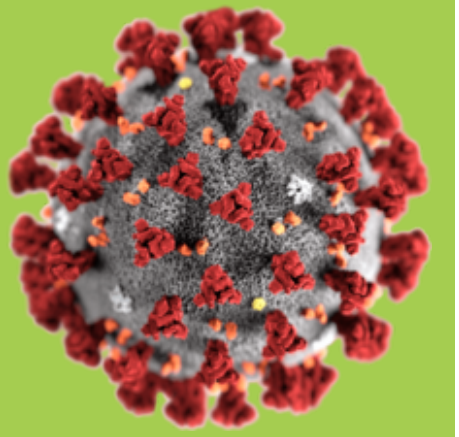

Re-imagining vaccine manufacturing

Shifting the paradigm of vaccine process development and manufacturing to address global health challenges

DCVMN AGM 2020

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Agenda

01 Introduction

02 A Paradigm Shift

03 Re-imagining vaccine manufacturing

04 Take away messages

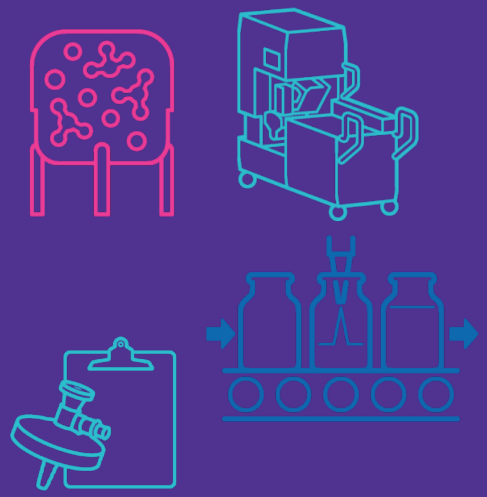
Vaccines are a major contribution to overall **Global Health**

Our mission

Enabling the industry to produce
better faster safer vaccines
to improve access, globally

We contribute
To global vaccine access

1 Technology, Services & expertise



2 Collaborations

iBET
BATAVIA biosciences
UNIVERCELLS
Bill & Melinda Gates foundation
Baylor College of Medicine
International Vaccine Institute
THE JENNER INSTITUTE
DEVELOPING INNOVATIVE VACCINES
IPT
AVMI AFRICAN VACCINE MANUFACTURING INITIATIVE

3 Training curricula

TRANSVAC
dcvmn Developing Countries Vaccine Manufacturers Network

Overview of Vaccines

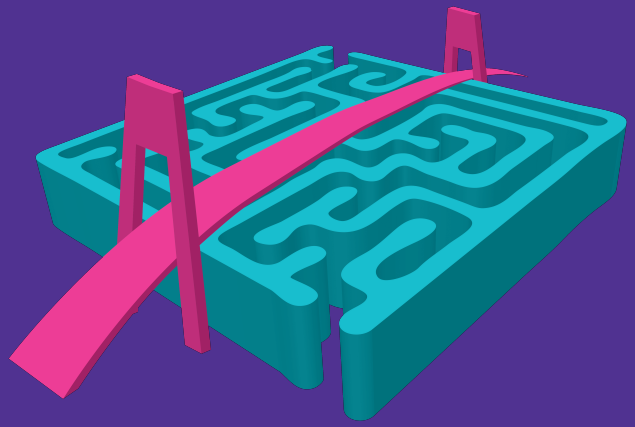
Vaccine Market Growth Drivers

Major Challenges of the Vaccine Industry

- Vaccine type and process diversity
- Economies of scale
- Funding processes
- Global capacity
- Outbreaks and pandemics

