

# Development of Minimally Invasive High-throughput Optical Condensation System

Protect human health, food, and the environment by our “optical condensation technology”!

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Director, Research Institute for LAC-SYS (RILACS), OPU



※ Institute for the development of “Light-induced Acceleration System (LAC-SYS)” for biochemical reactions.  
Category 2: Institutes founded by the President for strategic studies and researches since May, 2017)

# Our vision and realization for future society

**Detect previously undetectable molecules by optical condensation for saving lives of many people!**

We will realize "ultra-early examination, diagnosis and treatment of people at the pre-disease stage.

We believe our technology will provide a society with a long and healthy life span for everyone from the elderly to infants, without fear of cancer, infectious diseases, dementia, or food shortages.



**Bright, fun and energetic!**



Providing infrastructure for medical, food, and environmental measurements in Smart city (independent and decentralized)

**Portable, easy, fast testing & diagnosis anywhere**



"On-site" diagnosis  
at clinics and  
pharmacies

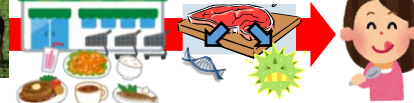


Examination at  
home as remote  
medical care

**Pre-shipment & onsite quality inspection of  
food & beverage products**



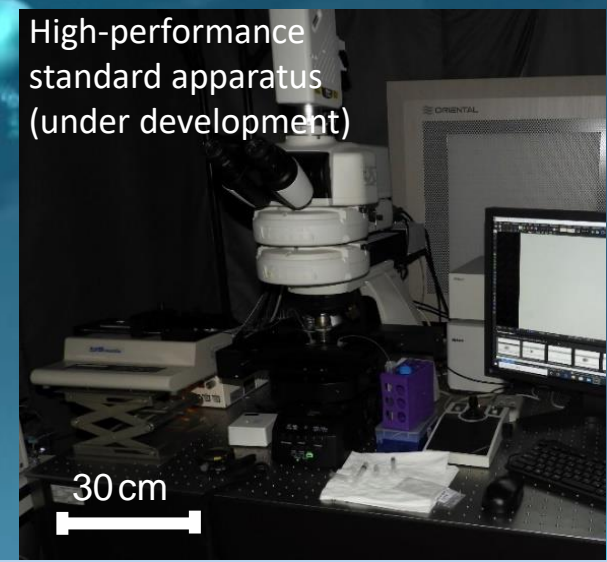
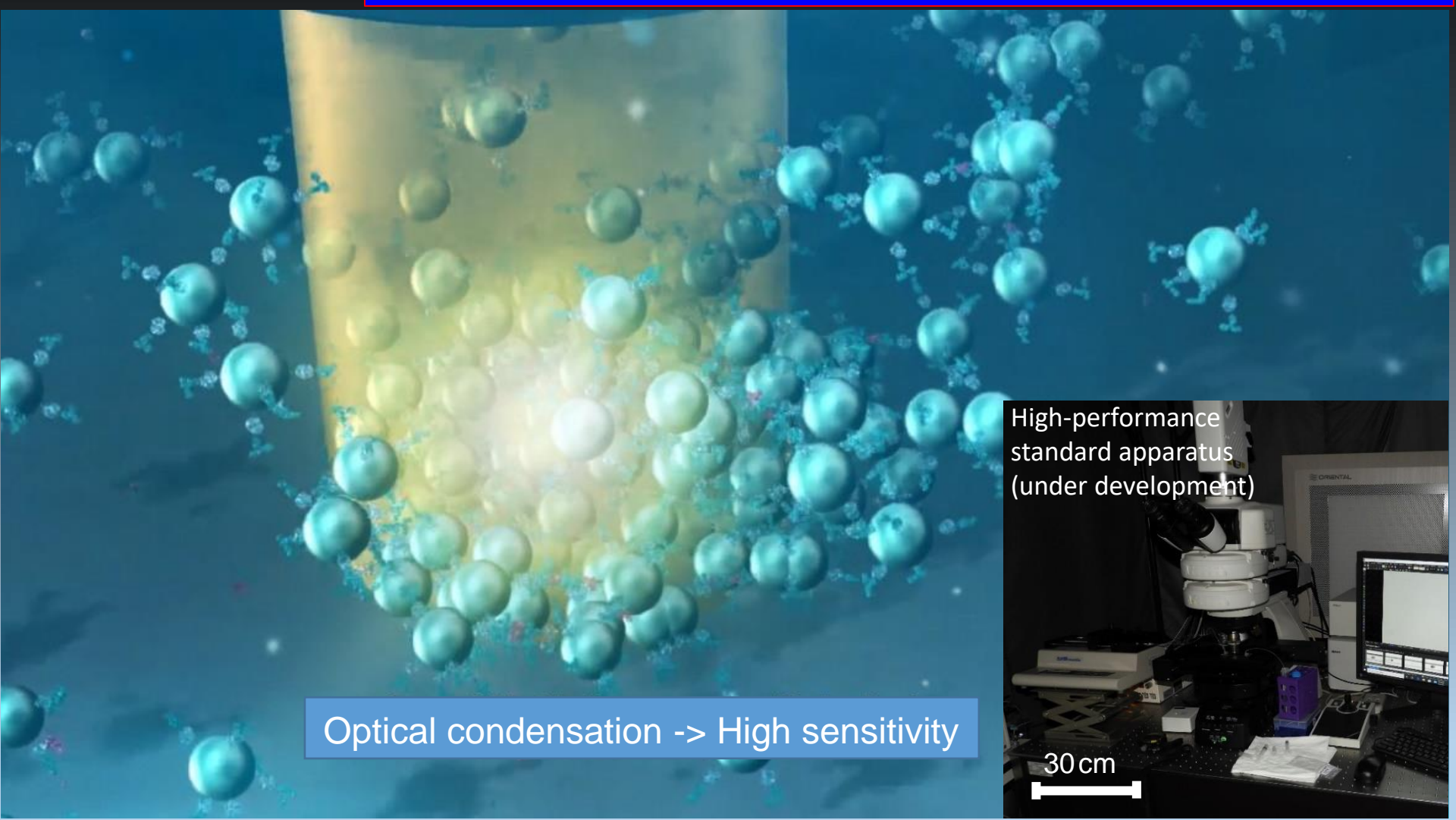
Super Market



