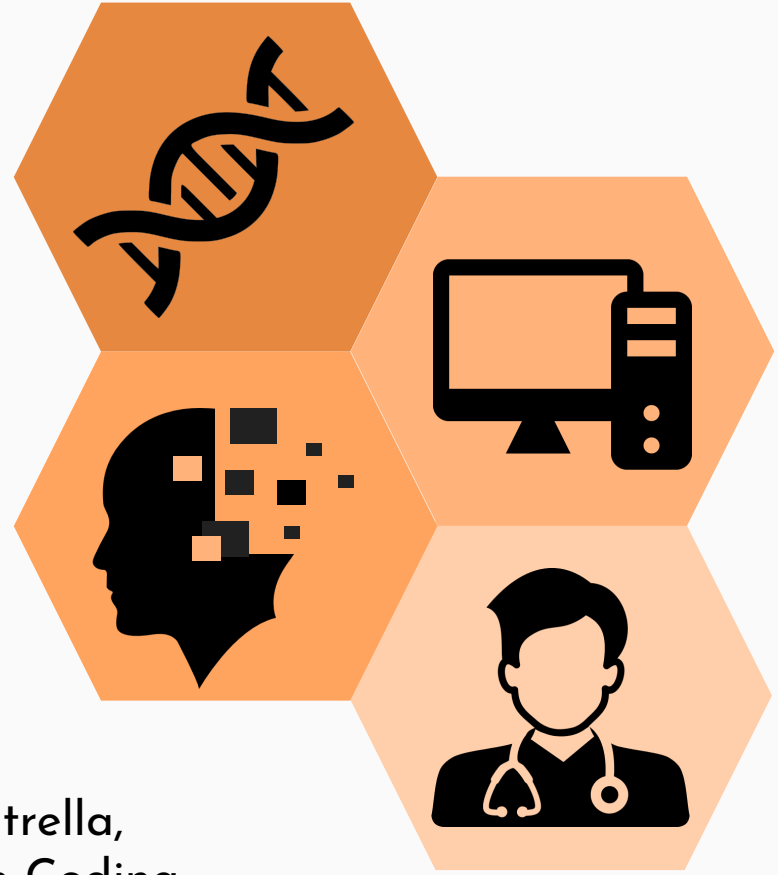
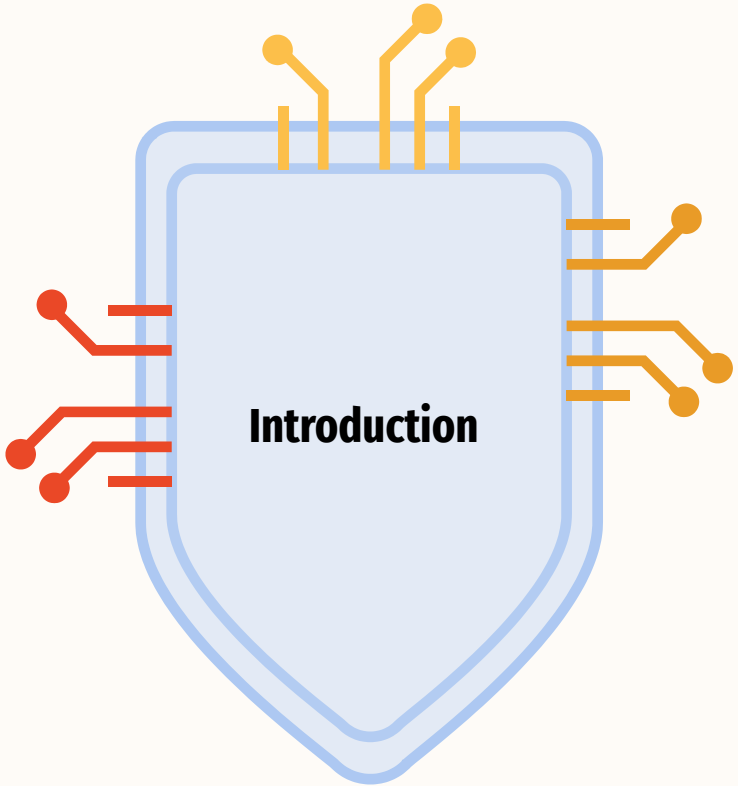
A NEW TECHNOLOGY IN MEDICINE

DIGITAL TWINS



Group 7
Gisela de Miguel Garcia, Olivia Dove Estrella,
Oriol Gómez Lores and Roger Parramon Codina

INDEX


Introduction

INTRODUCTION AND DEFINITION

DEFINITION:

- Digital replica of physical **object, process or service.**
- Pairs physical and digital worlds using modern technologies.
- Their goal is test and optimize physical objects virtually.

A LITTLE BIT OF CONTEXT

Dr. David Hillel Gelernter
1990s

Dr. Michael Grieves
2002

2010

DIGITAL TWINS IN A MEDICINE CONTEXT

The 3 components of a digital twin:

- The physical product in the physical space.
- The digital representation of the physical product in the virtual environment.
- Connection between the two of them.

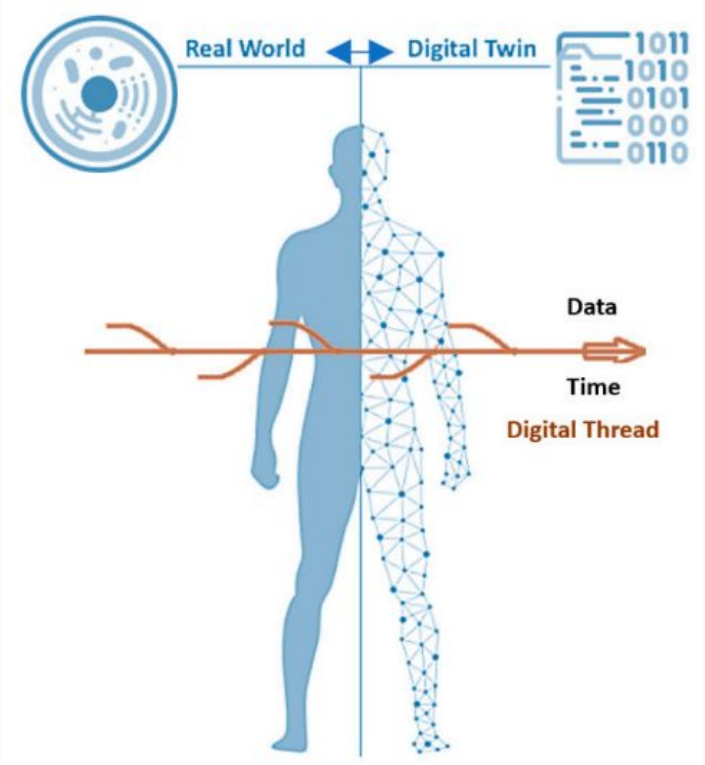


Figure 1. Composition of a digital twin. **Ref:** Kamel Boulos, M. N., & Zhang, P. (2021)

