

# SCIENCE MEETS BUSINESS

4 MARCH 2021



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Radboud University



Radboudumc  
university medical center



WAGENINGEN  
UNIVERSITY & RESEARCH



imec

enabled  
with the  
support of

≡ provincie  
Gelderland



## THE NEED TO ADDRESS GLOBAL CHALLENGES

HOW TO FEED 10 BILLION PEOPLE BY 2050 ?

HOW TO FEED PEOPLE IN A **HEALTHY** AND  
**SUSTAINABLE** MANNER ?

HOW TO KEEP PEOPLE **HEALTHY** ?

HOW TO REDUCE OUR IMPACT ON THE  
**ENVIRONMENT** ?

**AN APPLE A DAY  
KEEPS THE DOCTOR AWAY**



**AN APP A DAY  
KEEPS THE DOCTOR AWAY**



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 provincie  
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Radboud University



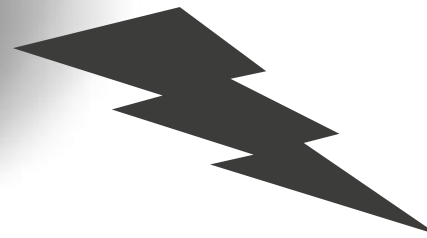
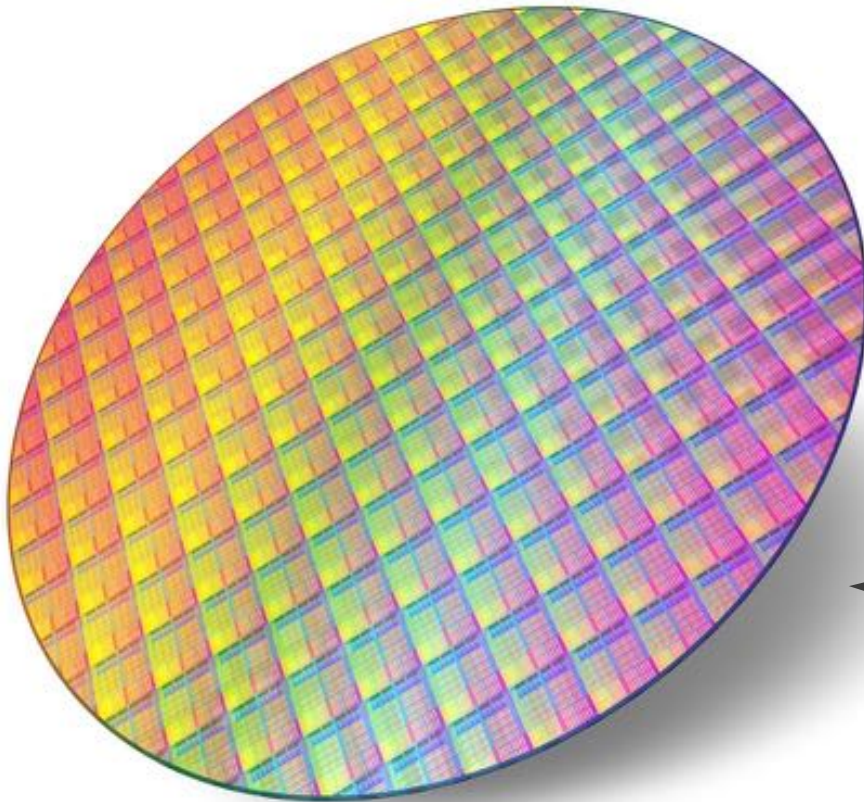
Radboudumc  
university medical center



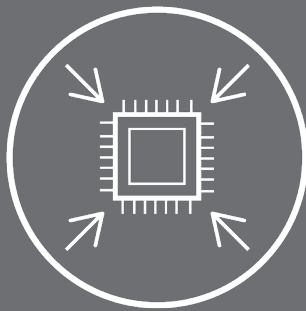
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# OUR TOOLBOX