Pre-shipment inspections for restaurants and  
supermarkets, and speed up "on-site"  
inspections and origin inspections

# Optical condensation

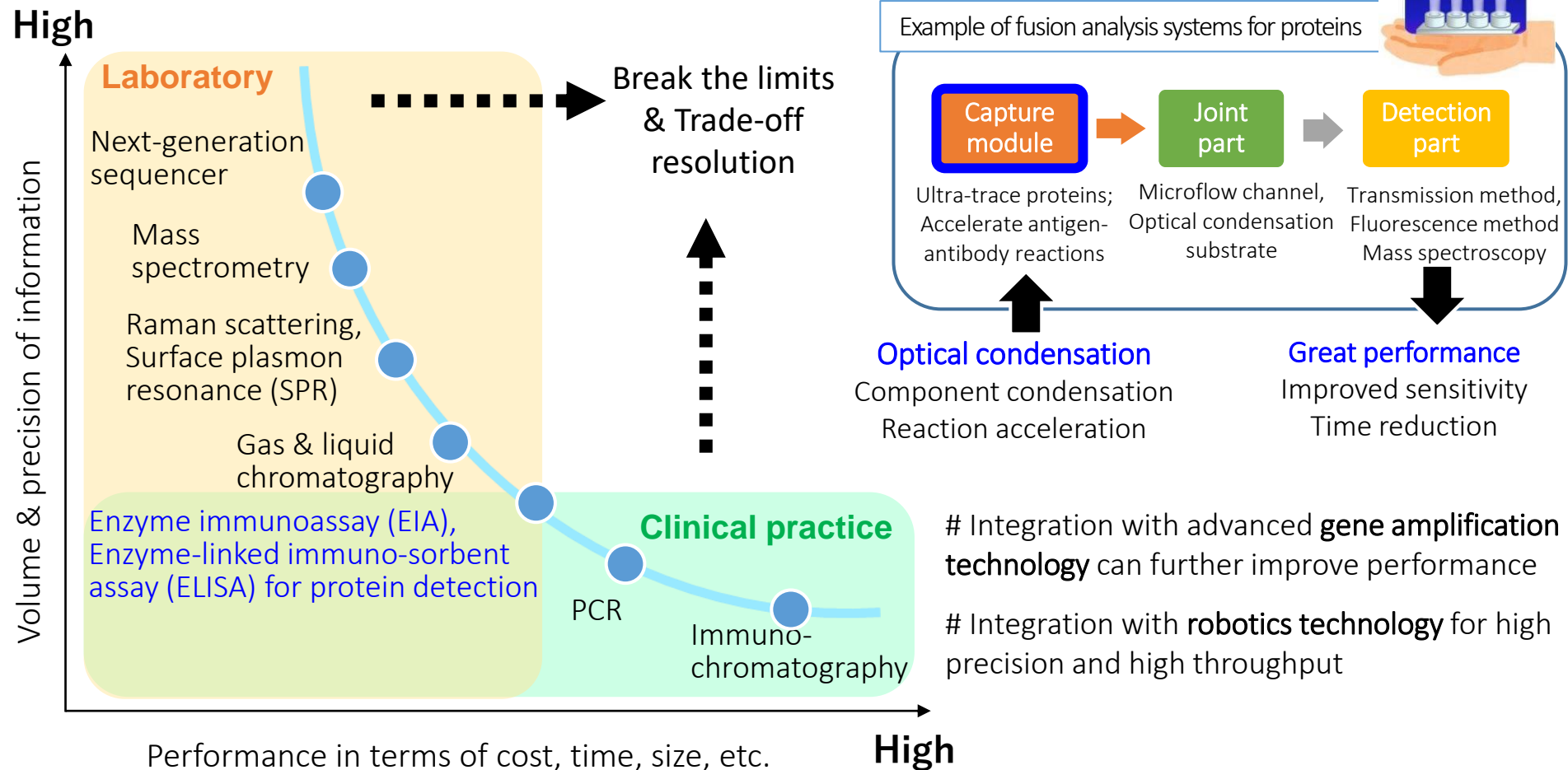
Highly efficient collection and condensation of biomolecules by "Light" leading to acceleration of reactions into a few minutes (conventional method: a few hours)