DIGITAL TWINS IN A MEDICINE CONTEXT

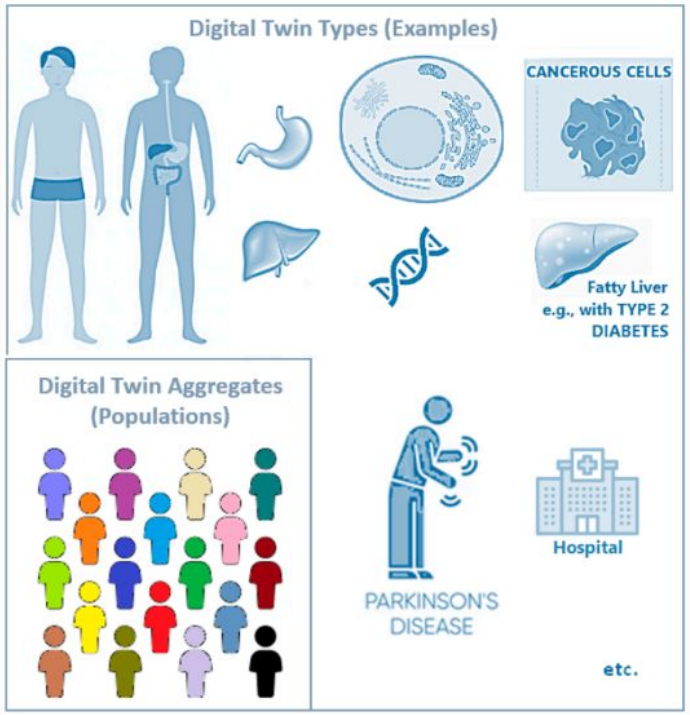


Figure 2. Some examples of different types of human digital twins. **Ref:** Kamel Boulos, M. N., & Zhang, P. (2021)

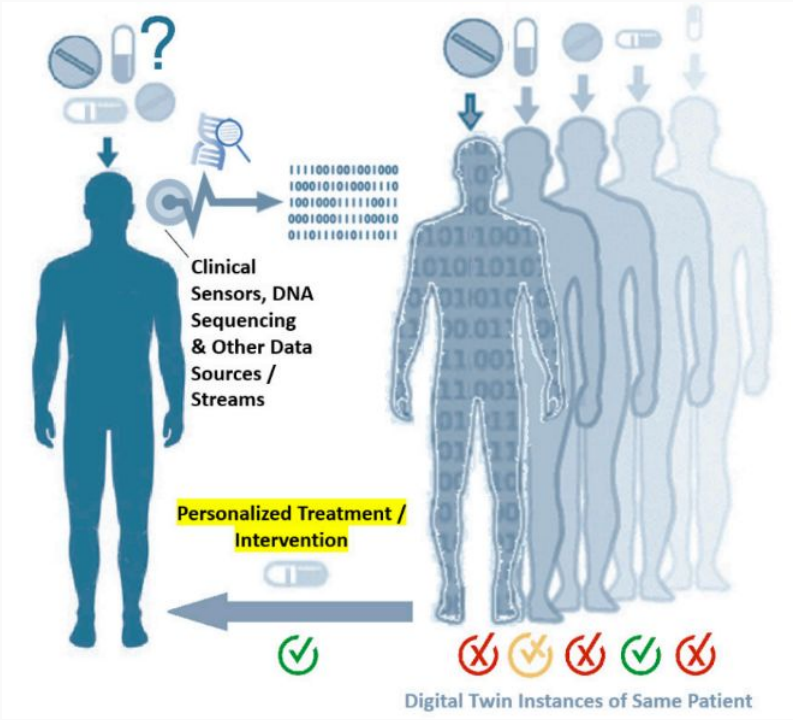


Figure 3. Summary image of the usability of digital twins in medicine. **Ref:** Kamel Boulos, M. N., & Zhang, P. (2021)

DIGITAL TWINS IN A MEDICINE CONTEXT

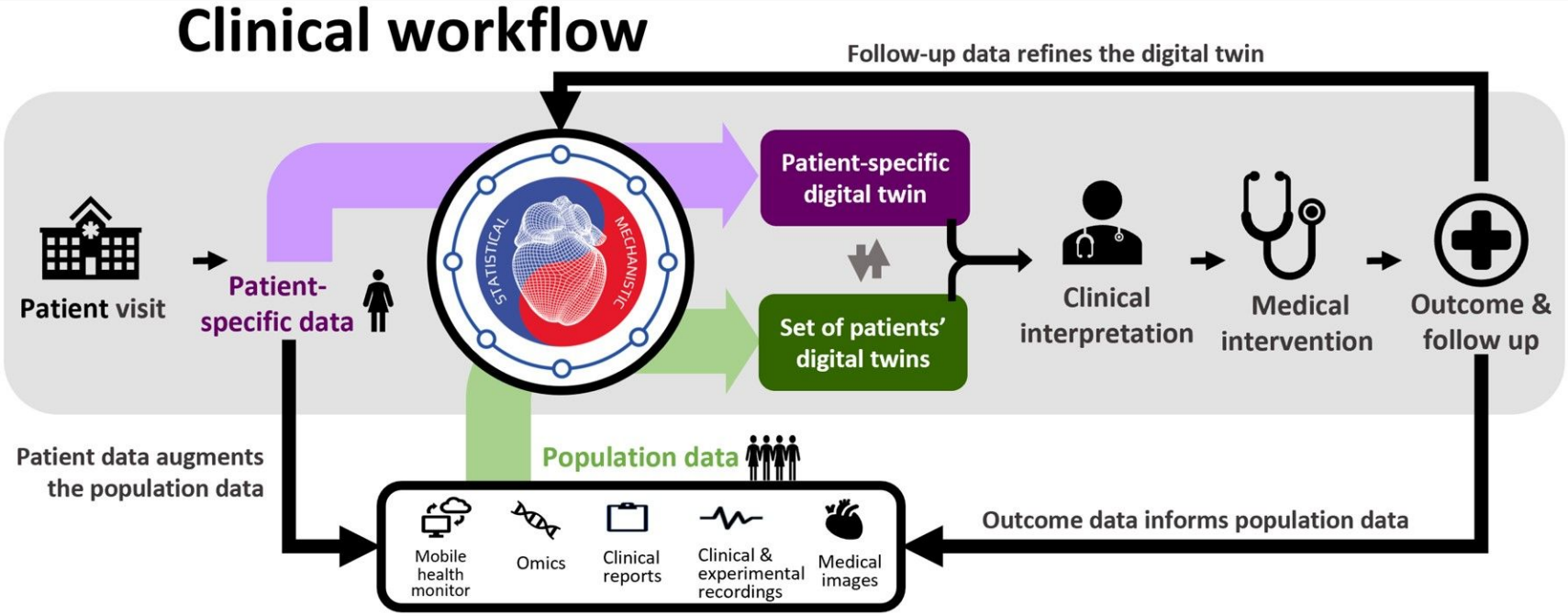
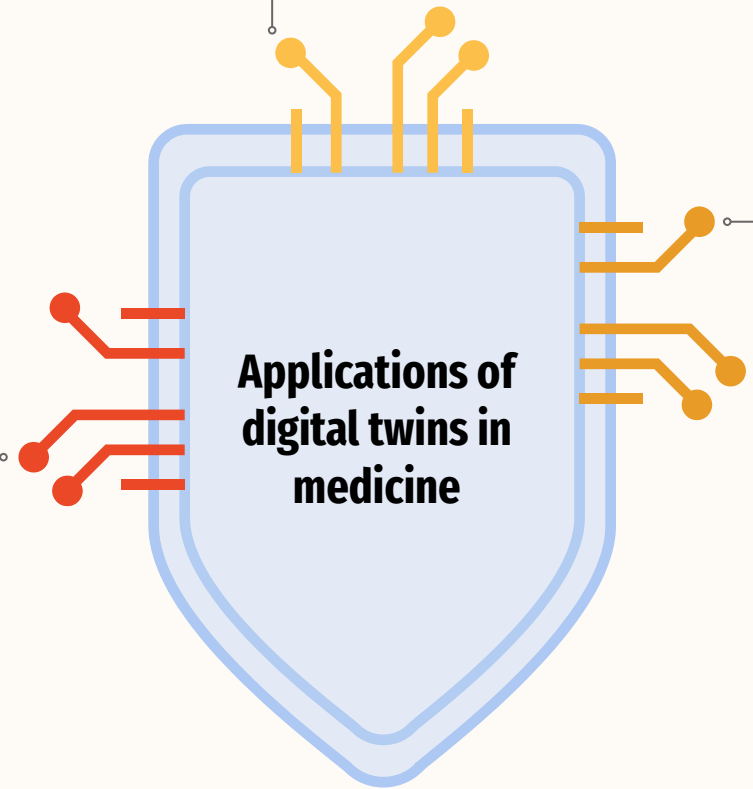


