The Promise of Digital Twin Technology for P4 Medicine

**Business Tampere and Tampere University**

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Insulin Pump Therapy

Like a healthy pancreas, insulin pumps deliver one type of insulin. Using your personal pump settings, insulin is delivered continuously (basal) and in larger doses for meals (bolus).
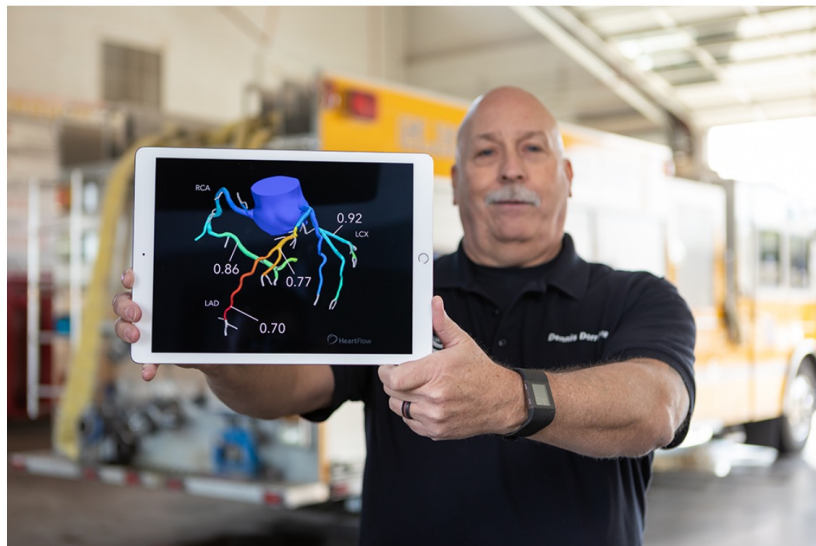
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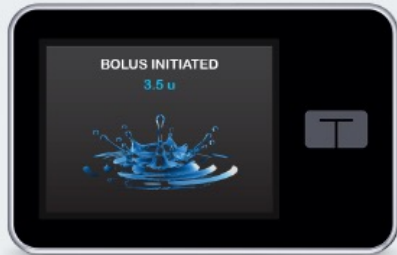
1 LARGE TOUCHSCREEN
Insulin delivery is personalized using a simple pump touchscreen.

2 TUBING
Insulin flows through thin, flexible tubing (variety of lengths available).

3 INFUSION SET
The tubing leads to an adhesive patch and fine tube under the skin.

BENEFITS OF PUMPING

Eviola
diagnosed
2012

Bringing together human ingenuity and advanced technology to help combat heart disease, the #1 cause of death.

HeartFlow's non-invasive personalized cardiac test provides unprecedented visualization of each patient's coronary arteries, enabling physicians to create more effective treatment plans for their patients.