## CHIP TECHNOLOGY & DIGITAL TECHNOLOGIES



■ imec



**SMALLER**



**MORE  
COMPLEX**



**FASTER**

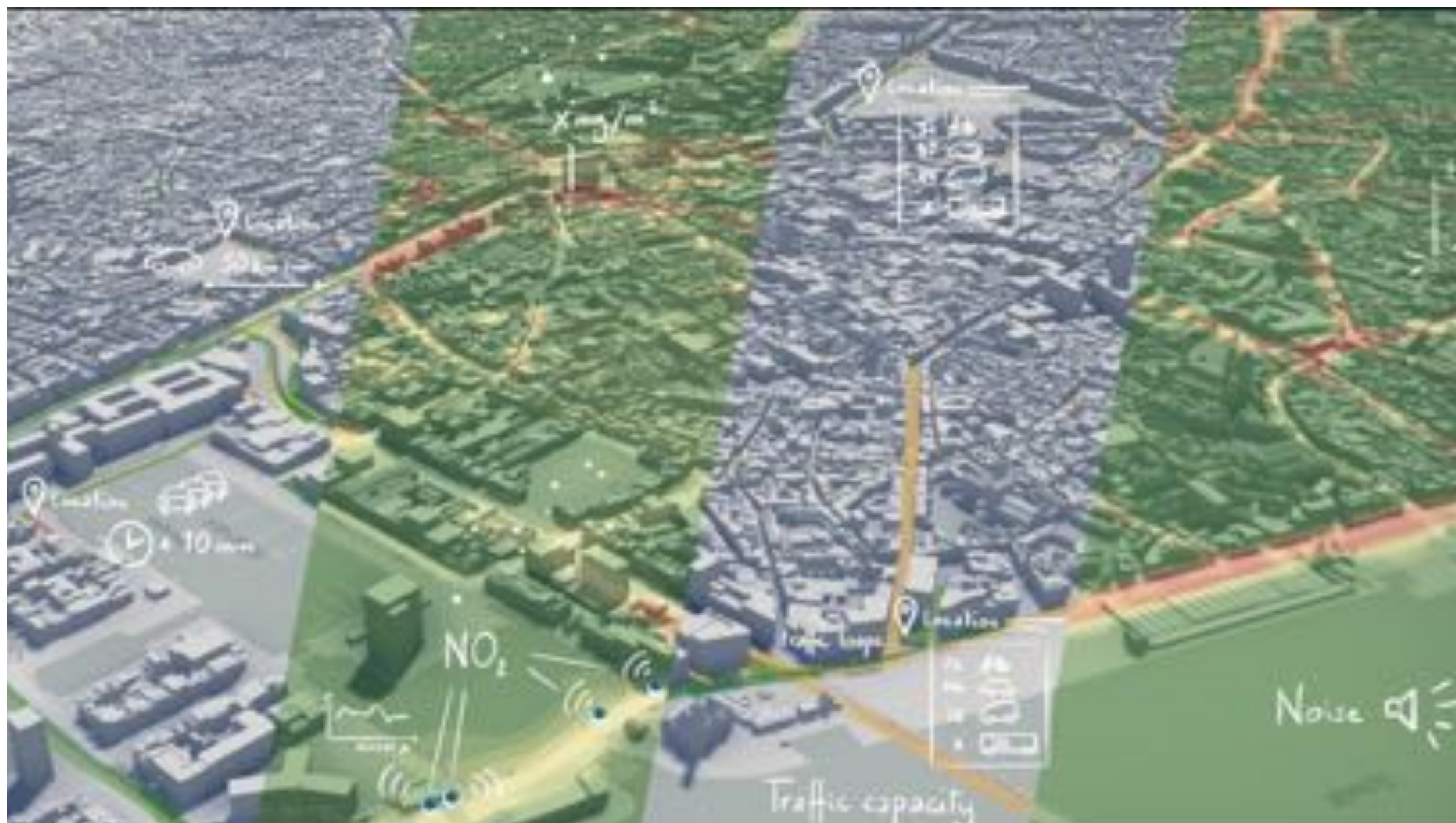


**LESS  
POWER**













**OUR  
GOAL**

**CREATE  
HUMAN  
DIGITAL  
TWIN**

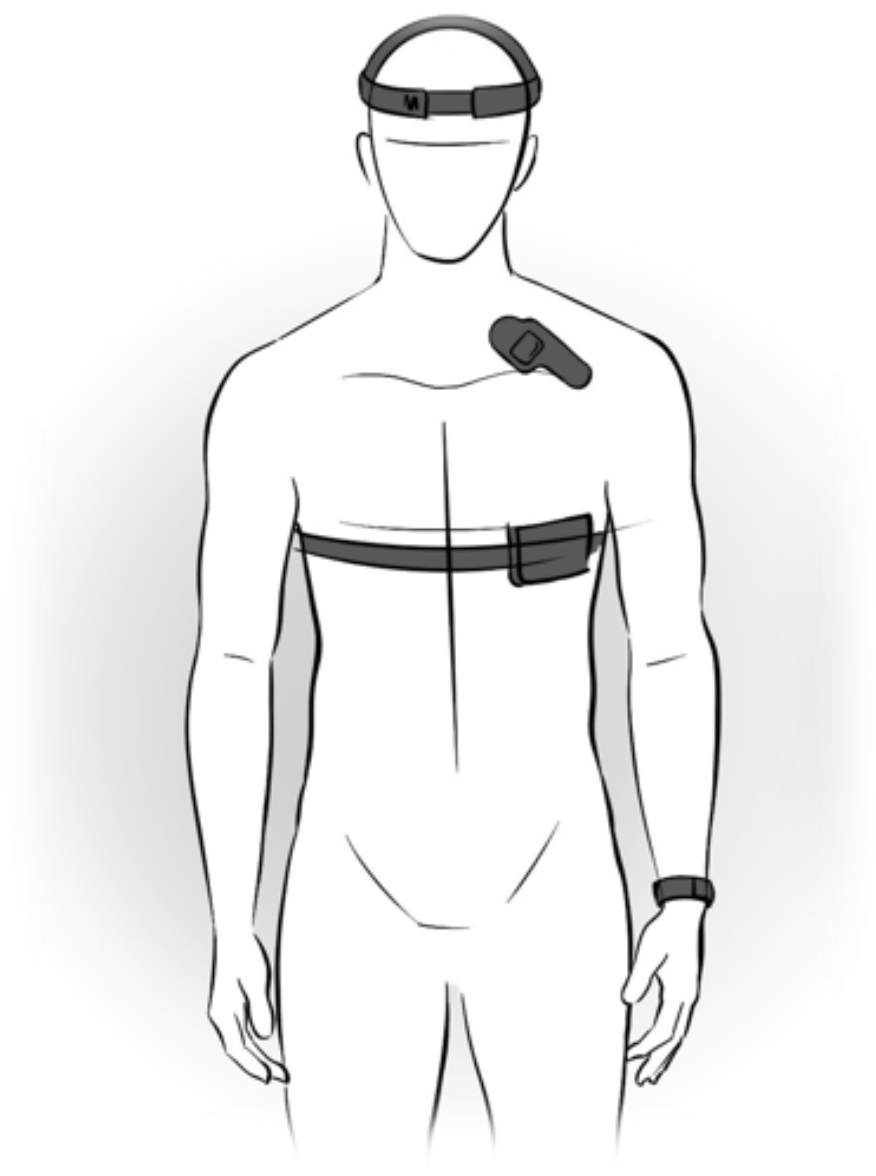


CREATE AND VALIDATE  
INNOVATIONS LINKED TO  
NUTRITION, METABOLIC  
HEALTH AND MENTAL  
WELLBEING



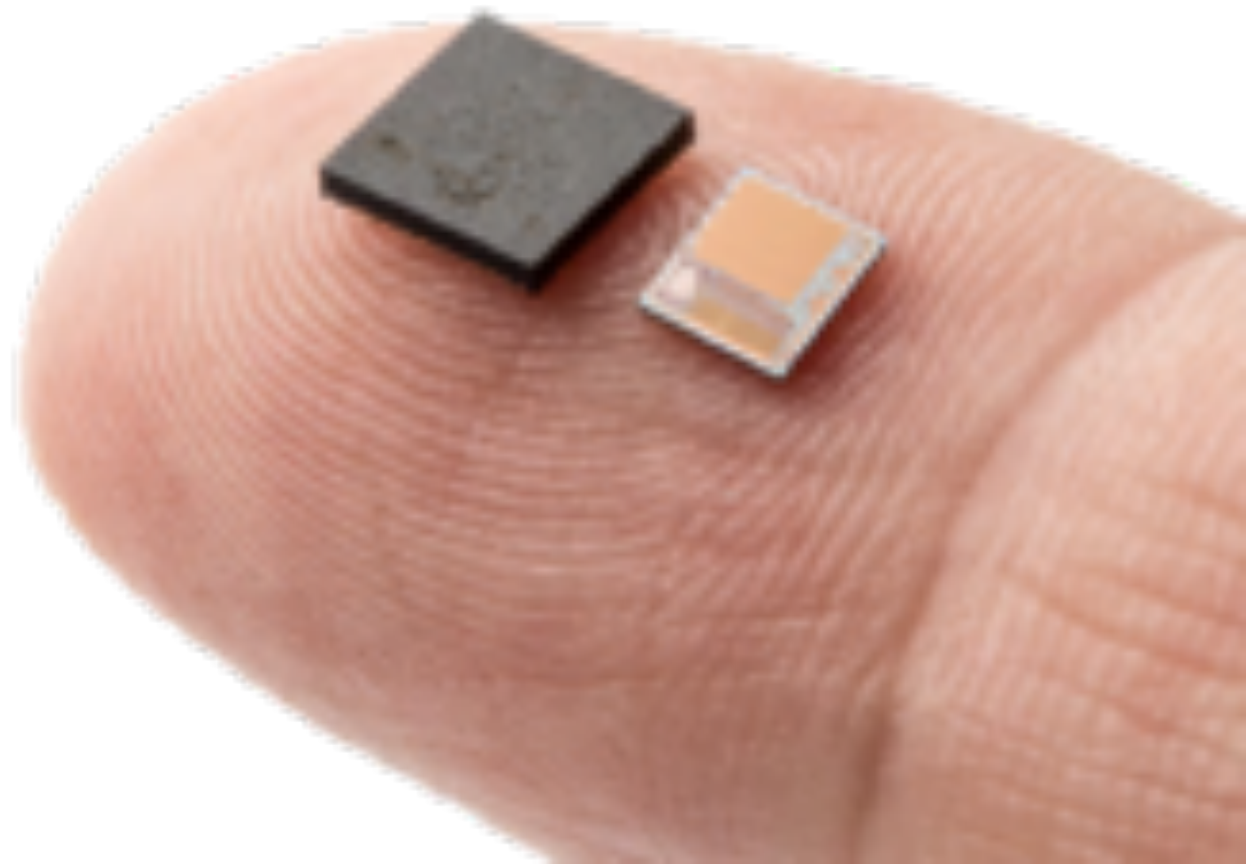








# NANOELECTRONICS HAS BROUGHT VITAL SIGN MONITORING IN A SINGLE CHIP



**... AND RESULTED  
IN MEDICAL  
GRADE  
WEARABLES**



**... AND WILL  
LEAD TO  
FUTURE  
MEDICAL  
GRADE  
WEARABLES**



# SMART HEALTH PLATFORMS WE ARE CREATING

# TO ENABLE HEALTH BREAKTHROUGHS



European College of Neuropsychopharmacology (ECNP) – press release

## *Depression risk detected by measuring heart rate changes*

**Embargo until: 00.05 CEST (Vienna) Saturday 12<sup>th</sup> September 2020**

Type of study: not peer-reviewed/experimental study/people

