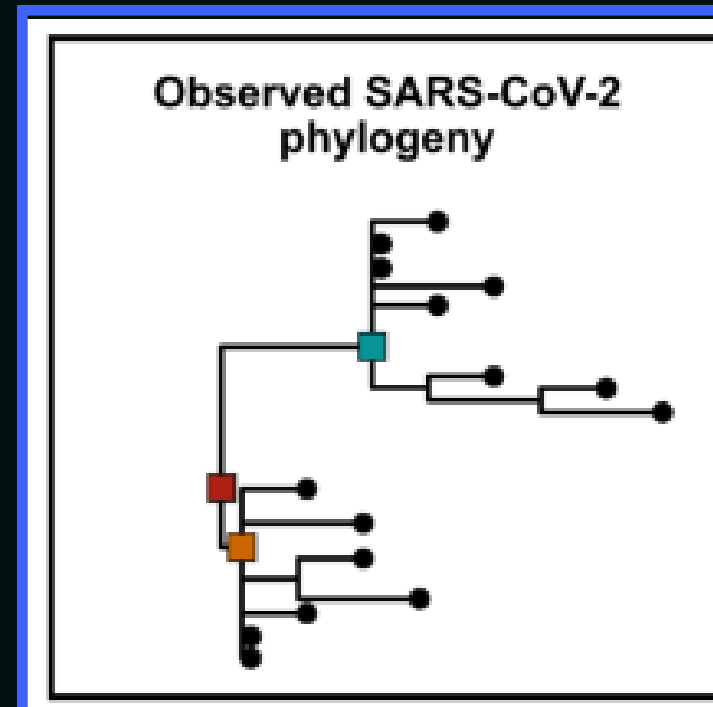


Figure: Pekar et al., Science, 2022

Figure: Rambaut et al, Nature Microbiology, 2020

Figure: Pekar et al., Science, 2022

# Where did the first humans get infected and how did it spread?

## Epidemiology

Hospitalizations and cases clustered around the Huanan market in Wuhan (WHO, 2021), both for epidemiologically linked and unlinked cases & controlled for population density, age and ascertainment bias (Worobey et al., Science, 2022) Many SC2 susceptible animals had been sold at the Huanan market & environmental swabs confirmed them being there (Xiao et al, Sci Reports, 2021 & Liu et al, CCDC, 2023, Crits-Christoph, Zenodo, 2023) Both lineage A & B have market as epicenter & were confirmed there (Worobey et al., Science, 2022)

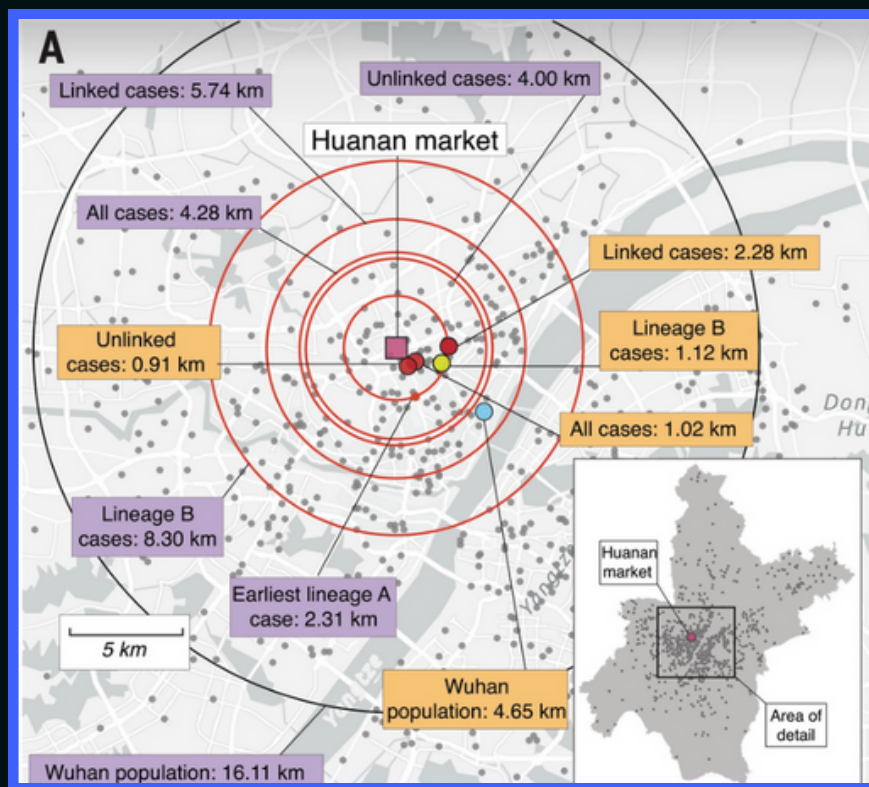


Figure: Worobey et al, Science, 2022



Figure: Xioa et al, Sci reports, 2021

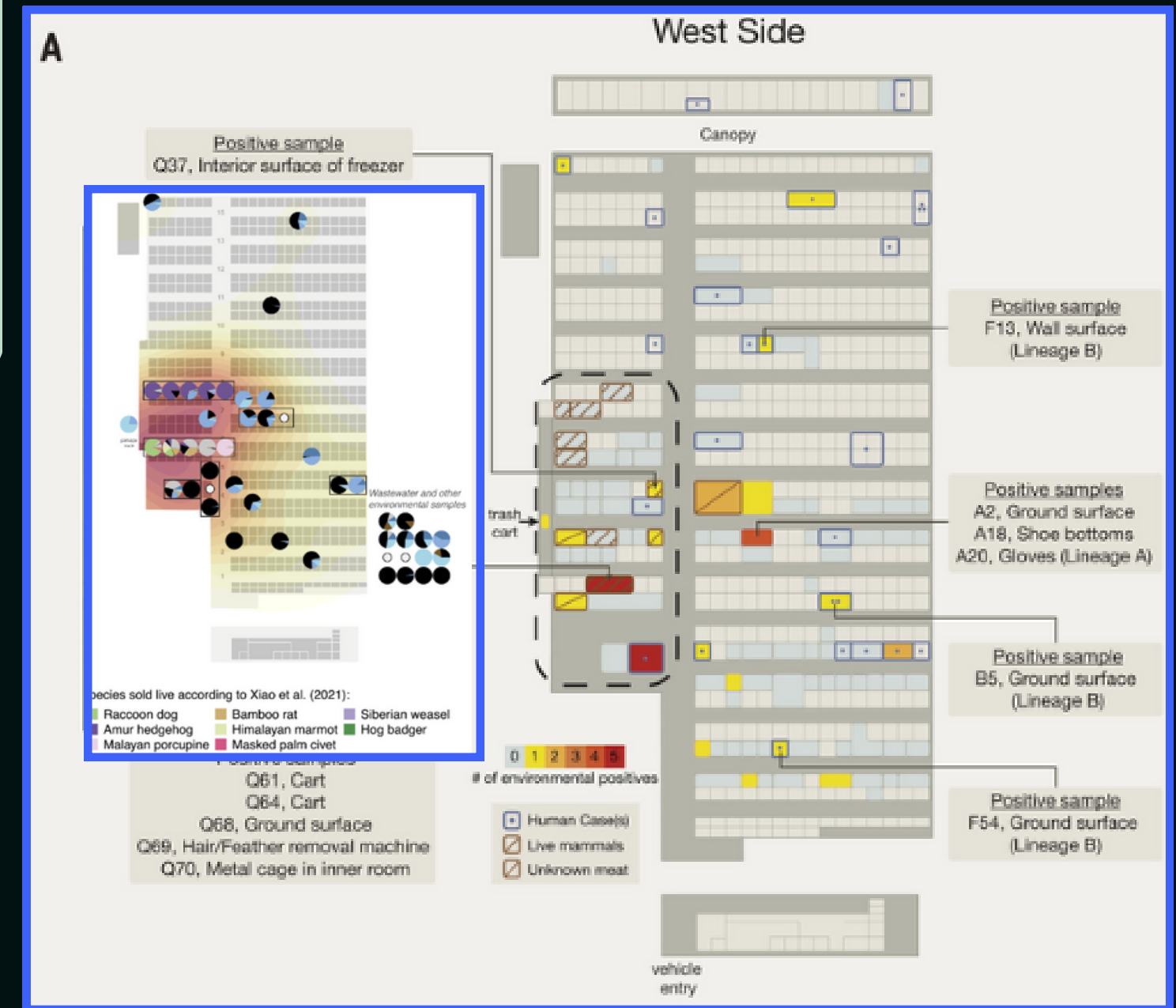


Figure: Worobey et al, Science, 2022 & Crits-Christoph, zenodo preprint, 2023



# Why did SC2 spill over in Wuhan, which houses the WIV, and far away from it's natural reservoir?

## City

The distance argument could have been advanced in 2003 with SARS1, it is irrelevant. SARS-CoV-2 could only have started a pandemic in a large city. (**Pekar et al, Science, 2021**) Housing a CoV lab is not unusual, 8/10 megacities in China work with potentially novel CoVs (4 labs in Beijing alone, also sampling in Yunnan and working with Ecohealth) (**Micheal Worobey lecture**) This "city" framing is wrong, because more granular data show that the outbreak started around an odd wildlife market from all possible places it could have been noticed first e.g restaurants, hospitals, schools, malls (**Worobey et al, Science, 2022**)

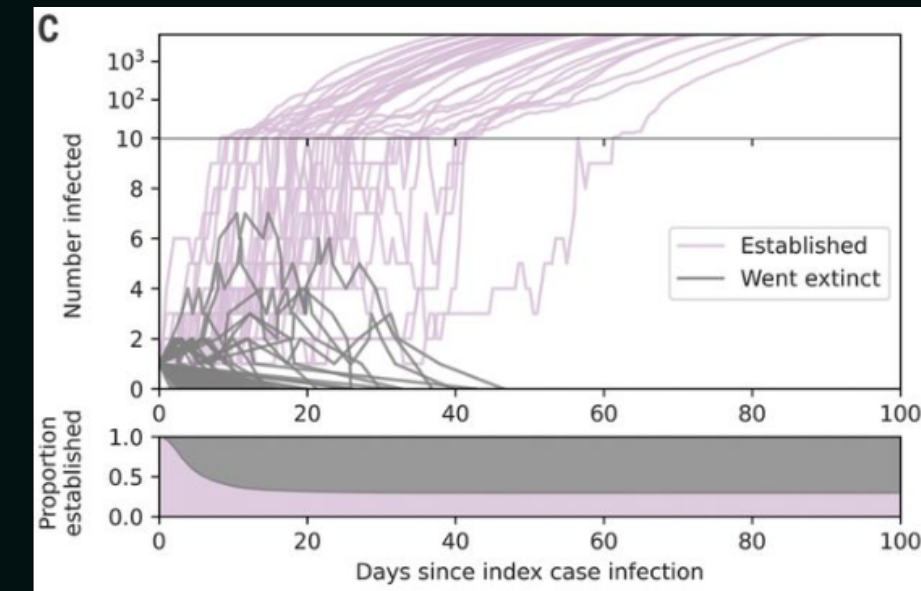


Figure: Pekar et al, Science, 2021



Figure: Micheal Worobey lecture

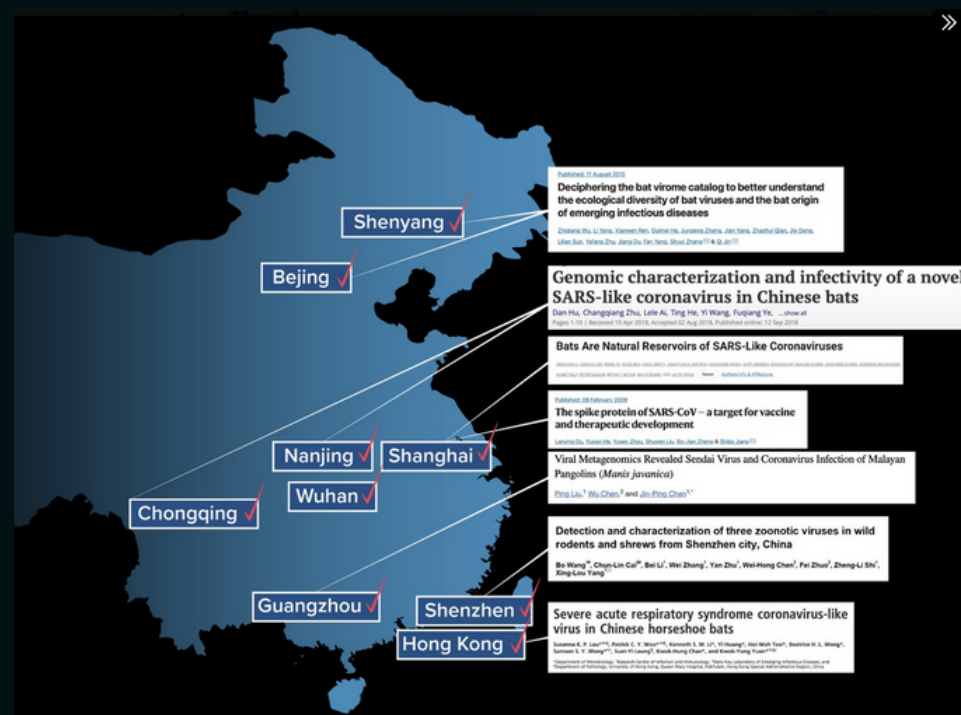


Figure: Micheal Worobey lecture

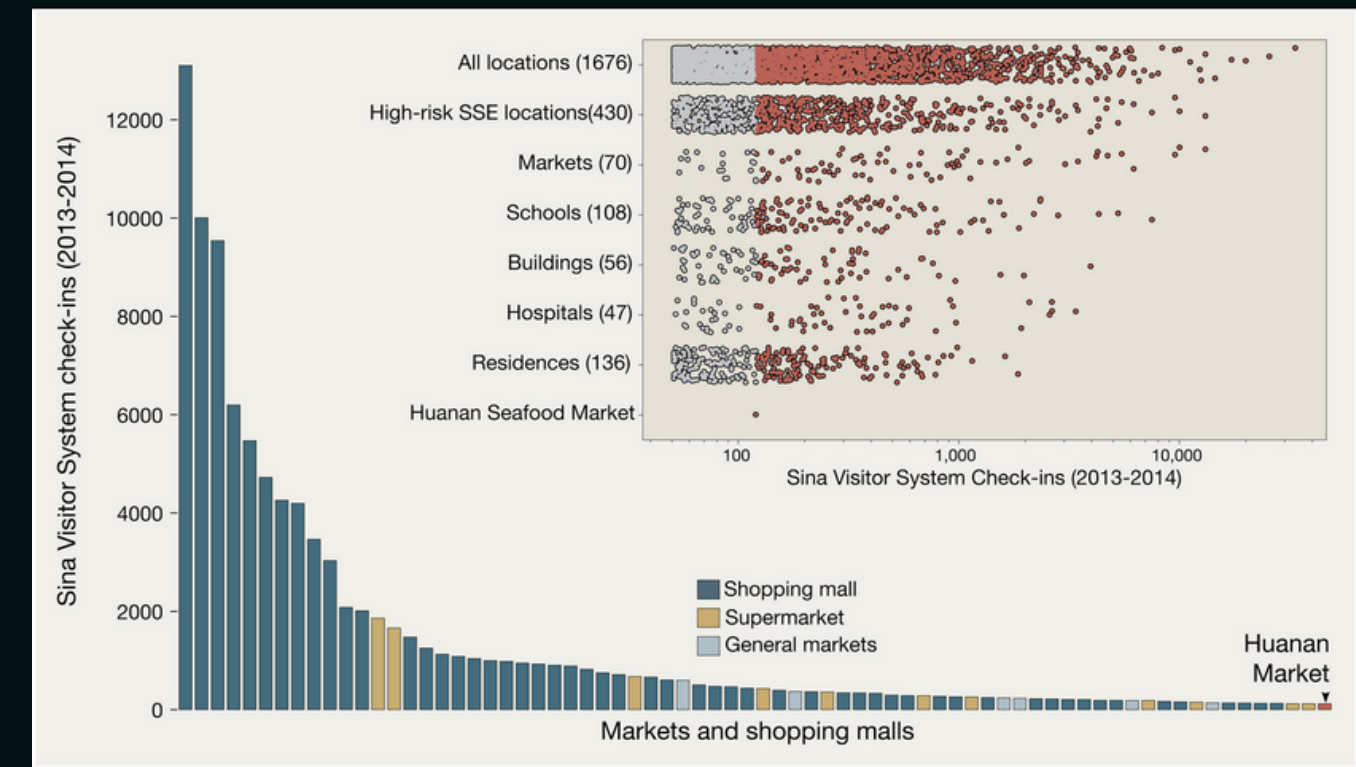


Figure: Worobey et al, Science, 2022

# Conclusion Question C

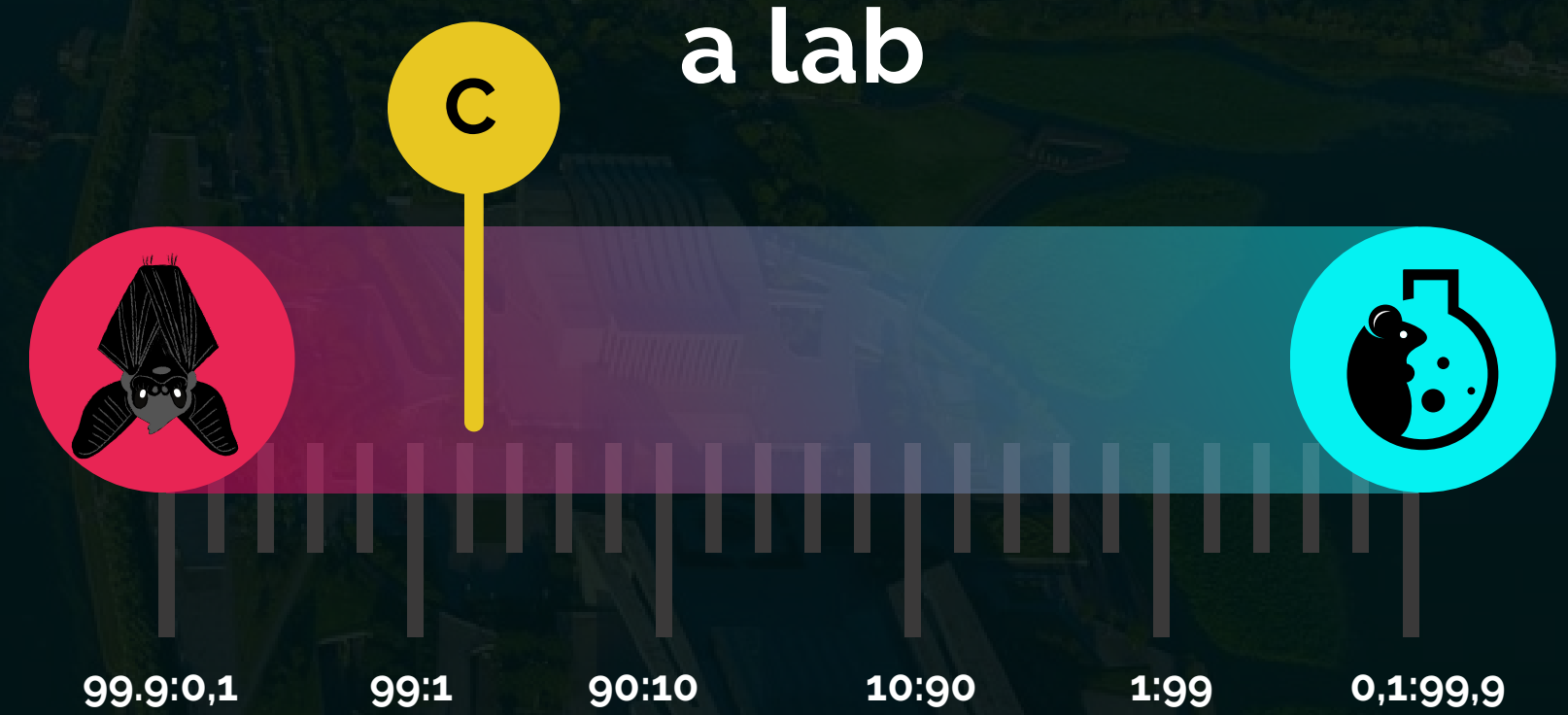
## Summary

- Phylogenetic studies show that there were two early lineages that most likely were introduced separately a week apart in late November,
- The Huanan market is the unequivocal epicenter from where the first human transmission chains started for both lineage A and B, it was not a super-spreading event
- SARS-CoV2 susceptible animals had been at the market at the time of the outbreak and cluster with virus-positive environmental samples in the western corner
- The city of Wuhan is not an unusual site for a novel CoV outbreak, yet the odds of both viral lineages starting an outbreak at a wildlife market if they escaped from a lab is almost inconceivably unlikely