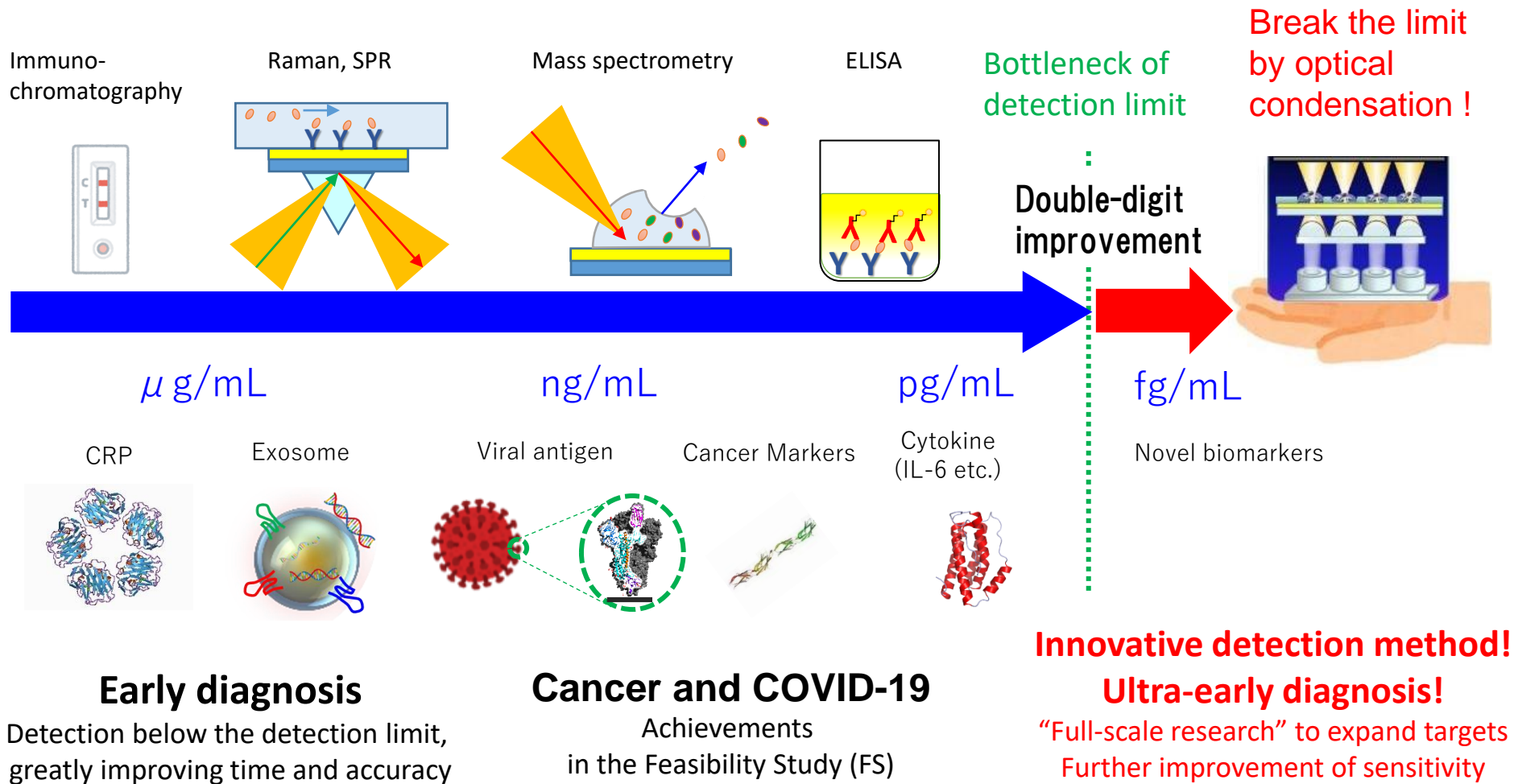
The 2018 Nobel Prize in Physics for its ability to capture and transcend optical tweezers  
Innovation revolutionizing the pretreatment of various bioanalytical instruments

# Breakthrough in reaction acceleration by optical condensation

“**Optical condensation**” provides us **remote, low damage, label-free, precise, compact, and fast pretreatment** in comparison with other condensation methods (physical principles such as centrifugal force, electric field, magnetic field, etc.).  
→ Contribute to “Common Platform Technology, Facilities, and Equipment” mission area  
(for increasing productivity and accelerating research)



# Realize the detection of proteins that were previously undetectable



"Optical condensation" is the accelerator for deepening blood proteomics!

