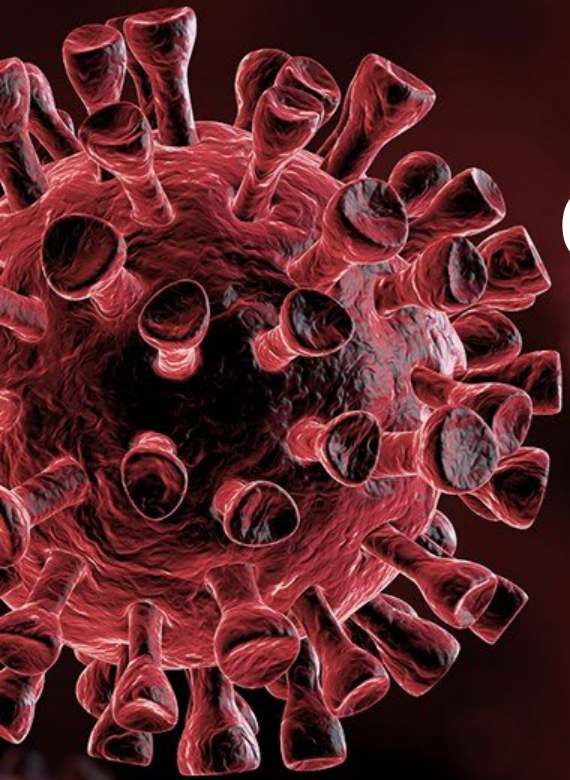
NORTHEAST
BUSINESS GROUP ON HEALTH

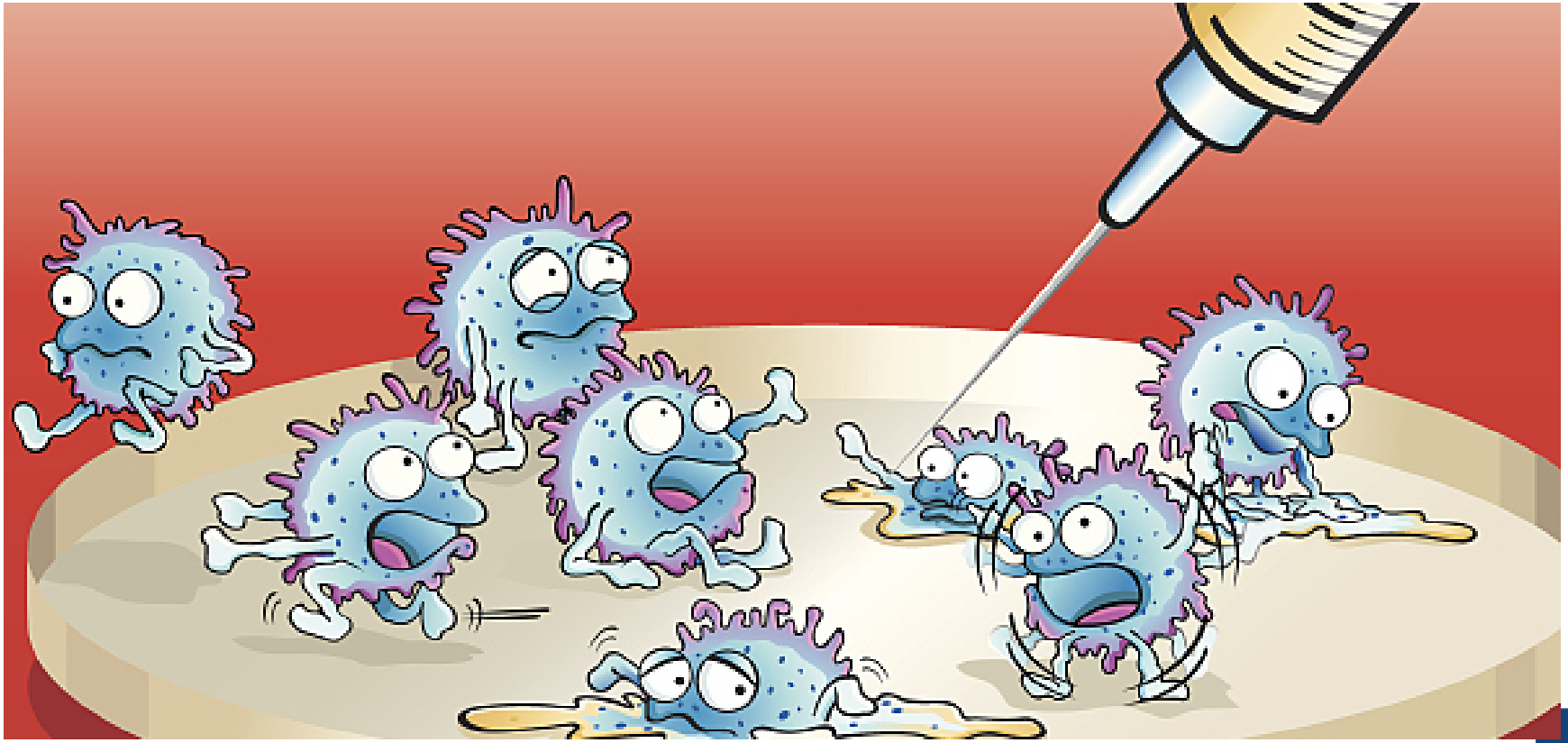


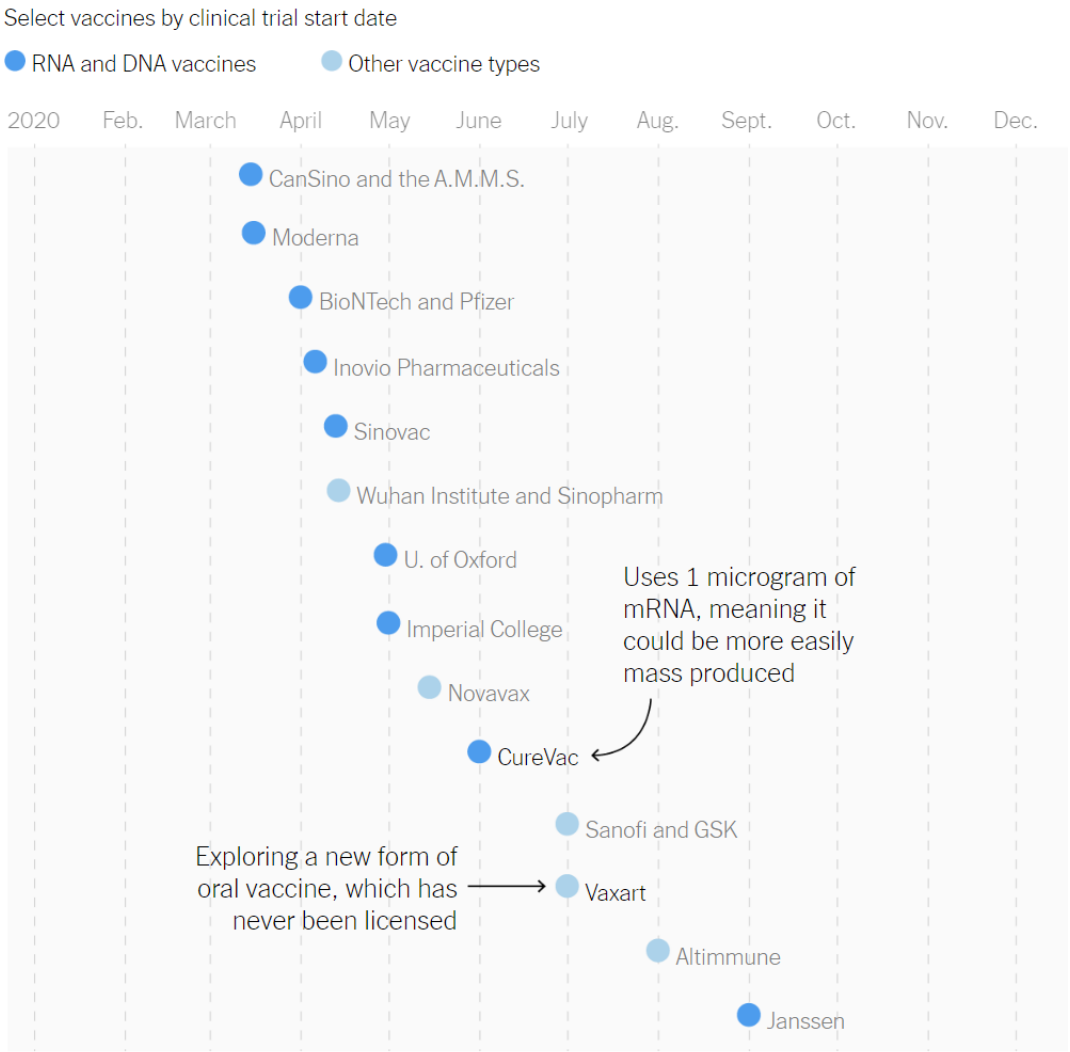
COVID-19 Update

Dr Mark Cunningham-Hill
Medical Director NEBGH

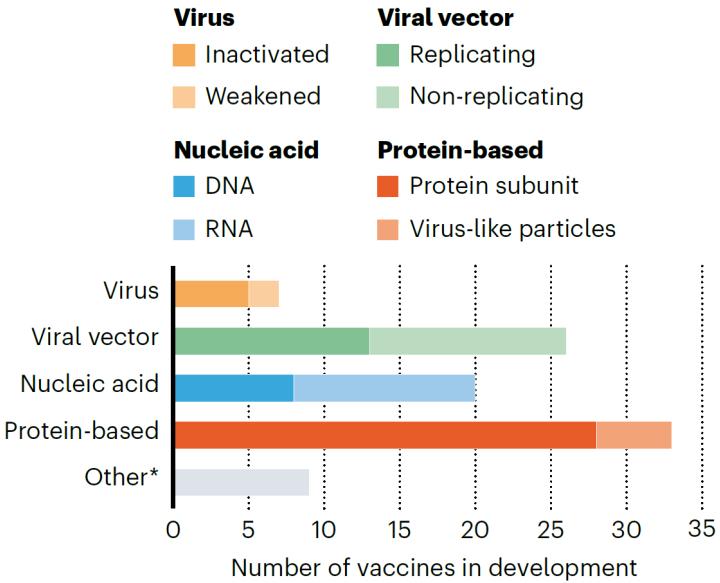
Monday May 4th