For the first time doctors have shown that measuring changes in 24-hour heart rate can reliably indicate whether or not someone is depressed. In practical terms, this may give clinicians an objective “early warning” of potential depression, as well as a rapid indication whether or not treatment is working, so opening the way to more rapid and responsive treatment. Presenting results of this pilot study at the ECNP virtual congress, lead researcher, Dr Carmen Schiweck (Goethe University, Frankfurt) said “*Put simply, our pilot study suggests that by just measuring your heart rate for 24 hours, we can tell with 90% accuracy if a person is currently depressed or not*”.

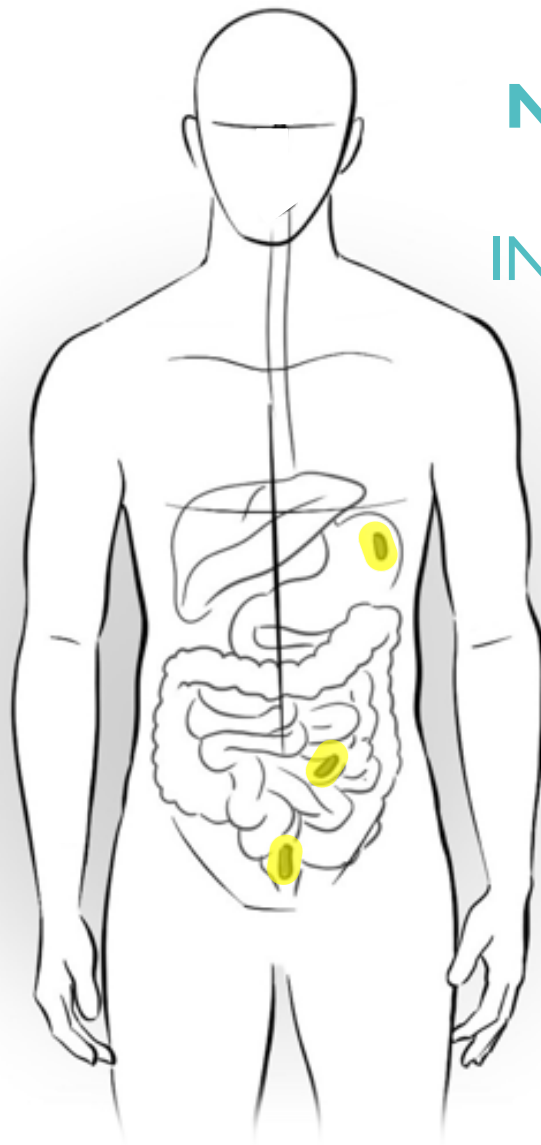


## Heart rate and heart rate variability as trait or state marker for depression? Insights from a ketamine treatment paradigm

C. Schiweck 1, E. Lutin 2, W. De Raedt 3, M. Morrens 4, V. Coppens 4, C. Van Hoof 2, A. Reif 1, E. Vrieze 5, S. Claes 5.

1 Goethe University, Frankfurt am Main, Germany, 2 KU Leuven, Belgium. 3 Imec, Belgium. 4 University of Antwerp, Belgium. 5 UZ Leuven, Belgium.

