SARS-CoV-2 (COVID-19) by the numbers

published in eLife, March 31st, 2020 https://elifesciences.org/articles/57309

Yinon M. Bar-On¹, Avi Flamholz², Rob Phillips^{3,4}, and Ron Milo¹

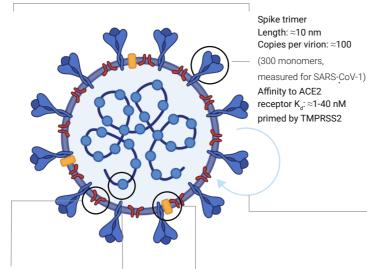
- ¹Weizmann Intitute of Science, Rehovot 7610001, Israel ²University of California, Berkeley, CA 94720, USA
- ³California Institute of Technology, Pasadena, CA 91125, USA ⁴Chan Zuckerberg Biohub, San Francisco, CA 94158, USA

Comments are welcome; this article is being updated on an ongoing basis at: https://bit.ly/2WOeN64

Size & Content

Diameter: ≈100 nm

Volume: $\sim 10^6$ nm³ = 10^{-3} fL Mass: $\sim 10^3$ MDa ≈ 1 fg



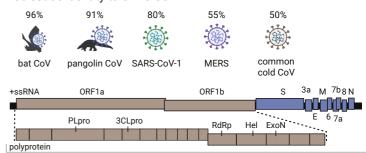
Membrane protein ≈2000 copies (measured for

Nucleoprotein ≈1000 copies (measured for Envelope protein ≈20 copies

(measured for SARS-CoV-1) (100 monomers, measured for TGEV coronavirus)

Genome

Nucleotide identity to SARS-CoV-2



Length: ≈30kb; β-coronavirus with 10-14 ORFs (24-27 proteins)

Evolution rate: $\sim 10^{-3} \text{ nt}^{-1} \text{ yr}^{-1}$ (measured for SARS-CoV-1)

Mutation rate: ~10⁻⁶ nt⁻¹ cycle⁻¹ (measured for MHV coronavirus)

Replication Timescales

in tissue-culture

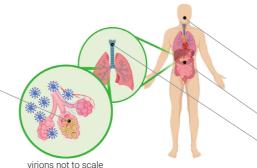
Virion entry into cell: ~10 min (measured for SARS-CoV-1)
Eclipse period: ~10 hrs (time to make intracellular virions)
Burst size: ~10³ virions (measured for MHV coronavirus)

Host Cells

SARS-CoV-1)

(tentative list; number of cells per person)

Type I & II pneumocytes ($\sim 10^{11}$ cells) Alveolar macrophage ($\sim 10^{10}$ cells) Mucous cell in nasal cavity ($\sim 10^9$ cells) Host cell volume: $\sim 10^3$ μm³ = 10^3 fL



Concentration

maximal observed values following diagnosis (Woelfel et al. 2020; Kim et al. 2020; Pan et al. 2020)

Nasopharynx: 10⁶-10⁹ RNAs/swab Throat: 10⁴-10⁸ RNAs/swab

Stool: 10⁴-10⁸ RNAs/g

Sputum: 10⁶-10¹¹ RNAs/mL

RNA counts can markedly overestimate infectious virions

Antibody Response - Seroconversion

Antibodies appear in blood after: ≈10-20 days Maintenance of antibody response:

 \approx **2-3 years** (measured for SARS-CoV-1)

Virus Environmental Stability

Relevance to personal safety unclear

 half-life
 time to decay 1000-fold

 Aerosols:
 ≈1 hr
 ≈4-24 hr

 Surfaces:
 ≈1-7 hr
 ≈4-96 hr

 e.g. plastic, cardboard and metals
 (van Doremalen et al. 2020)

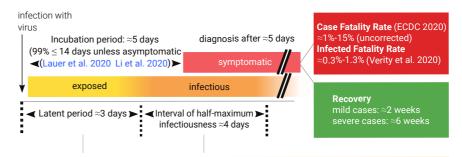
Based on quantifying infectious virions. Tested at 21-23ŰC and 40-65% relative humidity. Numbers will vary between conditions and surface types (Otter et al. 2016). Viral RNA observed on surfaces even after a few weeks (Moriarty et al. 2020).

"Characteristic" Infection Progression in a Single Patient

Basic reproductive number R₀: typically 2-4

Varies further across space and time (Li et al. 2020; Park et al. 2020)

(number of new cases directly generated from a single case)



Inter-individual variability is substantial and not well characterized. The estimates are parameter fits for population median in China and do not describe this variability (Li et al. 2020; He et al. 2020).

^{*}Corresponding author: ron.milo@weizmann.ac.il.