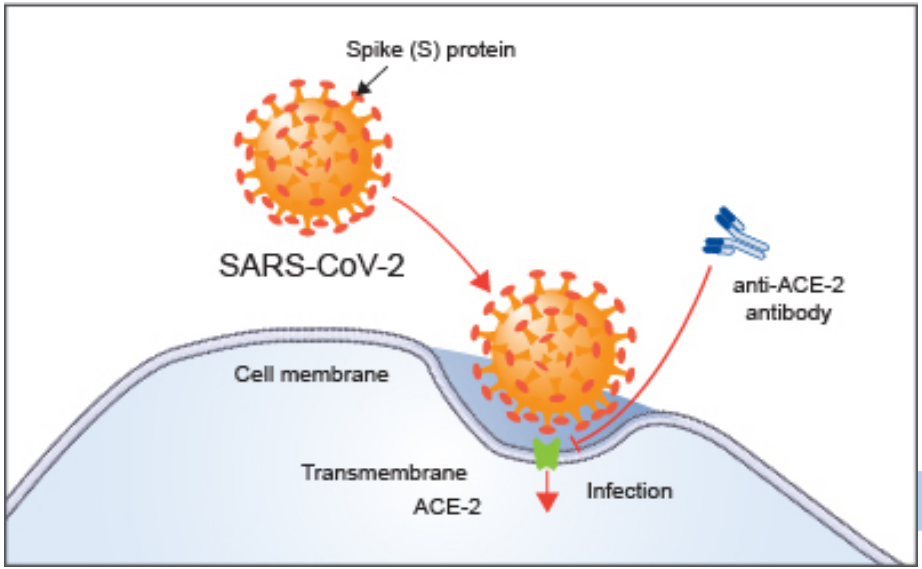
Road to a COVID-19 Vaccine




Select vaccines by clinical trial start date
RNA and DNA vaccines
Other vaccine types
2020
Feb.
March
April
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.
CanSino and the A.M.M.S.
Moderna
BioNTech and Pfizer
Inovio Pharmaceuticals
Sinovac
Wuhan Institute and Sinopharm
U. of Oxford
Imperial College
Novavax
CureVac
Uses 1 microgram of mRNA, meaning it could be more easily mass produced
Sanofi and GSK
Exploring a new form of oral vaccine, which has never been licensed
Vaxart
Altimmune
Janssen