RCA   0.92
LCX
0.86   0.77
LAD   0.70
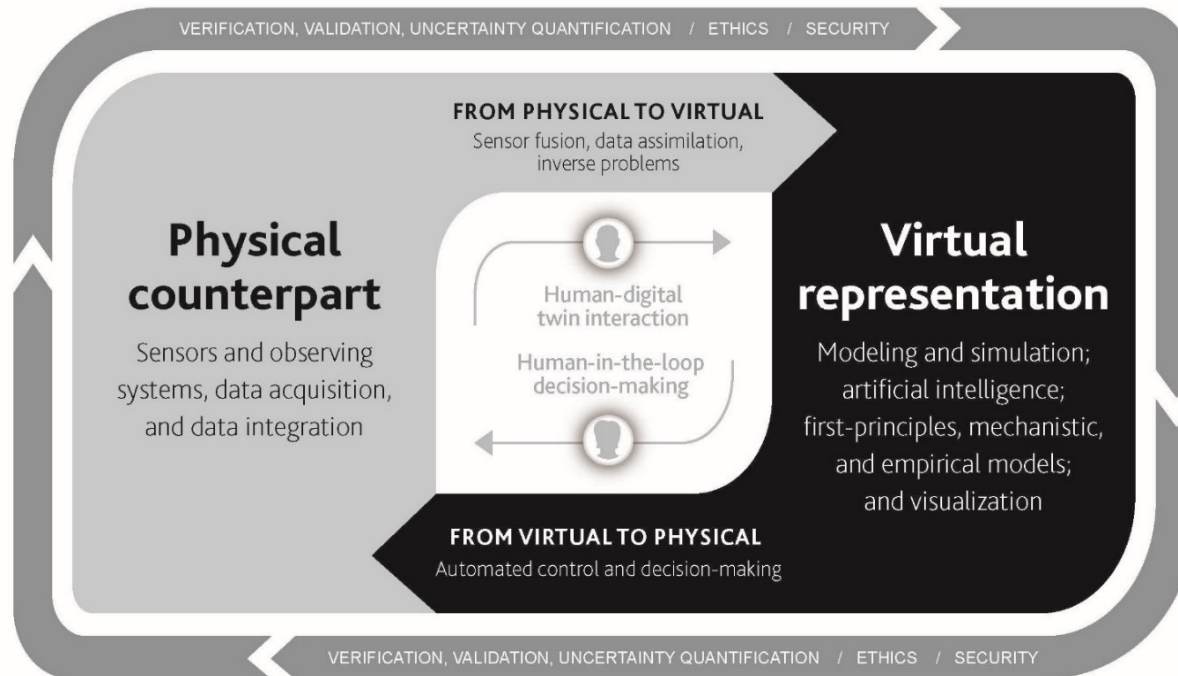
Digital Twins
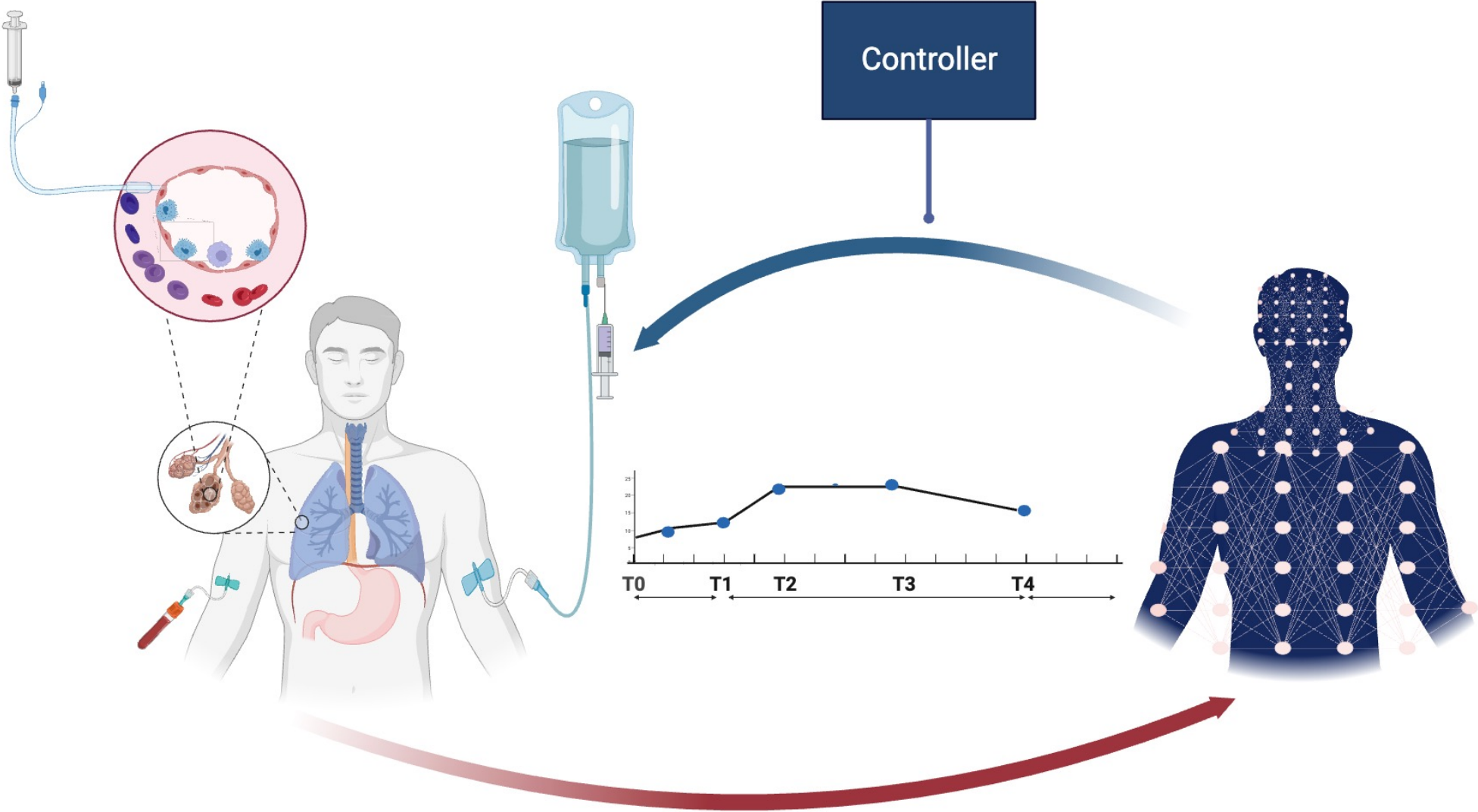

