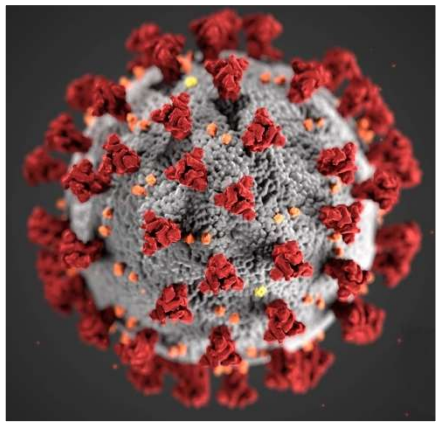
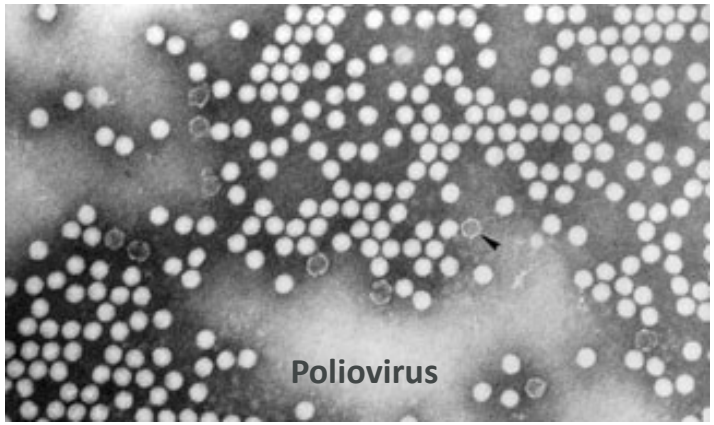
SARS-CoV-2 Variant Surveillance in Wastewater in Support of COVID-19 Mitigation Efforts



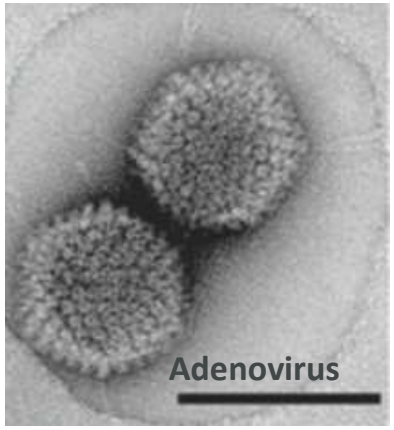
WALTER Q. BETANCOURT
THE UNIVERSITY OF ARIZONA, U.S.A

THE UNIVERSITY OF ARIZONA.

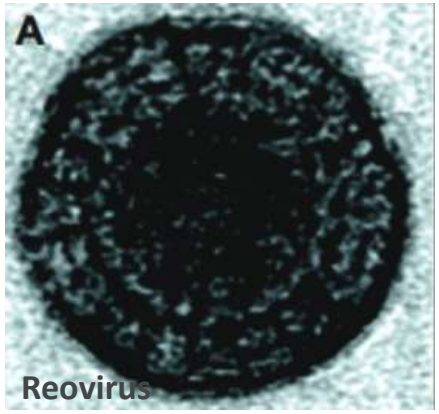
Transmission electron micrographs of viruses infecting humans, plants, and bacteria

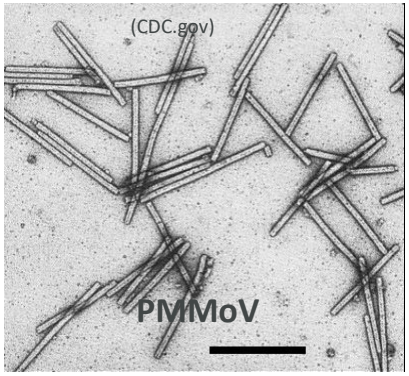


(ictvonline.org)

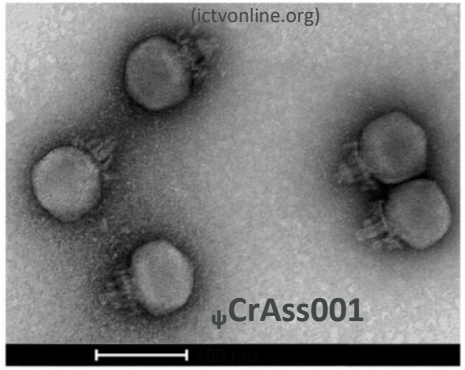


(ictvonline.org)

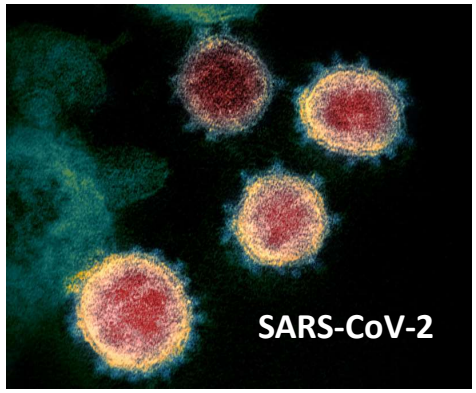




(dpvweb.net)