# CREATE NEW TOOLS FOR NUTRITION AND METABOLIC HEALTH INGESTIBLES & SMART BATHROOM

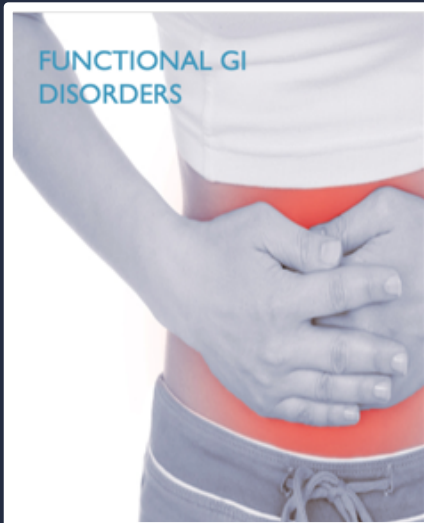


PUBLIC



# APPLICATION TARGETS

## FUNCTIONAL GI DISORDERS



### 3 primary requirements

- + Abnormal Motility
- + Hypersensitivity
- + Brain-Gut dysfunction



Ingestible sensing technologies will enable:

1. Reliable diagnosis
2. Targeted treatment
3. Sustained effectiveness

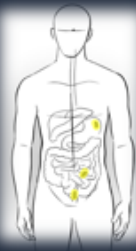
CDER - FDA report, Jan 2016

## INFLAMMATION MARKERS



### 3 primary requirements

- + Minimally invasive
- + Repeatable, inexpensive
- + Capture location, extent & intensity of inflamed area



Ingestible sensing technologies will enable:

1. Early diagnosis
2. Disease progression
3. Effect of interventions

Ananthakrishnan 2020, Clin. Gastroenterol. Hepatol.

Clin. Gastroenterol. Hepatol. Ananthakrishnan, A. N.; Kaplan, G. G., & Ng, C. (2020). Changing Global Epidemiology of Inflammatory Bowel Disease: Sustaining Health Care Delivery Into the 21st, 1252-1260. <https://doi.org/10.1016/j.cgh.2020.01.028>

## SHORT-CHAIN FATTY ACIDS



### primary features

- + SCFA are main metabolites of microbiome
- + Indirectly study balance of gut microbiome
- + Capture dysbiosis

Ingestible sensing technologies will enable:

1. Study intervention effects ( nutrition, pre/probiotics )
2. Study health effects of SCFA ( gut barrier, immune function, anti-inflammatory processes )

# INGESTIBLE SENSORS

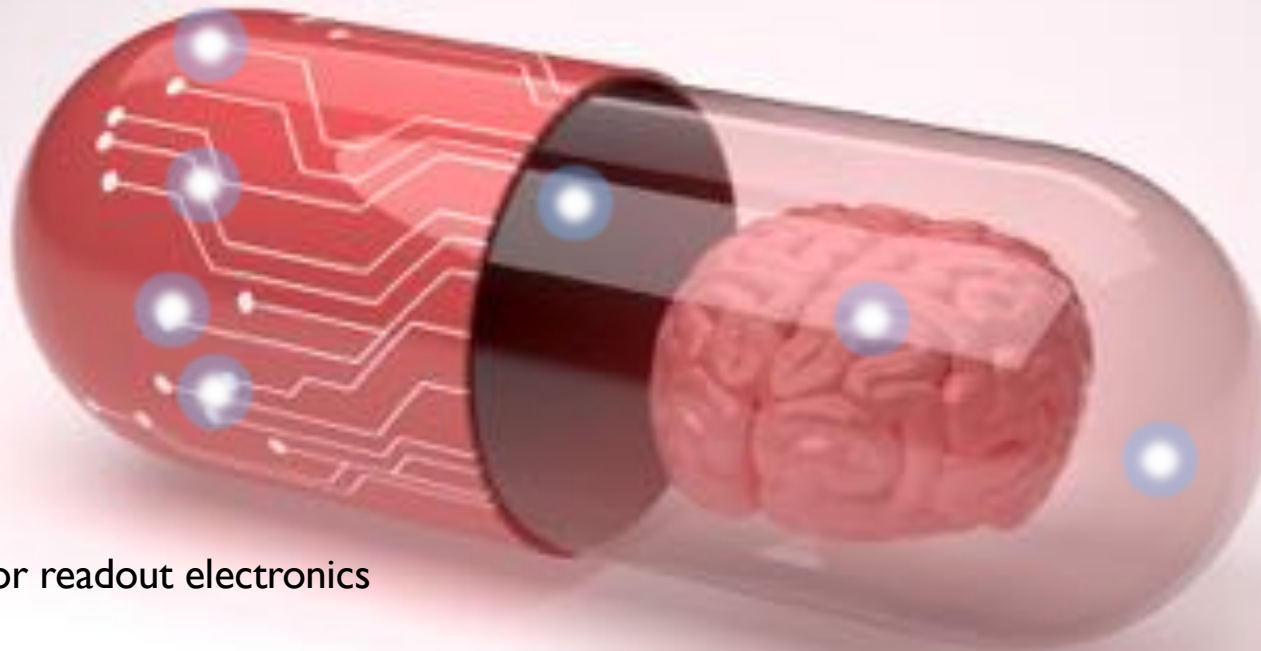
- Diagnostic applications
- Study interventions
- Dietary interventions
- Nutrition research



IS THIS POSSIBLE ?

