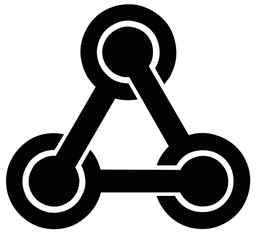
Creative Connections Bodylight

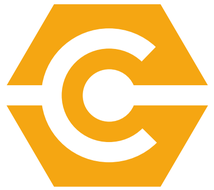
illuminating the function of the human body

Technology to combine biomedical research, graphical design and mathematical modeling

Enabling the creation of interactive in-browser simulators



Creative Connections



BODYLIGHT

Problem

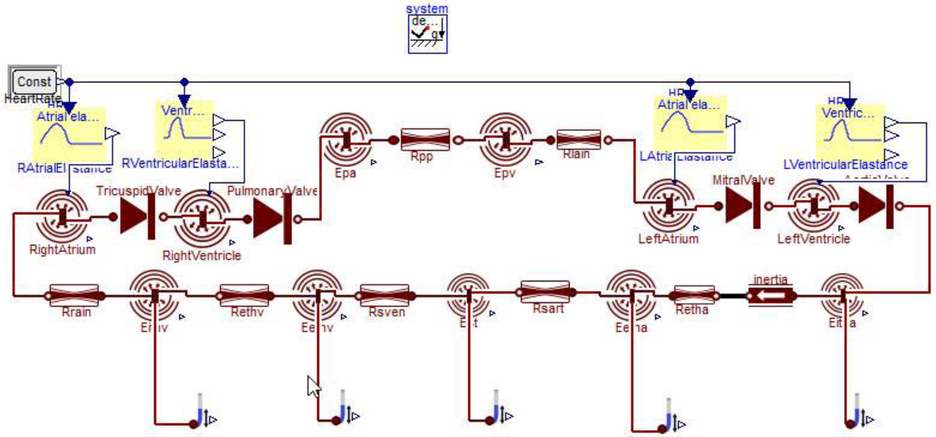
- complex problems in biology and medicine can be formally described as a set of mathematical equations- mathematical models

```
// Hepcidine-related stuff

der(hep) = hep_in - hep_out; // eq. 1
der(Bmp6) = Bmp6_in - Bmp6_out; // eq. 2
der(LPS) = -k_LPS_deg*LPS; // eq. 3
der(Il6mRNA) = Il6mRNA_in - Il6mRNA_out; // eq 4.
der(Il6) = Il6_in - Il6_out; // eq 5.

// Duodenum

Fe_duo = Fe_duo_2 + Fe_duo_3;
der(Fe_duo_2) = Fe_duo_in_food + Fe_duo_in_ser - Fe_duo_out_ser -
der(Fe_duo_3) = Fe_duo_to_ferritin - Fe_duo_from_ferritin;
der(Fpn_duo) = Fpn_duo_in - Fpn_duo_out; // eq 7.3
der(Fpn_duo_mRNA) = Fpn_duo_mRNA_in - Fpn_duo_mRNA_out; // eq 6.3
```



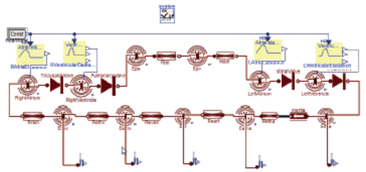
- Model simulators are hard to be implemented as computer software and visualize interactively

- Models of normal, pathological and clinical physiology are not yet widely used in education, clinical praxis, medical and biotechnology product design.

Solution

- Bodylight toolchain – https://bodylight.physiome.cz
- Step 1: Author can compile models in modeling language Modelica into WebAssembly, which enables the models to be executed in standard web browsers (Bodylight.js-FMU-Compiler)
- Step 2: Author can write web simulator using HTML and using our ‘Bodylight.js-Components’ which are configurable standard web-components (HTML like tags) adding interactive elements, web components are interpreted by standard web browser
- Web simulator = HTML & webcomponents only, no Javascript programming

