

Modelica Day 2015

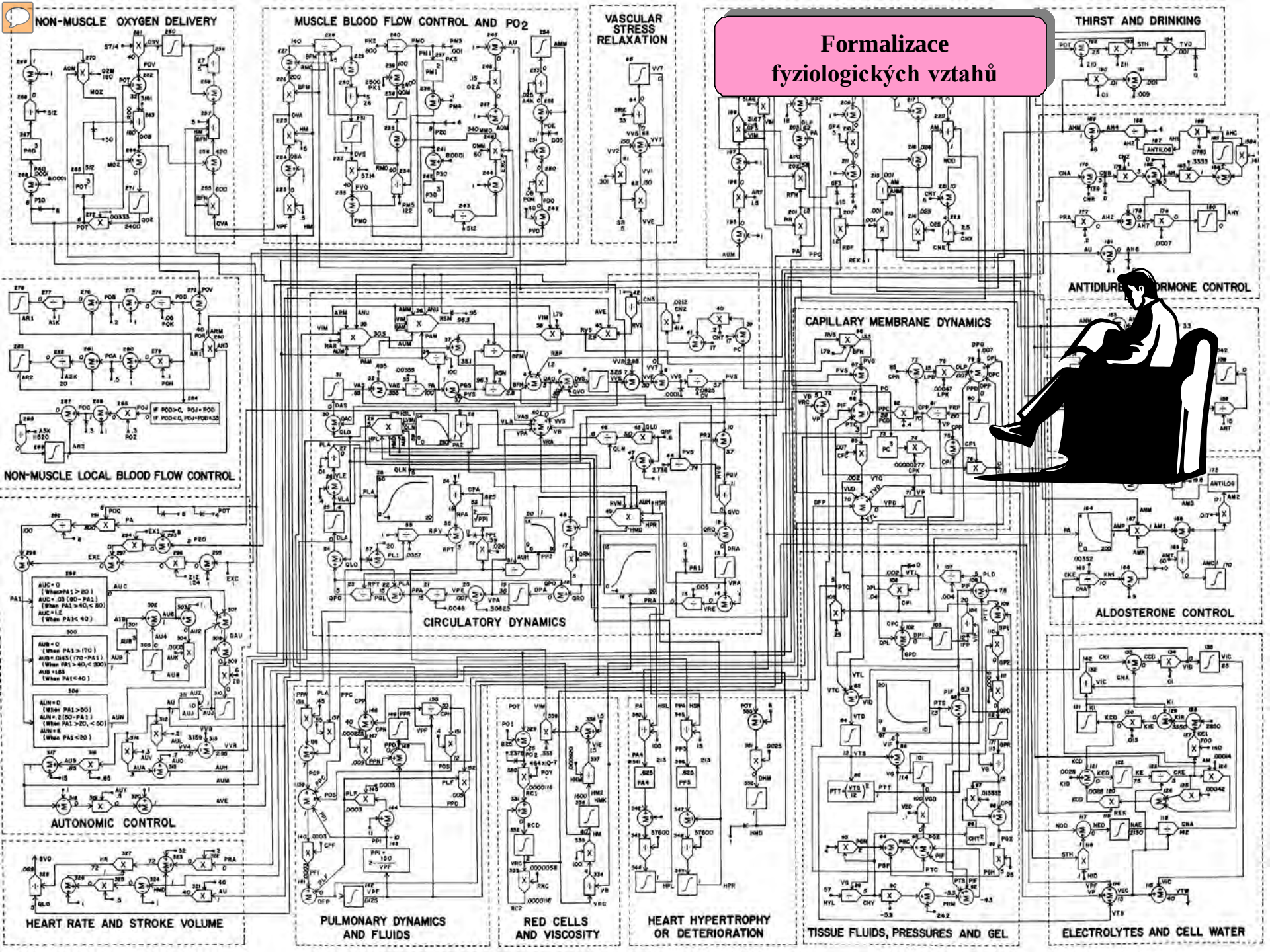
Jiří Kofránek



An aerial photograph of a mountain valley. A winding road or path leads through the valley floor, which is covered in green vegetation. In the background, several sharp, snow-capped mountain peaks rise against a cloudy sky. The overall scene is a high-altitude landscape.

Naše cesta k Modelice

Jiří Kofránek



Formalizace fyziologických vztahů

THIRST AND DRINKING

ANTIURETIC HORMONE CONTROL

CAPILLARY MEMBRANE DYNAMICS

ALDOSTERONE CONTROL

CIRCULATORY DYNAMICS

AUTONOMIC CONTROL

HEART RATE AND STROKE VOLUME

PULMONARY DYNAMICS
AND FLUIDS

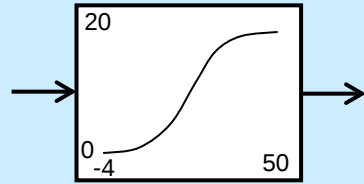
RED CELLS
AND VISCOSITY

HEART HYPERTROPHY
OR DETERIORATION

TISSUE FLUIDS, PRESSURES AND GEL

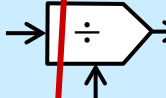
ELECTROLYTES AND CELL WATER

Functional block

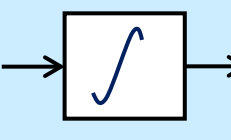


Formalizace
fyzilogických vztahů

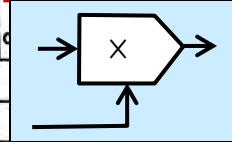
Divider



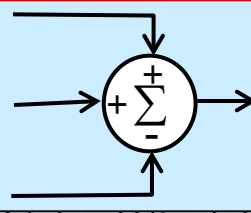
Integrator



Multiplier



Summator

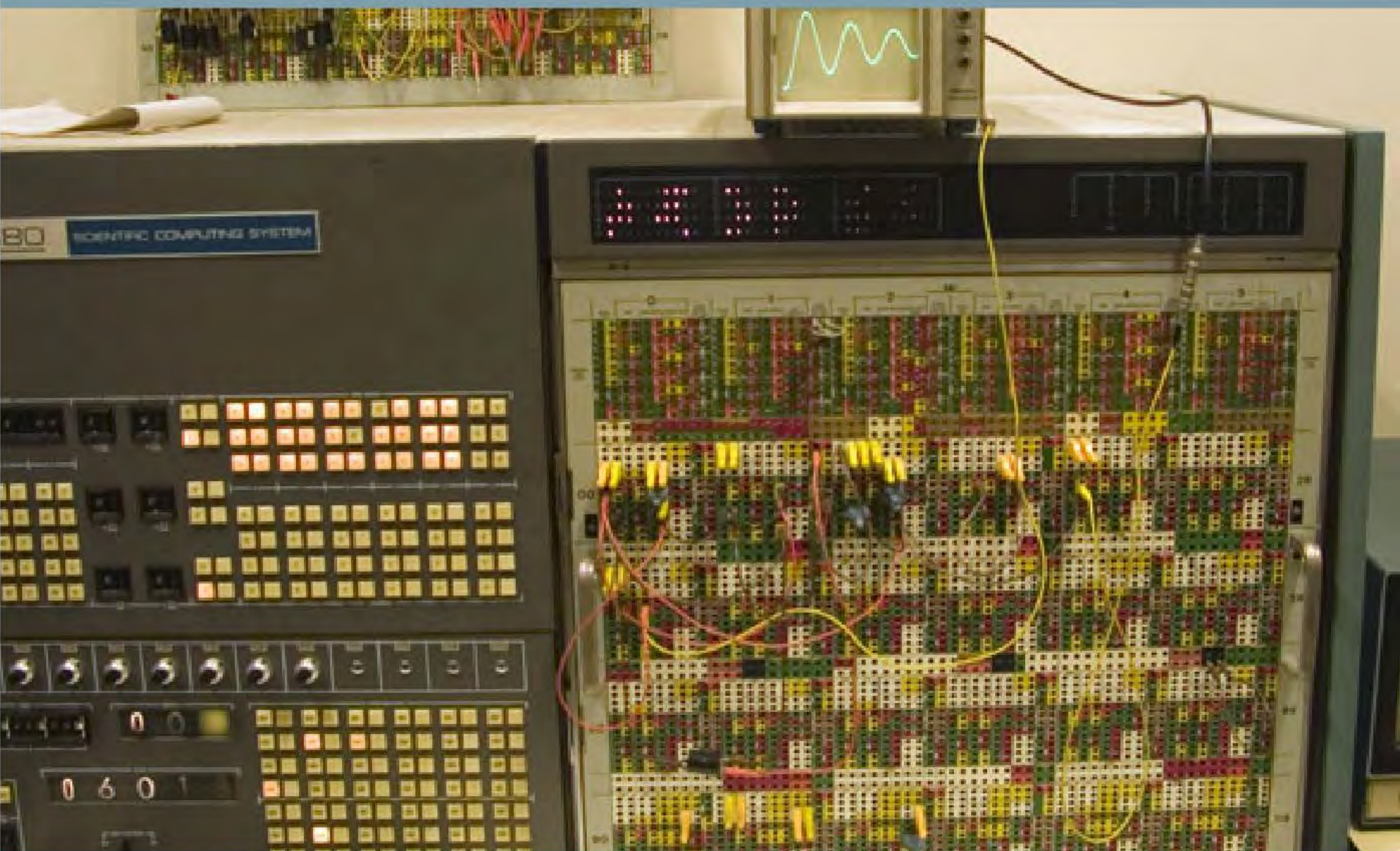


$$PCP = 0.55 PLA + 0.45 PPA$$

PPA PLA

PCP





Analogové a hybridní počítače: fyzické propojování výpočetních prvků kablíky





Analogové a hybridní počítače: fyzické propojování výpočetních prvků kablíky



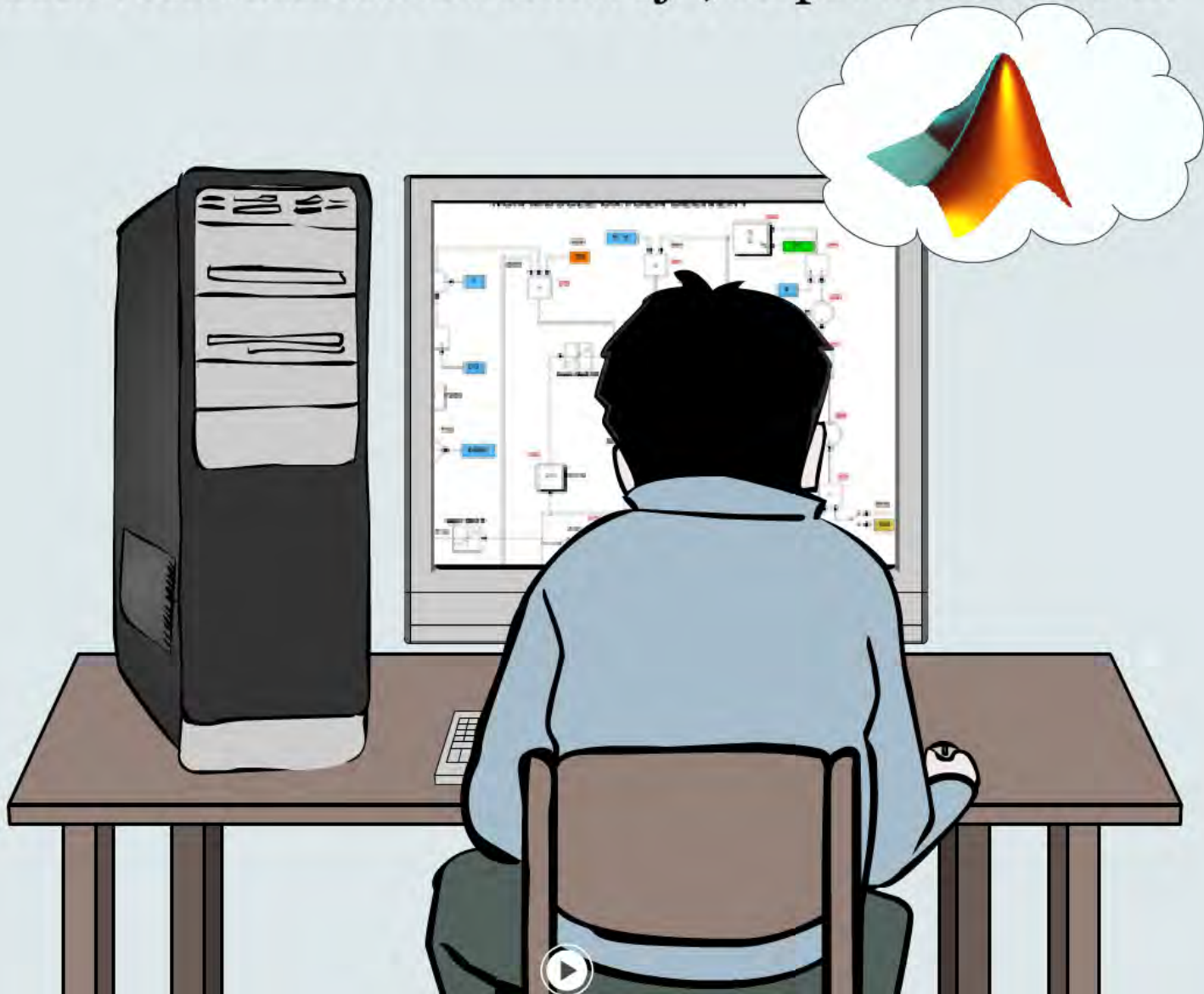
Číslicové počítače: modely ve standardních programovacích jazycích (FORTRAN, PASCAL, C++ ...)



