Organoid-Based Precision Lung Cancer Remodeling

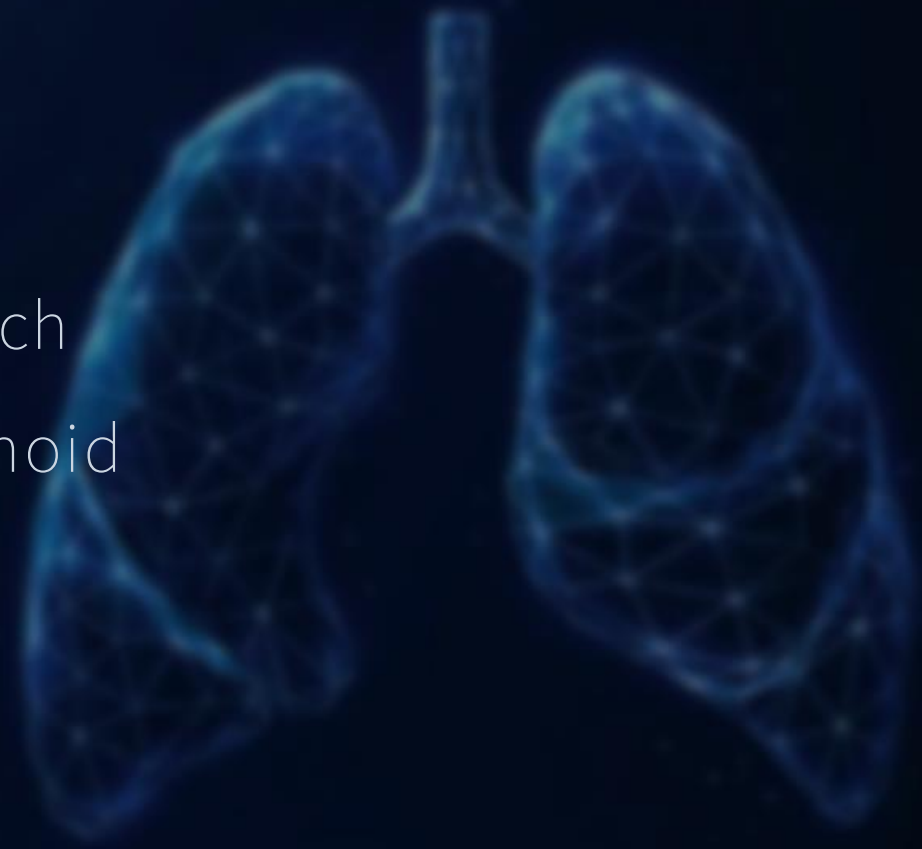
From Static 2D Models to Dynamic 3D Patient Avatars

Chaeuk Chung M.D./Ph.D. | Chungnam National University Hospital

Korean Molecular Lung Cancer Study Group Winter Workshop

CNU HOSPITAL 충남대학교병원 CHUNGNAM NATIONAL UNIVERSITY HOSPITAL

Contents



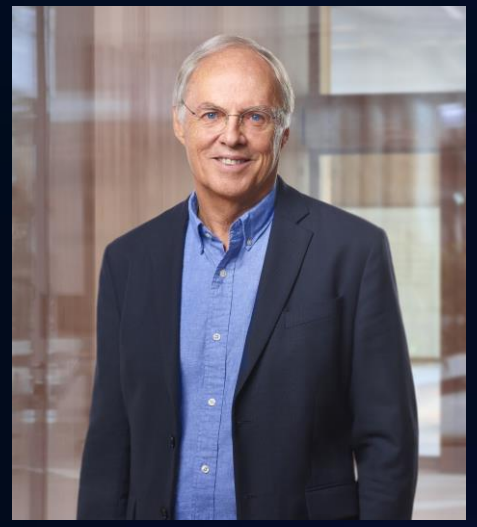
Organoid: Organ + oid (~Resemble Sth)

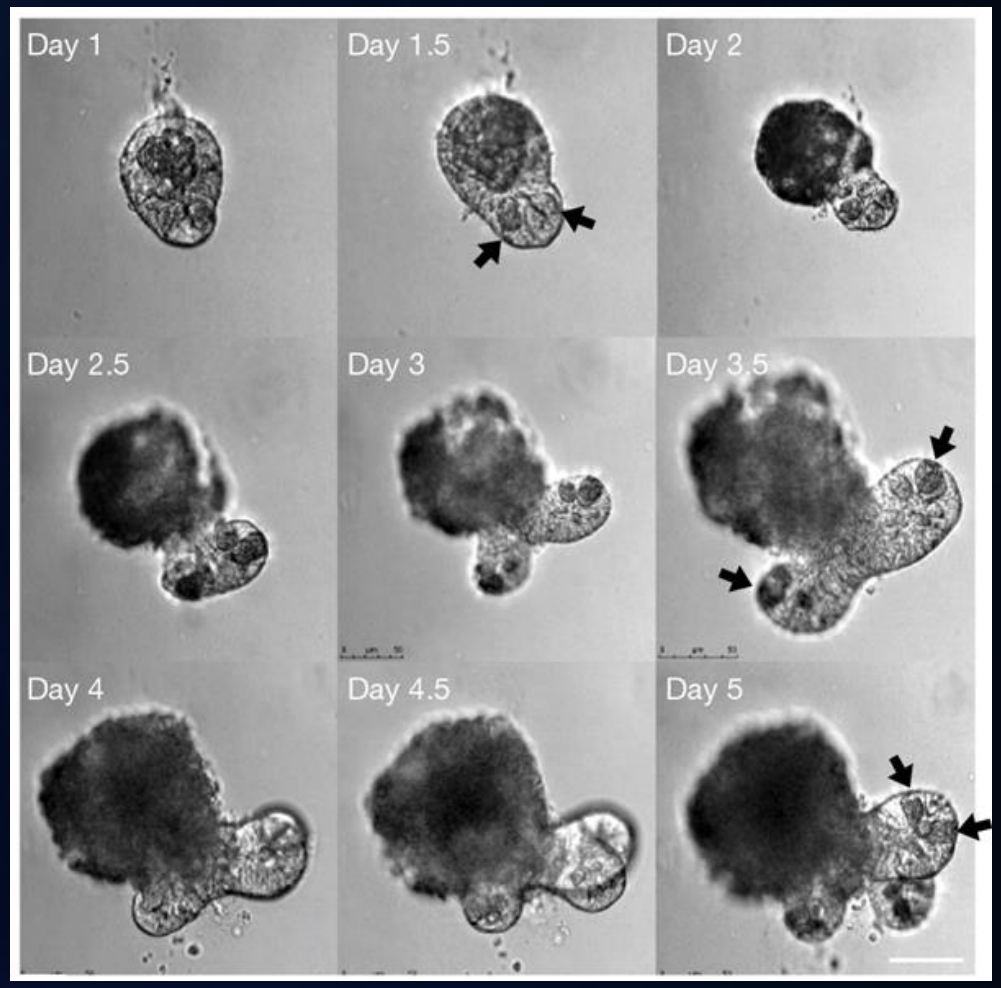
nature Vol 459|14 May 2009|doi:10.1038/nature07935

LETTERS

Single Lgr5 stem cells build crypt–villus structures *in vitro* without a mesenchymal niche

Toshiro Sato[1], Robert G. Vries[1], Hugo J. Snippert[1], Marc van de Wetering[1], Nick Barker[1], Daniel E. Stange[1], Johan H. van Es[1], Arie Abo[2], Pekka Kujala[3], Peter J. Peters[3] & Hans Clevers[1]





Organoids recapitulates heterogeneity of organ

nature Vol 459|14 May 2009|doi:10.1038/nature07935

LETTERS

Single Lgr5 stem cells build crypt–villus structures *in vitro* without a mesenchymal niche

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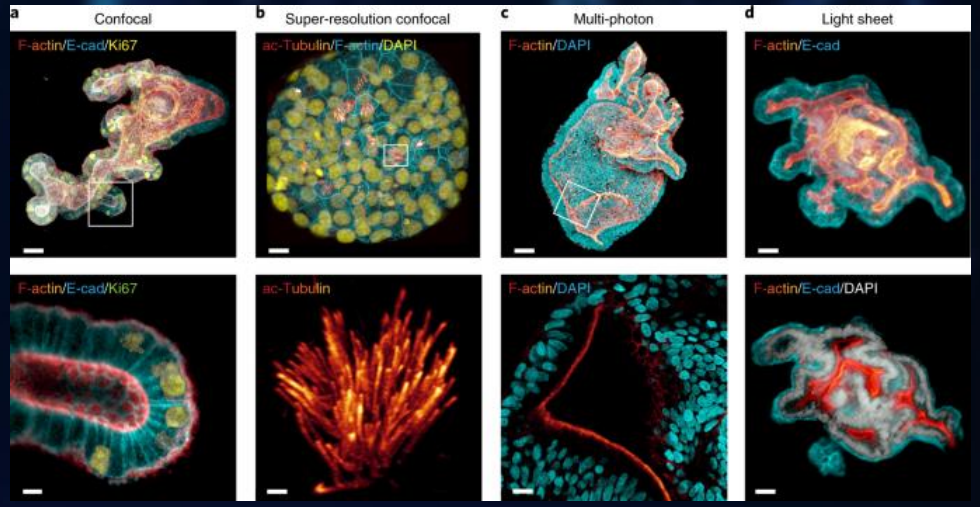
Commentary | Published: 03 January 2018

Imaging organoids: a bright future ahead

Anne C Rios & Hans Clevers

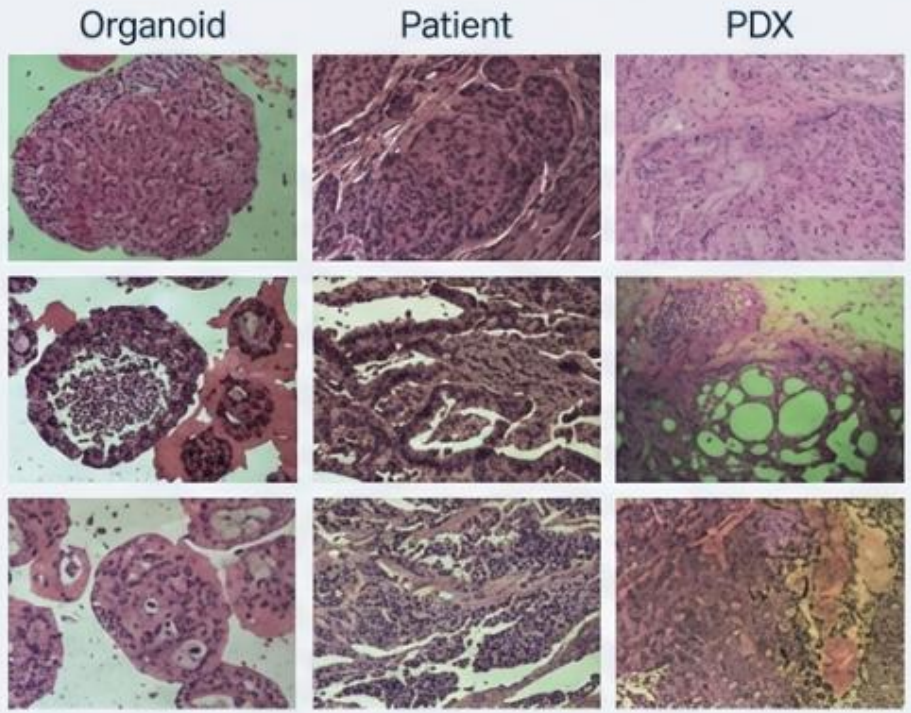
Nature Methods **15**, 24–26 (2018) | Cite this article



Organoids: Three-Dimensional Living Models of Human Cell Complexity

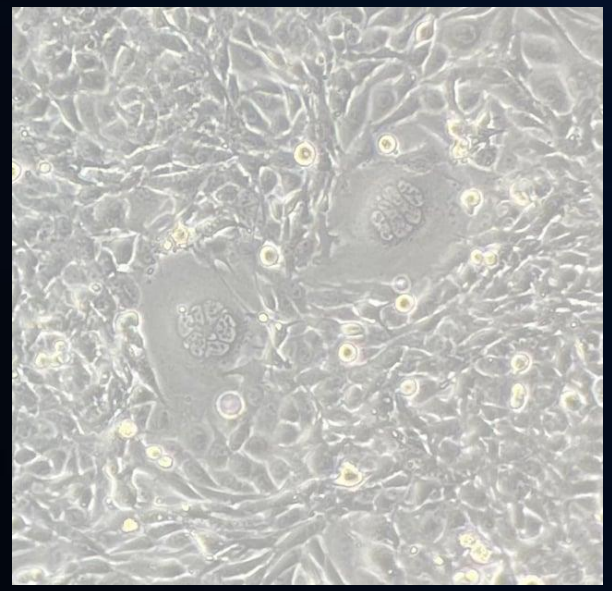
	2D Cell Lines	PDX Models	**LCO (Organoids)**
Cost	Low	High	Moderate
Speed	Fast [3-7 days]	Slow [4-8 months]	Moderate [2-4 weeks]
Heterogeneity Retention	Poor	Good	Good/Polyclonal
Throughput	High	Low	Moderate/High

Visual Proof

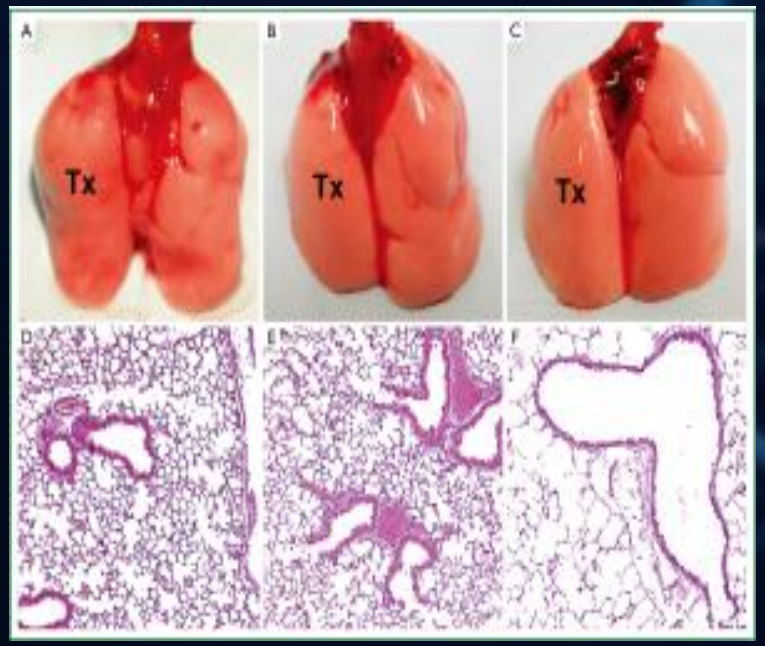


Histological analysis confirms LCOs retain the architectural features of the primary patient tumor.

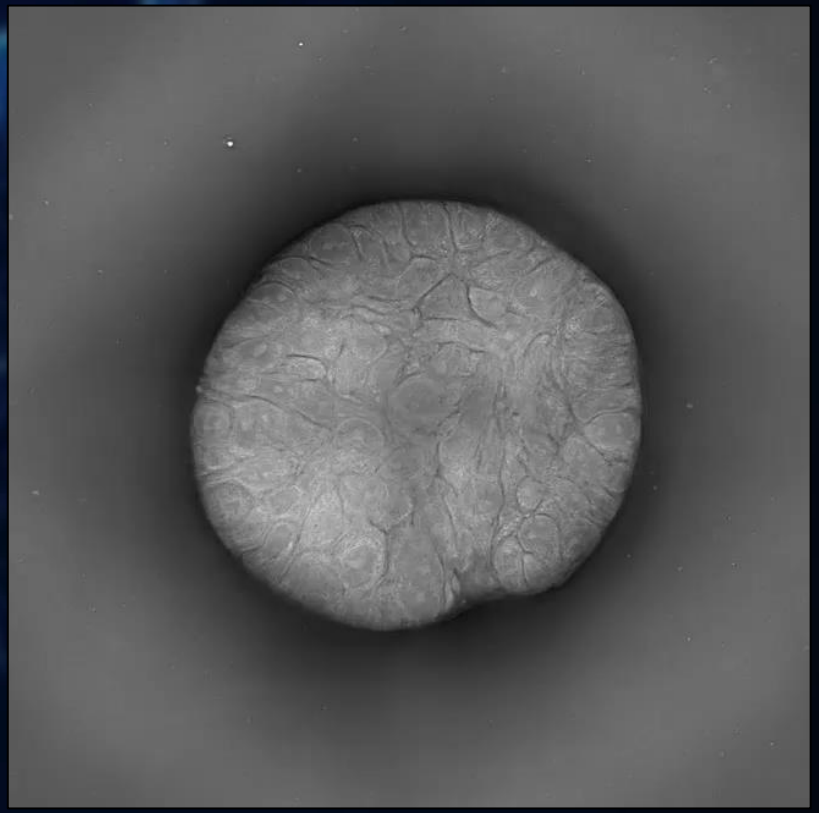
Organoids: Three-Dimensional Living Models of Human Cell Complexity



2D Cell Culture



Mouse Model



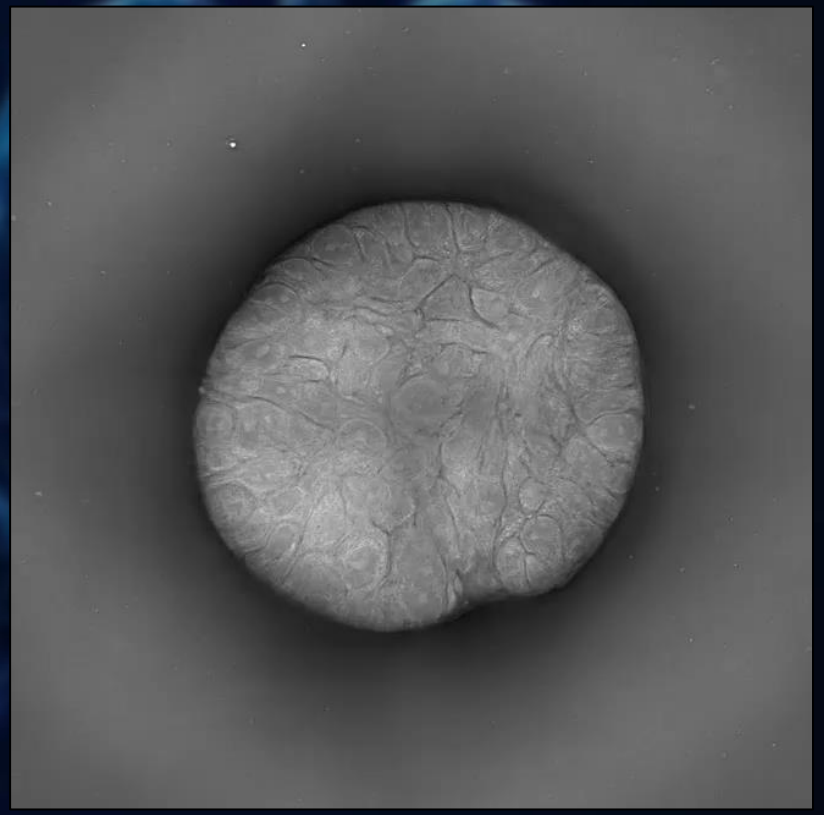
3D Human Lung Organoid

FDA, 식약처도 “마우스 그만“ 오가노이드가 바꾼 전임상 지도

서울경제

美 FDA 동물실험 단

미국 식품의약국(FDA)이 의약품 개발 과정에서 동물실험을 단계적으로 폐지하겠다고 선언했지만 국내 산업계는 사실상 무방비 상태다. 관련 법률은 현재 국회에 계류 중으로 통과될 기미가 보이지 않는 상황에서 담당 부처인 식품의약품안전처가 가이드라인을 마련 중이지만 법적 근거가 미비해 산업 육성에는 한계가 있다는 지적이 나온다.



nature COMMUNICATIONS

ARTICLE

https://doi.org/10.1038/s41467-019-11867-6 OPEN

Patient-derived lung cancer organoids as in vitro cancer models for therapeutic screening

Minsuh Kim[1], Hyemin Mun[1], Chang Oak Sung[1,2], Eun Jeong Cho[1], Hye-Joon Jeon[1], Sung-Min Chun[1,2], Da Jung Jung[3], Tae Hoon Shin[3], Gi Seok Jeong[3], Dong Kwan Kim[4], Eun Kyung Choi[5], Seong-Yun Jeong[5], Alison M. Taylor[6], Sejal Jain[6], Matthew Meyerson[6] & Se Jin Jang[1,2]

2019

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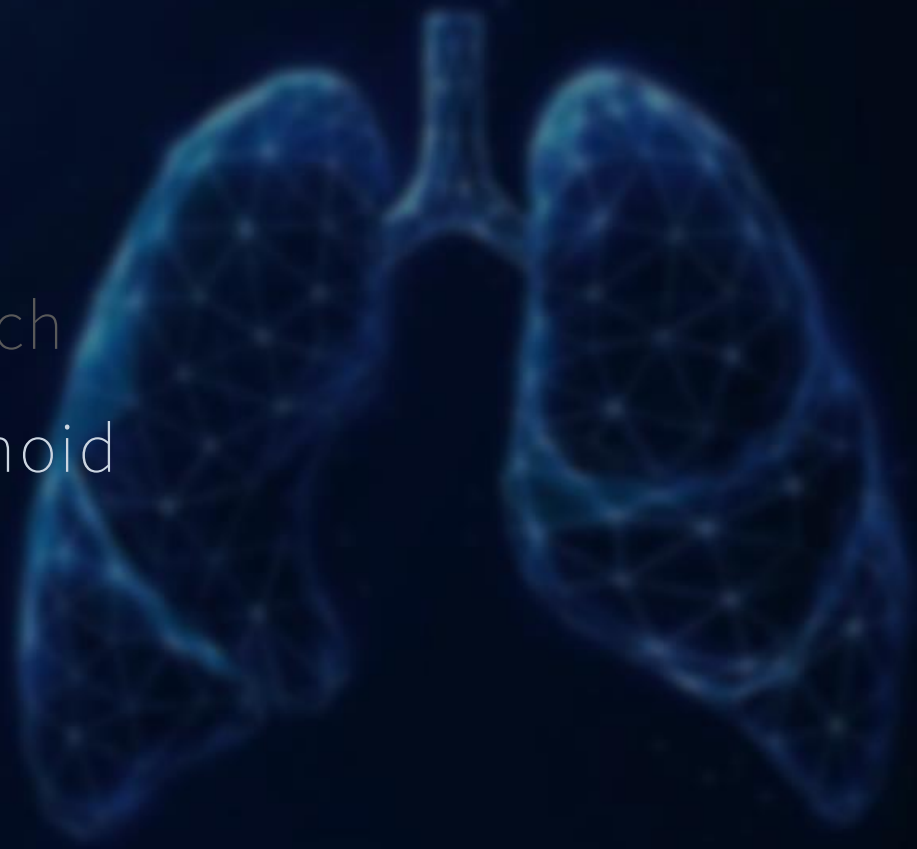
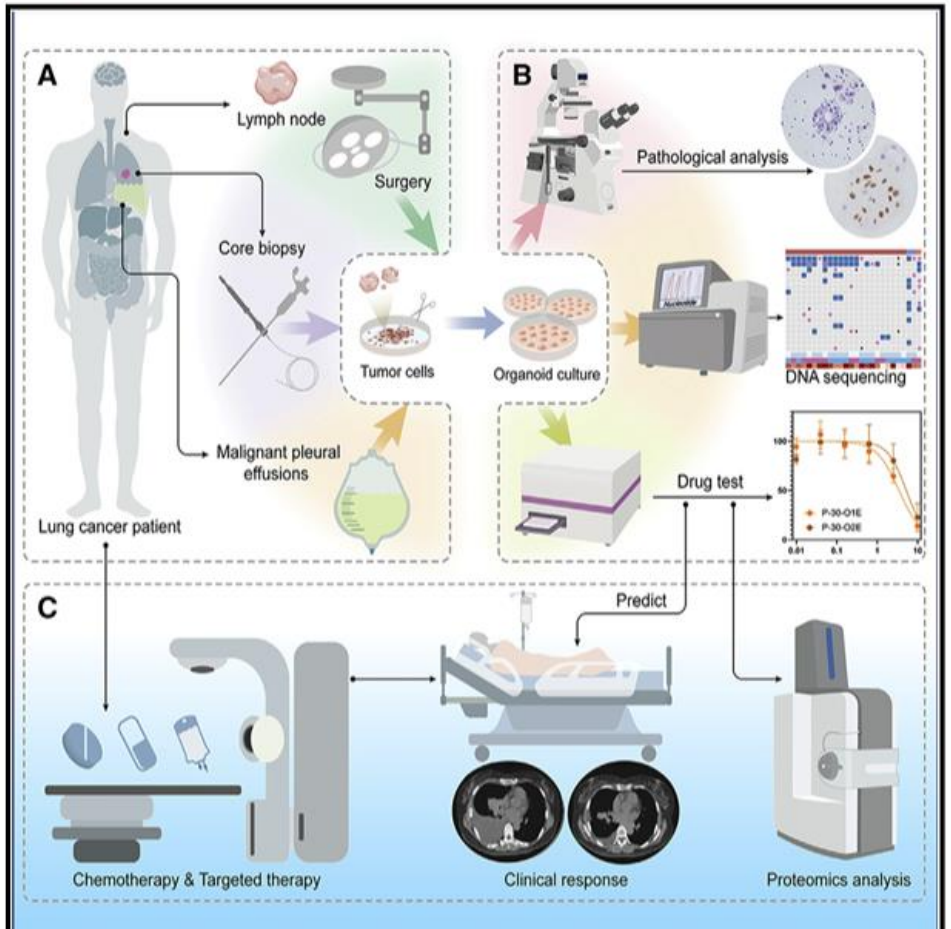


Cell Reports
Medicine

Article

Using patient-derived organoids to predict locally advanced or metastatic lung cancer tumor response: A real-world study

Graphical abstract



Authors

Han-Min Wang, Chan-Yuan Zhang, Kai-Cheng Peng, ..., Hua-Jun Chen, Yi-Long Wu, Jin-Ji Yang

Correspondence

chenhuajun@gdph.org.cn (H.-J.C.), syylwu@live.cn (Y.-L.W.), yangjinji@gdph.org.cn (J.-J.Y.)

In brief

Wang et al. generated lung cancer organoids (LCOs) derived from human malignant serous effusions and tissues. The LCOs accurately represented original tumor features. Drug sensitivity tests were performed to predict clinical response. The results illustrated enormous value of LCO as an *in vitro* platform for personalized medicine of lung cancer.

Cell Rep Med. 2023 Feb 21;4(2):100911

Cell Stem Cell. 2025 Aug 7;32(8):1218-1234.e7. doi: 10.1016/j.stem.2025.05.011. Epub 2025 Jun 12.