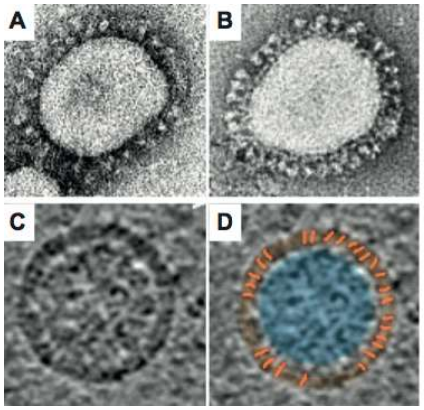


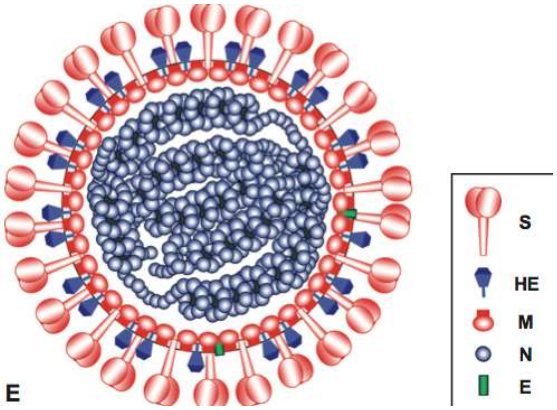
(Shkoporov *et al.*, 2018)