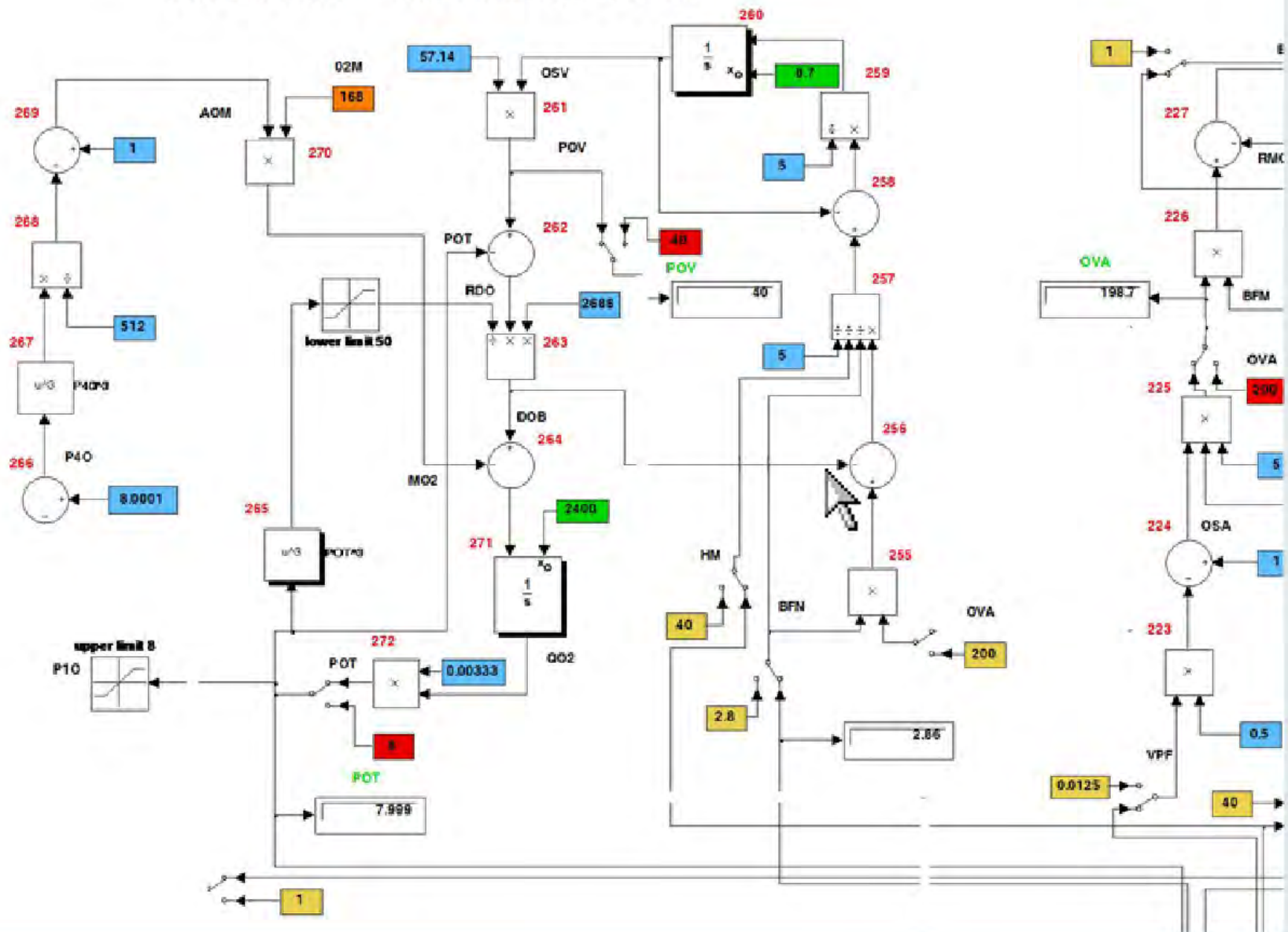
Analogové a hybridní počítače: fyzické propojování výpočetních prvků kablíky



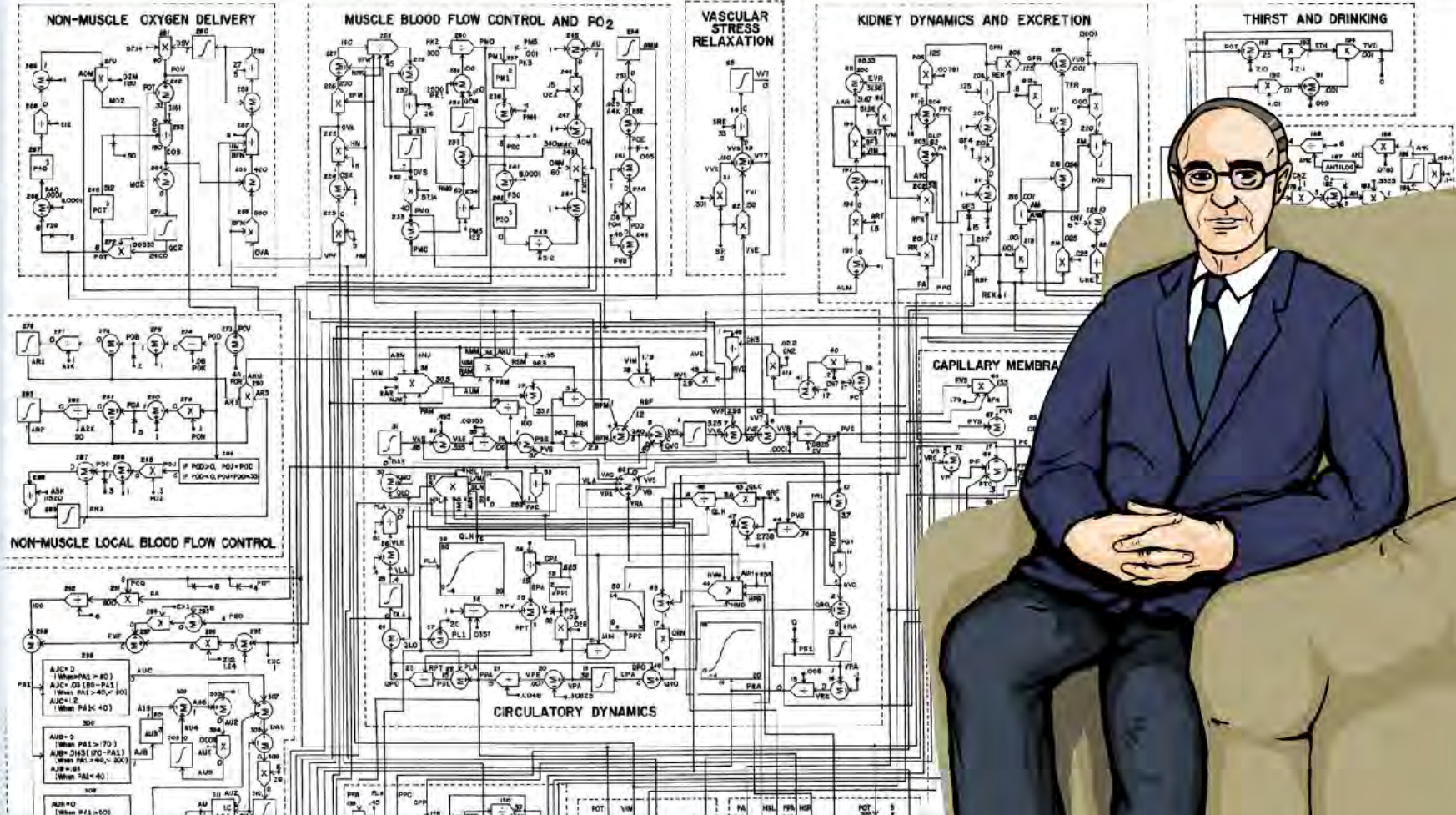
Specializované simulační nástroje, např. SIMULINK



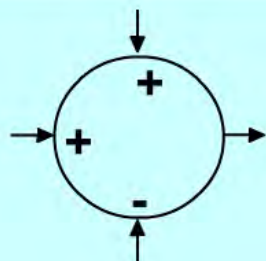
NON-MUSCLE OXYGEN DELIVERY



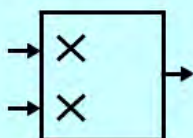
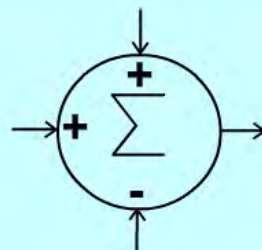
Guytonův diagram v Simulinku



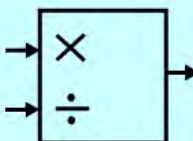
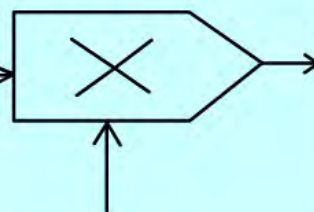
Guytonův diagram v Simulinku



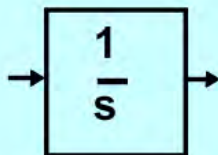
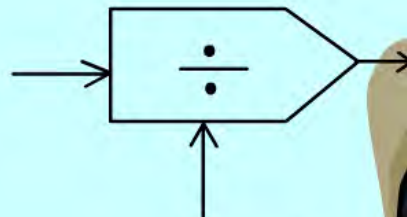
Sumátor



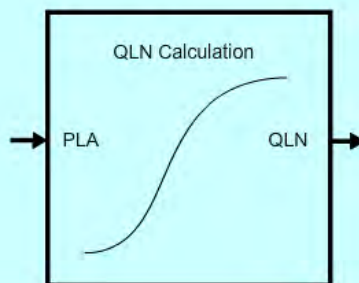
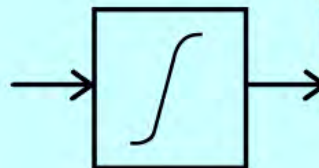
Násobička



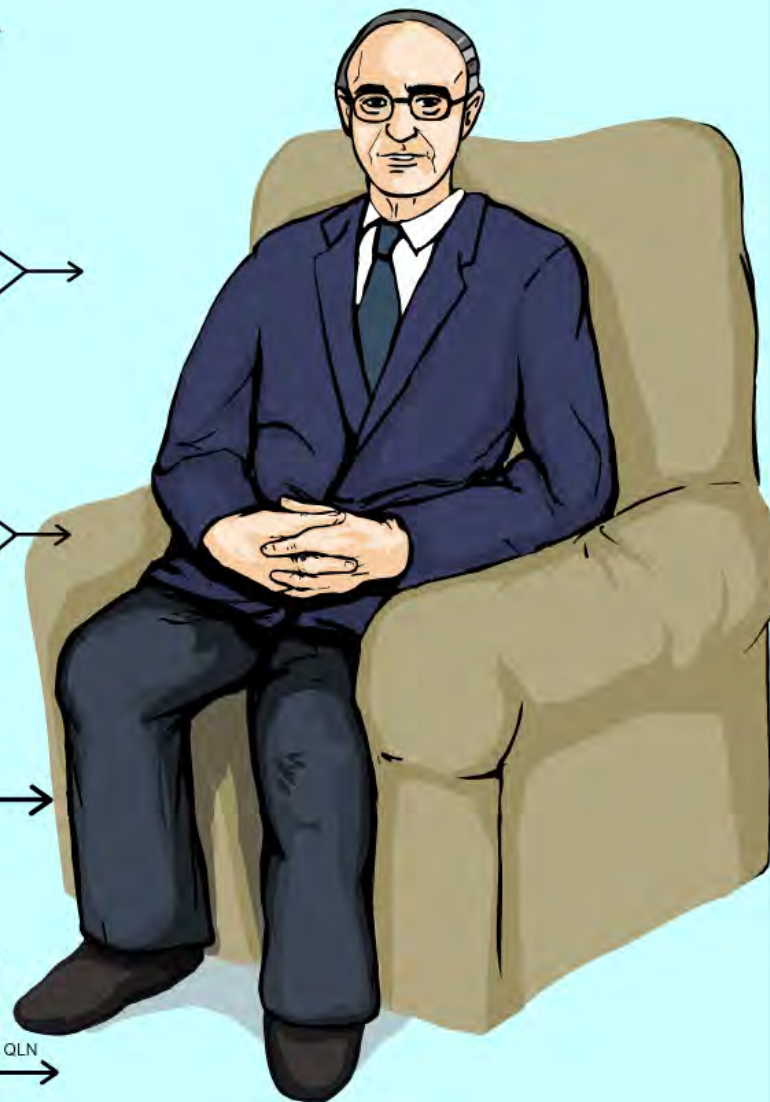
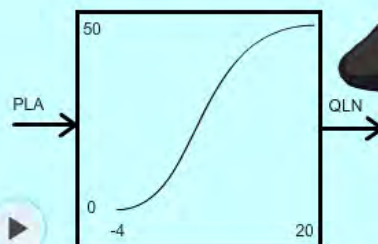
Dělička