*Can any lab leak hypothesis really account for the observed data?*

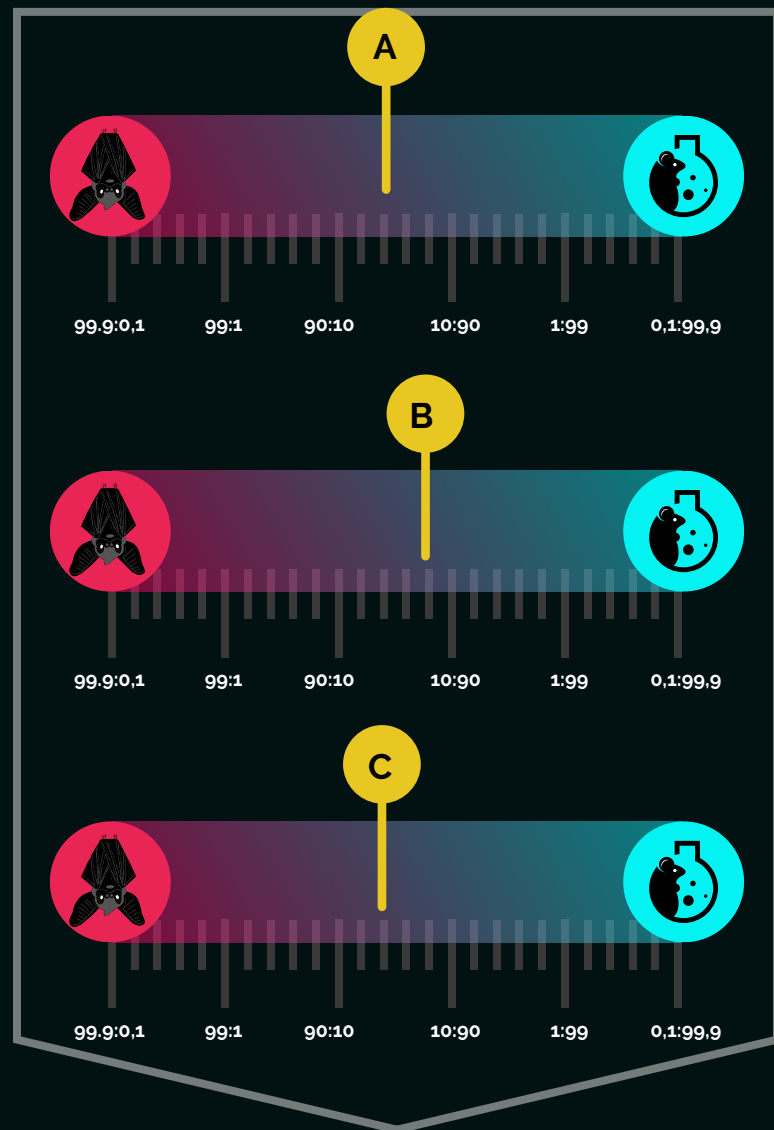


**The very first human infections most likely occurred at the Huanan market, and almost certainly not in a lab**



# As evidence accumulates, uncertainties shrink

## Knowledge & evidence base in Jan 2020



*"I had never expected this kind of thing to happen in Wuhan, in central China. Could they have come from our lab?"*

*--- Zheng-Li Shi's first thoughts, December 30, 2019*

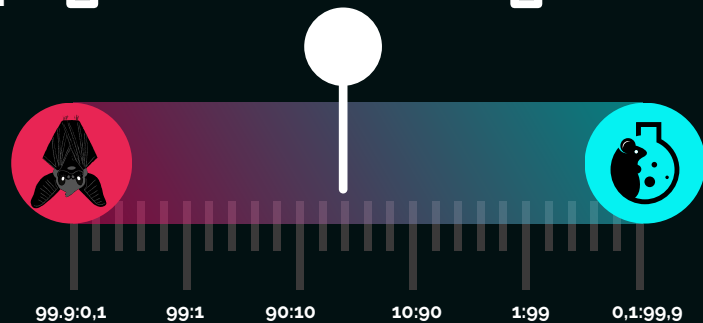
*"He said there's this furin cleavage site between the S1 and S2 junctions," ... "There are two restriction sites, BamHI, around it. And that section, between the restriction sites, looks like it has reduced variation."*

*--- Edward Holmes about K.G Andersen observations, January 31, 2020*

*"[...] this series of coincidences, what you know of the lab in Wuhan, how much could be in nature – accidental release or natural event? I am 70:30 or 60:40."*

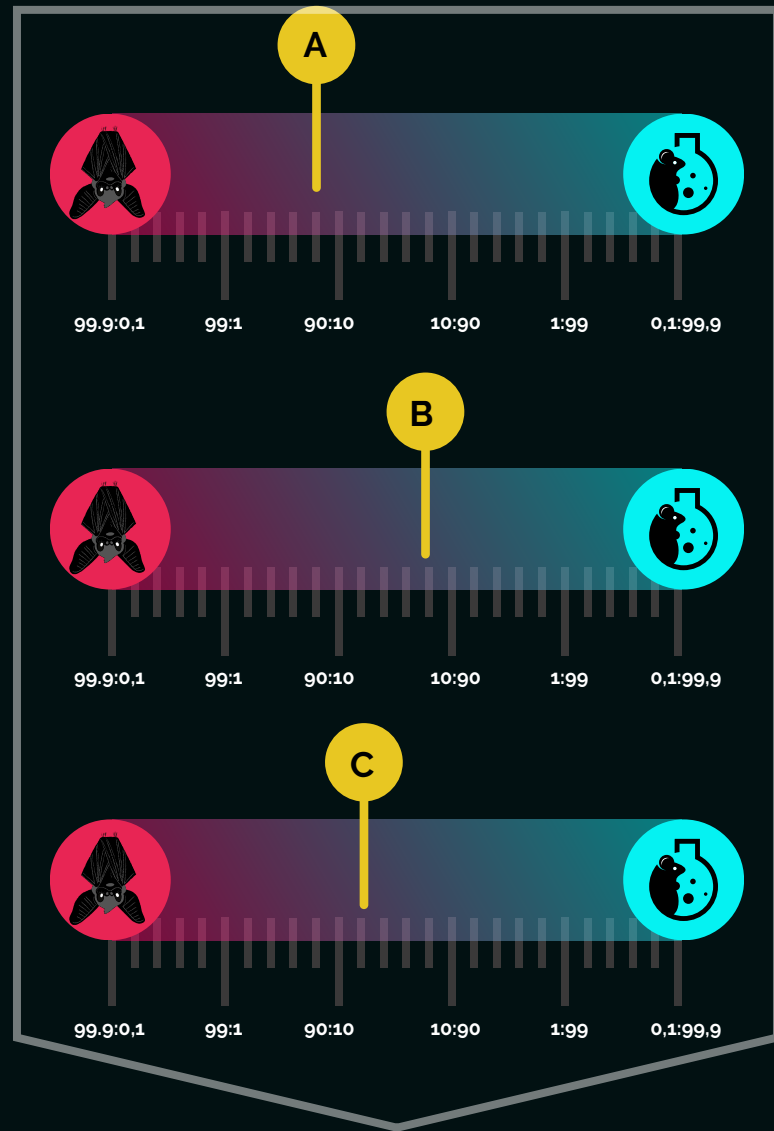
*--- Jeremy Farrar to Anthony Fauci, February 2, 2020*

Uncertainty: 



# As evidence accumulates, uncertainties shrink

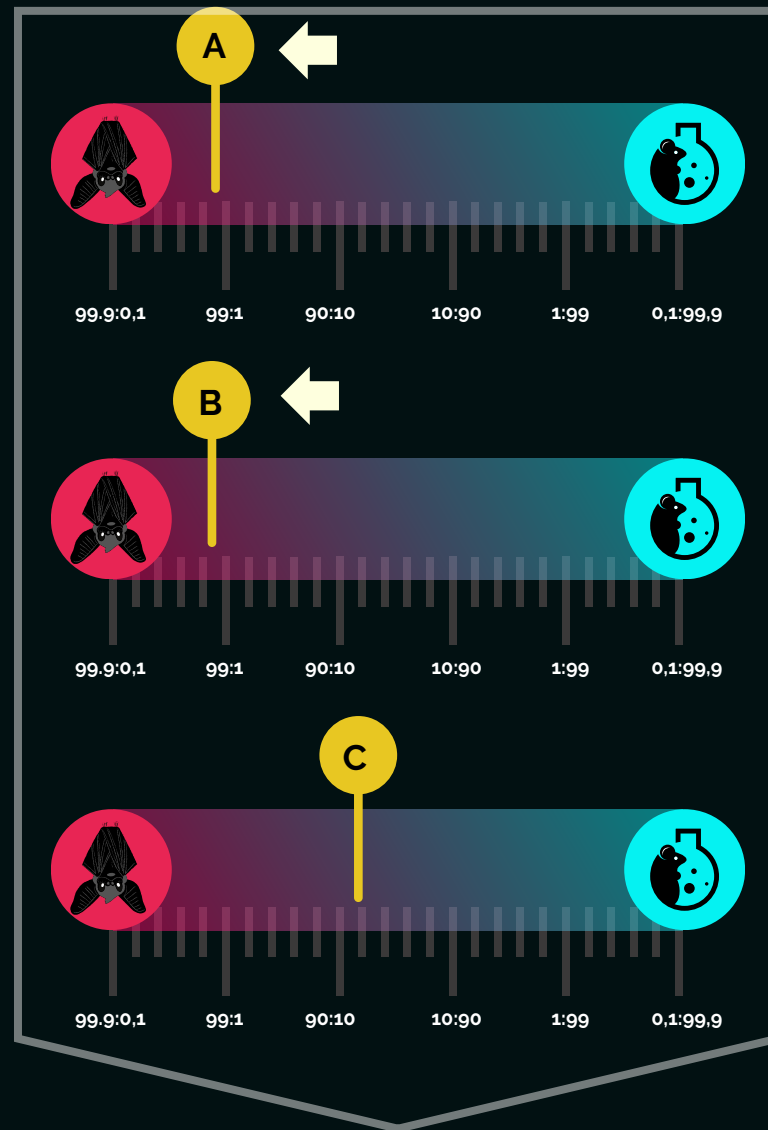
Knowledge & evidence base in early 2020



+ evidence

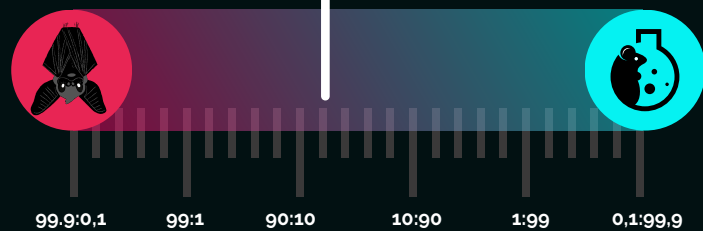
+ evidence

Knowledge & evidence base in mid 2021

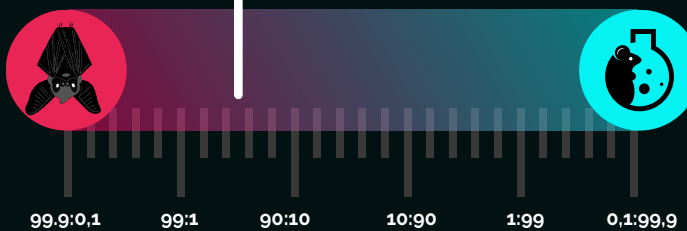


*"There is currently no evidence that SARS-CoV-2 has a laboratory origin. There is no evidence that any early cases had any connection to the WIV, in contrast to the clear epidemiological links to animal markets in Wuhan, nor evidence that the WIV possessed or worked on a progenitor of SARS-CoV-2 prior to the pandemic"*  
--- *The proximal origins of SARS-CoV-2: A critical review*

Uncertainty:

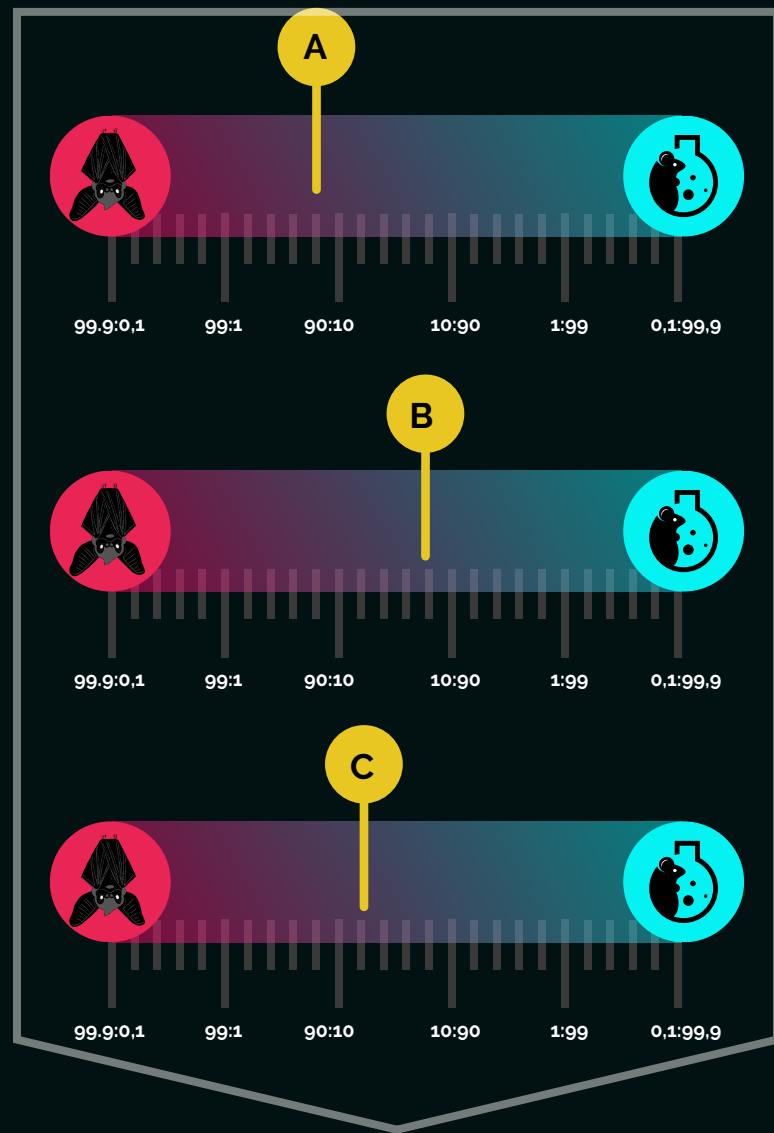


Uncertainty:



# As evidence accumulates, uncertainties shrink

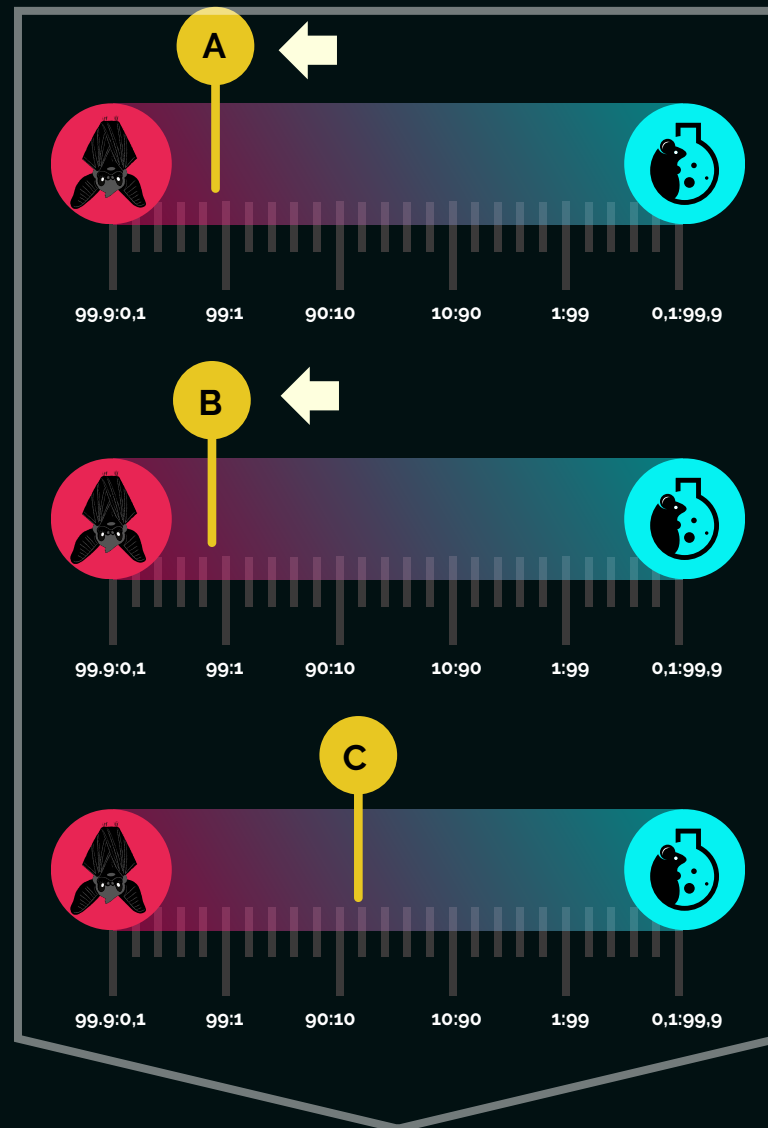
Knowledge & evidence base in early 2020



+ evidence

+ evidence

Knowledge & evidence base in mid 2021

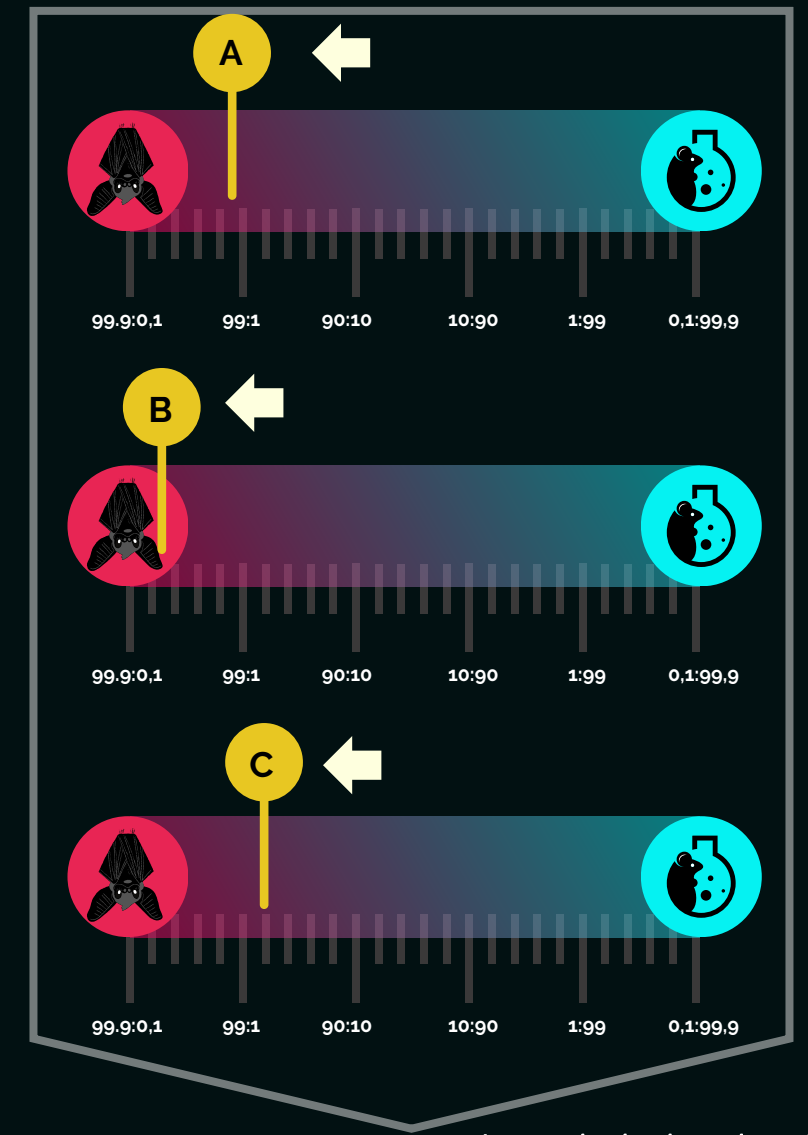


+ evidence

+ evidence

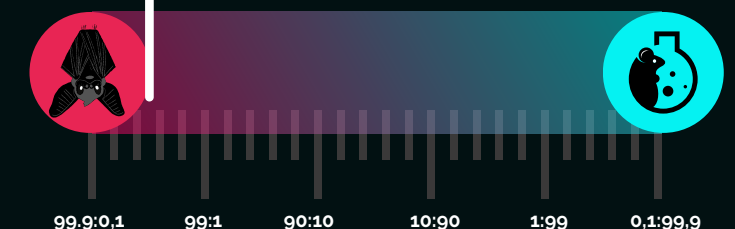
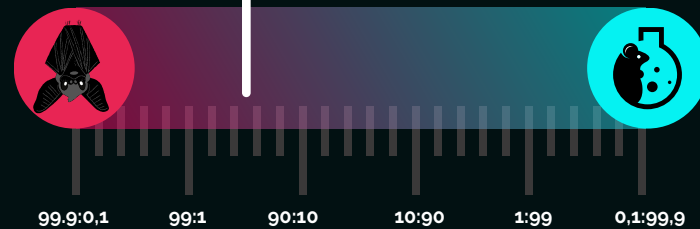
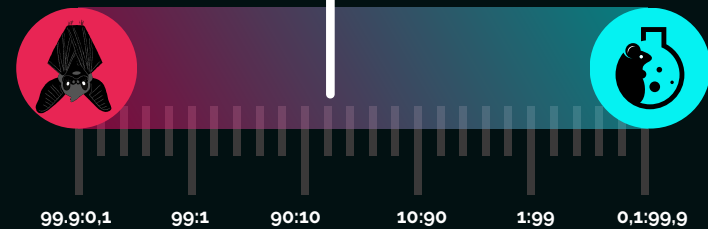
+ evidence

Knowledge & evidence base in 2023



*Is a lab leak still a viable scientific theory?*

Uncertainty:



# In 2023, all the available evidence is detailed & one-sided for zoonosis



## 01 Case Epidemiology

Hospitalizations and cases clustered around the Huanan market in Wuhan (WHO, 2021), both for epidemiologically linked and unlinked cases for the market (Worobey M, Science, 2021). That market link holds even when controlled for population density, age and ascertainment bias (Worobey et al., Science, 2022)

## 02 Natural genome

Subgenus	Genome	Accession	Reference
Sarbecovirus	SARS-CoV-2	NC_045919.2	Wuhan
	BCoV-Rh/2002	AF049314.1	China
	BCoV-Rh/2019	AF049315.1	China
	BCoV-Rh/2020	AF049316.1	China
Merbecovirus	BCoV-Mer/19	AF049317.1	China
	BCoV-Mer/20	AF049318.1	China
	BCoV-Mer/21	AF049319.1	China
Embecovirus	BCoV-Em/19	AF049320.1	China
	BCoV-Em/20	AF049321.1	China
	BCoV-Em/21	AF049322.1	China
Nibeovirus	BCoV-Ni/19	AF049323.1	China
	BCoV-Ni/20	AF049324.1	China
	BCoV-Ni/21	AF049325.1	China

The SARS-CoV-2 genome shows many hallmarks of natural evolution, and no signs of genetic engineering or other manipulations (Anderson et al, Nature medicine, 2020 & Holmes et al., Cell, 2021 & Garry R, PNAS, 2022)

## 03 Multiple introductions

A single spillover (e.g from a lab leak) would die out 70% of the time by itself. (Pekar et al., Science, 2021) Case history and simulations, phylogenetic clock and polytomies point to at least 2 separate successful introductions, and up to 15 total (Pekar et al, Science, 2022)

## 04 Two original lineages

Phylogenetic analysis showed that there were two separate lineages (Rambaut et al, Nature Microbiology, 2020) from the start of the outbreak, polytomies & lack of transitional genomes indicating multiple introductions from an animal population (Pekar et al., Science, 2022)

## 10 Recombination

The genome of SARS-CoV-2 is like a jigsaw puzzle with 27 pieces. All elements of its genome are found in nature (Zhou et al., Cell, 2021 & Temman et al., Nature, 2022) and the virus could have only come about through recombination in nature (on top of normal evolution & selection mechanism) (Lytras et al., Genome Biol Evol. 2022)

## 09 Environmental swabs

Sequencing of SARS-CoV-2 positive environmental samples have isolated animal sequences together with viral RNA (Gao G. et al., under review, 2023) Raccoon dog sequences were the most prevalent co-occurrence and there is photographic evidence of raccoon dogs present. (Worobey et al., Science, 2022)

## 08 Animals at market

Investigations have shown that many SC2 susceptible animals had been sold at the Huanan market up until December 2019. (Xiao et al, Sci Reports, 2021 & Worobey et al., Science, 2022) Environmental samples cluster around shops where live animals were sold.

## 07 History

Zoonotic coronaviruses are common and have caused pandemics before (Cui et al., Nature Reviews Microbiology, 2018). SC2 shows many parallels to SARS-1 outbreak, including wildlife trade, time of year and Hubei farms link (Shi et al., Virus Research, 2007). All previous pandemics with an unknown pathogen were caused by zoonotic spillovers, which are common and present danger (Keusch et al., PNAS, 2022)

## 06 Outbreak site

All early cases cluster around a poorly visited market, a place unlikely to facilitate a human-to-human outbreak compared to restaurants, churches, stadiums that have been observed as amplifying events after introduction of SC2 in other cities (Worobey et al., Science, 2022). The market is also far away from the Wuhan Institute of Virology on the other side of the Yangtze river. (Holmes et al, Cell, 2021)

## 05 Hotspots

Bats & other animals carrying SC2r viruses have a wide range and are found in China (Zhou et al., Cell, 2021), Laos, Thailand (Wacharapluesadee et al., Nature communications, 2021) and other countries in South East Asia. Models suggest >60,000 CoV spillovers per year (Sanchez et al., Nature Communication, 2021)

MULTIPLE LINES OF SCIENTIFIC EVIDENCE FOR ZOOONOTIC ORIGIN



NEW!

*Science paints a pretty one-sided picture. So what is all the media fuss about?*



**The Science communicator**

***Hey, maybe you should let me take over from here***



**The (Social) Media manipulator**

# The dark side

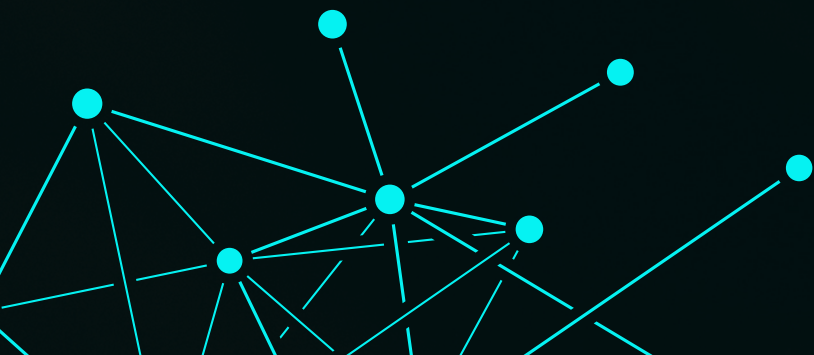
”

*Without facts, you can't have truth. Without truth, you can't have trust. Without trust, we have no shared reality, no democracy, and it becomes impossible to deal with the existential problems of our time.*

*—Maria Ressa, Nobel Peace Prize lecture, 2021*

03

**New vulnerabilities  
and an ecosystem of  
falsehoods**





# Technological disruption of our information sphere

## What changed?

- broadband internet expanded, social media platforms formed, and advertising-based free-access information replaced gated subscription-based models
- Some of these changes unequivocally good, think about Wikipedia, or scientific collaborations
- traditional institutions and media outlets came under pressure to digitize and compete in the online space, many did not manage to make this transition
- now everybody can create, share and consume as much information as they like, and there are sophisticated algorithmic systems that facilitate our interactions with information

*Society went from information scarcity to information abundance.*



# Why does science struggle today?

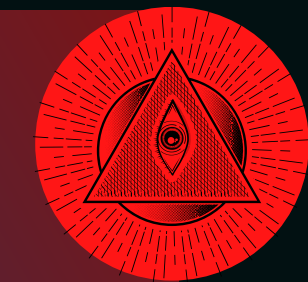
*How much should we think about how information moves through society?*



Looking at media dynamics, which favor science and which favor falsehoods?



favors science

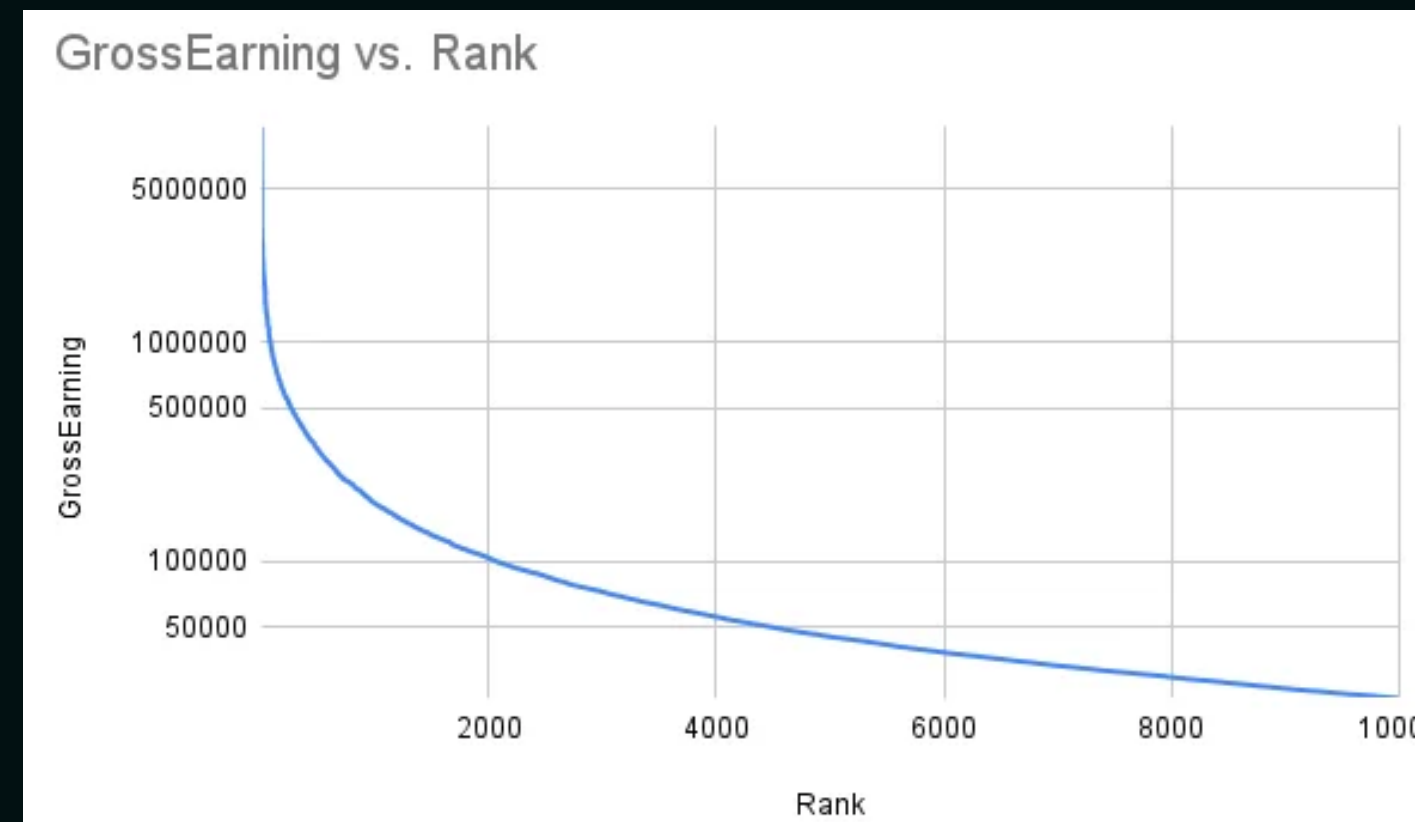
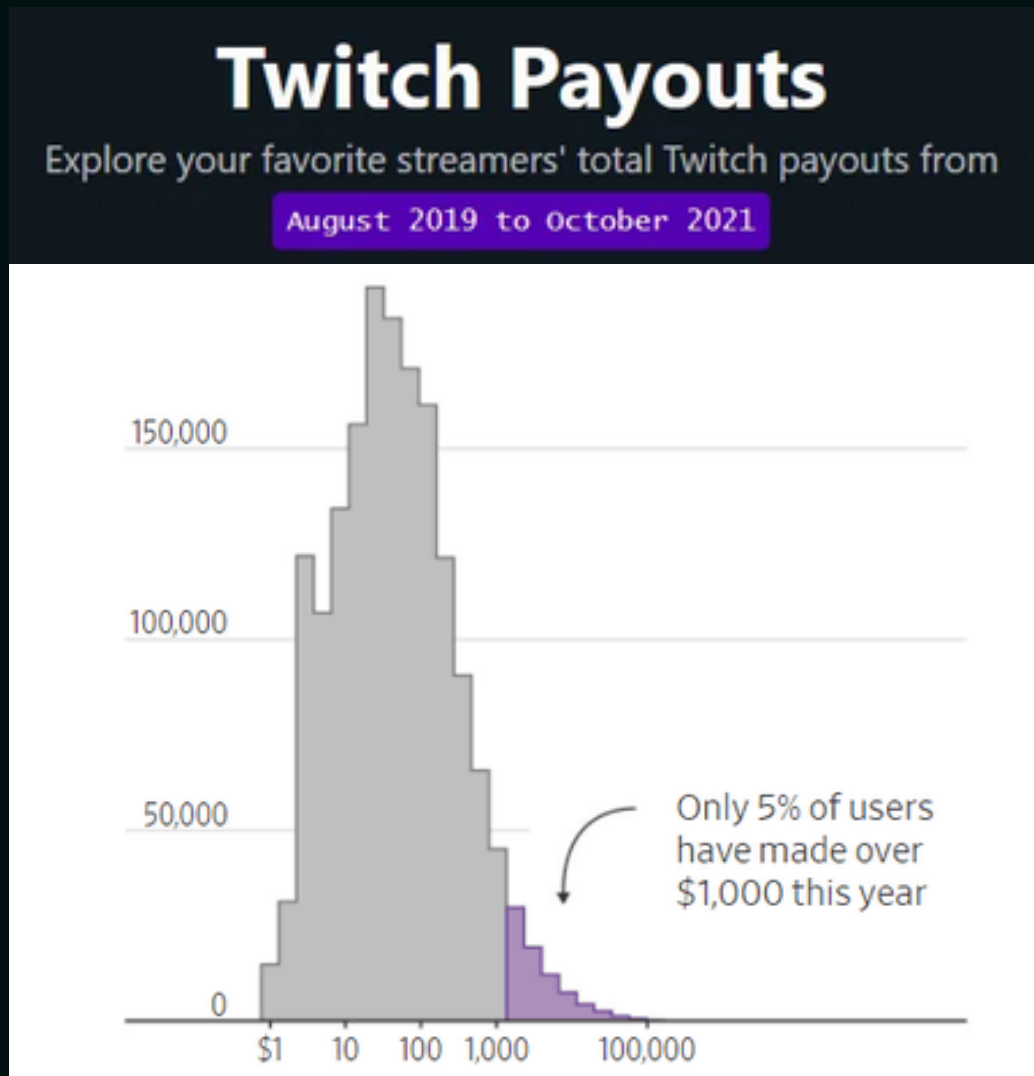


favors falsehoods

- Part 1** Asymmetries of the attention economy
- Part 2** The communication tactics of discourse manipulators
- Part 3** Information pathogens and information cascades

# The "rich getting richer" power law of attention

*There is no middle class in the attention economy. The winners take all.*



Only 2500 (0,03%) of 8 million creators get to a livable salary of like 40.000\$ per year

81 streamers earned more than 500k, and 25 streamers more than one million dollars per year

On social media:

- there is no tax system that redistributes eyeballs
- there is no regulation what can and cannot be done to attract attention
- capturing audiences brings power to the influencer & the platform

# Information as a product to sell

How influencers think about information:

- how much time and effort does it take to produce?
- what is my target or niche audience?
- what is the USP of the product?