A Paradigm Shift with Pandemics

Major Challenges with Outbreak and Pandemic Vaccines



Time

The typical vaccine paradigm doesn't allow adequate response to tackle outbreaks

Cost

Vaccine development & licensure requires >$500 million

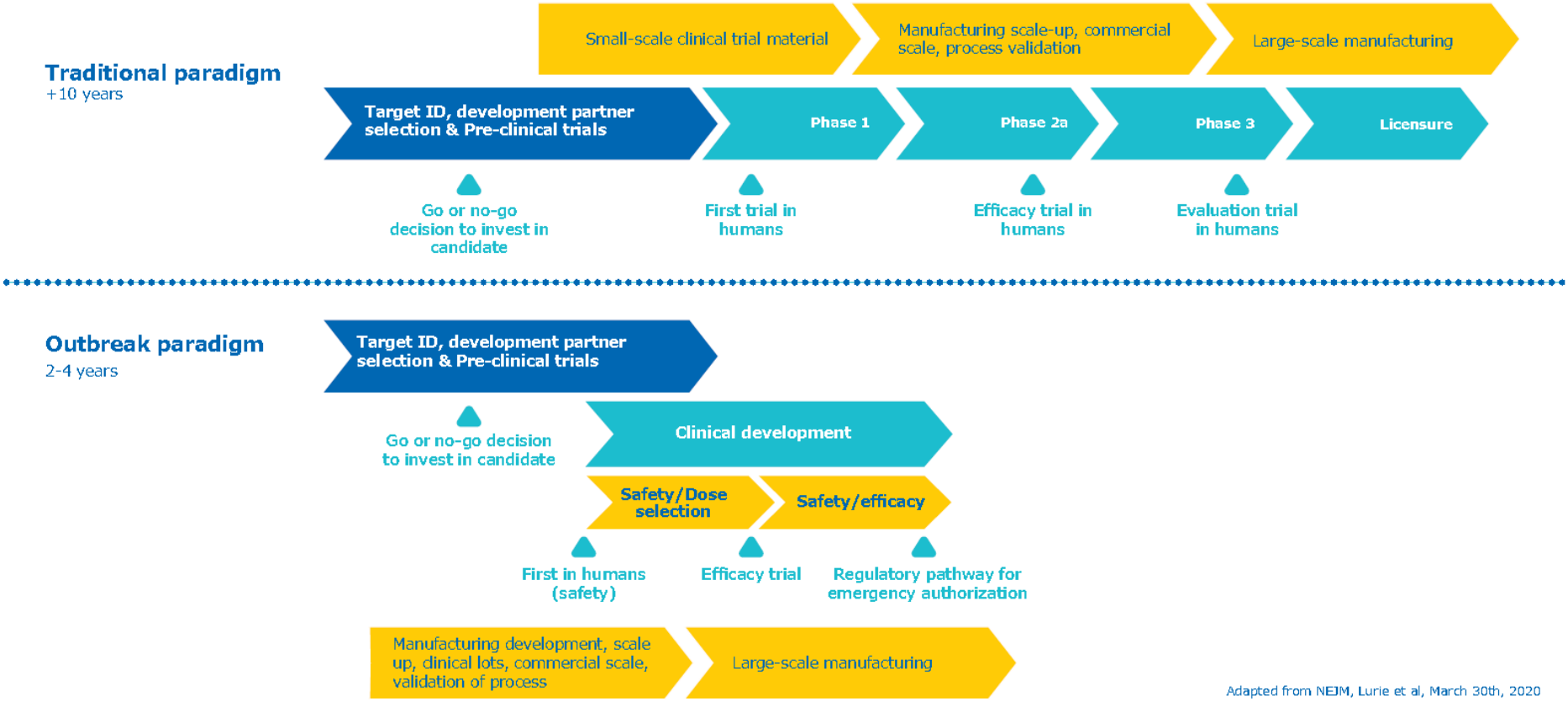
No guaranteed long-term market

Scalability

Need to be able to produce huge amount of doses in a short time