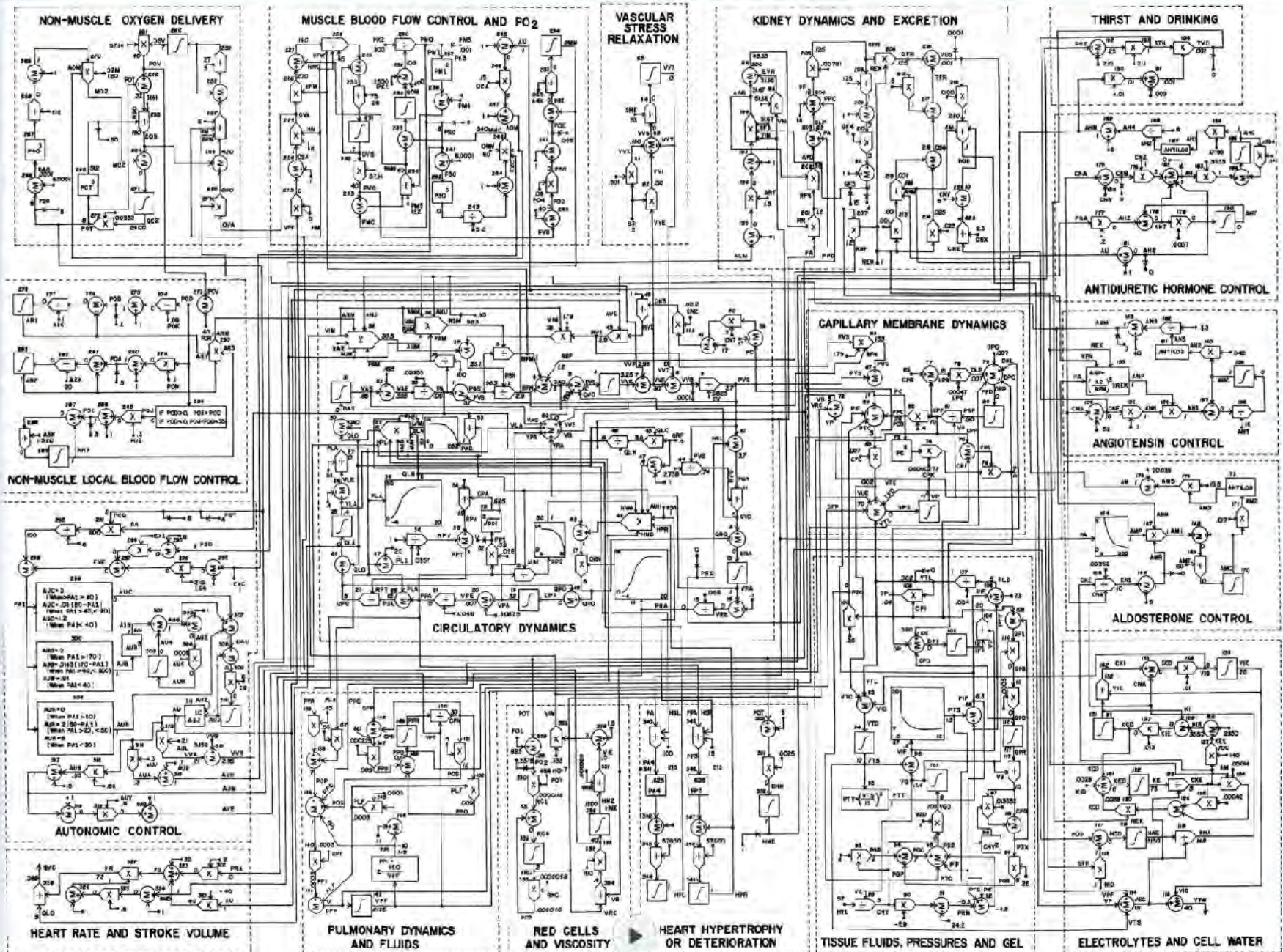
Integrátor



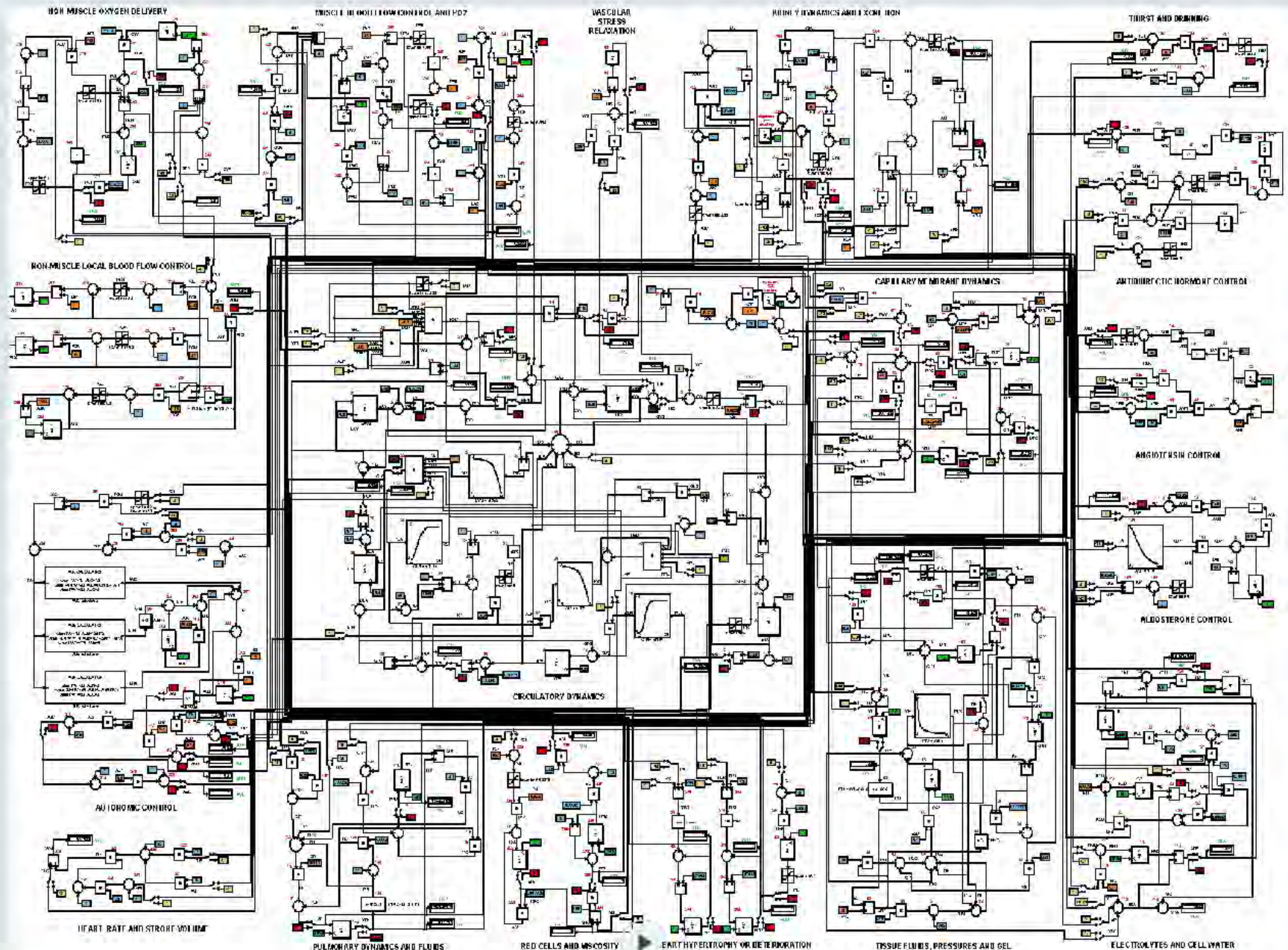
Funkční blok



Guytonův diagram v Simulinku



Guytonův diagram v Simulinku



Simulinková knihovna PhysiLibrary

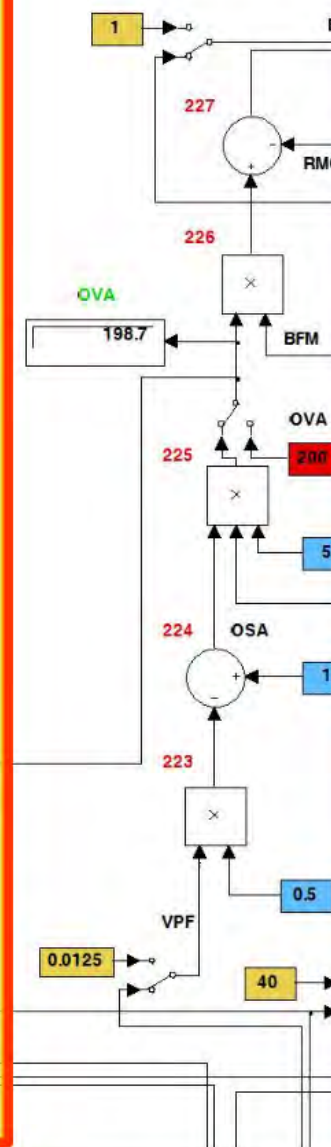


Složité provázané simulinkové výpočetní sítě jsou, zejména pro experimentální fyziology, málo srozumitelné

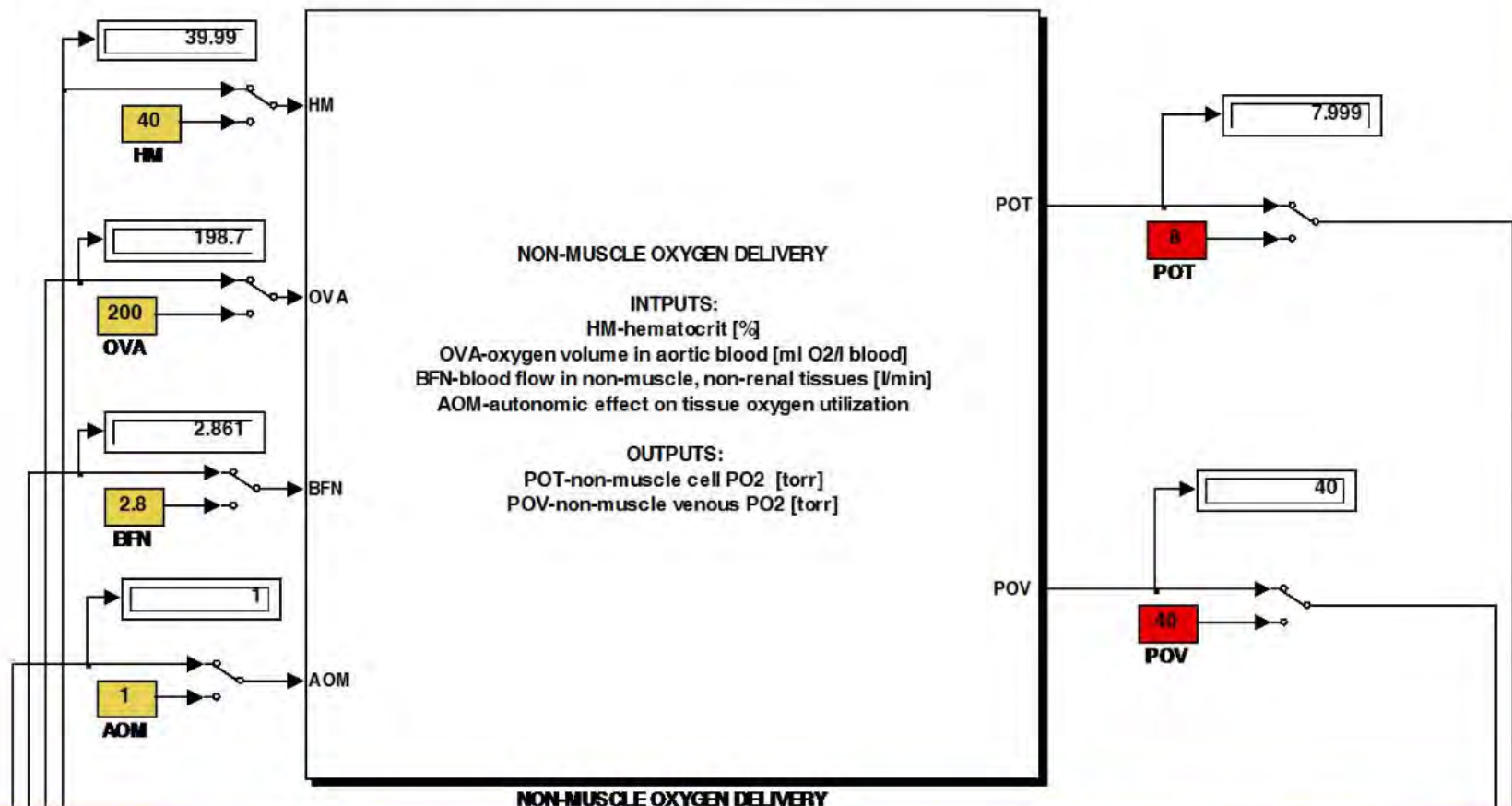
NON-MUSCLE OXYGEN DELIVERY



Proto se vyplatí jednotlivé výpočetní prvky agregovat do bloků a jejich vnitřní propojení před uživatelem skrýt

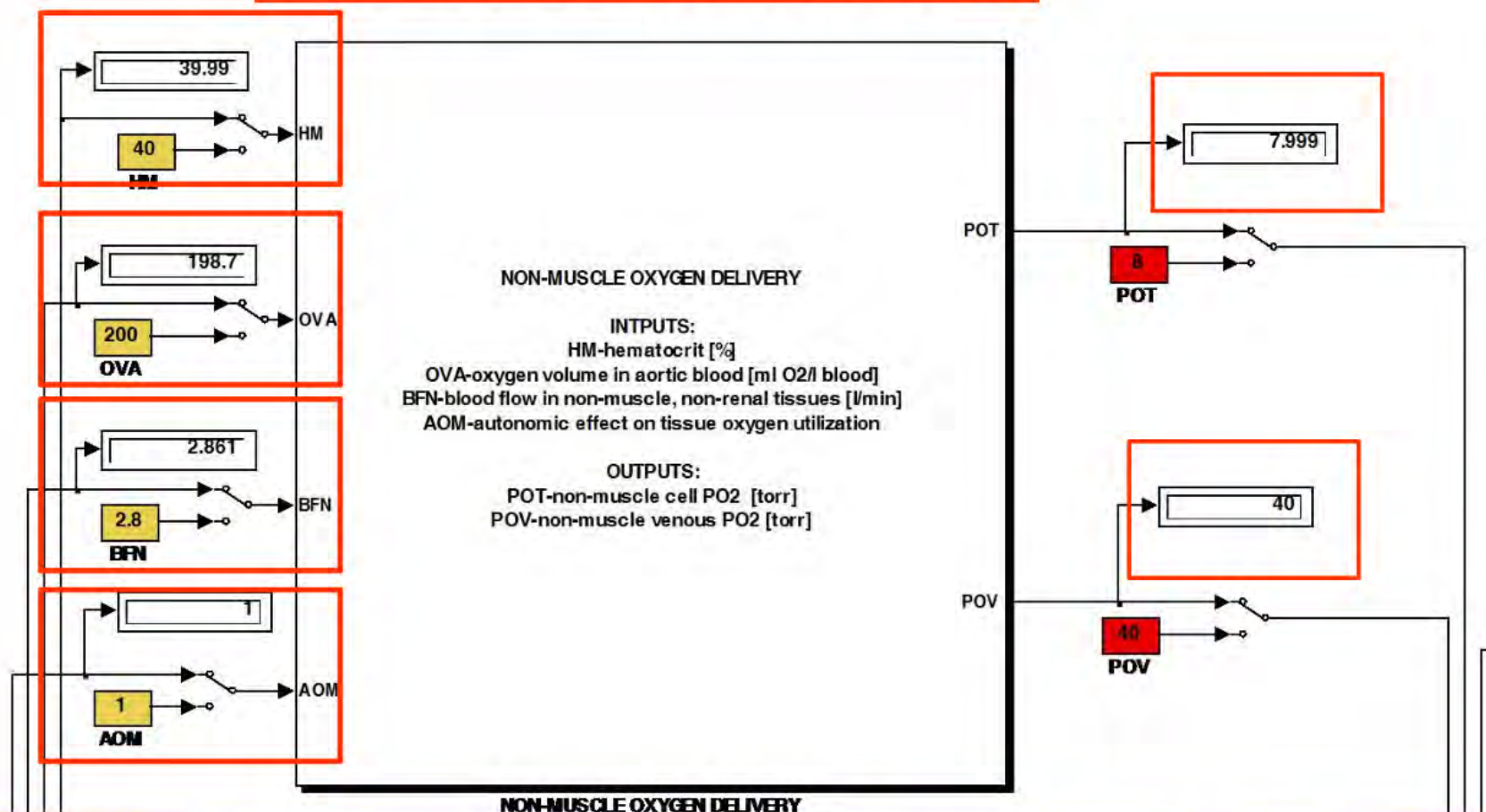


NON-MUSCLE OXYGEN DELIVERY



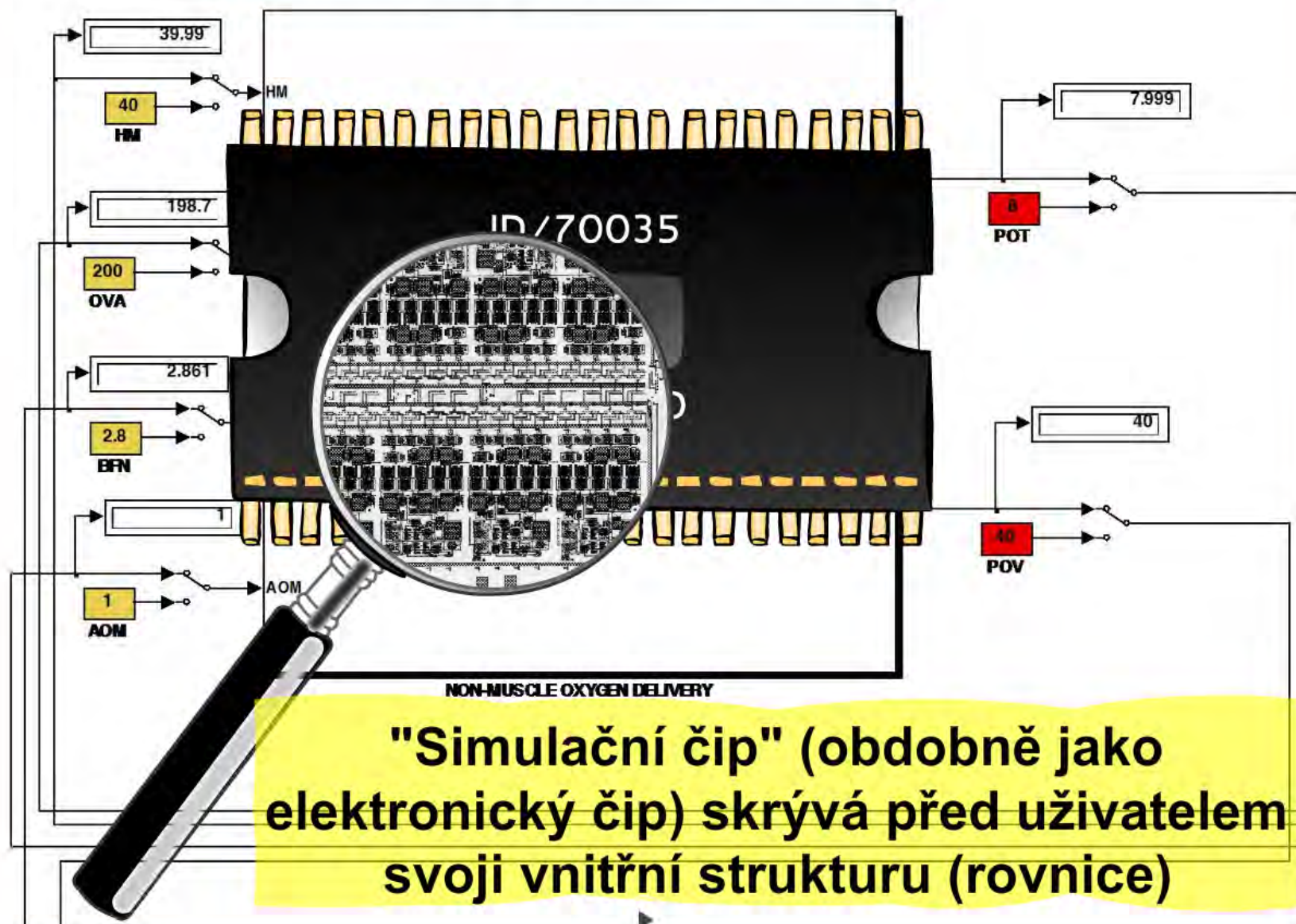
Agregovaný simulační blok s definovanými vstupy a výstupy je pro fyziology mnohem srozumitelnější