model as diagram



1

Source code of web simulator: (no code, only HTML and custom webcomponents)

```
<div style="float:left;width:50%">
  <h2>Simulation of hemodynamics of cardiovascular system</h2>
  <p>See changes in pressure in aorta when changing heart rate</p>
  <bdl-range id="id1" title="Heart Rate" min="40" max="188" default
  <bdl-fmi id="idFmi" src="PhysioLibrary_Fluid_Examples_Fernandez2
  <bdl-chartjs-time id="id10" width="300" height="200" fromId="idFm
</div>
<div style="float:left;width:50%">
  <bdl-animate-adobe src="CardiaccycleStage.js" name="Faze_srdce" f
  <bdl-bind2a fIndex="1" aName="ValveMV_anim" aMin="99" aMax="0" fM
  <bdl-bind2a fIndex="2" aName="ValveAOV_anim" aMin="0" aMax="99" f
  <bdl-bind2a fIndex="3" aName="ValveTV_anim" aMin="99" aMax="0" fM
  <bdl-bind2a fIndex="4" aName="ValvePV_anim" aMin="0" aMax="99" fM
  <bdl-bind2a fIndex="5" aName="ventricles.ventriclesTotal.Ventricl
  <bdl-bind2a fIndex="6" aName="ventricles.ventriclesTotal.Children
</div>
```