Global vaccine manufacturing capacity may not be sufficient for COVID19

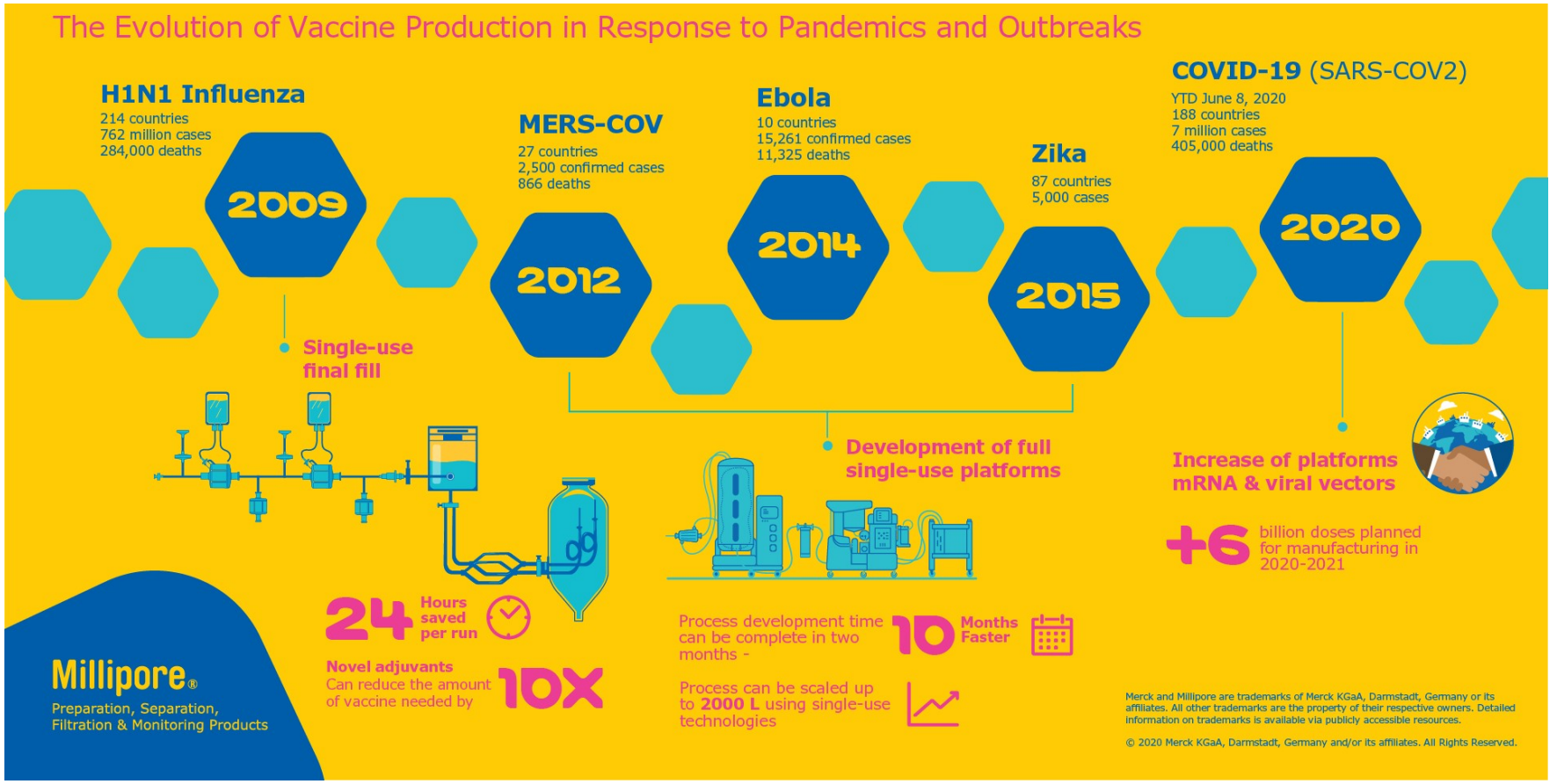
A paradigm shift
Time is compressed, phases overlap



Adapted from NEJM, Lurie et al, March 30th, 2020

Pandemics and outbreaks

How they have influenced vaccine manufacturing



COVID-19 pandemic has boosted development and capacity building
Unprecedent activities around a vaccine