Vaccines in Development

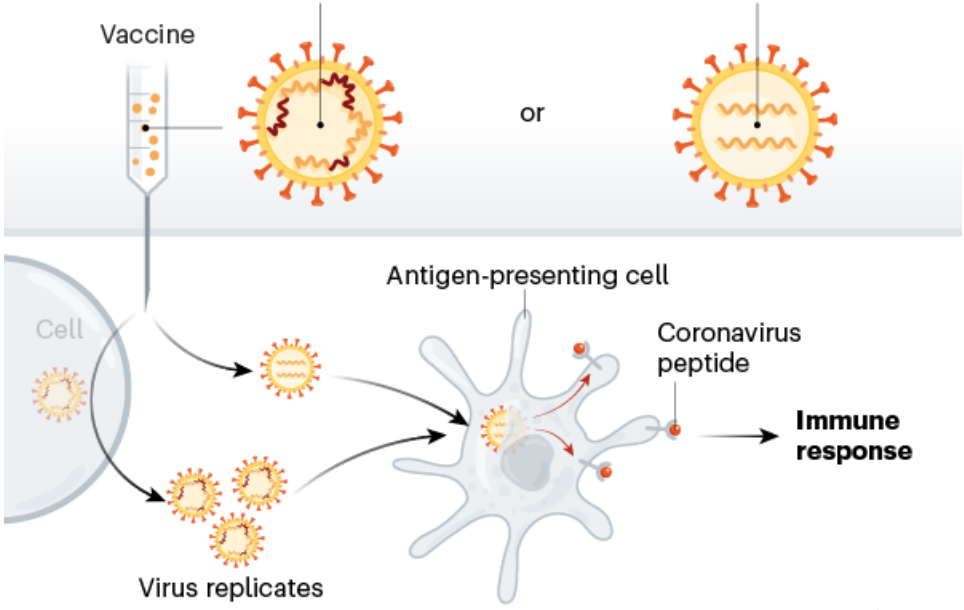




VIRUS VACCINES

Weakened virus
A virus is conventionally weakened for a vaccine by being passed through animal or human cells until it picks up mutations that make it less able to cause disease. Codagenix in Farmingdale, New York, is working with the Serum Institute of India, a vaccine manufacturer in Pune, to weaken SARS-CoV-2 by altering its genetic code so that viral proteins are produced less efficiently.

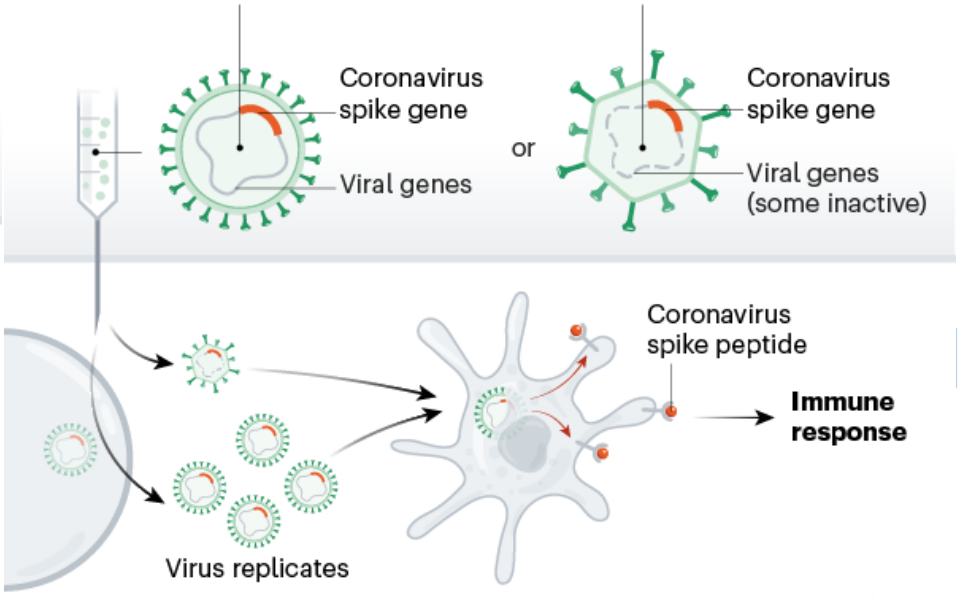
Inactivated virus
In these vaccines, the virus is rendered uninfectious using chemicals, such as formaldehyde, or heat. Making them, however, requires starting with large quantities of infectious virus.