NON-MUSCLE OXYGEN DELIVERY

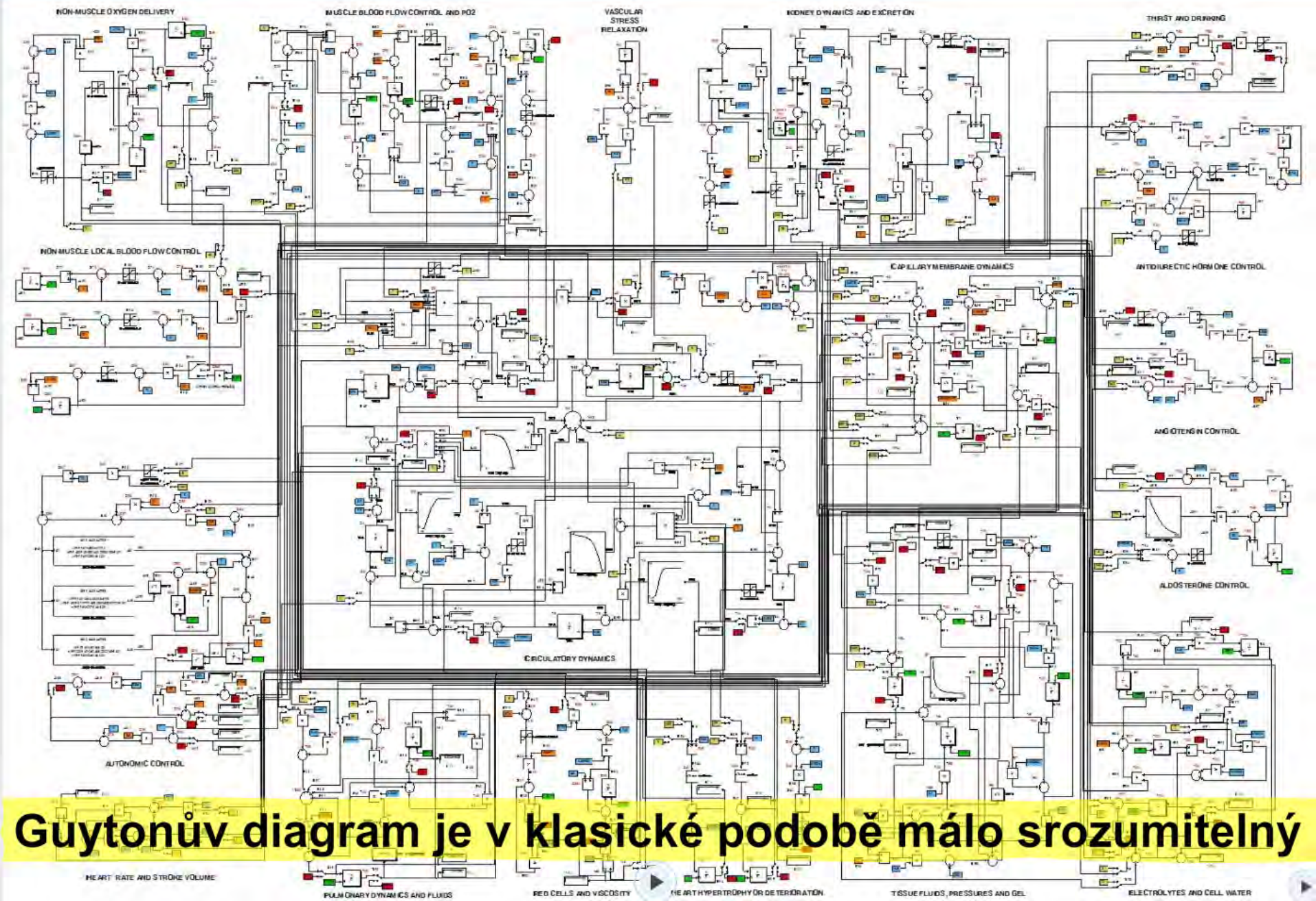


V simulačním nástroji "Simulink" můžeme testovat chování agregovaného simulačního bloku

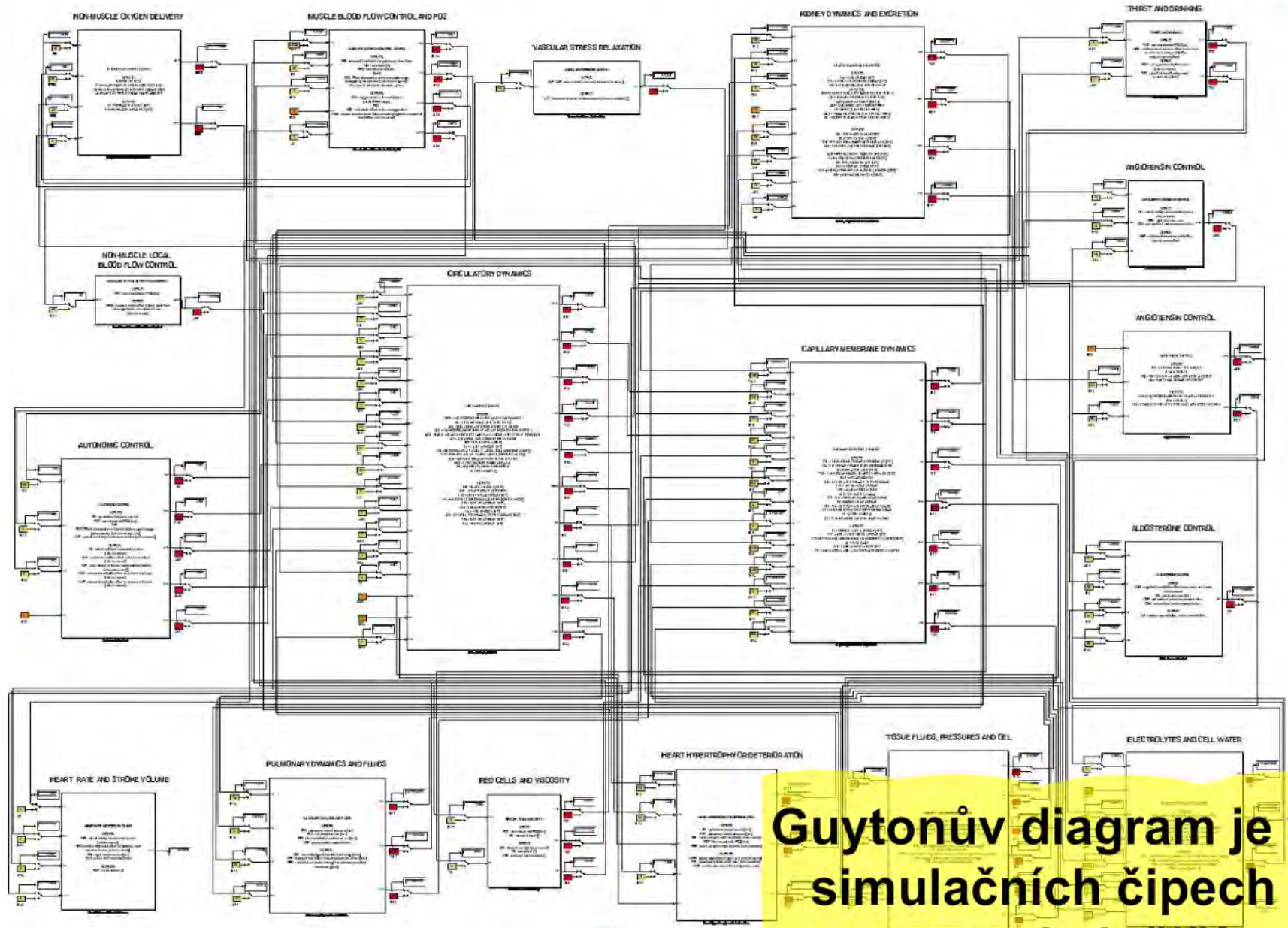
NON-MUSCLE OXYGEN DELIVERY



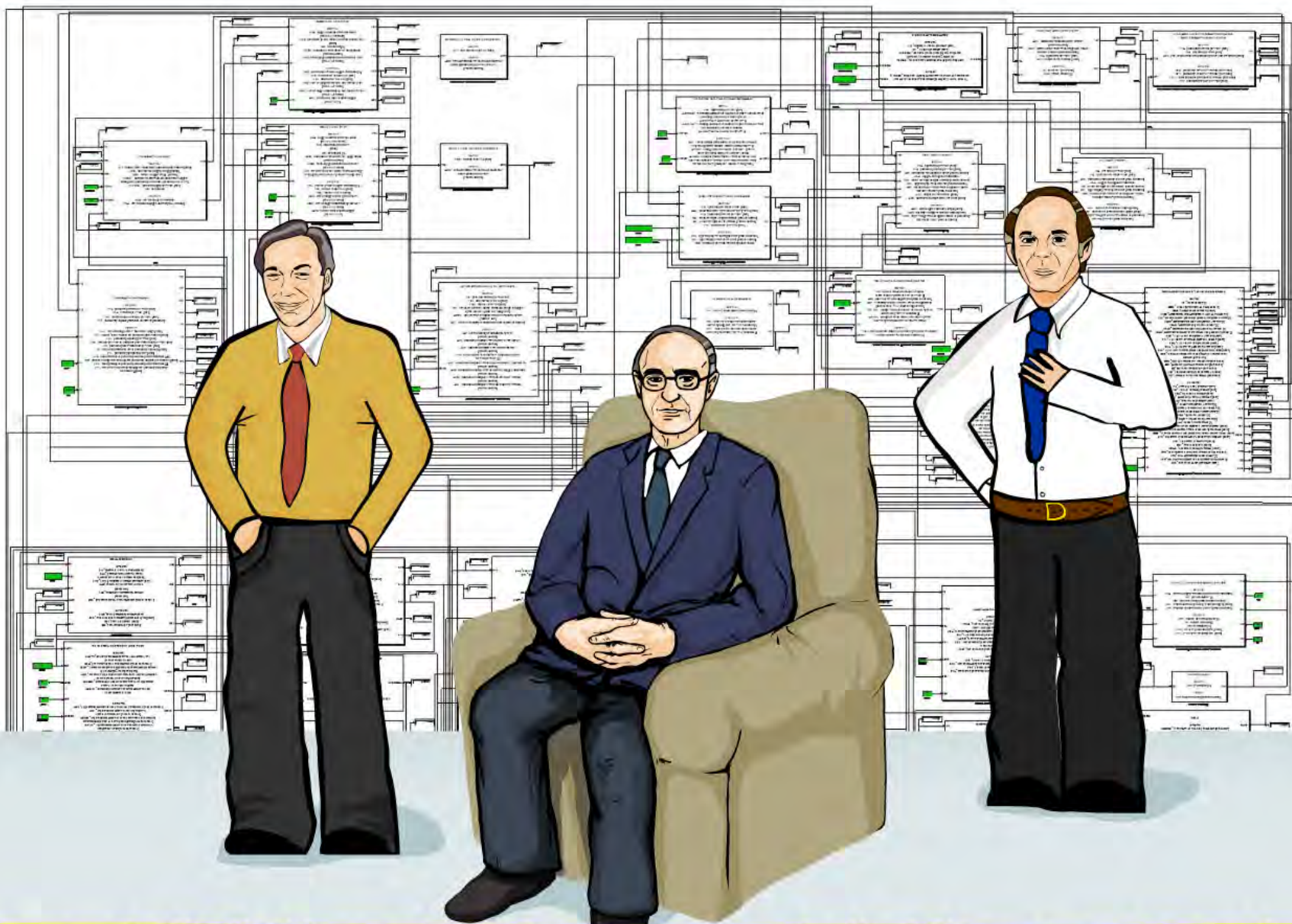
Simulinková knihovna PhysiLibrary



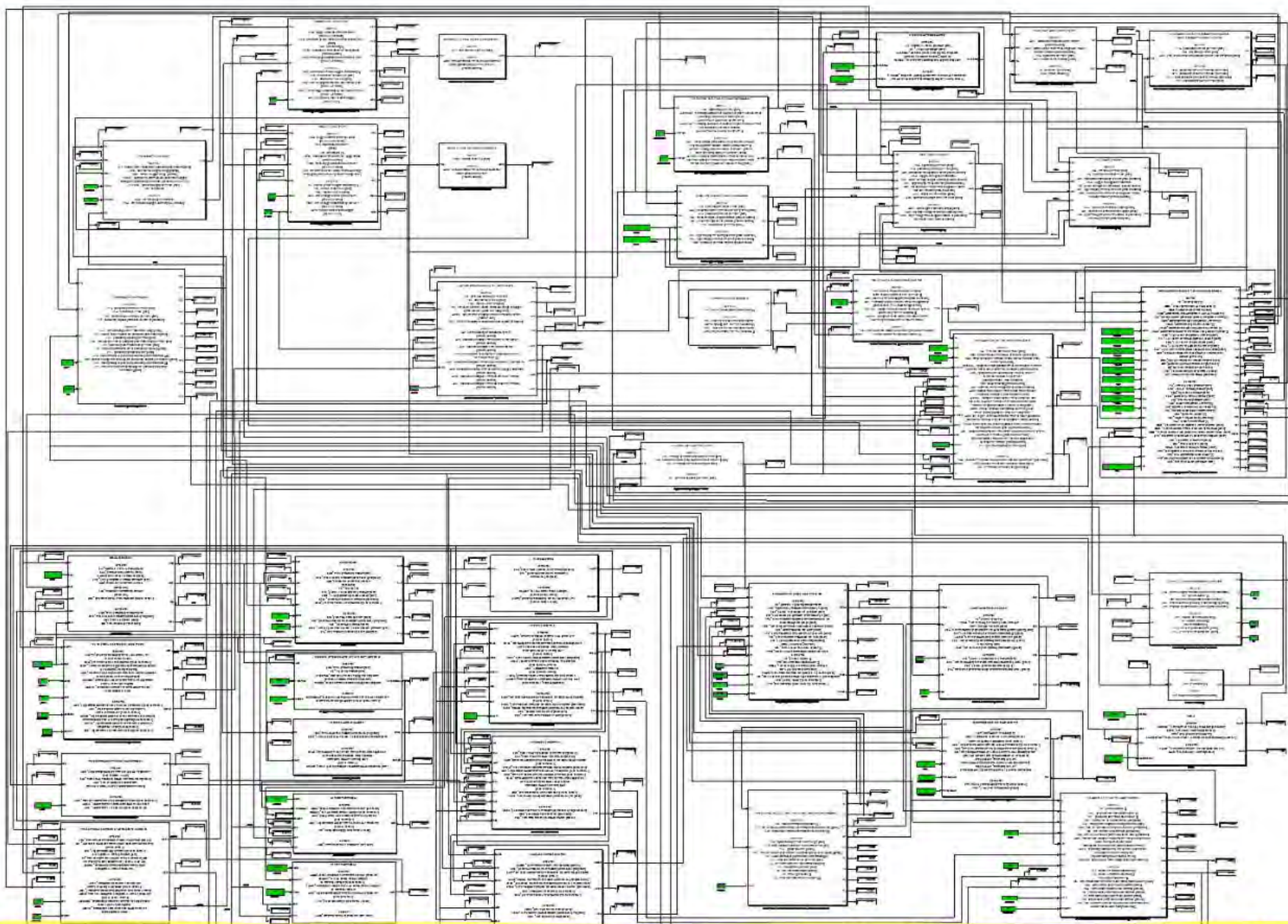
Guytonův diagram je v klasické podobě málo srozumitelný