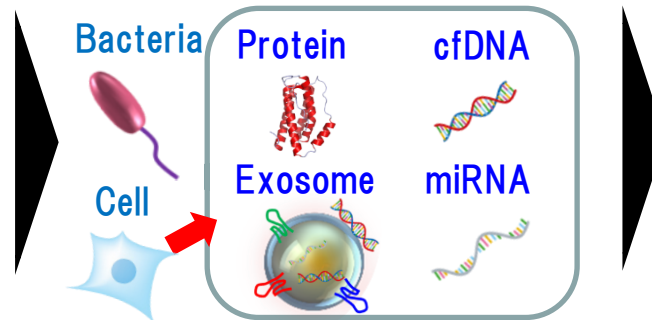
# Proof of concept (POC) in our “Full-scale research” stage

- (1) Elucidation of **mechanism of intermolecular interactions** by “**optical condensation**” and establishment of a high-throughput measurement method
- (2) Implementation of **high-performance standard apparatus**, and achievement of ultra-early diagnosis (colorectal cancer) in collaboration with medical institutions
- (3) Detection of microbes (SARS-CoV-2, bacteria etc.) by **portable general-purpose equipment**, and horizontal development toward food inspection, pharmaceuticals, and environment measurements.

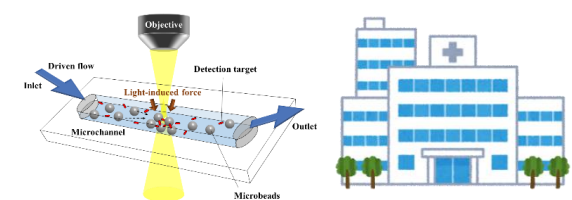
## Examples of non-invasive body fluid samples



## Examples of multi-biomarkers



## Example of social implementation



Expanding from implementation in large hospitals to general use

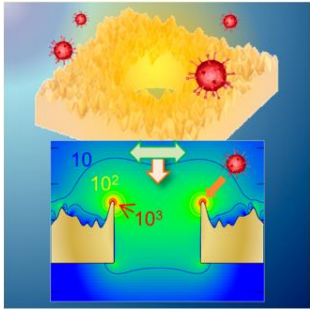
Successful validation of initial concept using clinical samples in FS stage

Biomarkers in trace amounts of body fluids (blood etc.), and microbes in food and beverage supernatants

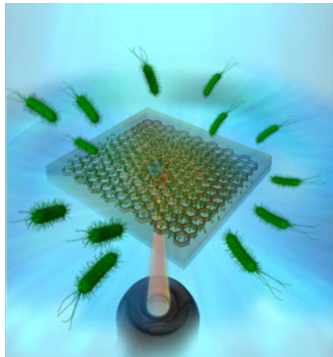
**100 times higher sensitivity, 60 times faster speed, and double-digit trace amounts**

# (Achievements) Damage-free assembly of microbes using our original “optical condensation substrates”

Theatrical prediction by Iida group  
J. Phys. Chem. Lett 2017



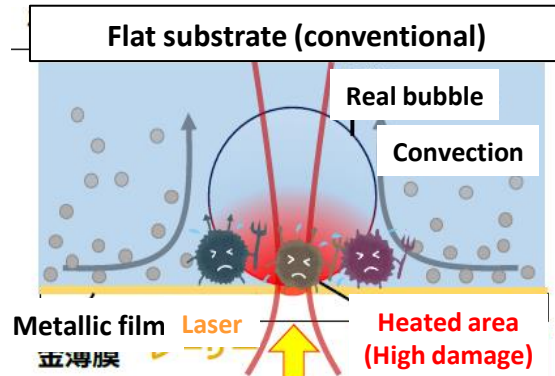
Honeycomb substrate by Tokonami group, Science Advances 2020



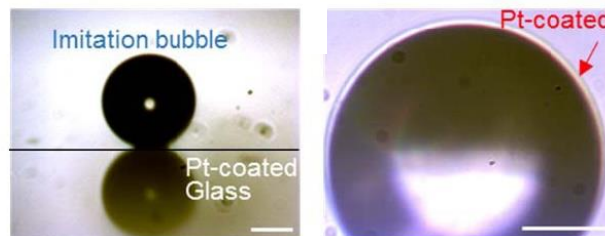
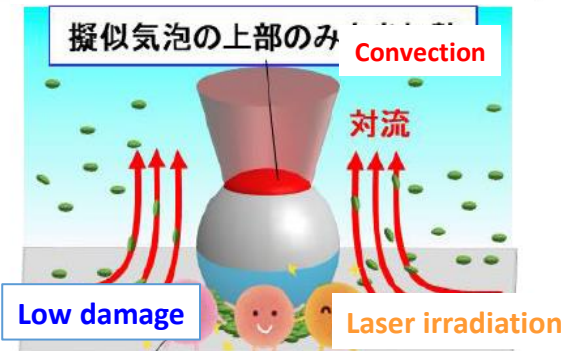
Portable optical condensation system, CEATEC 2019



