COLLEGE OF INFORMATION SCIENCES AND TECHNOLOGY

THE PENNSYLVANIA STATE UNIVERSITY

Manual for HumMod (Salt Version 3.0.4)

Manual Version: 2.9

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Abstract

HumMod is a tool that simulates the complex physiology of the human body through mathematical models. This manual describes HumMod v3.0.4 Salt (Clemmer et al., 2017), which is not the most recent version (3.2.0 is), however, all the information is relevant to the most recent versions. This manual is designed to provide the reader with a basic understanding of HumMod. We present three introduction simulations with step-by-step instructions for the reader to start running simulations. We then present an overview of how HumMod is programmed with details on the most commonly used commands. This primer should allow a user to begin to modify HumMod to fit their research needs.

This manual also provides the reader with a detailed description of all the screens and variables in the Heat module, along with the directory trees that make up the program. This is meant to give the reader an understanding of the scope and complexity of HumMod.

Acknowledgments

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Any opinions, findings and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the US Army Command Center, Aberdeen Proving Ground, Natick Contracting Division ACC-APG-NCD.

Stephan Crocker provided useful feedback on a final draft. This is a complex document about a complex simulation. We hope this manual is helpful, but we know it is often not fully correct.

Drew Pruett is listed as a co-author, but may not agree with all the criticisms about HumMod in this document.

Conflict of Interest Statement. Frank Ritter is required by the Pennsylvania State University Conflict of Interest Program to include this paragraph [sic]: "I have financial interest with Charles River Analytics Inc., a company in which I provide consulting services and could potentially benefit from the results of this research. The interest has been reviewed and is being managed by the Pennsylvania State University in accordance with its individual Conflict of Interest policy, for the purpose of maintaining the objectivity of research at the Pennsylvania State University."

Table of Contents

1 Introduction

HumMod is currently "the best, most complete, mathematical model of human physiology ever created" (hummod.org). It is based on the work of Dr. Arthur Guyton, who began the quest to create a tool that could simulate the complex human physiology through mathematical equations in the 1970s. Thus, "HumMod is the product of over 40 years of basic physiology research. Over those years, a database of documents and files was amassed. These documents and files support model assumptions and equations" (Hester et al., 2011a; 2011b). HumMod is heavily based on *Guyton and Hall, Textbook of Medical Physiology* (Hall, 2011). It models a fourteen organ system bound together with circulatory, endocrine, and neural systems. The model is composed of 10,420 variables spread over 2,335 blocks. Each block is a collection of ordered commands that will be called in linear order each solution interval, comprising some system or subsystem. This makes HumMod a very large simulation by cognitive science and physiology standards. HumMod offers the data files and equations as the documentation, but to someone who is not familiar with human physiology, it can be difficult to understand. By looking at HumMod through the lens of a manual, we can better explain HumMod's strengths and limitations.

This document starts to provide a manual for people using and extending HumMod. It serves as a deeper introduction than an article as to what variables, parameters, and systems are in HumMod to help those who those who are currently or considering using it. A careful reading will provide numerous open questions and ideas for research projects. On overview of the manual is provided next..

Chapter 2 *How to Load and Run HumMod* contains information needed to download and install HumMod. **Chapter 3** *How to Use HumMod* provides an overview of how to use HumMod and provides example simulations with step-by-step instructions. **Chapter 4** *Understanding HumMod* provides detailed information regarding the inner workings of HumMod with a focus on providing the basic tools needed to modify HumMod to suit your research needs. As an example, **Appendix A** *A Detailed Look at an Example Module: Heat* provides a detailed look at the modules relating to body heat module. **Appendix B** *Files in the Heat System* provides a list of all the files and directories in the heat module. **Appendix C** and **Appendix D** provides a list of all the files and directories in the Structure and Display directories respectively.

Another benefit of HumMod is that it takes a middle-out approach to representing human physiology (Hester et al., 2011a;b), which allows it to represent human physiology at levels that are typically measured in many behavioral and health studies. Thus, one can test out any of the subsystems by running simulations under conditions that mirror existing studies.

In addition, the model can also be run such that another process can communicate with and control the simulation. This allows more seamless integration of the model into other simulation systems, such as ACT-R/Φ (Dancy et al., 2015). Such integration may facilitate the development of models of human physiology (or more generally behavior) above or below those currently represented. For example, one could connect a more fine-grained model of the heart to this system and explore how social interaction affects heart behavior by also adding a model of social behavior.

As with all computational models and simulation systems, the HumMod system has strengths and weaknesses. Strengths of the system include a relatively robust and complete model of human physiology that are relatively easy to manipulate and explore, which is why it has been used to teach courses on physiology. A large advantage of this system is that the model is open-source and in XML. This allows extensions of the system as long as one understands how such variables or subsystems fits in with the overall system (e.g., Dancy & Kim, 2018, explore additional representations related to slow-breathing.)

This also gives the opportunity for models that use a different equation solver system (e.g., Mateják & Kofránek, 2015).

However, this system also has some weaknesses tied to topics such as computational speed of the simulations and the inevitable imbalanced representation of physiology, for example, sex-dependent physiology. Another important draw-back to the system is speed. Depending on the needs of a user, the simulation may not run fast enough. One reason for this is that the system that solves the mathematical equations may not use all the modern optimizations that are available. This can be especially important if a user is attempting to integrate HumMod with another simulation system.

Though HumMod does represent a wide-range of physiological systems, as shown in Table 1, it is still incomplete. For example, it lacks a strong representation of female hormones. This likely is due to the relative sparsity of female physiological data in the medical literature. Though it does not represent female hormones (and likely other sub-systems) with the same level of accuracy as male hormones, this lack of representation follows the sparsity of data and the different modeling projects as the model has gone through development. It also lacks details on the muscle system, the ability to model common drug reactions, and interactions and management of many traumas. Any of these may be added to HumMod and this manual should help with that undertaking.

