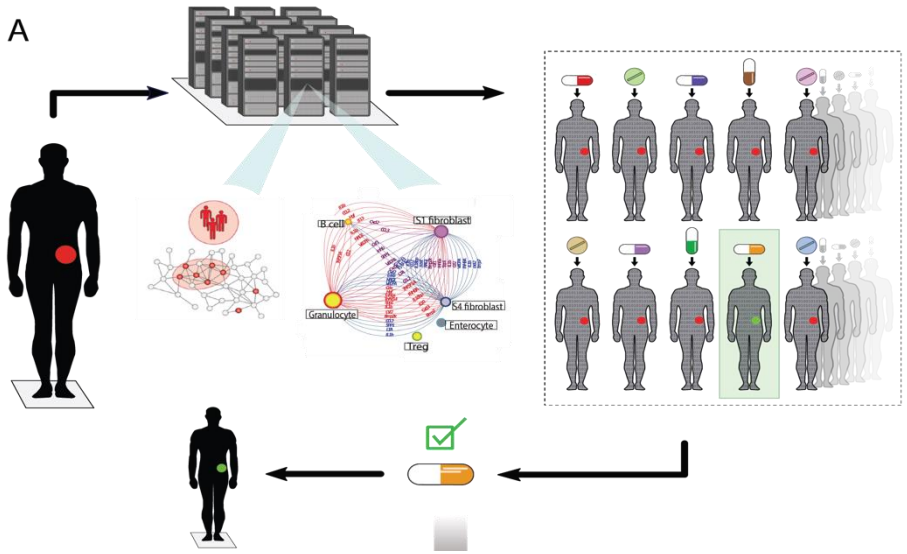
Dynamic digital twins for personalised early diagnostics and therapeutics