An organoid co-culture model for probing systemic anti-tumor immunity in lung cancer

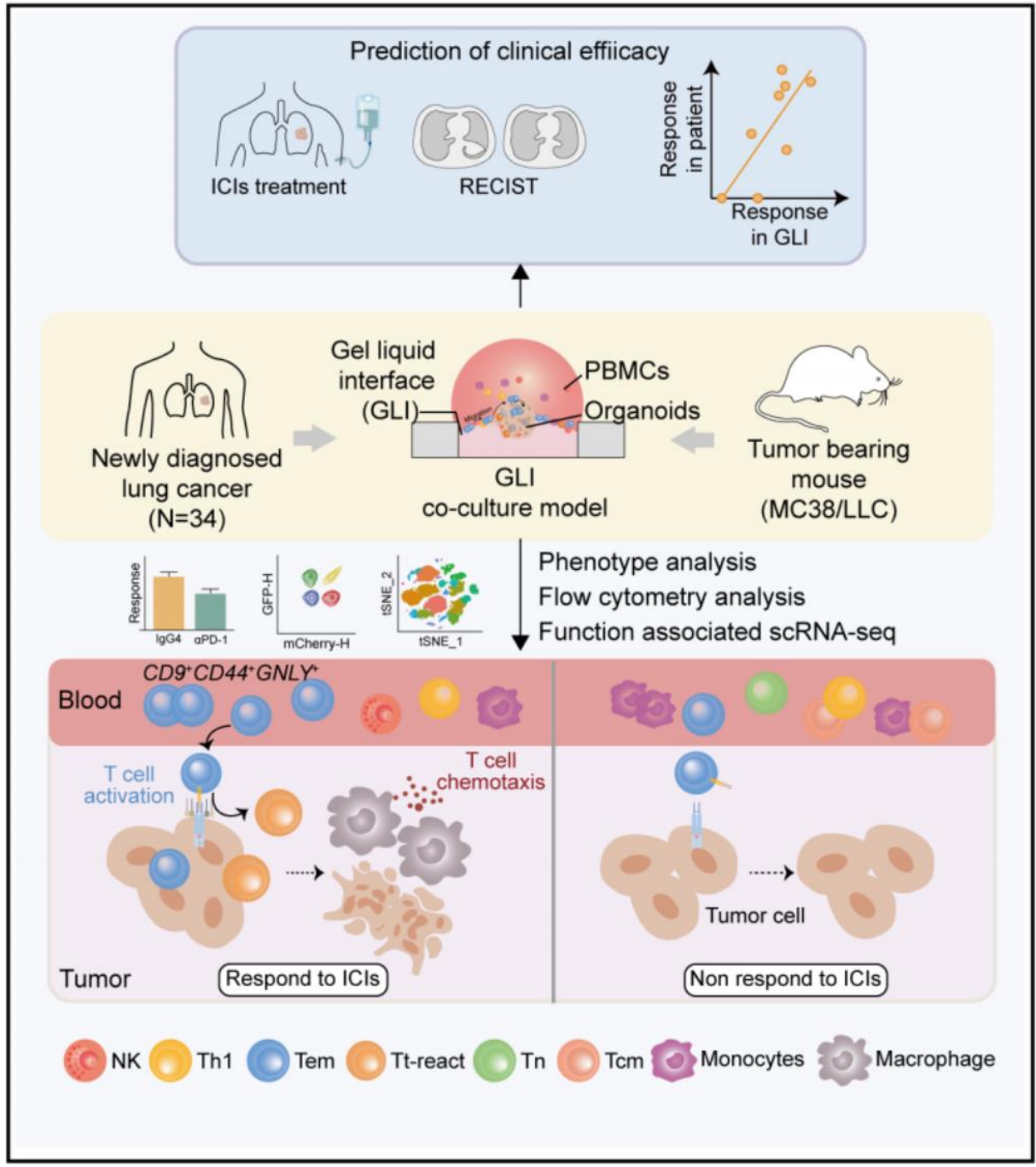
Kaiyi Li [1], Chang Liu [1], Xizhao Sui [2], Chao Li [2], Ting Zhang [1], Tian Zhao [1], Dong Zhang [1], Hainan Wu [3], Yuhan Liu [4], Shuai Wang [5], Yingshun Yang [5], Baobao Lin [1], Wenyan Wang [6], Fan Yang [7], Xiaofang Chen [8], Peng Liu [9]

Affiliations + expand

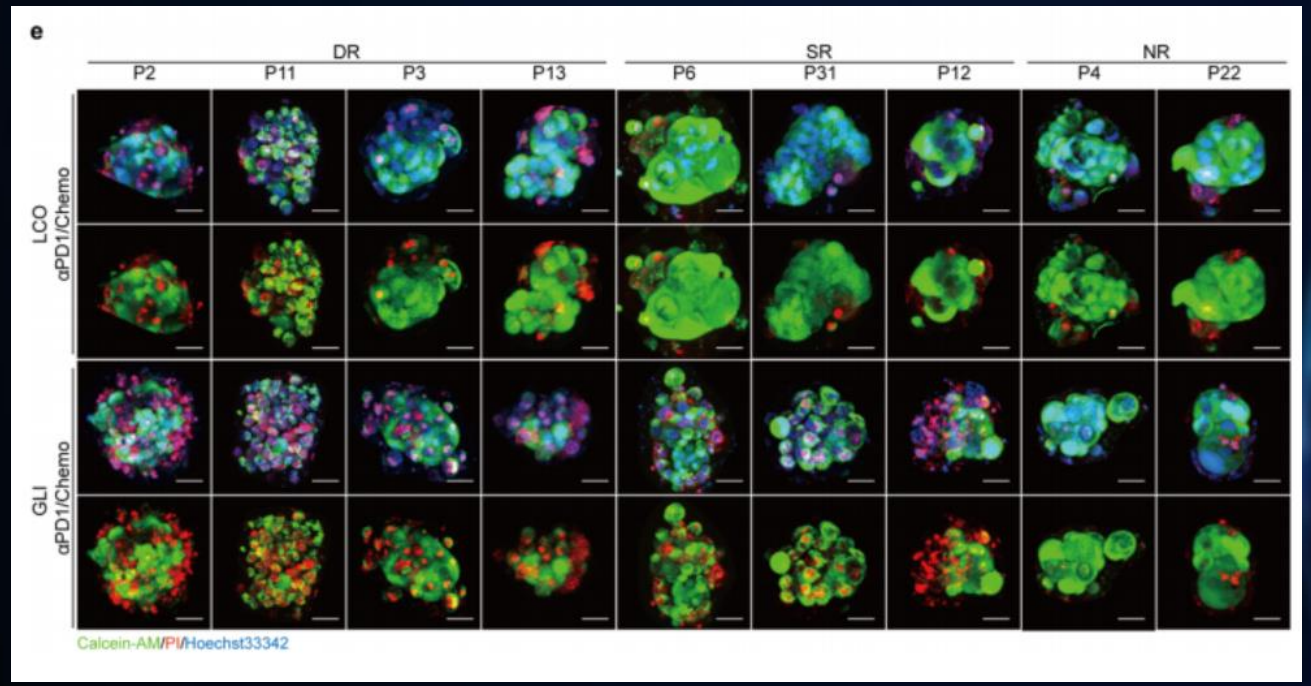
PMID: 40513558 DOI: 10.1016/j.stem.2025.05.011

Organoid co-culture model

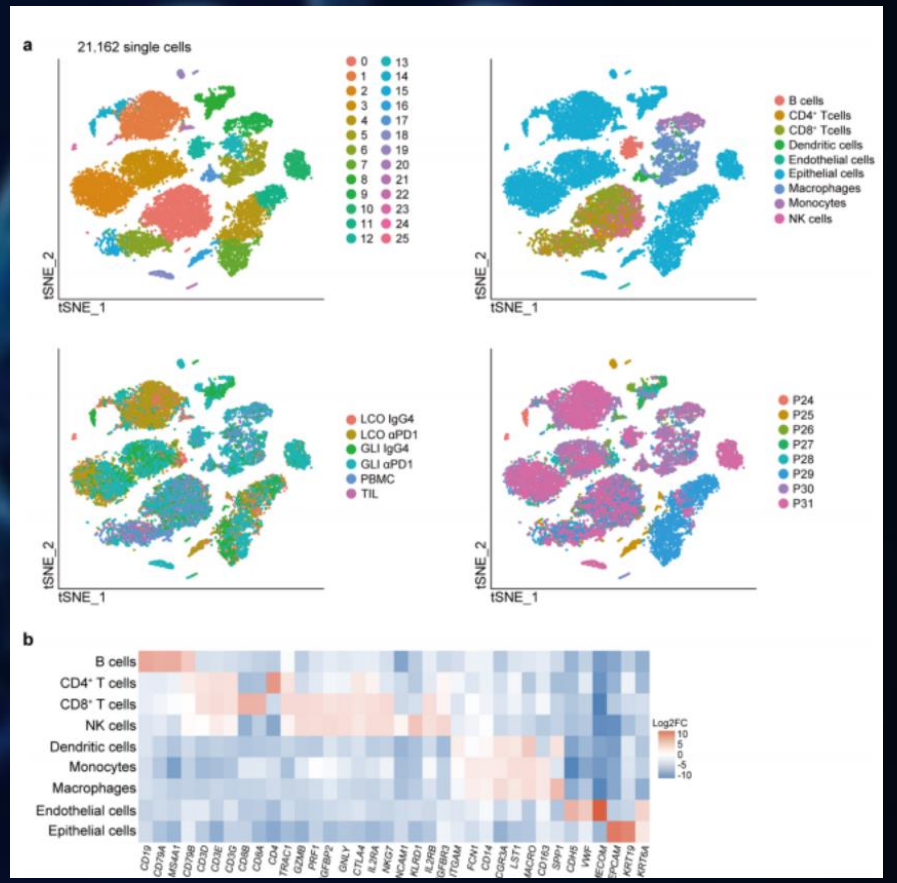
We established a gel-liquid interface (GLI) co-culture of lung cancer organoids (LCOs) and paired peripheral blood mononuclear cells (PBMCs), featuring with enhanced interactions of immune cells and tumor organoids, to mimic the in vivo systemic anti-tumor immunity induced by immune checkpoint inhibitors (ICI).



Confocal image and scRNA-seq in co-culture system



Confocal Fluorescence microscopy of LCO co-cultures



scRNA-seq data of lung cancer blood

nature biomedical engineering

Article

https://doi.org/10.1038/s41551-025-01594-3

Lung tumouroids as a testing platform for precision CAR T cell therapy

Received: 22 November 2024

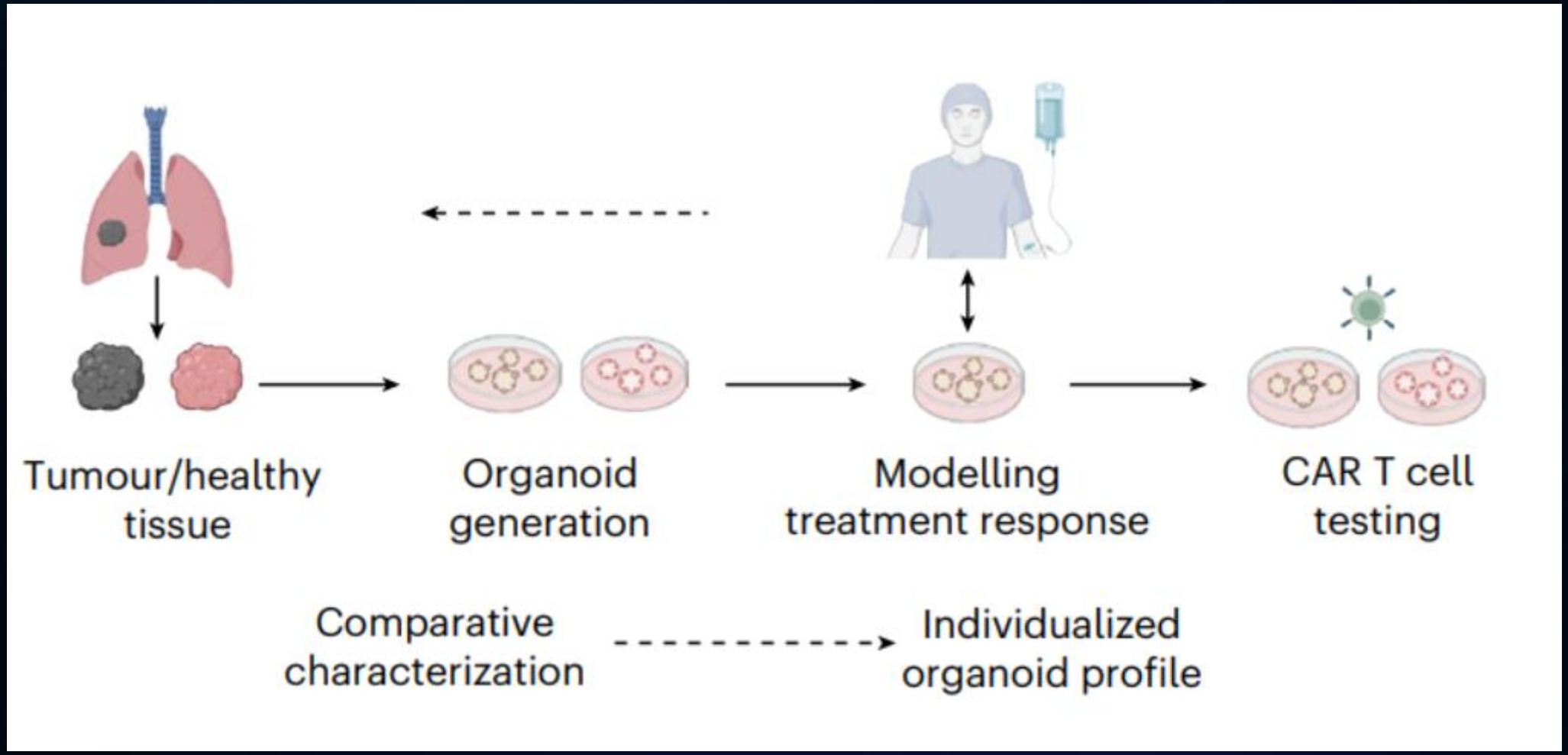
Accepted: 21 November 2025

Published online: 21 January 2026

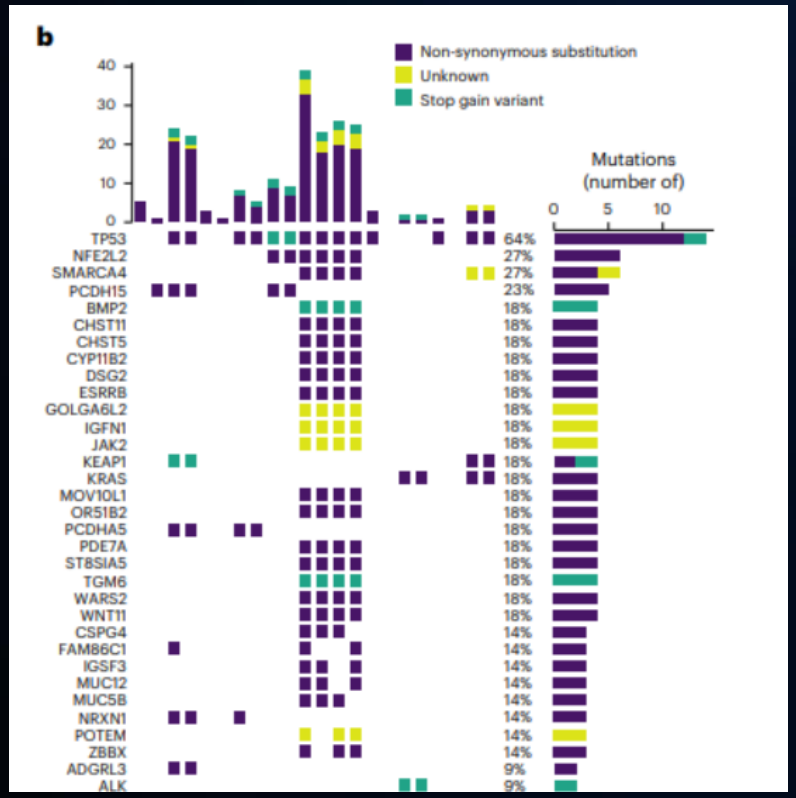
Check for updates

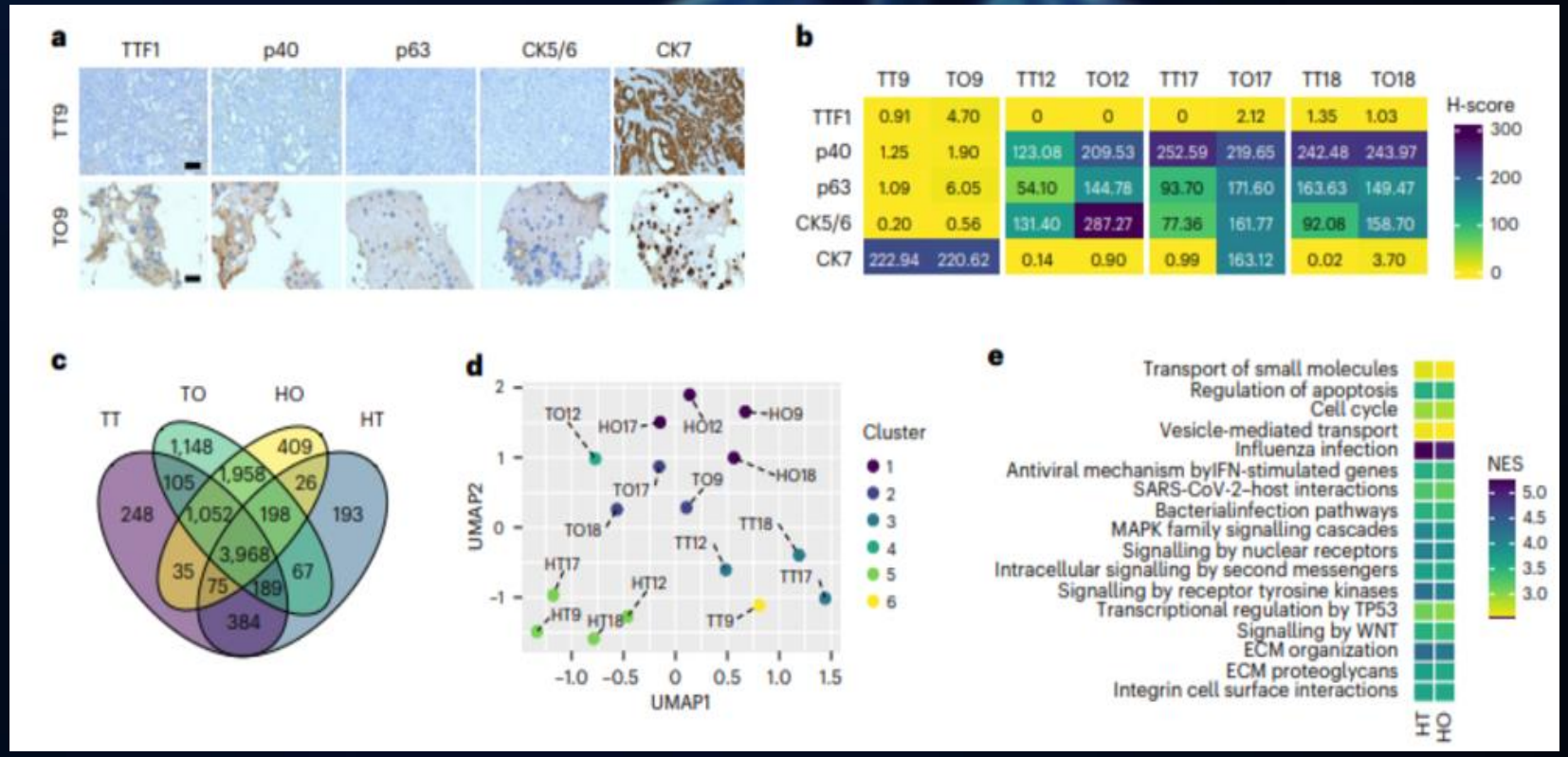
Lukas Ehlen[1,2,17], Martí Farrera-Sal[1,17], Martin Szyska[1,15], Janine Arndt[1,2], Simon Schallenberg[3], Cedric Scholz[1], Mingxing Yang[4], Claudia Vollbrecht[3], Anna Löwa[5], Rebecca Friedrich[1], Marco Mai[1], Lena Peter[1], Samira Picht[1], Sarah Schulenberg[1], Daniel Geray[1], Gabriela Korus[6,7], Anke Sommerfeld[3], Denise Treue[3], Julia Strauchmann[8], Aron Elsner[8], Jonas Kath[9,10], Valeria Fernandez Vallone[11], Maria Joosten[3], Franka Klatte-Schulz[6], Ansgar Petersen[6,7], Harald Stachelscheid[11], Dimitrios L. Wagner[9,10,16], Claudia Spies[2], Jens-Carsten Rückert[8], Andreas C. Hocke[5], Julia K. Polansky[4,12], Regina Stark[13,15], Oliver Klein[14] & Michael Schmueck-Henneresse[1] ✉

A schematic of the lung TO therapy testing platform

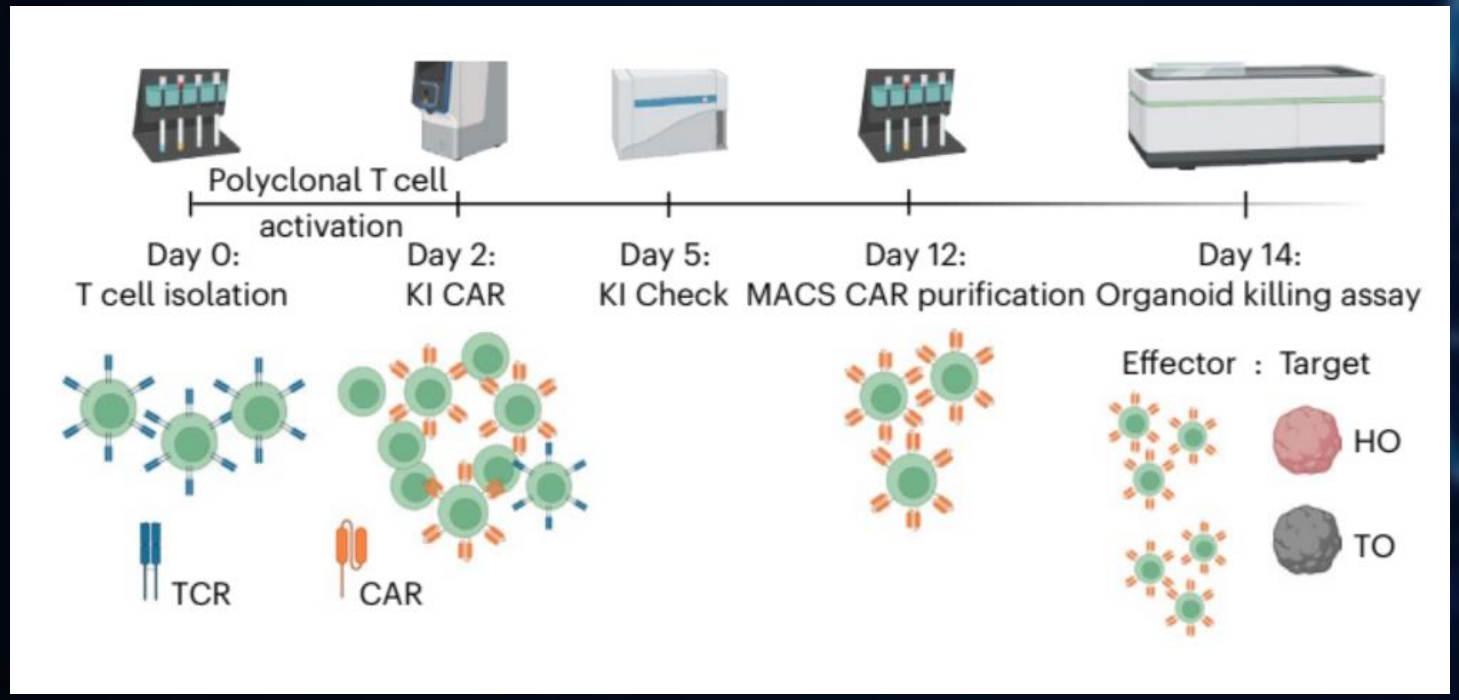


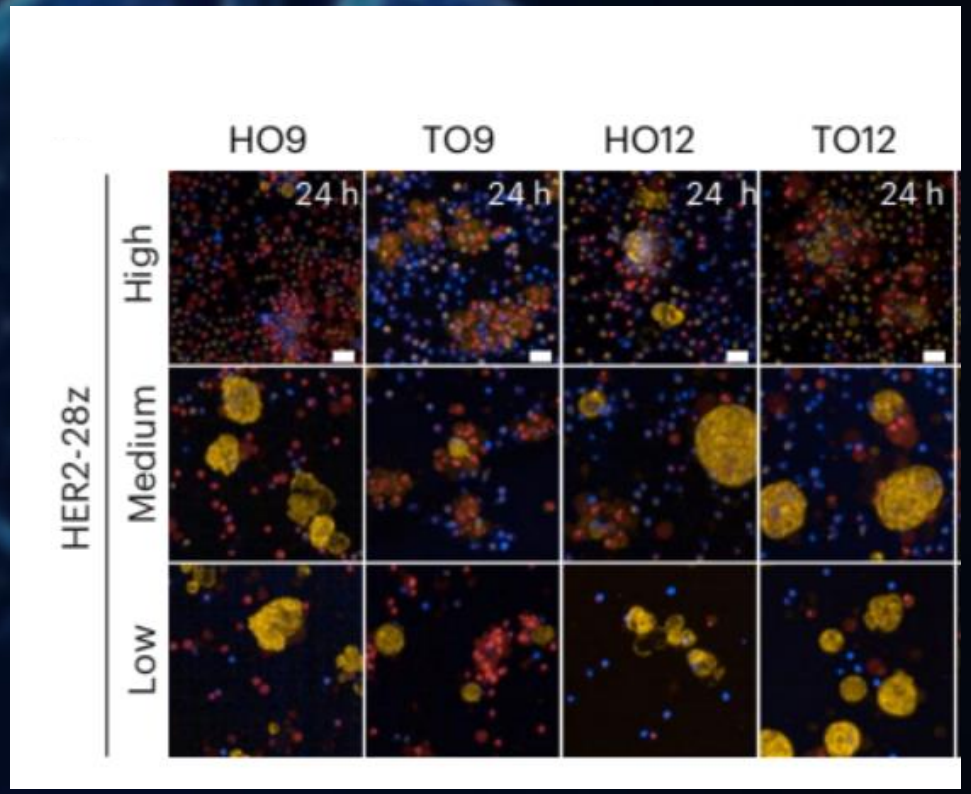
Validation of LCO with multi-omics





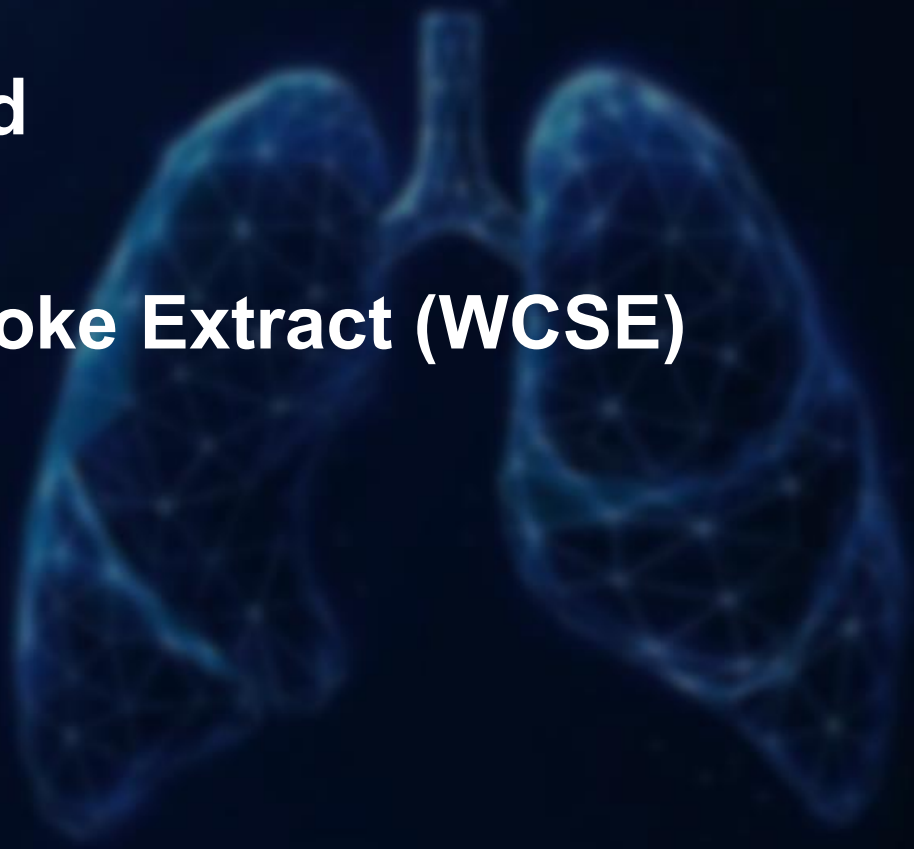
CAR T cell-mediated killing of TOs



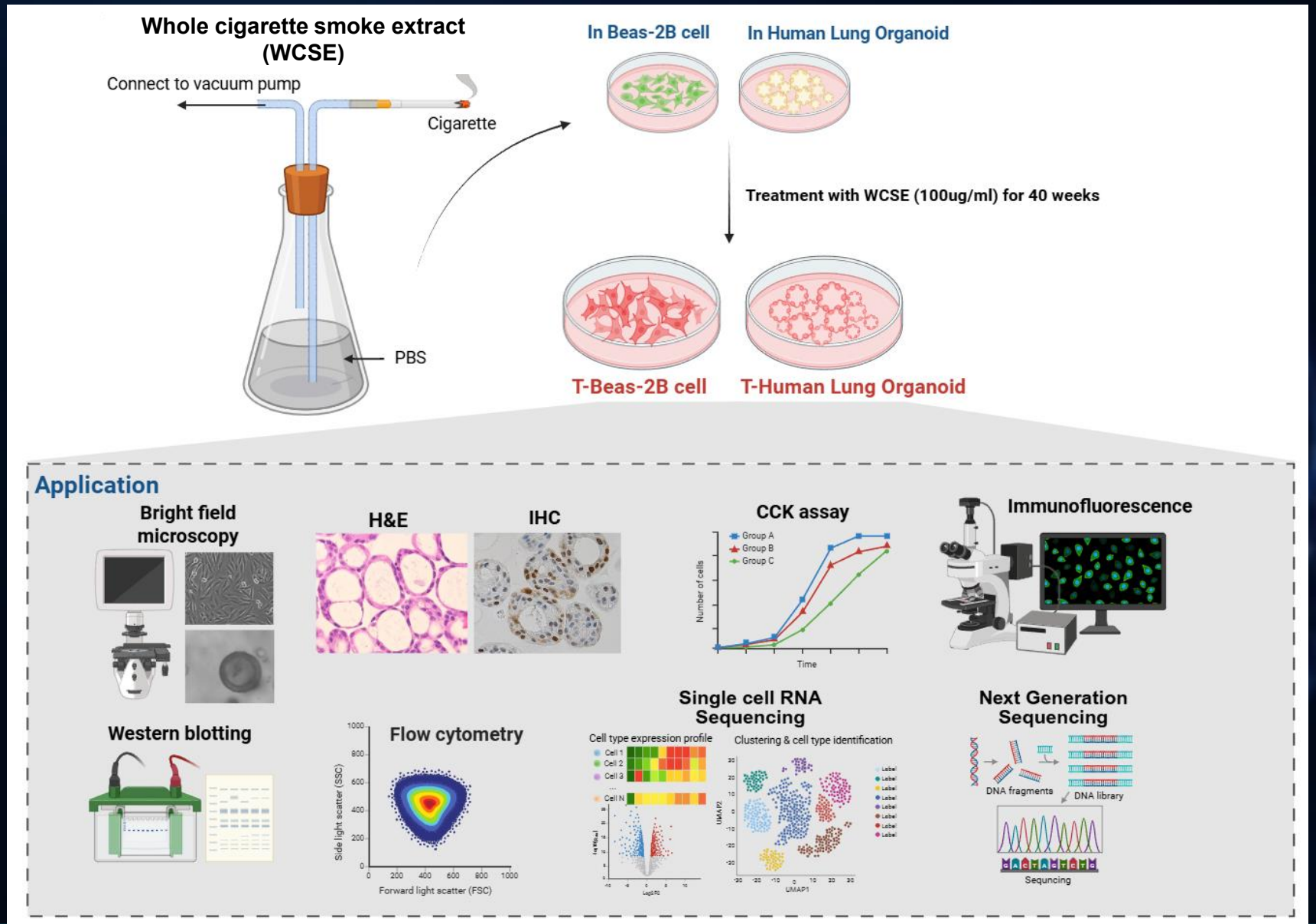


Lung Cancer Organoid in CNUH

- #1. Early Lung Cancer Organoid
- Long-term Whole Cigarette Smoke Extract (WCSE) Exposure Model