Figure 4. Envisioned clinical workflow using the fully developed digital twin concept. **Ref:** Corral-Acero, J., Margara, F., Marciniak, M., Rodero, C., Loncaric, F., Feng, Y., Gilbert, A., Fernandes, J. F., Bukhari, H. A., Wajdan, A., Martinez, M. V., Santos, M. S., Shamohammdi, M., Luo, H., Westphal, P., Leeson, P., DiAchille, P., Gurev, V., Mayr, M., Geris, L., ... Lamata, P. (2020)



01

Personalized medicine

02

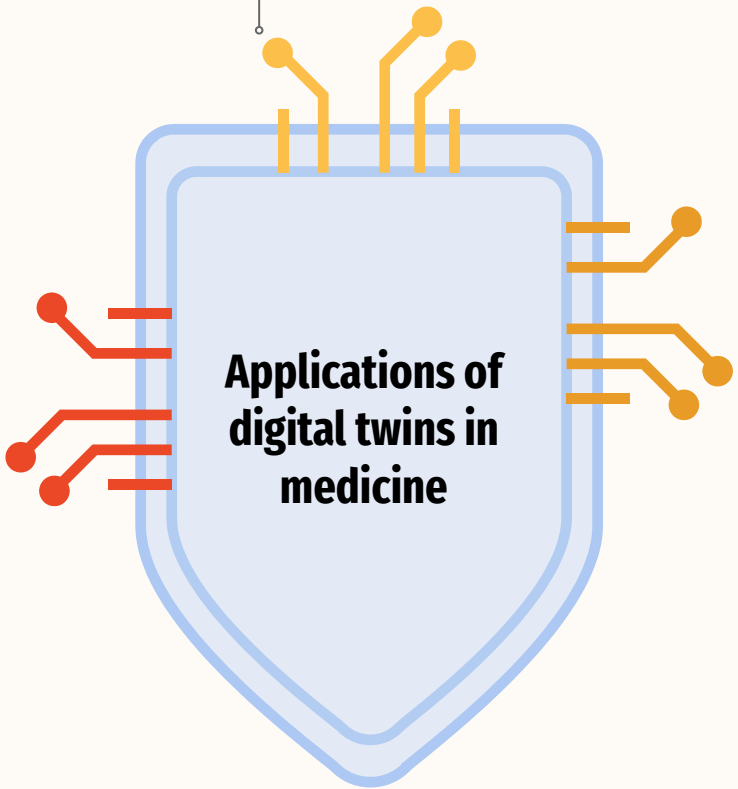
Improving healthcare organisations

03

Drug and medical device development

01

Personalized medicine



WHY IS PERSONALIZED MEDICINE NECESSARY?

INEFFECTIVENESS

40 - 70% patients **do not respond well to treatment.**

BIOMARKERS

Most illnesses are complex, which means, **a lot of biomarkers** should exist. One a few are analysed.

OMICS

The 'omics' sciences are extremely useful tools which could help choosing the **most effective drugs**.

WHAT ROLE DO VIRTUAL TWINS PLAY HERE?

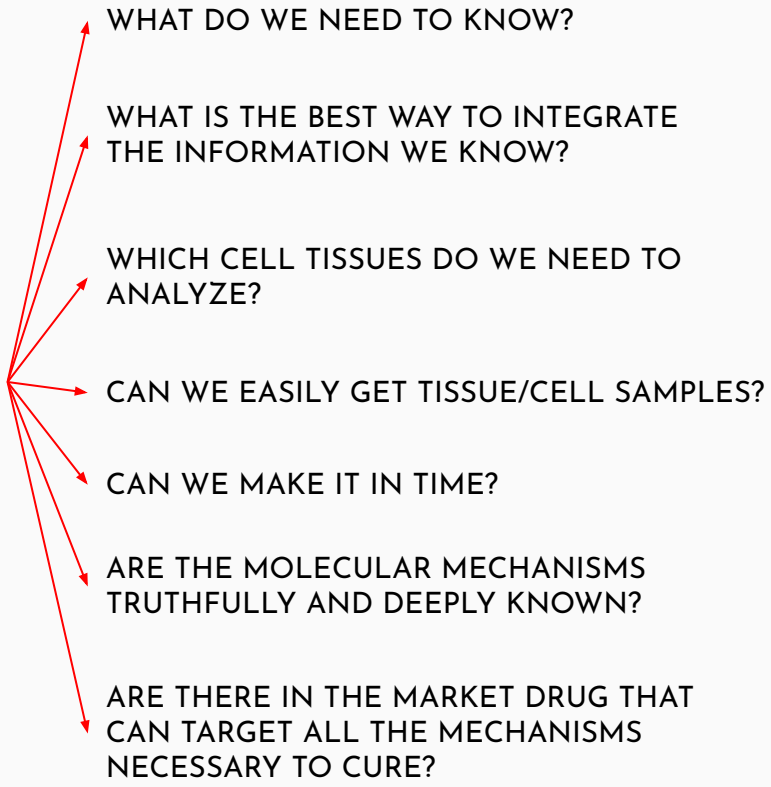
1. Recreate a **virtual phenotype**.
2. **Test** tons of drugs.
3. **Benefits** both the patient and hospitals.