National Academies of Sciences, Engineering, and Medicine. 2023. *Foundational Research Gaps and Future Directions for Digital Twins*. https://doi.org/10.17226/26894
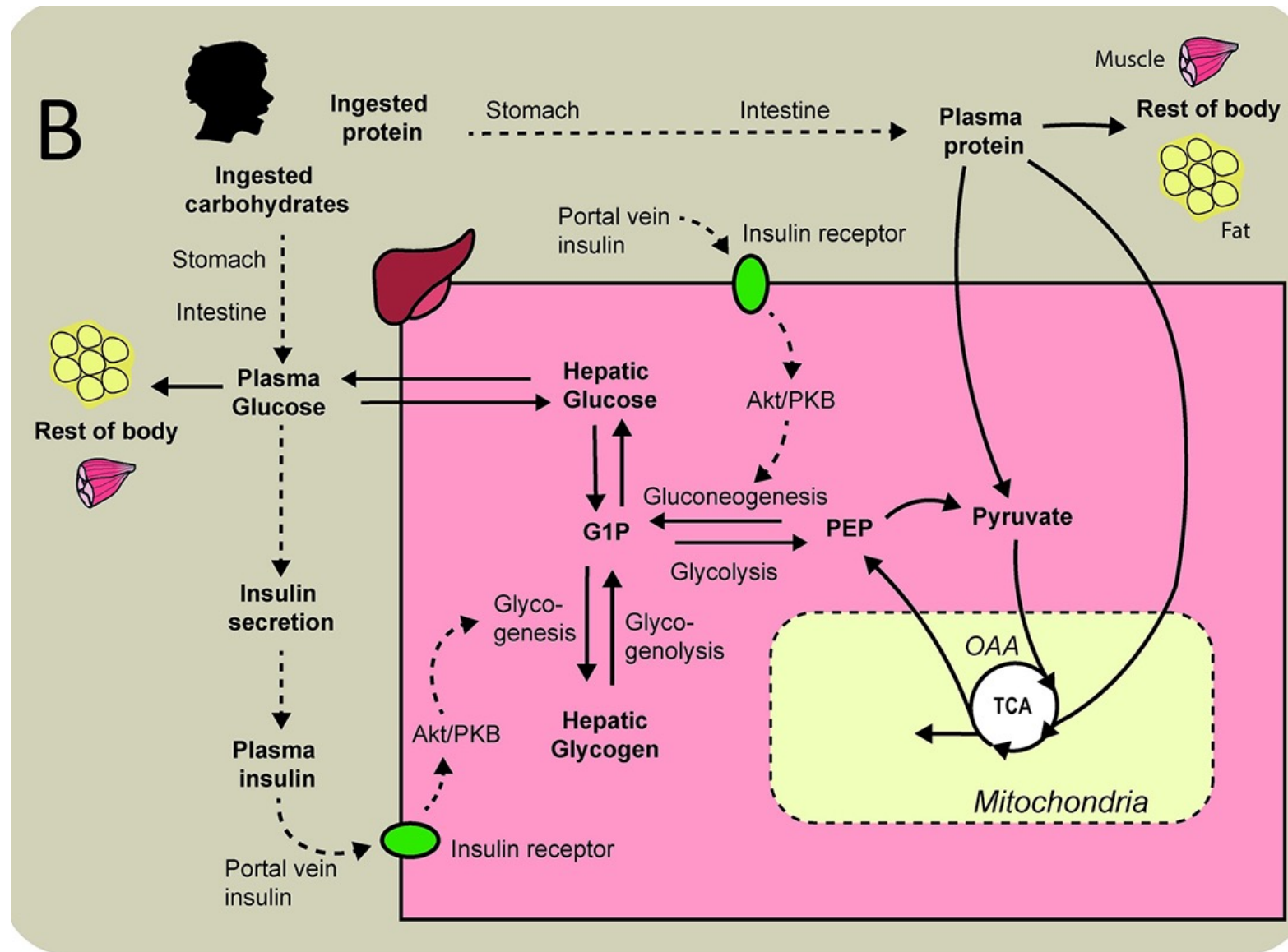
Precision Care