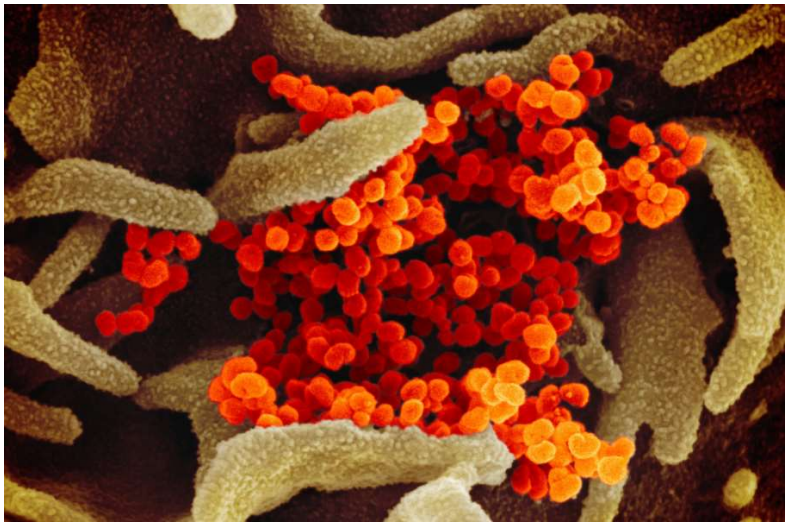


NIAID

HCoV-19 / SARS-CoV-2 / 2019-nCoV





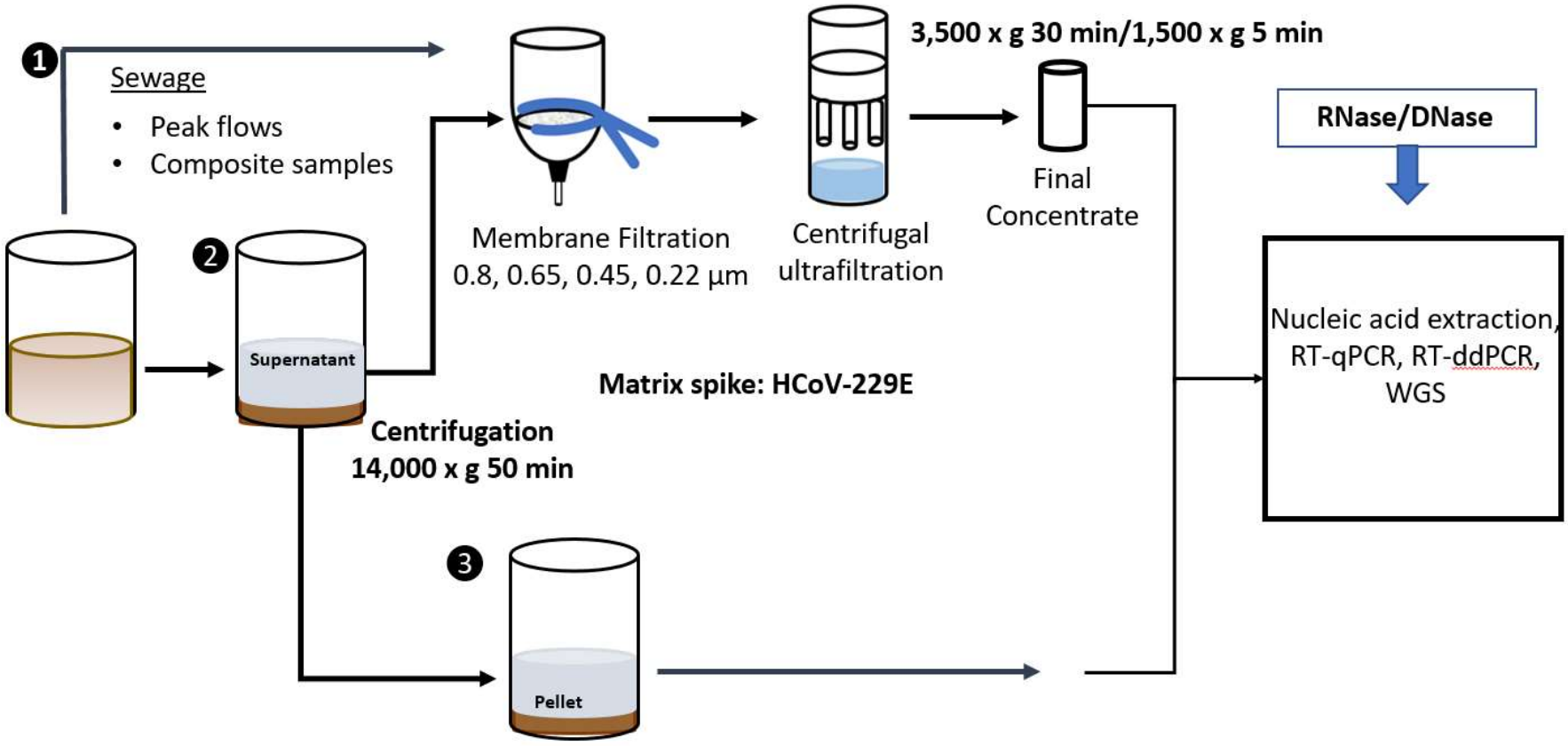


NIAID

SARS-CoV-2 research at UArizona WEST Center: Implications for Water Reuse

- Monitoring SARS-CoV-2 viral RNA in municipal wastewater for COVID-19 infection surveillance at a population-wide level
- Evaluation of the removal of SAR-CoV-2 by full-scale wastewater treatment processes
- Monitoring sewer and wastewater operations' bioaerosols
- Surveillance of SARS-CoV-2 variants in UArizona dormitory sewage/Agua Nueva WRF
- Assessment of SARS-CoV-2 viability and persistence in sewage using in vitro cell culture and molecular methods

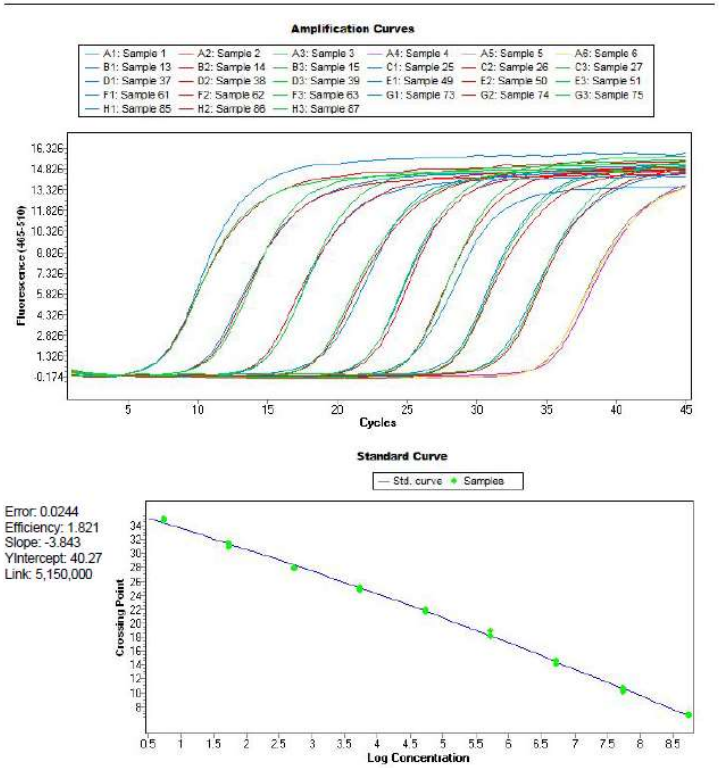
Methods for recovery and concentration of SARS-COV-2