*Any information product is a potential source of income for influencer... they worry about competition, not merit*



Going by the motto of 'the customer is always right', many influencers create content that the audience wants to see

The easiest way to game the system is to create an information product that is just **very addictive, broadly appealing, or shareable** (think click bait, cat memes, political outrage bait)

A more elaborate tactic is to create an addictive information product that has a **unique appeal, or that is custom-made for a specific audience** (US culture war, conspiracy theories, alternative medicine and antivaxx etc)

# Scientific information has to compete with all other information products

Science faces multiple limitations to create attractive information products for the attention economy

- slow and difficult to produce
- for wider society with broad backgrounds
- boring, bound-by-fact, unexciting or jargoned information products make for an unattractive USP

## These limitations create asymmetries:

- The asymmetry of narrative power
- The asymmetry of audience demand
- The asymmetry of responsibility
- The asymmetry of intuition
- The asymmetry of refutation (BS asymmetry)
- The asymmetry of volume
- The asymmetry of incentive
- The asymmetry of adaptation

....

### THE BS ASYMMETRY PRINCIPLE

THE AMOUNT OF ENERGY NEEDED TO REFUTE BS IS AN ORDER OF MAGNITUDE BIGGER THAN TO PRODUCE IT

Panel 1: "WAIT! I BET THE MOON'S MADE OF CHEESE"

Panel 2: "WELL, SPECTROGRAPHIC ANALYSIS AND ORBIT CALCULATIONS SUGGEST NOT. PLUS, WE BUILT A ROCKET, TOOK PEOPLE THERE, AND THEY COULDN'T EAT IT."

Panel 3: "... AM, YEAH... I'M STILL THINKING CHEESE."

EFFORT

AKA BRANDOLINI'S LAW

sketchplanations

# The asymmetry of narrative power: the lableak myth versus zoonosis

- The 'lableak' idea has many psychological, cultural and social advantages
- First, it is very intuitive to understand; somebody fucked up. It plays into our cultural practice of blaming diseases on people outside our tribe, instead of our own failings and responsibilities.
- It plays into our tendencies to view world events as product of conspiracies rather than bad luck or randomness.
- Pandemics have been with humanity for millennia, blaming them on others it is literally a story old as time for tribal beings such as us.
- Lastly, it offers us power. If only we can stop this minority of (in this case) "evil scientists", we could prevent a pandemic from happening ever again.
- Compare this to the 'zoonotic' idea, which is a lot more complicated and requires more background knowledge
- no concrete actors, but our collective ravaging of nature, farming practices, economic incentives and global transport hubs that are all somehow responsible for spillover risk.
- How can we understand all the interconnected layers to this problem? These issues are way harder to intuitively tackle.
- They leave the feeling that we might not be able to prevent the next pandemic, that we are somehow guilty but not in control.
- That we will see more and more horrible pandemics, and nobody knows what actions we even gotta take to stop it.

# The asymmetry of adaptation:

## EMERGENCE OF A NEW PNEUMONIA OF UNKNOWN ORIGIN

### LINK TO WILDLIFE TRADE AND HUANAN MARKET

Early case epidemiology trace the outbreak to a seafood and wildlife market in Wuhan. All indications point to a zoonotic spillover event, similar to SARS-1. The market gets closed and decontaminated, but by the time the chinese CDC arrives, animals had been cleared out. The proximity to a BSL-4 research lab in the same city raises concerns



### BIOWEAPON "WHISTLEBLOWER"

A chinese dissident billionaire and rightwing political actor Steve Bannon push a bioweapon conspiracy based on gibberish, also Trump spreads the 'China virus' narrative



### NO GENETIC INDICATION OF TINKERING

Proximal origins lays out that there are no genetic elements that would indicate engineering, viral genome most likely natural origin



### "UNNATURAL" CHINA VIRUS

Social media claims, fired on by pseudo-experts and online grifters, claim that SC2 has an 'unnatural' binding affinity to humans that only deliberate design could bring forth



### SARS-COV-2 RELATIVES FOUND IN THE WILD

Sampling expeditions in China find many close relatives to SARS-CoV-2, even closer similarity based on segments than any known virus incl. RATG13



### "SECRET" RATG13 & MOJIANG MINE

Internet sleuths and LARPer use google translate to browse through old master theses from WIV studentts, decontextualizing data to feed the conspiracy myth. Many of these talking points will be amplified by shady actors and incompetent media



### PHYLOGENETIC HISTORY PROVE BACKBONE IS NATURAL

SARS-CoV-2 possesses a mosaic genome and recombination analysis excludes that it could have been derived from any known viral backbone



### "SMOKING GUNS" FOR ENGINEERING

Contrarian scientists, journalists and commentators are given ever-bigger platforms to spread highly engaging and sensationalist claims that are not supported by evidence



### BANAL SEQUENCES ESTABLISH RBD IS NATURAL

Sampling expeditions in Laos find SARSr viruses that have an RBD that is capable to infect human ACE2 directly. These are the closes relatives of SC2 found so far



### "BLUEPRINT" PROJECT DEFUSE

Anti-science activists & self-proclaimed internet investigators start attacking experts, weaponize decontextualized FOIA requests to intimidate, silence and harass anybody who speaks up against rampant conspiracsm



### MULTIPLE LINES OF EVIDENCE TO ESTABLISH HUANAN MARKET AS PLACE OF EMERGENCE

Two science papers looking at the epidemiology, geography, phylogeny, timing and simulations of the outbreak. They also find evidence for SARSr susceptible animals at the market at the time of spillover and model a 99% likelihood of multiple introductions (separate jumps)



### "COVER-UP" IN US LABS

Political actors use a weaponized conspiracy myth as a tool for personal profit, and to induct people into rightwing ideology and anti-democratic radicalization



# The asymmetry of **targeting**:

## THE CONSPIRATORIAL MINDSET

### BEHAVIORAL CHARACTERISTICS

Uncertainty intolerance

False pattern recognition

Overconfidence & Narcissism

Tribal signaling & identity

Perceived outgroup threat

Lack of control or agency

VS

### PSYCHOLOGICAL DRIVERS

Uncertainty alters the way how evidence for and against conspiracy theories is evaluated (van Prooijen, 2013) Conspiracy belief is correlated with stronger "illusion of explanatory depth" (Vitriol & Marsh, 2018) and satisfies a need for cognitive closure (Marchlewska et al., 2018)

Believers in conspiracy theories display hypersensitive agency detection (Douglas et al., 2016) and increased illusory pattern perception (van Prooijen et al., 2018) on top of other intuitive biases (Binnendyk & Pennycook, 2022). Conspiratorial thinkers tend to show poor analytical thinking skills (Swami et al., 2014) and have a tendency to jumping to conclusions (Pytlik, 2020)

Overconfidence in one's own cognitive ability often underlies conspiratorial belief (Pennycook et al., 2022). People who reject scientific consensus think that they know the most about science (despite actually know the least) (Light et al., 2022). Conspiratorial belief is also related with narcissism (Cichocka et al., 2022)

Desire to be seen as original or unique (Imhoff & Lamberty, 2017) and to satisfy social identities or help achieve collective action (Cichocka et al., 2016). Preference to see themselves as "critical freethinkers" to positively distinguish themselves from "the sheeple" (Prooijen, 2019).

Perception that society's fundamental values are threatened by social change (Federico, 2018) Believers often feel a hostile outgroup is conspiring against a perceiver's ingroup (Imhoff & Lamberty, 2018). Conspiratorial thinking is associated with common motivations that drive intergroup conflict (Douglas, 2017). Some schizotypies are also predictive of conspiratorial belief (March et al., 2019)

Belief in conspiracy theories is intimately connected with feelings of fear, lack of control, or powerlessness (Imhoff and Bruder, 2014) and are exacerbated in times of social crisis (van Prooijen & Douglas, 2017). Social or political ostracism and marginalization also increases people's political conspiracy beliefs (Poon et al., 2020)

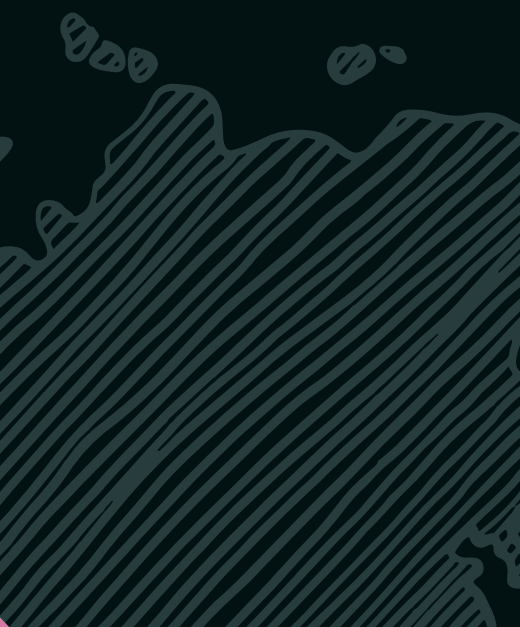
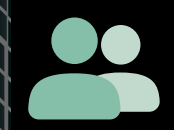


MOTIVATIONS

epistemic

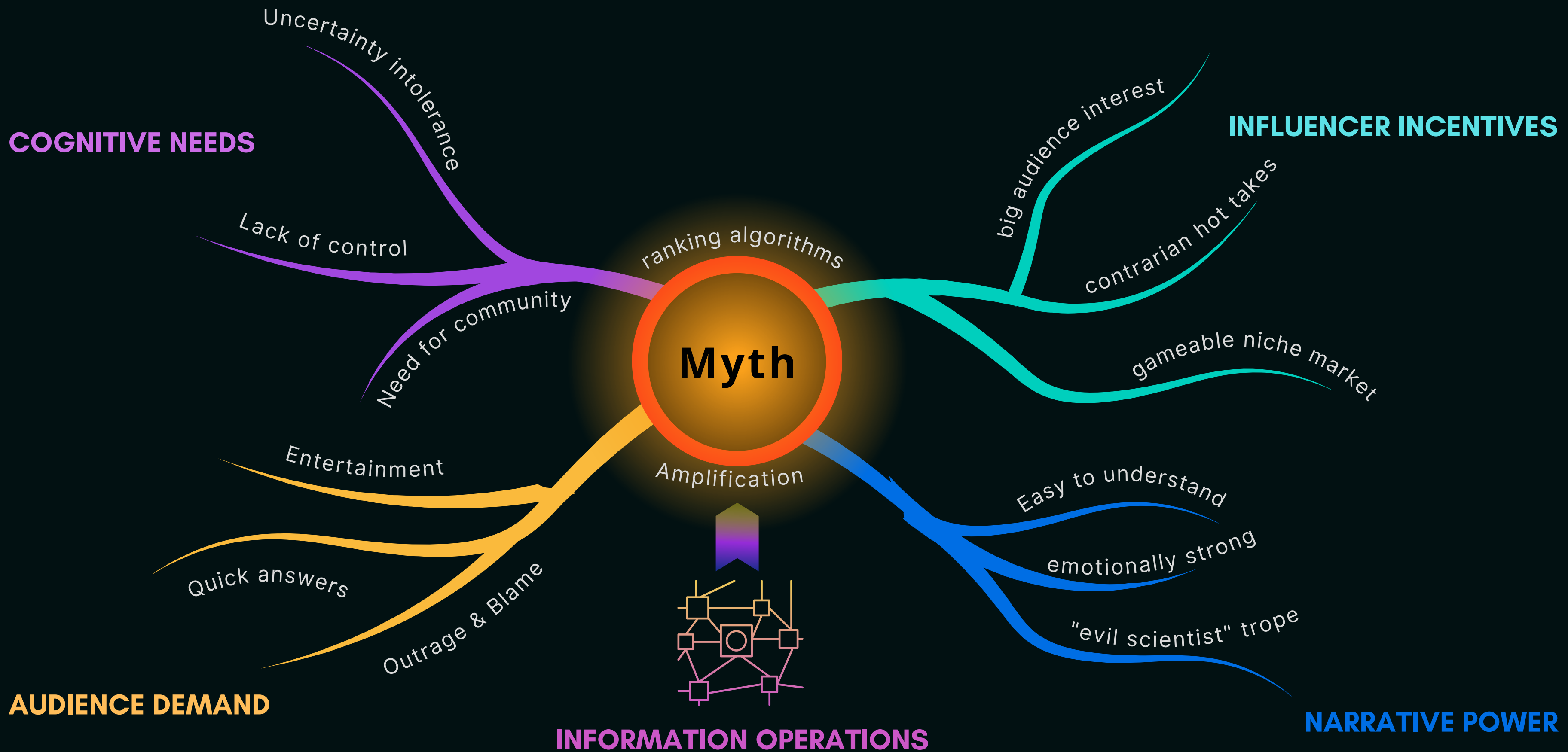
social

existential





# Many asymmetries on social media favor **compelling myths**, not **science**



## Conclusion Part 1

### Summary

- The attention economy is extremely unequal and dominated by only a small fraction of all participants
- influencers and other media manipulators are in competition to create & sell information products
- Microtargeting niche audiences and creating unique selling propositions for information content makes them more successful
- Science is not inherently attractive & science communication is limited by professional, ethical and factual requirements

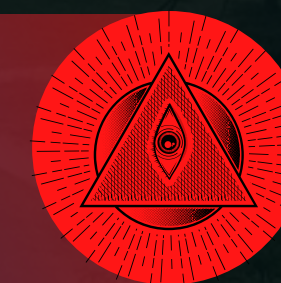
*Asymmetries in our info sphere tend to favor engaging falsehoods over mundane truths*



The attention economy **asymmetrically rewards** fast, entertaining and emotionally engaging content that is **custom-made for specific audience needs** and demands









favours science



favours falsehoods

# Science is a myth buster...

## The Merchants of Doubt

 <p>The "just asking" Questioners</p>	 <p>The sensationalist Storytellers</p>	 <p>The home-sleuthing Amateurs</p>
 <p>The contrarian "Experts"</p>	 <p>The grandstanding Moralists</p>	 <p>The perma-outraged Accusers</p>

Science disrupts the convenient stories we tell ourselves, and the narratives told by those who seek to control with fictions

**BREAKING:**  
Leaked documents point to STUNNING REVELATION



### The sensationalist Storytellers

#### Manipulating through "Optimized Fictions"

Storytelling is how we *make sense* of uncertain or novel situations (Currie & Sterelny, 2017, Bietti et al., 2019) **Sensationalist stories can shape public conversations**, even when baseless, speculative, or plainly false because compelling stories are full of peripheral cues such as familiarity, processing fluency and cohesion, thus creating an **"illusory truth effect"** (Wang et al., 2016 & Unkelback et al., 2017). Storytelling binds people together and creates shared cultures, which makes it an attractive tool for manipulators to undermine a scientific consensus.

**Science is bound by facts**, often boring and technical, whereas **fictions can be optimized** for narrative impact and audience demands.

BECOME A MEMBER

## LEAKED GRANT PROPOSAL DETAILS HIGH-RISK CORONAVIRUS RESEARCH

The proposal, rejected by U.S. military research agency DARPA, describes the insertion of human-specific cleavage sites into SARS-related bat coronaviruses.

Sharon Lerner, Maia Hibbett  
September 23 2021, 8:16 p.m.

PROPUBLICA

SCIENCE AND HEALTH CORONAVIRUS FEATURE FEBRUARY 6/13, 2023, ISSUE

## Unredacted NIH E-mails Show Efforts to Rule Out a Lab Origin of Covid

◆ WSJ NEWS EXCLUSIVE | NATIONAL SECURITY

## Lab Leak Most Likely Origin of Covid-19 Pandemic, Energy Department Now Says

U.S. agency's revised assessment is based on **new intelligence**

## COVID-19 Origins: Investigating a "Complex and Grave Situation" Inside a Wuhan Lab

The Wuhan lab at the center of suspicions about the pandemic's onset was far more troubled than known, **documents unearthed** by a Senate team reveal. Tracing the evidence, Vanity Fair and ProPublica give the clearest view yet of a biocomplex in crisis.

In my expert opinion, the WIV were doing GAIN OF FUNCTION research



### JEFFREY SACHS PRESENTS EVIDENCE OF POSSIBLE LAB ORIGIN OF COVID-19

An article in the Proceedings of the National Academy of Sciences calls for an independent investigation held by U.S.-based institutions that could determine the origins of Covid.

### Leading biologist dampens his 'smoking gun' Covid lab leak theory

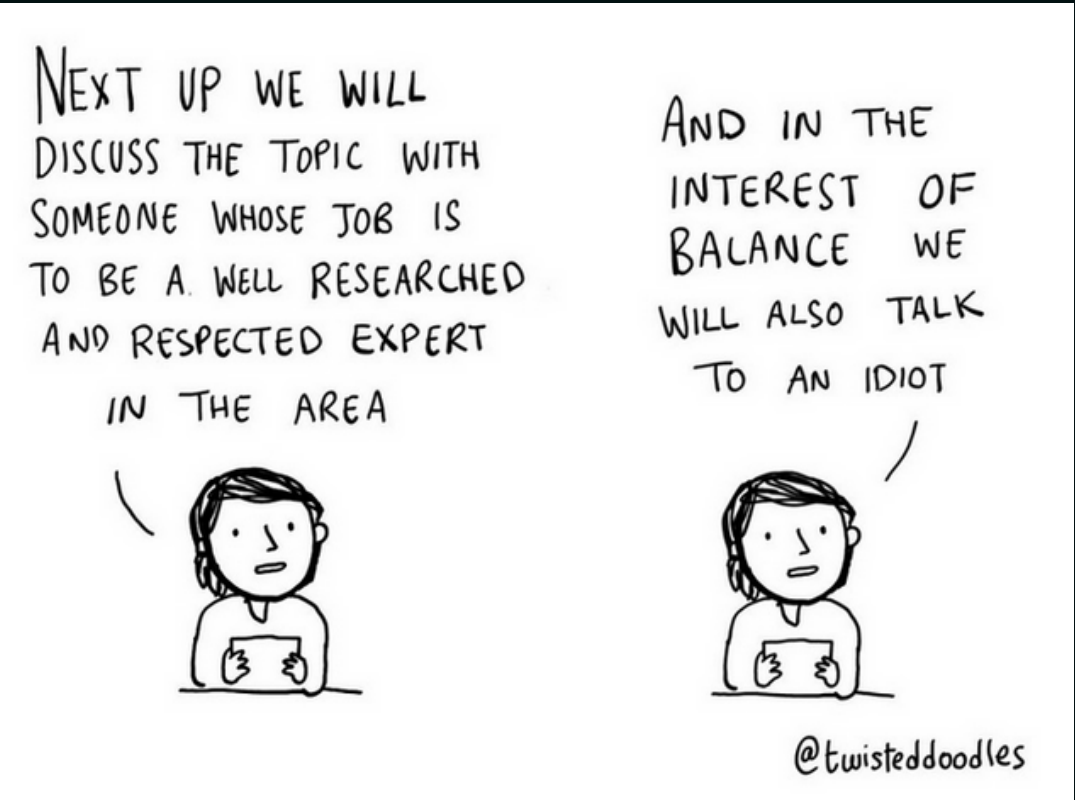
Nobel laureate David Baltimore says he overstated case, and the origins of the virus are still unknown

### The contrarian "Experts"

### Manipulating through "Media Neutrality Bias"

Audience perception and journalistic norms assume that there are always two sides to an issue. Journalists ought to act as "neutral transmitters" of information, and deviation from that invites charges of bias. Journalists feel a pressure to demonstrate that they take no sides, have no stake, ideology, or politics, and no views of their own (Kohl PA. et al., 2016).