2

1

model as equations

```
// Hepcidine-related stuff

der(hep) = hep_in - hep_out; // eq. 1
der(Hmp6) = Hmp6_in - Hmp6_out; // eq. 2
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// Duodenum

Fe_duo = Fe_duo_2 + Fe_duo_3;
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der(Fe_duo_3) = Fe_duo_to_ferritin - Fe_duo_from_ferritin;
der(Fpn_duo) = Fpn_duo_in - Fpn_duo_out; // eq 7.3
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```
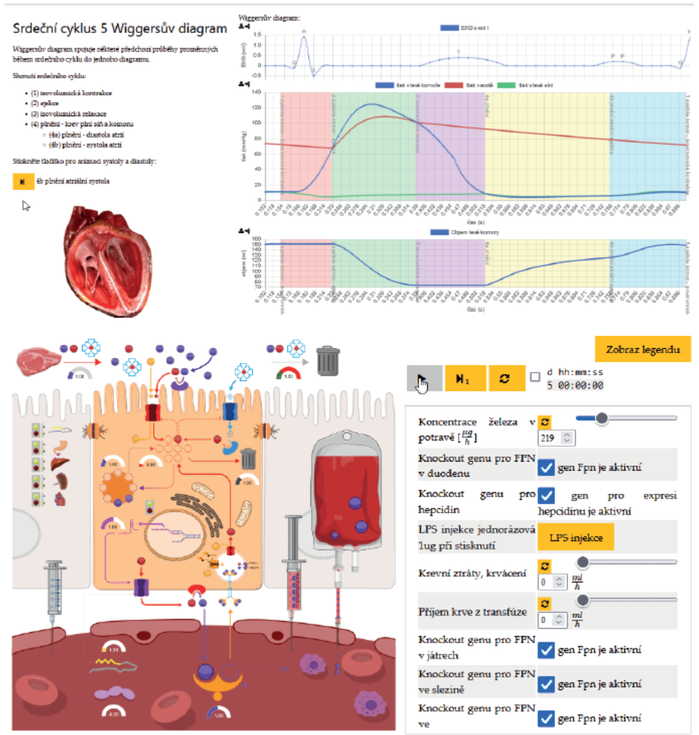
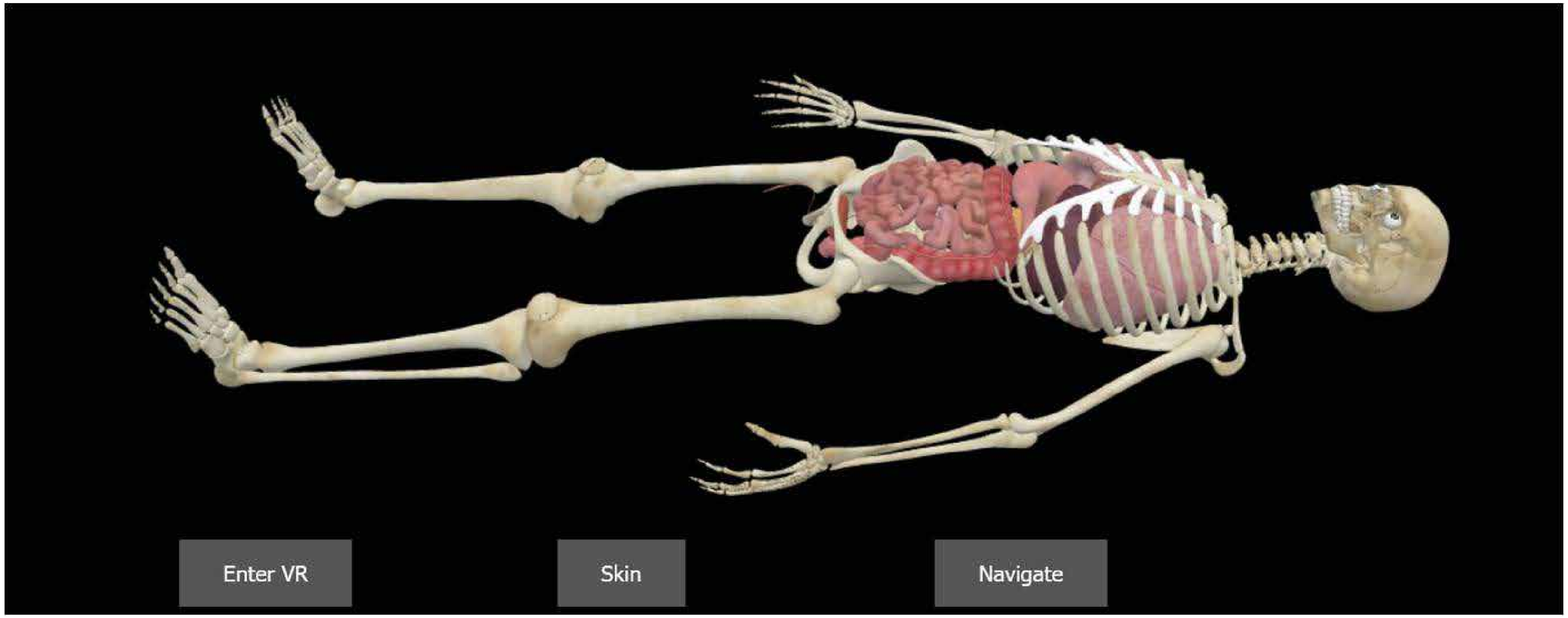

web animation with web simulator

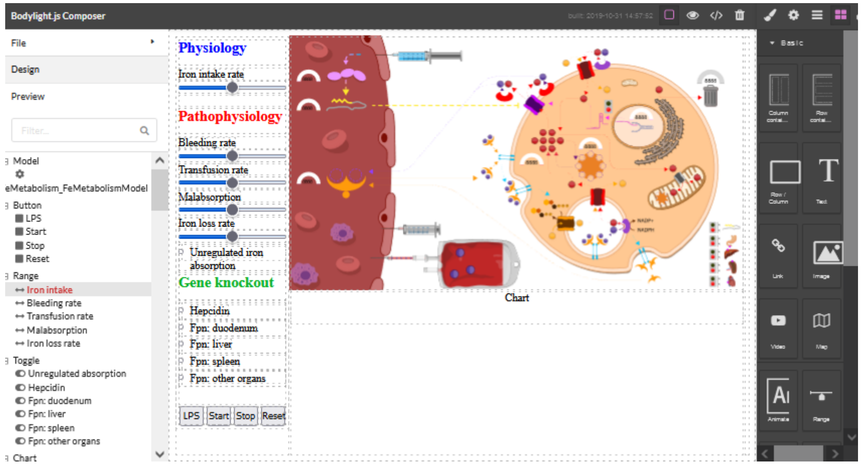


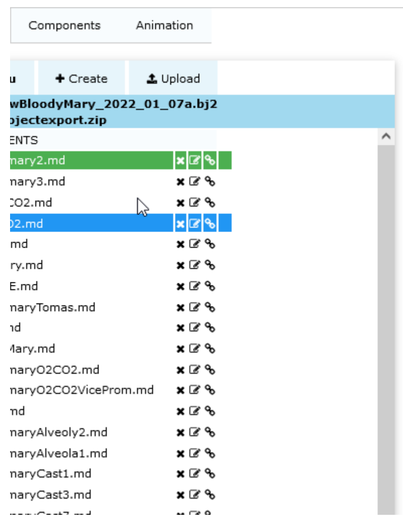
Solution

- Web simulators can be executed in virtual or augmented reality
- demo: https://bodylight.physiome.cz/VR/breathing/



Solution – no-code and low-code tools to create web simulator



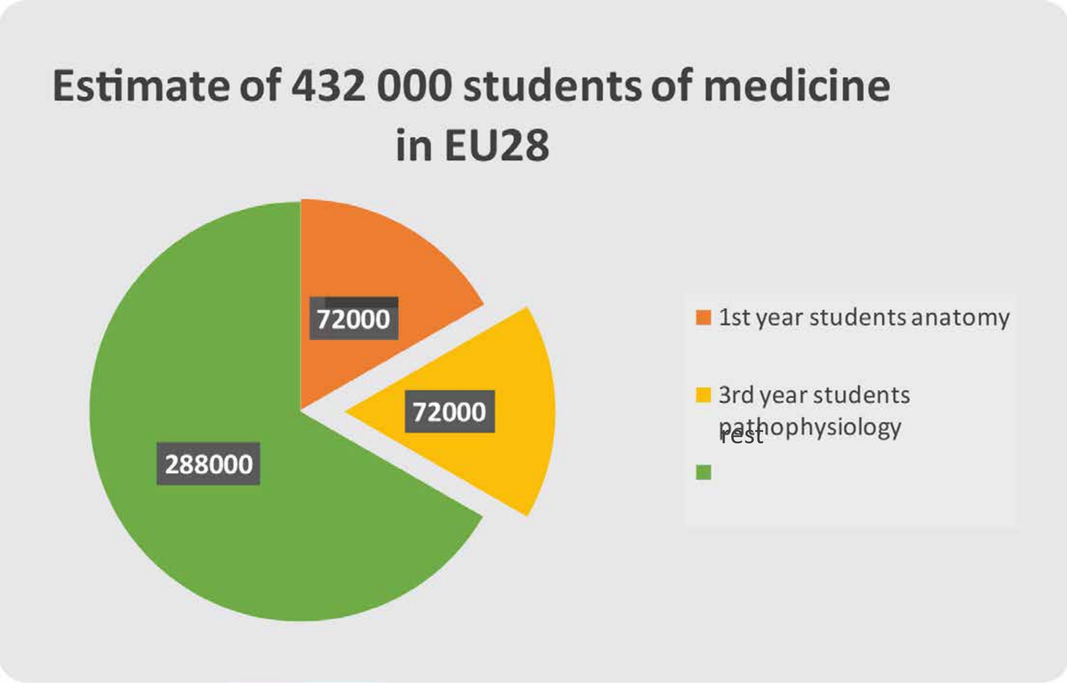


Bodylight-Composer
no-code tool to create basic web simulator

Bodylight-Editor
low-code tool to create advanced web simulator

Business plan A

- Interactive atlas of physiology, pathophysiology and clinical physiology
  - Problem – there are few interactive materials covering complex features of physiology and pathophysiology
  - Solution – online book with web simulators using Bodylight technology, we have domain experts to create the content
  - Potential market among students and clinical specialist



demo- interactive hemodynamics

https://bodylight.physiome.cz/Bodylight-Scenarios/hemodynamics/