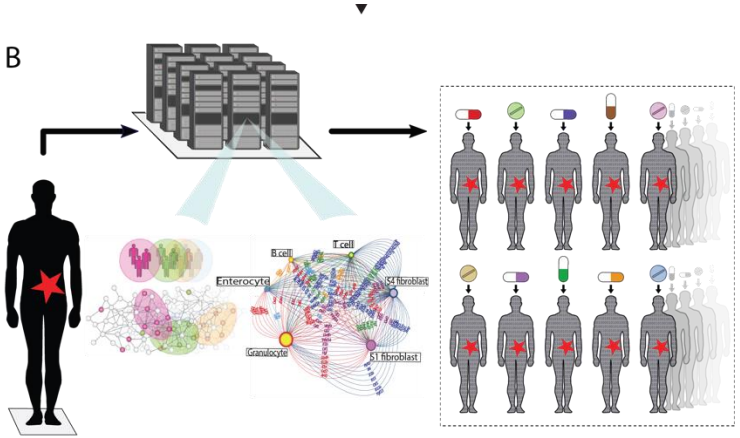
Mikael Benson

Digital Twins for personalised treatment



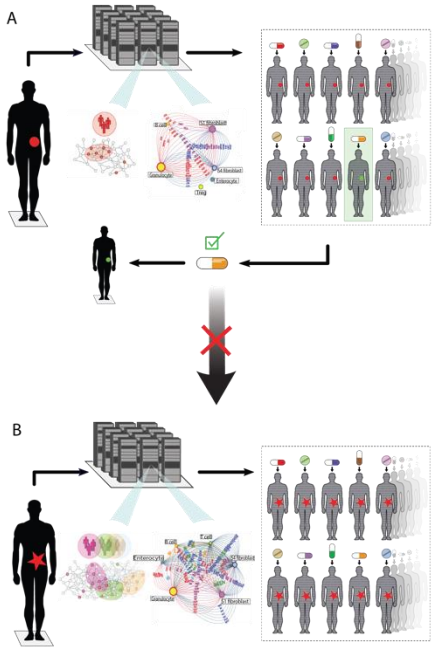
Björnsson et al Genome Med 2020

Digital Twins may not find any effective drugs in late disease stages



Björnsson et al Genome Med 2020

Dynamic Digital Twins for early personalised diagnostics and therapeutics



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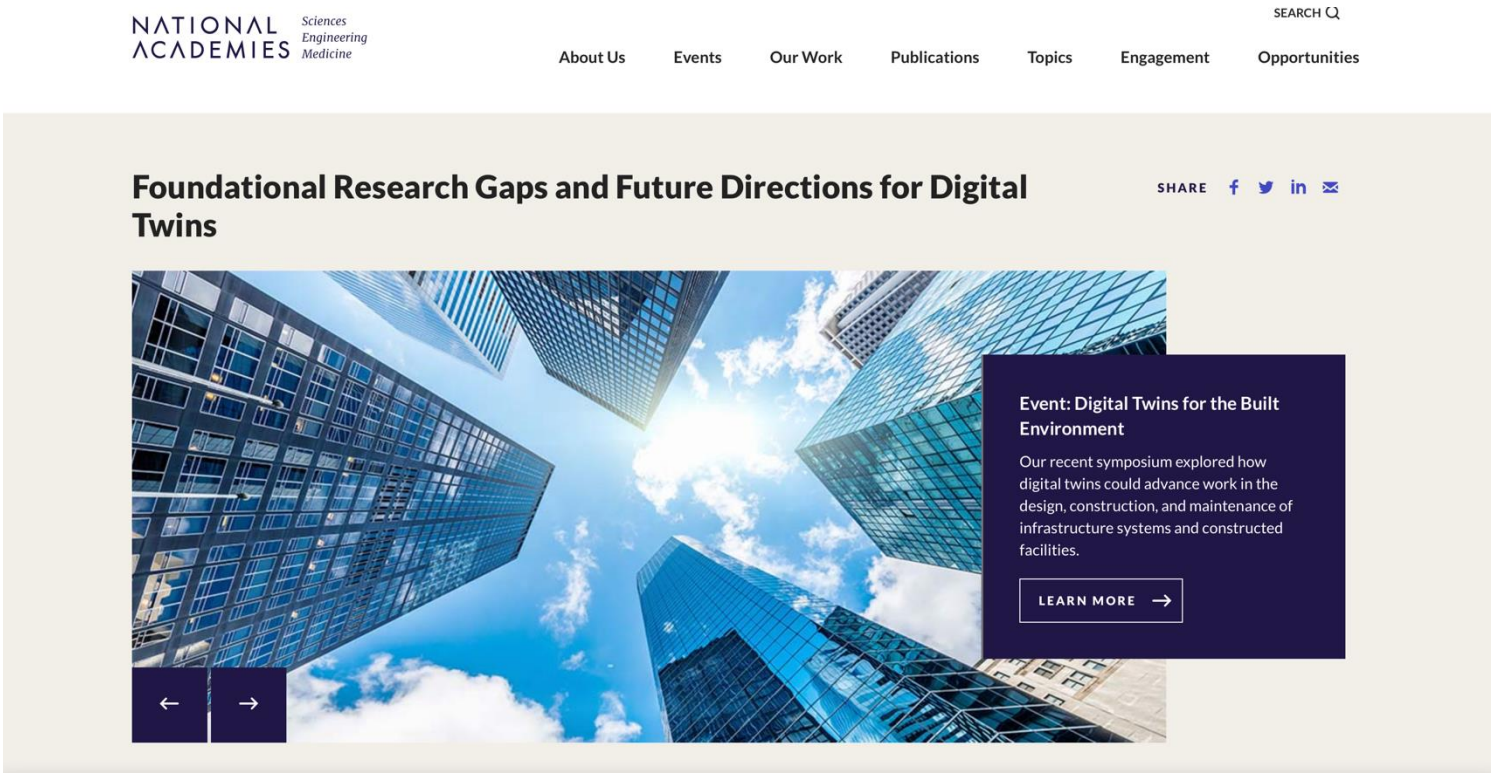
International Digital Twin Initiatives



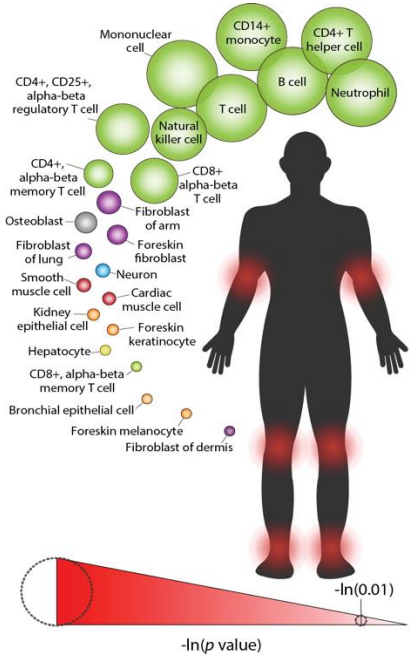
Swedish Digital Twin Consortium

Web: SDTC.se

Challenges

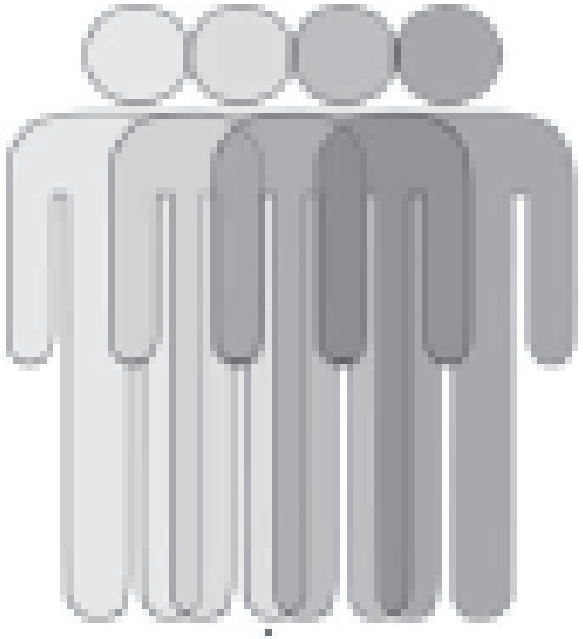
1. *Complexity and Heterogeneity*
2. Measurement of disease-relevant variables
3. Organisation of those variables
4. Prioritisation of variables, biomarkers and drug targets
5. Clinical implementation