P4 Medicine and Digital Twins

- Explainability
- Intervenability
- Learnability
- Diversability

A perfectly imperfect engine: Utilizing the digital twin paradigm in pulmonary hypertension

Melody Walker[1] | Helen Moore[1] | Ali Ataya[1] | Ann Pham[1] | Paul A. Corris[2] | Reinhard Laubenbacher[1] | Andrew J. Bryant[1]

Digital twins in medicine

R. Laubenbacher[1] ✉, B. Mehrad[1], I. Shmulevich[2] & N. Trayanova[3]

A modular computational framework for medical digital twins

J. Masison[a], J. Beezley[b], Y. Mei[c], HAL Ribeiro[d], A. C. Knapp[d], L. Sordo Vieira[d], B. Adhikari[a], Y. Scindia[d], M. Grauer[b], B. Helba[b], W. Schroeder[b], B. Mehrad[d], and R. Laubenbacher[d,1]

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Check for updates

Building digital twins of the human immune system: toward a roadmap

R. Laubenbacher[1] ✉, A. Niarakis[2,3], T. Helikar[4], G. An[5], B. Shapiro[1], R. S. Malik-Sheriff[6], T. J. Sego[7], A. Knapp[1], P. Macklin[7] and J. A. Glazier[7]

Forum on immune digital twins: a meeting report

Check for updates

Reinhard Laubenbacher[1] ✉, Fred Adler[2], Gary An[3], Filippo Castiglione[4], Stephen Eubank[5], Luis L. Fonseca[1], James Glazier[6], Tomas Helikar[7], Marti Jett-Tilton[8], Denise Kirschner[9], Paul Macklin[6], Borna Mehrad[1], Beth Moore[9], Virginia Pasour[10], Ilya Shmulevich[11], Amber Smith[12], Isabel Voigt[13], Thomas E. Yankeelov[14,15] & Tjalf Ziemssen[13]

Toward mechanistic medical digital twins: some use cases in immunology

Reinhard Laubenbacher[1]*, Fred Adler[2], Gary An[3], Filippo Castiglione[4], Stephen Eubank[5], Luis L. Fonseca[1], James Glazier[6], Tomas Helikar[7], Marti Jett-Tilton[8], Denise Kirschner[9], Paul Macklin[6], Borna Mehrad[1], Beth Moore[9], Virginia Pasour[10], Ilya Shmulevich[11], Amber Smith[12], Isabel Voigt[13], Thomas E. Yankeelov[14,15,16] and Tjalf Ziemssen[13]

Perspective

Immune digital twins for complex human pathologies: applications, limitations, and challenges

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Anna Niarakis [1,2] ✉, Reinhard Laubenbacher [3], Gary An[4], Yaron Ilan [5], Jasmin Fisher[6], Åsmund Flobak[7,8,9], Kristin Reiche[10,11,12], María Rodríguez Martínez[13], Liesbet Geris [14,15,16], Luiz Ladeira[16], Lorenzo Veschini[17,18], Michael L. Blinov [19], Francesco Messina[20], Luis L. Fonseca [3], Sandra Ferreira[21], Arnau Montagud[22,23], Vincent Noël [24,25,26], Malvina Marku[27], Eirini Tsirvouli[7,28], Marcella M. Torres[29], Leonard A. Harris [30,31,32], T. J. Sego[3], Chase Cockrell [4], Amanda E. Shick[33], Hasan Balci[34], Albin Salazar[35], Kinza Rian[36], Ahmed Abdelmonem Hemedan [37], Marina Esteban-Medina[36], Bernard Staumont[16], Esteban Hernandez-Vargas[38], Shiny Martis B[39], Alejandro Madrid-Valiente[22], Panagiotis Karampelesis[40], Luis Sordo Vieira[3], Pradyumna Harlapur [41], Alexander Kulesza[39], Niloofar Nikaein[42,43], Winston Garira[44,45,46], Rahuman S. Malik Sheriff [47,48], Juilee Thakar [49], Van Du T. Tran [50], Jose Carbonell-Caballero[22], Soroush Safaei[51,52], Alfonso Valencia [22,53], Andrei Zinovyev[54] & James A. Glazier[18]

DT projects in the UF Laboratory for Systems Medicine

- A DT for pneumonia patients in the Intensive Care Unit
- A DT for precision nutrition for premature babies
- A DT for detection of early rejection of lung transplants
- A DT for optimal dosing of immunosuppressant drugs
  for liver transplant patients