↓

SDTC

1. **Digital Twin Creation.**
2. **Test drugs.**
3. **Actual treatment.**

INCONVENIENCES



CREATION OF DIGITAL TWINS (I)

- **Systems biology** tools are indispensable.
- **Network tools** like PPI are used in complex biological systems.
- Genes can be mapped over proteins, creating **modules**.

NODES

MULTI-LAYER MODULES

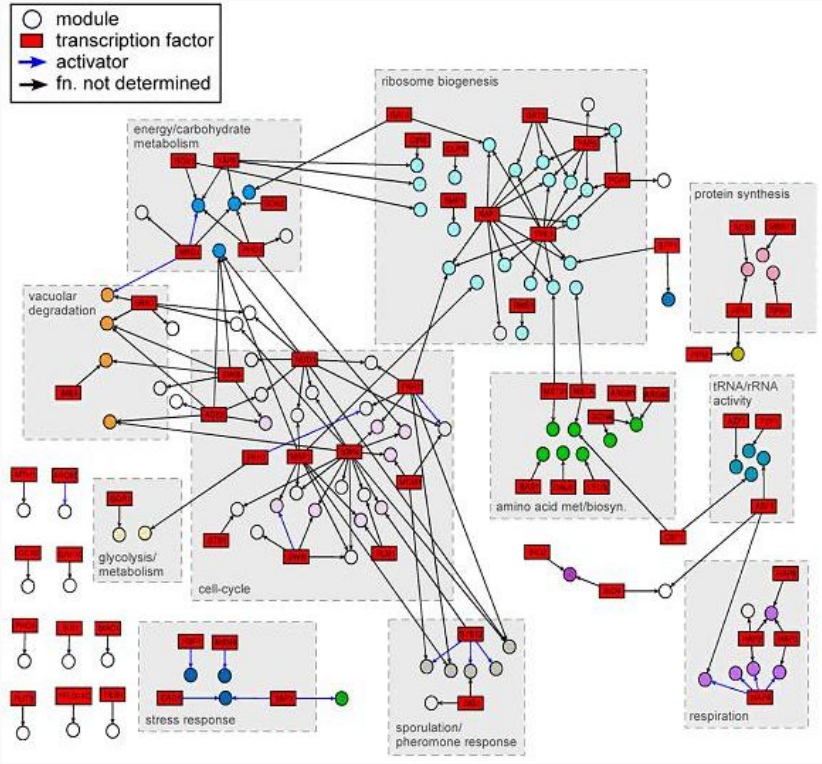


Figure 5. Example of a systems biology web. **Ref:** http://sb.cs.cmu.edu/Research/ (2012)

CREATION OF DIGITAL TWINS (II)

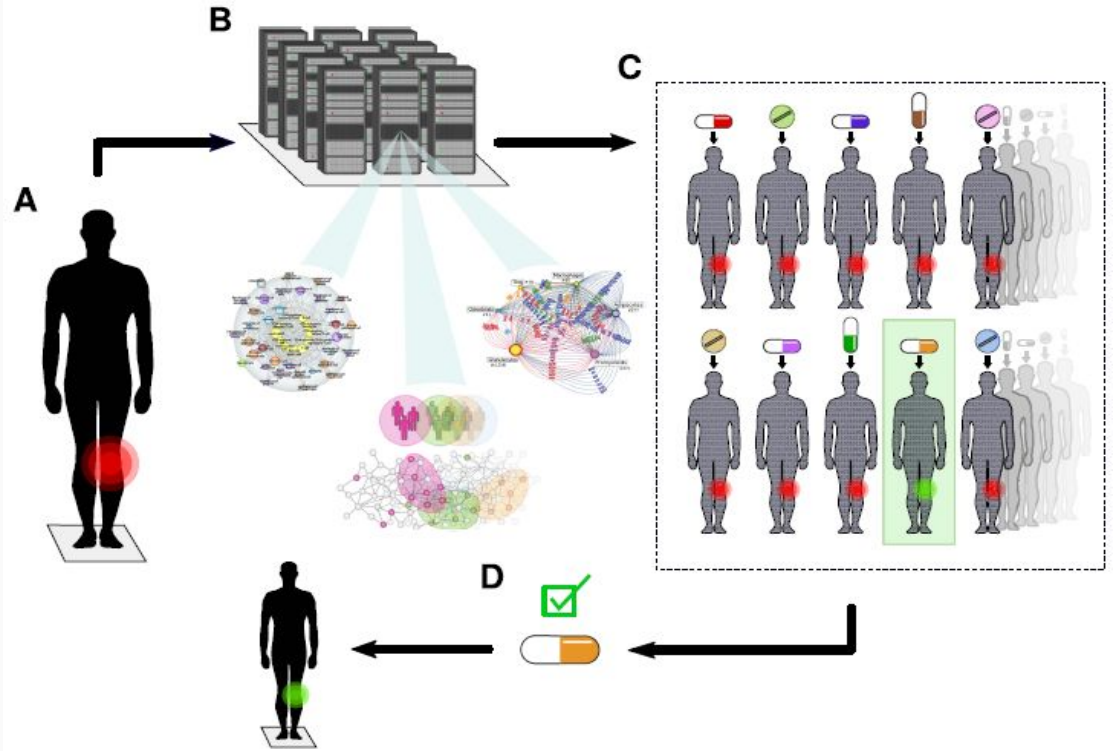


Figure 6. Scheme which would be used for digital twins personalized medicine. **Ref**: Björnsson, B., Borrebaeck, et al. (2019). BioMed Central Ltd. https://doi.org/10.1186/s13073-019-0701-3

HOW TO EXPAND DIGITAL TWINS?