Fastest human vaccine development in history

42 days 1st vaccine created after novel virus sequencing

$ 6.7 billion global investment

213 candidates in the pipeline

37 already in human studies

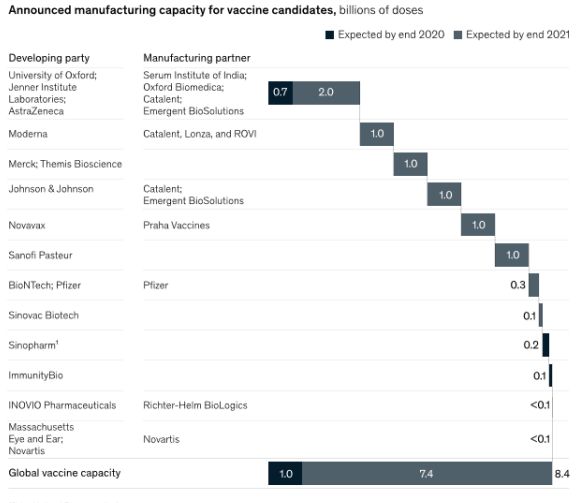
9 candidates in Phase III

Between 7-9 vaccines could obtain regulatory approval withing the next 2 years

Source: Milken Institute COVID vaccine tracker, Oct. 22, 2020

Unprecedent capacity building in short period of time

1 Billion COVID-19 vaccine doses in 2020 & 8-9 billion doses by 2021 announced by the industry vs 1 billion doses by 2022 predicted by experts with current capacity .



Source:https://www.mckinsey.com/industries/pharmaceuticals-and-medical-products/our-insights/on-pins-and-needles-will-covid-19-vaccines-save-the-world#

A Paradigm Shift
Lessons learned and Merck Approaches

- **Global capacity** is constrained to respond to COVID19 need
- **The "unknown"** preparedness remain the biggest challenge
- Next time, how can we **minimize risks** and be **better prepared?"**

- **Acceleration of development is needed.**
- **Platform Technology to reduce changes & increase production capabilities.**
- **Prepare for scalability once vaccine is developed.**

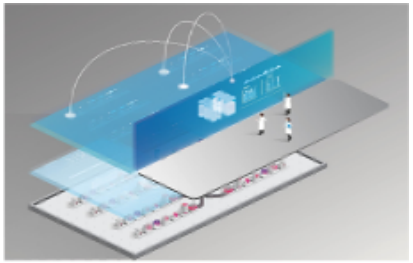
re-imagining

Vaccine manufacturing

Re-imagining vaccine manufacturing
Opportunity to Shift the Development and Manufacturing Paradigm