The same tumour can involve thousands of genes across many cell types

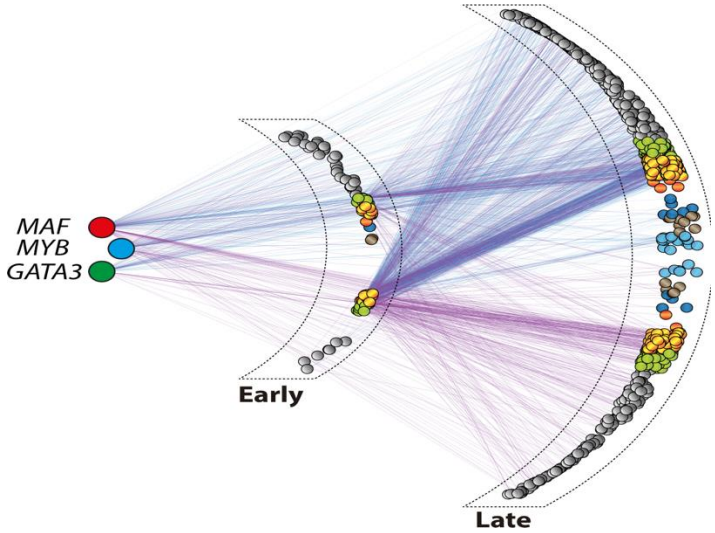


Gawel et al. Genome Med 2019

The same cancer diagnosis can differ between individuals

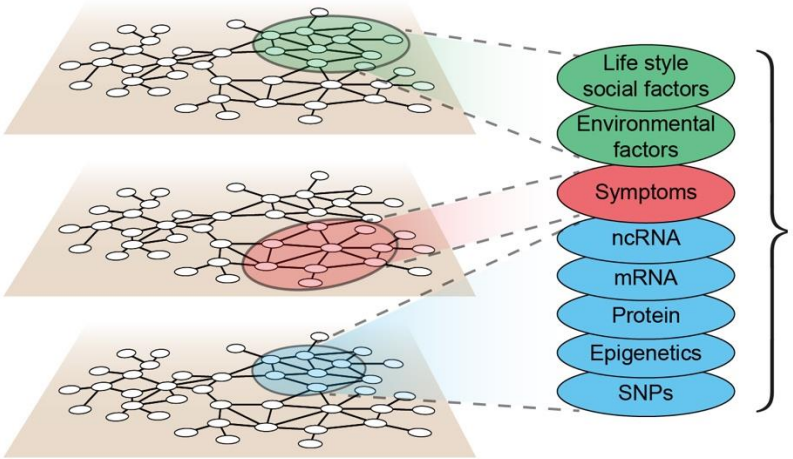


The same diagnosis changes over time



Gustafsson et al. Science Transl Med 2015

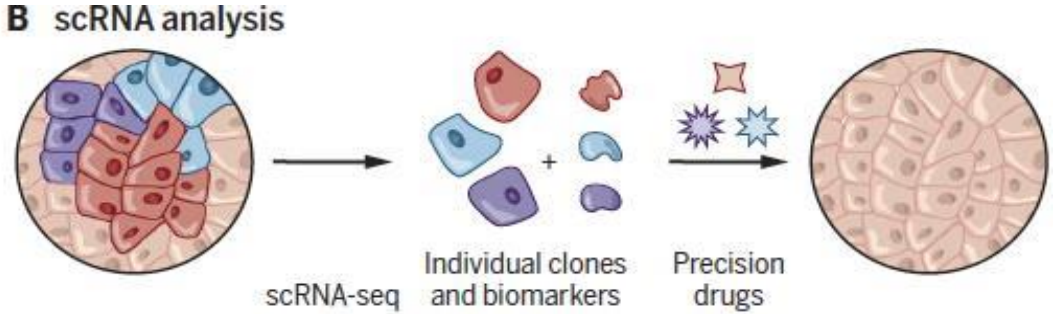
The same tumour diagnosis can involve many types of variables



Challenges

1. Complexity and Heterogeneity
2. *Measurement of disease-relevant variables*
3. Organisation of those variables
4. Prioritisation of variables, biomarkers and drug targets
5. Clinical implementation

Single cell technology for multicellular characterisation of tumours

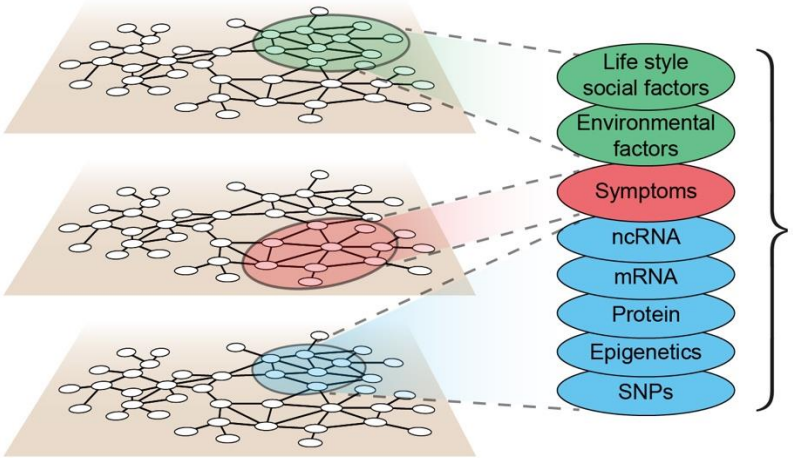


Shalek and Benson. Science Translational Medicine 2017

Challenges

1. Complexity and Heterogeneity
2. Measurement of disease-relevant variables
3. *Organisation of those variables*
4. Prioritisation of variables, biomarkers and drug targets
5. Clinical implementation