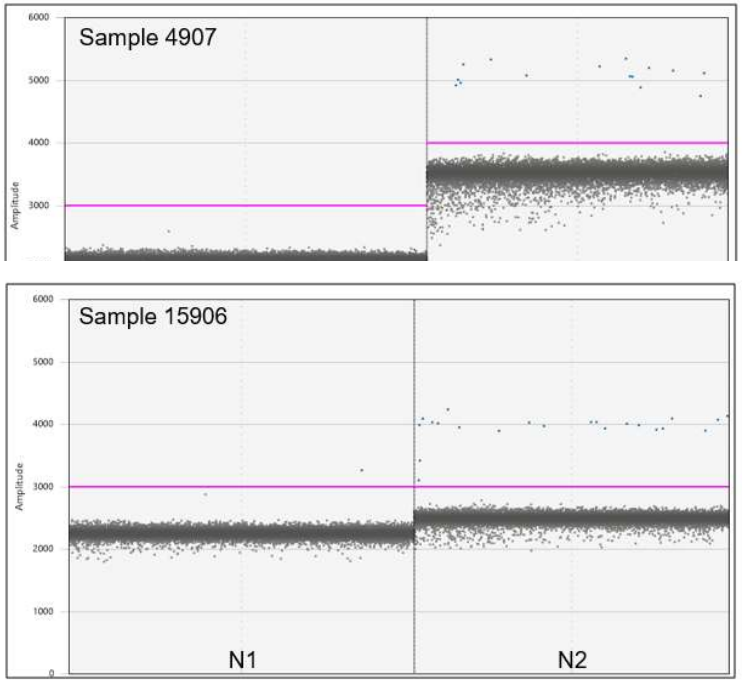


Methods for detection of SARS-COV-2

RT-qPCR: relative quantification

RT-ddPCR/dPCR: absolute quantification

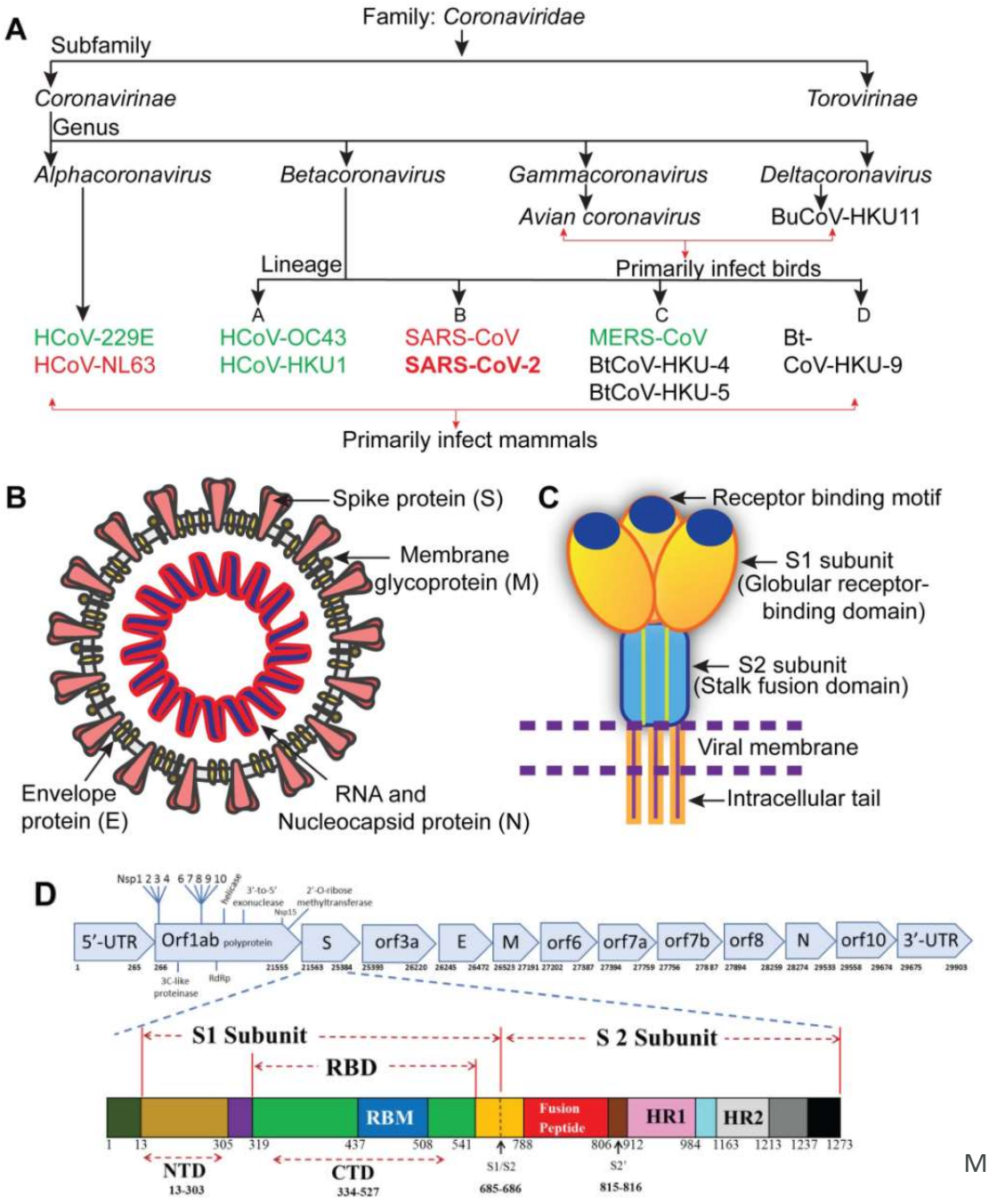




Nucleocapsid gene: N1 and N2

Levels of SARS-CoV-2 RNA in untreated and treated wastewater

Sample type	Date	Location	SARS-CoV-2 RNA Concentration
Stormwater runoff (Hudson River)	April 2020	New York	10E+06 GC/L
Untreated wastewater	May – June 2020	Florida	10E+05 – 10E+06 GC/L
Untreated wastewater	May – August 2020	California	10E+03 – 10E+07 GC/L
Primary sludge	April 2020	Arizona	10E+08 GC/L
Primary sludge		Florida	10E+08 GC/L
Secondary effluent without chlorine disinfection	April 2020	New York	10E+03 GC/L
Secondary disinfected effluent	April 2020	Arizona	<ALoD
Tertiary effluent	April –June 2020	Arizona	<ALoD