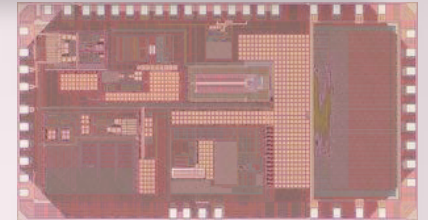
# DAUNTING MINIATURIZATION CHALLENGES

10x – 100x reduction in power, size, while all the while scalable to volume

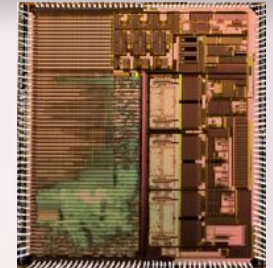


- + Sub- $\mu$ W sensor readout electronics
- + Multi-modal sensor combining electro-chemical, optical, wave-based sensing
- + Data analytics and sensor fusion algorithms
- + Location-aware sensing and sampling

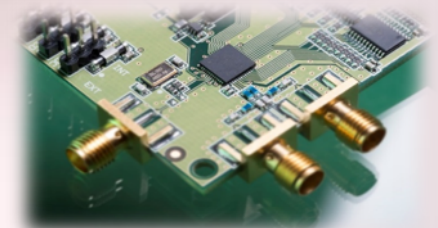
Bio-chemical sensor  
interface ICs



Data analytics ICs



Wireless interfacing



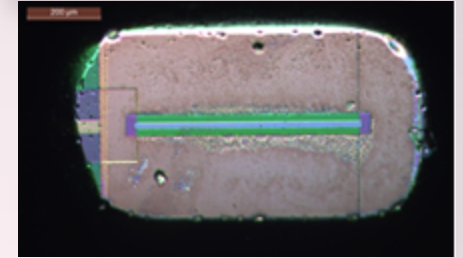


# DAUNTING MATERIAL & PROCESS CHALLENGES

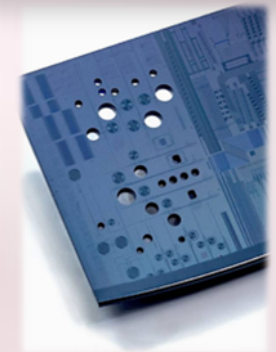


- (Micro-)fluidics for reliable sampling
- Integration and miniaturization of sensors
- Hermetic and biocompatible sealing of electronics
- Anti-fouling coating

Sensor technology

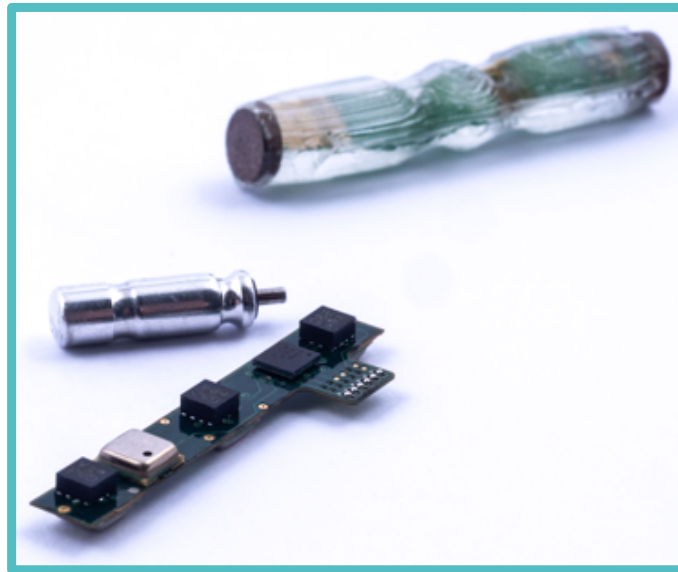
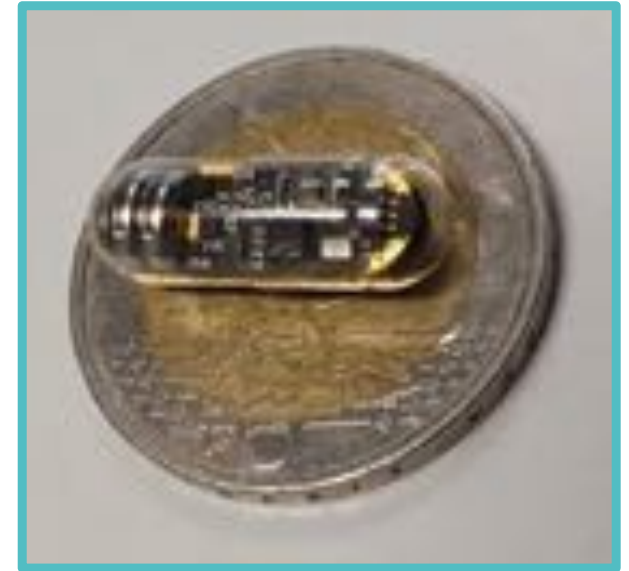
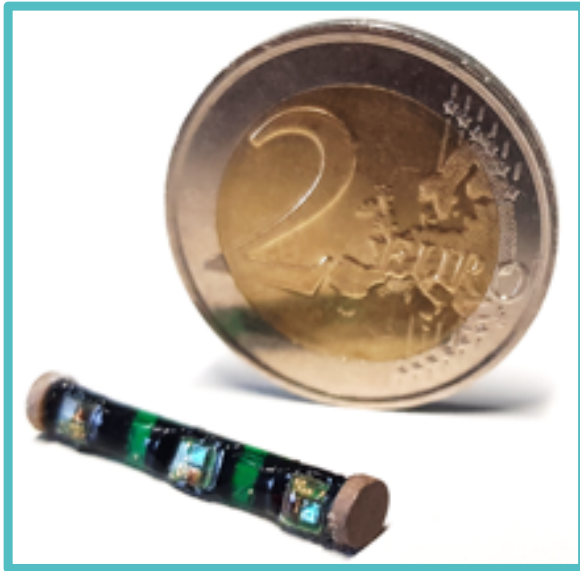


Fluidics & sampling



Packaging

# SEVERAL & FAST LEARNING CYCLES





## CURRENT STATUS

A close-up photograph of a person's hand holding a small, black, cylindrical battery. In the background, a blue printed circuit board (PCB) is visible, featuring a gold-colored SMA antenna connector. A thin copper wire is connected to the board. The entire setup is resting on a light-colored wooden surface.