Table 1.1: List of major systems in HumMod

Adrenal Gland	Creatine	Nerves
Air Supply	Creatinine	Organs
A-V Fistula	Density	Orthostatics
Bladder	Energy	Osmoles
Blood Chemistry	GI Tract	Other Tissue
Blood Vessels	Heart	Ovaries
Blood Volume	Heat	Pancreas
BMI	Hemodialysis	Pericardium
Body Density	Hepatic Artery	Peritoneum
Body Volume	Hepatic Vein	Pituitary Gland
Bone	Hypothalamus	Renin
Brain	Ketoacid	Respiratory Center
Ca	Kidney	Skeletal Muscle
Calcitonin	Lactate	Skin
Cardiac Cycle	Leptin	Symptoms
Catechols	LH	Testes
Cell Protein	Lipid Deposits	Thyroid Gland
Cell SID	Liver	Urea
Cerebrospinal Fluid	Lower External Pressure	Uterus
Circulation	Lungs	Venae Cava
Circy Protein	Metabolism	Venous Valves
Coronary Sinus	Nephrons	
Cortisol	Mineralocorticoid Receptor	

Important Warning about Time Step Size

When the model is run with longer time durations, these use larger time steps for the calculations, which can cause significant and sometimes major inaccuracies in the results. If you use the incorrect time steps for your simulation, the results will not be accurate and sometimes greatly so.

Section 4.6 *Timing* in HumMod details how timing works in HumMod and how to create custom time steps and durations. The inaccuracies of using the incorrect time steps are explored as an example exercise in Section 3.1.3.

Note About Pathnames

HumMod only runs on Windows and as such all pathnames in the document are specified in Windows format—using backslashes instead of forward slashes to delimitate directories.

However, when pathnames are displayed within HumMod both forward and backslashes are used; the rightmost slash will be a backslash, the rest are forward. This artifact in the display has no effect on system performance.

2 How to Load and Run HumMod

HumMod currently only works on Windows. To utilize it on a Mac, an emulator or virtual environment is necessary.

To obtain the version of HumMod-Salt used in this manual:

1. Download HumMod-Salt at https://github.com/HumMod/hummod-salt/tree/master.
2. Download all the files as a .ZIP file.
3. Extract the contents of the .ZIP file to your preferred location on your computer.
4. Run HumMod.EXE.

If you wish to download an older version of HumMod:

1. HumMod can be downloaded at www.hummod.org.
2. Select Standalone Package.
3. Read the terms and conditions.
4. Check "I have read and agree to the above terms and conditions."
5. Click Download button.
6. Extract the contents of the .ZIP file to your preferred location on your computer.
7. Run HumMod.EXE

3 How to Use HumMod

When HumMod is first opened, the user will be presented with the default HumMod home screen as shown in Figure 3.1, which displays the most important physiological variables; the home screen can always be brought up by going to Diagnosis->Chart in the menu bar. The right side of the screen shows renal perturbations, which were of interest to the project that developed HumMod v3.0.4 Salt, the version of HumMod that this manual is based on. The current version, 3.2.0, was not publicly available at the time this document was compiled. It may be necessary to enlarge the window to view all the information.

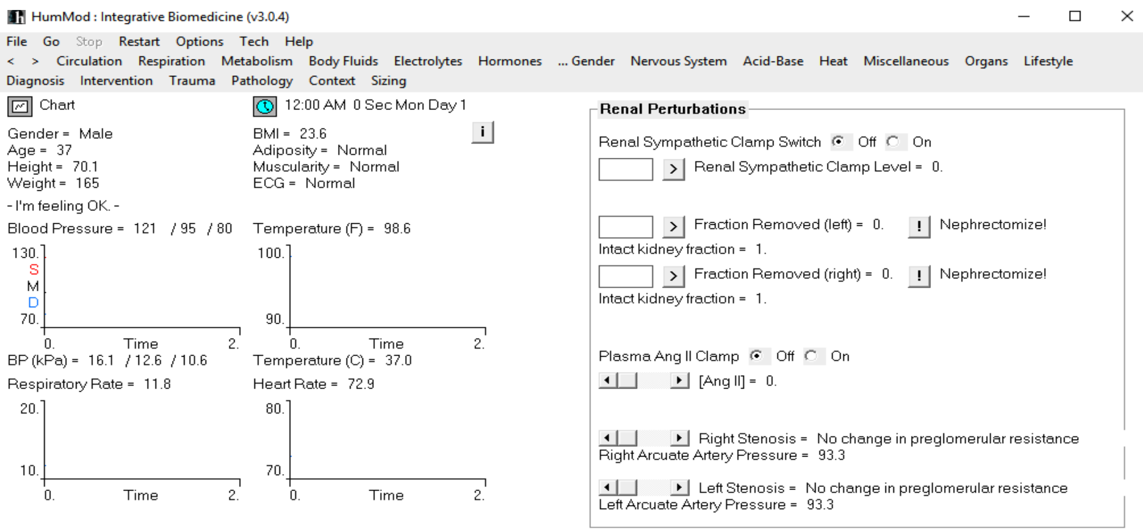

Figure 3.1: HumMod Home Screen. This is the initial default screen displaying the most important physiological variables. The left side of the screen is a summary of the simulated person's state. The right side displays renal perturbations.

Once HumMod is opened, the user may modify any of the controls to meet the needs of their particular simulation. To start the simulation, go to "Go" and select a time duration to run the simulation for. HumMod should finish the calculation in (at most) a few minutes and the display and charts will be periodically updated during the calculation. The available options range from 1s to 90 days, and with some effort, custom times may be added by the user (more details are provided in Section 4.6). Be aware that the longer time durations use larger time steps for the calculations, which can cause significant and sometimes major inaccuracies in the results. This is further discussed in the introduction, Section 4.6.1, and explored as an example exercise in Section 3.1.3.