Mittal et al. 2020

Variants of Concern

WHO Label	Pango Lineage	Earliest documented samples	Transmissibility	Immune Evasiveness	Vaccine Effectiveness
Alpha	B.1.1.7	United Kingdom	+ + +	— —	√
Beta	B.1.351	South Africa	+	+ + + +	√
Gamma	P.1	Brazil	+ +	+ +	√
Delta	B.1.617.2	India	+ + + +	+ +	√

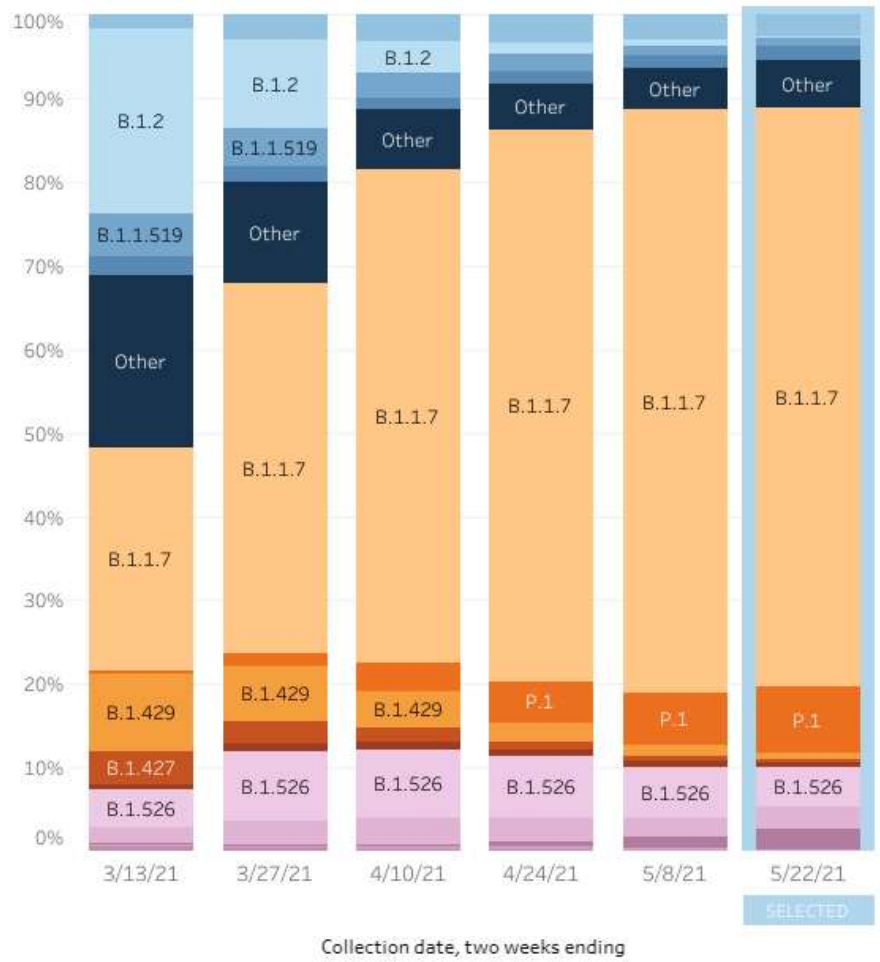
Potential consequences of emerging variants:

- Ability to spread more quickly in people
- Ability to cause either milder or more sever disease in people
- Ability to evade detection by specific viral diagnostic tests
- Decreases susceptibility to therapeutic agents such as monoclonal antibodies
- Ability to evade natural or vaccine-induced immunity

CDC Centers for Disease Control and Prevention
CDC 24/7: Saving Lives, Protecting People™

Estimated Proportions of SARS-CoV-2 Lineages in the United States

United States: 2/28/2021 – 5/22/2021



United States: 5/9/2021 – 5/22/2021

USA

	Lineage		Type	%Total	95%CI
Most common lineages	B.1.1.7		VOC	69.2%	66.4-71.9%
	P.1		VOC	8.1%	6.2-10.5%
	B.1.526		VOI	4.7%	3.4-6.4%
	B.1.526.2			2.7%	2.1-3.4%
	B.1.526.1		VOI	2.5%	1.9-3.4%
	B.1.617.2		VOI	2.5%	1.9-3.4%
	B.1			1.8%	1.4-2.3%
	B.1.1.519			0.9%	0.5-1.4%
	B.1.2			0.1%	0.1-0.2%
Additional VOI/VOC lineages	B.1.429		VOC	0.7%	0.4-1.1%
	B.1.351		VOC	0.6%	0.4-0.9%
	B.1.427		VOC	0.4%	0.2-0.8%
	B.1.525		VOI	0.1%	0.1-0.3%
	B.1.617.1		VOI	0.1%	0.0-0.2%
	B.1.617	†	VOI	0.0%	NA
	B.1.617.3	†	VOI	0.0%	NA
	P.2	†	VOI	0.0%	NA
Other*	Other			5.6%	4.7-6.7%