Digital twins can be constructed using multi-layer network modules

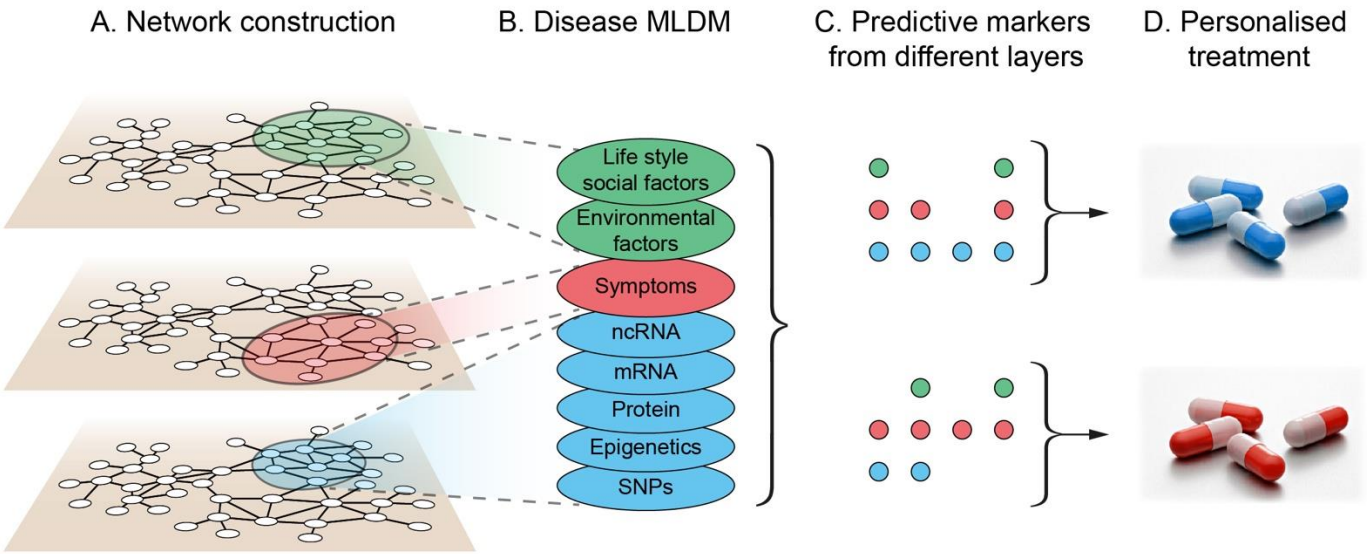


Li et al Genome Med 2025

Challenges

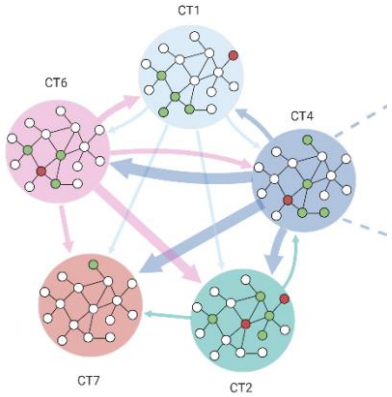
1. Complexity and Heterogeneity
2. Measurement of disease-relevant variables
3. Organisation of those variables
4. *Prioritisation of variables, biomarkers and drug targets*
5. Clinical implementation

Machine learning can be used to infer biomarkers and drug targets



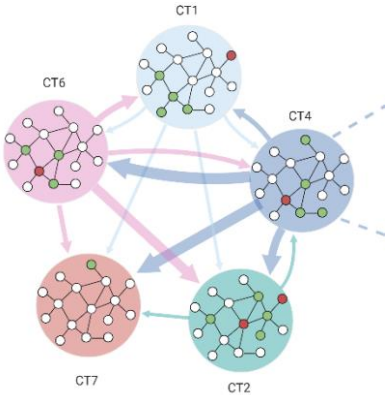
Li et al Genome Med 2025

Network tools can be applied to construct multicellular network models and infer biomarkers and drug targets



Schäfer et al. Genome Med 2024

Multicellular network models can be computationally “treated” with thousands of drugs



9) Drug ranking

	Intercellular centrality			Drug target centrality		
Cell type	Drug A	Drug B	Drug C	Drug A	Drug B	Drug C
CT1	~~0.6~~	0.5	~~0.6~~	~~0.0~~	0.3	~~0.0~~
CT2	~~0.6~~	~~0.6~~	~~0.6~~	~~0.0~~	~~0.0~~	~~0.0~~
CT4	1.0	1.0	~~0.6~~	0.7	1.0	~~0.0~~
CT6	0.8	0.8	~~0.6~~	1.0	0.7	~~0.0~~
CT7	~~0.1~~	~~0.1~~	~~0.1~~	~~0.0~~	~~0.0~~	~~0.0~~
Combined	1.8	2.3		0.8	0.6	

Ranked candidates

#1 Drug B

#2 Drug A

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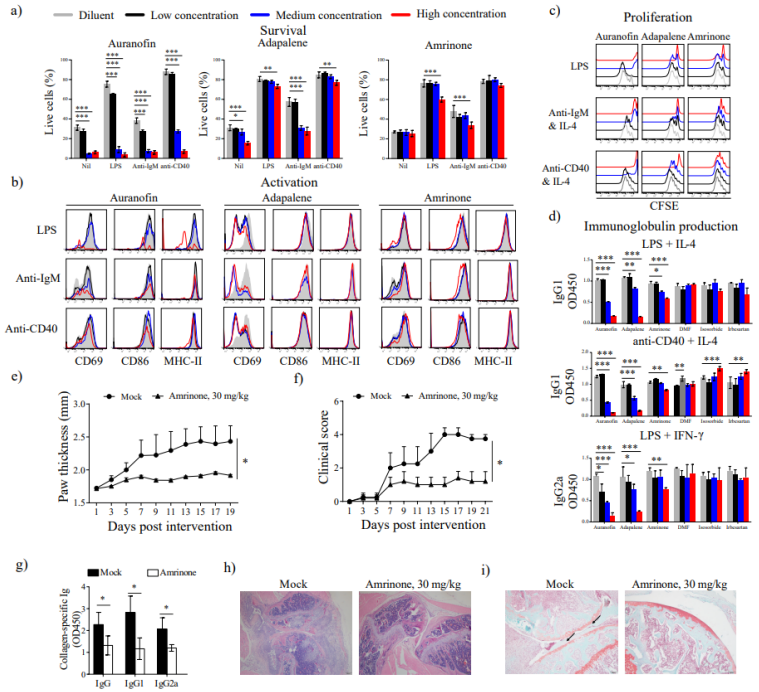
Validation of “computational treatment” of multicellular network models