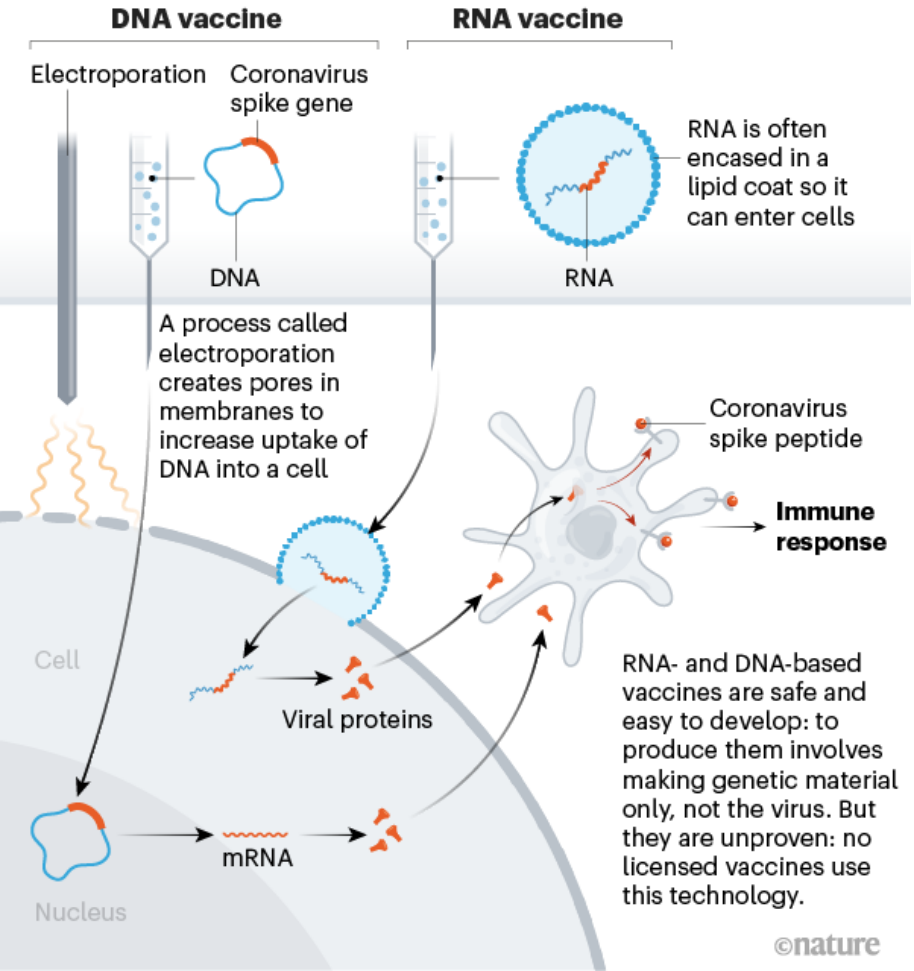
VIRAL-VECTOR VACCINES

Replicating viral vector (such as weakened measles)
The newly approved Ebola vaccine is an example of a viral-vector vaccine that replicates within cells. Such vaccines tend to be safe and provoke a strong immune response. Existing immunity to the vector could blunt the vaccine's effectiveness, however.

Non-replicating viral vector (such as adenovirus)
No licensed vaccines use this method, but they have a long history in gene therapy. Booster shots can be needed to induce long-lasting immunity. US-based drug giant Johnson & Johnson is working on this approach.



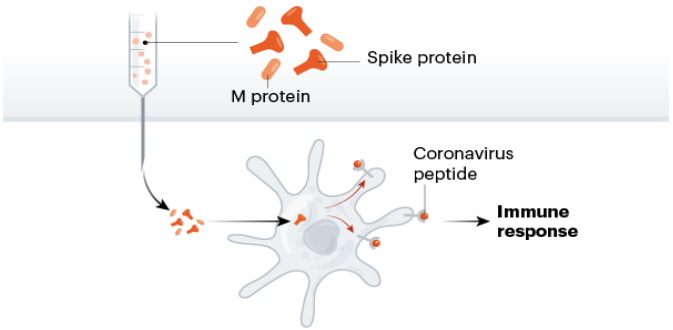
NUCLEIC-ACID VACCINES



PROTEIN-BASED VACCINES

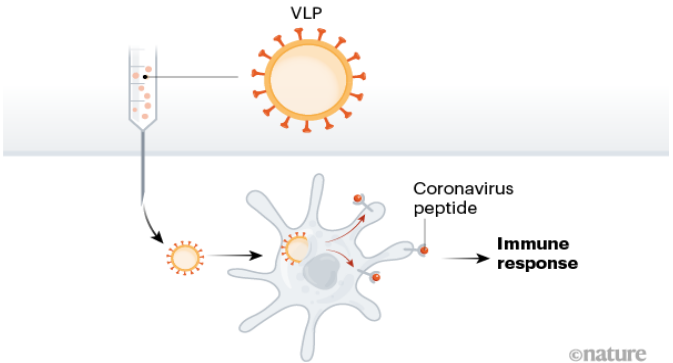
Protein subunits

Twenty-eight teams are working on vaccines with viral protein subunits — most are focusing on the virus's spike protein or a key part of it called the receptor binding domain. Similar vaccines against the SARS virus protected monkeys against infection but haven't been tested in people. To work, these vaccines might require adjuvants — immune-stimulating molecules delivered alongside the vaccine — as well as multiple doses.



Virus-like particles

Empty virus shells mimic the coronavirus structure, but aren't infectious because they lack genetic material. Five teams are working on 'virus-like particle' (VLP) vaccines, which can trigger a strong immune response, but can be difficult to manufacture.