**Guytonův diagram je v
simulačních čípech
srozumitelnější**

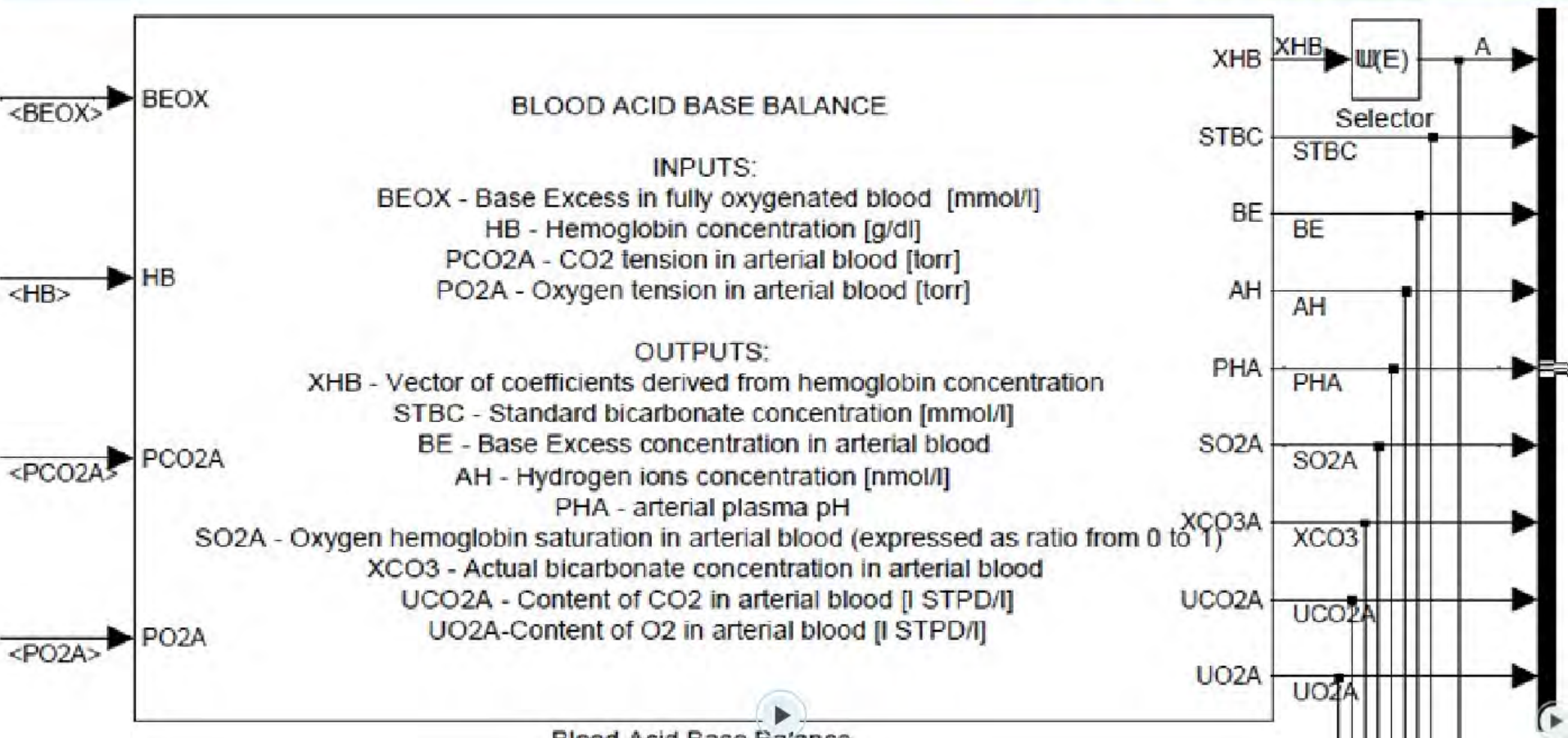


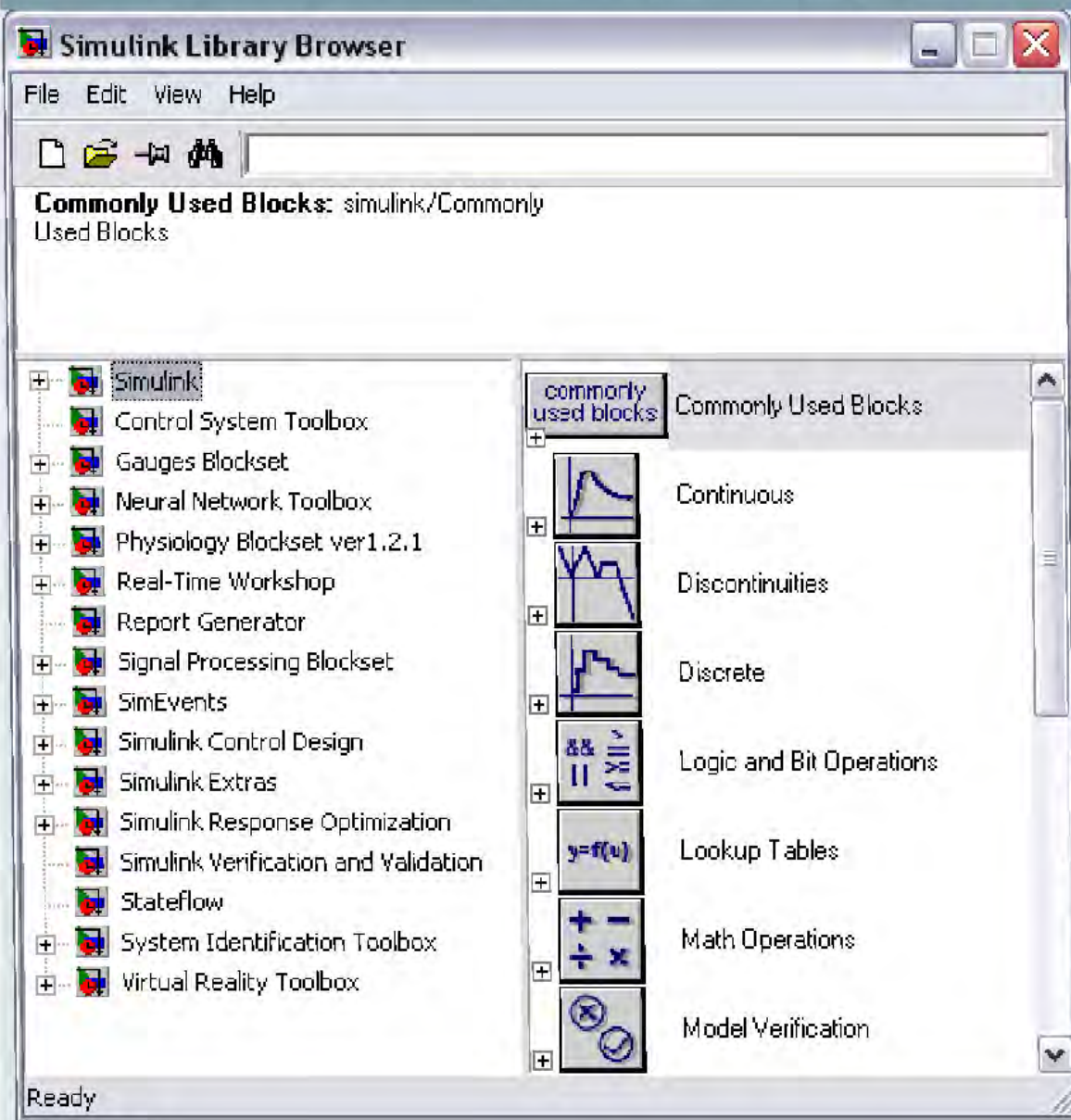
Pro složitější modely jsou "simulační čipy" nutností



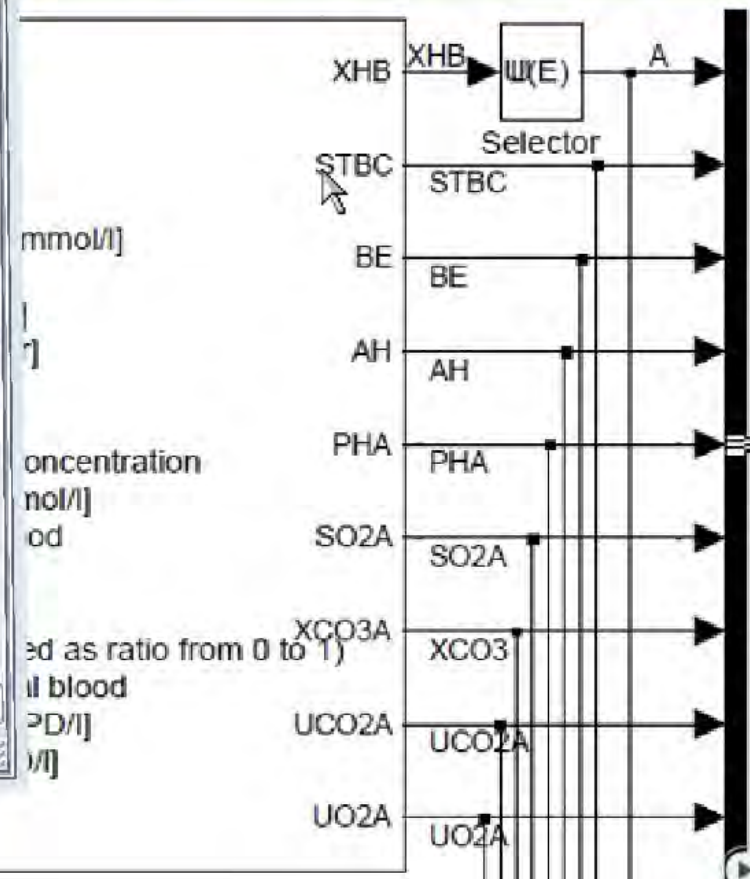
Pro složitější modely jsou "simulační čipy" nutností

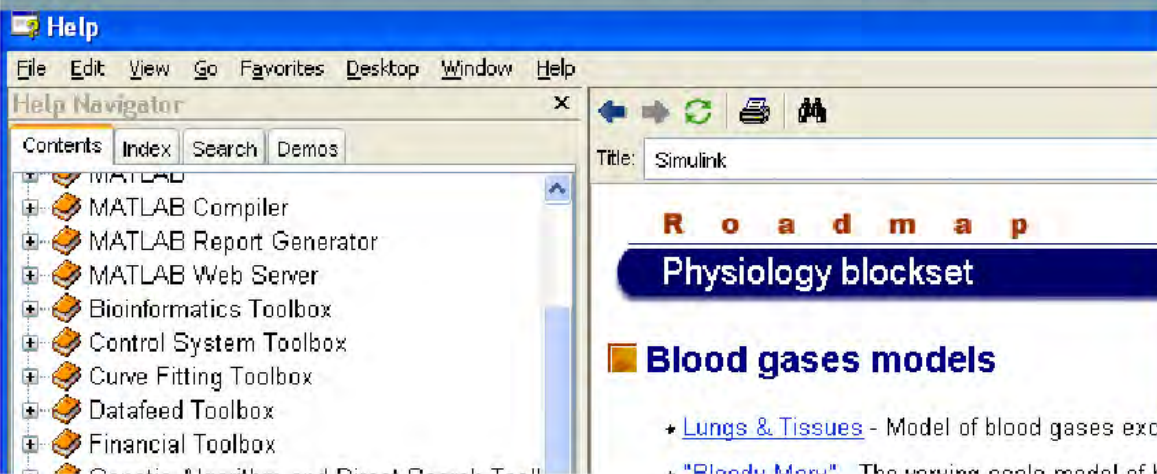
**Jednou už vytvořené
"Simulačních čipy"
jsou znovupoužitelné!
Dají se využívat v
různých modelech**





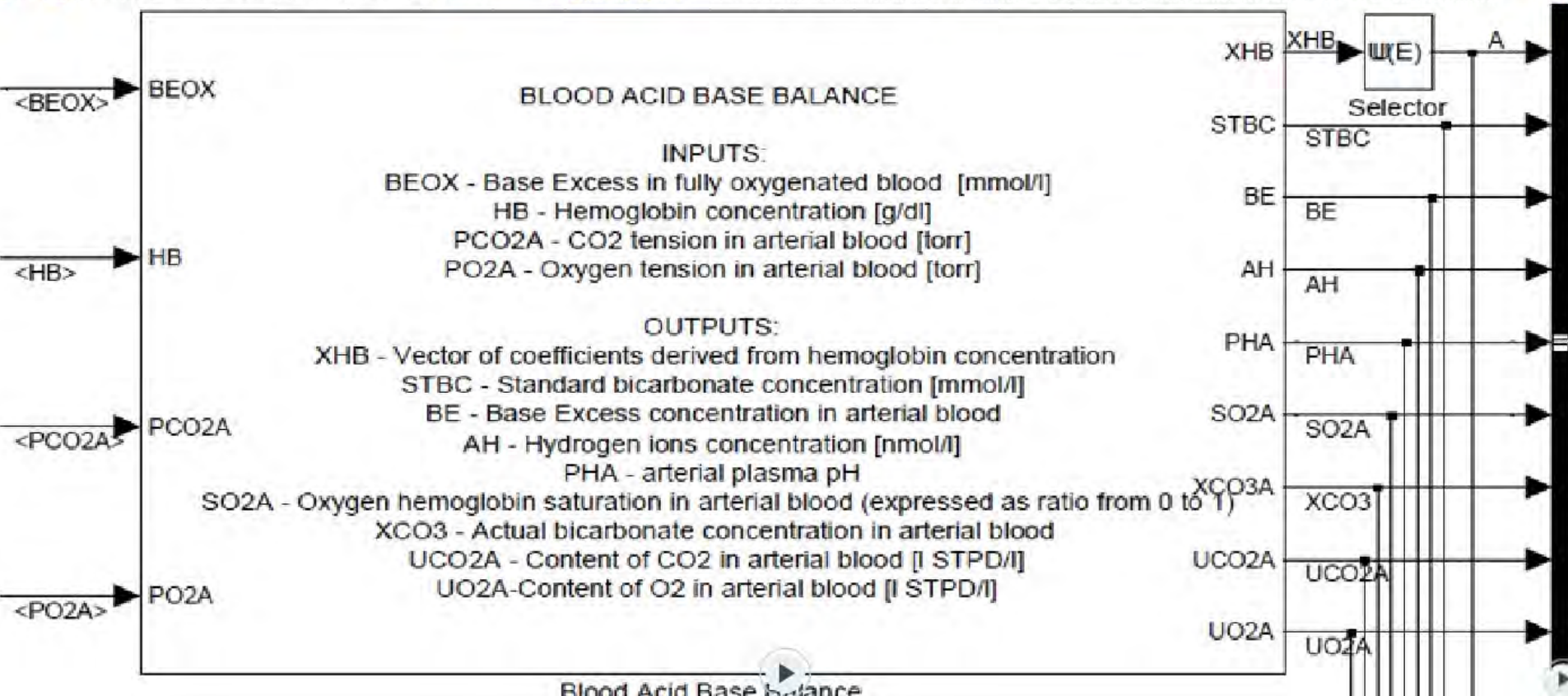
**Ve veřejně přístupné
knihovně
PHYSIOLIBRARY je
nabídka "simulačních
čipů" ke stažení**