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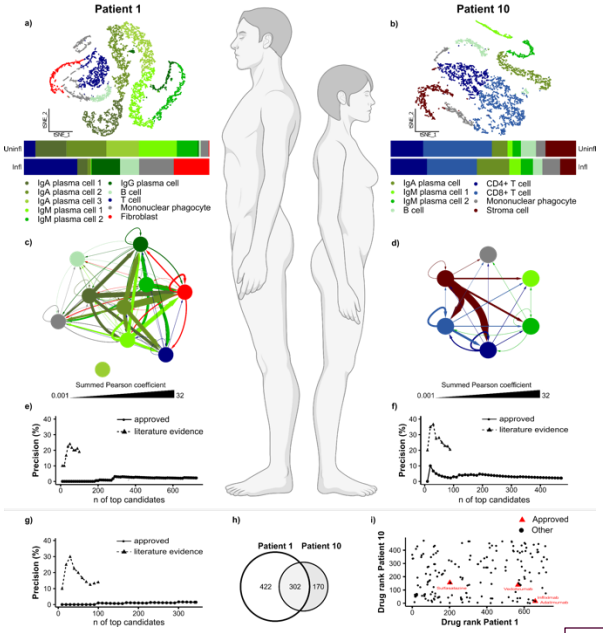
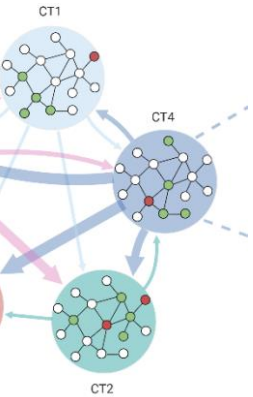
Validation of computational treatment of multicellular network models of **individual** patients' diseases



Schäfer et al. Genome Med 2024

Multicellular network models can be frameworks to construct and treat digital twins



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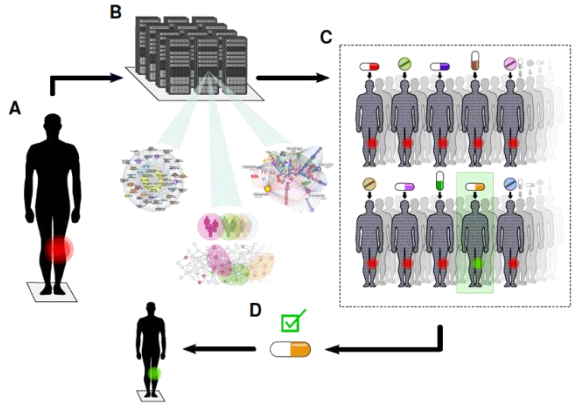
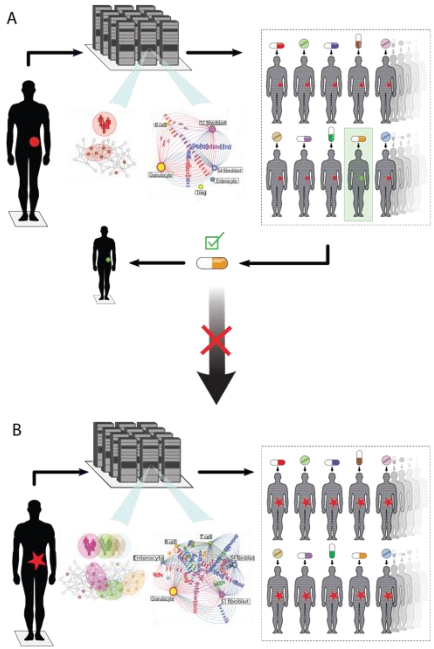
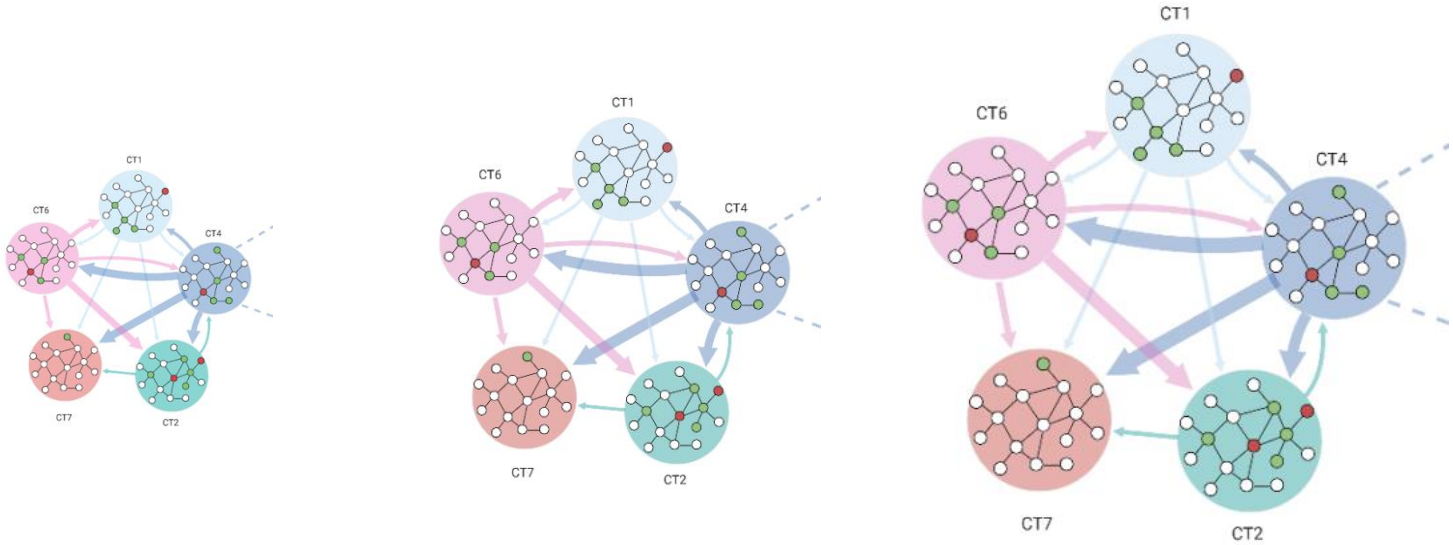