MORE FIELDS OF INFORMATION

- Rather than just molecular traits.
- **Environmental factors.**
- **Symptoms.**

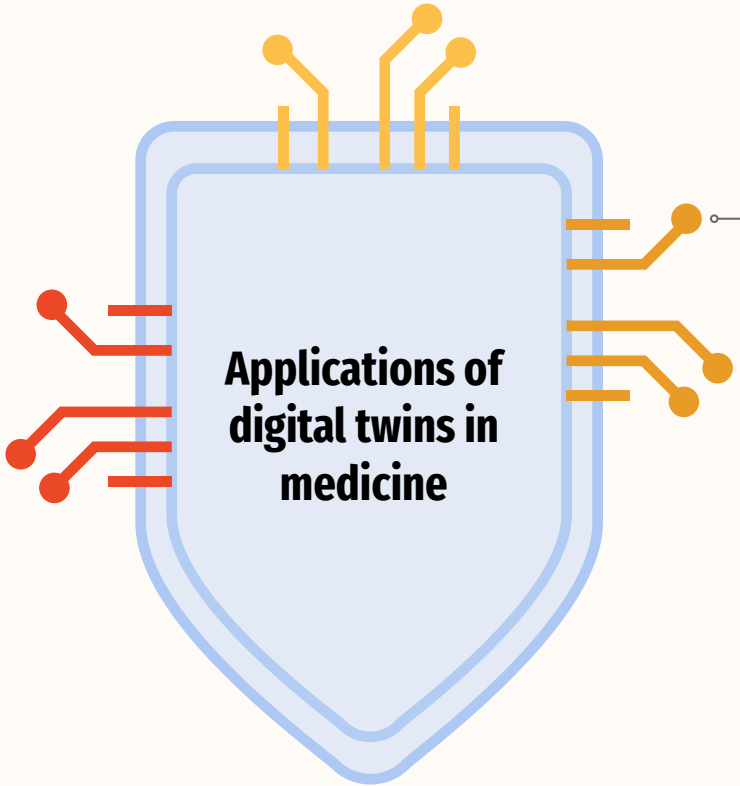
DIRECTING TREATMENTS TO OTHER TARGETS

- Sometimes the causal tissues are **not associated with symptoms**.
- Many illnesses like cancer do not show symptoms until **advanced development**.

DYNAMISM OF NETWORKS

- **Machine learning.**
- **Deep learning.**
- **Artificial intelligence.**

DIGITAL TWIN OPTIMIZATION



02

Improving healthcare organisations

HEALTHCARE ORGANIZATIONS

CLINICIANS

Increased accuracy
Rejecting/Validating treatment

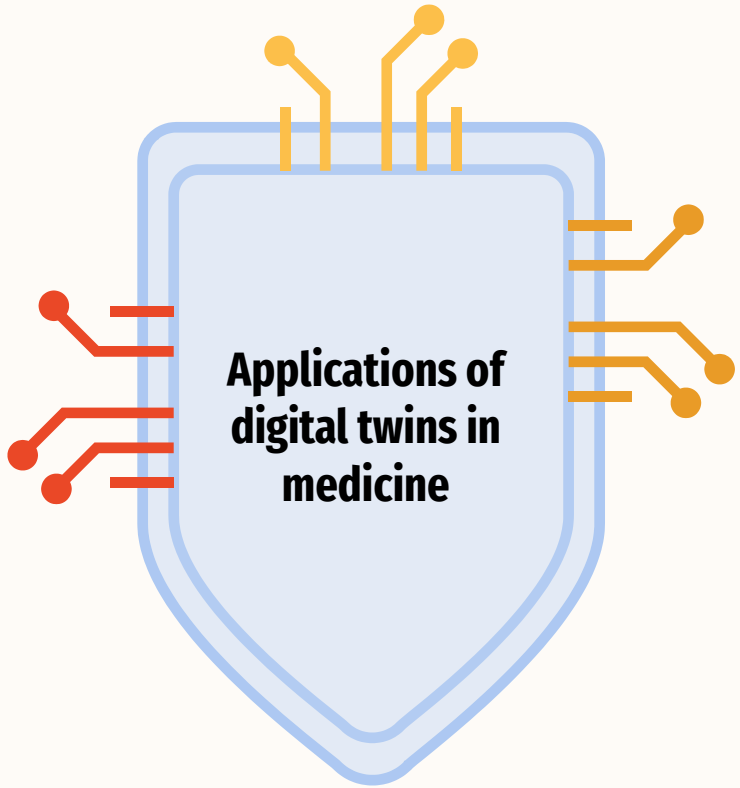
COVID-19 situation
Reducing infection risk