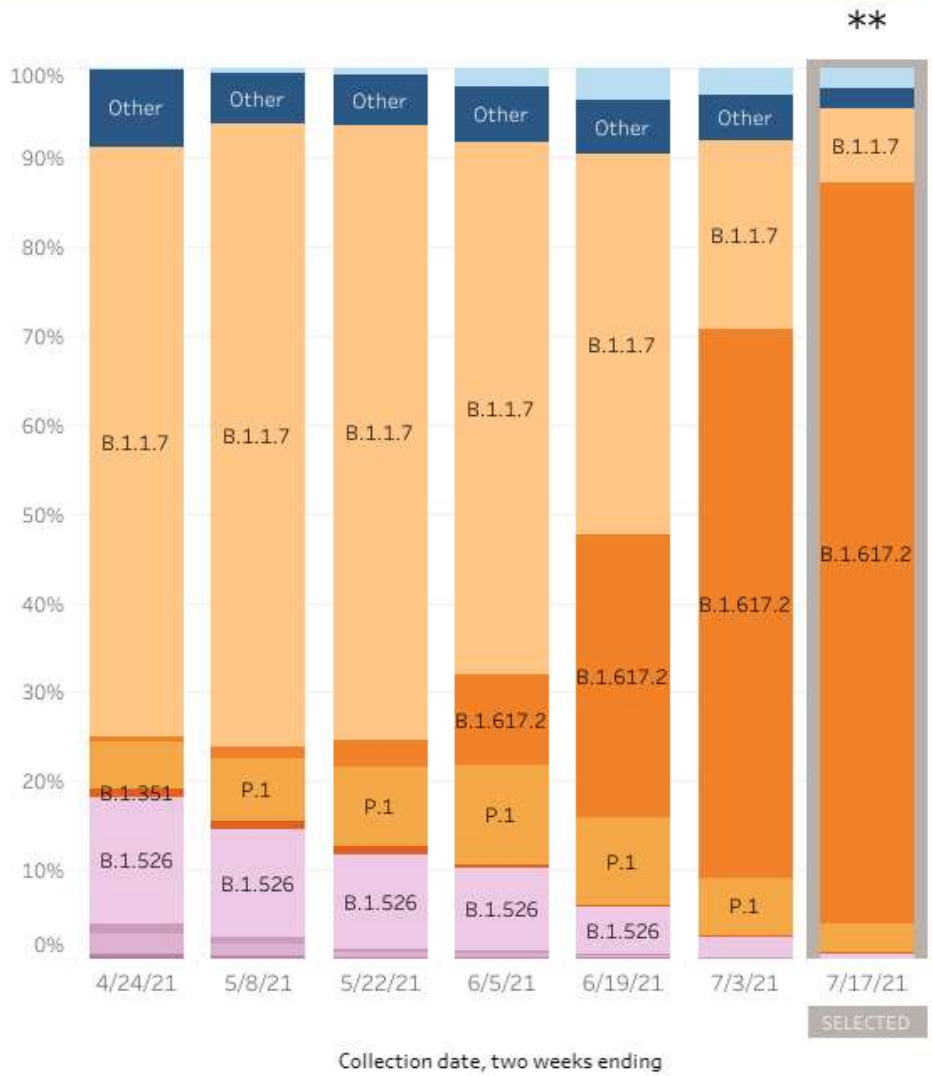
* Other represents >200 additional lineages, which are each circulating at <1% of viruses

† Fewer than 10 observations of this variant during the selected time/location context

CDC's national genomic surveillance program

Estimated Proportions of SARS-CoV-2 Lineages in the United States

United States: 4/11/2021 – 7/17/2021



United States: 7/4/2021 – 7/17/2021 NOWCAST

USA

Lineage		Type	%Total	95%PI
B.1.617.2	Delta	VOC	83.2%	79.2-86.8%
B.1.1.7	Alpha	VOC	8.3%	5.6-11.1%
P.1	Gamma	VOC	3.3%	1.5-5.1%
B.1.621			2.2%	0.8-3.8%
B.1.526	Iota	VOI	0.7%	0.0-1.5%
B.1.351	Beta	VOC	0.0%	0.0-0.3%
B.1.427	Epsilon	VOI	0.0%	0.0-0.3%
B.1.525	Eta	VOI	0.0%	0.0-0.3%
B.1.617.3		VOI	0.0%	0.0-0.3%
B.1.429	Epsilon	VOI	0.0%	0.0-0.3%
Other			2.2%	0.3-5.1%

* Other represents lineages each circulating at <1% of viruses over the last 12 weeks

** These data include Nowcast estimates, which are modeled projections that may differ from weighted estimates generated at later dates

Sublineages of P.1 and B.1.351 (P.1.1, P.1.2, B.1.351.2, B.1.351.3) are aggregated with the parent lineage and included in parent lineage's proportion. AY.1, AY.2, and AY.3 are aggregated with B.1.617.2.