**>6 days battery lifetime**  
when measuring and transmitting  
every 3 seconds.

# FIRST VALIDATION IN AN IN-VITRO MODEL OF THE GI TRACT (SHIME @ Wageningen University)

- Sensitivity in harsh environment
- Specificity in in-vivo setting
- Anti-fouling techniques

# A SMART BATHROOM FOR YOUR DAILY CHECK-UP ?



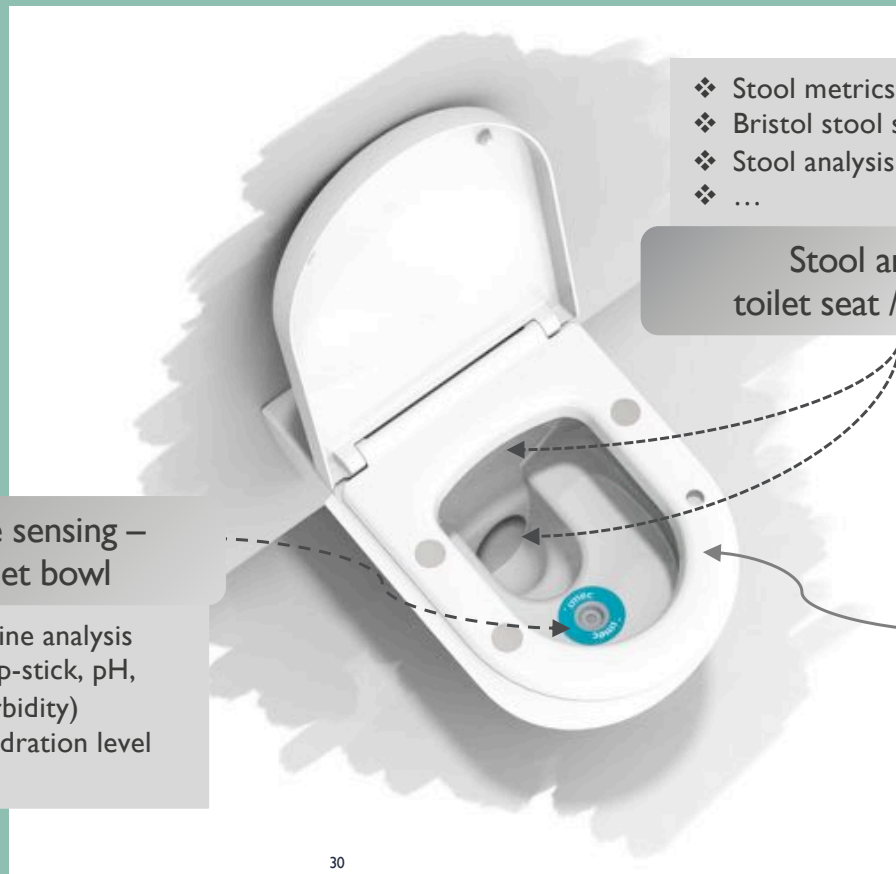
# BATHROOM FOR HEALTH

MEASUREMENT OF BIOMARKERS AS EARLY INDICATORS FOR DISEASE OR NUTRITIONAL INTERVENTION



## Urine sensing – toilet bowl

- Urine analysis (dip-stick, pH, turbidity)
- Hydration level
- ...



- ❖ Stool metrics
- ❖ Bristol stool scale
- ❖ Stool analysis (specific gravity, ...)
- ❖ ...

## Stool analysis – toilet seat / toilet bowl

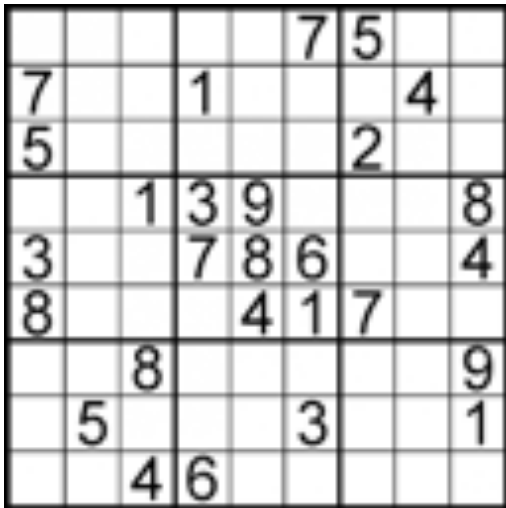
## Physiology measurements – toilet seat

- Heart Rate
- Heart Rate variability
- Blood Pressure changes
- Blood Oxygenation
- Skin/core temperature
- PAT / PTT
- ...





# HUMAN INTELLIGENCE (*SLIGHTLY* SIMPLIFIED)



WE LEARN BY RULES



WE LEARN BY EXPERIENCE

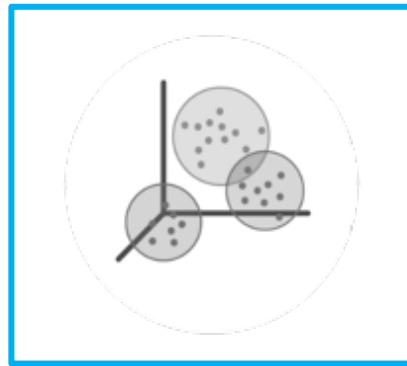


# OUR DIGITAL TWIN GROWS BY USING **ARTIFICIAL INTELLIGENCE**

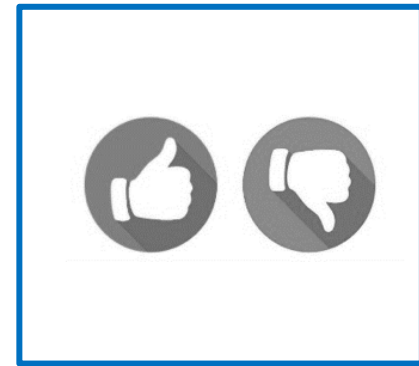
“LEARNING BY EXPERIENCE”