Media neutrality bias can be exploited by credentialed contrarians to present groundless assertions next to well-established scientific truth, creating a false balance and doubt about established knowledge. Abusing a desire to present all views equally can be a Trojan horse for spreading damaging falsehoods (Grimes DR., 2019).



### Science takes back seat to politics in first House hearing on origin of COVID-19 pandemic

Familiar arguments aired in yet another Republican and Democratic sparring match

8 MAR 2023 · 6:30 PM · BY JON COHEN



RECKLESS VIROLOGISTS want us to forget millions of deaths!



### The grandstanding Moralists

#### Manipulating through "Moralizing Discourse"

People experience **moral outrage** when they perceive that a moral norm has been violated and express outrage when they believe that it will prevent future violations. Moral outrage is both amplified and trained by social media (Brady et al., Science, 2021) and **media manipulators** abuse our susceptibility to moral outrage to shape public discourse on scientific issues.

**Moral grandstanding** reduces free expression, makes deviation from shared beliefs socially costly (Tosi & Warmke, 2021) and is associated with status-seeking and conflict, not truth-finding (Grubbs et al., 2019). **Moral panics** (emotionally driven reactions to perceived crises) create divisions in medicine (Lasco & Curato, 2018).

**Benny Johnson** @bennyjohnson

Dr. Fauci paid Chinese virologists to create a bioweapon virus.

This is not up for debate. We have the receipts.

Then Fauci promised a "surprise pandemic" during the Trump administration a day before Donald Trump was sworn in as president.

Largest crime in human history? [Tweet übersetzen](#)



6:16 nachm. · 2. Jan. 2023 · 5,2 Mio. Mal angezeigt

25.503 Retweets 1.965 Zitate 71.763 „Gefällt mir“-Angaben

**Robert W Malone, MD** @RWMaloneMD · 2. März

The lab leak **killed** millions of people. Most likely, this research was done by the US Gov thru Ecohealth, with the CCP/**WIV** cooperating. Why is the USG/DTRA/NIH still funding **WIV** & Ecohealth? Why is the The Int. Court of Justice at the Hague not investigating? We need justice.

644 5.601 17.902 557.220

**Stew Peters** @realstewpeters · 14. Jan. I'm not going to debate this anymore.

It's a **Bioweapon**.

Read the patents.

Anyone who says otherwise, or is unwilling to say it is lying and complicit, and should stand trial for accessory to murder.

458 4.709 17.258 494.797

**Marjorie Taylor Greene** @mtgreenee · 24. Okt. 2021 It's time to pass my #FireFauci Act.

Funding the creation of a **bioweapon** that has killed millions of people and cruel experiments that torture puppies are the things only a monster could do.

What else has this psychopath done?

Fauci must be fired, investigated, and arrested.

# Anti-science discourse manipulators use same tactics

## The Merchants of Doubt – lableak edition

Why would you trust the CCP? Don't we need an independent investigation?

**BREAKING:** Leaked documents point to **STUNNING REVELATION**

How can a virus break out in a city that has labs? **THIS IS NO COINCINCENCE**

In my expert opinion, the WIV were researching **BIOWEAPONS**

**RECKLESS VIROLOGISTS** are playing with fire at our expense!

**Corrupt SHILLS and STOOGES!!!** Biggest **COVER-UP** of the century!!!



## The Merchants of Doubt – climate edition

Does the planet *really* heat up? What about global cooling? What about sun cycles?

**BREAKING:** Leaked emails of IPCC scientists **EXPOSE** uncertainty

Another record winter in a random place...**THIS IS NO COINCINCENCE**

In my expert opinion, volcanic **ACTIVITY**, not CO2, is responsible

**INNOCENT CHILDREN** are brainwashed into climate **HYSTERIA**

Establishment **SHILLS** promote a **#CLIMATESCAM** new world order

The grandstanding Moralists

The toxic Mudslingers

Manipulating through "Moralizing Discourse"

Manipulating through "Digital Repression"

People experience moral outrage when they perceive that a moral norm has been violated and express outrage when they believe that it will prevent future violations. Moral outrage is both amplified and trained by social media (Brady et al., Science, 2021) and media manipulators abuse our susceptibility to moral outrage to shape public discourse on scientific issues.

Mudslinging or negative campaigning is the purposeful attack of an opponent with smears, misrepresentations and falsehoods. It works by blaming or framing problems on issues the adversarial party has perceived ownership of (Seeberg, 2020). Multiple variations such as character assassination, poisoning the well or scapegoating exist (Smith & Eberly, 2021; Rothshild et al., 2012)

## The Merchants of Doubt – vaccine edition

Do vaccines *really* work? What about alternatives? What about long-term?

**BREAKING:** FDA whistleblower comes out with **STUNNING** claim

Another athlete died of mysterious circumstances... **THIS IS NO COINCINCENCE**

In my expert opinion, the mRNA vaccines are **UNSAFE**

**INNOCENT CHILDREN** are forced to take experimental jab!

Record profits for **BIG PHARMA!!!** Nuremberg 2.0 for medical fascists!!!



The "just asking" Questioners

The sensationalist Storytellers

The home-sleuthing Amateurs

The contrarian "Experts"

The grandstanding Moralists

The toxic Mudslingers

Manipulating through "Framing Effects"

Manipulating through "Optimized Fictions"

Manipulating through "Anomaly Hunting"

Manipulating through "Media Neutrality Bias"

Manipulating through "Moralizing Discourse"

Manipulating through "Digital Repression"

Questions act as a collection of possibilities with attached social expectations. One such expectation is that "Question Set" in the conversation is something everyone is committed to answering (Portner, P., 2004). This social aspect of discourse opens the door for bad actors to covertly shape the conversation through the tactical use of illegitimate, dishonest, misleading, or manipulative questions.

Storytelling is how we make sense of uncertain or novel situations (Currie & Sterelny, 2017; Bietti et al., 2019). Sensationalist stories can shape public conversations, even when baseless, speculative, or plainly false because compelling stories are full of peripheral cues such as familiarity, processing fluency and cohesion, thus creating an "illusory truth effect" (Wang et al., 2016 & Unkelback et al., 2017). Storytelling binds people together and

Anomalies, fake or real, are powerful anecdotes that capture attention. Anomaly hunting is a social practice that aims to find unexplained phenomena or coincidences that are perceived at odds with "official" narratives on a topic (Wood & Douglas, 2013). They shape perceptions because we have a tendency to seek patterns in random signals that manipulators can

Audience perception and journalistic norms assume that there are always two sides to an issue. Journalists ought to act as "neutral transmitters" of information, and deviation from that invites charges of bias. Journalists feel a pressure to demonstrate that they take no sides, have no stake, ideology, or politics, and no views of their own (Kohl PA, et al., 2016). Media neutrality bias can be exploited

People experience moral outrage when they perceive that a moral norm has been violated and express outrage when they believe that it will prevent future violations. Moral outrage is both amplified and trained by social media (Brady et al., Science, 2021) and media manipulators abuse our susceptibility to moral outrage to shape public discourse on scientific issues.

Moral grandstanding reduces free expression, makes deviation from held beliefs socially costly (Tosi & Burke, 2021) and is associated with s-seeking and conflict, not truth-telling (Grubbs et al., 2019). Moral acts (emotionally driven reactions to perceived crises) create divisions in society (Lasco & Curato, 2018).

Mudslinging or negative campaigning is the purposeful attack of an opponent with smears, misrepresentations and falsehoods. It works by blaming or framing problems on issues the adversarial party has perceived ownership of (Seeberg, 2020). Multiple variations such as character assassination, poisoning the well or scapegoating exist (Smith & Eberly, 2021; Rothshild et al., 2012)

Media manipulators regularly use these strategies to discredit inconvenient experts or institutions, create toxicity and foment online hate against them. Online hate has a chilling effect and can be weaponized to suppress free speech and silence dissent, a form of digital repression (Earl J. et al., 2022).

# Discourse manipulators are pretty good **velocity hackers**



*Certain information products (i.e a funny meme, a tweet we like, an outrageous video, or a sensationalist article) have an easier time spreading through society than their competition.*

## What is information velocity?

- Velocity refers to the speed of how information flows through a social network
- We want information products that have high relevance to us to have high velocity
- .Velocity can also be understood as a measure of contagiousness.
- Velocity hacking is the true business model of information merchants

- **Velocity is a property of information that can be optimized**  
Two identical articles can have very different velocities depending on their headline. Two identical videos can have very different velocities by just changing the thumbnail.
- **Velocity is not related to the merit of information content.**  
Misleading, false, or harmful information about an issue can have much higher velocity than competing good information on the same issue
- **Velocity is dependent on the social and media environment.**  
Seeding information microtargeted at specific communities/echo chambers/niche audiences might spread faster and further than seeding it organically or randomly, where it might not spread at all and die out.



# How to hack information velocity?

## Example of velocity hacking:

### Some used tactics:

- A) *sensationalist content optimized for successful keywords like "gain-of-function, Fauci, bioweapon, lab leak"*
- B) *visual differentiation of suggestive content through yellow marking*
- C) *clout chasing of prominent influencers e.g by tagging & highlighting antivaxx activist RFK Junior to get amplified by his sizable online audience (and to target that audience too!)*
- D) *content is designed to provoke moral outrage with outrage-inducing lies*
- E) *copies a previous viral tweet by using Elon Musk's reply & starts a thread to get people deeper engaged*

**There is an industry trying to figure out how to best hack velocity & go viral**



# Velocity hackers dominate discourse

## TOXIC VELOCITY HACKING

- I** Use the attention on the news/events /crises of the day to time, frame or shape content with audience preference
- II** Visual differentiation through manipulative capitalization, structure, linked content
- III** Use emotionally charged language, keywords, topics and ideologies to provoke moral outrage
- IV** Target influencers and their audiences with QTs, snapshots or linked content that will likely get a reaction (good or bad!)
- V** Be fast to react to a viral tweet and produce identically copies in either word/structure/spirit.
- VI** Politicize, polarize, attack, denounce, deceive etc. to signal your tribal allegiance to targeted audiences & to provoke ideological enemies

**Truth Justice™** @SpartaJustice · 17. März

BREAKING NEWS: Three U.S. Law Enforcement Agencies working to bring indictments against Ralph Baric, Anthony Fauci and Peter Daszak who collaborated to bring this global pandemic, genocide and **bioweapon** against all of humanity. Over 14 million dead from the **bioweapon** vaccines....

**PASCAL NAJADI - TRIBUNAL JUDGE**  
SWISS CRIMINAL COVID CASE AGAINST SWISS PRESIDENT  
417.738 Mal angezeigt 0:14 / 9:35

575 8.426 16.449 1 Mio.

**Collin Rugg** @CollinRugg

BREAKING: CNN told their staff to not share COVID-19 “lab leak” theory due to it being a “Trump talking point.”

Hey @elonmusk: When are you going to label CNN as State Affiliated Media?

Zuletzt bearbeitet 5:03 nachm. · 6. März 2023 · 2,8 Mio. zeigt

5.366 Retweets 119 Zitate 37.156 „Gefällt mir“-Angaben

**Kyle Becker** @kylenabecker

If the Covid lab leak theory being a 'conspiracy theory' was a lie and '15 days to stop the spread' was a lie and 'masks work' to stop the spread was a lie and 'vaccine mandates will stop the spread' was a lie and 'natural immunity is a myth' was a lie and 'there are no side effects' was a lie and 'safe and 100% effective' was a lie then you can pretty much bet that whatever the U.S. government is telling us about anything right now is a lie.

9:25 nachm. · 26. Feb. 2023 · 5,1 Mio. zeigt

11.207 Retweets 622 Zitate 52.085 „Gefällt mir“-Angaben

**Catturd™** @catturd2 · 27. Feb.

We were right about the **lab leak**.  
We were right about natural immunity.  
We were right about masks.  
We were right about lockdowns.  
We were right about the vaccines.  
We were right about boosters.  
We were right about them faking COVID numbers.  
We were right about the deadly... [Mehr anzeigen](#)

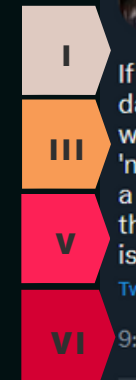
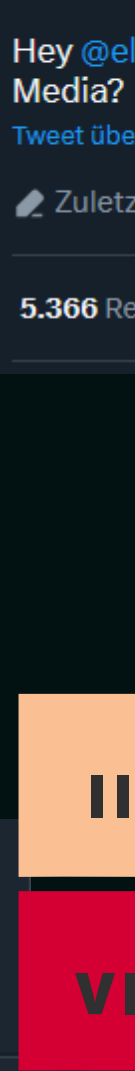
5.258 51.487 182.185 10,9 Mio.

**Graham Allen** @GrahamAllen\_1 · 27. Feb.

We were right about the **lab leak**.  
We were right about natural immunity.  
We were right about masks.  
We were right about lockdowns.  
We were right about the vaccines.  
We were right about boosters.  
We were right about them faking COVID numbers.  
We were right about the deadly hospital... [Mehr anzeigen](#)

1.289 11.890 52.855 2,9 Mio.

4 hours later



## Conclusion Part 2

### Summary

- Science faces a lot of opposition from public and powerholders when it interferes with commonly held beliefs or strategic interests
- Science in general is however highly regarded in public, and outright rejection of science is unpopular
- A common tactic has been to denounce scientific experts, deny a scientific consensus exists, and deceive the public about the state of evidence
- Gaming the info sphere through paid, inauthentic or artificial amplification and toxic velocity hacking defines what most people get to see most of the time

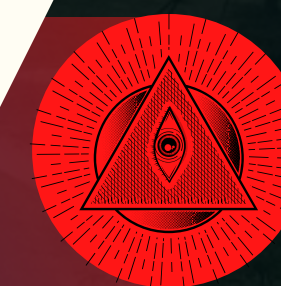
*The velocity of information products is independent of what we traditionally valued about information content, i.e the relevance, accuracy, context, utility, or truthfulness of its content.*



Discourse manipulators **sabotage & drown out scientific** voices when scientific results interfere with popular sentiment or strategic, ideological or financial goals



favors science



favors falsehoods

# Information pathogens

*While biological pathogens compete over space in our host bodies, information pathogens compete over space in our minds.*



## The making of information pathogens

- When information is judged based on **ability to capture engagement**, not truth or value of content
- when the **information environment gets artificially distorted** to facilitate spread
- when **harmful information is recklessly optimized** for spread

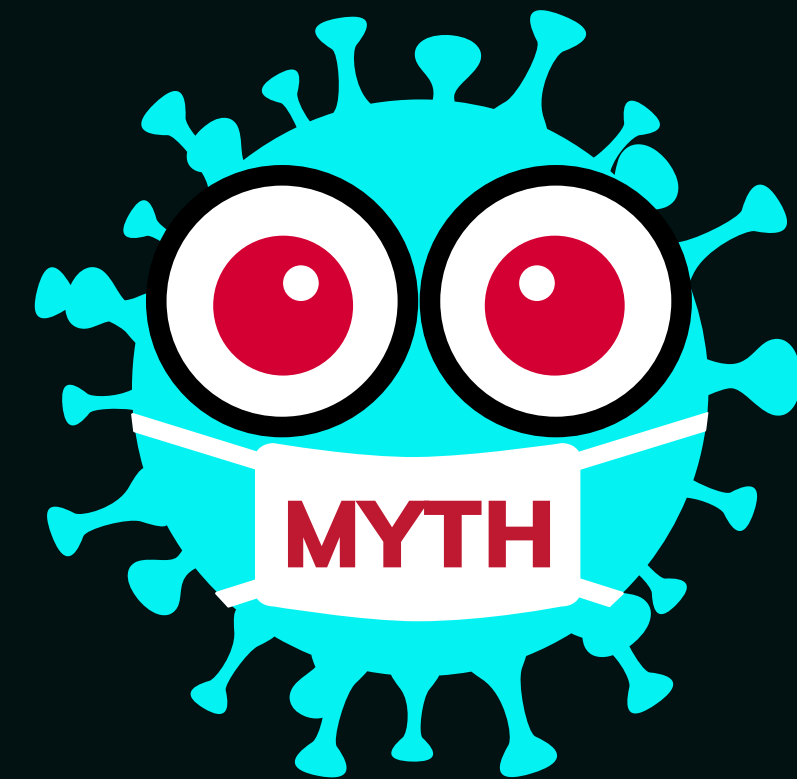
**Then:** Information products turn into information pathogens

### Information viruses harm our societies

they make people sick with false perceptions & beliefs.