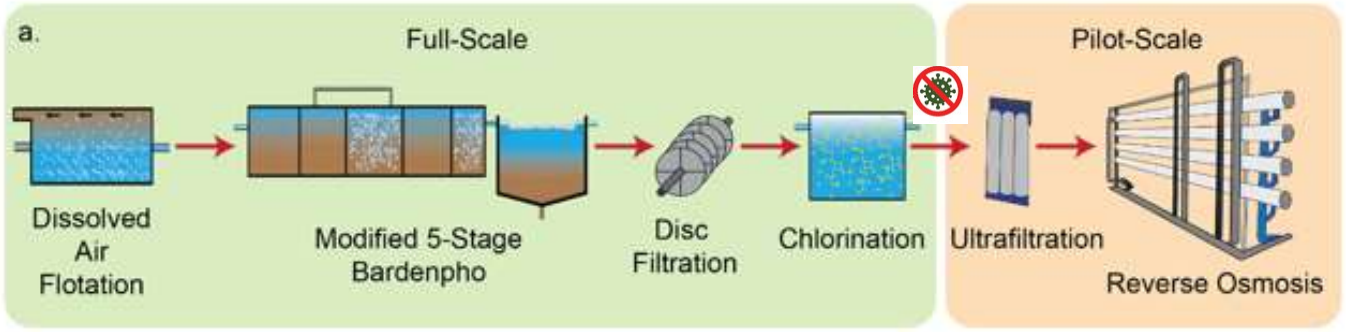
SARS-CoV-2 and Variants of Concern in Wastewater: Implications for Safe Water Reuse

SARS-CoV-2/COVID-19 virus and Variants of Concerns in Untreated Wastewater (Pima County, Arizona)

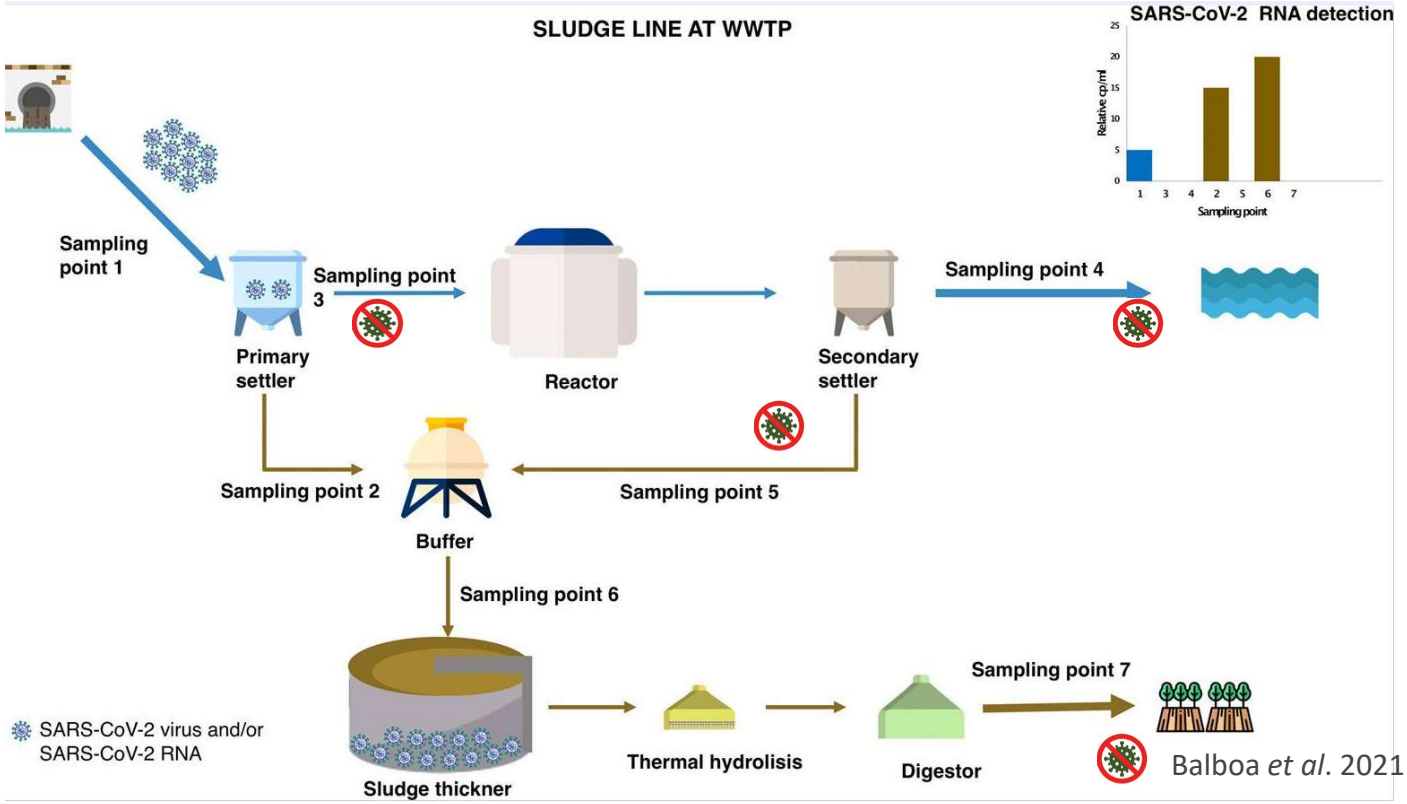
Sample type	Date	Levels of SARS-CoV-2	Presumptive variant
Untreated wastewater	6/16/21	10E+06 GC/L	Delta (B.1.617.2)*
Untreated wastewater	6/23/21	10E+06 GC/L	Delta (B.1.617.2)
Untreated wastewater	6/29/21	10E+06 GC/L	Delta (B.1.617.2)
Untreated wastewater	7/7/21	10E+06 GC/L	Delta (B.1.617.2)