SUPERVISED  
LEARNING

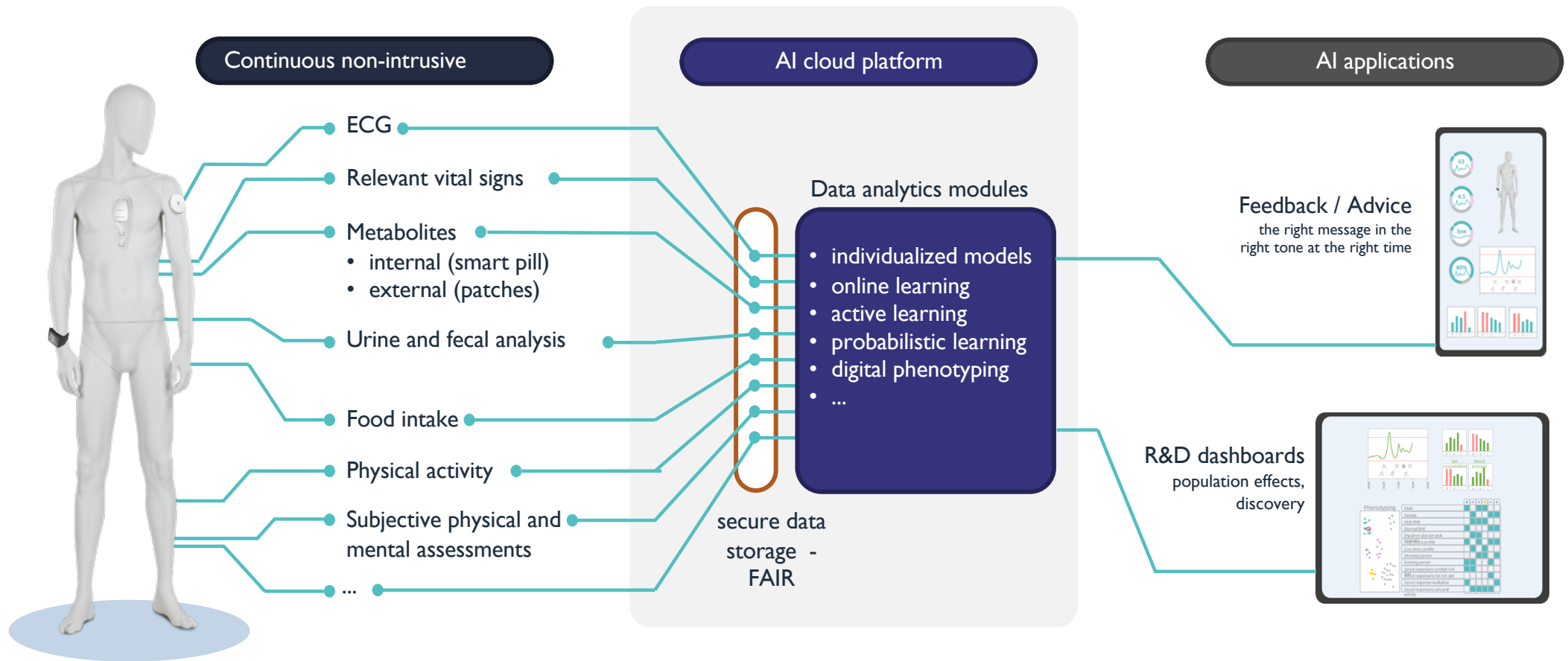


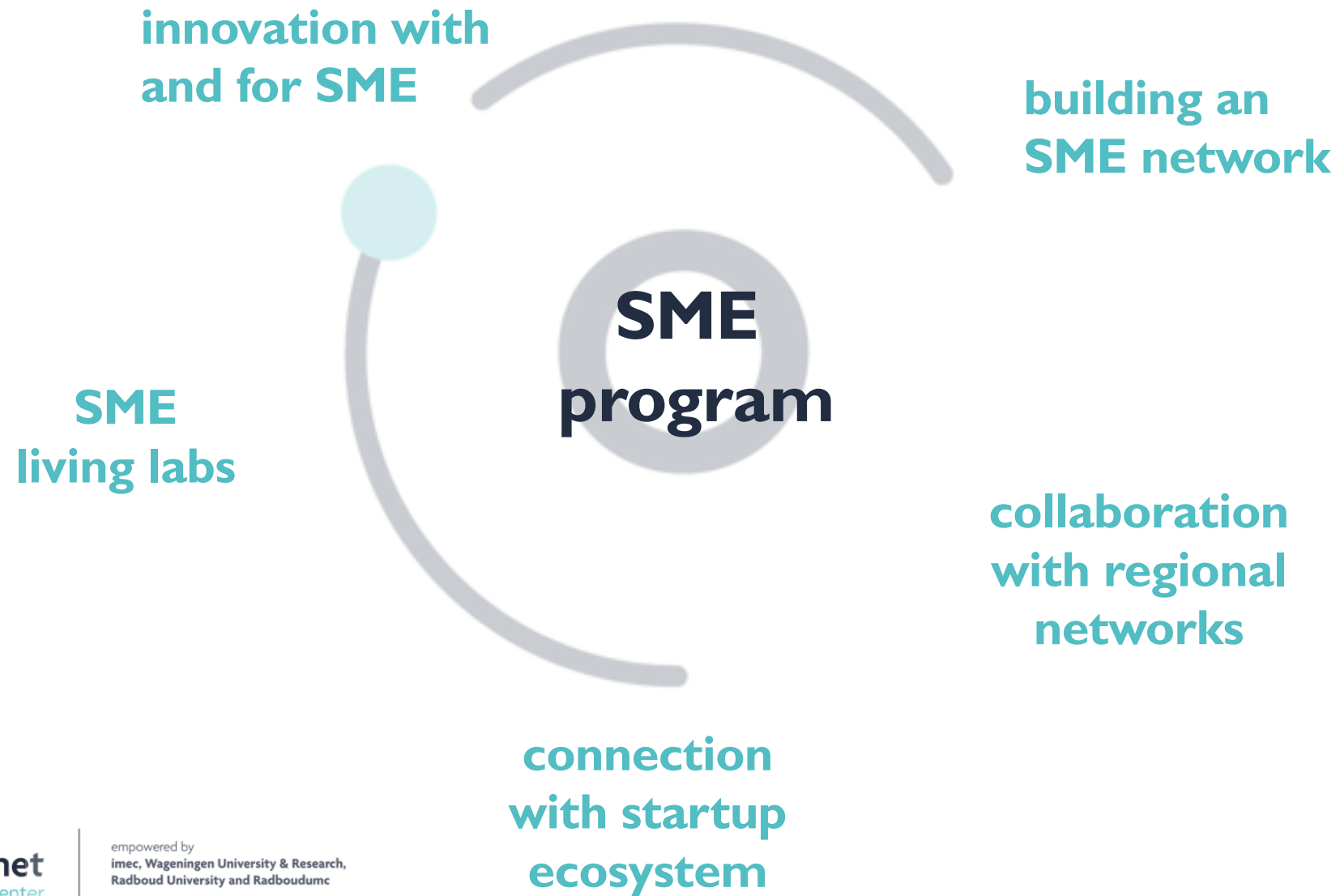
UNSUPERVISED  
LEARNING



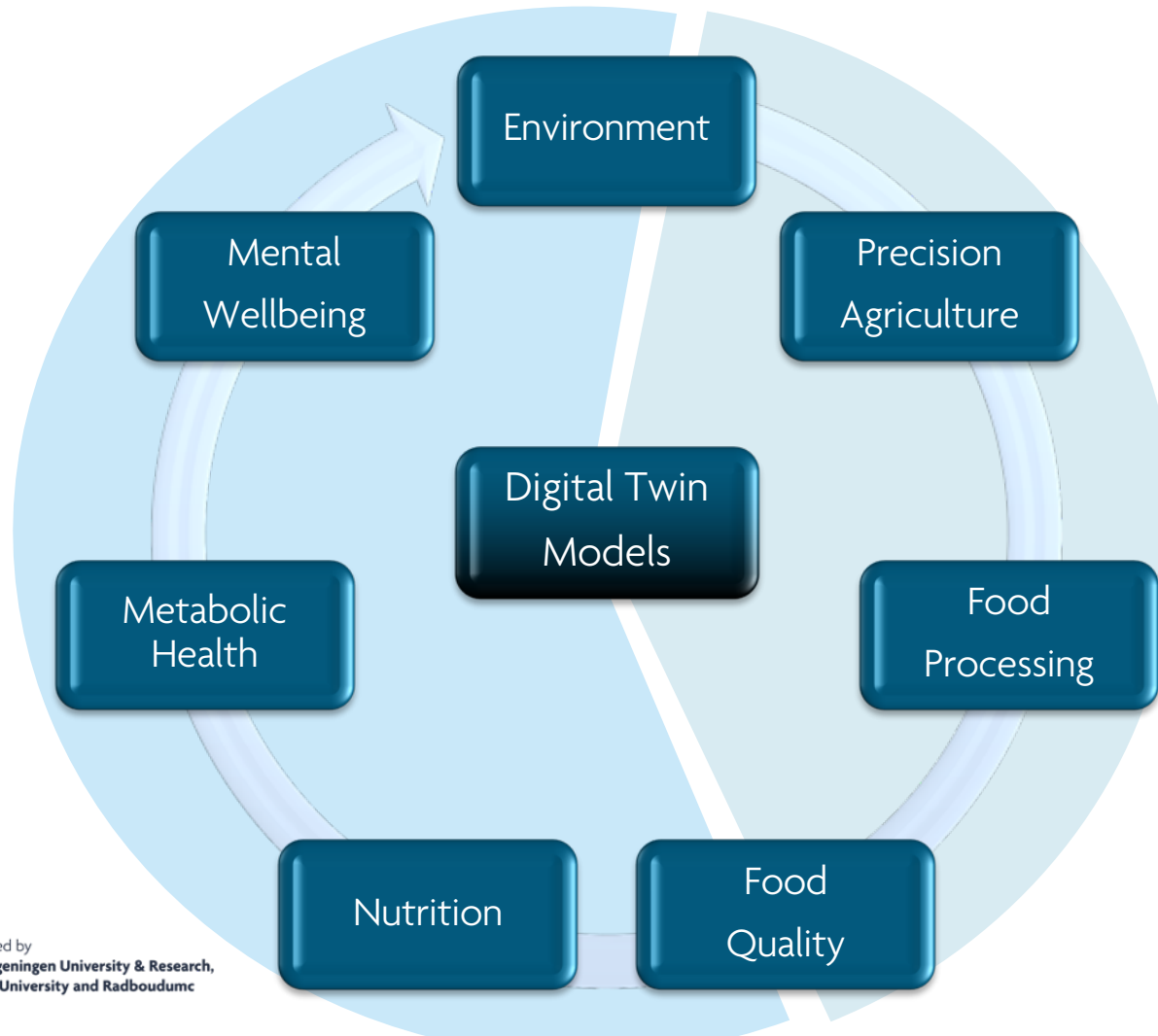
REINFORCEMENT  
LEARNING

# ONEPLANET HUMAN DIGITAL TWIN





# ONEPLANET INNOVATION THEMES







## **Stichting OnePlanet Food & Health**

mogelijk gemaakt met de steun van:

≡ provincie  
Gelderland

# THANK YOU



empowered by  
imec, Wageningen University & Research,  
Radboud University and Radboudumc

[www.oneplanetresearch.com](http://www.oneplanetresearch.com)