Establishment and Applications of a Long-term Whole Cigarette Smoke Extract (WCSE) Exposure Model in Human Lung Cells and Organoids

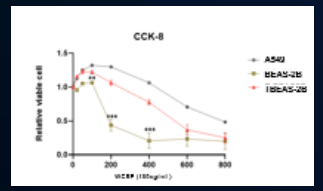


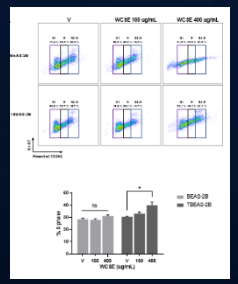
Under review

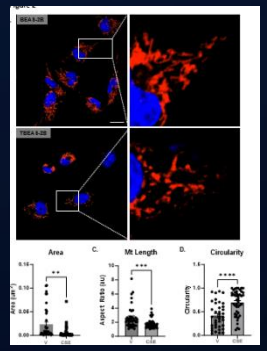
Multi-Dimensional models for investigating Cigarette smoke-induced lung carcinogenesis

Human lung cells

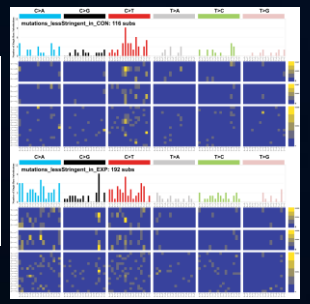
Model validation after cigarette exposure

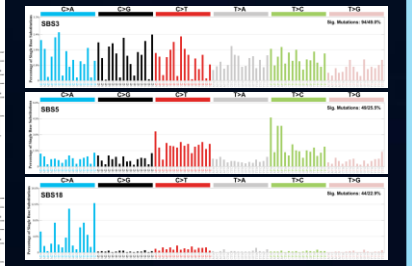




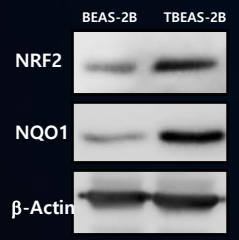


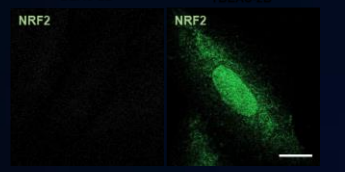
Omics analysis

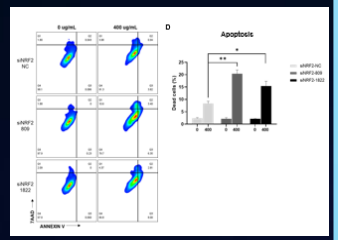




Mechanistic Validation

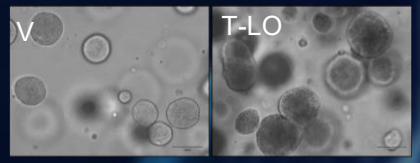


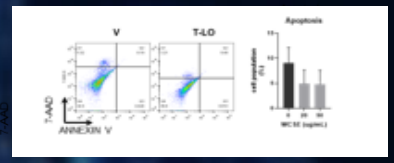




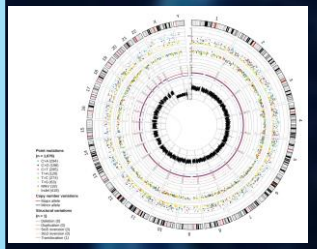
Human Lung organoids

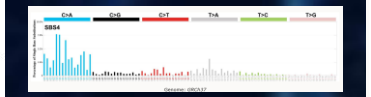
Model validation after cigarette exposure

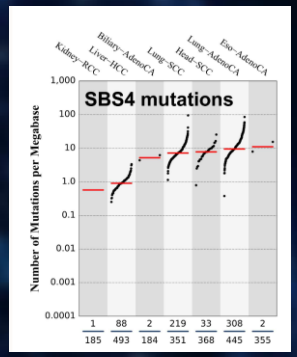




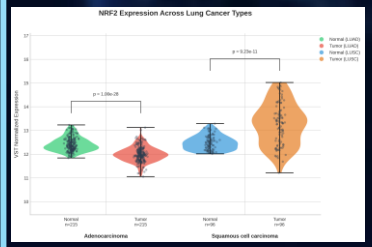
Omics analysis



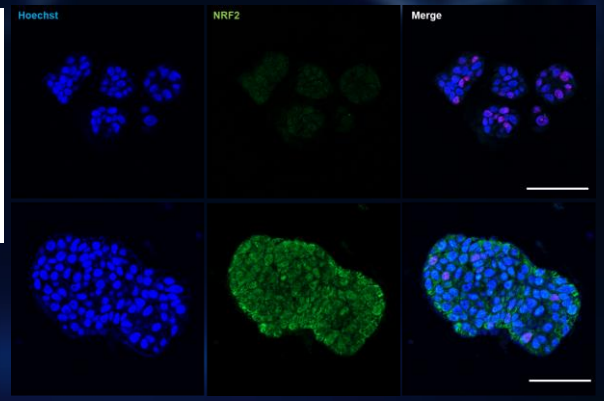




TCGA analysis



Mechanistic Validation



Under review

#2. Organoid Biobank

질병관리청

KBP 5기 인체자원은행 특성화 지원사업 계획

개인 맞춤형 의료 및 신약 스크리닝을 위한

바이오뱅크 플랫폼 구축

특성화 질환 : 간암, 위암, 폐암

거점은행 충남대학교병원 인체자원은행 |

협력은행#1 세종충남대학교병원 |

협력은행#2 건양대학교병원 |

CNU HOSPITAL 충남대학교병원 CHUNGNAM NATIONAL UNIVERSITY HOSPITAL

1 특성화 사업 배경 및 필요성 | 사업의 필요성

CNU HOSPITAL 충남대학교병원

질환 중요성

대상질환 난치성 암종 치료
불확실성 극복 필요성

간암, 위암, 폐암
국내 발생률 및 사망률 상위권

임상적 미충족 문제

동일 병기라도
환자별 치료 반응 상이,
진행성 단계에서 예후 불량

해결방안

환자 종양 특성을 재현하는 오가노이드(Organoid) 등
고부가가치 인체자원 확보 필수

오가노이드 Organoid

종양의 유전자 변이·표현형·조직 구조 보존
3차원 배양 모델

▼

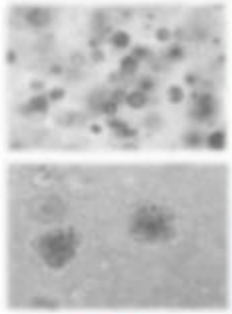
표적치료제·면역항암제·세포독성 항암제·병용요법
반응 예측 및 스크리닝 도구로 활용 가능

II 사업수행기관 개요

CNU HOSPITAL 충남대학교병원 CHUNGNAM NATIONAL UNIVERSITY HOSPITAL

CNU HOSPITAL 충남대학교병원 CHUNGNAM NATIONAL UNIVERSITY HOSPITAL

CNUH BIOBANK

STEP 1	STEP 2	STEP 3	STEP 4	STEP 5
Sampling	PBMC isolation	Organoids production	Quality control	Preservation
				
• Cryo-biopsy • 30 cc~50 cc blood • 흉수	• PBMC isolation • hLO generation • Tissue cryo-preservation in a LN_2 tank • RNA • DNA	• Human lung organoid culture	• H&E staining • IHC • NGS (exome sequencing)	• Lung cancer organoid cryo-preservation in a LN_2 tank

V 기대효과 및 향후 계획

CNU HOSPITAL 충남대학교병원

상생협력

CNU HOSPITAL 충남대학교병원

1 특성화 질환에 대한 공동 운영체계 구축 | 2 특성화 인체자원 임상역학정보 표준화 체계 구축

3 인체자원 수집 및 (공동)분양 | 4 인체자원 임상역학정보 수집 및 (공동)분양

CNU HOSPITAL 세종충남대학교병원

1 특성화 인체자원
수집 및 (공동)분양

2 특성화 인체자원 임상역학정보
수집 및 (공동)분양

건양대학교병원

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수집 및 (공동)분양

2 특성화 인체자원 임상역학정보
수집 및 (공동)분양

산학연

충남대학교 | 건양대학교

고려대학교 세종캠퍼스 | 을지대학교

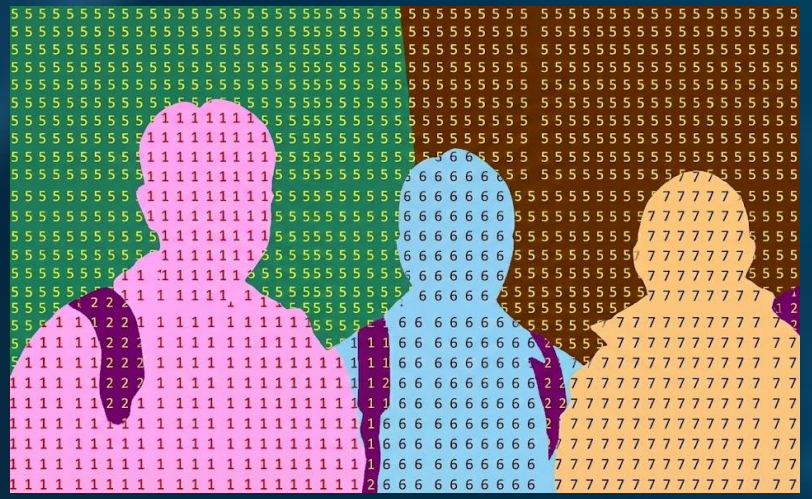
한국생명공학연구원 | KAIST 한국과학기술원

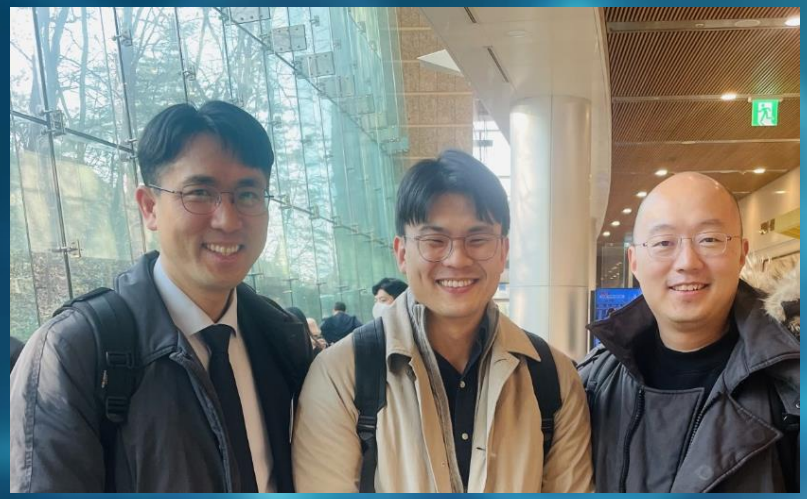
KIST 한국과학기술연구원 | KRISS 한국표준과학연구원

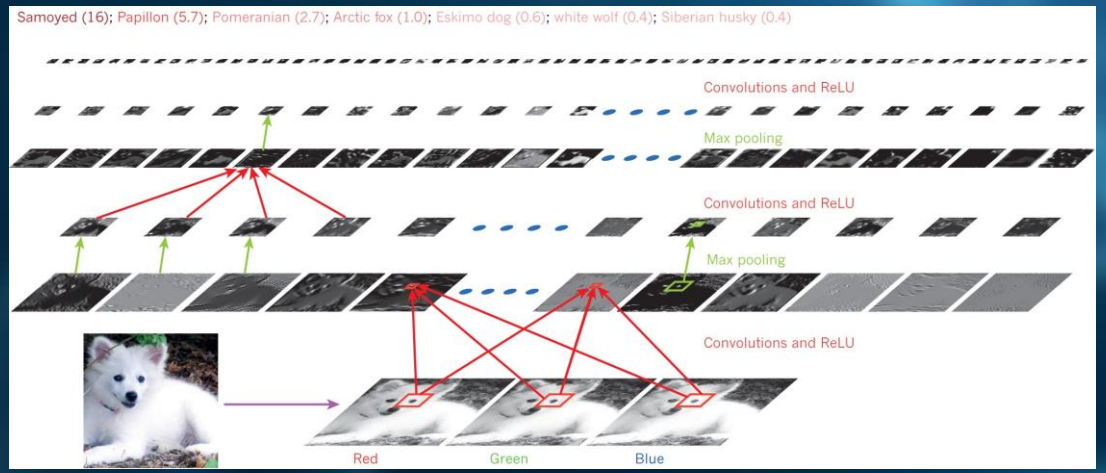
ablbio | CUROCELL

EnhancedBio | JD BIOSCIENCE

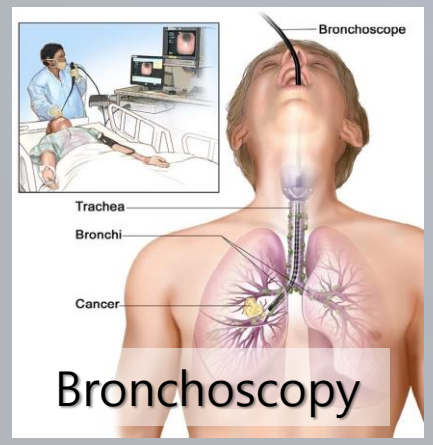
#3. Organoid 3D holotomography and live imaging



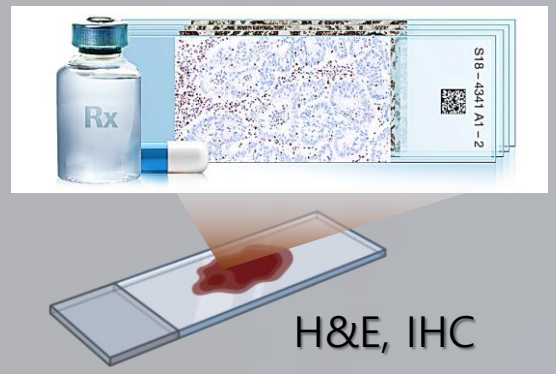


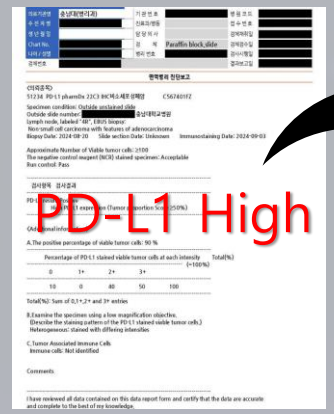


Conventional Workflow of Immunotherapy



Pathologist Examination





Tx. Decision

Cancer Res Treat. 2025 Oct 28. doi: 10.4143/crt.2025.548. Online ahead of print.

Predictive Role of Baseline Peripheral Lung SUVmax on PET/CT for Immune-Related Pneumonitis and Adverse Events in Lung Cancer Patients Treated with Immune Checkpoint Inhibitors

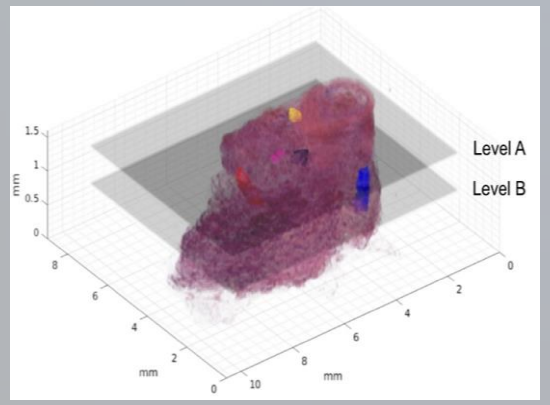
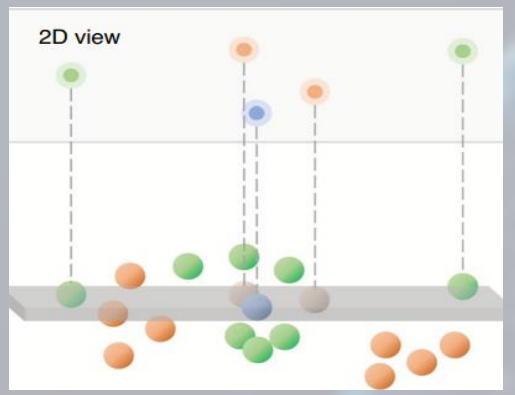
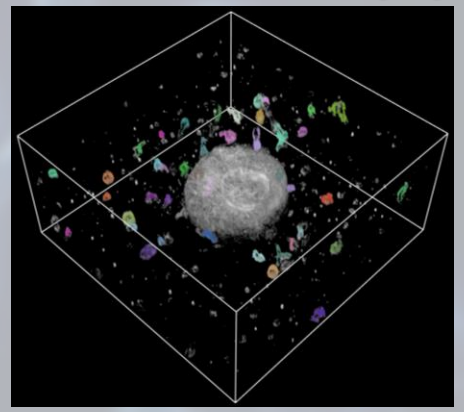
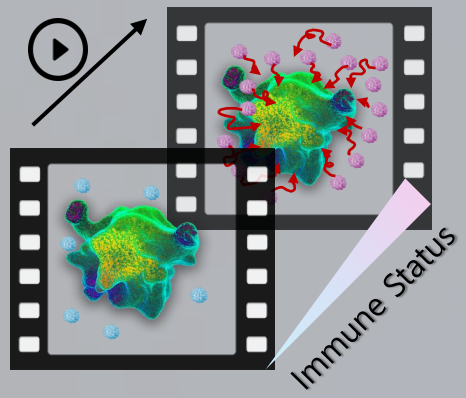
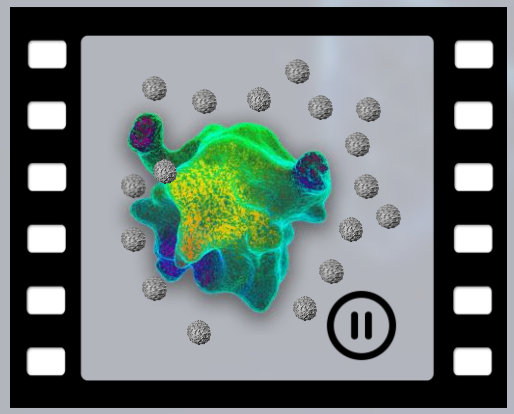
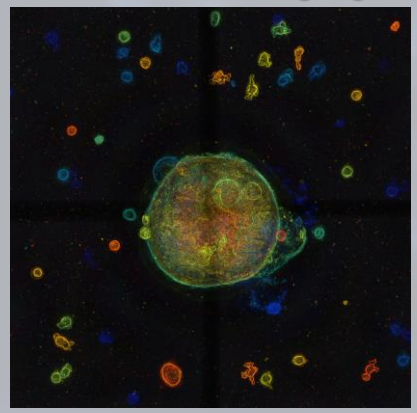
Kun Ho Kim [1], Seong Min Kim [1], Jeong Eun Lee [2], Song Soo Kim [3], Da Hyun Kang [2], Chaeuk Chung [2]

Lung Cancer. 2026 Jan:211:108879. doi: 10.1016/j.lungcan.2025.108879. Epub 2025 Dec 13.

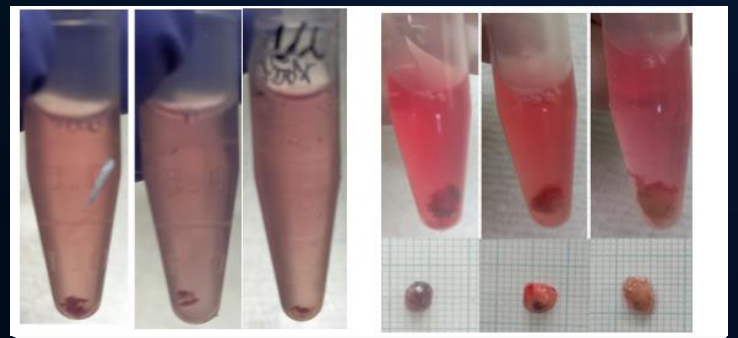
Multiomic analysis of treatment-naïve NSCLC before the era of neoadjuvant immunotherapy reveals contrasting immune phenotypes in stage IIIA: node-dominant (T1N2) exhibiting hot versus tumor-dominant (T4N0) cold features

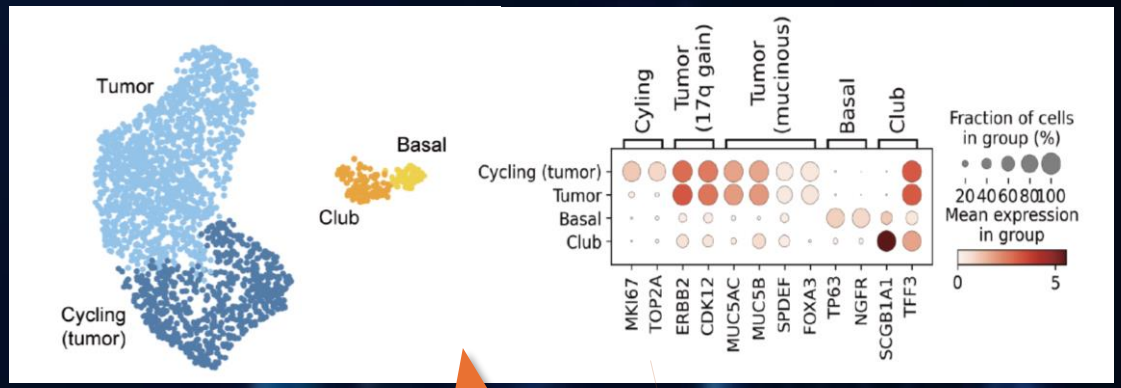
Duk Ki Kim [1], Yooyoung Chong [2], Min-Kyung Yeo [3], Da Hyun Kang [1], Joo-Eun Lee [4], Hyun-Yi Kim [5], Min-Woong Kang [6], Chaeuk Chung [7]

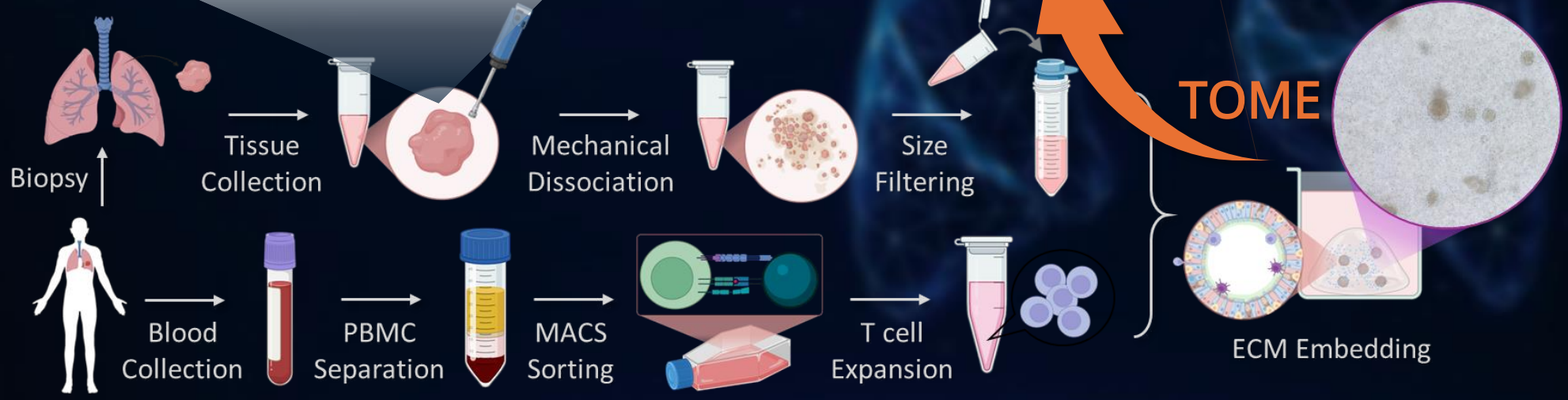
Solution: Live 3D Imaging

	Real World	What We Measure	Our Solution
Spatial Aspect	3-Dimensional 	2-Dimensional 	Non-Invasive 3D Imaging 
Temporal Aspect	Dynamic TME 	Single Time Point 	Real Time Imaging 

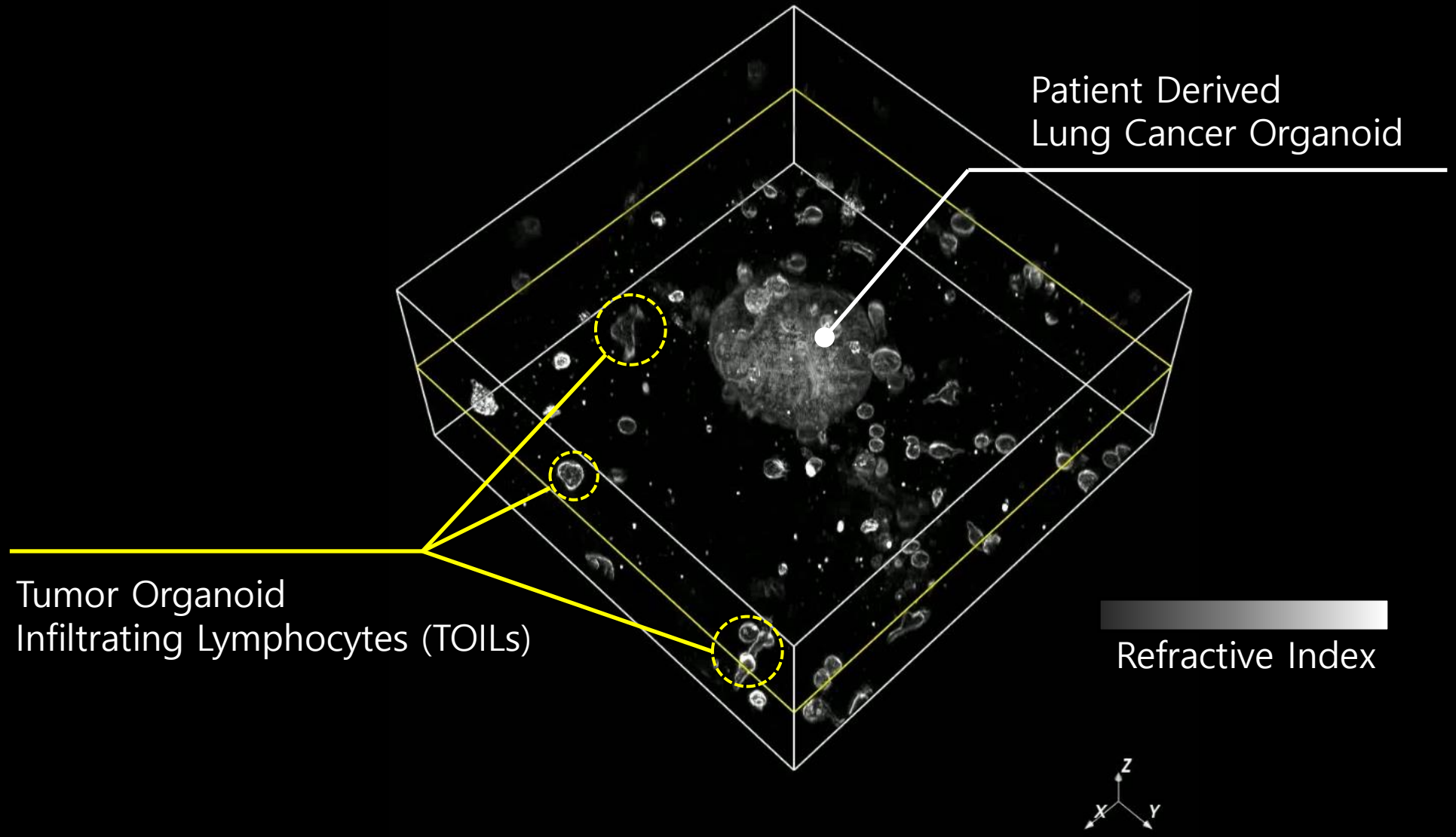
Tumor Organoid Microenvironment (TOME)