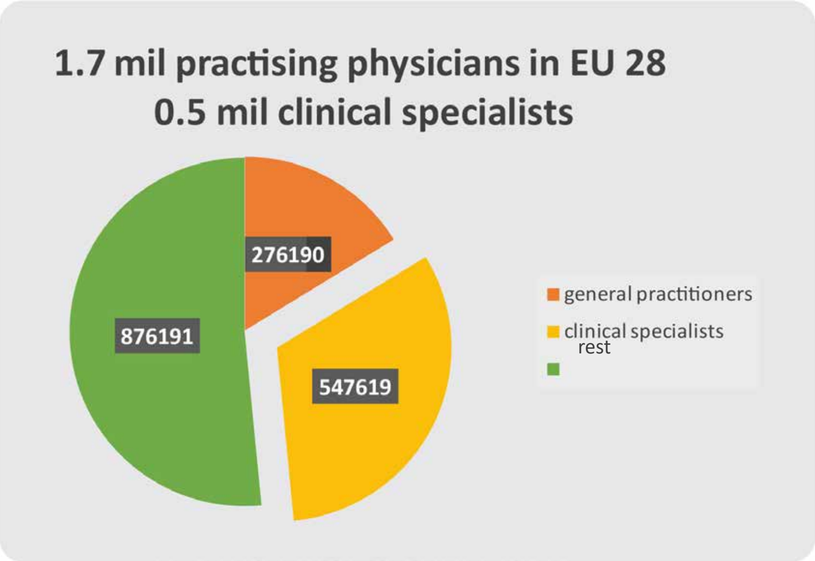
demo – physiology of iron metabolism

https://bodylight.physiome.cz/Bodylight-Scenarios/ironmetabolism/

data, Eurostat 2018
https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Healthcare_personnel_statistics_-_physicians#Healthcare_personnel

Business plan B

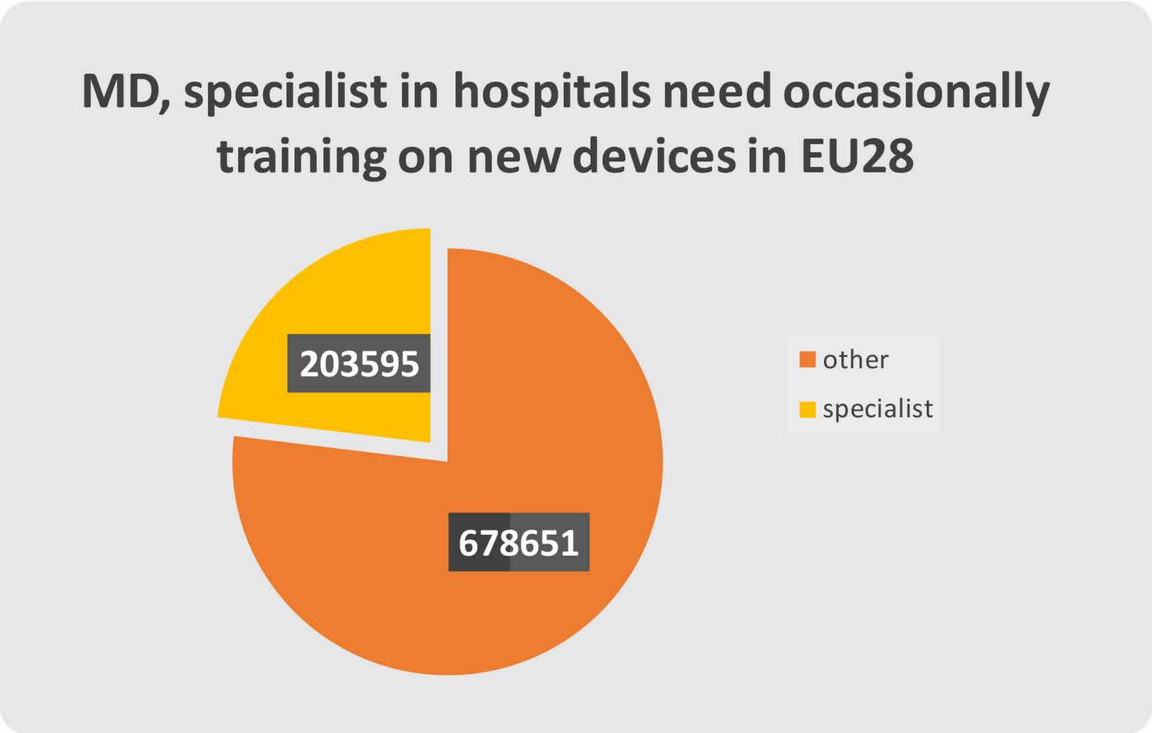
- Create and use models to deliver web simulators for other (not only medical) domains
  - B2C or B2B
  - our tools and technology facilitates connecting different domain experts, software engineer, modeler, graphical designer to create interactive web simulator
  - sell access to advanced tools, customer can fine-tune simulators – Bodylight-Composer, Bodylight-Editor
  - Goal: Increase usage of simulators to provide precise pharmacotherapy
  - Goal: Decrease time of delivery of solution with web simulator
  - Model source code – usually open source, Model parameters – know-how of potential business partner



data, Eurostat 2018
https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Healthcare_personnel_statistics_-_physicians#Healthcare_personnel

Business plan C

- Use models and tools from plan A and B to deliver simulators in virtual/augmented reality
  - B2B, Simulating human body, medical devices, training physician and other personnel in hospitals
  - Market – specialists in hospitals needing occasionally training on new devices or therapy, vendors of medical devices



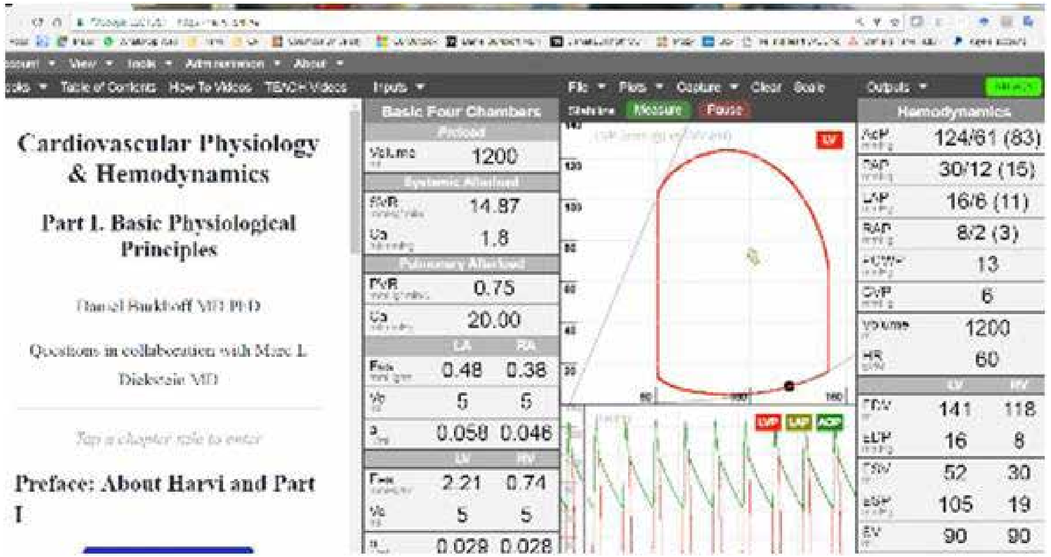
demo - breathing virtual body with basic anatomy:

https://bodylight.physiome.cz/VR/breathing/

data, Eurostat 2018
https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Healthcare_personnel_statistics_-_physicians#Healthcare_personnel

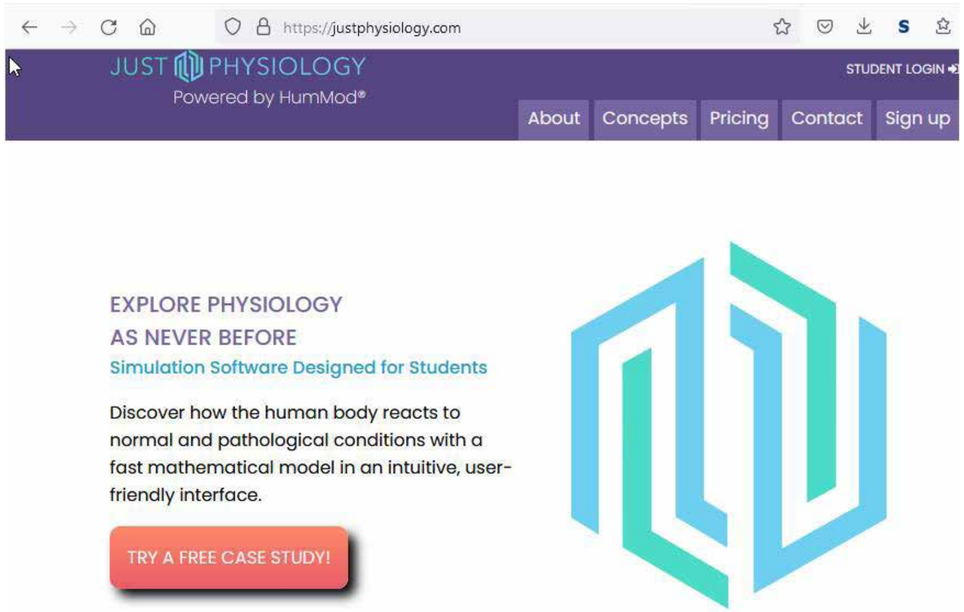
Potential competitor

- Lot of free online videos – authors and users potential customers
  - Our advantage is that the web simulators are live –not prerecorded videos
  - we can input values into scenarios and get answer/solution in terms of physiological explanation
  - This gives feedback about understanding the concept
- Few interactive simulation based – harvi online – cloud based simulation of hemodynamics https://harvi.online/site/welcome/
  - Our advantage – in-browser simulation
    - no need of cloud infrastructure
    - can be off-line,
    - Our model implementation is open source part of www.physiolibrary.org



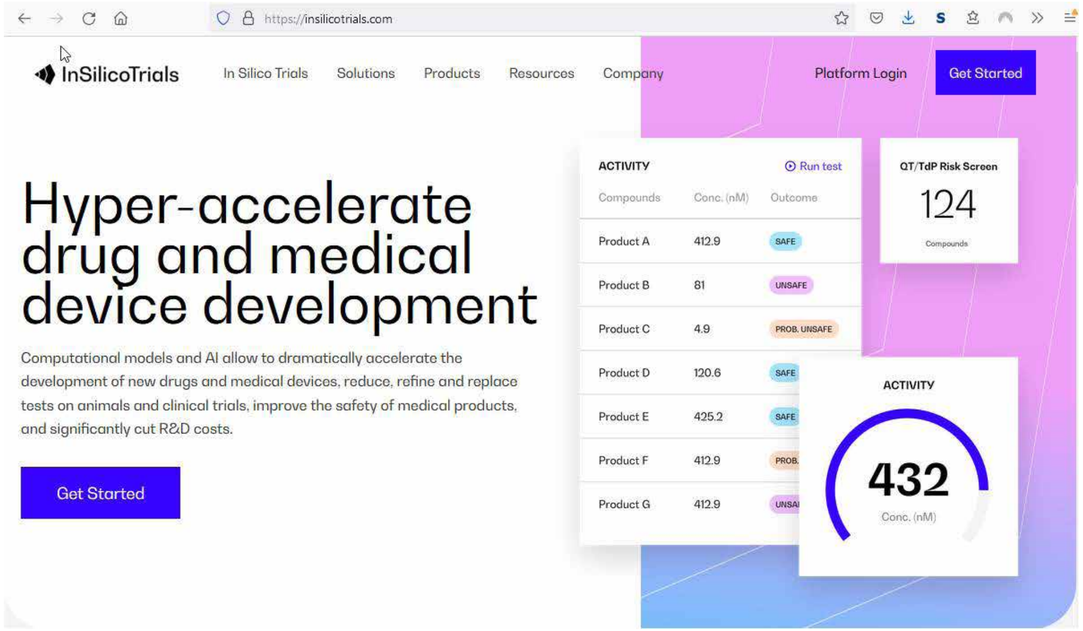
Potential competitor

- JustPhysiology https://justphysiology.com/
  - Based on HumMod – most advanced and complex model of physiology
  - Lot of charts and educational material
  - Used in some US universities
  - Models source is closed – almost closed
- Our advantage
  - We reimplemented and enhanced HumMod in Modelica language as open source model, see www.physiomodel.org
  - We have advanced interactive graphics
  - We can be partners in EU or contractors for advanced visualisation



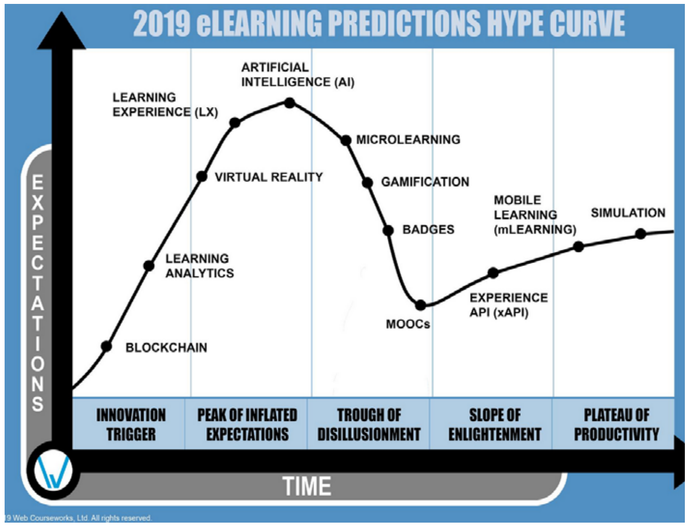
Potential competitor

- InSilicoTrials – www.insilicotrials.com