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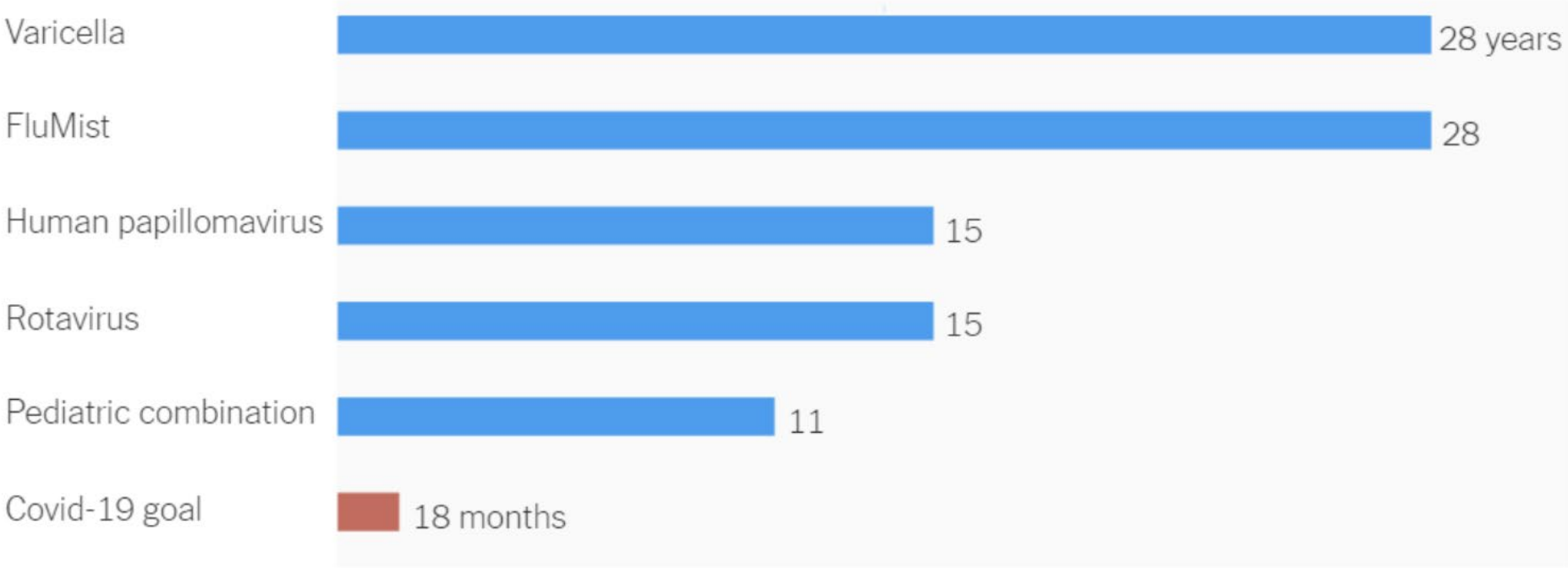