* T478K/L452R

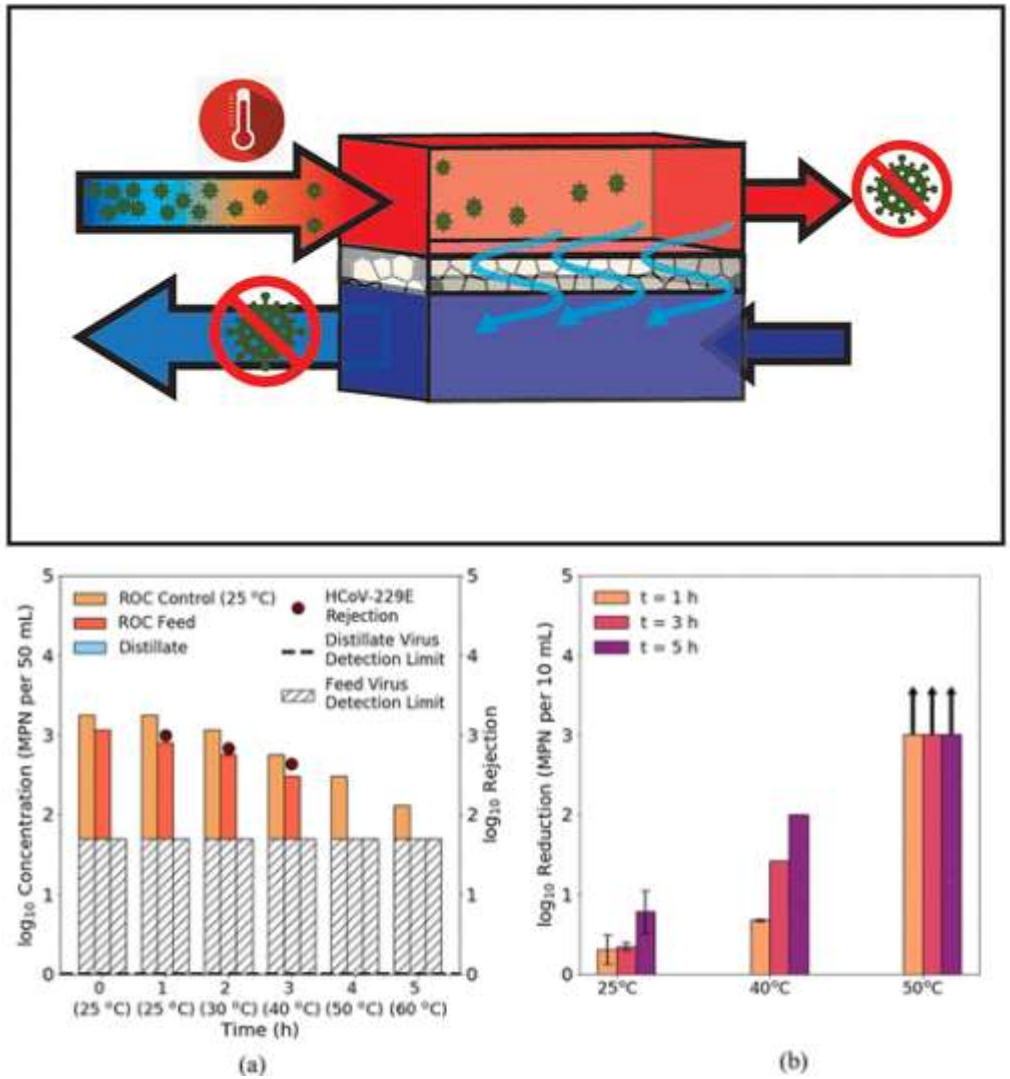
SARS-CoV-2/COVID-19 virus in Wastewater Treatment Processes



WEST Center



Balboa *et al*. 2021



Membrane distillation and Coronavirus removal (a) MD bench-scale test with RO concentrate as the feed solution, ultrapure water as distillate, and a control volume RO concentrate spiked with HCoV-229E at 25 °C. (b) RO concentrate spiked with HCoV-229E at different temperatures

Hardikar *et al*. 2021