Once the simulation time has been completed, the user has a few options: they may restart the simulation, run the simulation for a longer time period, or modify some of the controls and continue the simulation. This process may be repeated as many times as necessary. Be aware that if the simulated subject dies and the HumMod continues to run, the simulation will become inaccurate and will possibly crash. Example simulations with step-by-step instructions are provided in Section 3.1.

3.1 Example Exercises

This chapter covers a few introductory HumMod simulations intended for instructional purposes. The example exercises are ordered in increasing complexity.

3.1.1 Ventricular Fibrillation

For this exercise, we will put a normal person into ventricular fibrillation and then shock their heart back to normal rhythm.

1. Open HumMod and run for 1 hour by going to Go->1 Hour. This step is not necessary when running HumMod for demonstrating or training purposes; however, it allows the variables to reach equilibrium and produces more accurate results. For best results run for at least 1 day (this will only take a few minutes in real time). HumMod will report when it finishes in the bottom left of the screen.

2. Open the Ventricular Fibrillation screen by going to Trauma->Ventricular Fibrillation. You should see a window similar to Figure 3.2. HumMod can have up to 10 screens open at one time and the user can switch between screens by using the forward and back buttons below the menu bar.

Figure 3.2: Ventricular Fibrillation screen.

3. Press "On" next to "Start VFib." The simulated person is now in ventricular fibrillation.

4. Run the simulation for 2 minutes by running HumMod for 1 minute twice.

5. Press one of the arrows on the left side of the menu bar to cycle back to the chart screen. Notice that person was normal, and now Heart Rate, Blood Pressure, and Respiratory Rate have all dropped to zero (or close to zero).

6. Go to Intervention->Defibrillator. You should see a window similar to Figure 3.3.

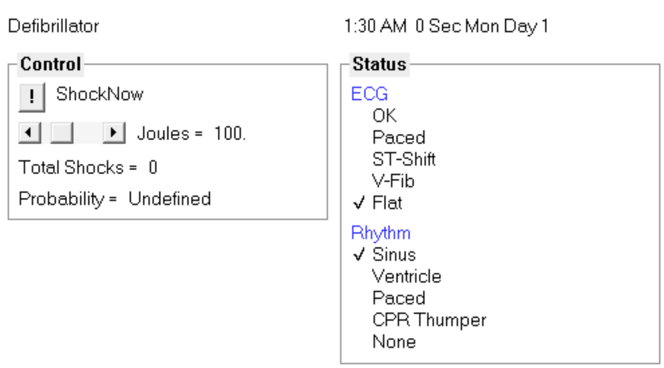

Figure 3.3: Defibrillator screen.

7. Press the "!" button next to "ShockNow." The status on ECG should move to Ok. Use the arrows to go back to the chart screen and run HumMod for 30 minutes. You should see all vitals return to normal. It should look similar to Figure 3.4.

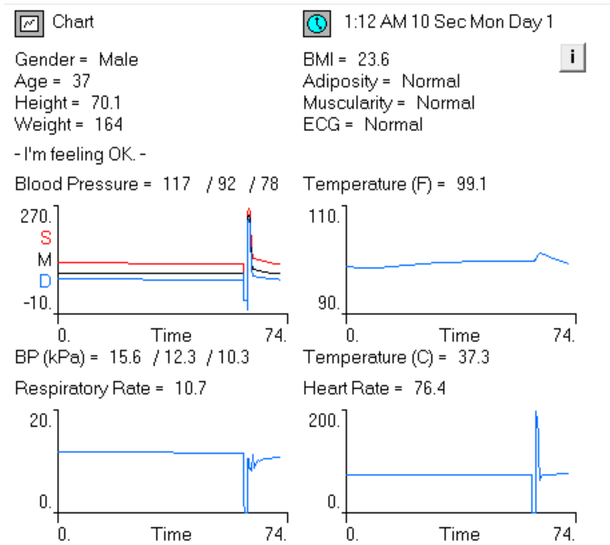

Figure 3.4: The chart screen after the defibrillation simulation. For clarity, the full 30 minutes is not shown. The x-axis units are in minutes. Both axes auto scale.

3.1.2 Effect of Increased Insulin

For this exercise, we will turn on an insulin pump in a normal person and observe the effects. This exercise provides an example of how the results differ when using different time increments. It is important that you use the restart command on the menu bar before running a new simulation.

1. Open HumMod (or start) and open the Insulin-Circulating screen from Hormones->Insulin->Circulating.

2. On the Insulin-Circulating screen, turn the insulin pump on and set the rate to 200 mU/min as shown in Figure 3.5. The normal insulin secretion rate of the pancreas is 20 mU/min. Slider bars are the only way to input a numerical value into HumMod's user interface.

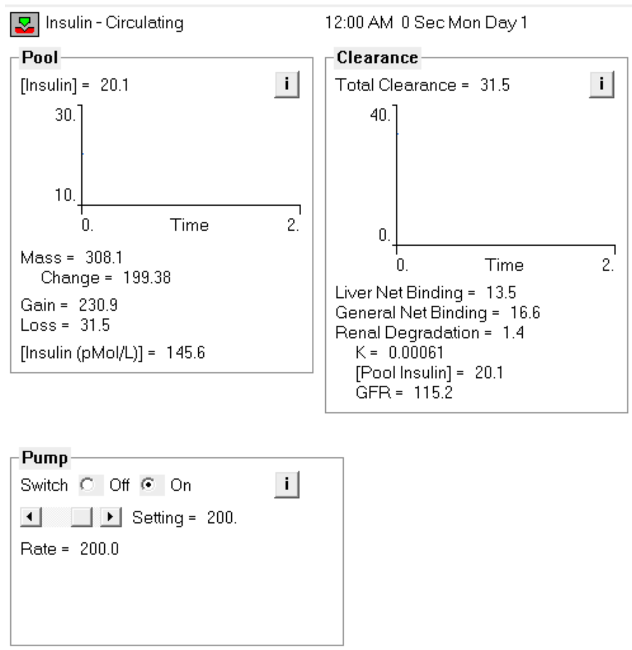

Figure 3.5: Insulin-Circulating screen.