PATIENTS

Higher involvement
Rejecting/Validating treatment

Better feedback

Intuitive app interface
Clear data visualization, simple language



03

Drug and medical device development

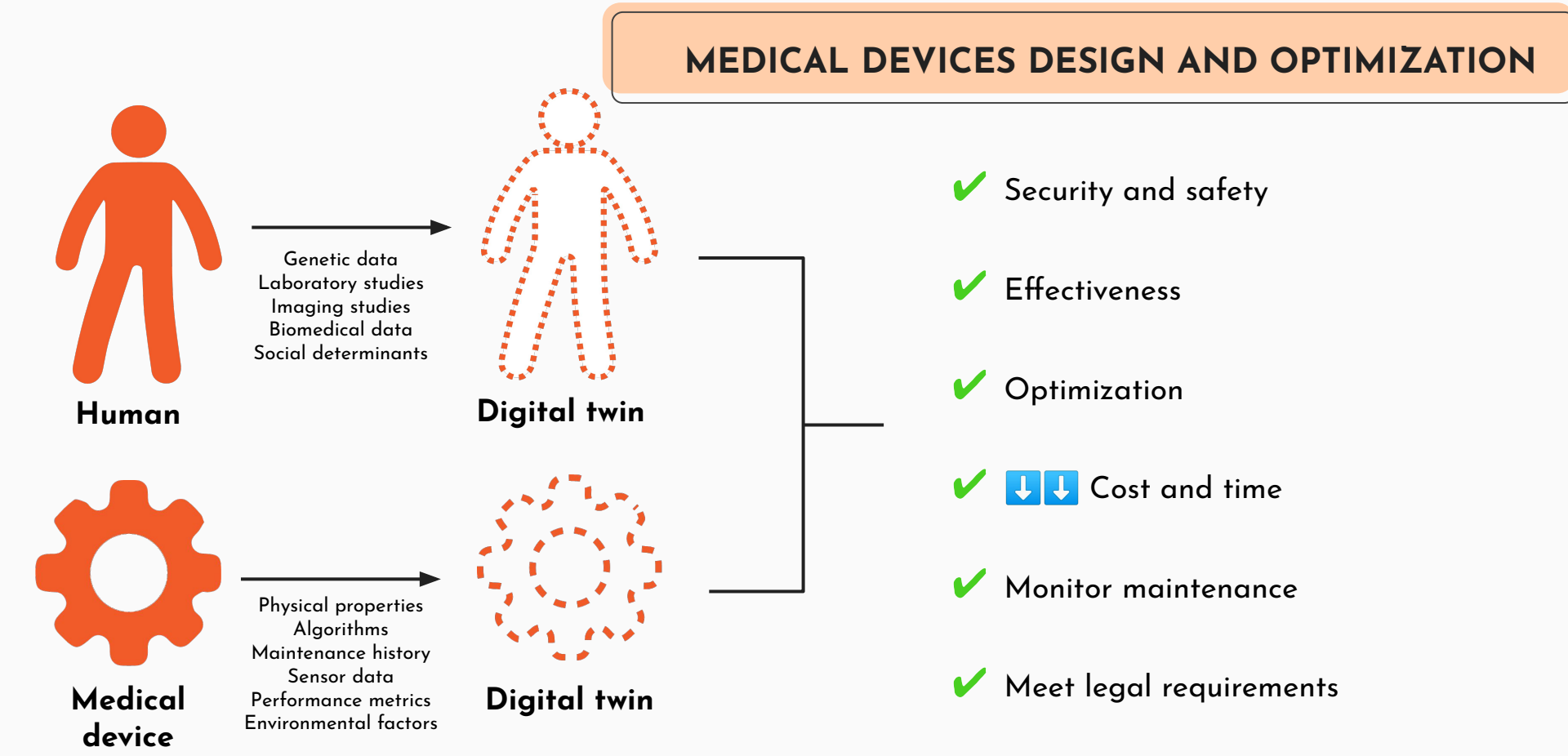


Figure 7. Digital twins in medical devices design and optimization. **Ref:** Adapted from (Kesari 2021)

DRUG DESIGN AND OPTIMIZATION

Drug design is extremely **research-intensive**, **long** and **expensive.**

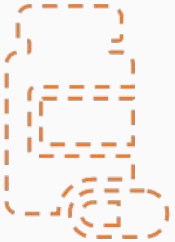
- ✖ 50,000 chemical compounds are tested
- ✖ Only 1 in 12 drugs arrive successfully to the market
- ✖ Drug failures due to toxicity and efficiency

DRUG DESIGN AND OPTIMIZATION

Cohort of humans with shared symptoms

Digital twin

Novel drug

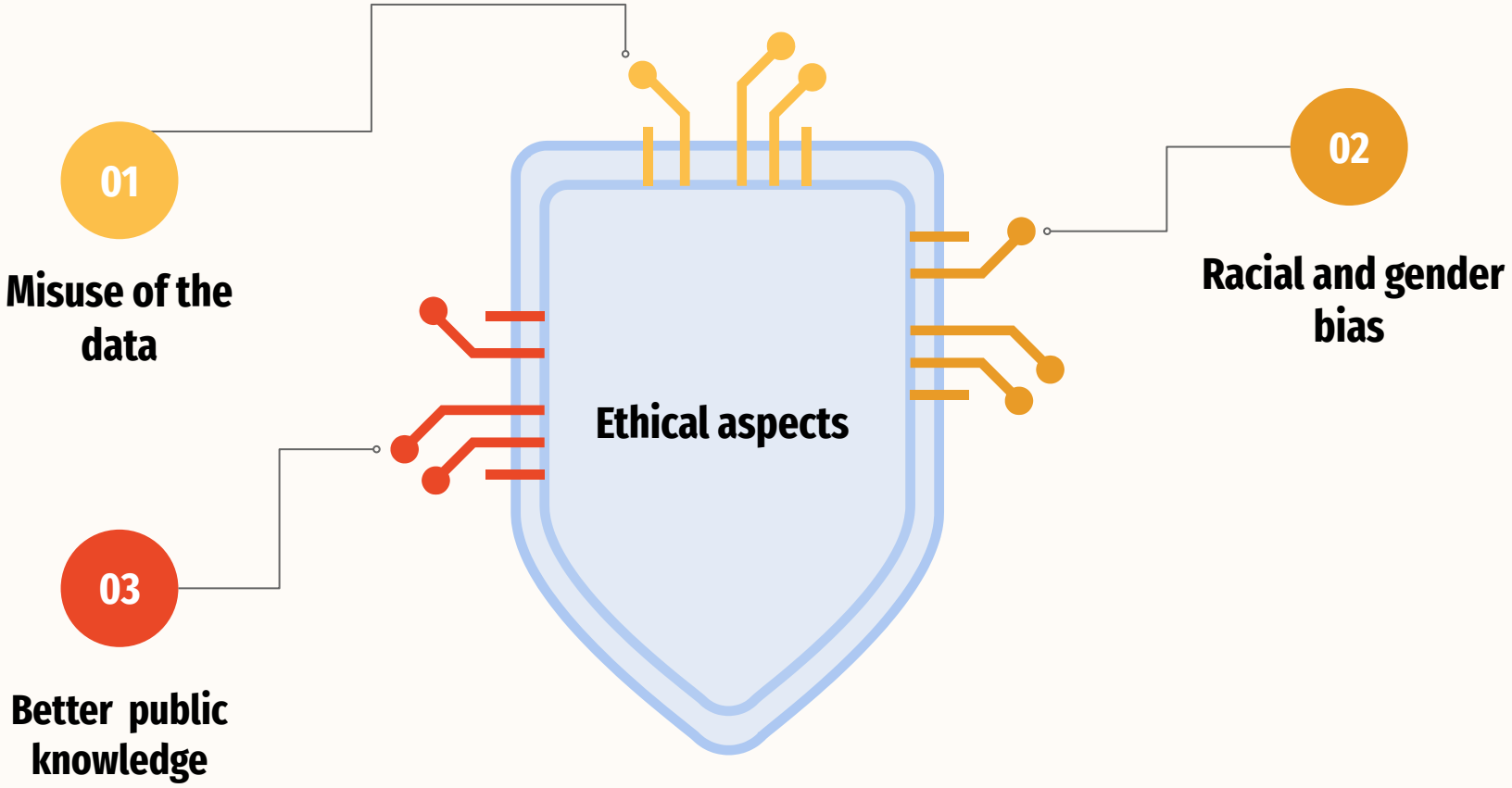


Digital twin

- ✔ Predict the best novel candidate
- ✔ Effectiveness
- ✔ Optimization
- ✔ ⬇️⬇️ Cost and time
- ✔ Optimal dosage
- ✔ Indications
- ✔ Conivence