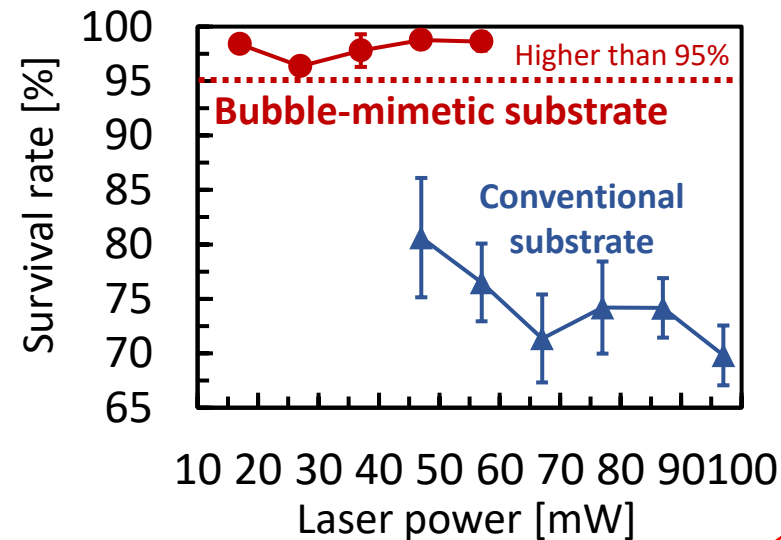
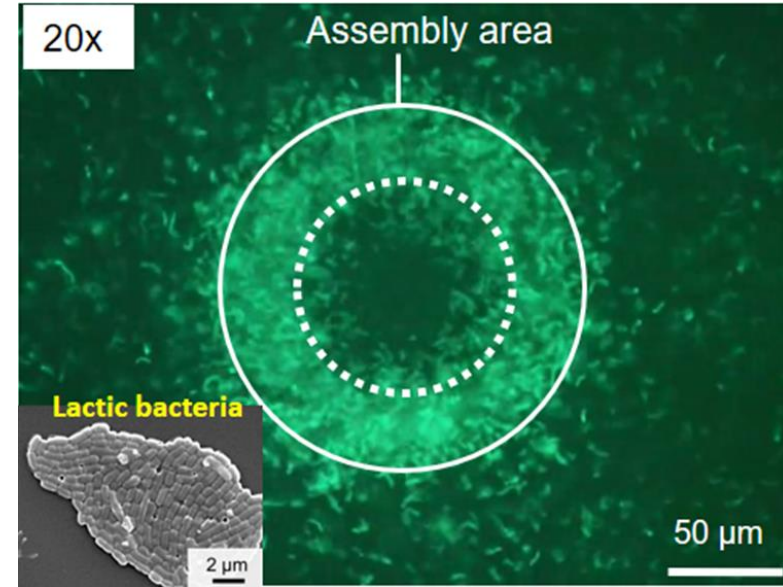
K. Hayashi, S. Tokonami\*, T. Iida\*, et al., Communications Biology 2021, [Nature Research]



**Bubble mimetic substrate**  
Heating only upper part of imitation bubble



**40000 cells can be assembled within 300 s**

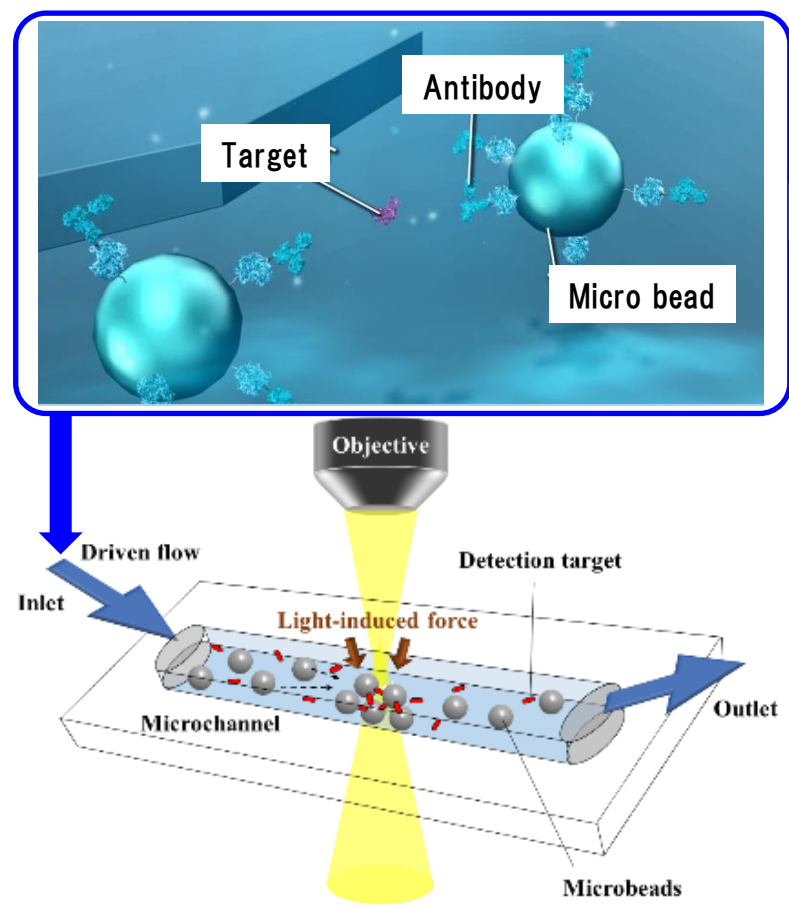
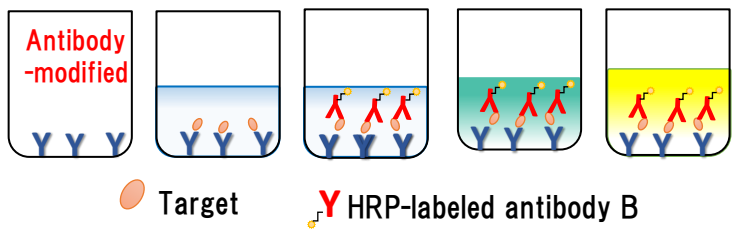