3. Go back to the chart screen and run for two hours in 1-hour increments. The person will not survive as denoted by a "not responding," status listed on the home page between the person's weight and blood pressure and corresponding to their vitals as shown in Figure 3.6.

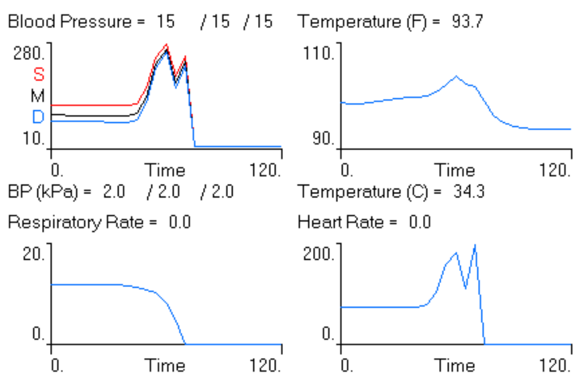

Figure 3.6: Insulin test at 1-hour increments.

4. Restart HumMod by clicking on "Restart" on the menu bar, turn the insulin pump on, set the rate to 200 mU/min and run again for 90 minutes in 30-minute increments. The chart screen should look like Figure 3.7.

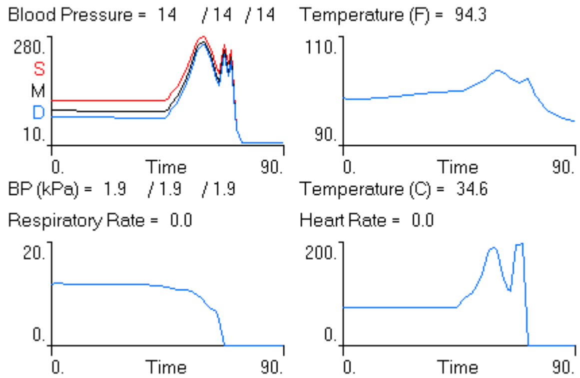

Figure 3.7: Insulin test 30-min increments.

5. Restart HumMod, turn the insulin pump on, set the rate to 200 mU/min and run again for 90 minutes in 10-minute increments. The chart screen should look like Figure 3.8.

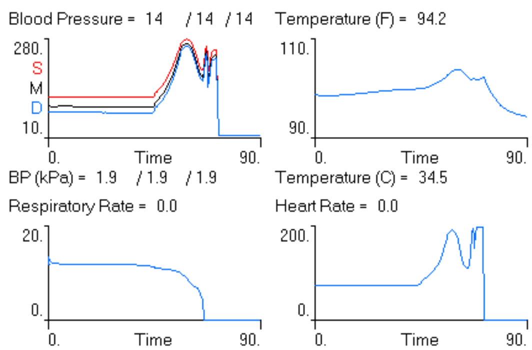

Figure 3.8: Insulin test 10-min increments.

6. Notice that while the result was the same, and the general behavior of the vitals was similar, there was more fine detail with smaller time increments. This is a result of the discrete time steps used in the equation updating algorithm in HumMod, and one must always be aware of this when running HumMod. Sometimes the effects of different time steps are minor, and sometimes the differences are significant.

7. Restart HumMod, turn the insulin pump on, set the rate to 200 mU/min and run again for 40 minutes in 10-minute increments. Then turn off the insulin pump and run for another 50 minutes in 10-minute increments. The chart screen should look like Figure 3.9. Notice that while the vitals spiked, they returned to normal and the person survived.

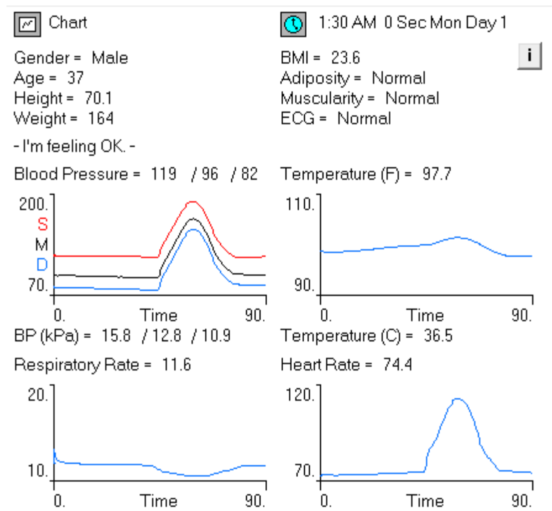

Figure 3.9: Insulin test 10-min increments showing survival of the person. The pump was turned off after 40 minutes.

3.1.3 Aerobic Exercise until Exhaustion

For this exercise, we will have the person exercise for 30 minutes, with 30 minutes to rest and then back to exercise, repeatedly until exhaustion and observe the effects. This exercise also provides a more extreme example of how the results differ when using different time increments.

1. Open HumMod and open the Daily Planner-Schedule screen from Lifestyle->Daily Planner->Schedule. Set every time increment to "Aerobics." Your screen should look like Figure 3.10, but it will have entries for the entire day. The periods of rest will be set on another screen.

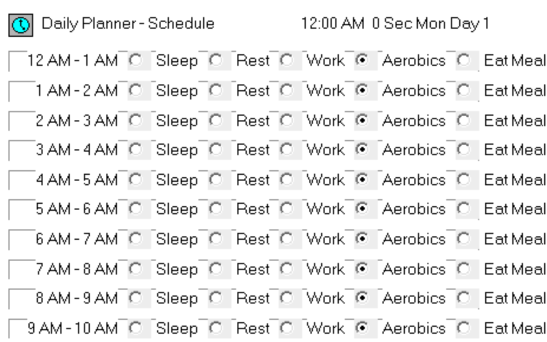

Figure 3.10: The Daily Planner-Schedule screen (upper part).