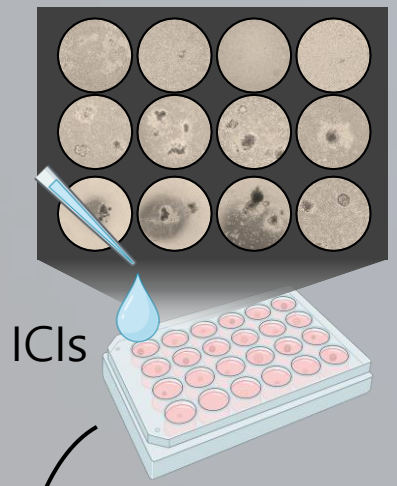


Real-Time Holotomography of TOME

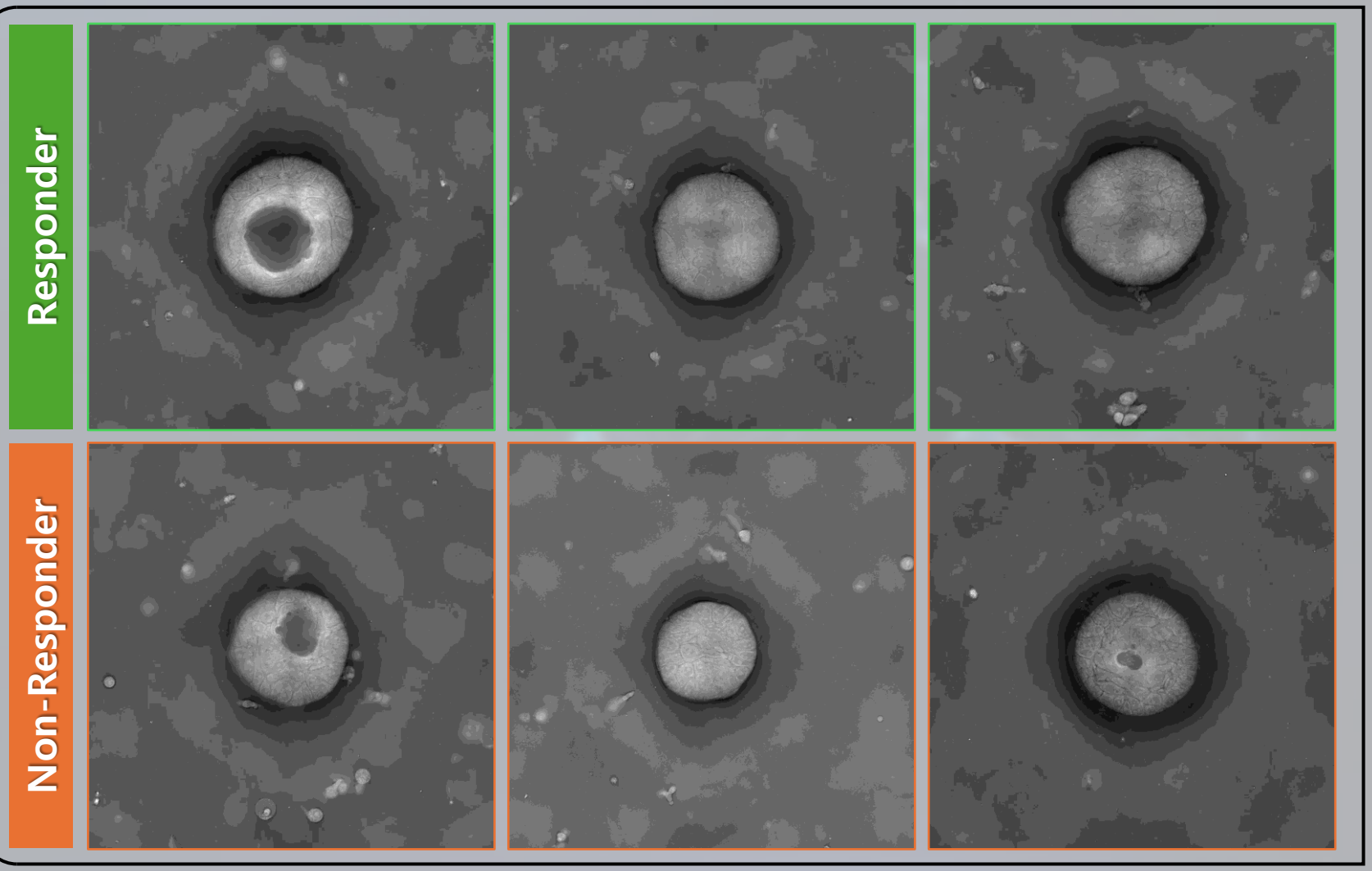


Result

In vitro Immunotherapy Responses



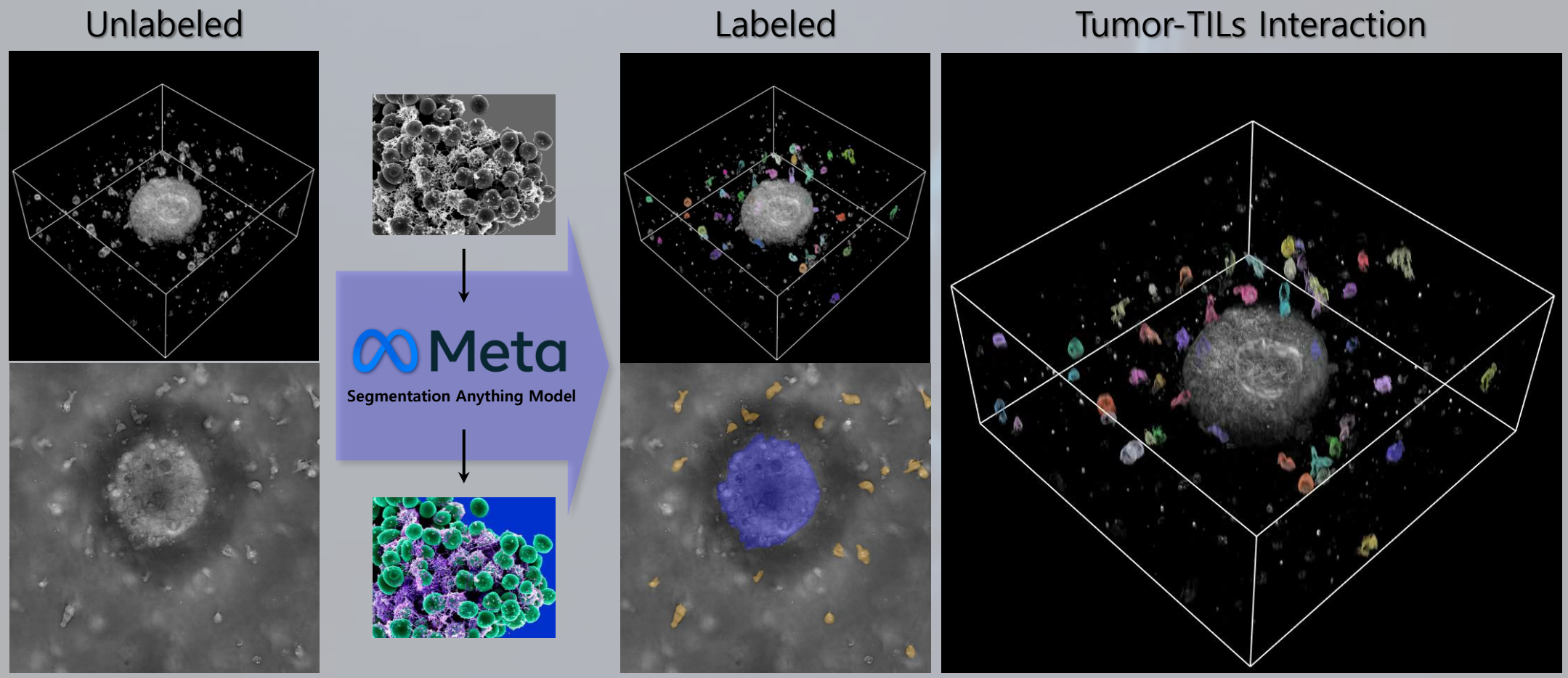
Tomocube



Unpublished

Result

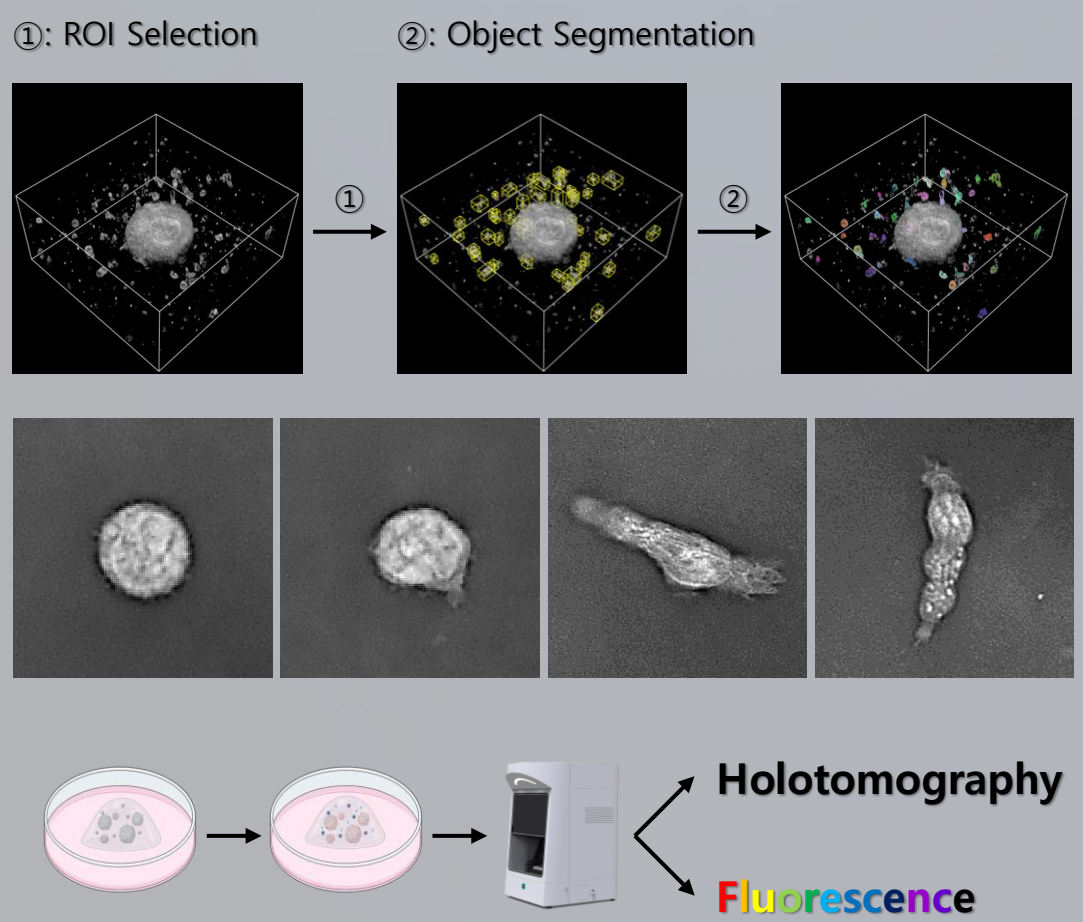
Deep Learning-Based Single TIL Segmentation

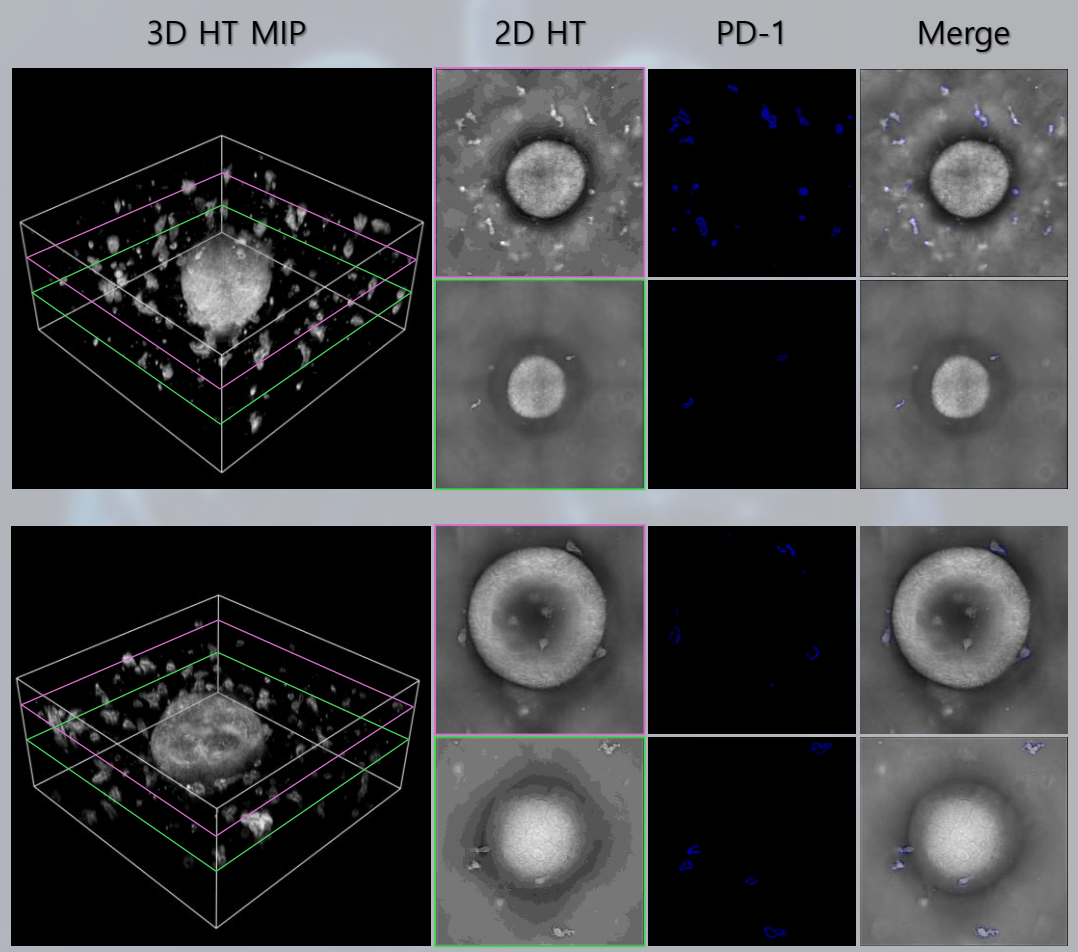


Unpublished

Result

Validation: Immunophenotypes of TIILs

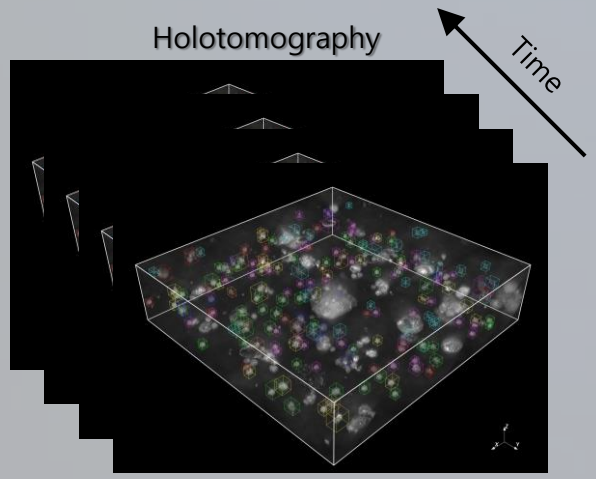


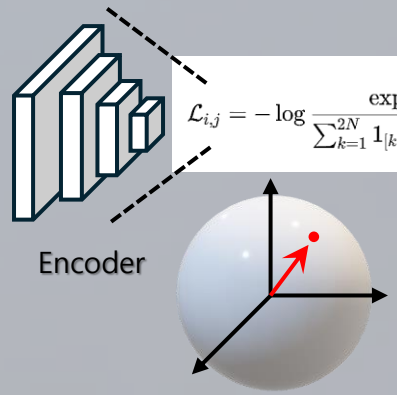


Unpublished

Result

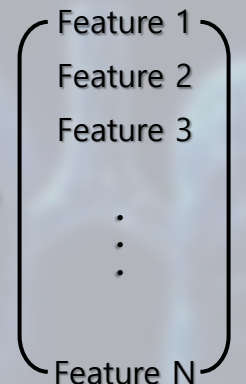
Holotomogram-Based Features for Identifying Immunophenotypes

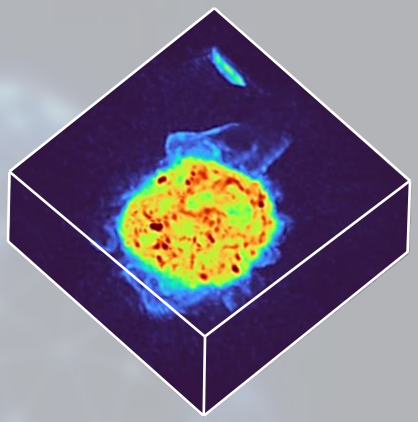


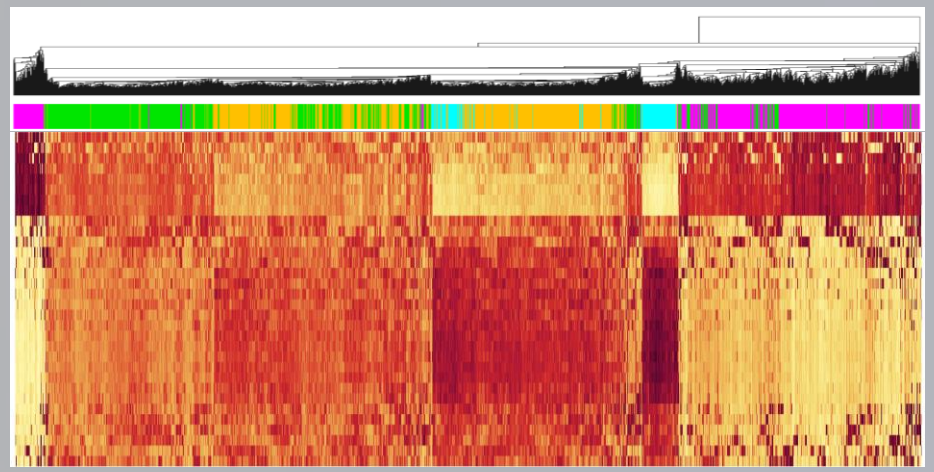


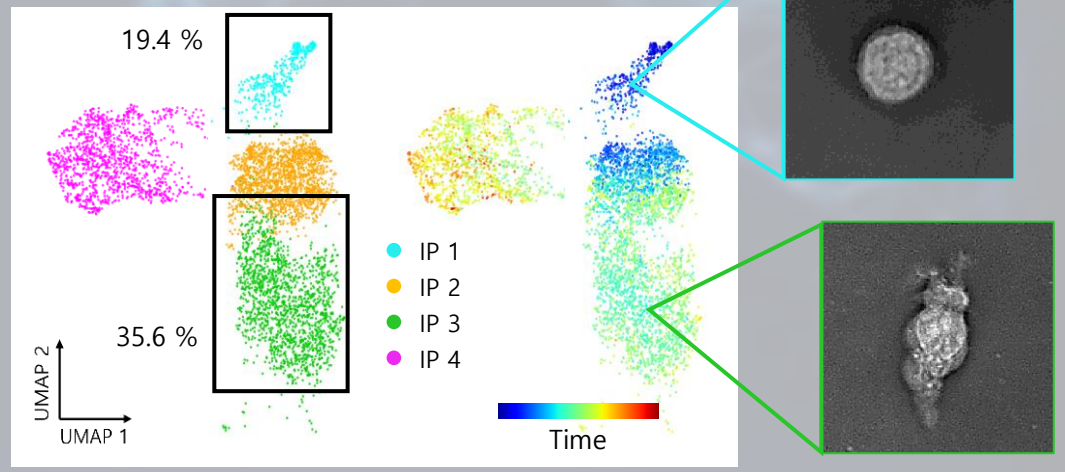
$$\mathcal{L}_{i,j} = -\log \frac{\exp(sim(z_i, z_j)/\tau)}{\sum_{k=1}^{2N} 1_{[k \neq i]} \exp(sim(z_i, z_k)/\tau)}$$

Embedded
Latent Features





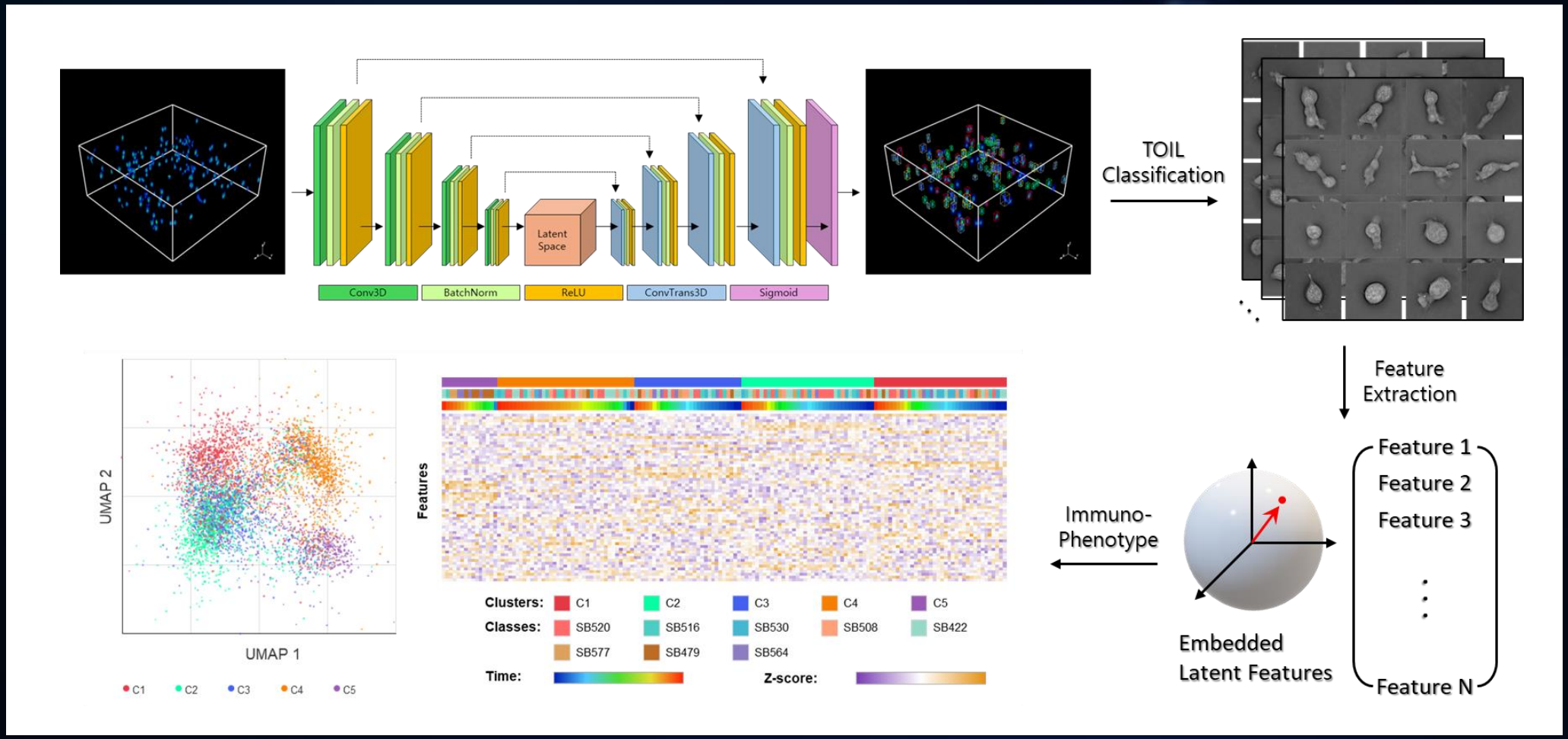




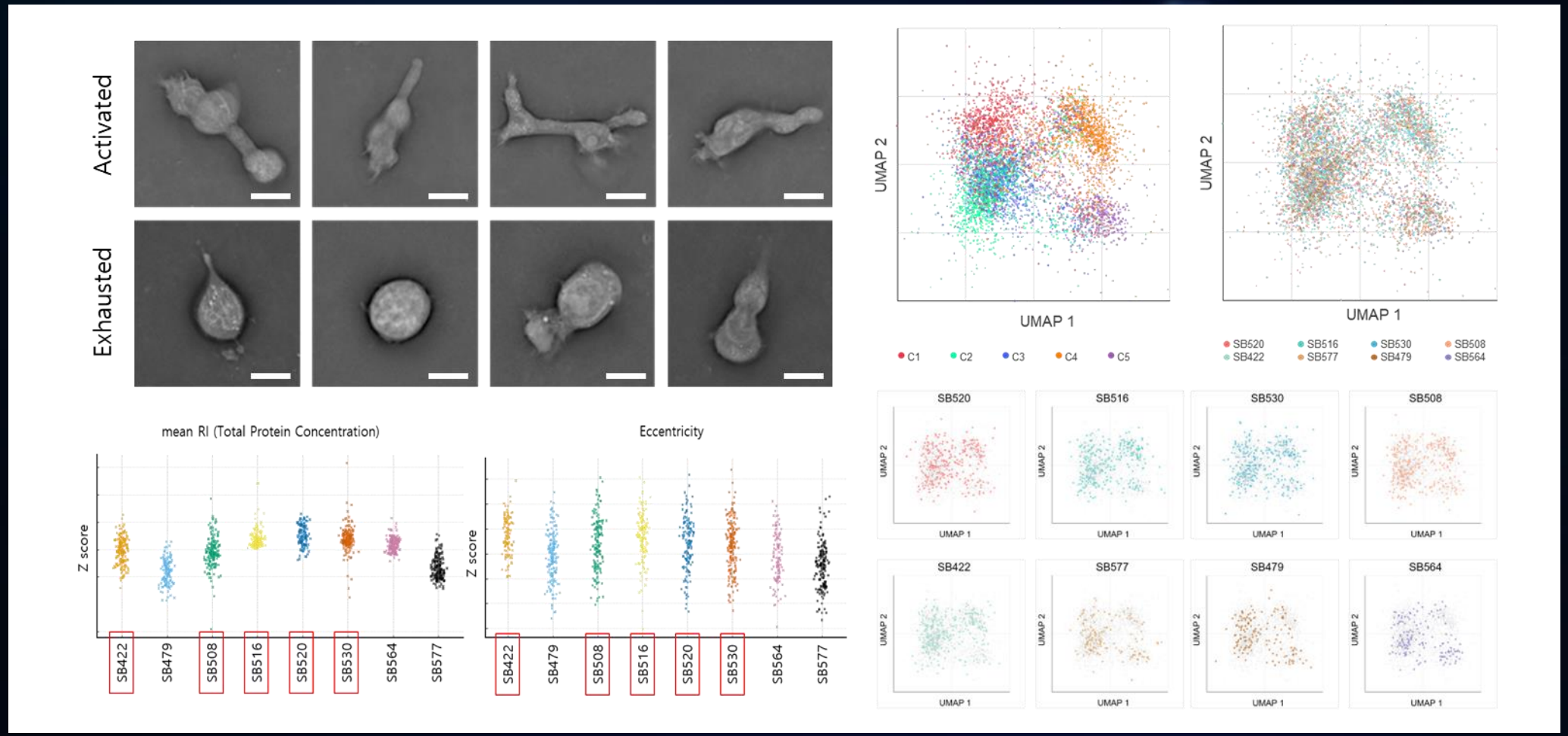
in collaboration with prof. 박용근 at KAIST

