Have Questions?

Type them into questions box!

“Why am I muted?”
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Thank you and enjoy the show.

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<th>Technology &amp; Innovation</th>
<th>Drug Design and Delivery</th>
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THIS ACS WEBINAR WILL BEGIN SHORTLY...

COVID-19 Vaccines: Progress, Challenges and Hope

Presentation slides are available now! The edited recording will be made available as soon as possible.

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This ACS Webinar is co-produced with CAS.
How do vaccines mimic pathogens to prepare our immune system for real invaders?

Antigen
How do vaccines mimic pathogens to prepare our immune system for real invaders?

1. Antigen interacts with APC (antigen presenting cell)

2. APC cell passes the information to effector B cells and T cells

Effector B cell

Effector T cell
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4. Activates cytotoxic T cell
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Major vaccine development platforms

**Live attenuated virus**
- Modified virus that can still replicate and produce immunity, but not cause disease
- Examples: 
  - Tuberculosis (BCG)
  - Measles
- Clinical trial: 1
- Pre-clinical: 2

**Inactivated virus vaccine**
- Whole virus killed by chemicals, heat or radiation
- Examples: 
  - Rabies
  - Hepatitis A
- Clinical trial: 7
- Pre-clinical: 15

**COVID-19 candidate vaccines**
- Using another harmless virus to carry the genetic code that can give cells the instruction to make the antigenic protein
- Using a lipid nanoparticle to deliver an mRNA strand that can give cells the instructions to make the antigenic protein
- Clinical trial: 1
- Pre-clinical: 2
## Major vaccine development platforms

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<tr>
<th>Live attenuated virus</th>
<th>Inactivated virus vaccine</th>
<th>Viral protein vaccine</th>
<th>Viral vector vaccine</th>
<th>mRNA vaccine</th>
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<td>Modified virus that can still replicate and produce immunity, but not cause disease</td>
<td>Whole virus killed by chemicals, heat or radiation</td>
<td>Viral protein, or virus-like particles formed by proteins, without DNA/RNA</td>
<td>Using another harmless virus to carry the genetic code that can give cells the instruction to make the antigenic protein</td>
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<td>• Tuberculosis (BCG)</td>
<td>• Rabies</td>
<td>• Hepatitis B (HBV)</td>
<td>• Ebola vaccine</td>
<td>• COVID-19 vaccine (EUA)</td>
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<tr>
<td>• Measles</td>
<td>• Hepatitis A</td>
<td>• Papillomavirus (HPV)</td>
<td></td>
<td></td>
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### COVID-19 candidate vaccines

- Clinical trial: 1
- Pre-clinical: 2
- Clinical trial: 7
- Pre-clinical: 15
- Clinical trial: 18
- Pre-clinical: 71
- Clinical trial: 14
- Pre-clinical: 36
- Clinical trial: 6
- Pre-clinical: 22
How do mRNA vaccines work?

1. Sequence info of the Spike protein is used to synthesize an mRNA sequence

2. The synthesized mRNA is packaged in a lipid nanoparticle
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4. Once the Spike protein is made, it will be used by the APC cell to activate immune B cells and T cells
5. Antigen specific antibody generated, cytotoxic T cell activated and memory cells remain

How do the vaccine front-runners compare?

- Pfizer/BioNtech BNT162b2
  - mRNA in lipid nanoparticles
  - Efficacy: 95%

- Moderna mRNA-1273
  - mRNA in lipid nanoparticles
  - Efficacy: 95%

- AstraZeneca/Oxford Univ. ChAdOx1-S/AZD1222
  - Non-replicating adenovirus vector
  - Efficacy: 70%
How do the vaccine front-runners compare?

<table>
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<th>Vaccines</th>
<th>VACCINE TYPE</th>
<th>EFFICACY</th>
<th>DOSAGE</th>
<th>PHASE III ENROLLMENT SIZE</th>
<th>PLANNED PRODUCTION VOLUME</th>
<th>STORAGE REQUIREMENT</th>
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<tr>
<td>Pfizer/BioNTech BNT162b2</td>
<td>mRNA in lipid nanoparticles</td>
<td>95%</td>
<td>Requires 2 Doses 21 Days Apart</td>
<td>43,000 Age 16-85</td>
<td>50 Million (2020) 1.3 Billion (2021)</td>
<td>-70°C±10°C</td>
</tr>
<tr>
<td>Moderna mRNA-1273</td>
<td>mRNA in lipid nanoparticles</td>
<td>95%</td>
<td>Requires 2 Doses 28 Days Apart</td>
<td>30,000 Ages 18+</td>
<td>20 Million (2020) 0.5-1 Billion (2021)</td>
<td>-20°C</td>
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<tr>
<td>AstraZeneca/Oxford Univ. ChAdOx1-S/AZD1222</td>
<td>Non-replicating adenovirus vector</td>
<td>70%</td>
<td>Requires 2 Doses 28 Days Apart</td>
<td>11,500 Ages 18+</td>
<td>3 Billion (2021)</td>
<td>2-8 °C</td>
</tr>
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</table>
How many COVID-19 candidate vaccines are currently in clinical trials worldwide?

- Only a handful
- Around ten to fifteen
- Around fifty
- A hundred
- A few hundred

Where are COVID-19 candidate vaccines currently being developed?

As of 12/8/2020, 214 in development and 52 in clinical trials worldwide

Top 15 countries

- USA
- China
- UK
- India
- Canada
- Turkey
- Germany
- Russia
- Japan
- Thailand
- France
- Spain
- Kazakhstan
- Peru
- Iran

*Derived from WHO data
What has COVID-19 vaccine research focused on?

Number of COVID-19 vaccine related papers per topic

- Vaccine platform
- Epitopes/Mutations
- Immunity
- Adjuvant/Formulation
- Animal model

Number of papers

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Number of COVID-19 vaccine related papers per topic

- Vaccine platform
- Epitopes/Mutations
- Immunity
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- Animal model

COVID-19 papers per vaccine development platform

- RNA-based
- DNA-based
- Viral Vector-based
- Protein Subunit
- Virus-like particle
- Inactivated
- Live Attenuated
What are the challenges and questions?

- How immunity will last?
  - Antibodies & memory cells
  - Mutation is not as fast as that for influenza

- Are these vaccines safe?
  - No compromise of safety standards in clinical trials
  - Continue to assess in post-marketing surveillance

- What about herd immunity?
  - Varies, but needs large % of population vaccinated
  - Impact of public trust

- When to resume normal life?
  - Effectiveness of the vaccines
  - Vaccination process
  - Social distance and masks

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Explore more at cas.org/blog or cas.org/covid19

Blogs
- Top 5 COVID-19 vaccine questions answered
- Meet the mRNA vaccine rookies aiming to take down COVID-19
- Building on “flu shot” success to tackle COVID-19

Videos
- How mRNA COVID-19 Vaccines Work to Fight COVID-19?
  - https://youtu.be/LcTEmHlwY10

Paper Publications
- Coronavirus Therapeutics & Vaccines
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