2. Open the Daily Planner-Control screen from Lifestyle->Daily Planner->Control. Set the Aerobics Level to 50 and select "Start Now" under "Switch." Notice how the duration is set to 30 minutes. Your screen should look like Figure 3.11.

Figure 3.11: The Daily Planner-Control screen.

3. For this exercise, you will be resetting HumMod a few times. To avoid having to readjust every setting when you reset HumMod, open the HumMod options window from "Options" on the upper menu bar. The Reset|Restart tab is automatically displayed first. Press the lower "Apply" button. Now when HumMod is reset, it will retain all the current settings and variables. To reset HumMod to the configuration as it was when first opened, press the upper "Apply" button. The Reset | Restart tab of the HumMod options window is shown in Figure 3.12.

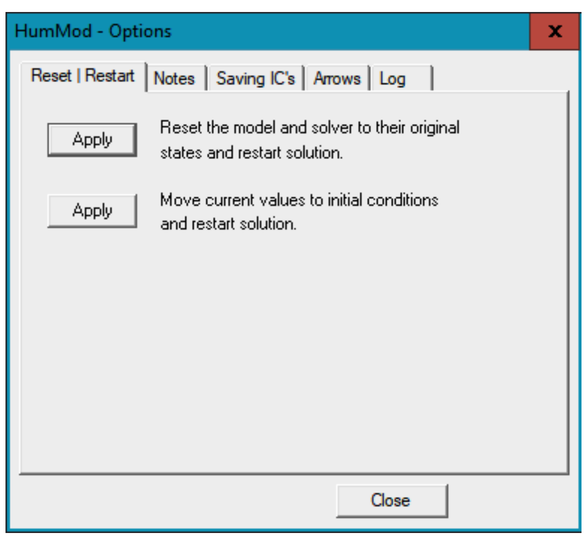

Figure 3.12: The Reset|Restart tab of the HumMod options window.

4. Run HumMod for six hours in 1-hour increments. The chart screen should look like Figure 3.15. Notice how the person did not survive because they kept getting told to do aerobic exercise every

hour. With internal water loss (due to the modeling of salt, thus the Salt model v. 3.0.4), the effect accumulated and was catastrophic.

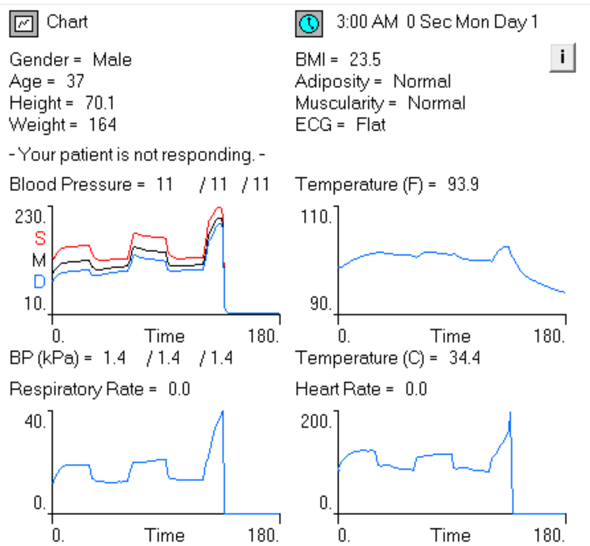

Figure 3.13: Exercise test in 1-hour increments. The simulation turned off the aerobic activity after 30 minutes per the stetting on the Daily Planner – Control screen.

5. Run HumMod for six hours in a single 6-hour increment. The chart screen should look like Figure 3.14. Notice how HumMod automatically over rode the aerobic activity command, and the person's vitals return to normal.

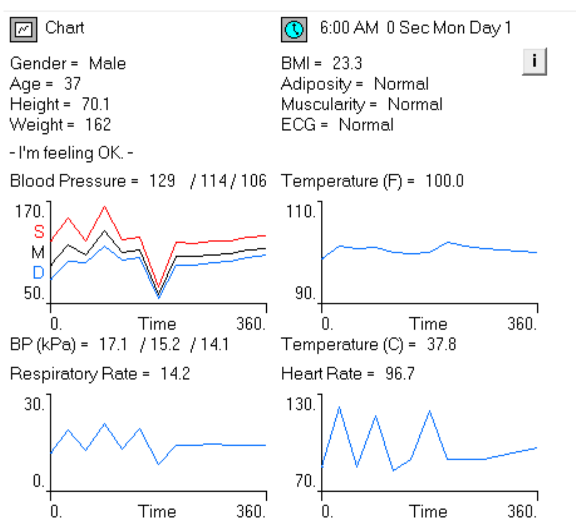

Figure 3.14: Exercise test in a single 6-hour increment. The simulation turned off the aerobic activity without user intervention.

6. Run HumMod for three hours in 30-minute increments. The chart screen should look like Figure 3.15. Notice how HumMod again automatically over rode the aerobic activity command, and the person's vitals return to normal. HumMod will terminate exercise if certain conditions are met such as when the subject has chest pains or brain function is impaired. This is programmed into

the code and more details can be found in the Exercise.REF file. These conditions can be changed by the user by modifying the Exercise.DEF file, however that is beyond the scope of this exercise. In this case the conditions to rest (stop exercising), including minimum exercise time, are met, and thus the model does not work past exhaustion.

These three simulations are an example of how using different time increments can result in drastically different outcomes.