Establishing multiple platforms to accelerate Development

Flexible & next generation manufacturing

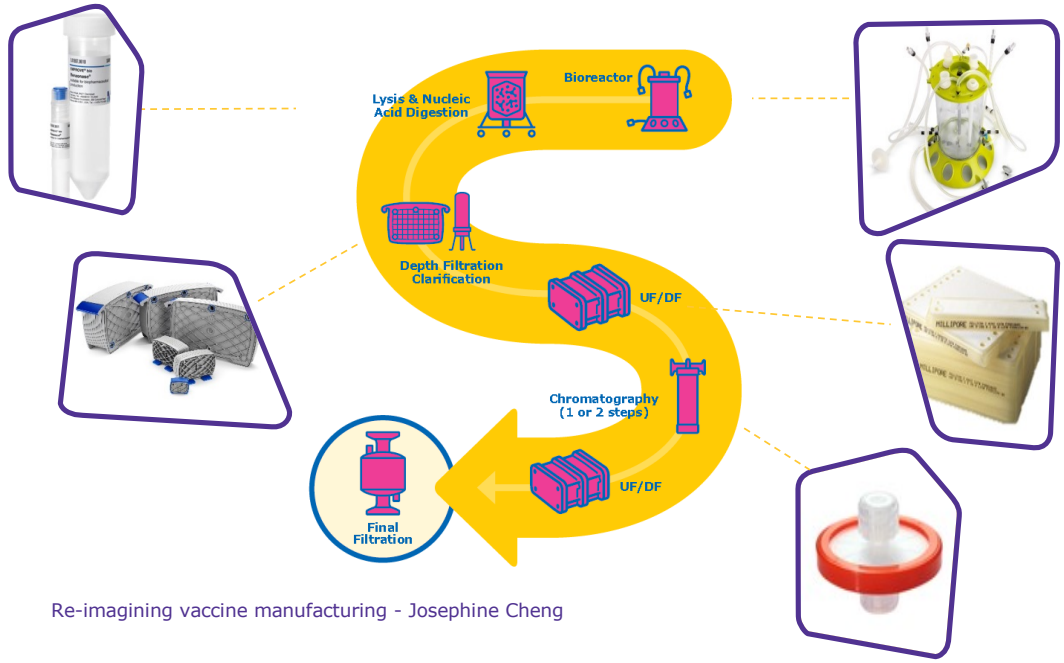


Decentralized manufacturing

Establishing platforms to accelerate vaccine development and manufacturing

Collaboration with the Jenner Institute

- **Collaboration with the Jenner Institute, started in 2017: Objective:** Develop a cost effective, rapid platform for adenovirus vector using a Rabies vaccine candidate for clinical phase 1 material, using single use and filtration technologies.
- The platform is currently leveraged for **COVID-19 efforts**



THE JENNER INSTITUTE
DEVELOPING INNOVATIVE VACCINES

Key achievements

- Development of a platform at 4L batch scale for 2000 doses
- Process **simplification** and single use implementation
- Increased **p**rocess efficiency
- Platform was leveraged for COVID-19 and allowed significant time saving

Publication: Fedosyuk et al, Vaccine, 2019

Flexible & next generation manufacturing

Flexible Manufacturing Will Be Required to Accelerate and De-risk Vaccine Manufacturing Preparedness

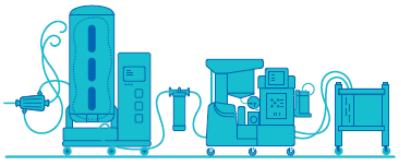
Implementation of Single use in Final filling – GSK case study H1N1, 2009

	Traditional	Single use
Clean and set-up	14 Hrs	<1 Hr
Cleaning validation	Extensive	Zero
Filling time	24 hrs	10 hrs
Average vials/hr	3,000	10,000
Aseptic connections	50	0
Operator training	2 weeks	2 days
Equipment utilization	35%	82%
Total time	38 hrs	12 hrs

Faster deployment
Flexibility to change scale or process
Reduces time to market
Accelerate response to high surge of vaccines

Traditional large vaccine manufacturing facilities

Manufacturing facility using single-use technologies



	Traditional stainless facility	Single-use facility
Capex required	~$500M to $1B	$20-100M
Time to construct	5-10 years	1.5 years
Change over time	4 weeks	0.5 days
Footprint	~>70,000 m²	~11,000 m²

Flexible & next generation processing
Facility of the future

Revisiting vaccine manufacturing through the integration of next generation processing concepts