Mechanisms versus AI
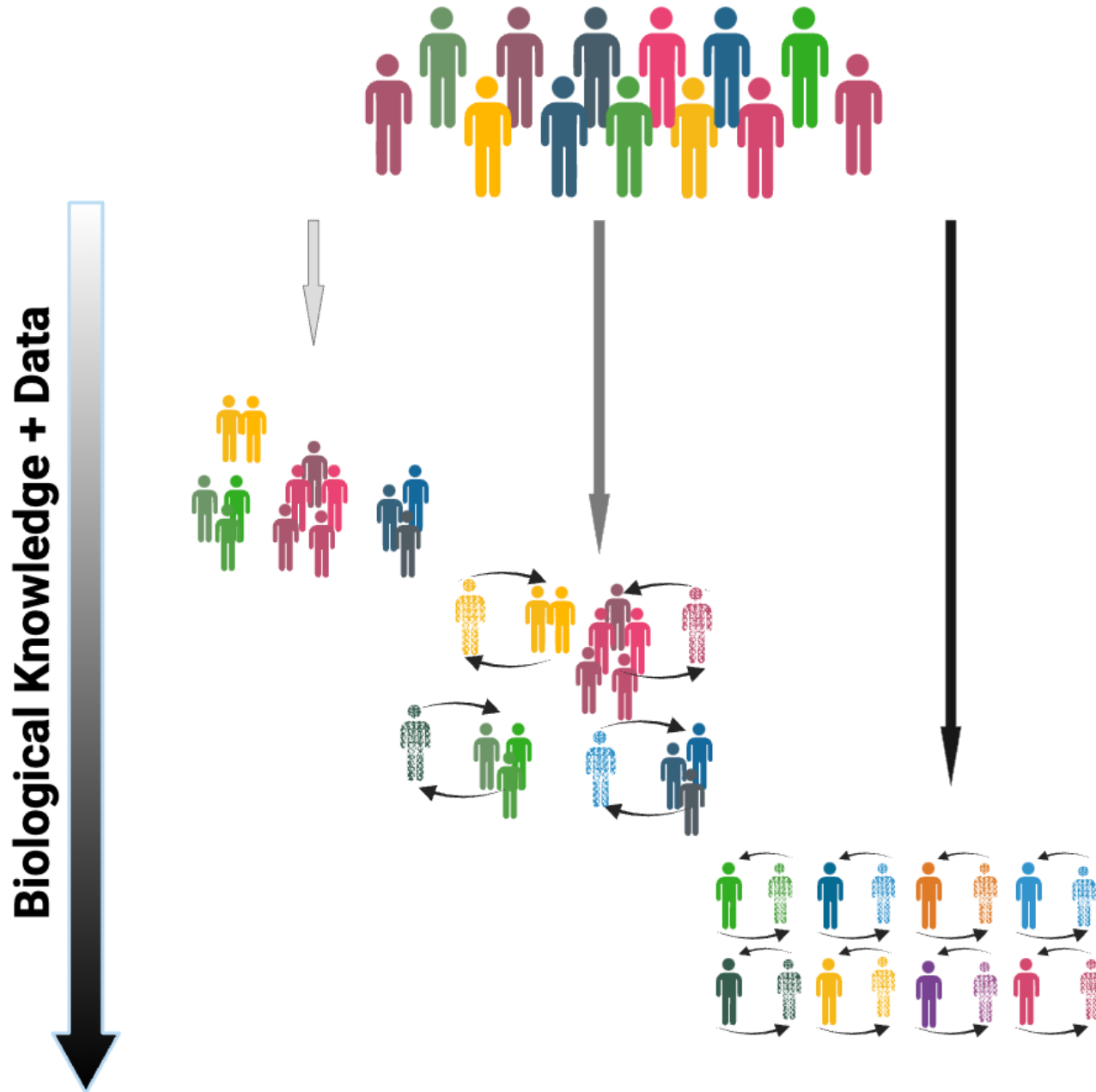
Challenges:
- Meld four cultures: mathematical sciences, biology, medicine, industry
- Develop novel sensor technology for noninvasive data collection
- Develop novel computational technology, data science techniques
- Solve ethical, legal, organizational challenges
- Create the basis for a DT industry based on standardization, interoperability
- Develop an international, multi-pronged funding strategy for DT development

https://www.wsj.com/articles/intensive-care-gets-friendlier-with-apps-devices-1426535128