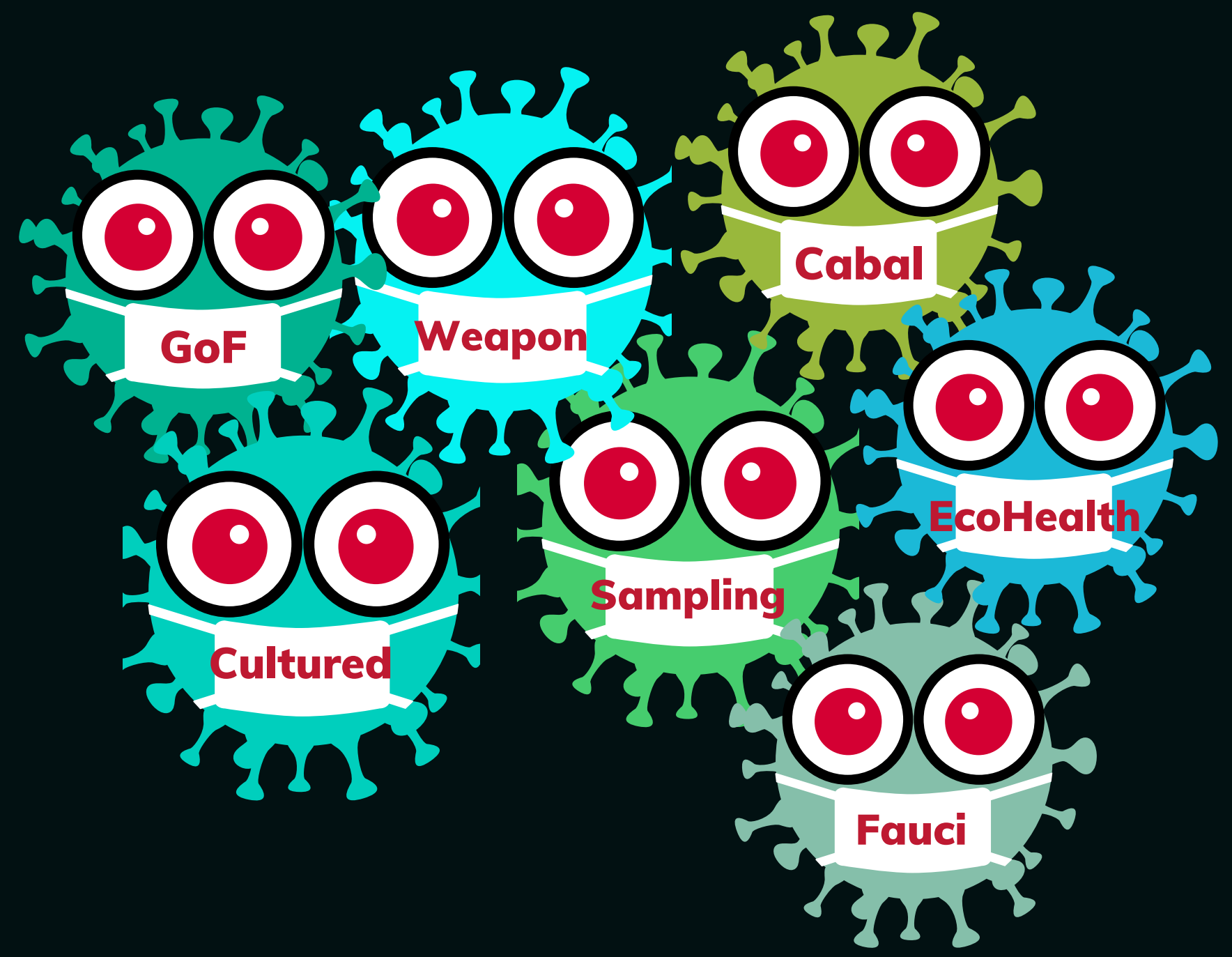
**The WHO: infodemic of false and misleading information.**

**George Gao calls for infodemiology: the study of information viruses.**



**Information pathogens are toxic organisms that we get exposed to without our seeking. They break into our attention and minds against our will.**

# Information pathogens use us as hosts and adapt

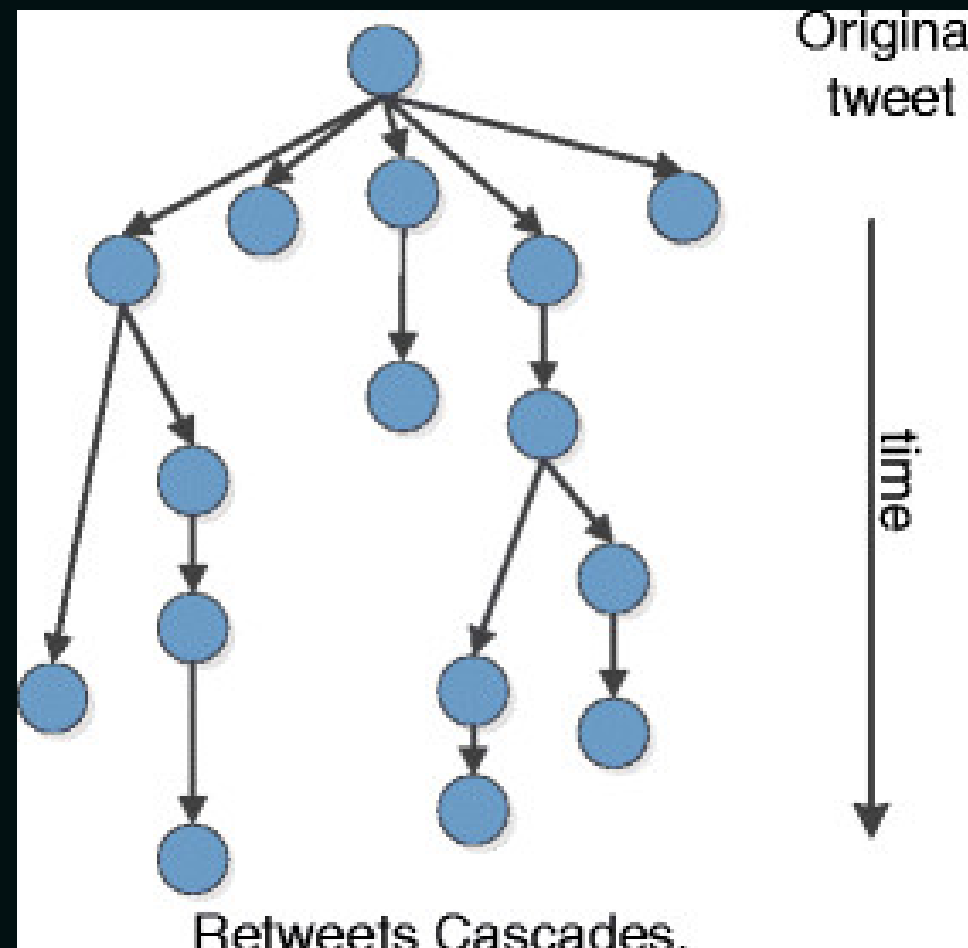


Information pathogens, once they spill over, are often outside our control

- **adaptation:** just like biological viruses, information pathogens develop a life of their own when they take over minds, they mutate
- **chronic infections:** information pathogens can entrench themselves in the form of beliefs and world views
- **outbreaks cause crises:** biol. pathogen cause health crises, information pathogens cause epistemic crises; the loss of ability to tell what is real and what is true

# Information cascades

In many social and economic situations, individuals are influenced by the decisions of others. Information cascades describe a sequential series of coordinated decisions, like buying a new product.



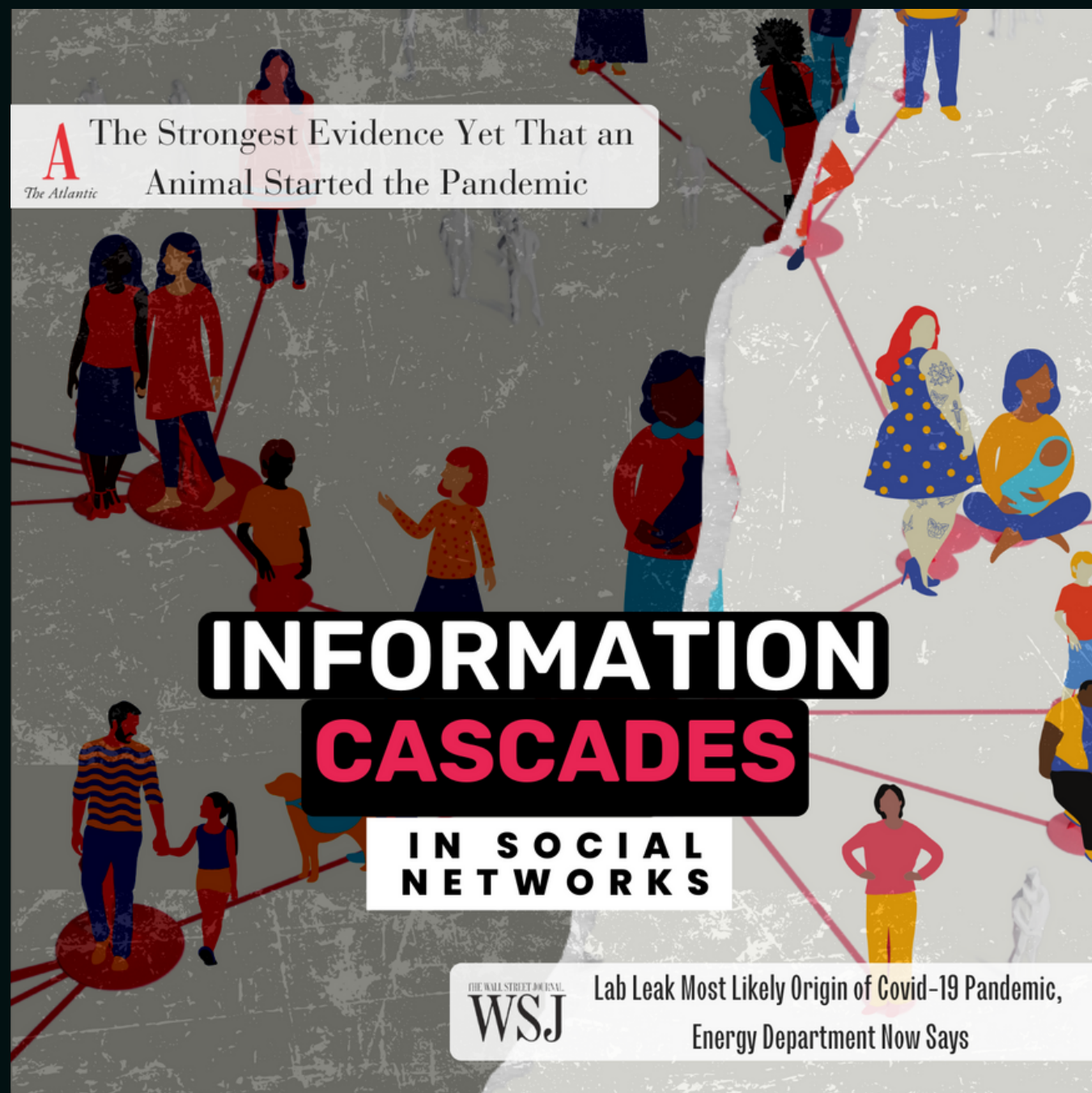
Zhuang, K. et al., Multimed Tools Appl, 2017

## Information cascades on social media

- bit imprecise, standing in for phenomena such as information diffusion, social persuasion, or influence
- works when we see information on social media as a product
- we make the binary decision to reject or buy it in the form of liking/sharing/commenting
- our decisions are not fully our own, they depend on decisions others took before us

# Information cascades restructure social networks

## The latest lab leak information cascade



*Information cascades both amplify and make us vulnerable to outbreaks of viral information pathogens.*

**Research suggest viral news coverage can create political polarization by sorting social networks along political lines.**

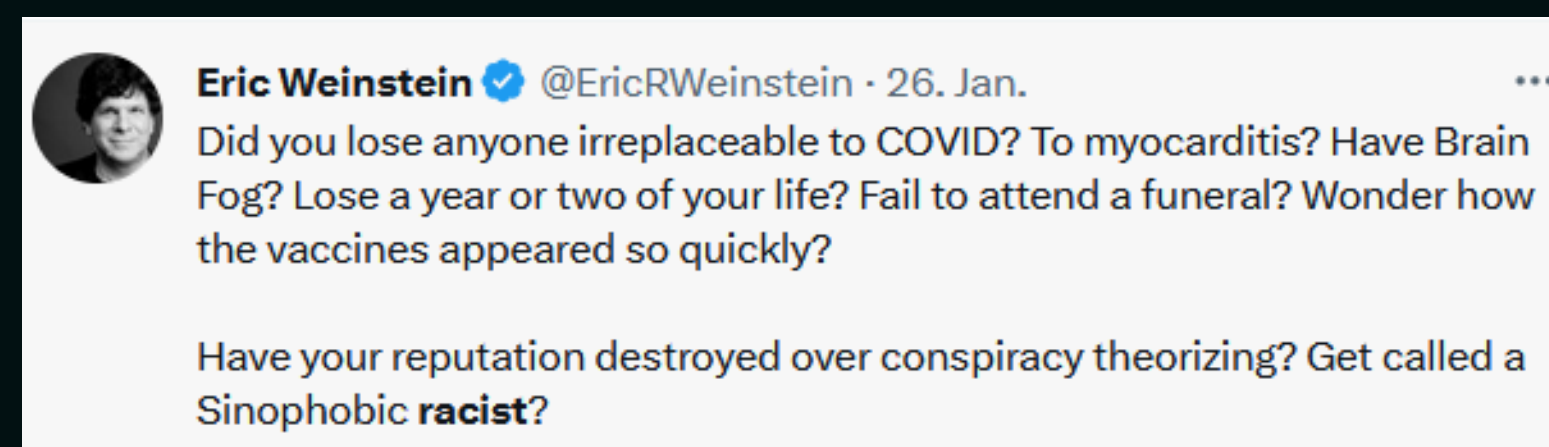
*[...] information cascades can create assortative social networks, where people tend to be connected to others who are similar in some characteristics. Tweet cascades increase the similarity between connected users, as users lose ties to more dissimilar users and add new ties to similar users. — (Myers & Lescovex, Proceedings of the 23rd international conference on World wide web, 2014)*

*[...] Twitter users who follow and share more polarized news coverage tend to lose social ties to users of the opposite ideology. (Tokita CK. et al., PNAS, 2021)*

# Information pathogen outbreaks rely on information cascades

- **natural immunity:** As with most viruses, there is a vast number of diverse strains that spill over, infect humans, and sizzle out soon after
- **vulnerable communities:** discourse manipulators create psychological and social circumstances that favor infections with info pathogens
- **amplification cascade:** when an info pathogen meets such close-knit vulnerable communities, they become amplifiers that **can start info cascades**
- **self-sustaining outbreaks:** within these niche audiences, chronically infected hosts become reservoirs that breed ever new variants

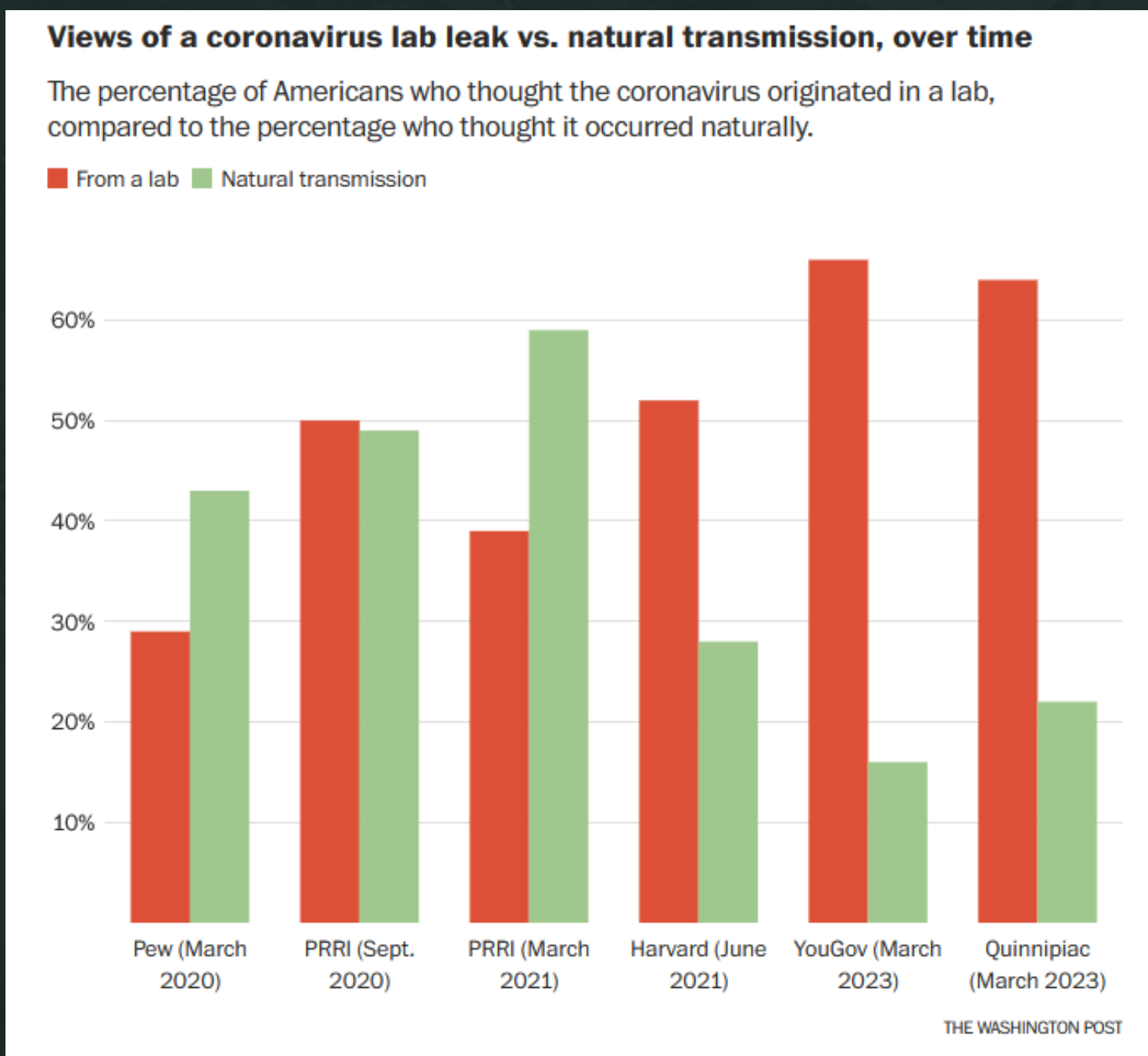
Anti-science, anti-establishment conspiracy theory entrepreneurs create vulnerable communities where information pathogens can fester and gain momentum





# A contagious topic: Covid-19 origins

Recent pools find that 68% of Likely U.S. voters think it's likely that the COVID-19 virus originated in a Chinese laboratory, including 48% who say it's Very Likely