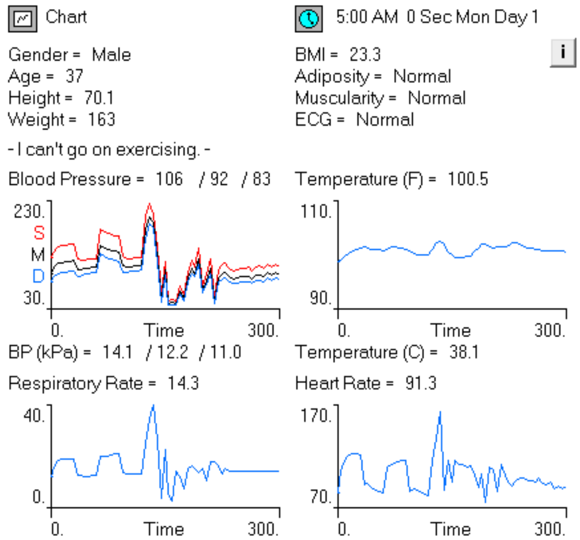

Figure 3.15: Exercise test in 30-minute increments. All other variable and starting conditions were identical to the other simulations.

3.2 Heat Module Demonstration

For this exercise, we will have the person do light exercise in different ambient temperatures while we look at their skeletal-muscle temperature and sweat output. This is designed to provide a demonstration of the heat and sweat algorithms in HumMod.

1. In HumMod, open Lifestyle->Environment, Lifestyle->Exercise->Control, Heat->Skeletal Muscle, and Heat->Sweat->Gland.

2. Run HumMod for two hours, in 1-hour increments.

3. Go to the Exercise Control screen and set the Request to Exercise Bike and Status to Warmup level, as shown in Figure 3.16. Note that this is a different method for starting exercise then shown previously, demonstrating that some HumMod controls are on multiple screens.

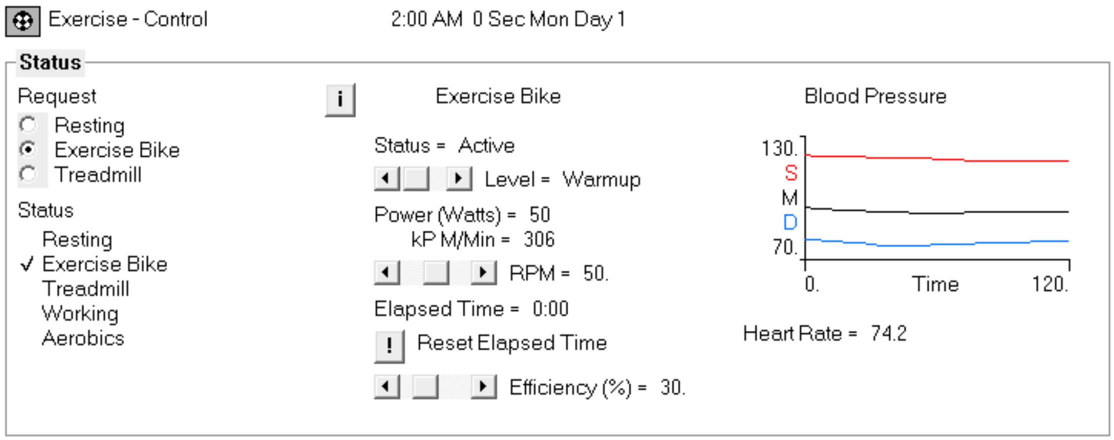

Figure 3.16: The Lifestyle -> Exercise -> Control screen.

4. Run HumMod for one hour in a 1-hour increment. Look at the other screens that were opened and observe the increased vitals, skeletal muscle temperature, and sweat output.

5. On the Environment screen, set the Ambient Temperature to 90 deg F as shown in Figure 3.17. Run HumMod for one hour in a 1-hour increment, and again observe the increased vitals, skeletal muscle temperature, and sweat output on the plots.

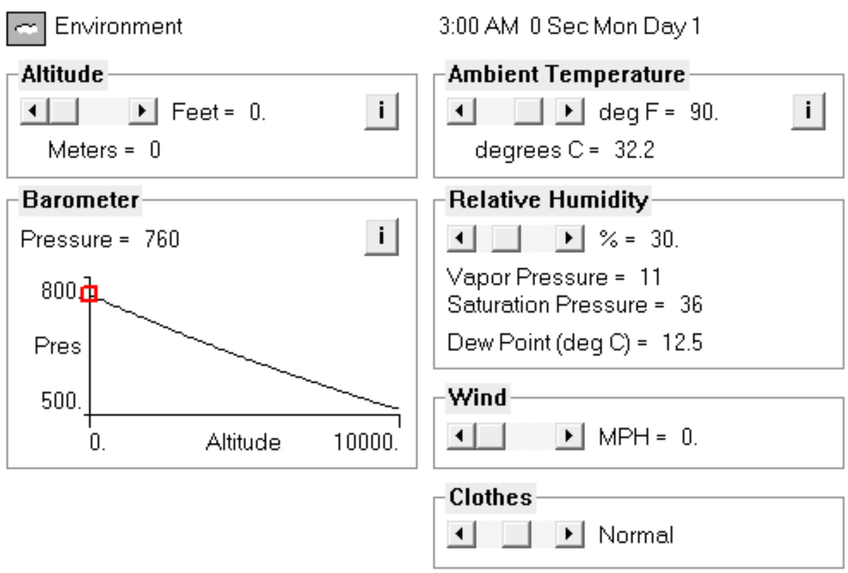

Figure 3.17: The Environment screen.

6. On the Environment screen, set the Ambient Temperature to 90 deg F. Run HumMod for one hour in a 1-hour increment and again observe the vitals, skeletal muscle temperature, and sweat output on the plots. Notice that the sweating has stopped.

7. On the Environment screen, set the Ambient Temperature back to 72 deg F, and on the Exercise Control screen set Status to Inactive. Run HumMod for one hour in a 1-hour increment and observe that the plots have returned to the normal, resting levels. Your plots should look like the ones shown in Figure 3.18.