  - Evangelist in the use of simulation in the clinical-trial phase of testing drugs and medical products
  - They use finite-element method (3D model) simulation
  - We use mechanistic models (1D) and 3D approach is actively researched in the technology domain we use (partial differential equation in Modelica)
  - We can be contractors delivering in-browser simulators and advanced visualisation



Technology innovation in e-learning and Life Science R&D

- WebCoursework's document `Hype Cycle for eLearning 2019` before COVID-19 lists e-learning methodologies and technologies in different phases of hype cycle.
    - Our plan A focus on `Simulation` which is already in plateau of productivity. `virtual/augmented reality` was in rise, however in 2020 and further it is expected to go to disillusionment.
- Gartner's Research Document 'Hype Cycle for Life Science Research and Development, 2020'– lists different innovation technologies again in different phases of hype cycle. Our plan B and C focus on these:
    - On the rise
        - Digital Life Science Platform (DLSP)
        - Immersive AR/VR/MR experience in life science
    - At the Peak
        - Clinical Data Analytics Platforms
        - RWE in Clinical Research
    - Entering the plateau
        - Scientific Analytics Platforms



Team

Jiří Kofránek
Co-Founder & visionary

MD, Ph.D.,Assoc. prof in technical cybernetics

Tomáš Kulhánek
Co-Founder & CTO

MSc. in computer science, Ph.D. in biomedical informatics

Jitka Feberová
Marketing and sales