The Washington Post  
*Democracy Dies in Darkness*

## How the covid lab leak became the American public's predominant theory

Analysis by [Aaron Blake](#)  
Staff writer

March 16, 2023 at 3:33 p.m. EDT

News | Coronavirus pandemic

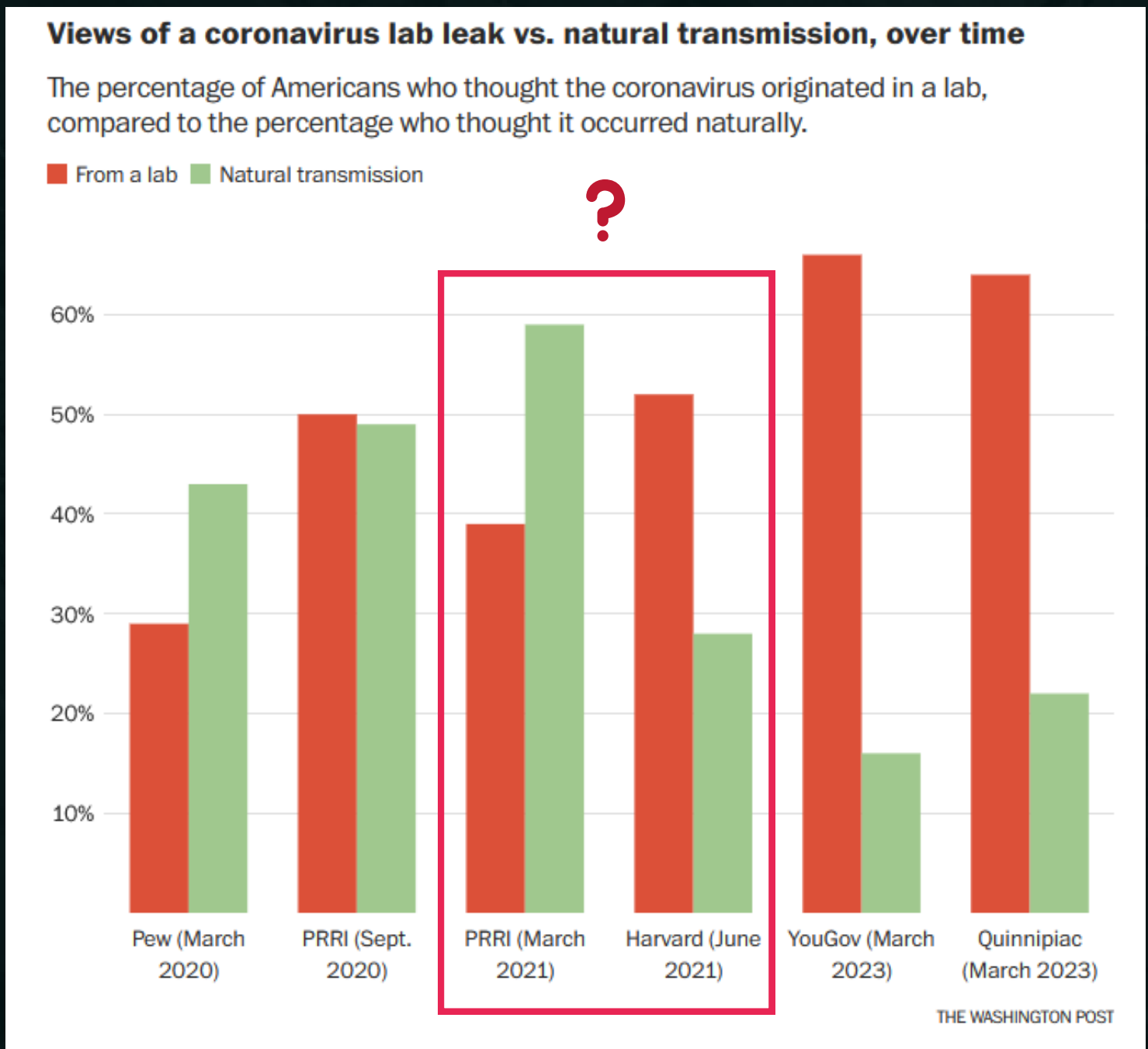
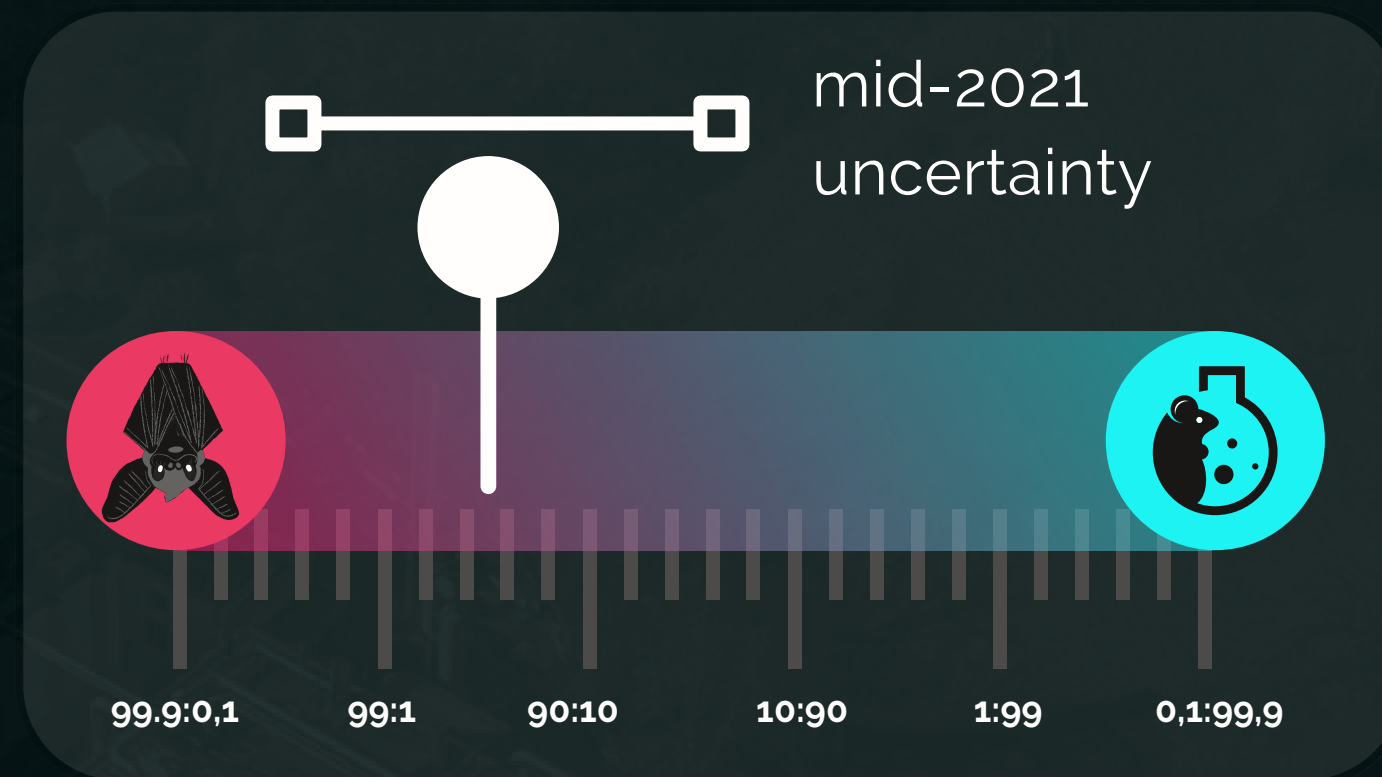
### Reports on COVID origin reignite conspiracy theories about virus

*FBI director, US Department of Energy say the coronavirus originated in a lab, but other US officials say there's no consensus.*

# A contagious information cascade



*The scientific evidence did not change, the media coverage did*



- by mid-2021, the 'manmade' theory has been incubated for a year, and a new set of viral variants emerged from isolated communities
- these information pathogens were optimized for media manipulation and had incredibly high velocity
- many amplifiers in the media made the same decision to cover the lab leak story in the same way, causing an information cascade, and that outbreak infected much of the world

# Lableak: A history of digital outbreaks



*The lableak theory is dead. The lableak cover-up myth will never die.*

## EMERGENCE OF A NEW PNEUMONIA OF UNKNOWN ORIGIN

-  **BIOWEAPON "WHISTLEBLOWER"**  
A chinese dissident billionaire and rightwing political actor Steve Bannon push a bioweapon conspiracy based on gibberish, also Trump spreads the 'China virus' narrative
-  **"UNNATURAL" CHINA VIRUS**  
Social media claims, fired on by pseudo-experts and online grifters, claim that SC2 has an 'unnatural' binding affinity to humans that only deliberate design could bring forth
-  **"SECRET" RATG13 & MOJIANG MINE**  
Internet sleuths and LARPer use google translate to browse through old master theses from WIV studentts, decontextualizing data to feed the conspiracy myth. Many of these talking points will be amplified by shady actors and incompetent media
-  **"SMOKING GUNS" FOR ENGINEERING**  
Contrarian scientists, journalists and commentators are given ever-bigger platforms to spread highly engaging and sensationalist claims that are not supported by evidence
-  **"BLUEPRINT" PROJECT DEFUSE**  
Anti-science activists & self-proclaimed internet investigators start attacking experts, weaponize decontextualized FOIA requests to intimidate, silence and harass anybody who speaks up against rampant conspiracsm
-  **"COVER-UP" IN US LABS**  
Political actors use a weaponized conspiracy myth as a tool for personal profit, and to induct people into rightwing ideology and anti-democratic radicalization

*That wave infected me*

Pandemics & outbreaks were always followed by conspiracy myths that blame somebody for it - few ever spread better than the biological virus

We've seen multiple information cascades over the years amplifying different variants of the same viral pathogen

Some variants were better at spreading, others got outcompeted

Like Covid-19 itself, the lableak information pathogen has become endemic and will keep infecting society

# I got infected too, for months I believed in a lab leak...



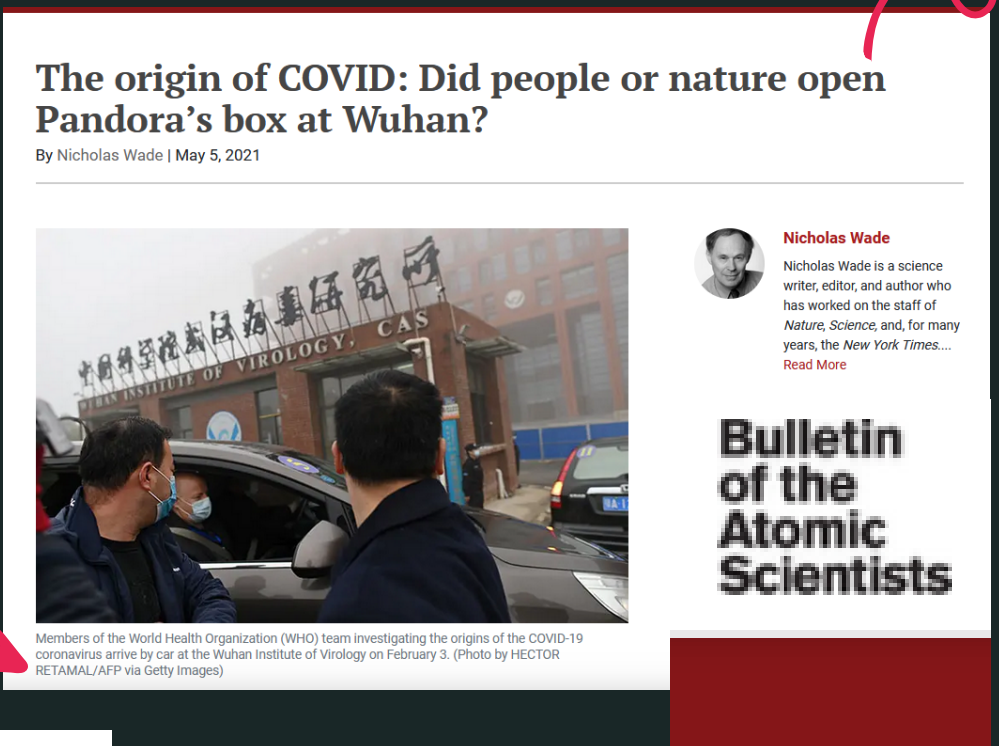
*I felt my insider knowledge on lab accidents gave me the edge to judge the odds better than most.*

Summer 2020



Bret Weinstein and Yuri Deigin: Did Covid-19 leak...

May 2021



The blog was written in April, 2020

## Lab-Made? SARS-CoV-2 Genealogy Through the Lens of Gain-of-Function Research



Philipp Markolin @PhilippMarkolin

May 2021

Antwort an @PhilippMarkolin und @ESYudkowsky

I personally tend to believe that it is more likely than not that SARS-CoV-2 is part of a lab leak than not, but I am open to new evidence and aware that at the moment, both scenarios (natural vs leak) are very much possible. In any case, I am for finding out.



Philipp Markolin @PhilippMarkolin · 20. Mai 2021

Antwort an @PhilippMarkolin @StartsWithABang und @SCStreet  
And probably that is what many people think when they hear: "lab leak". But lab leaks did happen before, and none of them was because of bioweapon research. Incompetence will always be a better explanation than malice, and the Wuhan BL4 lab failed BL4 standards before on record.

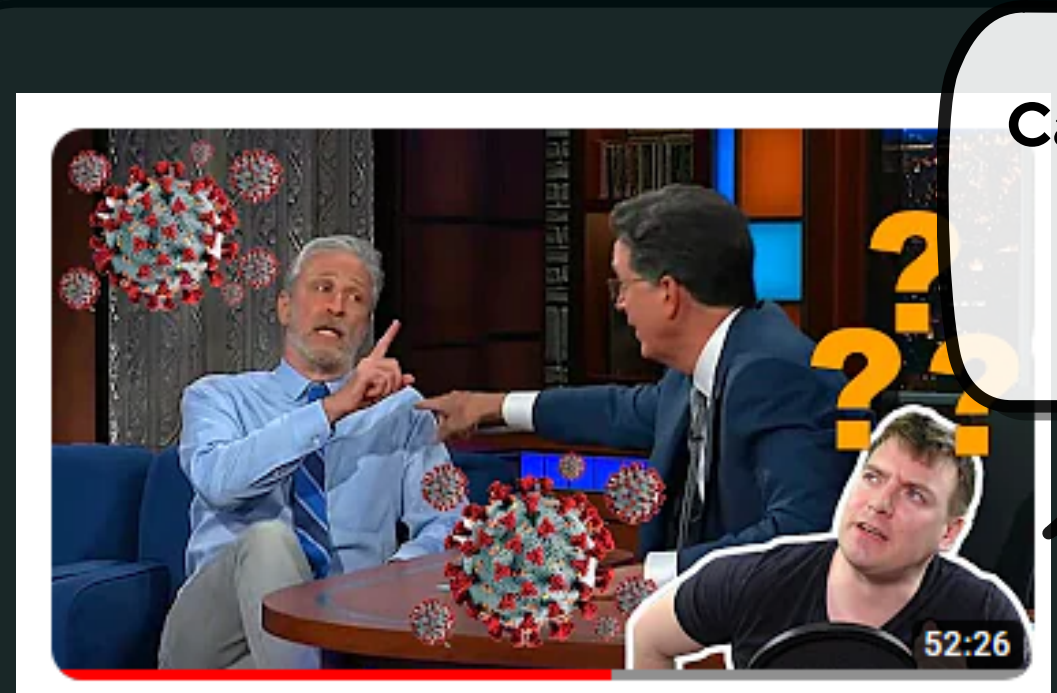


Philipp Markolin @PhilippMarkolin · 20. Mai 2021

Antwort an @PhilippMarkolin @StartsWithABang und @SCStreet  
And just to give some personal perspective working BL2: I know many people who made mistakes on this level, from throwing stuff away wrongly, not disinfection properly to self-infection (through eyes, open wounds) to even self-injection (stabbed themselves with viral syringe)

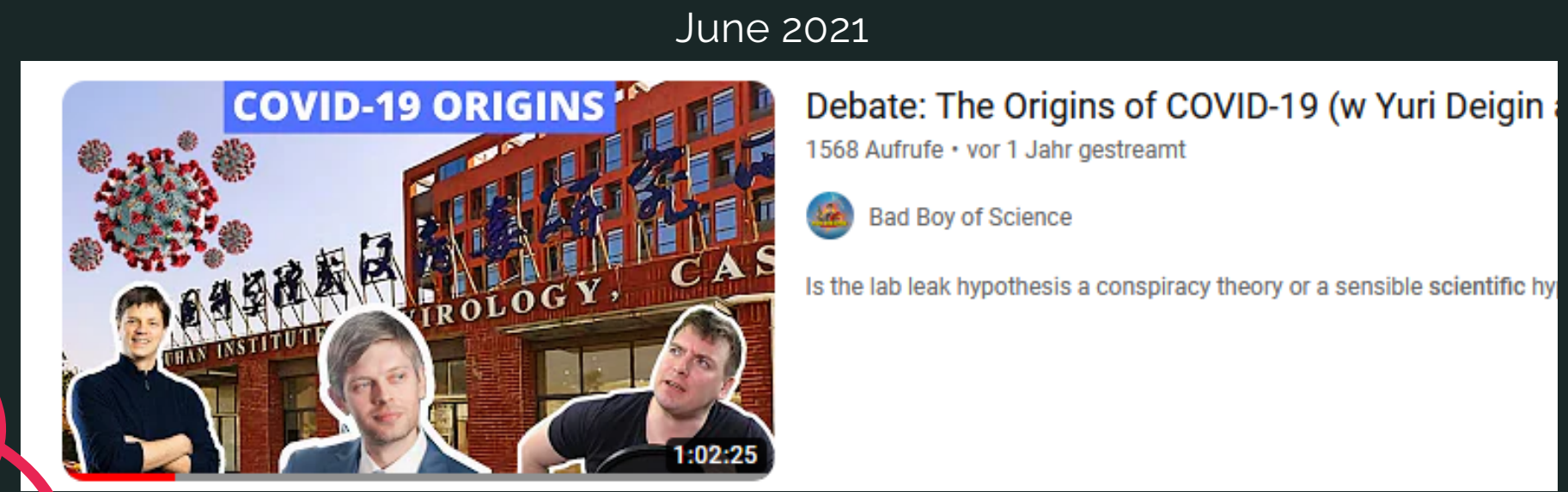
# ...until I tried to really understand it

*I tried to find every argument for and against a potential human origin of SARS-CoV-2*



Can we look into the evidence behind this?

4 weeks later



**Philipp Markolin** @PhilippMarkolin · 20. Juni 2021  
 Antwort an @PhilippMarkolin @Samuel\_Gregson und @horizonSci  
 I have to correct this point. Having paid more attention to the actually sequence of the furin cleavage site, especially the out-of-place proline in front, it is highly unlikely any genome engineer would come up with that, only evolutionary processes.