Unpublished

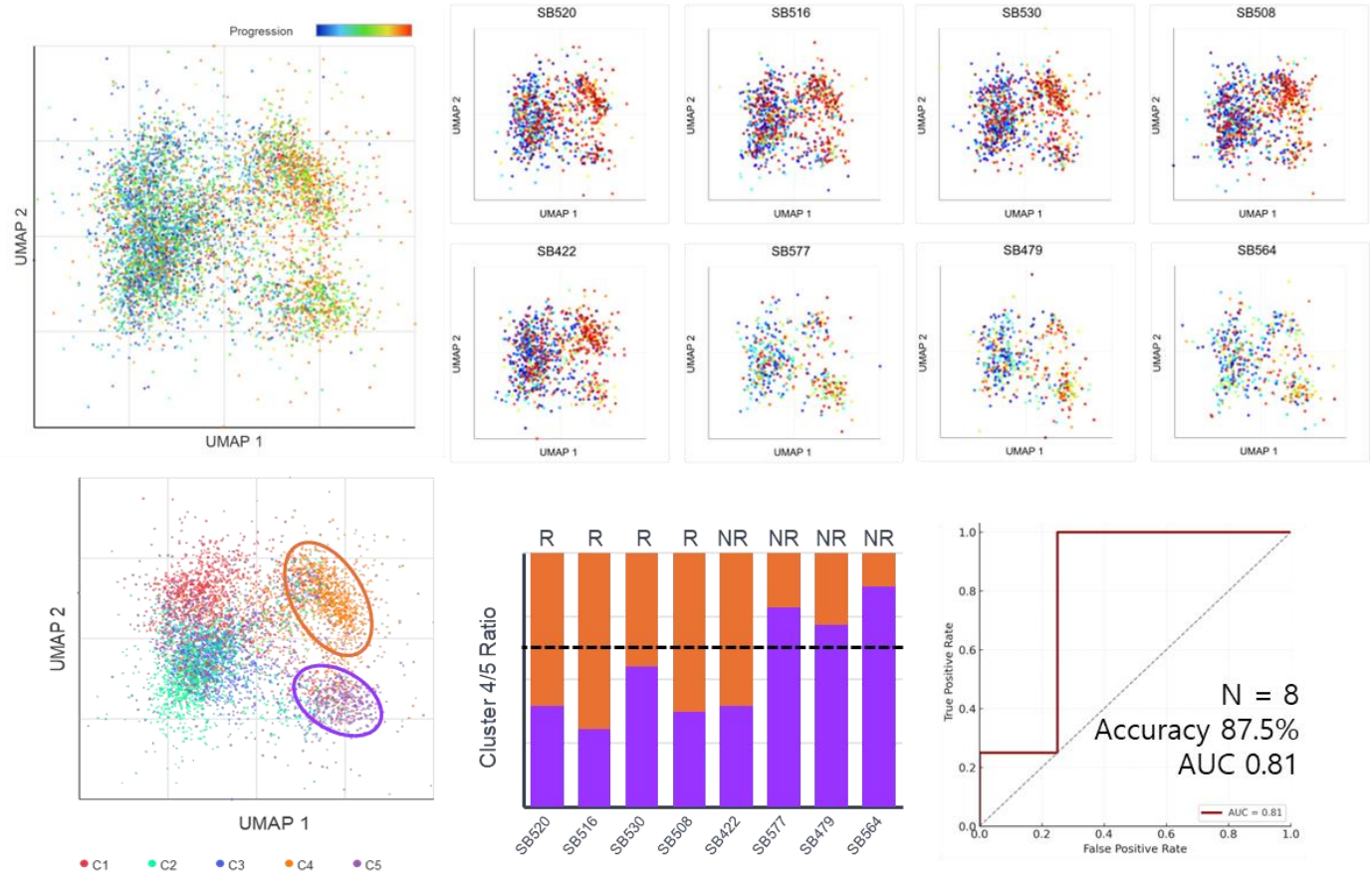
Morphology-Based Immunophenotyping



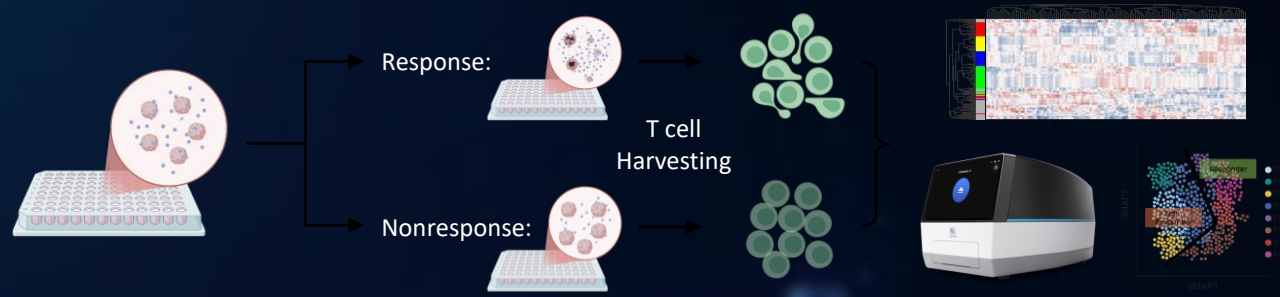
Quantitative Features of TOILs

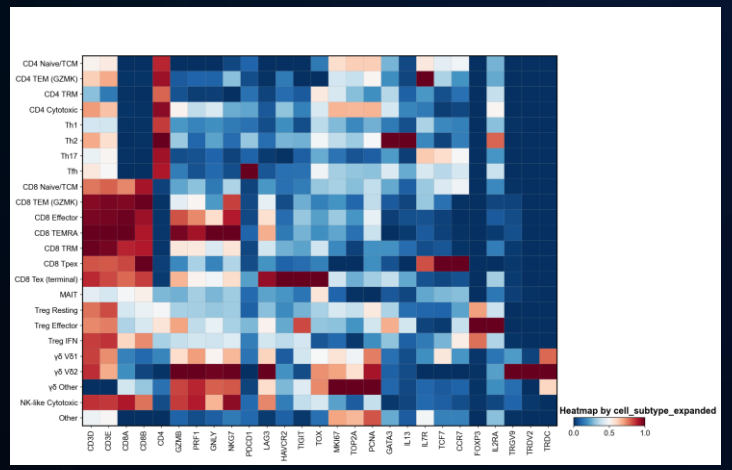


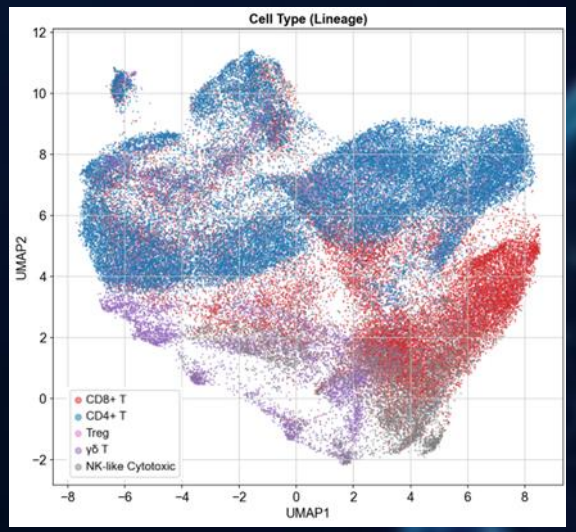
Morphology-Based Biomarkers of ICI Response

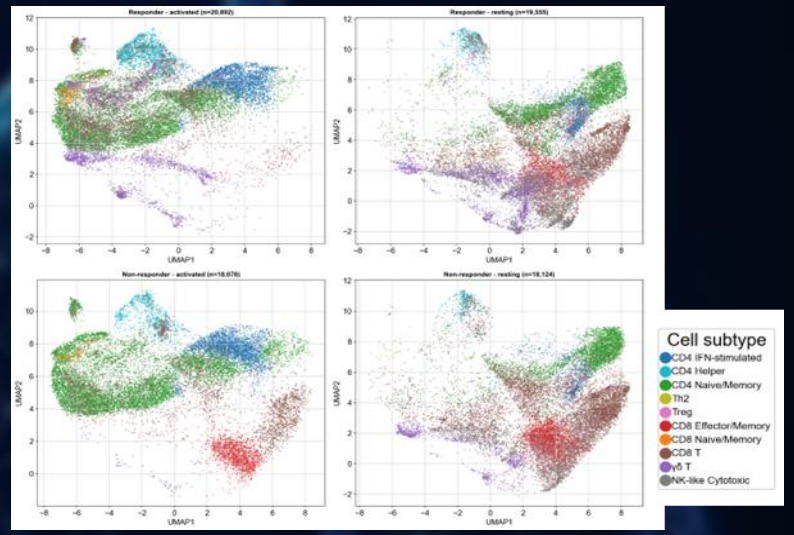


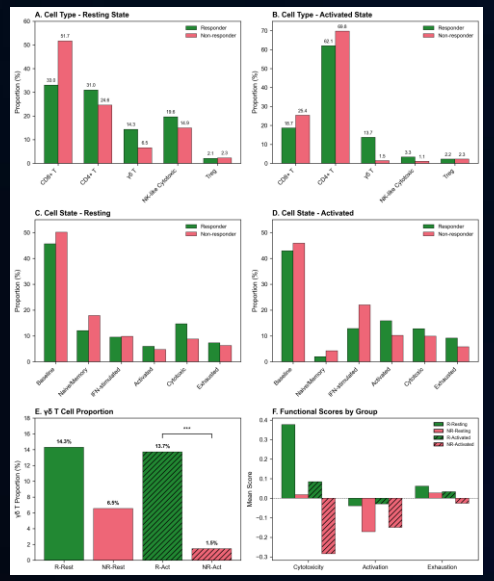
Morphomics & scRNAseq

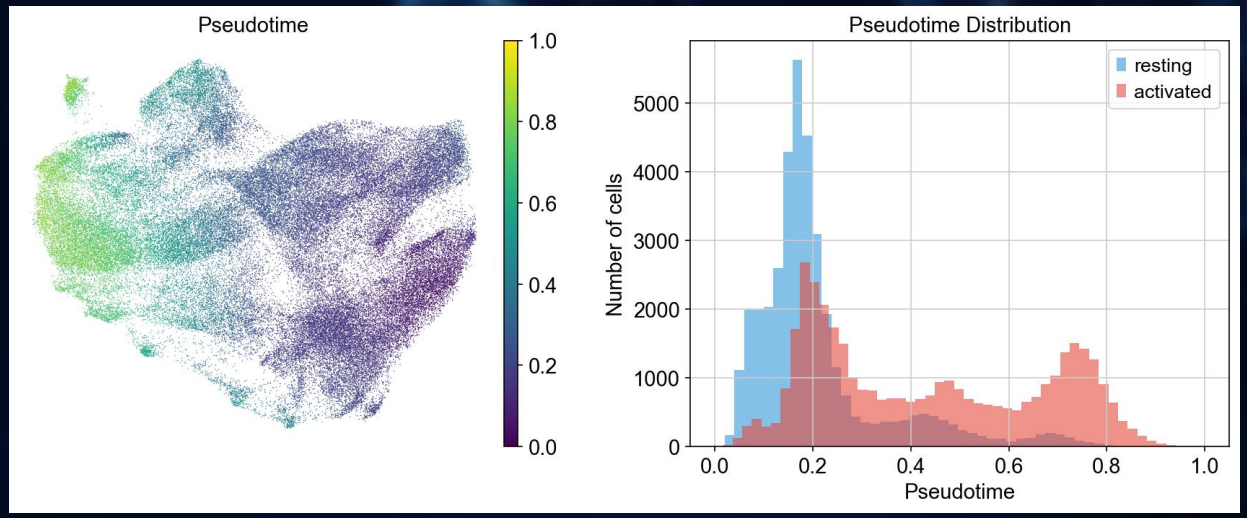




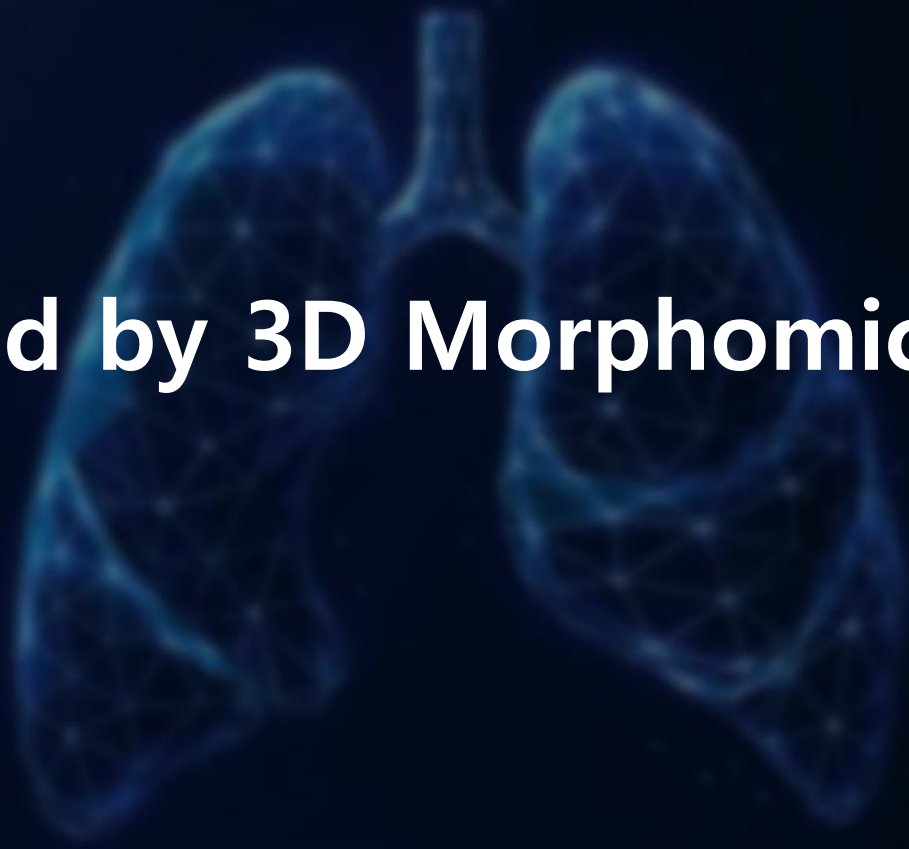








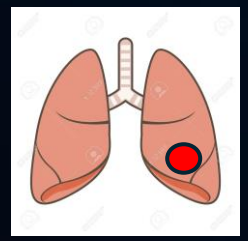
#3. Validation of Organoid by 3D Morphomics



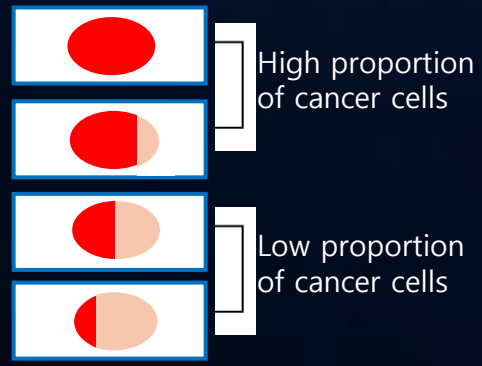
Why Validation of Lung Cancer Organoids Matters

Current

Lung cancer Patient

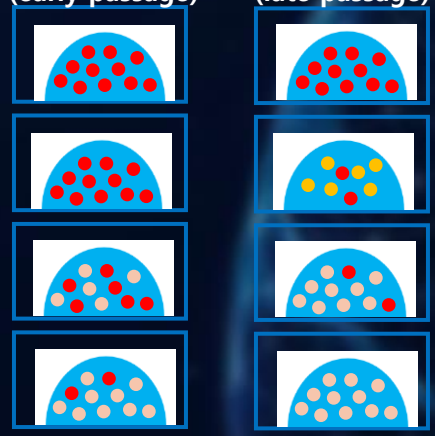


H&E slide

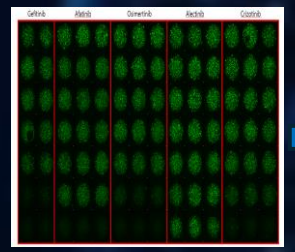


Organoid culture (early passage)

Organoid culture (late passage)



Drug screening



Clinical study → Fail

Pure tumor organoid : 17%

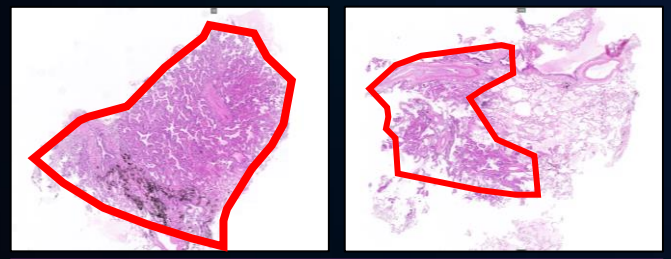
Results from unvalidated lung cancer organoids are unreliable.

There is no way to monitor organoid status in real time.

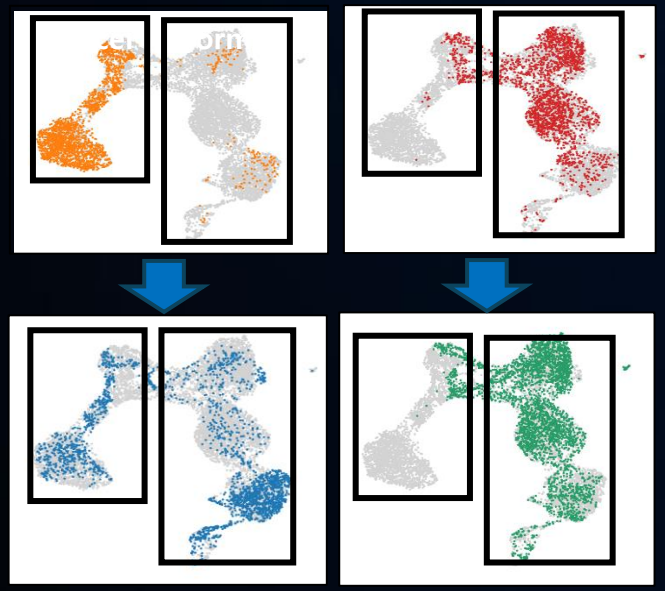
Once sent for NGS or scRNA-seq, the organoids are destroyed.

AI-Driven Organoid Analysis from Live 3D Imaging

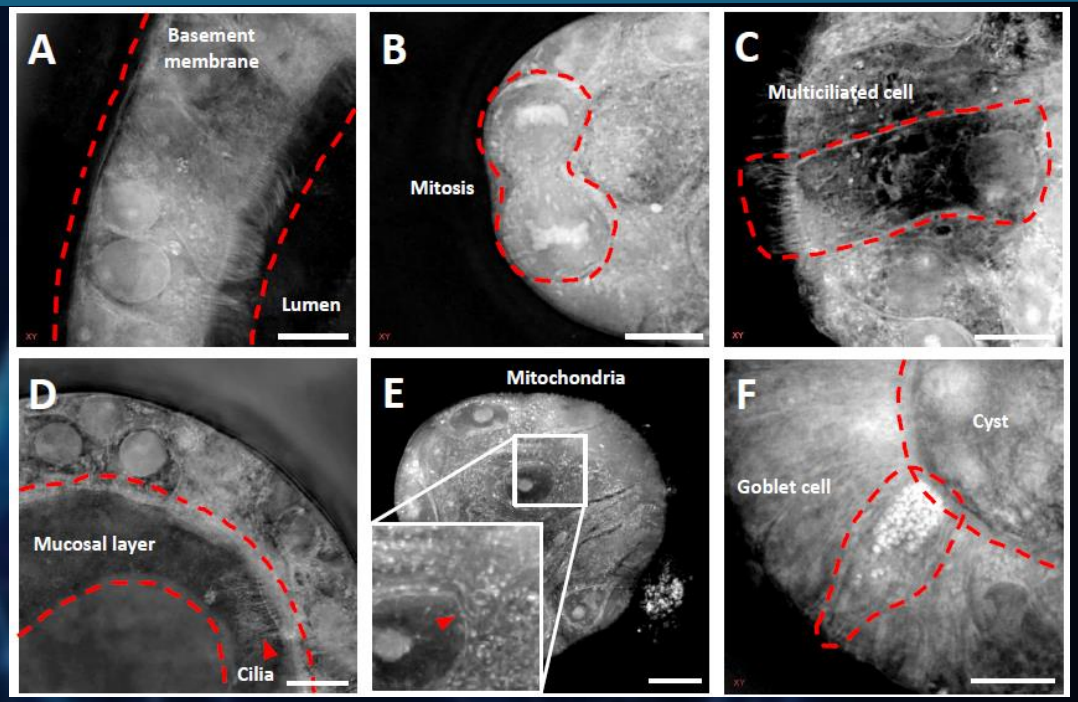
Suboptimal enrichment of malignant cells
Dynamic cellular and genetic alterations

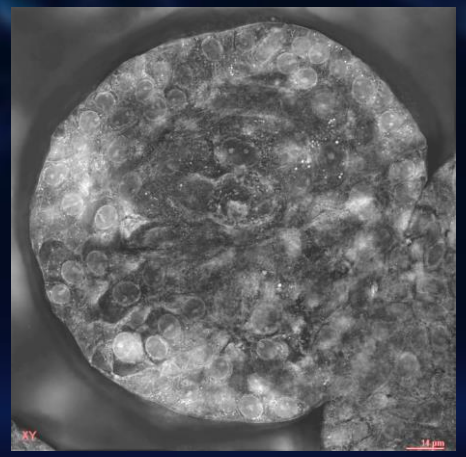


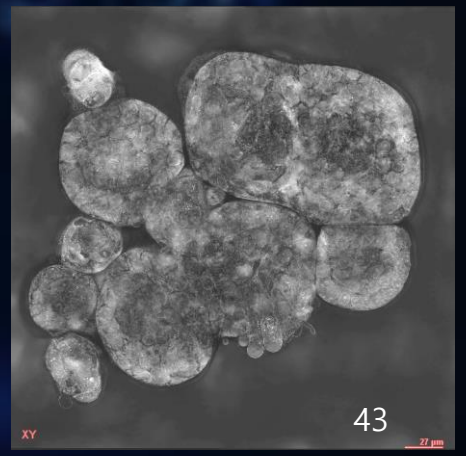
Organoid scRNA sequencing



Live image, No labeling
3D image



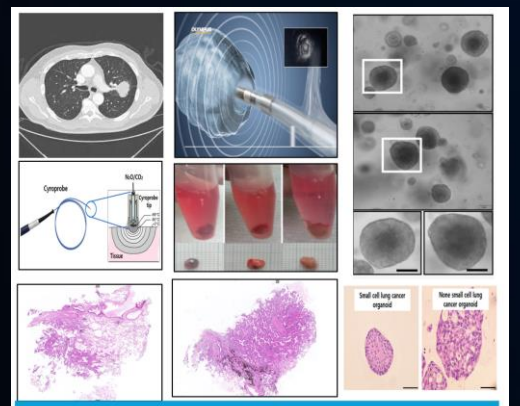




Q. How can we monitor the state of organoids in real time?

Development of an AI-Based Platform for Lung Cancer Organoid Multi-Omics and 3D Imaging Big Data

Lung cancer organoid Bank

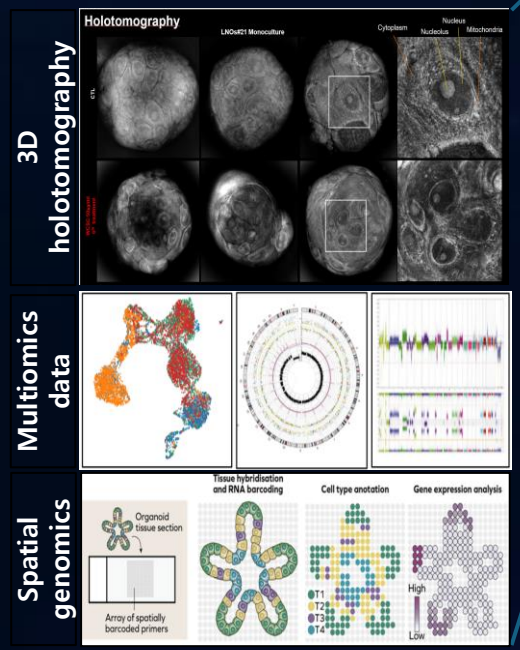


Clinical database

Pathology, Stage, Genetic profile, Target therapy, Immunotherapy, Response, Adverse event

Validated organoid
-100% cancer, 100% normal cell
-Mixed organoid

Labeled big data



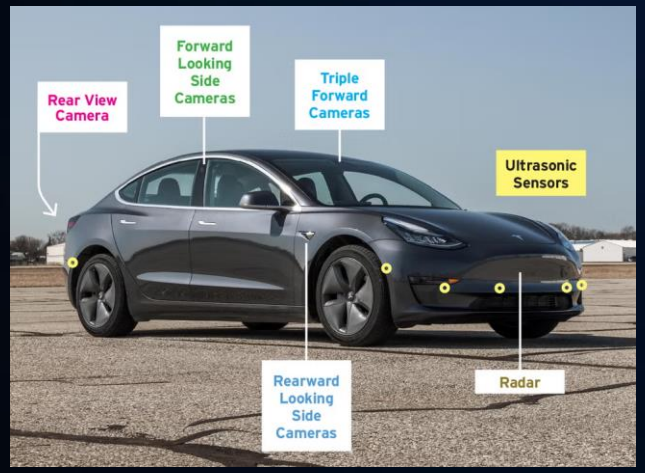
	3D image	Multi-omics	Spatial genomics
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