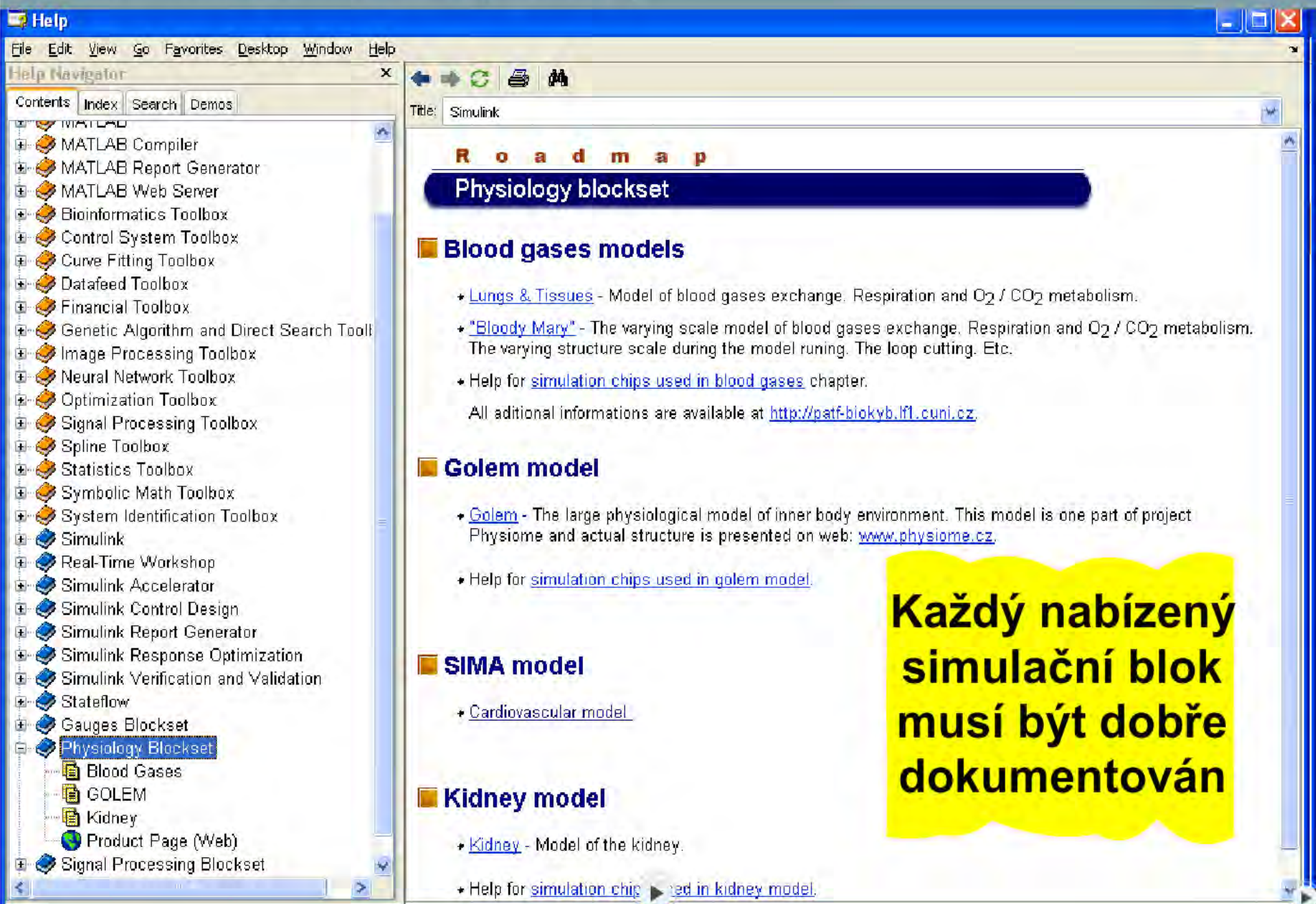


Ve veřejně přístupné knihovně

PHYSIOBRARY je nabídka "simulačních čipů" ke stažení



Simulinková knihovna Physioblibrary



Help

File Edit View Go Favorites Desktop Window Help

Help Navigator

Contents Index Search Demos

MATLAB

- MATLAB Compiler
- MATLAB Report Generator
- MATLAB Web Server
- Bioinformatics Toolbox
- Control System Toolbox
- Curve Fitting Toolbox
- Datafeed Toolbox
- Financial Toolbox
- Genetic Algorithm and Direct Search Tool
- Image Processing Toolbox
- Neural Network Toolbox
- Optimization Toolbox
- Signal Processing Toolbox
- Spline Toolbox
- Statistics Toolbox
- Symbolic Math Toolbox
- System Identification Toolbox
- Simulink
- Real-Time Workshop
- Simulink Accelerator
- Simulink Control Design
- Simulink Report Generator
- Simulink Response Optimization
- Simulink Verification and Validation
- Stateflow
- Gauges Blockset
- Physiology Blockset**
 - Blood Gases
 - GOLEM
 - Kidney
 - Product Page (Web)
- Signal Processing Blockset

Title: Simulink

R o a d m a p

Physiology blockset

Blood gases models

- ✦ [Lungs & Tissues](#) - Model of blood gases exchange. Respiration and O_2 / CO_2 metabolism.
- ✦ ["Bloody Mary"](#) - The varying scale model of blood gases exchange. Respiration and O_2 / CO_2 metabolism. The varying structure scale during the model runing. The loop cutting. Etc.
- ✦ Help for [simulation chips used in blood gases](#) chapter.

All additional informations are available at <http://patf-blokyb.f1.cuni.cz>.

Golem model

- ✦ [Golem](#) - The large physiological model of inner body environment. This model is one part of project Physiome and actual structure is presented on web: www.physiome.cz.
- ✦ Help for [simulation chips used in golem model](#).

SIMA model

- ✦ [Cardiovascular model](#)

Kidney model

- ✦ [Kidney](#) - Model of the kidney.
- ✦ Help for [simulation chip used in kidney model](#).

**Každý nabízený
simulační blok
musí být dobře
dokumentován**

Simulinková knihovna Physioblibrary

Help

File Edit View Go Favorites Desktop Window Help

Help Navigator

Contents Index Search Demos

- MATLAB Compiler
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- Bioinformatics Toolbox
- Control System Toolbox
- Curve Fitting Toolbox
- Datafeed Toolbox
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- Statistics Toolbox
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- Real-Time Workshop
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- Simulink Report Generator
- Simulink Response Optimization
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- Gauges Blockset
- Physiology Blockset
 - Blood Gases
 - GOLEM
 - Kidney
 - Product Page (Web)
- Signal Processing Blockset
- Support and Web Services

Title: How Simulink Works (Using Simulink)

Physiology blockset - SIMA, Cardiovascular model

SIMA - Cardiovascular model

SIMA CM is an implementation of cardiovascular model according to description in [Applied Mathematical Models in Human physiology](#), Chapter 6. It's assembled from building blocks found in SIMA simulator part of library.

Current version in Physioblibrary serves as a demonstration and provides three outputs:

- Atrial pressure [mmHg]
- Left ventricular pressure [mmHg]
- Left ventricular volume [ml]

Number of outputs can be changed easily.



**Každý nabízený
simulační blok
musí být dobře
dokumentován**



MODELLING THE RESPIRATORY CONTROL SYSTEM IN HUMAN SUBJECTS FOR EXERCISE CONDITIONS

In our model, blood pH is calculated using a model developed by researchers at the University of Prague (Kofranek et al., 2007). The calculation can be regarded as a computer implementation of the Siggaard-Andersen nomogram which was explained in



A THESIS

SUBMITTED TO THE FACULTY OF ENGINEERING

OF THE UNIVERSITY OF GLASGOW

FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY



**Knihovna
"simulačních čipů"
PHYSIOLIBRARY
je využívána**

The screenshot shows a software window titled "Simulinková knihovna Physiolibrary". The window has a menu bar with "Window" and "Help", and a toolbar with navigation icons. The main content area displays the title "ref: GOLEM" and a subtitle "Help for Physiological Blockset - (blocks references)". Below this is a large heading "Golem library - Alphabetical List of blocks references". A section titled "GOLEM Library" in red text lists 15 physiological blocks, each preceded by a small diamond icon. The list includes: Acid Base Metabolic Balance, Blood Acid Base Balance, Blood Glucose Control, Body Fluid Volume Balance, Ca & Mg Balance, Cardiovascular Block, Chloride Balance, Controller of Renal Function, Diuresis & Urine Osmolarity, Interstitial Pressure and Lymph Flow Rate, Na & K Balance, and O₂ & CO₂ Exchange. A yellow callout box on the right contains text in Czech describing the library as a model for the Golem simulator.

Window Help

Title: ref: GOLEM

Help for Physiological Blockset - (blocks references)

Golem library - Alphabetical List of blocks references

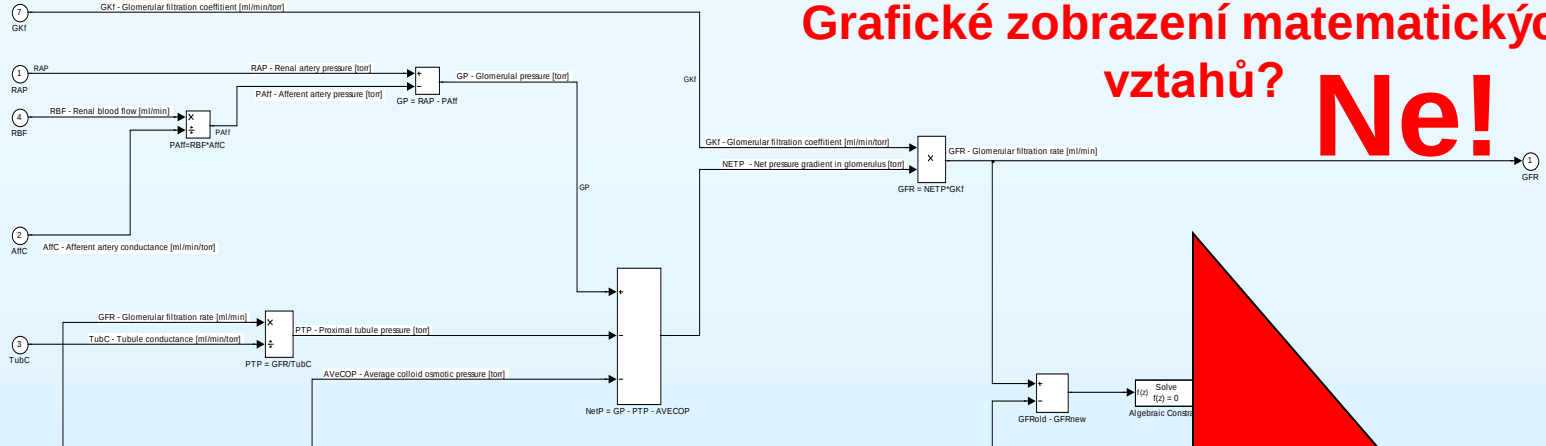
GOLEM Library

- ♦ Acid Base Metabolic Balance
- ♦ Blood Acid Base Balance
- ♦ Blood Glucose Control
- ♦ Body Fluid Volume Balance
- ♦ Ca & Mg Balance
- ♦ Cardiovascular Block
- ♦ Chloride Balance
- ♦ Controller of Renal Function
- ♦ Diuresis & Urine Osmolarity
- ♦ Interstitial Pressure and Lymph Flow Rate
- ♦ Na & K Balance
- ♦ O₂ & CO₂ Exchange

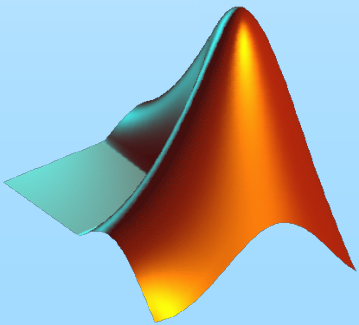
**Součástí knihovny
PHYSIOLIBRARY je i
model, který byl
podkladem výukového
simulátoru GOLEM**



Grafické zobrazení matematických vztahů? **Ne!**



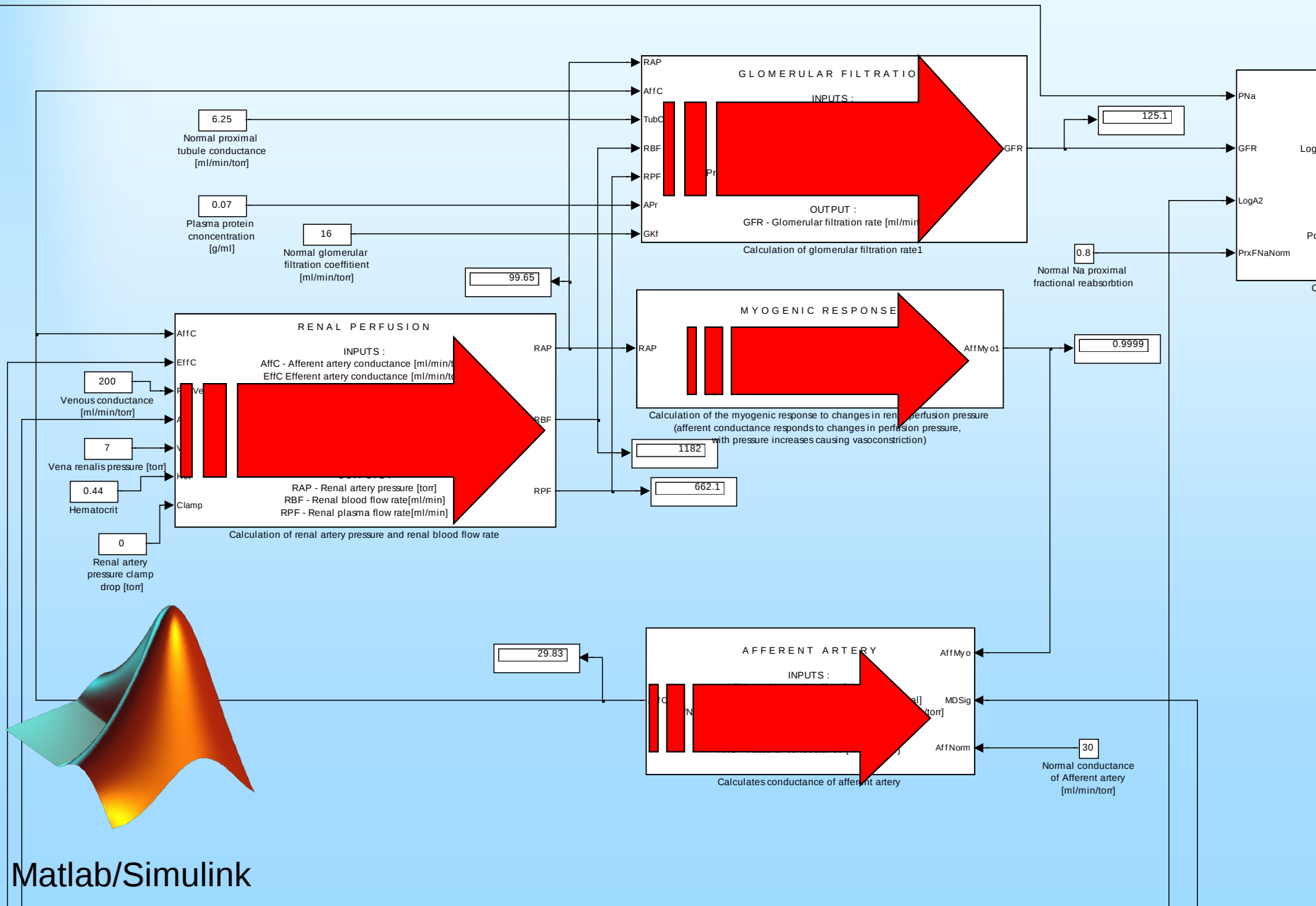
**Grafické zobrazení
transformace
vstupních hodnot na výstupní**