**Sam Gregson** @Samuel\_Gregson · 20. Juni 2021  
 Antwort an @PhilippMarkolin und @horizonSci  
 We've been through quite the journey of discovery this week 😊

**Philipp Markolin**  
 Jun 21, 2021 · 11 min read · Listen

## Explained: The hard evidence why the SARS-CoV-2 genome was not engineered and unlikely leaked

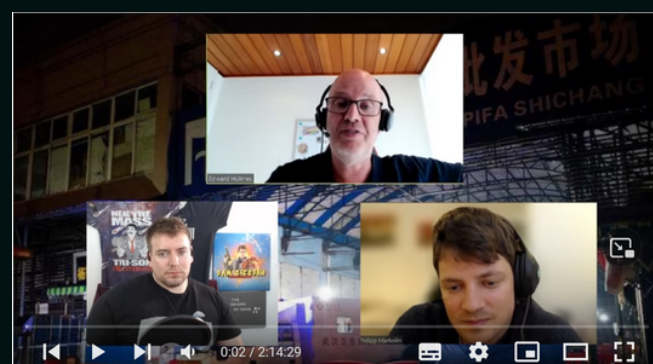
The science behind ACE2-domain adaptations, furin cleavage site and 'CGG' codon usage among other considerations

# Countering bad information on social media

*What could I do to bring science back into focus?*



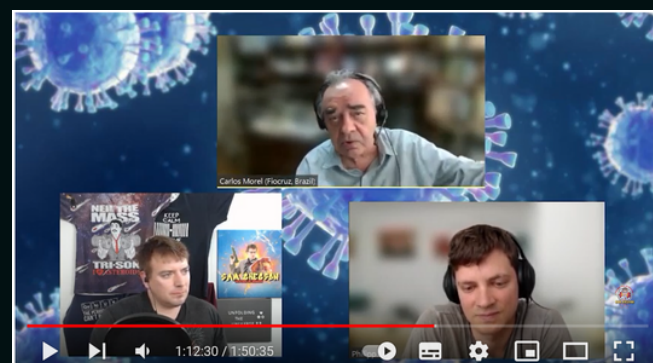
## Expert interviews



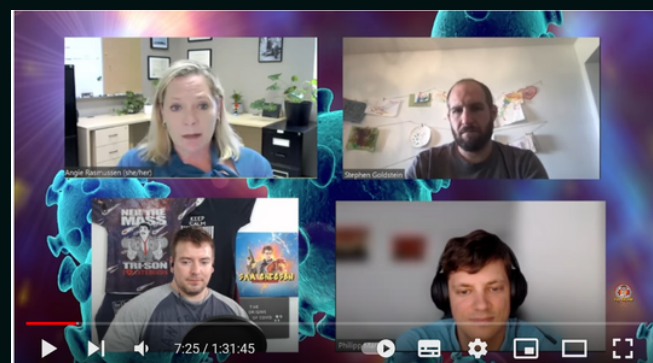
Eddie Holmes: Zoonotic Diseases, China, Fauci, And The Lab Leak Hypothesis



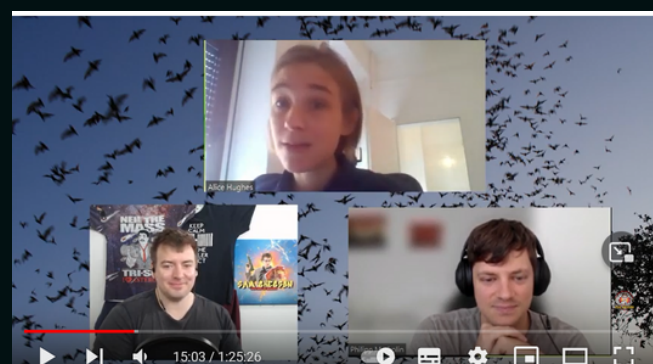
Is The COVID Lab Leak Hypothesis Dead? w Kristian Andersen, Mike Worobey & Philipp Markolin



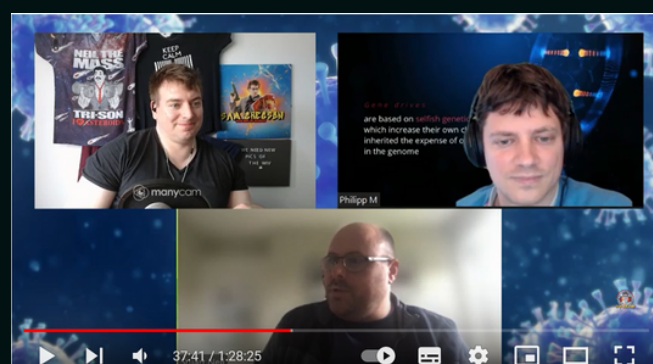
Novel Pathogens, Lab Leaks and the WHO (w Dr Carlos Morel and Dr Philipp Markolin)



Debunking Bad Lab Leak Arguments - w Angela Rasmussen, Stephen Goldstein Philipp Markolin



Bats, Ecosystems And Guarding Against SARS-CoV-3



COVID ORIGINS: The Latest Evidence (w Stuart Neil and Philipp Markolin)

## longform articles



### Algorithmic misinformation

Online conversations are routinely plagued by extremist and polarizing narratives with little attachment to factual reality. The more attention any particular topic garners, the worse the online information system surrounding it becomes.



### The true origins of SARS-COV-2

Scientific uncertainty is common but not ever-lasting. In the absence of clear scientific proof, or direct and compelling evidence, scientists use a Bayesian probability framework to assess the likelihood of competing hypotheses.



### The grifter playbook

Influencers and grifters usually excel at one particular thing: Catching eyeballs and building trust with their audiences so they can then leverage that 'special' relationship into some kind of profit.

# The reward? Toxicity

*Current public discourse is mostly driven by a polarized tribal war about world views, not scientific evidence*



Speaking up for science and a zoonotic origin has been difficult because scientists, journalists and even commentators arguing against the lab leak hypothesis have been insulted, harassed, ridiculed, doxxed, intimidated or received death threats.

I get mostly called a paid shill, a propagandist or a troll. Lies & memes are spread about me, My employer was urged to fire me and some private information released.



## Conclusion Part 3

### Summary

- Reckless and toxic optimization of information products creates information pathogens
- Like biological pathogens, information pathogens adapt & develop a life of their own
- Information cascades restructure our social networks and make society more vulnerable to information pathogens and quite exploitable by profiteers and bad actors
- Information pathogens such as conspiracy theories can infect whole populations when spread via information cascades and become entrenched in communities that turn into breeding grounds for new variants

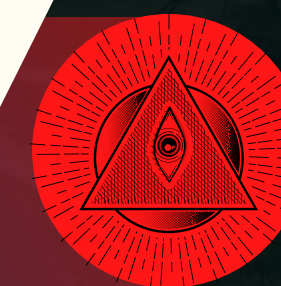
*The velocity of information products is independent of what we traditionally valued about information content, i.e. the relevance, accuracy, context, utility, or truthfulness of its content.*



Contagious information pathogens spread via **information cascades** play a key role in **the fragmentation** of our info sphere and cause societal and epistemic crises



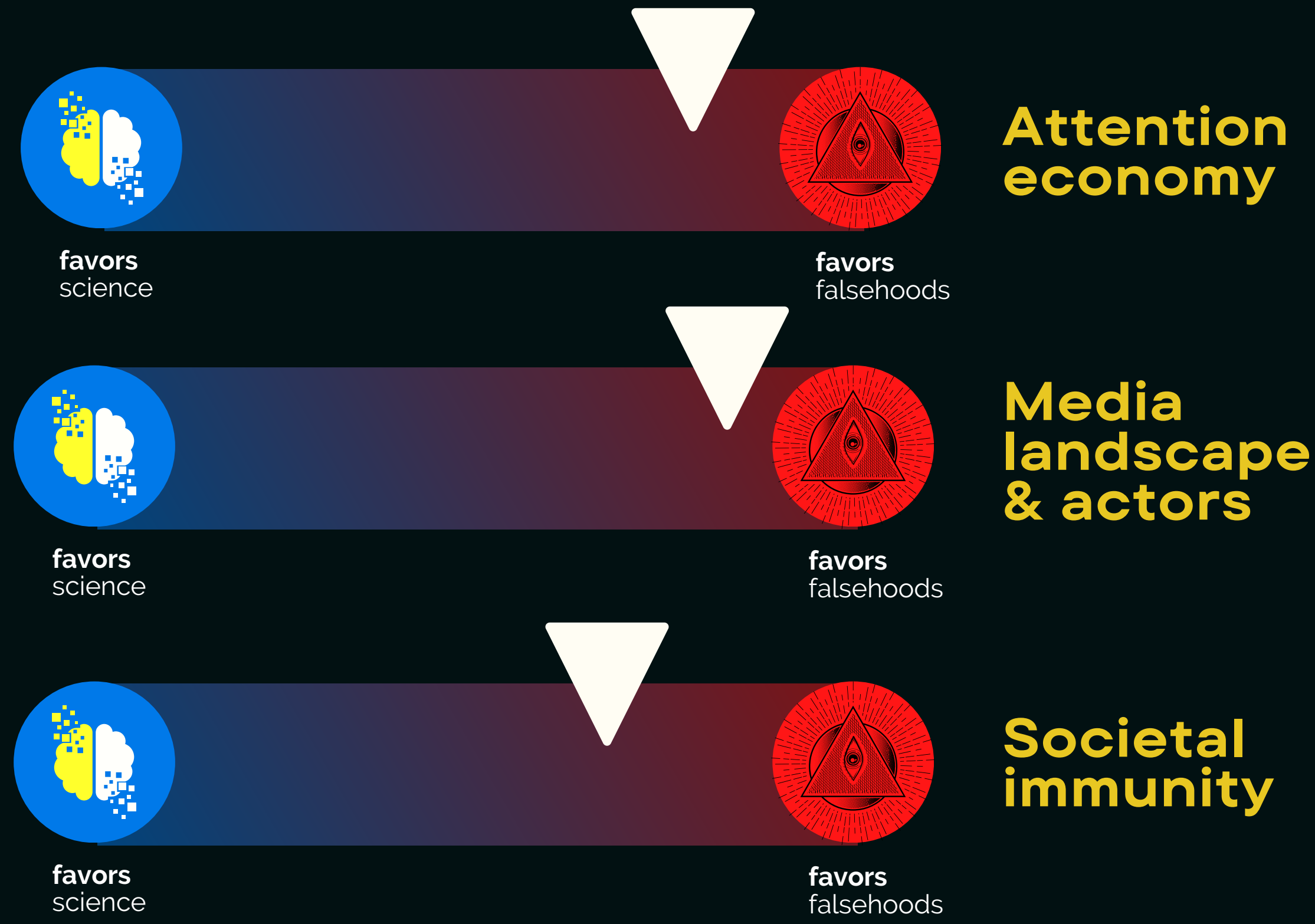
favours  
science



favours  
falsehoods



# We have created an ecosystem where anti-science falsehoods flourish



How can we move these levers back to favor science?

”

*The candle flame gutters. Its  
little pool of light trembles.  
Darkness gathers. The  
demons begin to stir.*

*—Carl Sagan, The Demon-  
Haunted world*

04

Concluding remarks



# The shifting use of information in society



We are used to judge information based on "content", not on "effect"

## Information content

- we build institutions and democratic societies that operated on an assumption: that **citizens value, want and deserve good information** that is factual, timely, relevant, accessible, useful, contextual and accurate
- content includes what we traditionally understand of as information; i.e the merit comes from **the substance of what is said, written, shown** or otherwise communicated

## Information effect

- the attention economy caused the **commodification of information** into a digital product that is judged based on its **utility to further the financial, strategic or ideological aims** of information combatants
- effect includes old and new attributes of information that go beyond content, how it flows through society, how it is received, impacts human behavior, beliefs or worldviews, i.e the merit comes from **how effectively it manipulates our shared info sphere**

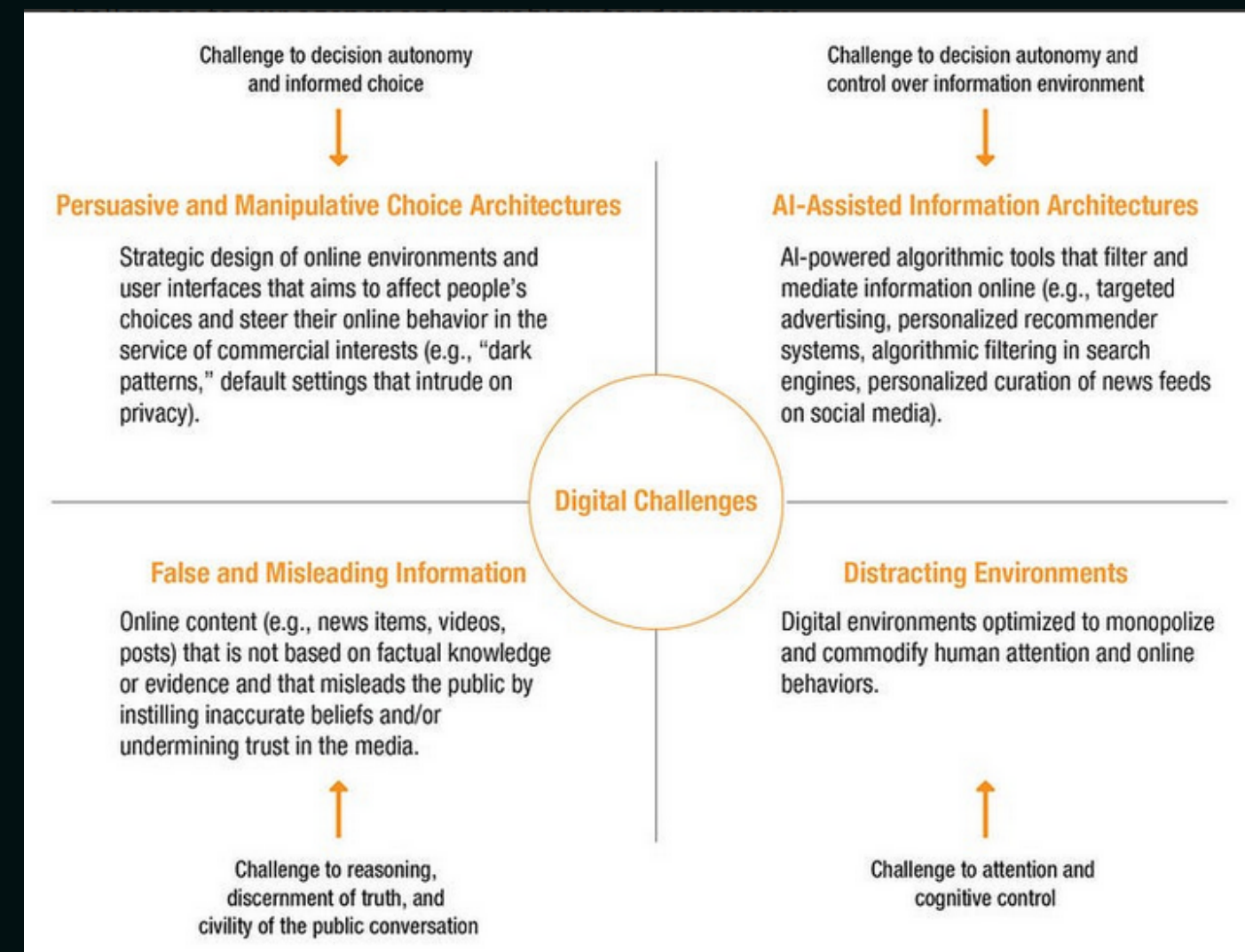
# How does information flow through society?



## Current roadblocks for free flow of scientific information:

- **noise pollution** can sabotage unpopular but valuable information from flowing freely
- **velocity hacking** creates toxic information pathogens that outcompete normal information products
- **information cascades** restructure social connection and change the landscape of information flow
- **algorithmic & choice architectures** on social media platforms manipulate information flow in service of financial interests

*“The more freely information flows, the stronger the society becomes, because then citizens of countries around the world can hold their own governments accountable. They can begin to think for themselves.” –Barack Obama*



(Kozyreva A. et al., Psychological Science in the Public Interest, 2020)

# The current information environment poses a threat to science, and with it, democracy



## Science is central to build shared reality

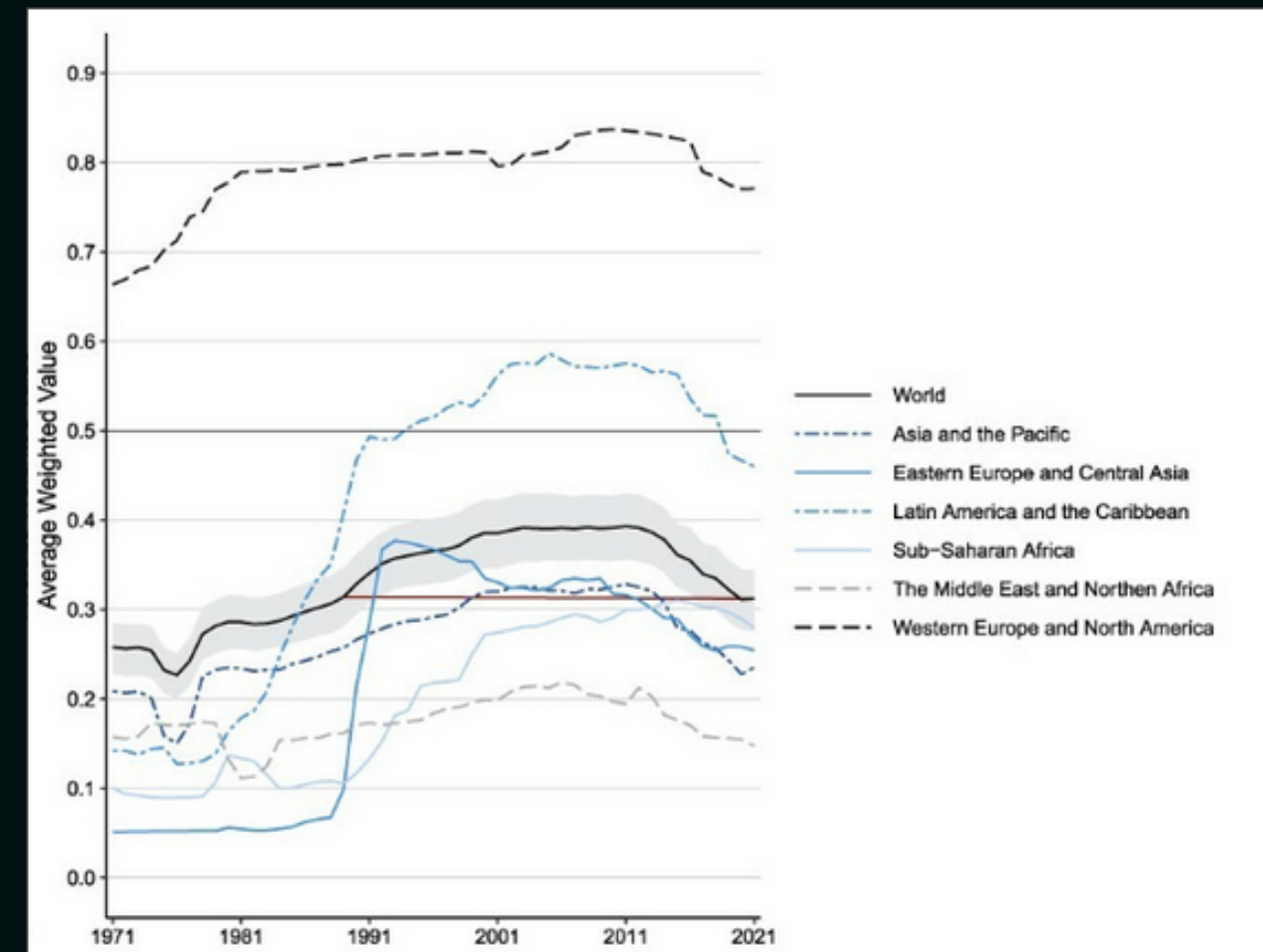


The pandemic has brought science to the center of attention for society. Scientific advisers, public health experts, scientists all seem to have taken up an outsized role over our lives; from lockdowns to vaccine mandates, mask wearing to contract tracing.



Inadvertantly, this newfound centrality did not go down well with some citizens, and more importantly; some politicians, interest groups, anti-science actors and media manipulators who dominate in public spaces by manipulating popular sentiment.

*Without facts, you can't have truth. Without truth, you can't have trust. Without trust, we have no shared reality, no democracy, and it becomes impossible to deal with the existential problems of our time. -- Maria Ressa, Nobel Peace Prize lecture, 2021*



Until about 2011, people living in democracies worldwide steadily increased (Boese VA. et al., Democratization, 2022)

# Science as a candle in the dark

## The real role of lableak myth:

The lableak myth has an outsized, global role in bringing science and scientists under pressure.

Blaming the pandemic on scientists is a once-in-a-generation chance anti-science actors can use to mobilize citizens against the supremacy of science and the authority of scientific voices. It is also an opportunity to manipulate sentiments against faceless elites and geopolitical adversaries such as China.

It is an incredible powerful myth that might change the world.

*Where the light of truth flickers, democracy withers.*



Unless we change the constituent parts of our broken information ecosystem, it's algorithmic, social, psychological and political vulnerabilities, we will keep sliding further and further back into a dark age of superstition and myth.

A world where the loudest and most powerful will get to shape reality and entrench their manipulative grip over society.



Q&A

# Thank you for your attention

Happy to  
answer your  
questions!



Philipp Markolin, PhD

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