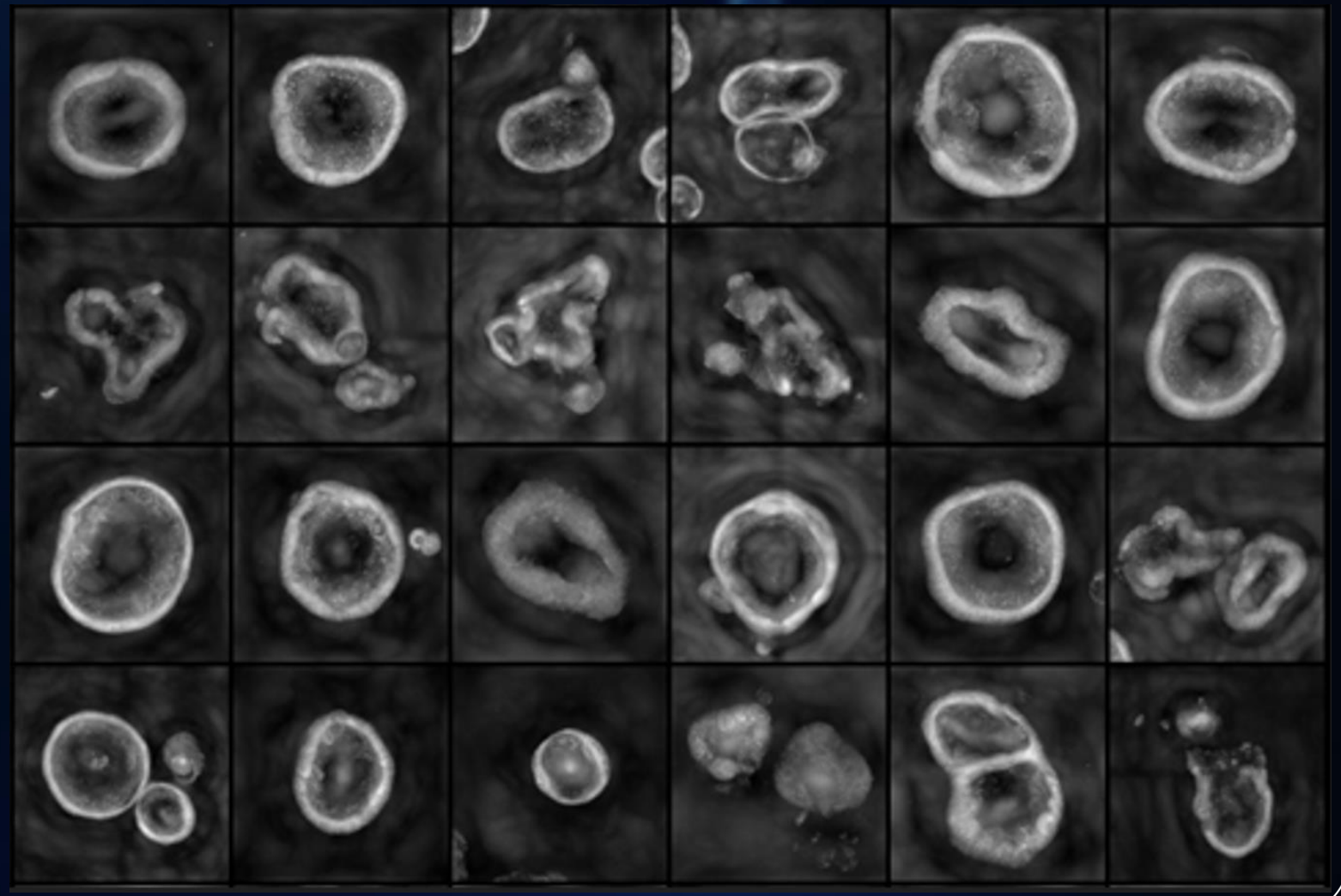
Supervised learning

CNN-based Deep learning

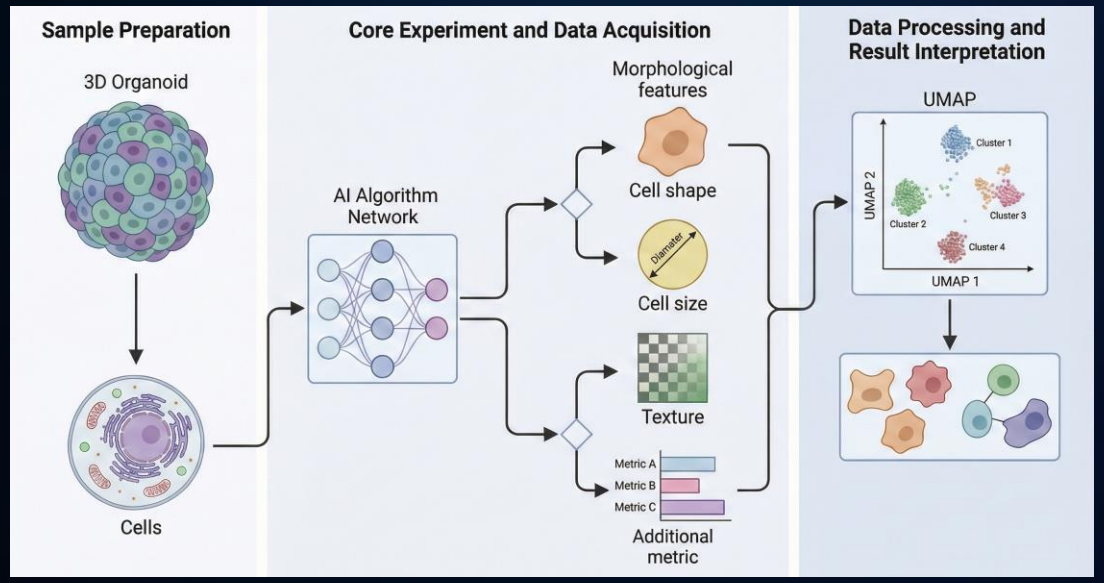
AI assisted Organoid Analyzer

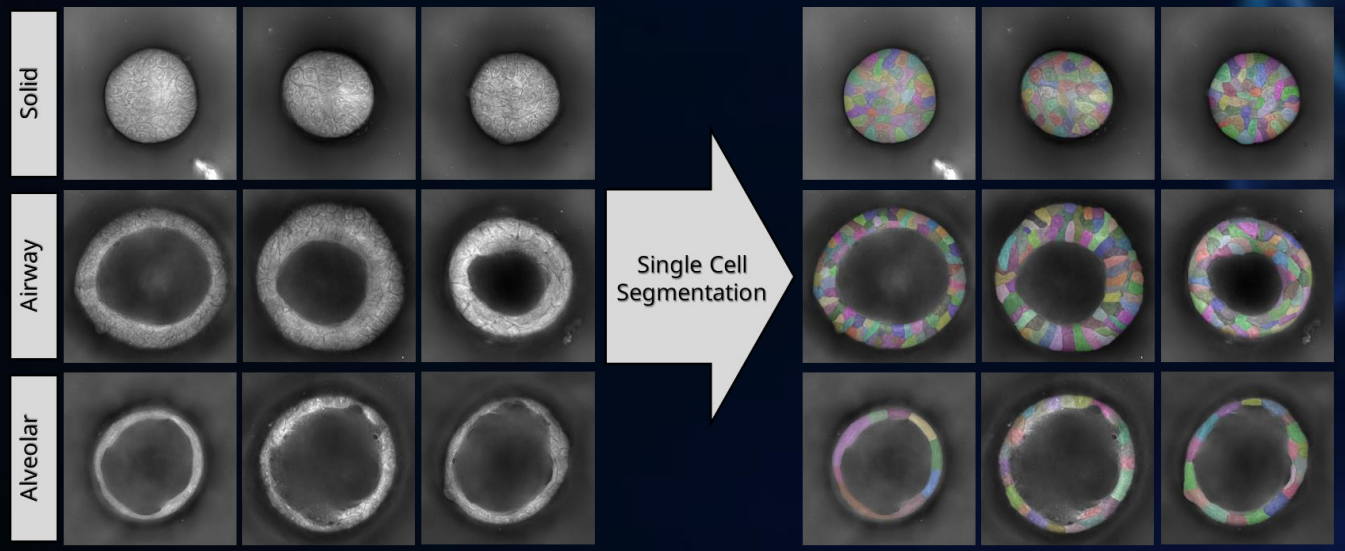
Bank of Organoid 3D images

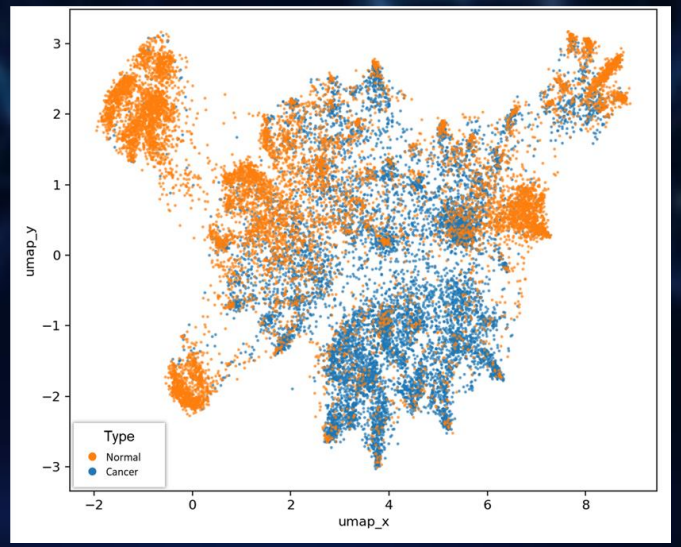




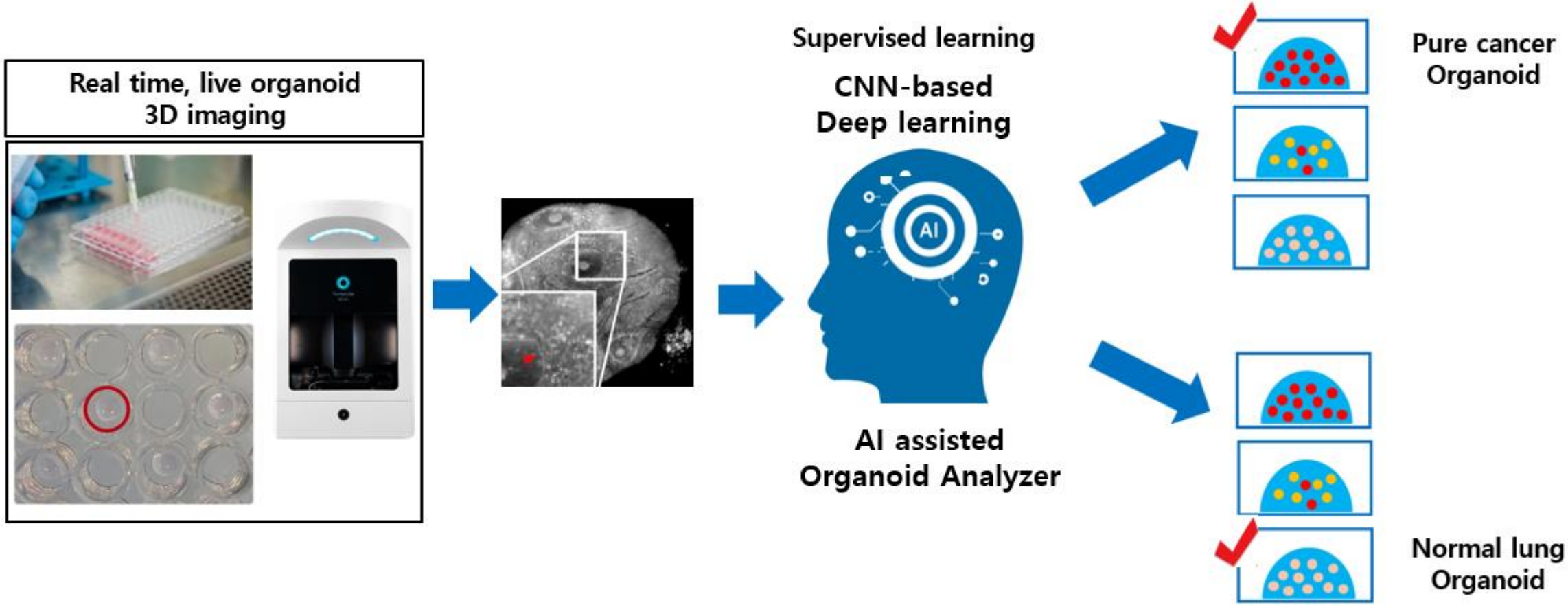
Organoid Characterizing by 3D holotomography



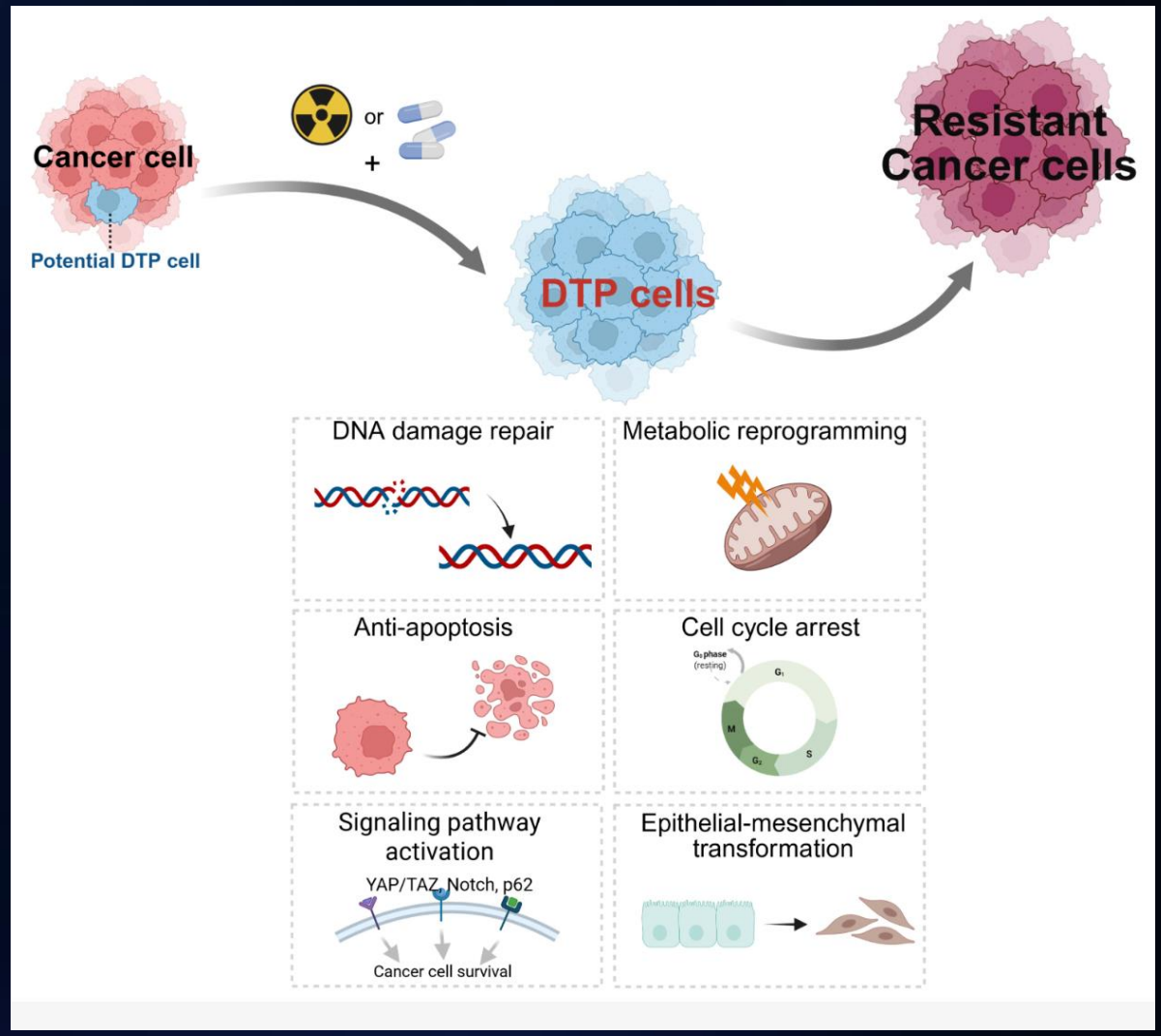




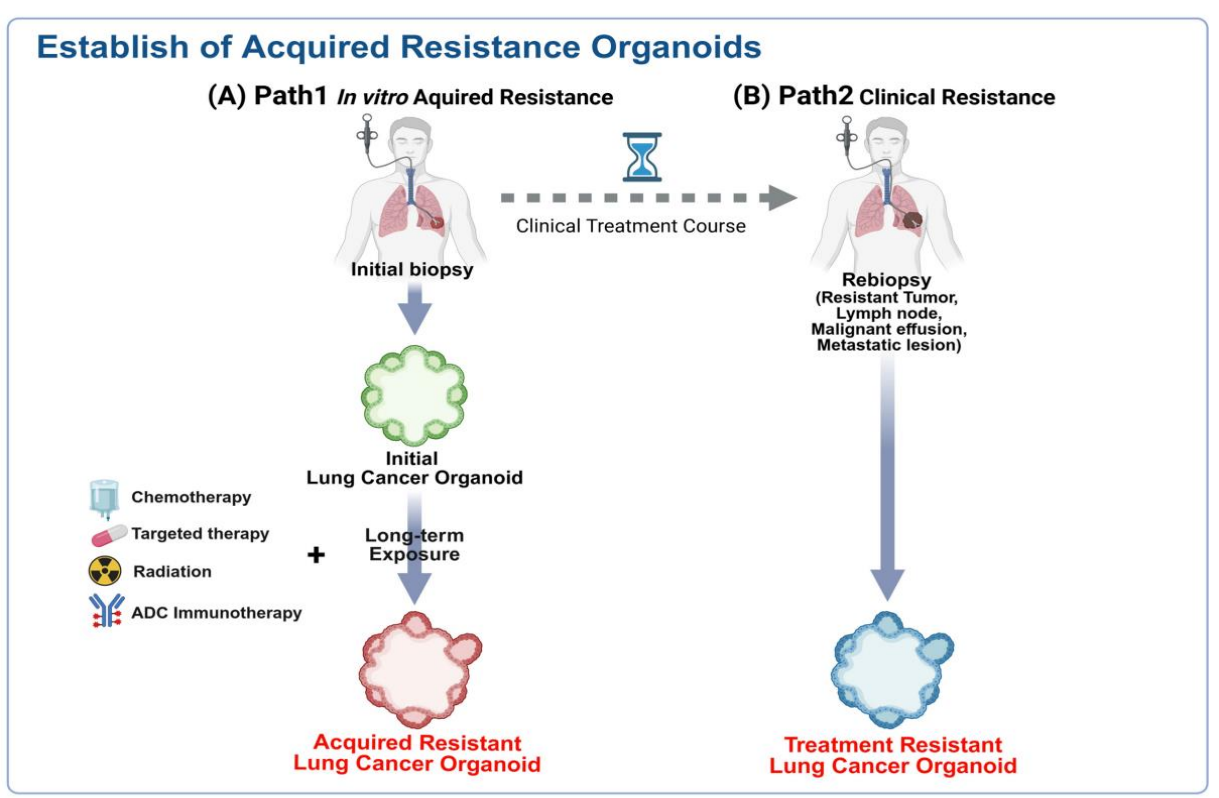
AI Automatically Analyzes Organoid Characteristics from Real-Time, No-Label, Live 3D Imaging

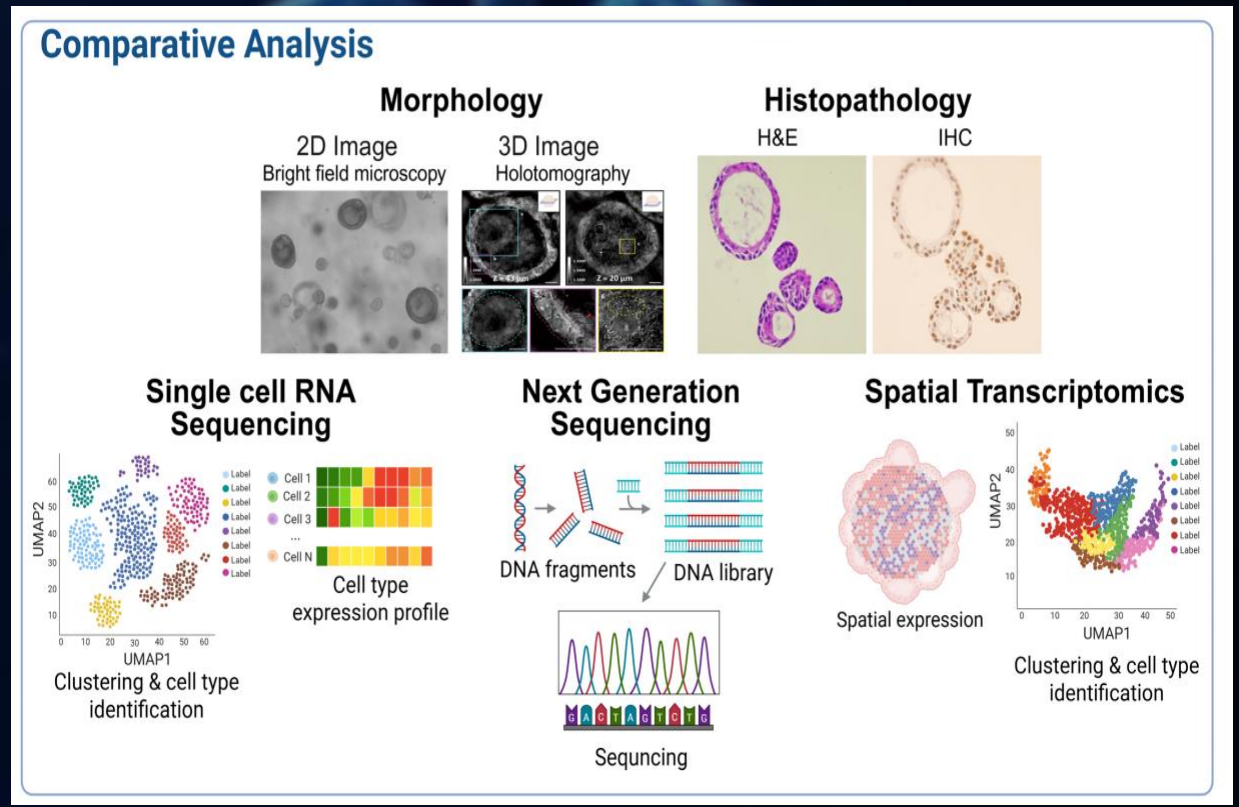


#4. Modeling Drug and Radiation Resistance with Patient-Derived Organoids



Establishment and multi-faceted comparative analysis of acquired resistance organoid models

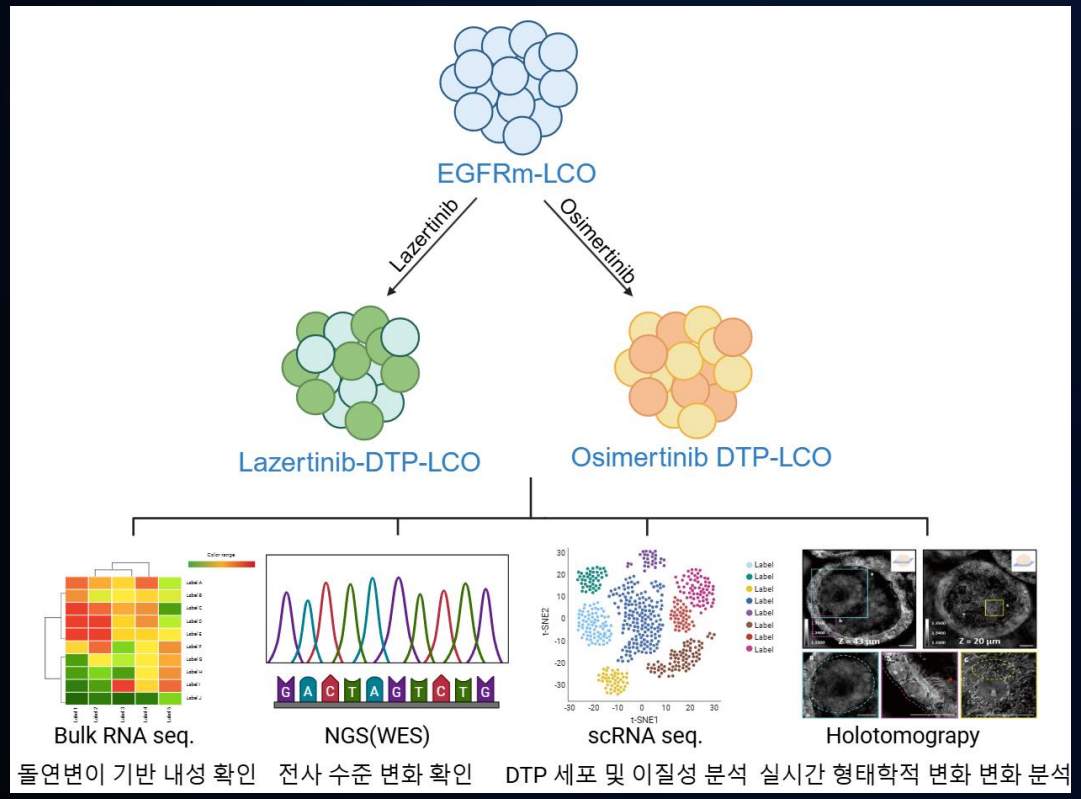


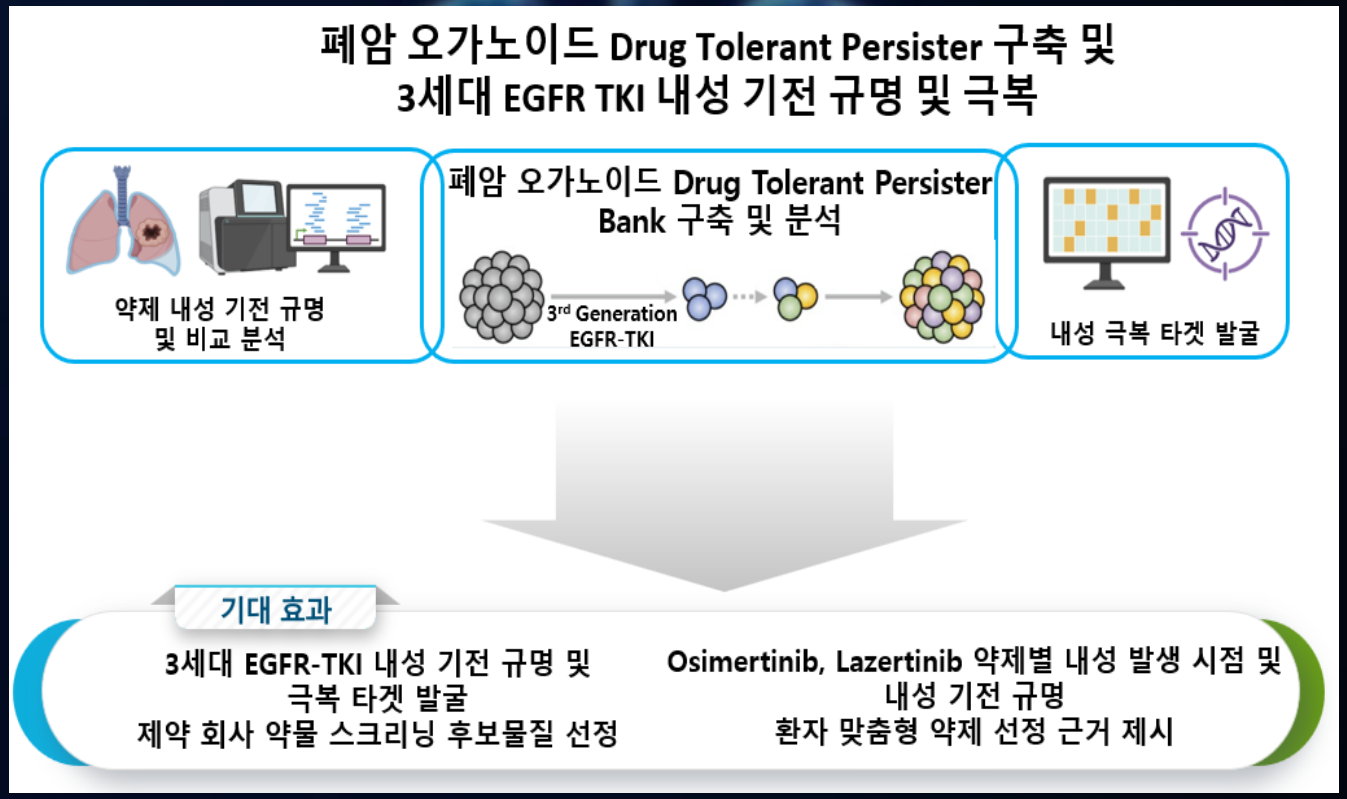


2025년도 대한 결핵 및 호흡기 학회
산하 분자 폐암 연구회 연구 과제

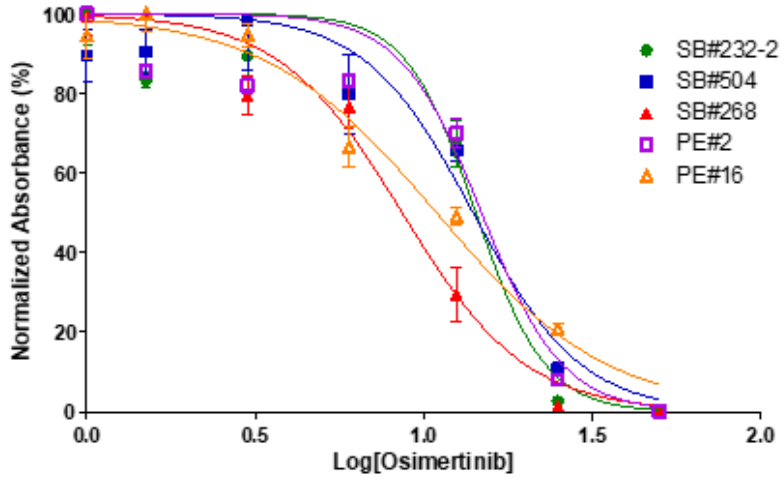
환자유래 폐암 오가노이드를 활용한 약물 내성 지속세포 상태 모델링 및 EGFR 변이 폐암의 3세대 EGFR-TKI 내성 기전 규명 및 극복

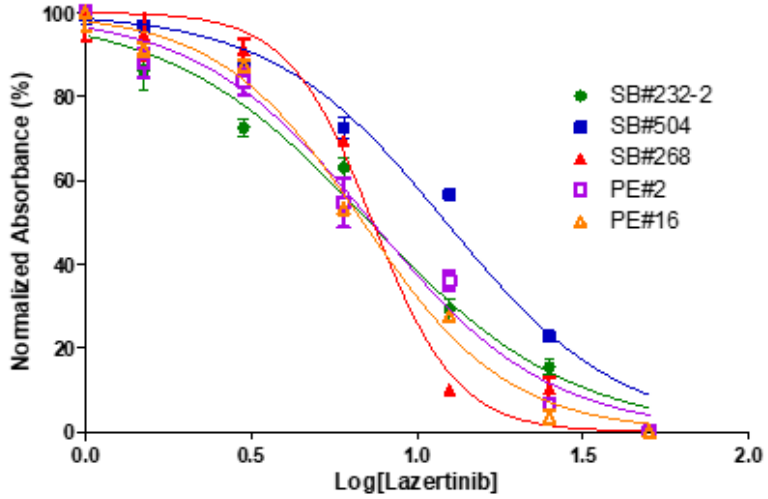
3rd Generation EGFR-TKI tolerant persistent LCO





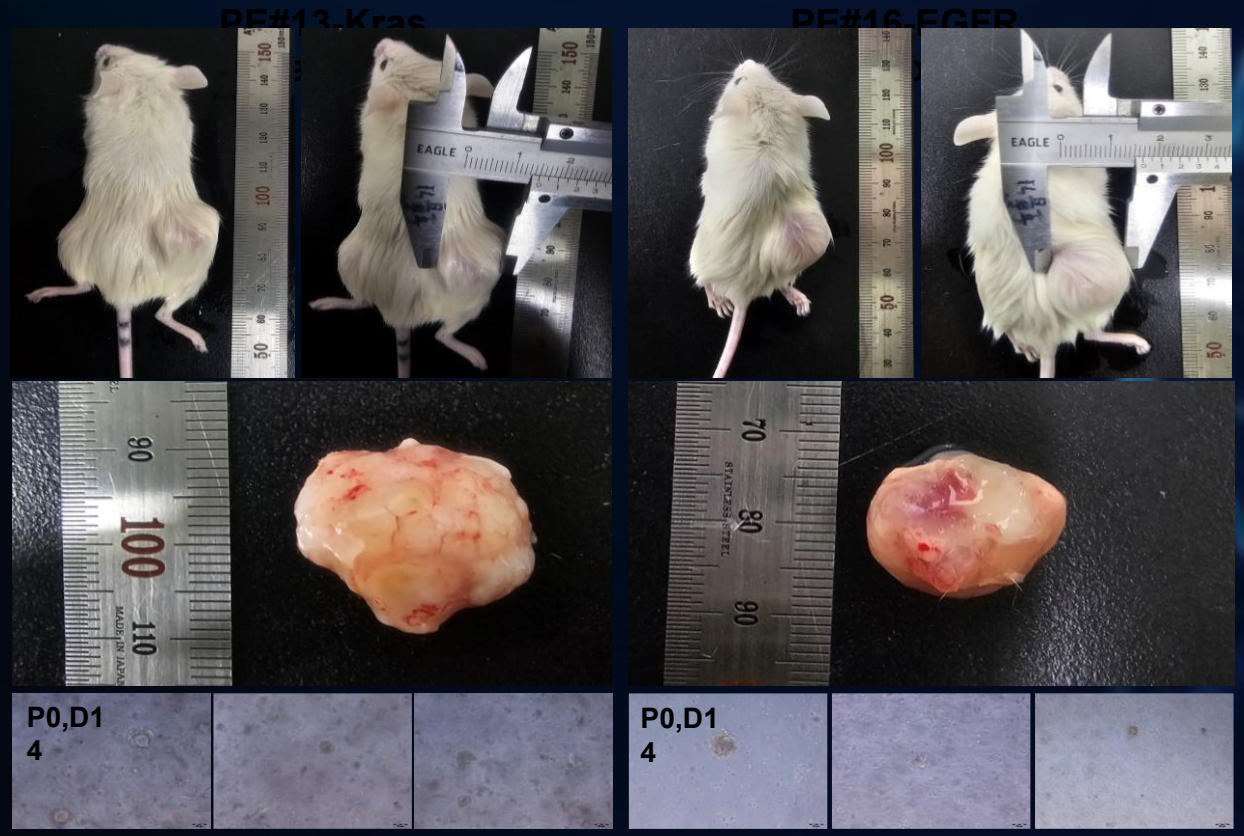
3rd Generation EGFR-TKI resistant LCO



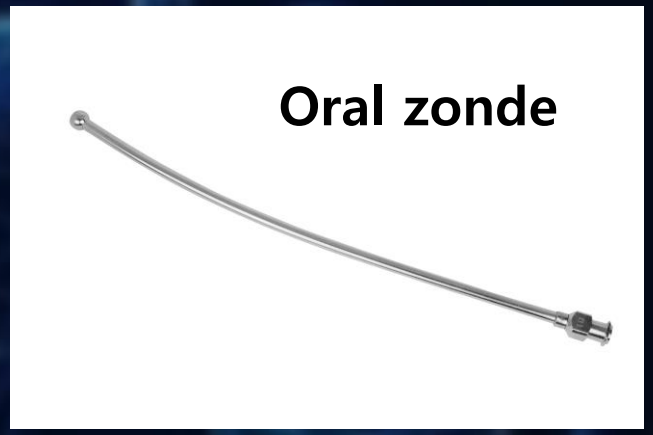


	Osimertinib		Lazertinib	
	LogIC50	IC50	LogIC50	IC50
SB#232-2	1.155	14.28	0.8560	7.178
SB#504	1.147	14.03	1.087	12.21
SB#268	0.9364	8.637	0.8663	7.351
PE#2	1.172	14.85	0.8642	7.315
PE#16	1.038	10.91	0.8367	6.866