<https://www.youtube.com/watch?v=CGNjohGkFxl>

(Achievement) Sensitive & rapid specific detection of **proteins** by light-induced antigen-antibody reaction

T. Iida, S. Tokonami, et al.,  
Patent applied (2020);  
APL Photonics (2019);  
New paper submitted (2021)

5-6 hours are required in conventional ELISA



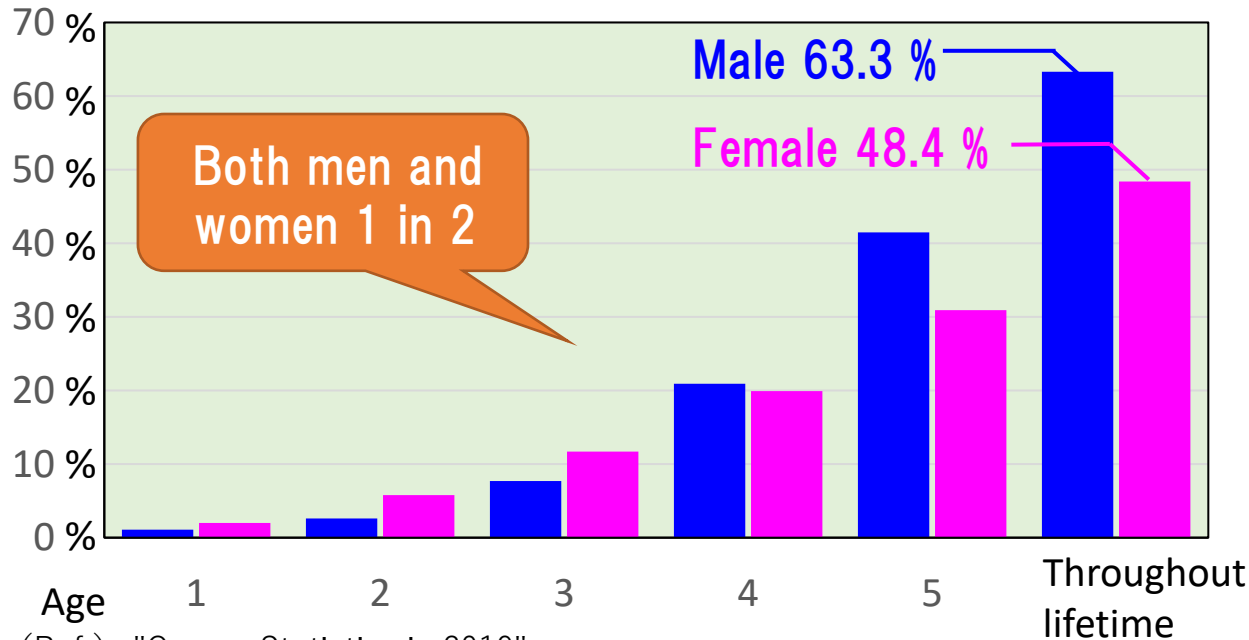
Optical condensation → High sensitivity

- Omits complicated processes such as incubation and washing
- Sample volume:  $10^2$  nl to  $1\mu$ l, measurement time 3 to 5 min
- Detection sensitivity: 1-2 order higher sensitivity than ELISA

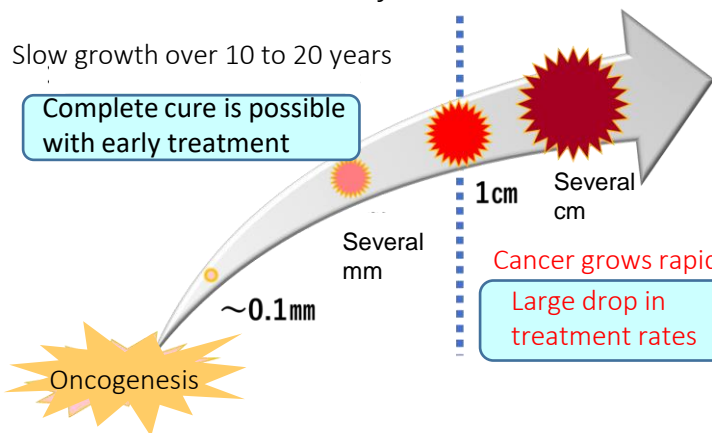


# Social issues (A): Early detection of cancer

One in two Japanese will develop cancer in their lifetime.