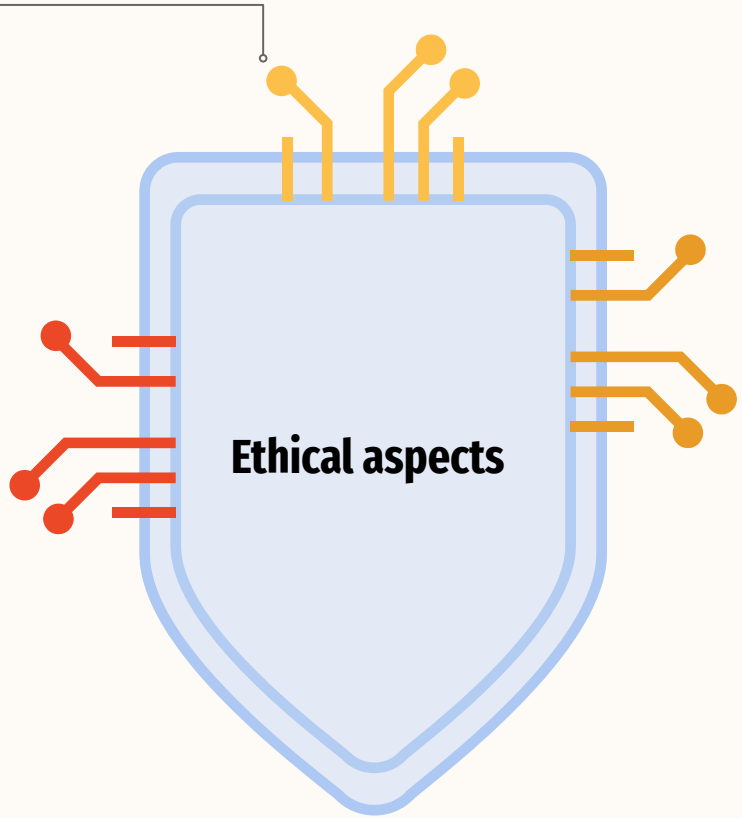
CLINICAL TRIALS

✖ Not an accurate representation of the real world	✔ Coverage
✖ Problems recruiting the patients on time	✔ Speed
✖ Not every patient is treated by a trial's new drug (placebo)	✔ Predictability
✖ Safety issues	✔ Safety

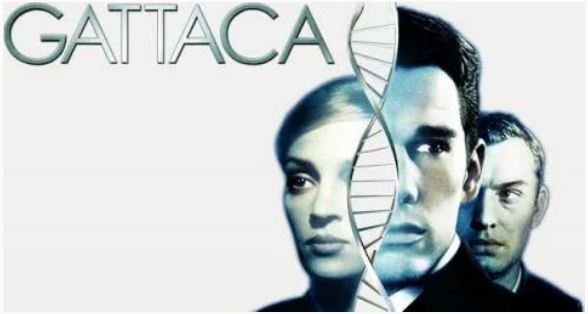

01
Misuse of the data
02
Racial and gender bias
Ethical aspects
03
Better public knowledge

01

Misuse of the data



MISUSE OF THE DATA



- Possibility of abuse by external entities
- Using data against the patients' best interests
- Twisting the intended use of a digital twin
- Root of most of the ethical conflicts

❌ Don'ts

Denying job offers

Raising insurance prices

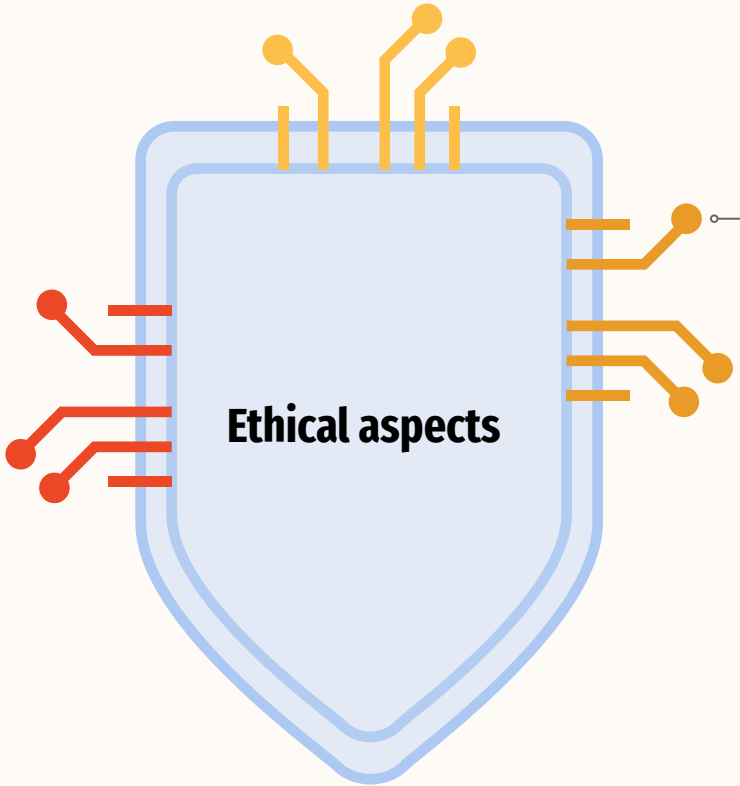
MISUSE OF THE DATA

✔ Do's

- Ownership of the data
- Explicit informed consent
- Anonymity of public data
- Strong legal support

HIMSS
transforming healthcare through IT

Xcertia™
mHealth App Guidelines

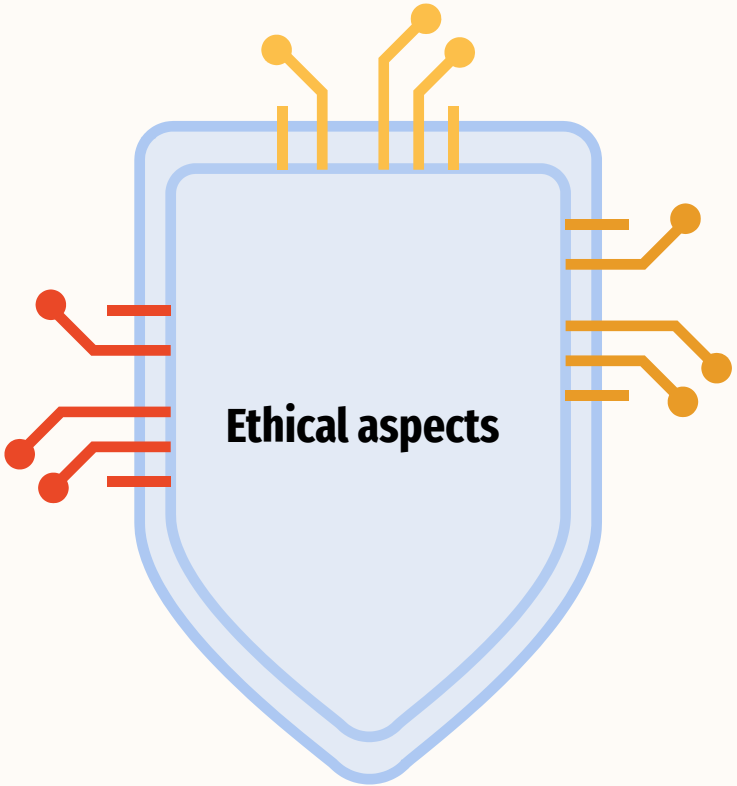


02

Racial and gender bias

RACIAL AND GENDER BIAS

- Perpetuating and intensifying historical bias
- Originated by biased datasets
- Identifying the origin of the bias