Upstream intensification

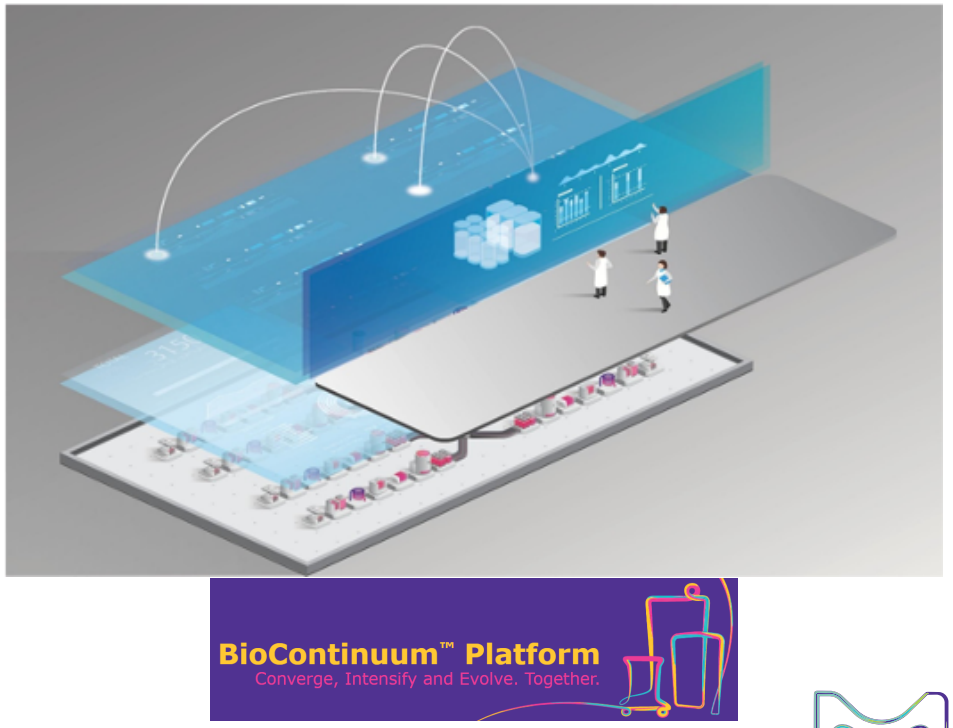
Better cell culture platforms, scale out strategies

Downstream intensification

De-complexification and efficient processing

Enabling smart manufacturing

Increased automation & digitalization



Decentralized vaccine manufacturing
Increasing Global Capacity & Sustainability

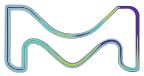
Strengthening and/or developing local manufacturing

- Several LMICs have developed local vaccine capacities to **« own their vaccination strategy »**
- Emerging vaccine manufacturers represent now almost **~20% of the market**, led by India, China and Brazil.
- Additional countries have expressed their desire to localize and expand current vaccine manufacturing in **different regions in the globe.**
- COVID19 pandemic **is urging governments** to fill their current **gaps and reduce weaknesses** when it comes to **pandemic preparedness**

Own the supply
& national security

Meet local
& unique needs

Increase access &
affordability



Re-imagining vaccine manufacturing for the future

Conclusions

1. Pandemic and outbreaks are **inevitable and unfortunately** difficult to predict

2. Past occurrences have **improved vaccine manufacturing** and the response speed

3. **Efforts** are still needed **to simplify and accelerate** manufacturing

4. **Global capacity** increase, **flexibility, evolving towards template 4.0** and **decentralization** will be key to respond better to pandemics

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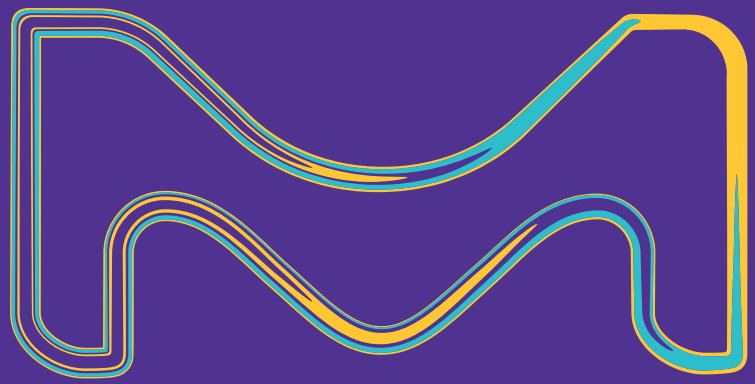
Thank You for listening!



For more information about Vaccine Production: please visit

https://www.sigmaaldrich.com/process-solutions/vaccines.html