3rd Generation EGFR-TKI resistant PDOX mouse



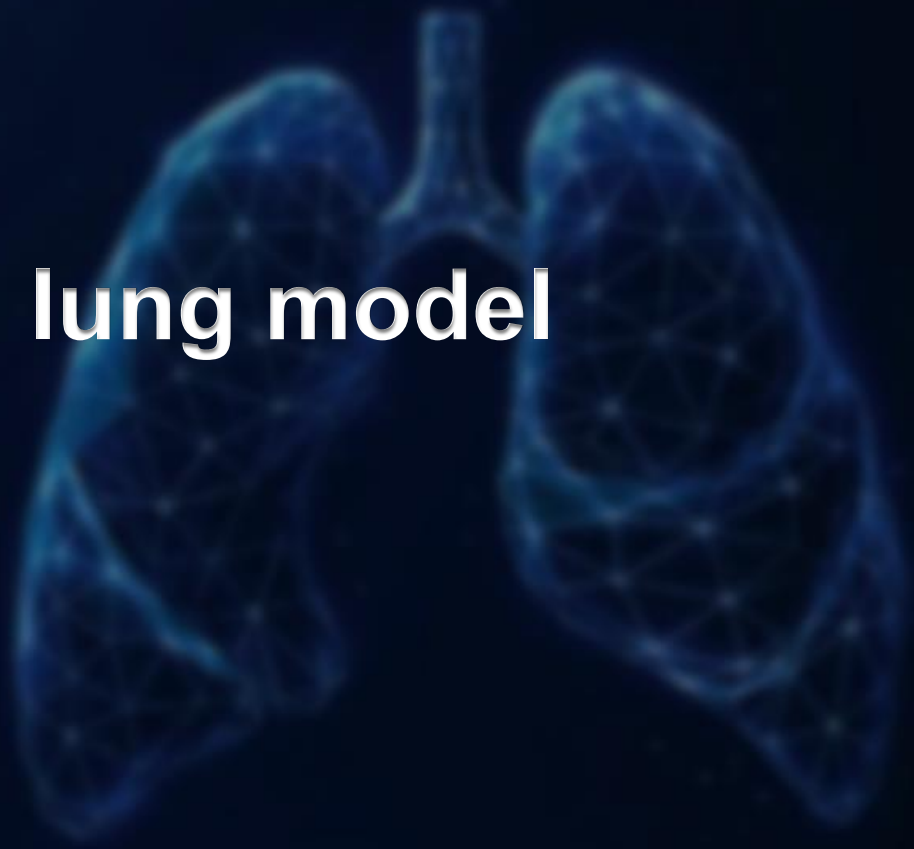
Patient-Derived Organoid Xenograft



CNU HOSPITAL 충남대학교병원 CHUNGNAM NATIONAL UNIVERSITY HOSPITAL

Contents

#1. 3D printed breathable lung model (BIO-Chip)

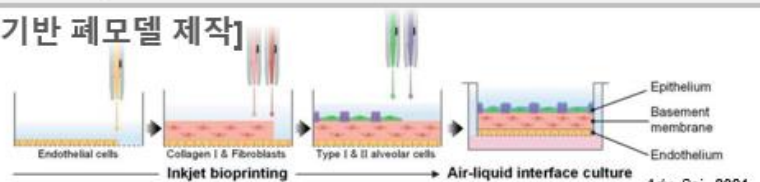


#1. Collaboration with Bio-chip

Overview of breathable lung model

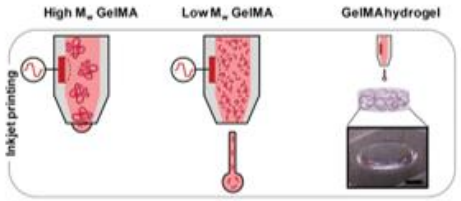
제조공정 개발

[잉크젯 기반 폐모델 제작]



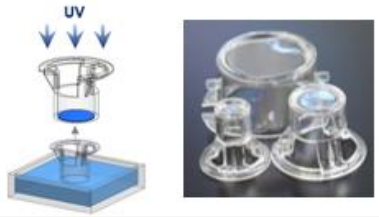
Adv. Sci., 2021

[초음파를 이용한 잉크물성 조절]



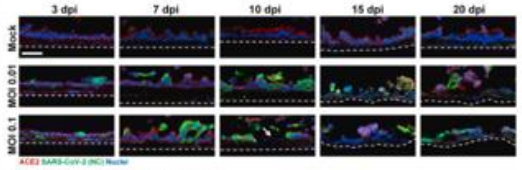
Macromol. Biosci., 2023

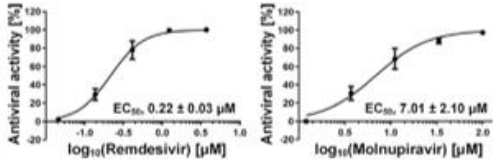
[얇은 생체막 제작]



질병모델링 및 약물 평가

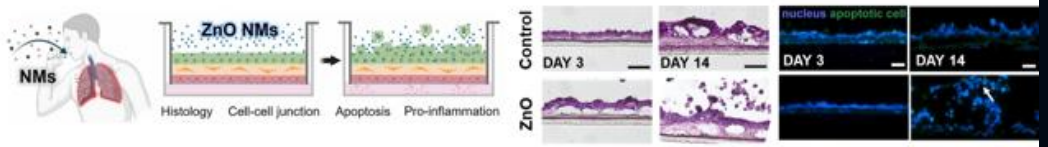
[바이러스]





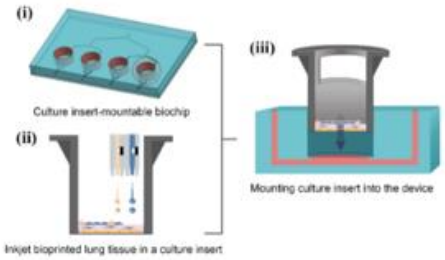
Biomaterials., 2024

[흡입독성평가]



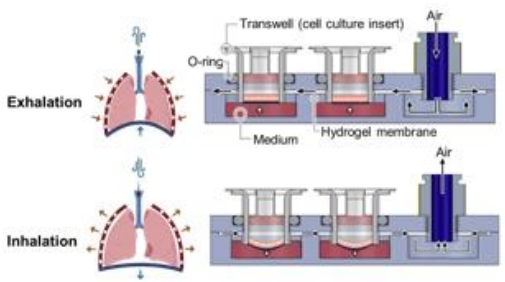
생체환경 재현 시스템

[혈류 재현 칩]



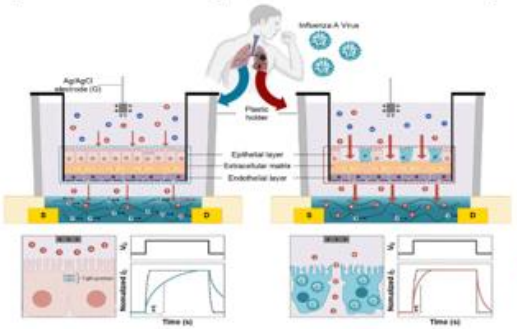
ACS Biomater. Sci. Eng., 2023

[호흡운동 재현 챔버]



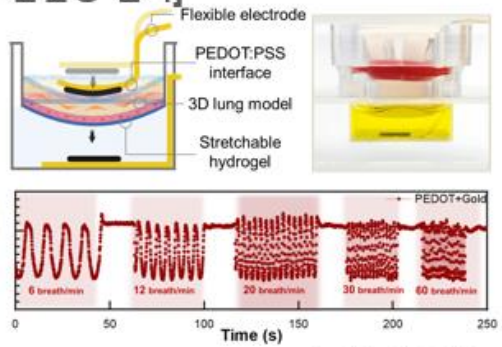
센서통합 스마트 체외모델

[장벽저항 센서]



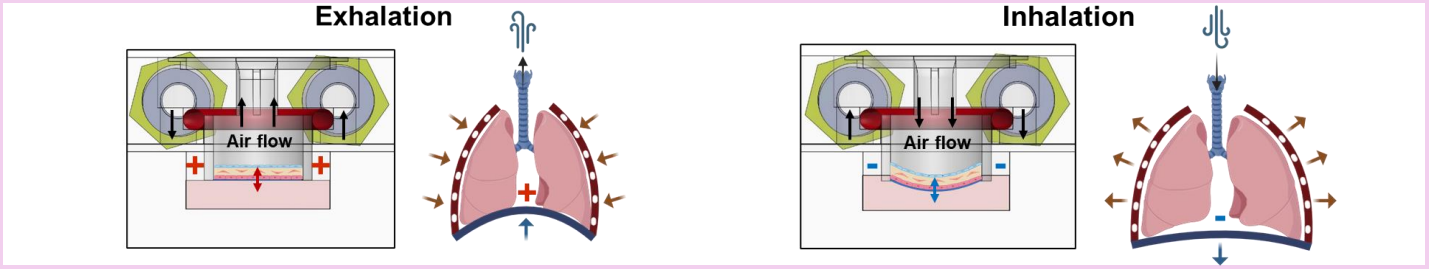
Biomaterials, 2025

[호흡운동 센서]

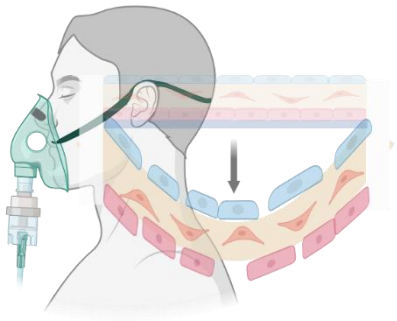


Mechanical stretch modulate physiology & pathophysiology

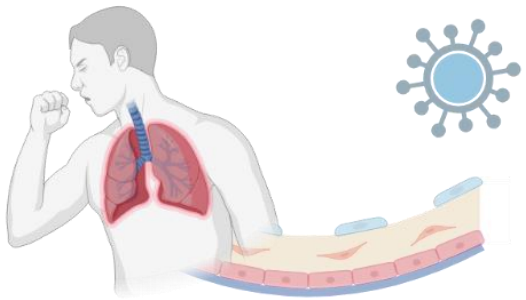
3D in vitro Breathable lung model



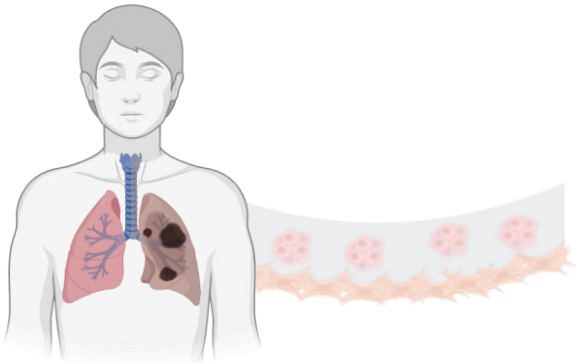
Breathing dynamics affect cellular property



Virus infection and drug efficacy test



Disease model (Cancer)



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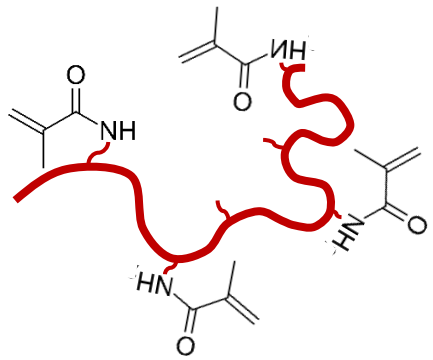
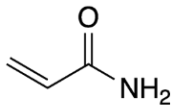
Developmemt scaffold for breathable lung model

➢ **Fabrication of stretchable hydrogel membrane**

Materials for hydrogel membrane



Gelatin methacryloyl (GelMA)



Acrylamide (AAm)

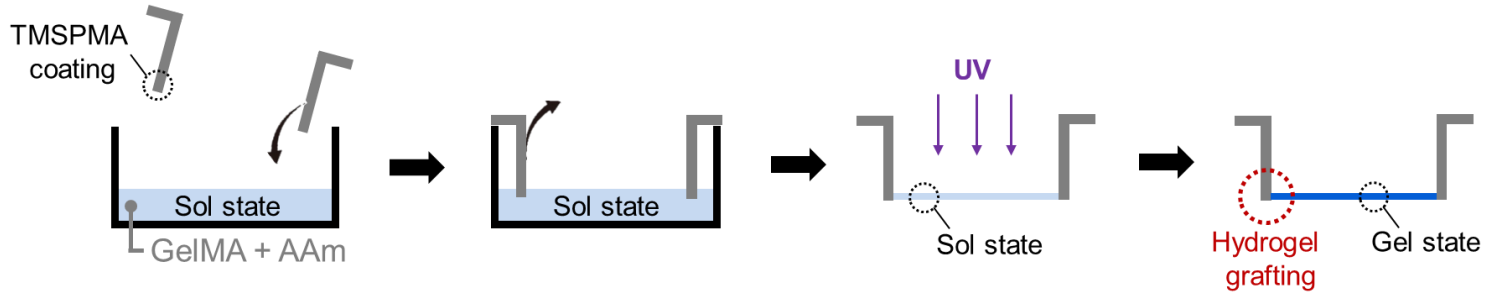
- Bio compatible
- Stretchable

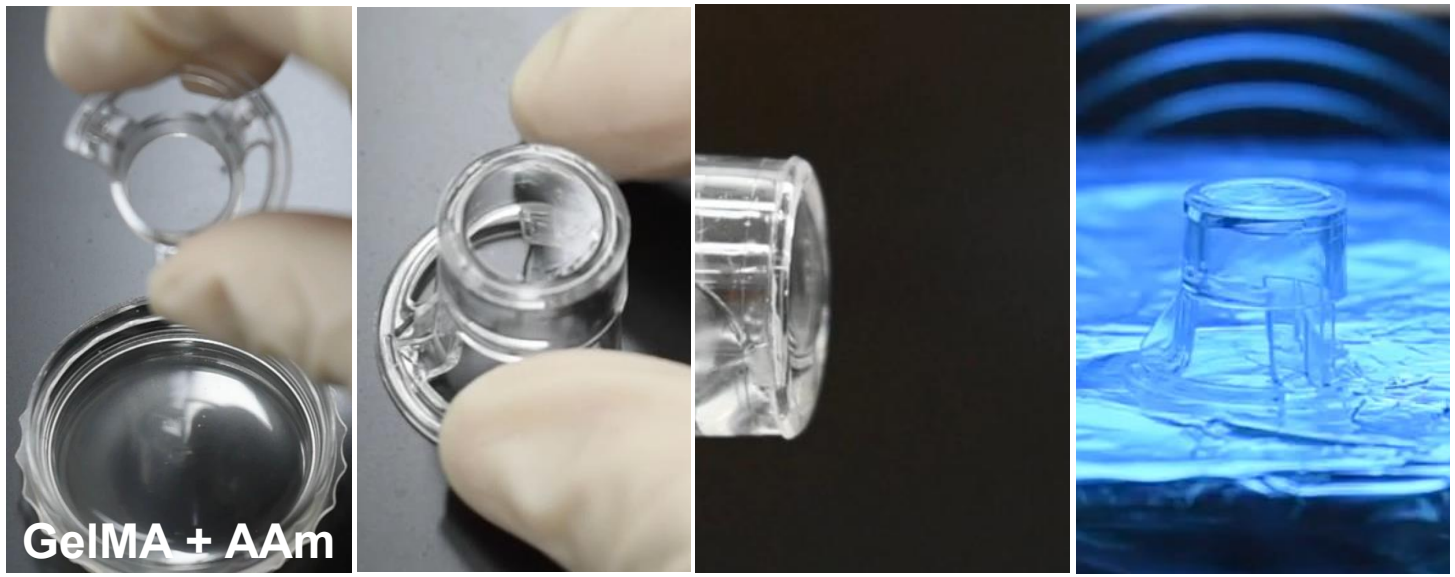
- Reduce surface tension

High surface tension

Low surface tension

Surface tension assisted manufacturing





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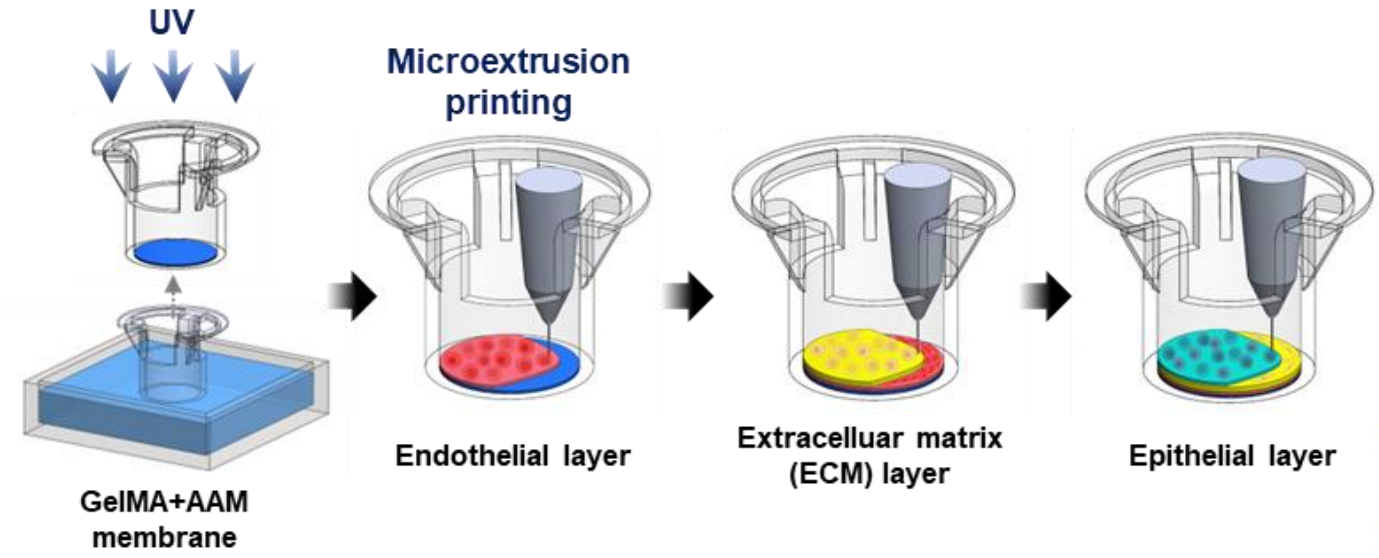
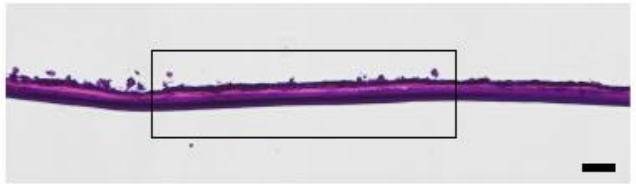
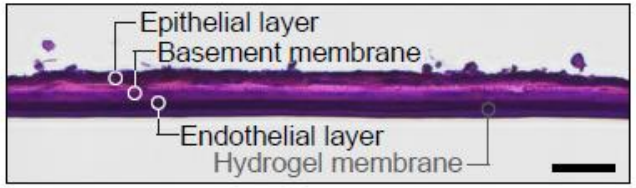
3D bioprinting of lung model on the hydrogel membrane

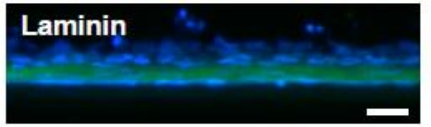
➢ Fabrication process of printed lung model

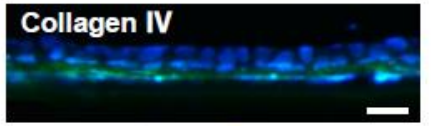


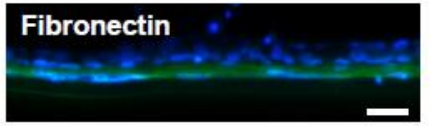
➢ Characterization of histolgical property

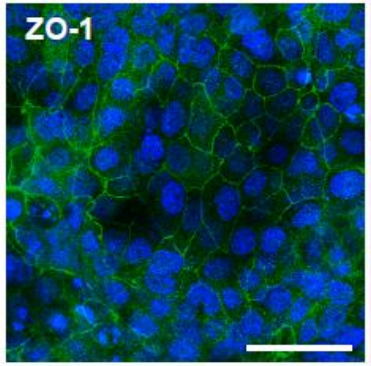


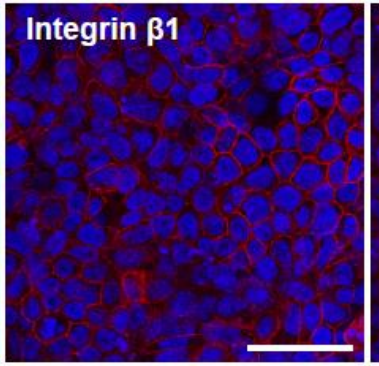


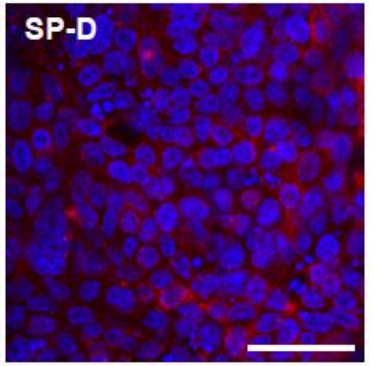












Our lung model has **thin three-layer structure** by using 3D bioprinting.

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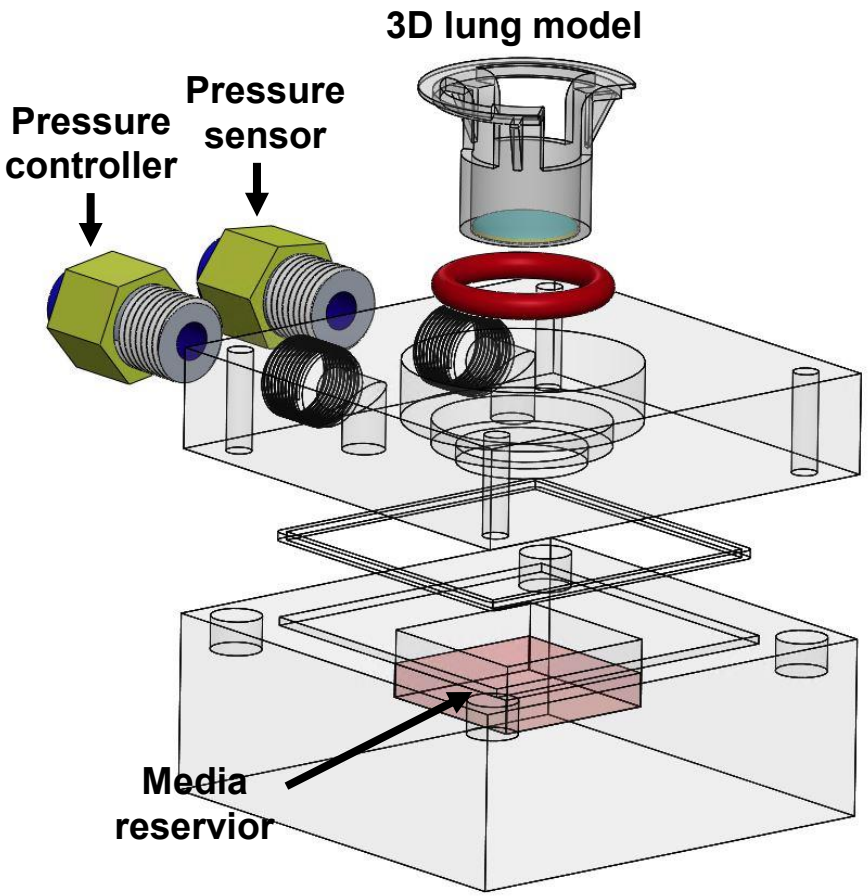
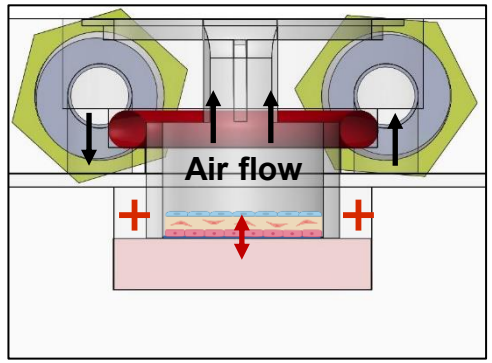
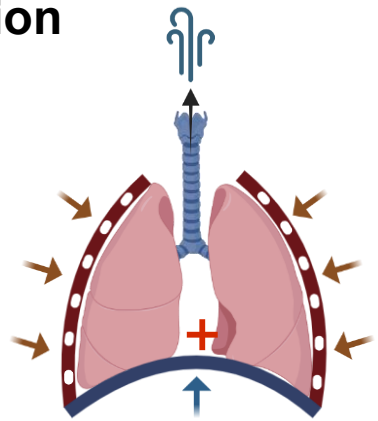
Reproduction of physiological breathing mechanics

➢ **Breathable chamber**

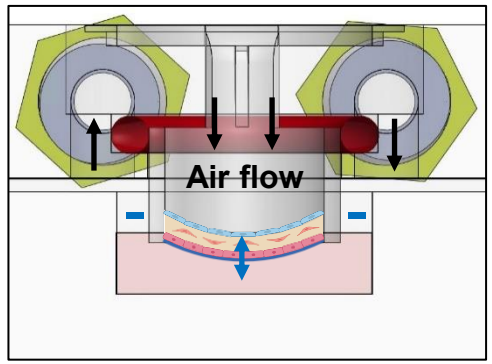


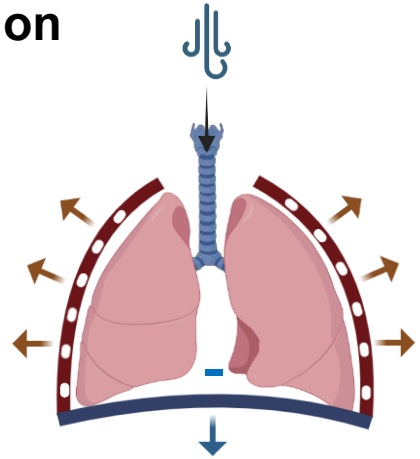
Exhalation

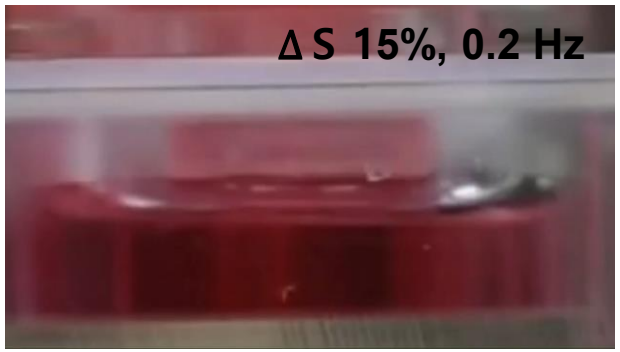




Inhalation







A stretchable lung model was cultured in a breathable chamber capable of applying **negative pressure and air-exposed conditions** to **reproduce human lung physiological environment.**

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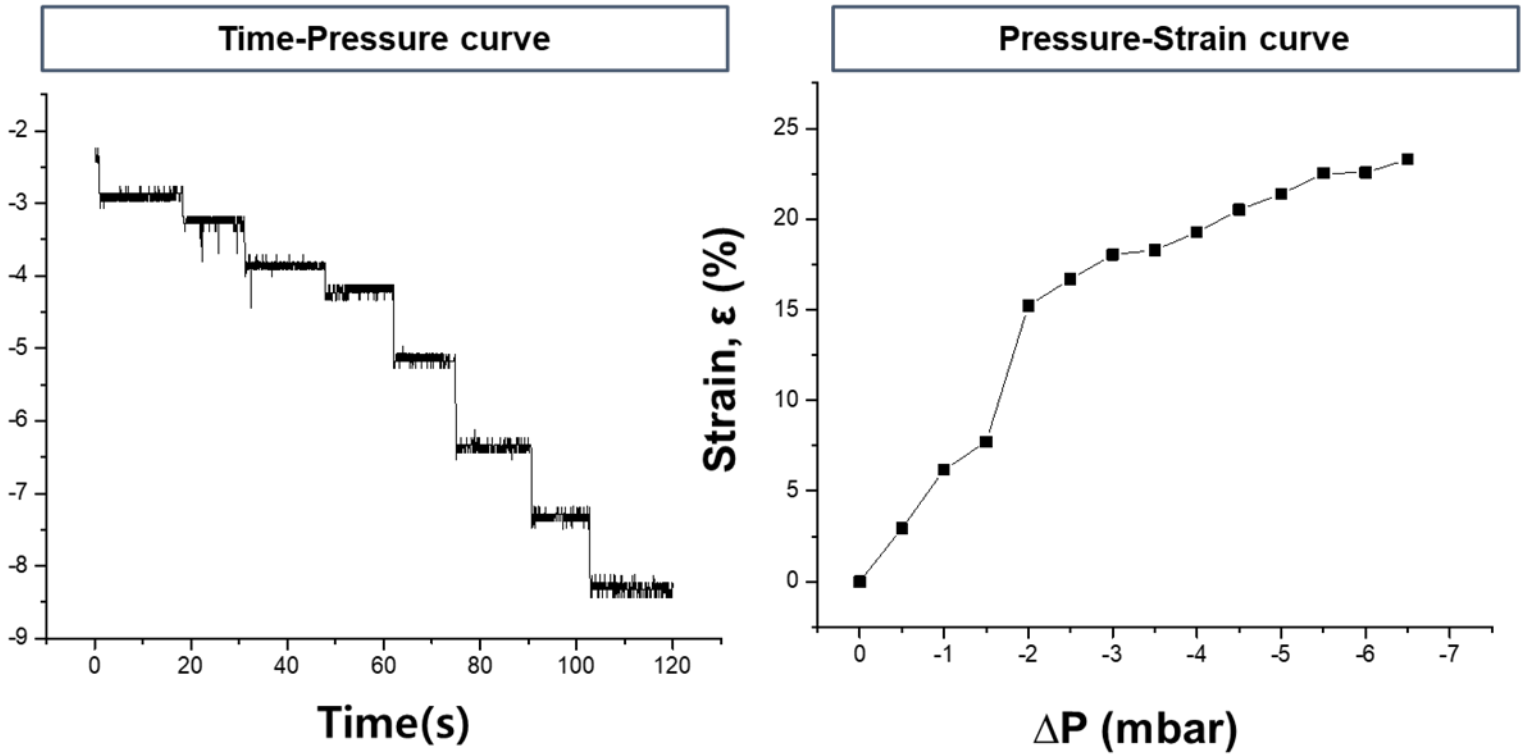
Reproduction of physiological breathing mechanics

➢ Lung model mechanical property analysis

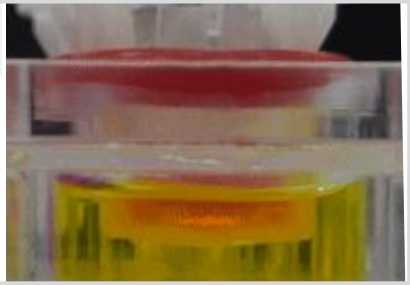


Breathing mechanics mimetic chamber **reproduce various breathing dynamics** and allows for the observation of tissue movement in response to internal chamber pressure.