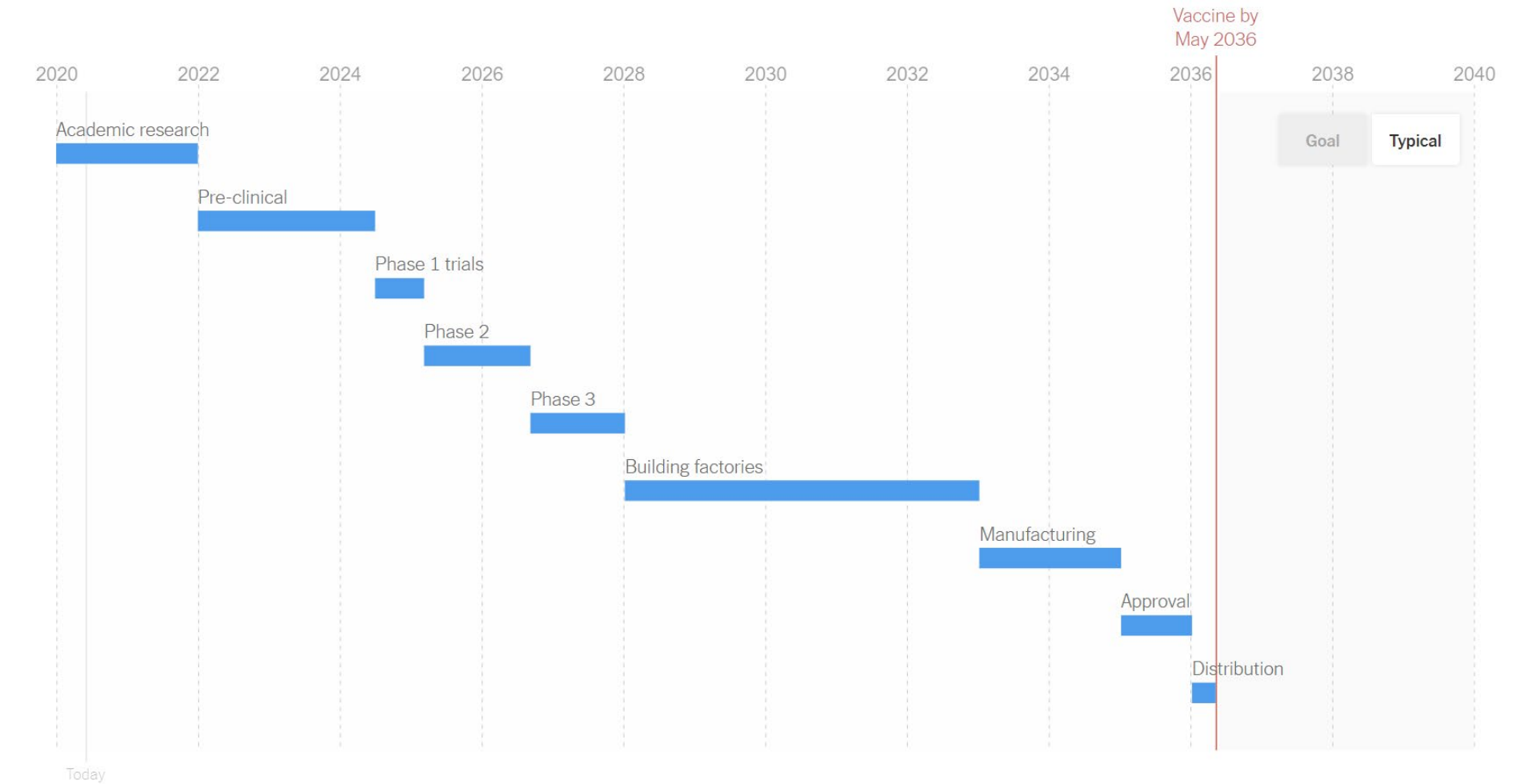
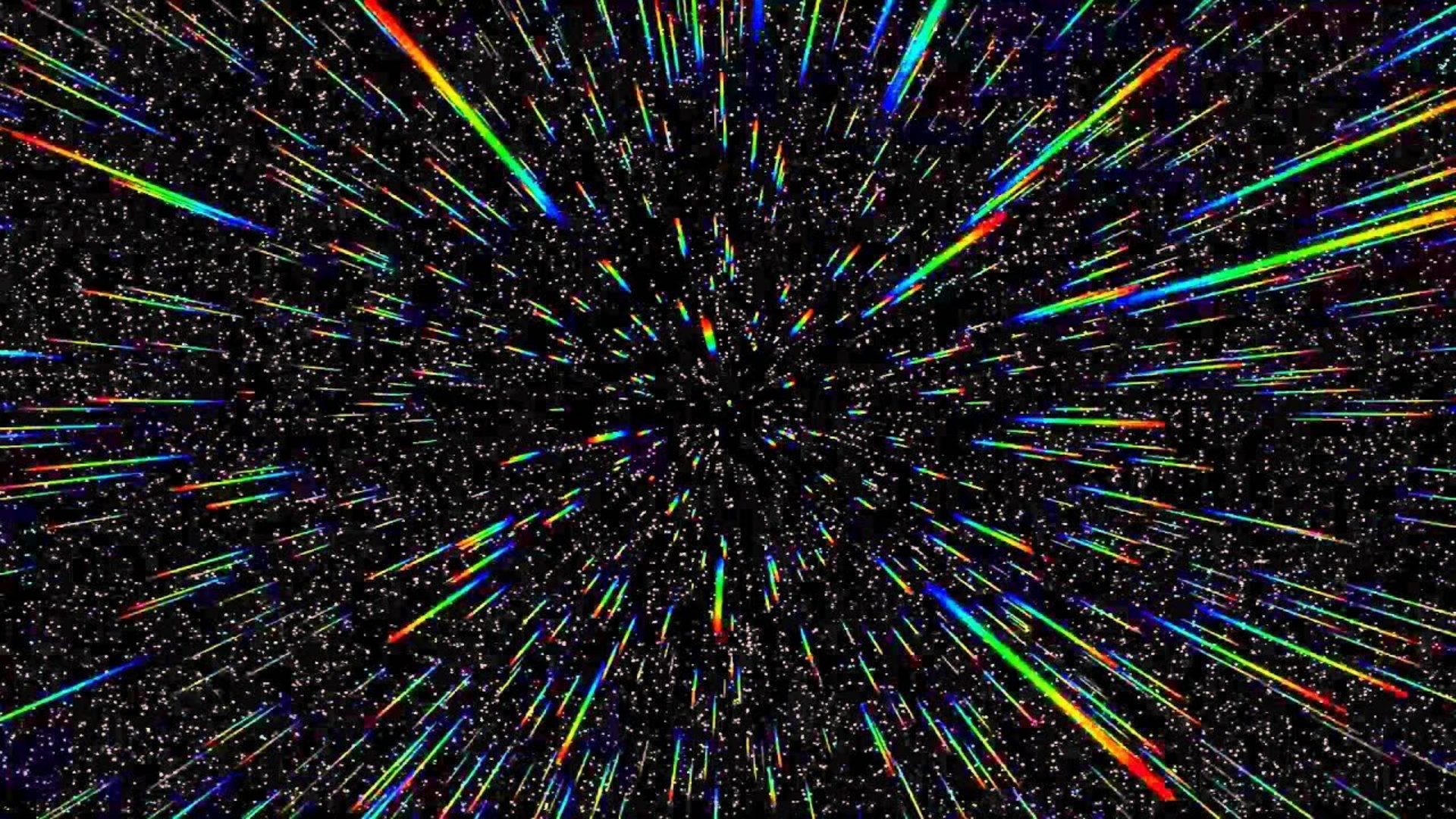
Years and years, at minimum