Dynamic Digital Twins for early personalised diagnostics and therapeutics



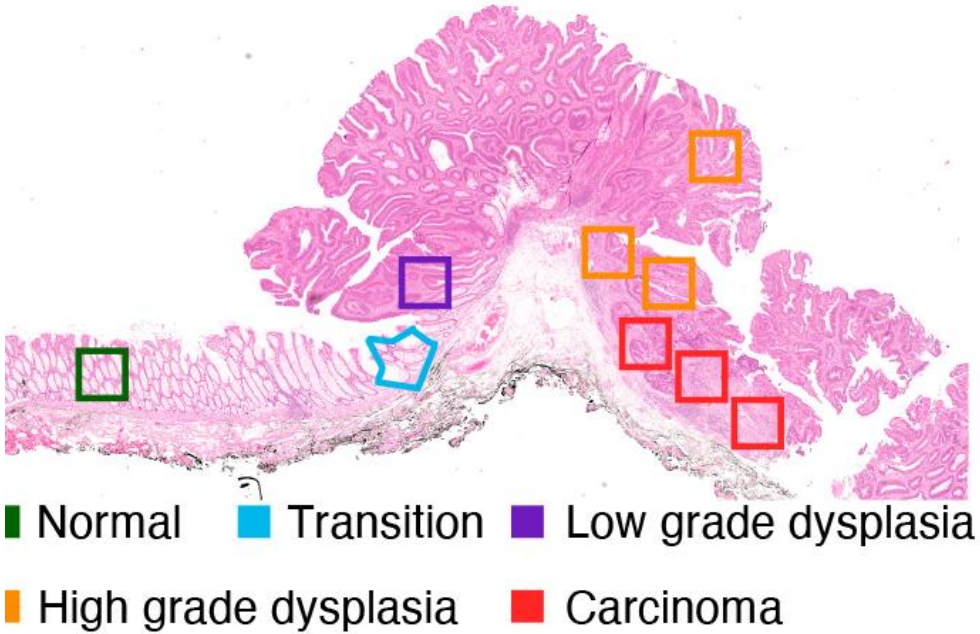
Björnsson et al Genome Med 2020

Dynamic digital twins can be constructed by connecting multicellular network models from different stages of a disease process