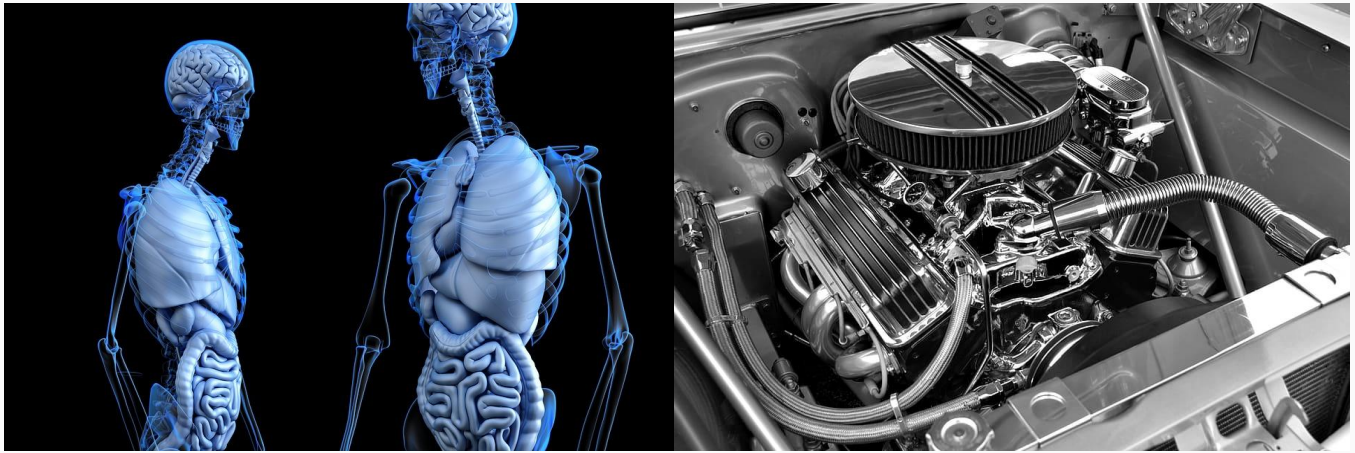


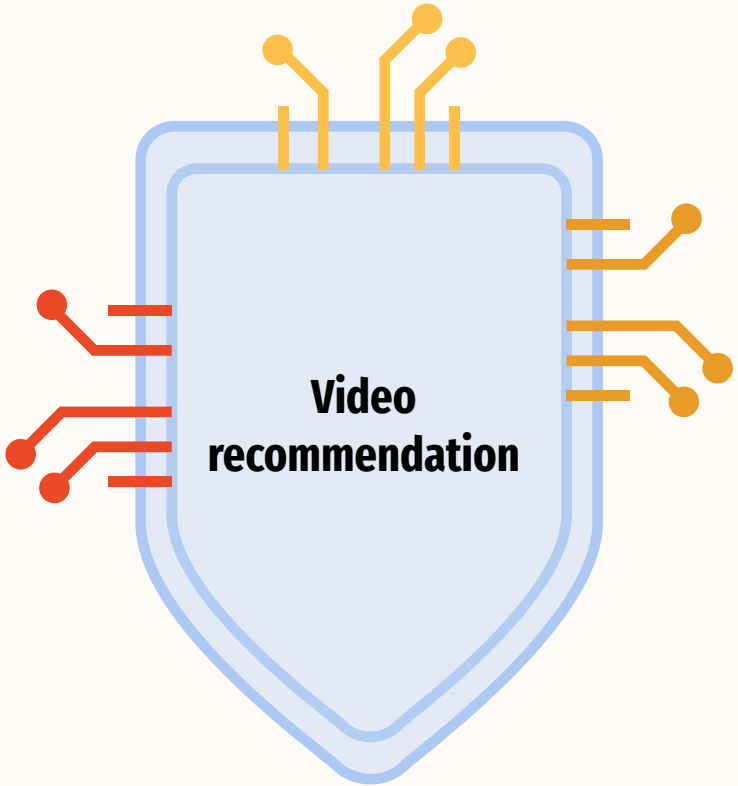
03

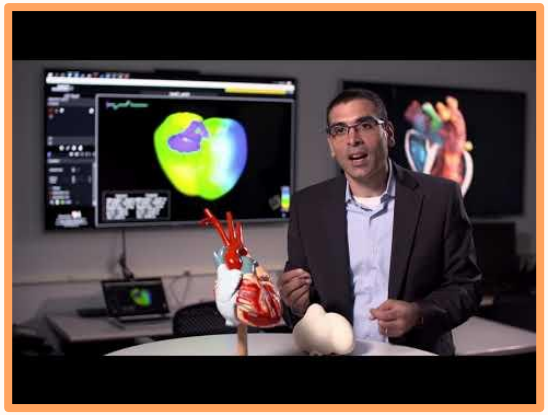
Better public knowledge

BETTER PUBLIC KNOWLEDGE

- Allowing patients to weight costs and benefits
- Potentially avoid paternalism




Video
recommendation



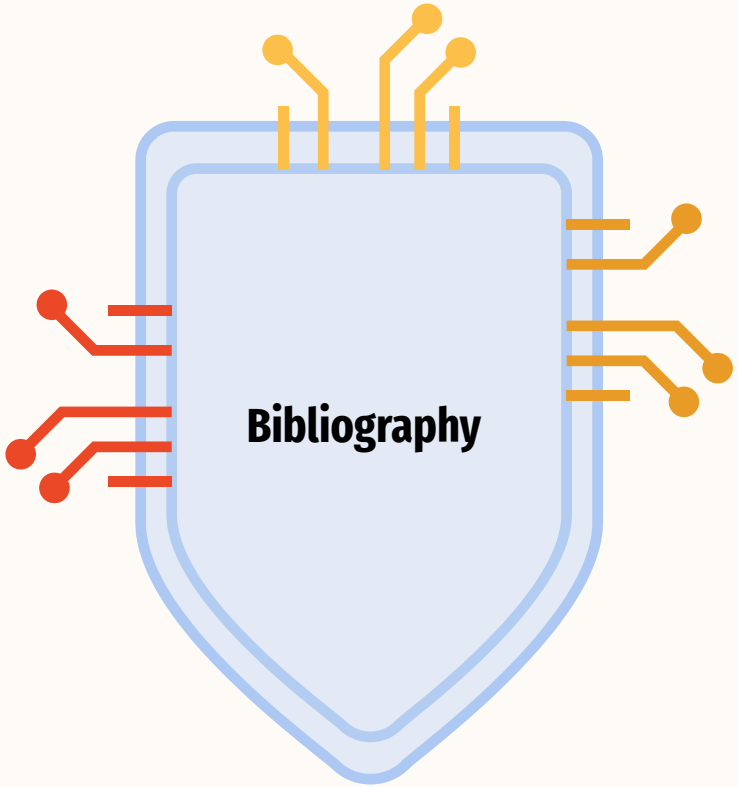
Developing a digital twin of the heart

Hope you enjoy them !

Will your digital twin make you healthier?

Digital twin for smart pharma

Mitigating Racial Disparities with Data Science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THANKS

DOES ANYONE HAVE ANY QUESTIONS?