MD and Ph.D. in medicine and information sciences

Arnošt Mládek

MSc. In molecular physics, Ph.D. in biochemistry and neuroscience,
MD candidate 2023

Klára Ulčová

Diplome specialist in 2D and interactive graphics

Martin Brož

Diplome specialist in 2D and 3D computer graphics

History

- Multidisciplinary team members
    - We teach medicine at Charles University
    - We teach modeling and simulation at Czech Technical University
    - We teach interactive graphics at High School V. Hollara
    - Source of multidisciplinary students and ideas – Dipl.spec. in computer graphics, M.Sc., Ph.D. students in computer science, biomedical engineering and biomedicie
- Creative Connections s.r.o. founded in 1992
    - Formerly publishing company
    - From 2000 principal investigator or participant of research grants – with Charles University and other SME
    - Funding MSc. and Ph.D. students
    - From December 2021 changed incorporation documents , 3 founders, increased the base capital, focus on technology transfer to market
- Investment history
    - Founders already invested 160 000 EUR in the past 20 years
- Aim to create subsidiary company focusing on business only

Selected scientific publication

- ŠILAR, Jan, David POLÁK, Arnošt MLÁDEK, Filip JEŽEK, Theodore W KURTZ, Stephen E DICARLO, Jan ŽIVNÝ a Jiri KOFRANEK. Development of In-Browser Simulators for Medical Education: Introduction of a Novel Software Toolchain. Journal of Medical Internet Research [online]. 2019, 21(7) [cit. 2019-11-25]. DOI: 10.2196/14160. ISSN 1438-8871. https://www.jmir.org/2019/7/e14160