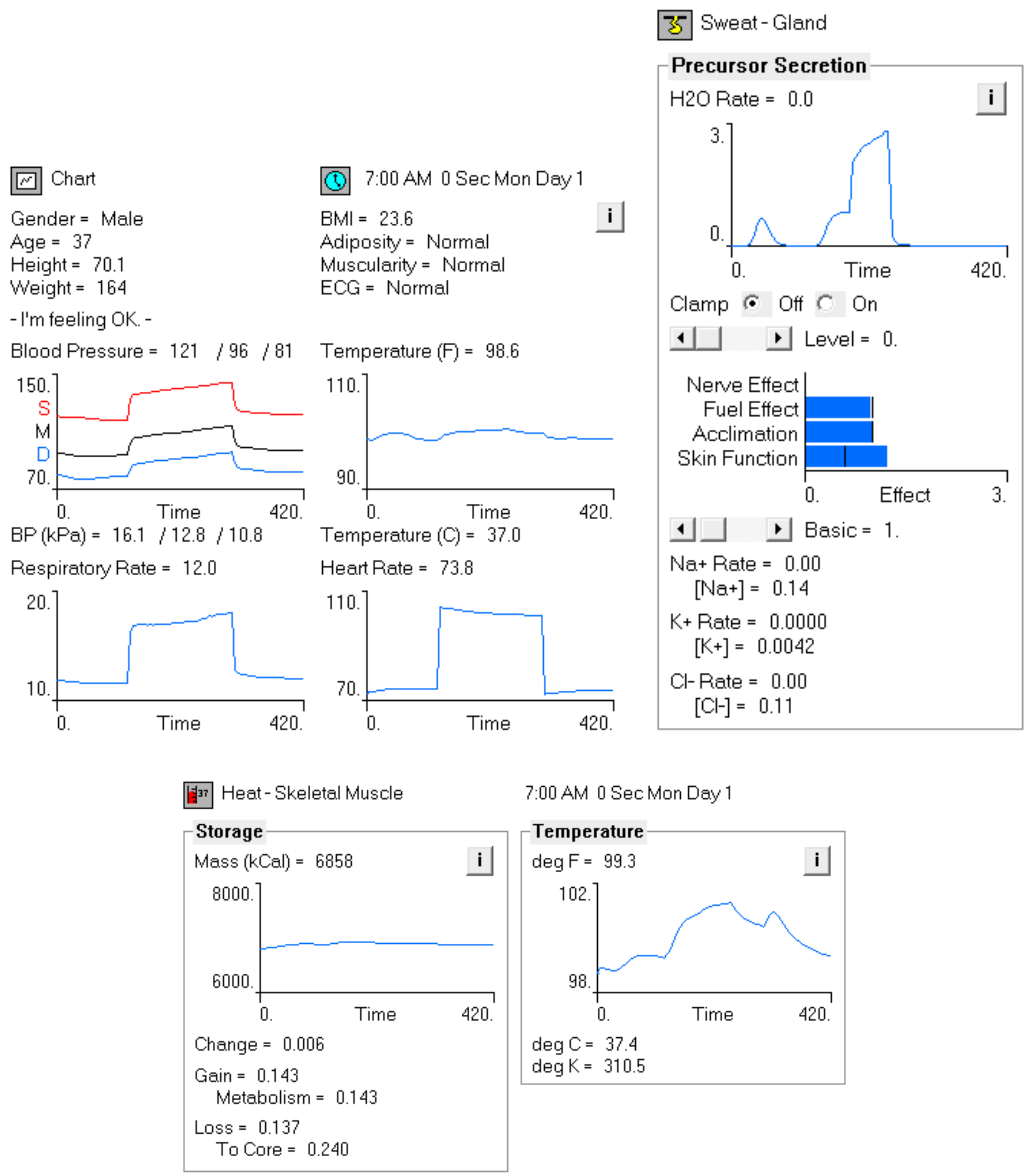

Figure 3.18: The Chart, Sweat-Gland, and Heat – Skeletal Muscle screens showing the final plots of this exercise.

3.3 Exporting Data

Data from any variable or chart may be exported by left clicking on the variable or chart of interest to bring up a window similar to Figure 3. and clicking on “Send History to Clipboard”. The data may then be pasted into another program, such as Excel, for further analysis.

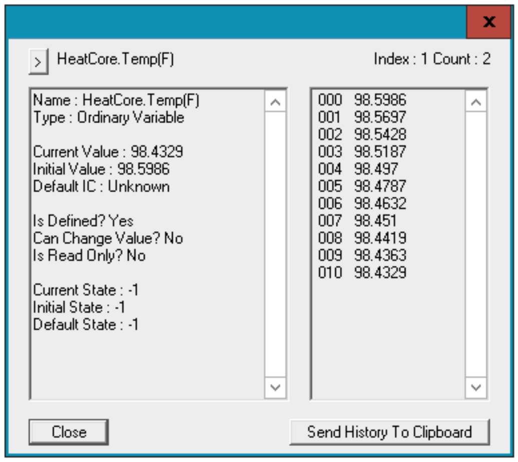

Figure 3.19: Data window from left clicking on the Temperature plot on the opening screen.

4 Understanding HumMod

The most important aspect of HumMod to understand is that the user interface (UI) and the underlying simulation code are separate. The UI simply provides a convenient way to interact with the simulation. HumMod can be run without using the UI, but that requires software not included in this distribution.

Note to users: This chapter is meant to give an overview of the code and mathematics of HumMod. However, HumMod is far more complex than can be presented in this chapter. If one needs further details or is looking for a specific command not mentioned here, those details can be found in *HumMod 2010 Schema* (Coleman et al. 2010), which is a lengthy document that provides details on every command in HumMod.

For the rest of this chapter, it is helpful if the user has HumMod and can look at the directories and files on their own, using this chapter as a guide. This chapter will introduce the .DES file, which is the basis of the HumMod simulation, and provide a detailed look at the components and commands that are in .DES files.