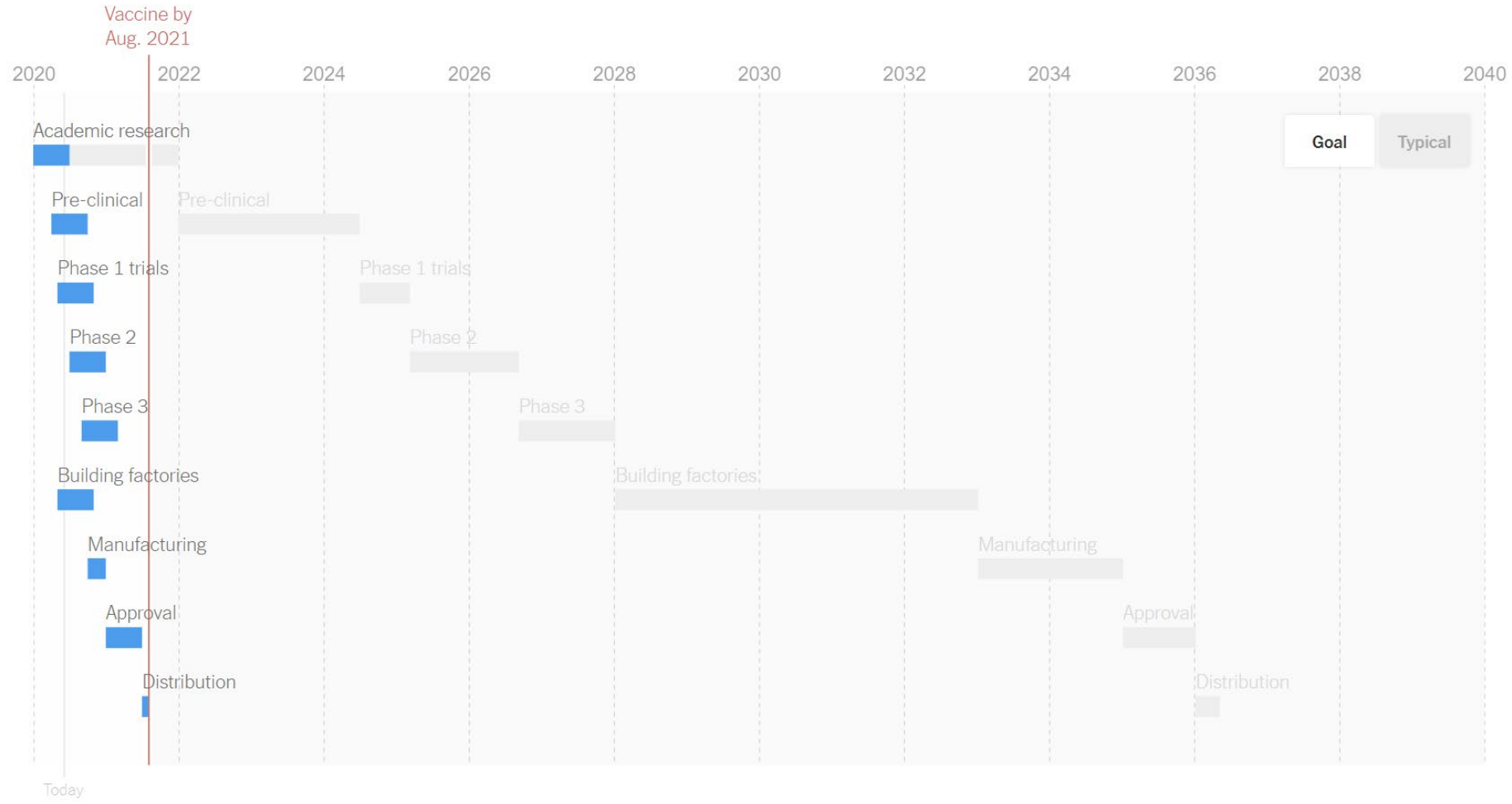
The vaccine development process has typically taken a decade or longer.



Note: Rotavirus and HPV vaccines include time from filing of the first investigational new drug to approval.
Source: "Plotkin's Vaccines" (7th edition)


Vaccine by
May 2036
2020
2022
2024
2026
2028
2030
2032
2034
2036
2038
2040
Goal
Typical
Academic research
Pre-clinical
Phase 1 trials
Phase 2
Phase 3
Building factories
Manufacturing
Approval
Distribution
Today




Vaccine by
Aug. 2021
2020
2022
2024
2026
2028
2030
2032
2034
2036
2038
2040
Goal
Typical
Academic research
Pre-clinical
Pre-clinical
Phase 1 trials
Phase 1 trials
Phase 2
Phase 2
Phase 3
Phase 3
Building factories
Building factories
Manufacturing
Manufacturing
Approval
Approval
Distribution
Distribution
Today


Questions