➢ Dynamics of breathing

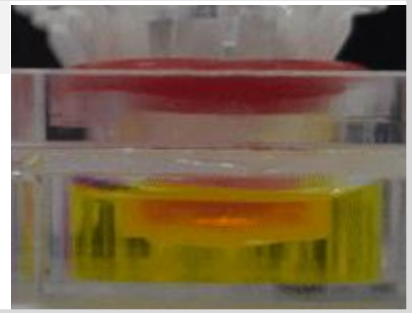
Sleep

- **Δ S 10%**
- **8 BPM**



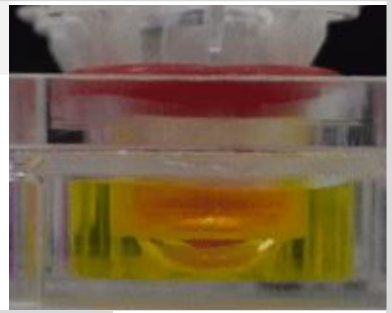
Sleep

- **Δ S 10%**
- **12 BPM**



Exercise

- **Δ S 20%**
- **30 BPM**



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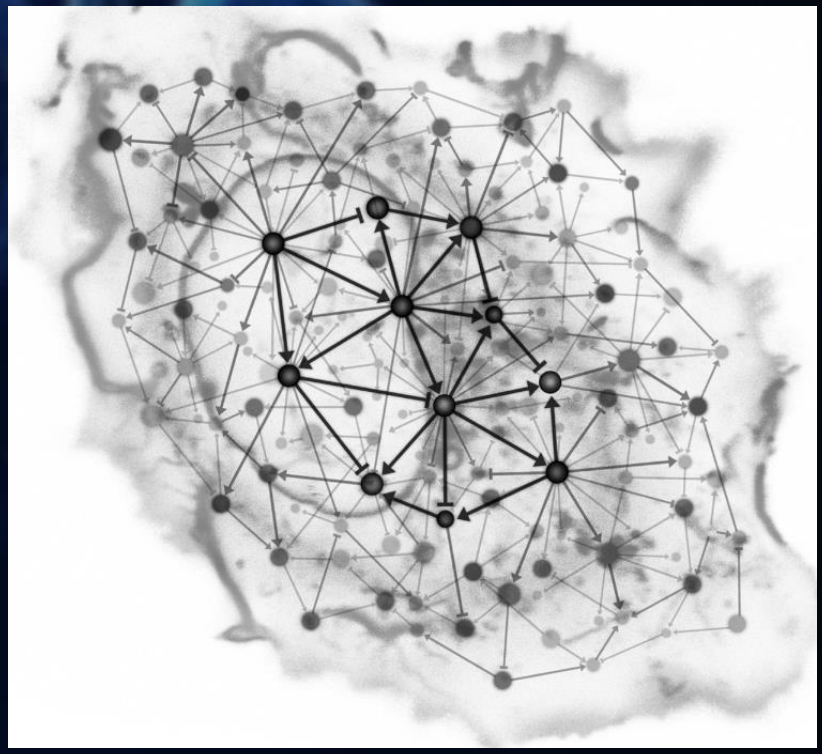
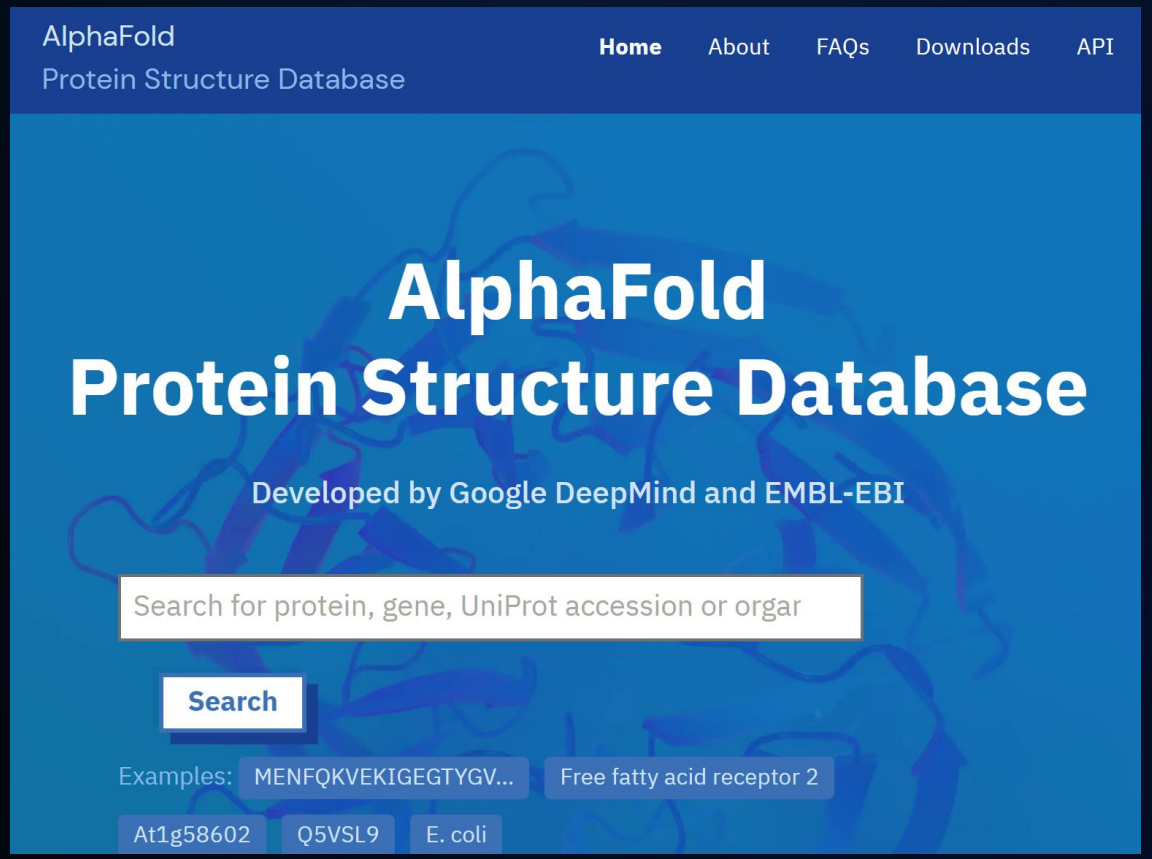
BioPrinting & Printed Electronics

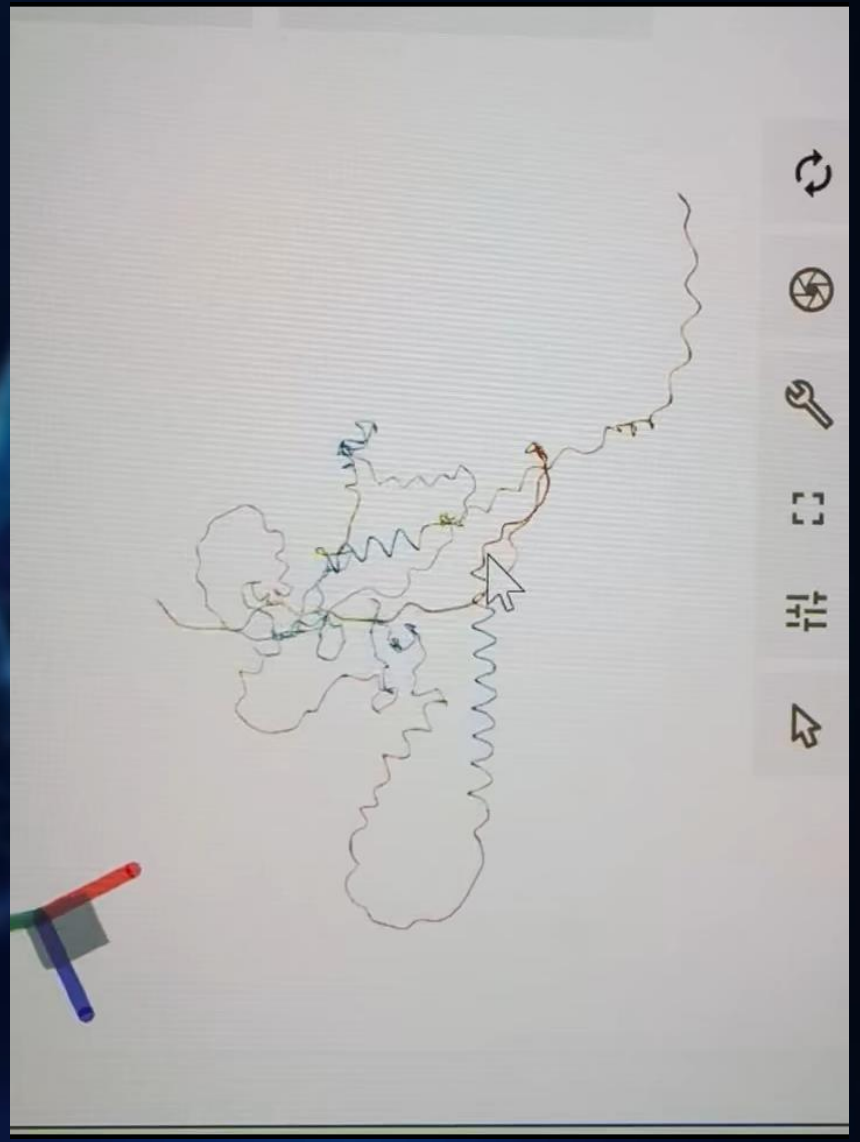
#2. Digital Twin (Digital Organoid)



System biology leveraging computational modeling and digital twins to understand and interact with complex biological systems

AlphaFold

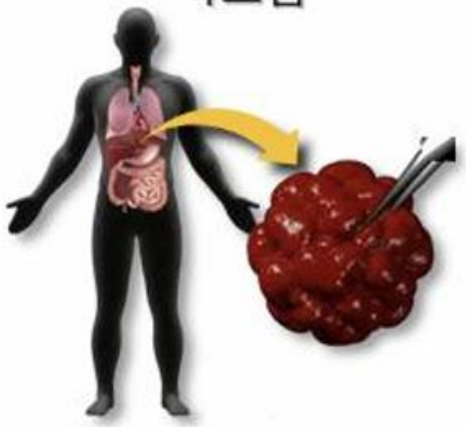

AlphaFold
Protein Structure Database
Home
About
FAQs
Downloads
API
AlphaFold
Protein Structure Database
Developed by Google DeepMind and EMBL-EBI
Search for protein, gene, UniProt accession or orgar
Search
Examples:
MENFQKVEKIGEGTYGV...
Free fatty acid receptor 2
At1g58602
Q5VSL9
E. coli



A Digital Twin Platform Based on a lung cancer

최종목표 폐암 디지털 트윈 플랫폼(Omega Twin)을 기반으로 항암제 효과를 정밀 예측하여, 신약 스크리닝과 임상시험 성공률을 높이고 환자 맞춤형 정밀의료에 활용하고자 함.

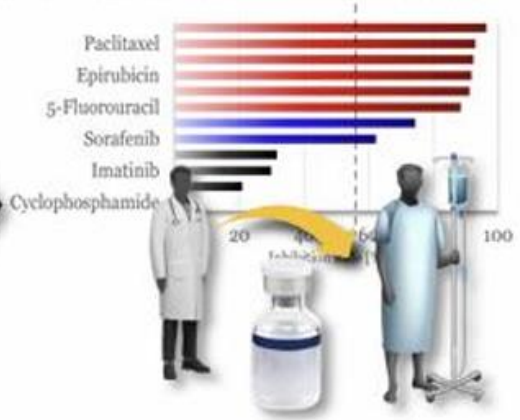
수술/생검 종양조직 유래 폐암 오가노이드, 공배양 시스템



Omega-Twin

종양오가노이드 미세환경 디지털트윈 시뮬레이션

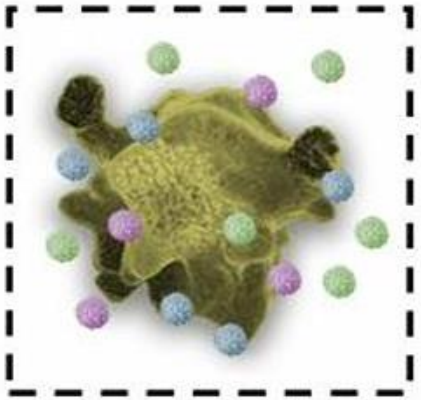
치료 타겟 발굴, 신약 스크리닝 예상 반응률 기반 맞춤처방



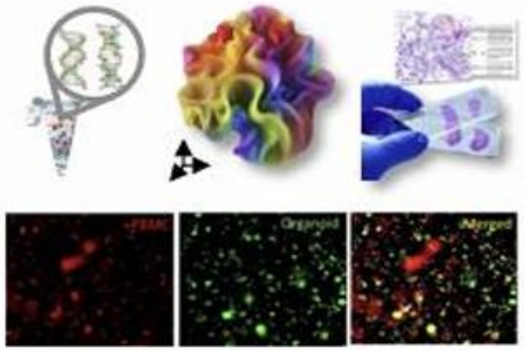
OMEGA: Organoid-based Microenvironment-Embedded Graph-AI architecture for Drug Evaluation

연구요약 Translational Research (From Bed to Bench to Digital, and Back to Bed)

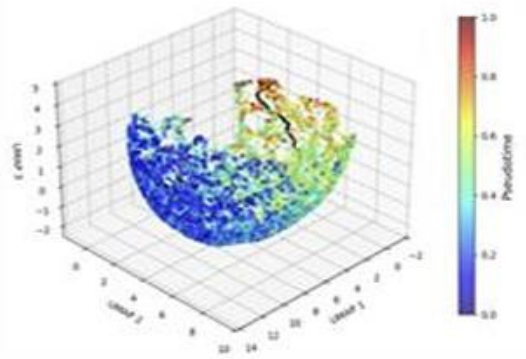
종양오가노이드
미세환경



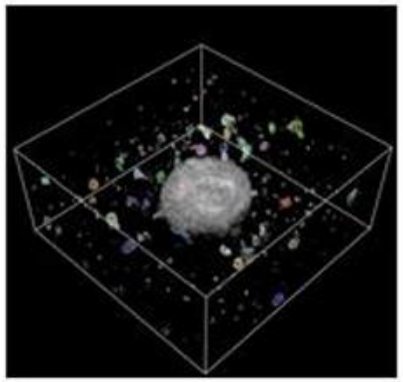
이미징 멀티오믹스
데이터



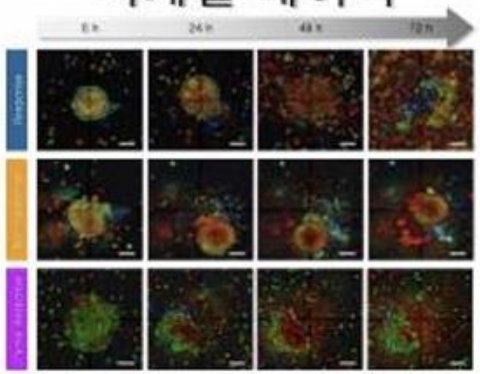
다차원 공간특성
매핑



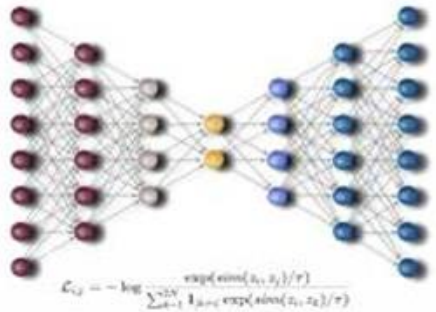
디지털트윈 생성



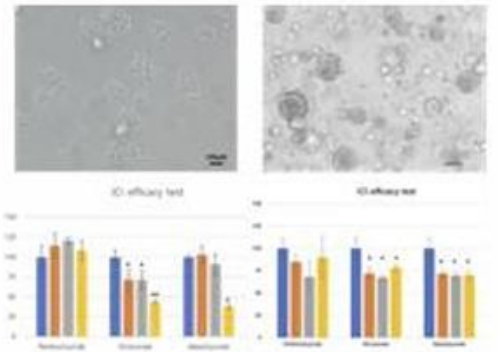
디지털트윈 면역반응
시계열 데이터



면역반응 예상
심층신경망 개발



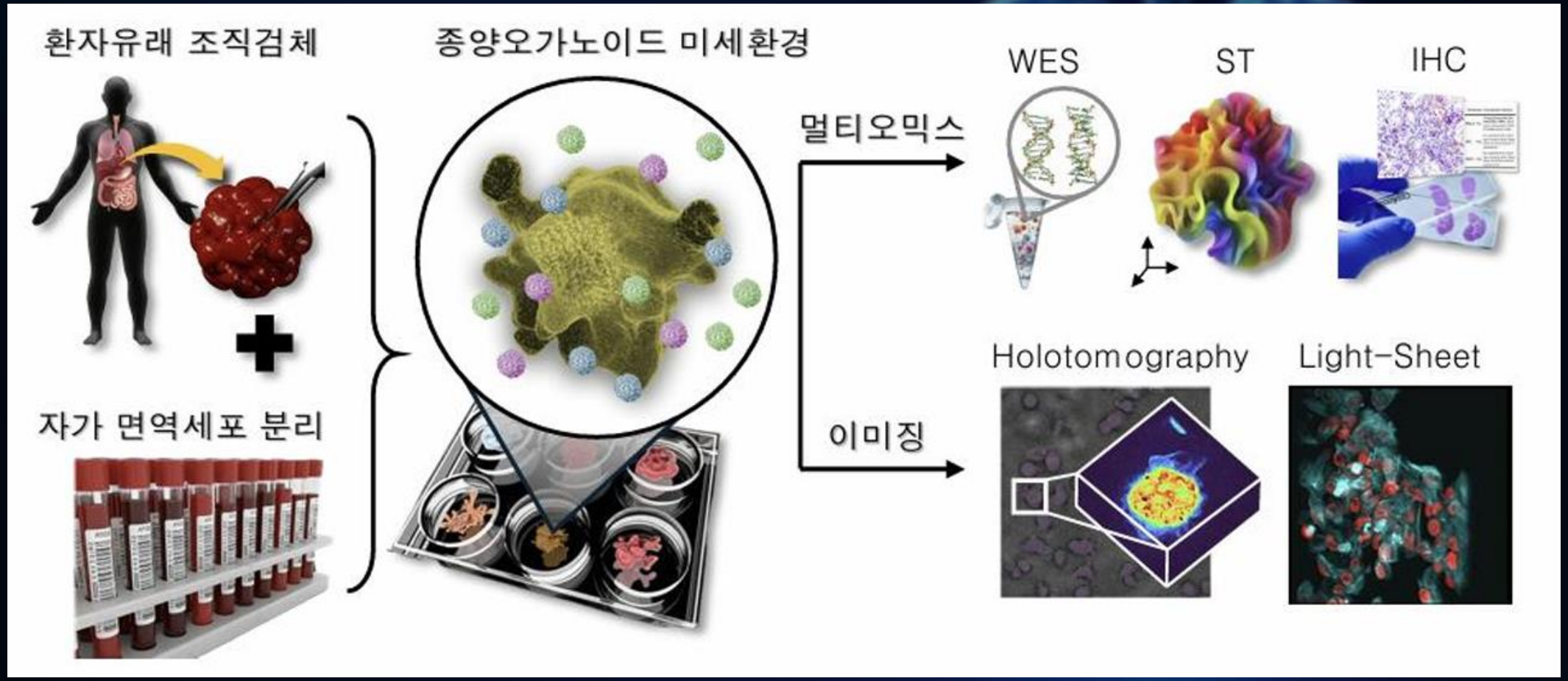
실제 종양오가노이드
반응결과



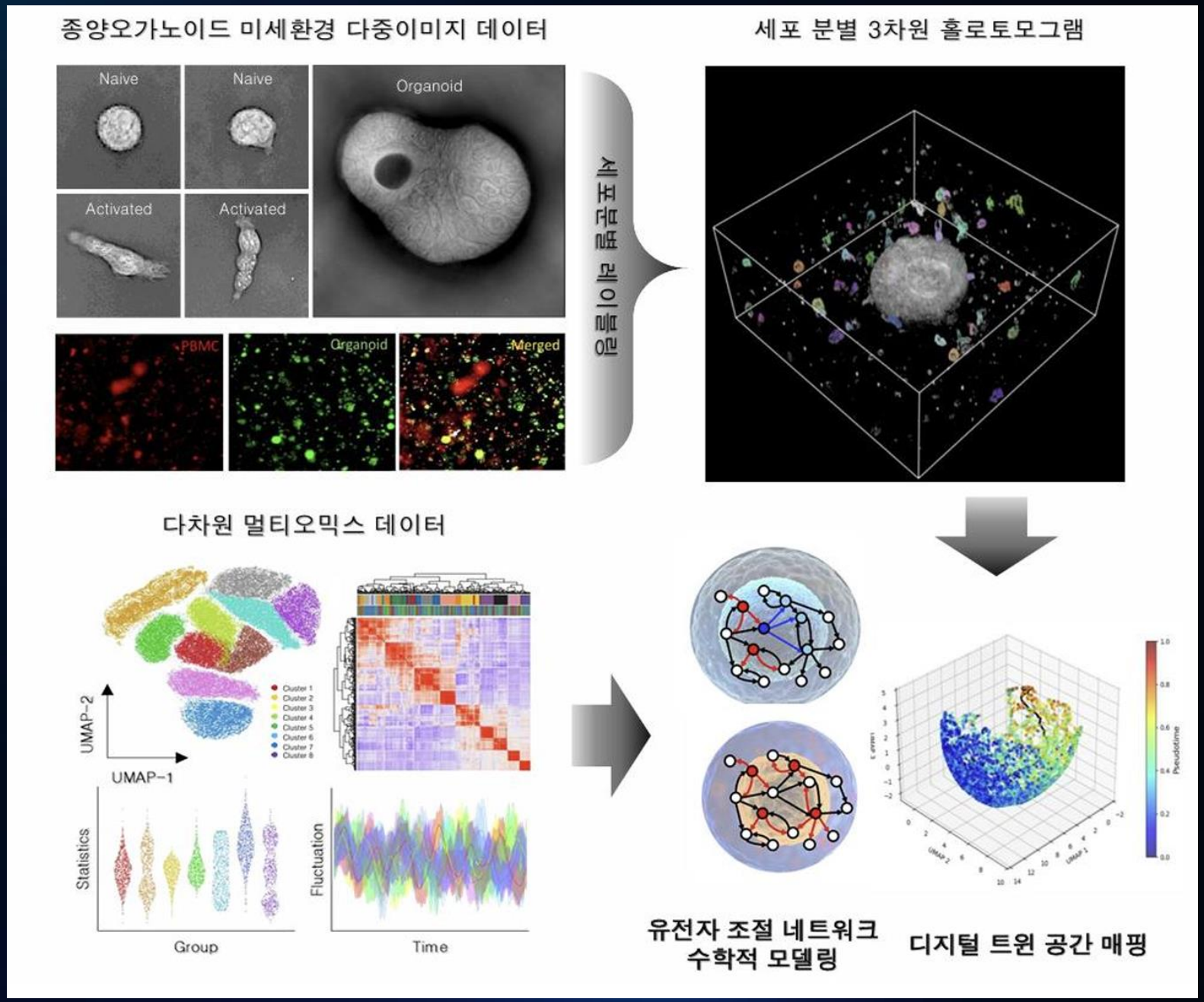
임상결과 확인

폐암 디지털 트윈 플랫폼 (Omega Digital Twin)

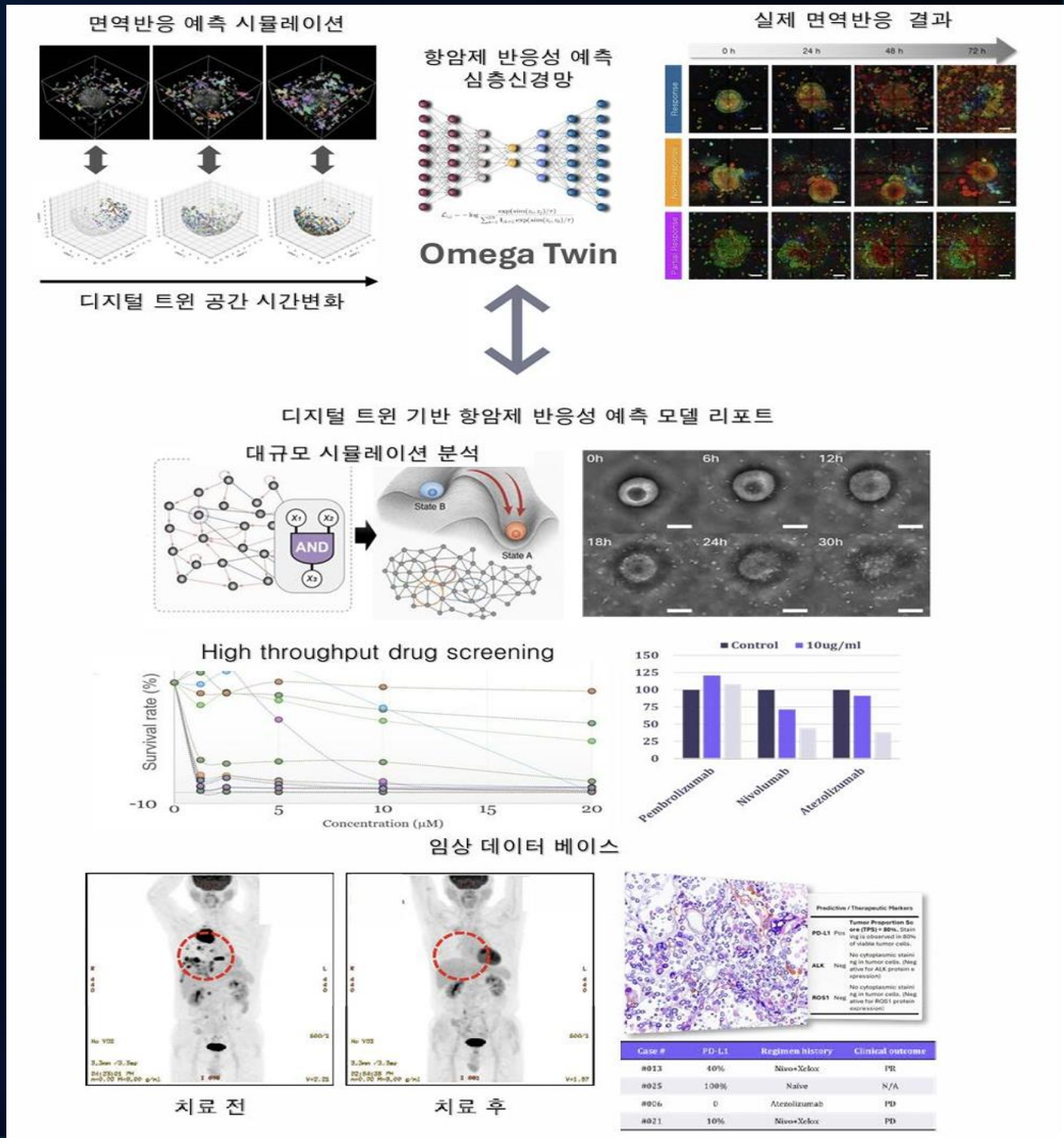
Organoid-based Microenvironment-Embedded Graph-AI architecture for Drug Evaluation



Bench to Digital (Omega Twin)



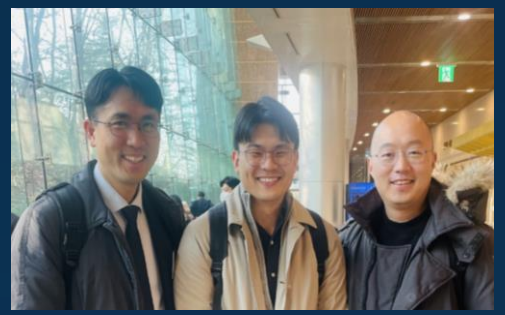
From Digital
to Bench (Drug screening) & Bed (Precision medicine)



Take Home Message

1. **Organoid-Based Precision Lung Cancer Remodeling and Limitations**
   - *Validation of lung cancer organoids (LCOs) using multi-omics approaches and co-culture systems with immune cells and CAR-T cells*
2. **Cigarette Smoke–Induced Lung Carcinogenesis Model in Lung Organoids**
3. **3D Holotomography for Visualization of Cellular Events and Components**
   - *Comprehensive 3D imaging of dynamic cellular events and structural components*
4. **Morphomics-Based Prediction of Immune Cell and LCO Characteristics**
5. **Modeling Drug and Radiation Resistance Using Patient-Derived Organoids**
6. **Integration of Lung Cancer Organoids with Breathable Bio-Chips and Digital Twin Platforms**

Thank you for your attention



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KAIST (Jong Eun Park)

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