Matlab/Simulink



Softwarové nástroje pro tvorbu modelů



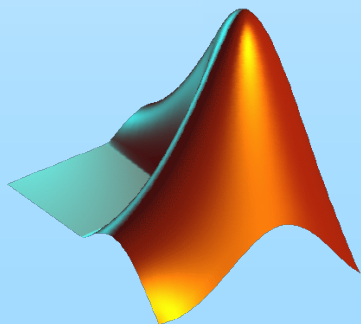


Kauzální modelovací nástroje

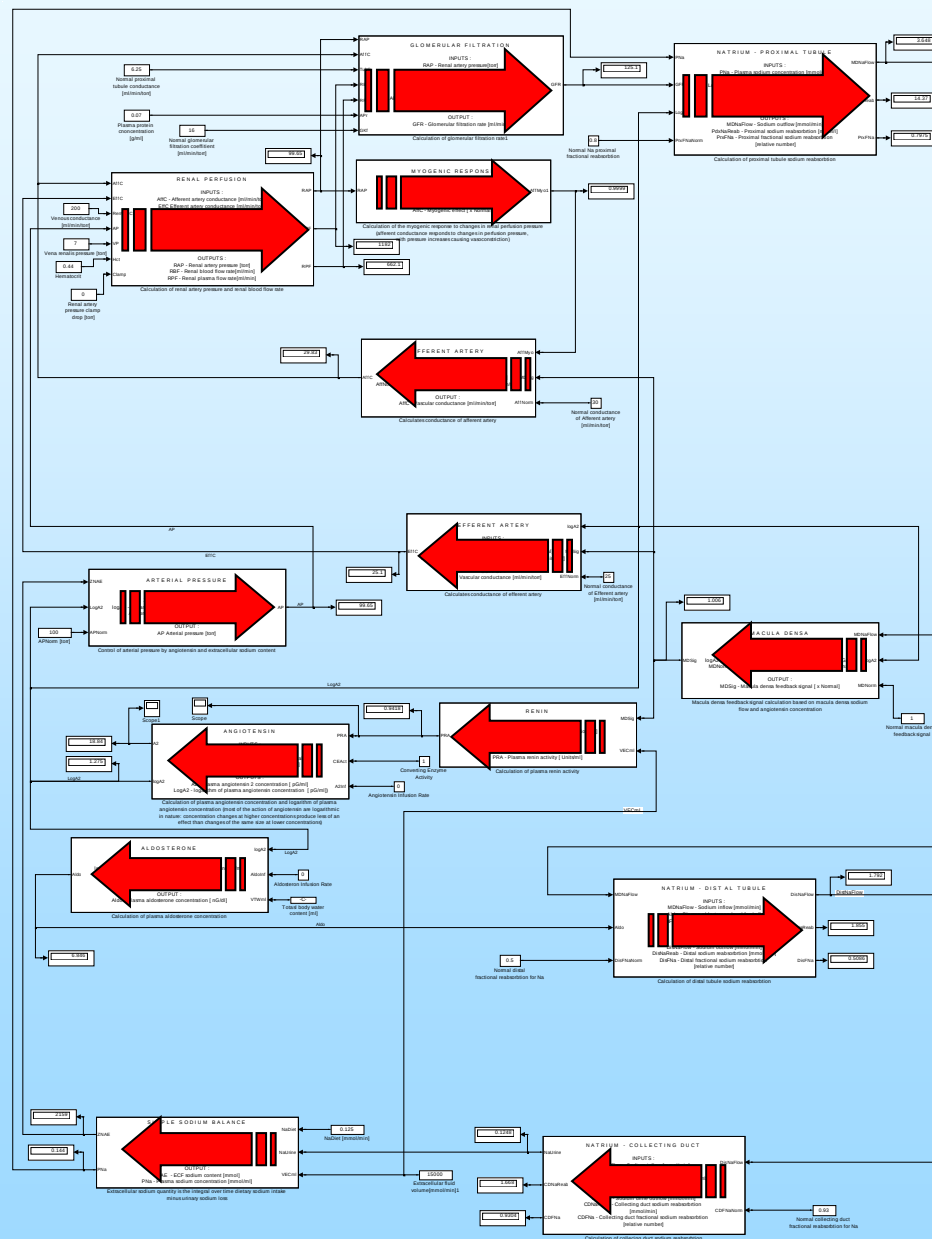
*Je jednoznačně
definován
postup výpočtu*

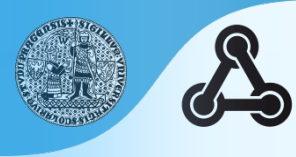
Kauzální modelování

*Model v Simulinku
vyjadřuje spíše
způsob výpočtu než
strukturu modelované
reality*



Matlab/Simulink



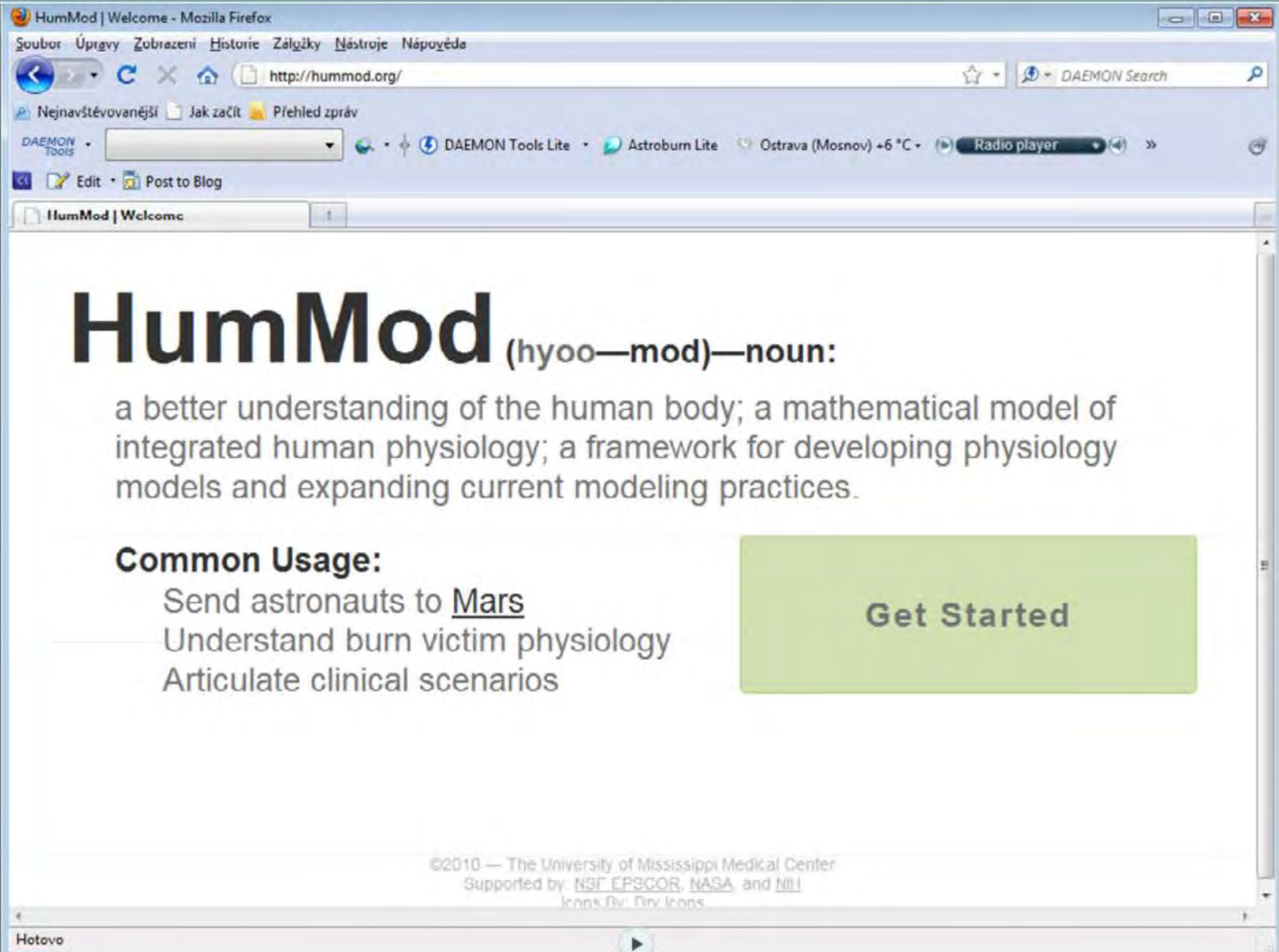


Modelica pro simulace



Guytonův model po 40 letech

Model HumMod (QHP - Quantitative Human Physiology)



The screenshot shows a Mozilla Firefox browser window with the title "HumMod | Welcome - Mozilla Firefox". The address bar shows "http://hummod.org/". The browser's toolbar includes various icons for navigation and search. The website content features a large heading "HumMod" followed by a definition in parentheses and a noun label. Below this is a descriptive paragraph. A section titled "Common Usage:" lists three bullet points. A prominent green button labeled "Get Started" is positioned to the right of the usage list. At the bottom, a copyright notice and supporting organizations are listed.

HumMod | Welcome - Mozilla Firefox

Soubor Úpravy Zobrazení Historie Záložky Nástroje nápověda

http://hummod.org/

Nejnavštěvovanější Jak začít Přehled zpráv

DAEMON Tools DAEMON Tools Lite Astroburn Lite Ostrava (Mosnov) +6 °C Radio player

Edit Post to Blog

HumMod

(hyoo—mod)—noun:

a better understanding of the human body; a mathematical model of integrated human physiology; a framework for developing physiology models and expanding current modeling practices.

Common Usage:

- Send astronauts to Mars
- Understand burn victim physiology
- Articulate clinical scenarios

Get Started

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Supported by: [NSF EPSCOR](#), [NASA](#), and [NIH](#)
Icons By: Tiny Icons

Hotovo

Model HumMod (Quantitative Human Physiology) je patrně dnes nejrozsáhlejším modelem integrativní fyziologie člověka

The screenshot shows a web browser window with the HumMod website. The browser's address bar shows 'HumMod | Welcome'. The website has a light blue header with navigation links like 'Edit' and 'Post to Blog'. The main content area features the title 'HumMod' in large black font, followed by its pronunciation '(hyoo—mod)—noun:' and a descriptive paragraph. Below this, a 'Common Usage:' section lists three bullet points. A green 'Get Started' button is positioned to the right of the usage list. At the bottom, a copyright notice for 2010 is displayed, along with logos for NSF, EPSCOR, NASA, and NIH.

HumMod (hyoo—mod)—noun:

a better understanding of the human body; a mathematical model of integrated human physiology; a framework for developing physiology models and expanding current modeling practices.

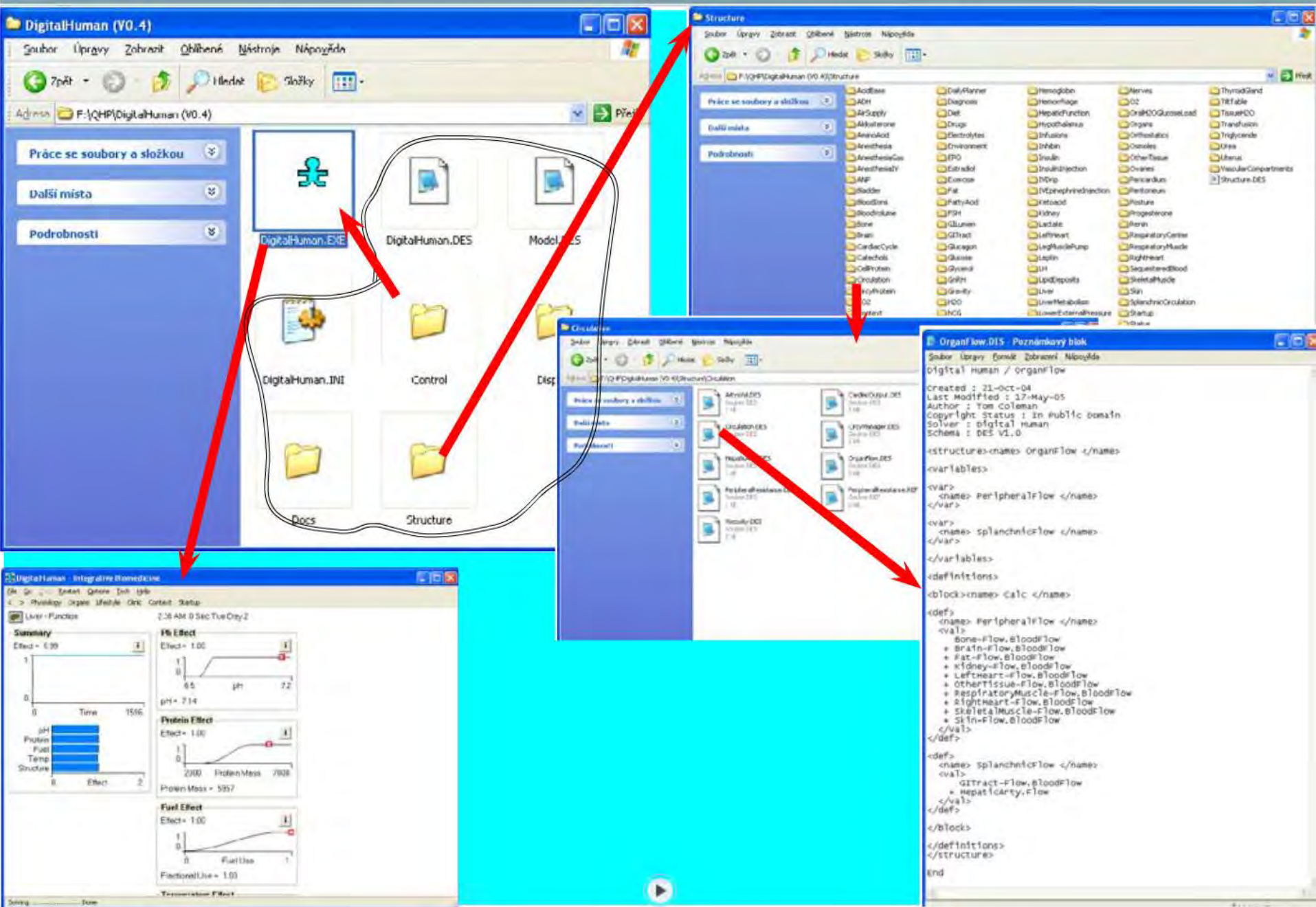
Common Usage:

- Send astronauts to Mars
- Understand burn victim physiology
- Articulate clinical scenarios

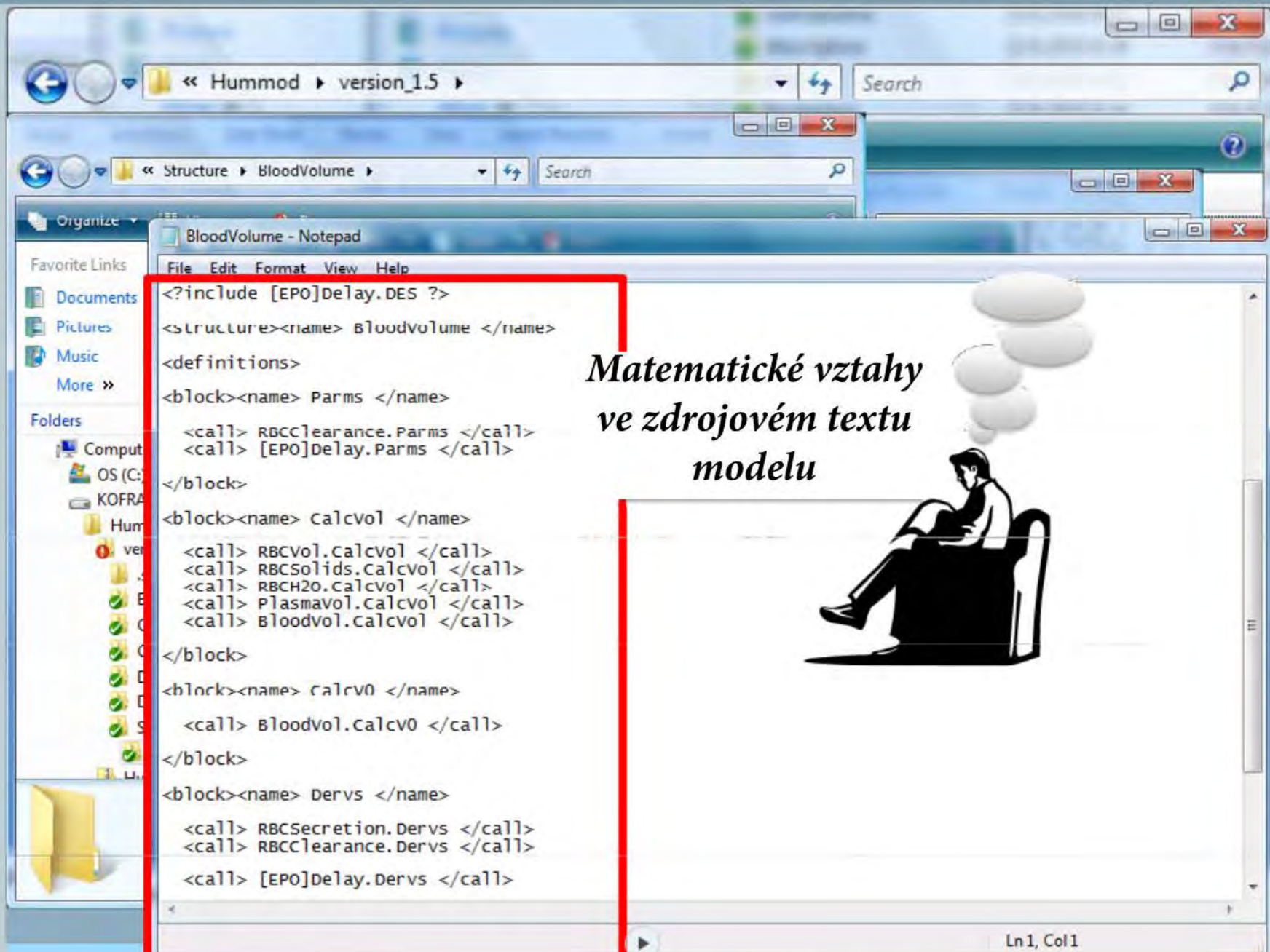
Get Started

©2010 — The University of Mississippi Medical Center
Supported by: NSF EPSCOR, NASA, and NIH
Icons By: Dry Icons

Model HumMod (QHP - Quantitative Human Physiology)



Model HumMod (QHP - Quantitative Human Physiology)



Hummod version_1.5

Structure BloodVolume

BloodVolume - Notepad

File Edit Format View Help

```
<?include [EPO]Delay.DES ?>
<structure><name> Bloodvolume </name>
<definitions>
<block><name> Parms </name>
  <call> RBCClearance.Parms </call>
  <call> [EPO]Delay.Parms </call>
</block>
<block><name> calcvol </name>
  <call> RBCvol.calcvol </call>
  <call> RBCsolids.calcvol </call>
  <call> RBCH2O.calcvol </call>
  <call> PlasmaVol.calcvol </call>
  <call> Bloodvol.calcvol </call>
</block>
<block><name> calcv0 </name>
  <call> Bloodvol.calcv0 </call>
</block>
<block><name> Dervs </name>
  <call> RBCSecretion.Dervs </call>
  <call> RBCClearance.Dervs </call>
  <call> [EPO]Delay.Dervs </call>
```

*Matematické vztahy
ve zdrojovém textu
modelu*

Ln 1, Col 1



HumMod

Version 1.2.1

Build : Apr 20 2010

University of Mississippi Medical Center
Jackson, MS 39216 USA

Dr. Tom Coleman

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Dr. Robert Hester

Department of Physiology Biophysics
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Dr. Richard Summers

Department of Emergency Medicine
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www.hummod.org



Thomas Coleman

***Thomas Coleman -
spoluautor původního
Guytonova modelu
a nyní hlavní architekt
modelu HumMod na
návštěvě v Praze***

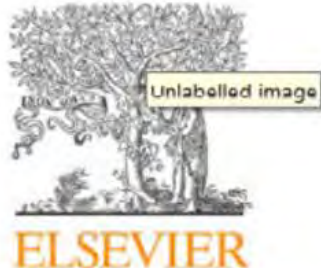
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Location:	D:\Hummod
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Contains:	14 115 Files, 9 674 Folders



SAPHIR: a physiome core model of body homeostasis and blood pressure

BY S. RANDALL THOMAS, JEAN-PIERRE KOFRANEK & RUSZ 2007), *et al.* 1972) with SIMULINK has recently been published (Kofranek & Rusz 2007), not to mention the current very elaborate and comprehensive Quantitative Human Physiology model at the University of Mississippi, directly descended from the early Guyton models by the colleagues of Guyton (Abram *et al.* 2007). The originality of our core model implementation is our commitment to provide documentation for each basic module, interactive modification of any aspect of the model parameters or equations and, especially, the possibility of contributing new detailed local sub-modules to complement or replace selected 'basic modules'.

Crucial to this approach is an underlying computational toolbox that is sufficiently robust to handle the wide range of spatial and temporal scales, as flexible enough to accept sub-modules in a variety of formalisms, including not only ODE/PDE dynamical systems models but also discrete modelling methods (e.g. renal),



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Graphical simulation environments for modelling and simulation of integrative physiology

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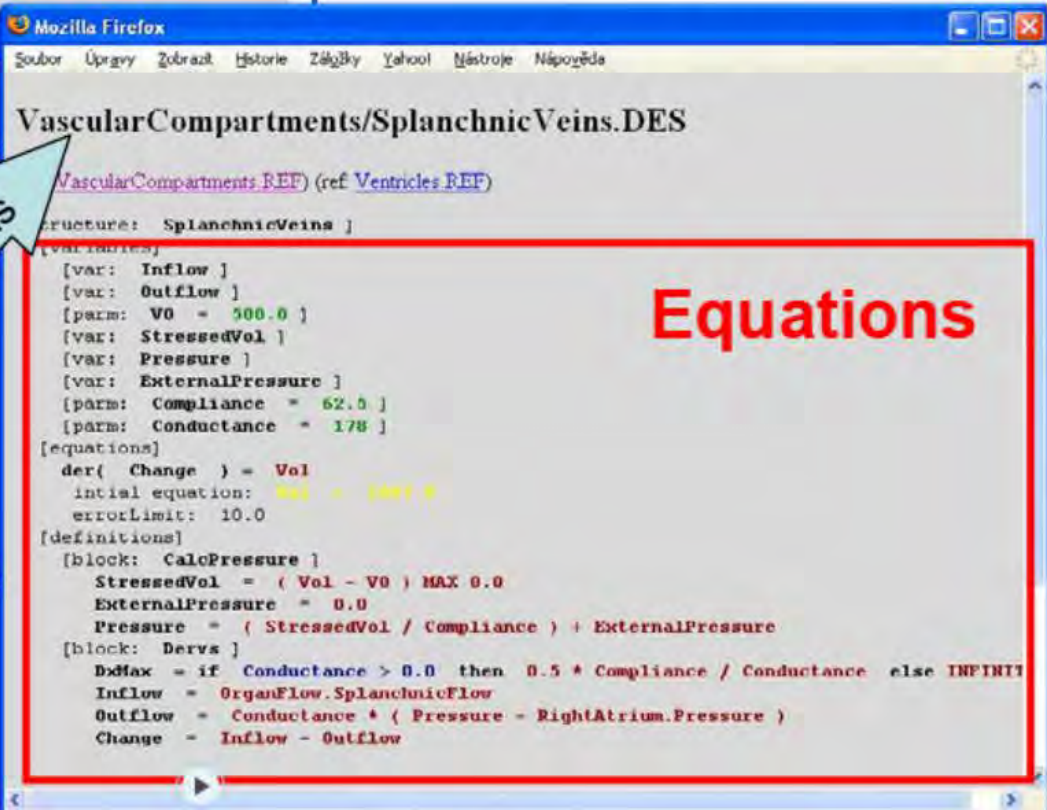
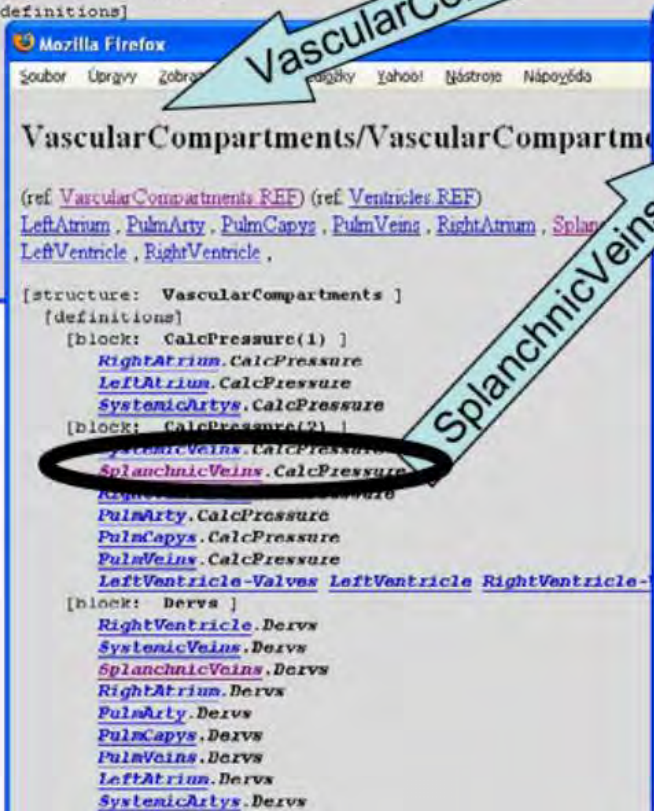
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makes the wider interactions in the model difficult to visualise. Coleman's extension of Guyton's work [5] via the QHP (Quantitative Human Physiology) model was available only in executable form (for teaching purposes) until recently, when an eXtensible Markup Language (XML) version of the model was released [6,7]. This extended model, however, is difficult to read and visualise, since no diagrammatic form exists.

Model HumMod (QHP - Quantitative Human Physiology)



QHPView





Physiolibrary

www.physiolibrary.org

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Physiolibrary

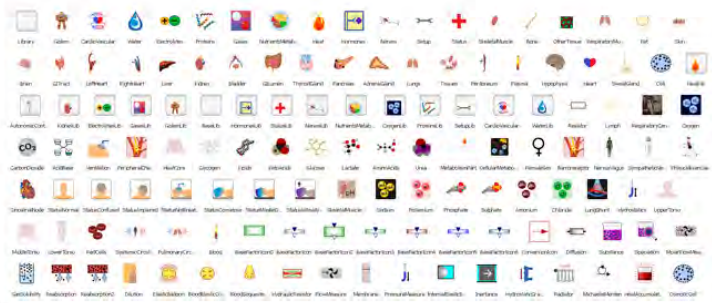
Physiolibrary is a free open-source **Modelica** library designed for modeling human physiology. This library contains basic physical laws governing human physiology, usable for cardiovascular circulation, metabolic processes, nutrient distribution, thermoregulation, gases transport, electrolyte regulation, water distribution, hormonal regulation and pharmacological regulation.

Library description

Our laboratory have a long tradition building physiological libraries, starting with **Physiolibrary in Matlab/Simulink** environment. The origin of this Modelica Physiolibrary was in the first version of our **HumMod Golem Edition** model implementation, where it was called HumMod.Library. As the successors of Guyton's Medical Physiology School write, the original **HumMod** model is "The best, most complete, mathematical model of human physiology ever created". In cooperation with this group we are now developing together the new complex integrative model of physiology called **Physiomodel** based on Physiolibrary and HumMod.

We are also developing many types of smaller physiological models for use in **medical education**, so it was essential to separate this library from our Modelica model implementations. Our Physiolibrary contains only carefully-chosen elementary physiological laws, which are the basis of more complex physiological processes. For example from only three type of blocks (ChemicalReaction, Substance and MolarConservationMass) it is possible to compose the allosteric transitions or the Michaelis-Menten equation.

Library contains also the icons for higher level (HumMod) subsystem implementations:



HumMod-hummod-s...Z...

Zobrazit všechny stažené soubory...

Modelica pro simulace



Physiomodel

Model of physiology in [Modelica](#) based on [HumMod](#) and [Physiolibrary](#)

[View on GitHub](#)

[.zip](#)

nutrientsAndMeta...

heat

water

proteins

gases

cardioVas...

nerves

hormones

electrolytes

status

setup

Physiomodel maintained by [physiology](#)

Published with [GitHub Pages](#)

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