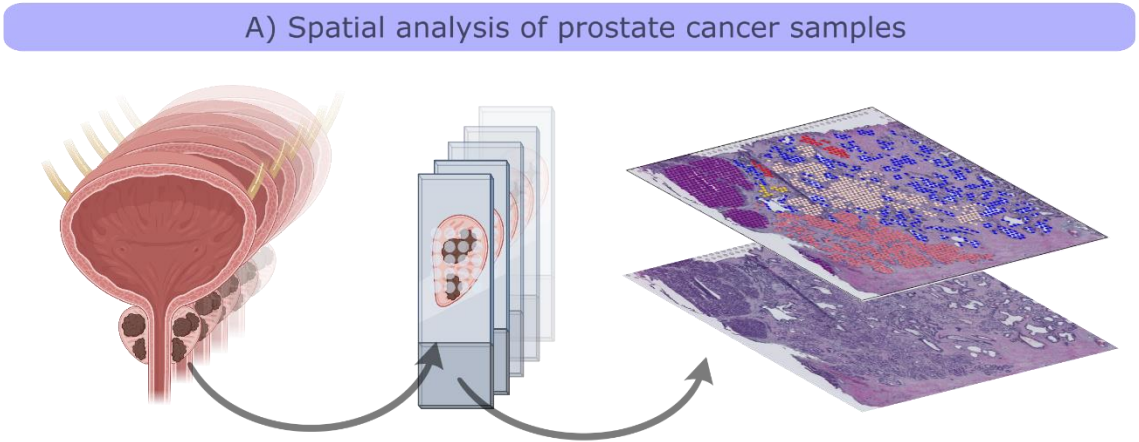
Li et al Genome Med 2025

Dynamic digital twins can be constructed based on spatial transcriptomics



Smelik et al. Cancer Research, in press

Dynamic digital twins can be constructed based on spatial transcriptomics



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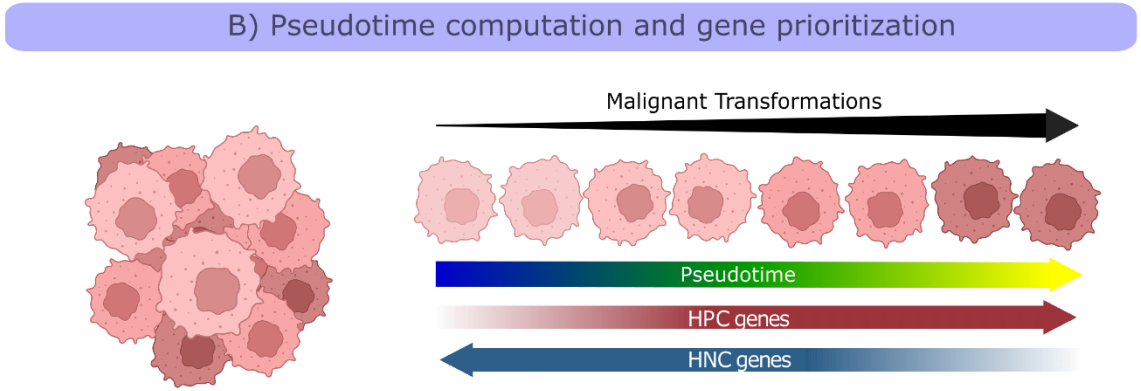
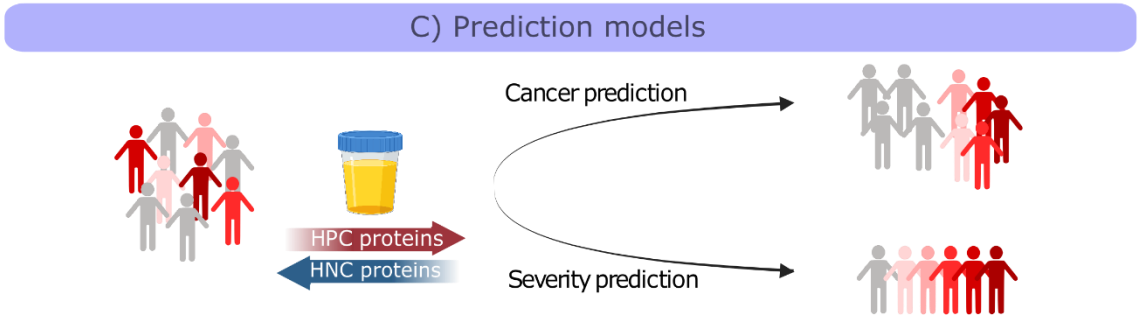