- Kurtz, Theodore W; DiCarlo, Stephen E; Pravenec, Michal; Ježek, Filip; Šilar, Jan; Kofránek, Jiří; Curtis Morris Jr, R: Testing Computer Models Predicting Human Responses to a High Salt Diet: Implications for Understanding Mechanisms of Salt Sensitive Hypertension. **Hypertension**, AHA/ASA Journals

- JEŽEK, Filip, Tomáš KULHÁNEK, Karel KALECKÝ a Jiří KOFRÁNEK. Lumped models of the cardiovascular system of various complexity, **Biocybernetics and Biomedical Engineering**, 37(4), str. 666-678, [online]. [cit. 2018-09-12]. DOI: 10.1016/j.bbe.2017.08.001. ISBN 0208-5216. https://linkinghub.elsevier.com/retrieve/pii/S0208521617300268

- Kulhánek T.,Kofránek J. and Mateják M. Modeling of short-term mechanism of arterial pressure control in the cardiovascular system: Object oriented and acausal approach. Computers in Biology and Medicine, Received 15 May 2014, Accepted 22 August 2014, Available online 1 September 2014. http://dx.doi.org/10.1016/j.compbiomed.2014.08.025

Investment round 1

- Seeking for 250 000- 400 000 EUR
- Hire 6 people to develop MVP for plan A
    - online atlas of physiology, pathophysiology and clinical physiology 30 chapters of selected areas of physiology and pathophysiology
- Hire 2 people to improve low-code, no-code tools for plan B and C
- Gain customers/users, create simulators in different applied physiology and seek business opportunities for plan B and C

https://bodylight.physiome.cz