(Ref.) "Cancer Statistics in 2019"  
by Foundation for Promotion of Cancer Research



Cancer grows rapidly in 1 to 5 years

Large drop in treatment rates

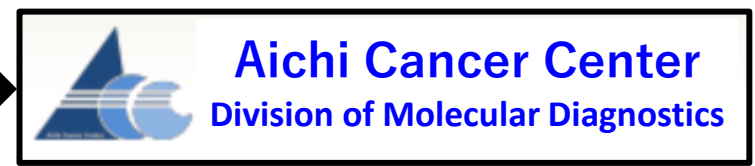


#Busy  
#Scared  
#Pain

Approximately 50,000 people die every year from colorectal cancer  
Annual medical expenses: approximately 600 billion yen

(Ref.) Ministry of Health, Labour and Welfare (2017)

# Solution: Development of an ultra-early diagnosis by “Optical condensation”



Prof. Takuya Iida,  
Director of RILACS



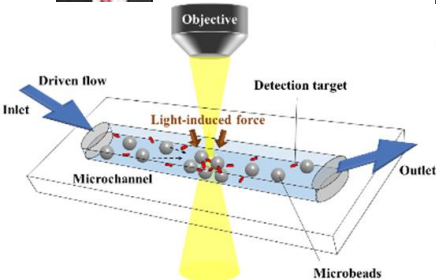
Prof. Shiho Tokonami,  
Deputy Director of RILACS



Prof. Ayumu Taguchi, Chief of  
Division of Molecular Diagnostics, ACC



Prof. Ikuhiko Nakase,  
Assistant Director of RILACS



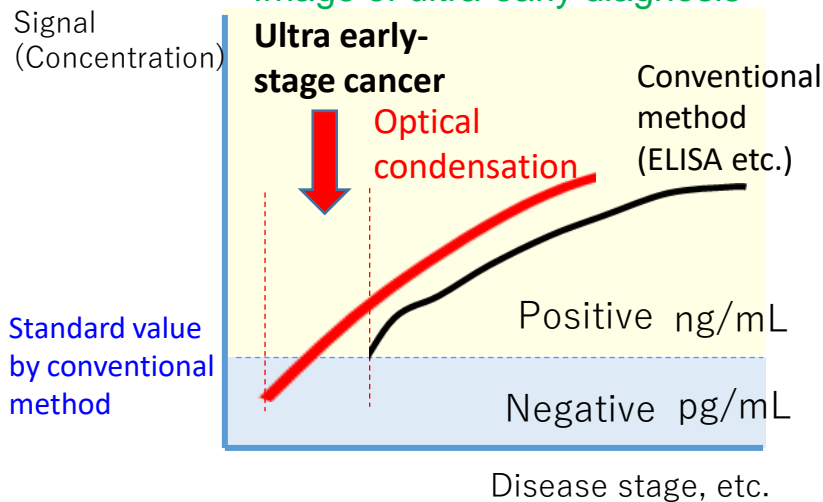
- #Development of apparatus
- #Measurement method
- #Elucidation of mechanism



- #Proof of concept in clinical practice
- #Novel marker discovery and expansion to low frequency refractory cancer markers
- #Multi-itemization

also, collaboration with “Advanced Optics Team”  
(Osaka University, Waseda University, Okayama University)

## < Image of ultra-early diagnosis >

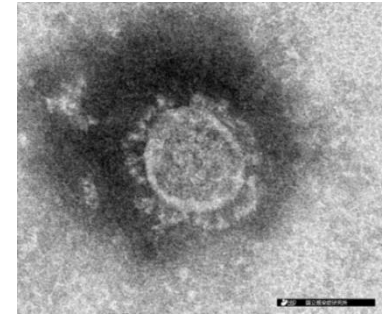


Ultra-early-stage cancer,  
which is difficult to detect  
with conventional  
methods, can be detected  
by “optical condensation”,  
leading to ultra-early  
diagnosis and treatment.

Mont Saint-Michel  
(Ref.) Wikipedia

# Social issue (B): COVID-19 pandemic and our solution

Solution: Easy “on-site” and high-sensitivity testing  
by compact optical condensation devices

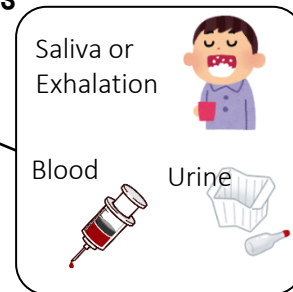
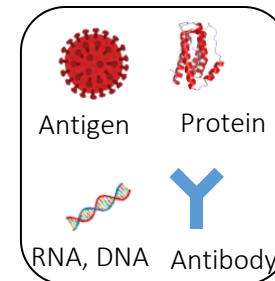


Electron micrograph of a SARS-CoV-2 virus  
(diameter ~100 nm)  
(Ref.) National Institute of Infectious Diseases

Home, health centers, clinics, airports,  
and drive-through "on-site" inspections