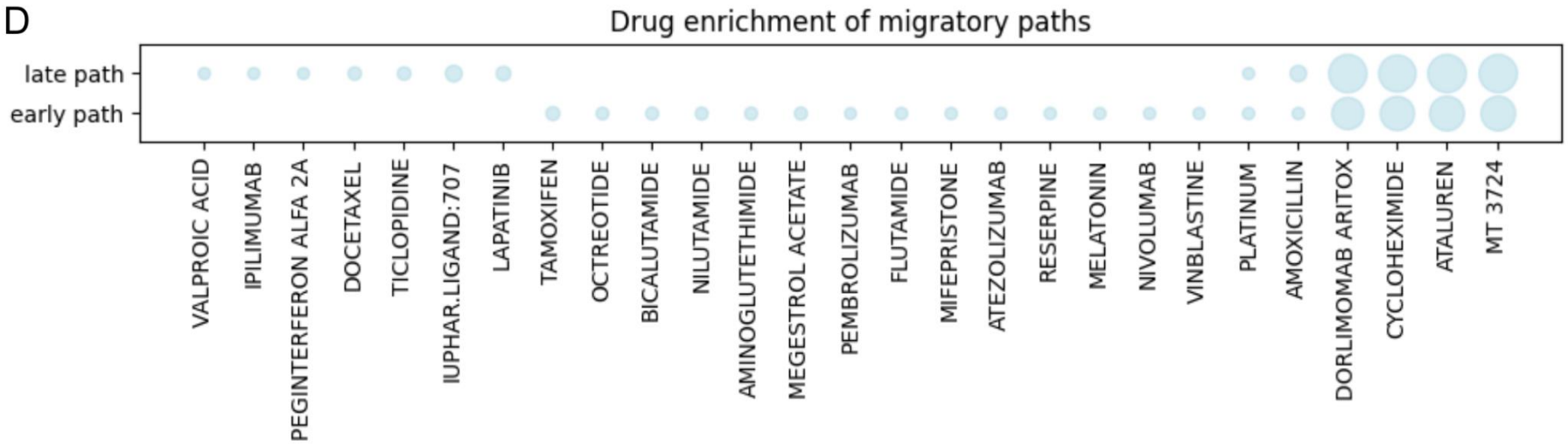
Smelik et al. Cancer Research, in press

Dynamic digital twins to find biomarkers



Smelik et al. Cancer Research, in press

Dynamic digital twins to find early and late drug targets



Smelik et al. Cancer Research, in press

Challenges

1. Complexity
2. Heterogeneity
3. Measurement of disease-relevant variables
5. Organisation of those variables
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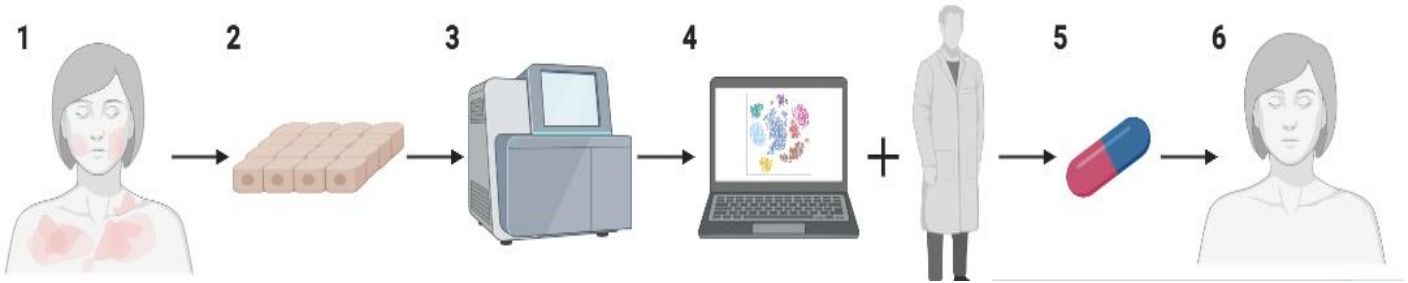
6. *Clinical implementation*

Clinical implementation



Summary

Network tools can potentially be used to construct dynamic digital twins to predict and prevent disease

Karolinska Institutet

Interested in a post doc to construct and treat digital twins?

Mikael.benson@ki.se

Funding

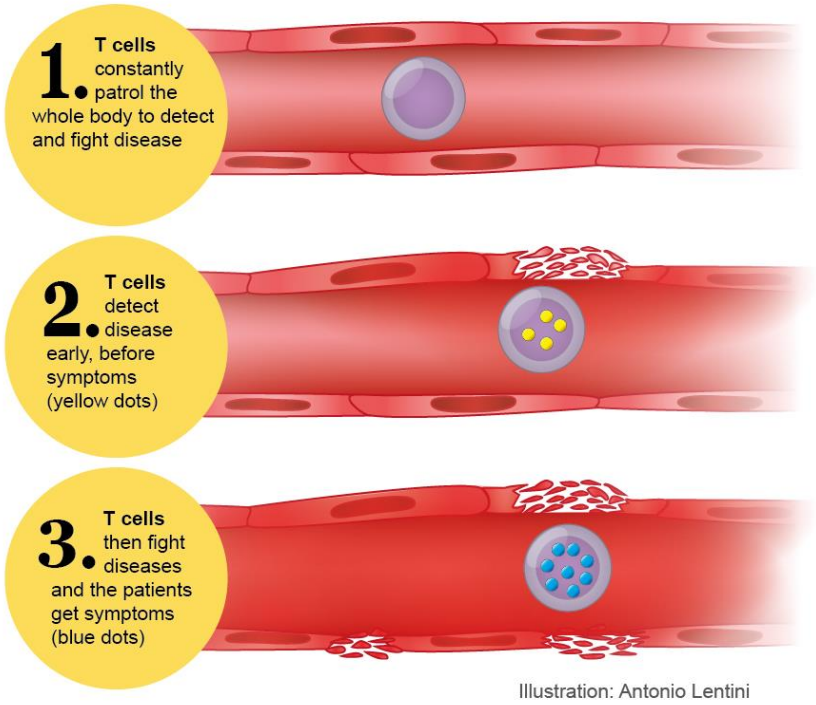
RADIUMHEMMETS
FORSKNINGSFONDER

CANCERFONDEN

Vetenskapsrådet

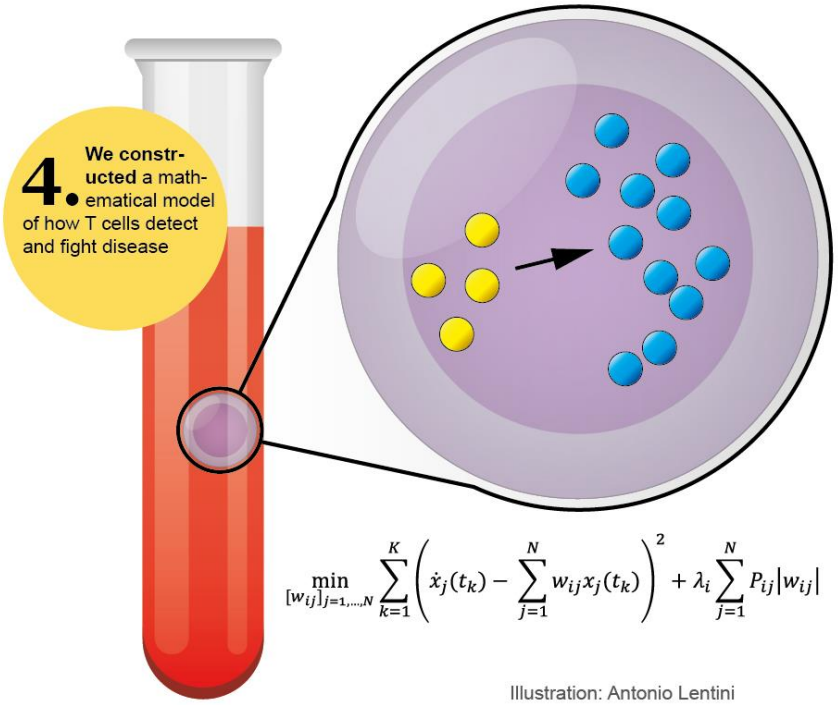
europa.eu

Early diagnosis



Gustafsson et al. Science Transl Med 2015

Early diagnosis



Gustafsson et al. *Science Transl Med* 2015

Cellular sensors for predictive and preventive medicine, starting in childhood?