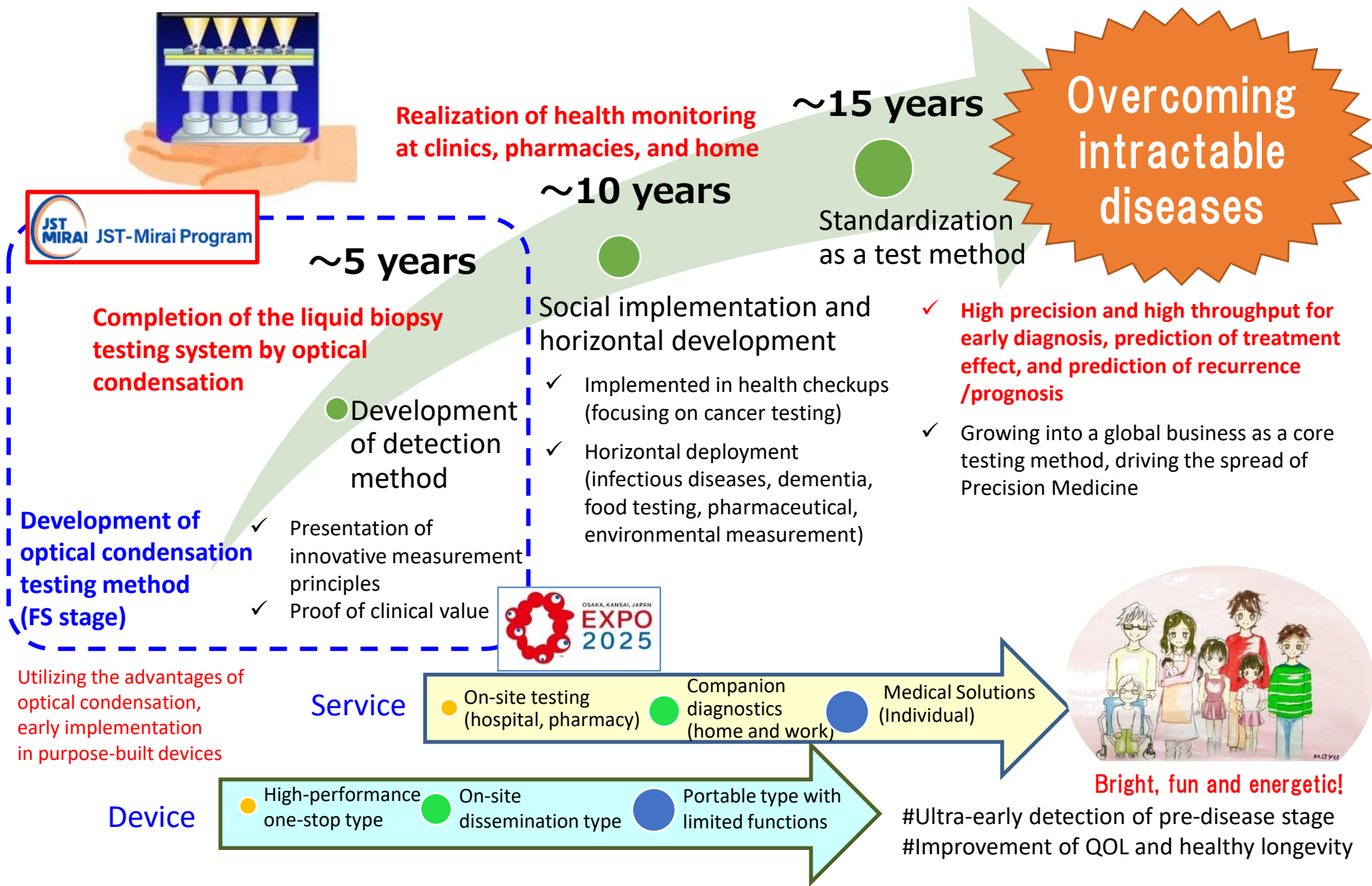
Virus related-samples



Aiming at the same or better performance as high-  
performance standard machines (Large travel bag size)

By Mayu I.

# Research and development roadmap for “Well-being of people in the world”

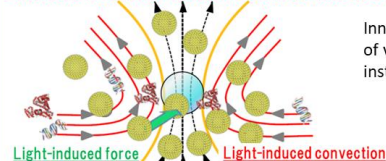


# Thank you very much for your kind attention !

Protect human health, food, and the environment by our “Optical condensation technology”!

## Optical condensation Accelerate reactions in a trace amount of biomaterials

High-performance optical condensation system to detect a small amounts of biomaterials in a few minutes



Innovate pretreatment of various bioanalytical instruments

Applicable to various biological substances

High sensitivity, Rapid, Trace amount, Convenience, Low cost, High scalability

Body fluid sample  
Minimally invasive



Target biomaterials

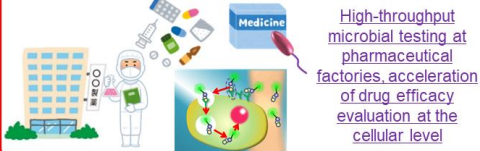


## Examples of social problems and implementation of this technology (medical, pharmaceutical, food, environment)

### Easy and quick inspection / diagnosis anywhere



### Inspection and drug evaluation pharmaceutical process



### Pre-shipment and on-site inspection of food & drink



### Environmental measurement and monitoring



Bright, fun and energetic!



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