4.1 .DES Files

HumMod is based on a very large number of XML based .DES (descriptive) files. Each .DES file describes a particular physiological function, organ, or chemical. These are found in the \Structure directory in HumMod. The \Structure directory has a subdirectory for all the organs, chemicals, and other physiological functions. Some subdirectories have as single .DES file, and some have multiple files. For the subdirectories that have more than one file, there will be a master .DES file that calls all the other files. An example of this is shown as Figure 4.1. Some directories contain .REF (reference) files, which cite the academic literature that the .DES file is based on. Each .DES file must have a unique filename.

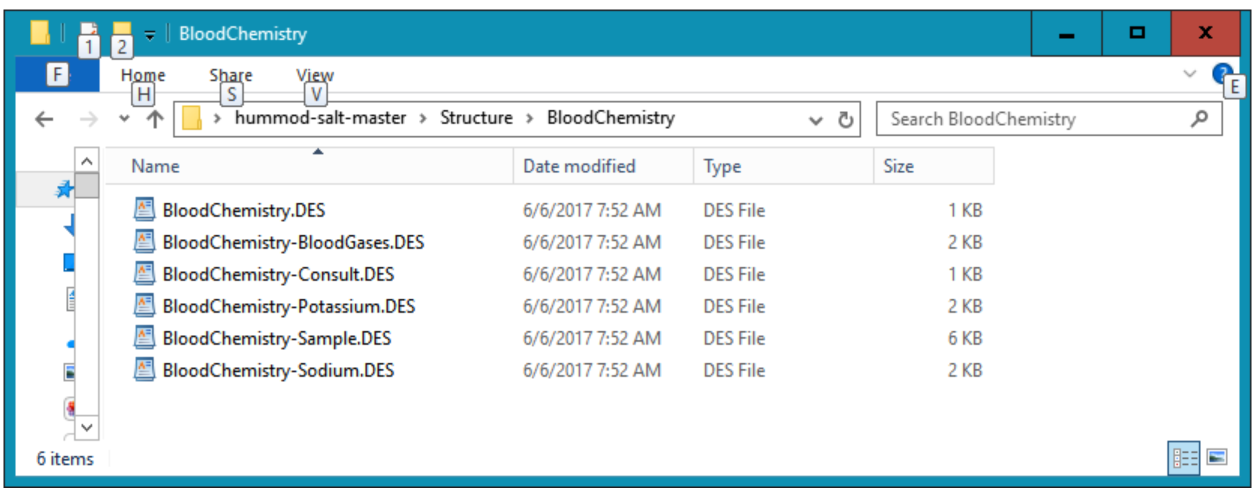

Figure 4.1: An example of a subdirector in HumMod. The master file for this directory is BloodChemisty.DES.

As an XML document, the model is described as a set of nested elements that describe each parameter, variable, differential equation, curve, and definition that appears in the model. A parameter is a variable that can be changed by the user while HumMod is running. The outermost element, <model>, along with its close-tag, </model>, contains all other elements of the model. When one element contains another, the pair can be represented as two nodes with a branch connecting the upper element (parent) to the lower element (child). One parent can have many children, but each child contains only one parent. Hence this describes a rooted tree. The XML syntax specifically describes what children a particular parent can have.

All elements in the .DES files are presented as pairs; an open tag and a close tag, with the exception of a small number of “modifier” tags that appear in <display> elements and the <?include *filename* > tag which inserts the contents of file *filename* into the tree where the <?include> call is made.

To simplify coding, HumMod is broken into multiple files at the level of <structure> and <display> elements. Files that are called via <?include *filename* > are placed in a folder with the file that calls them with the exception of calls made in Structure.DES and Display.DES; the only contents of the directories containing these files are the directories of the files they call. In this way, the file structure of the model mirrors the tree structure of the model itself.

If a new .DES file is created, one must modify \Structure\Structure.DES and add an <?include> reference to the new .DES file and add a <call> </call> reference to the block or blocks in the .DES file. The <call> </call> reference can be put in the Parms, Dervs, or Wrapup section in \Structure\Structure.DES.

4.1.1 Organization of .DES files

Structure files are the model components of HumMod, as opposed to Display files that manage the UI and Control which informs the UI what intervals can be simulated. Structure files take two forms: master files, and content files. Master files consist only of <?include> statements, and <call> statements to the calculation blocks that appear in the content files (described below). Each folder has a unique master file that bears the same name as the folder itself. Examples include Structure.DES in the \Structure directory, and BloodChemistry.DES in \Structure\BloodChemistry. Content files contain the variable and parameter assignments and mathematical objects that determine the model. Each content file can contain

1. a <structure> element that carries the same name as the file,
2. a <variables> element, in which all variable and parameter assignments are carried out,
3. a <parm> element, which is a variable which the user can change via the interface,
4. an <equations> element, in which all differential and implicit equations are assigned names and errors (the allowable absolute tolerance used for determining a step size),
5. a <functions> element, in which curves (cubic splines) are defined, and
6. a <definitions> element which contains blocks of calculations.

Upon opening HumMod, the solver parses the XML files and

1. creates a vector that contains all model variables and parameters,
2. explicitly realizes cubic splines and the calculation objects required to perform numerical integration, and
3. arranges the definition blocks into a calculation sequence in the order determined by the <call> sequences in the master files.

Equations are detailed in Section 4.5.4. The only objects in the <functions> element are curves, which are detailed in Section 4.5.3.

4.1.2 Definitions

<definitions> elements contain the math of the model. They only one child element: <block>. The blocks are the code snippets that are pasted together by the XML parser to create the mathematical model.

Blocks contain equations, with syntax <def><name> VarName </name><val> Equation describing variable </val></def>. Blocks are typically named one of four things, corresponding to the types of math in the model, detailed below. These names are Context, Parms, Dervs (also called Calc or Calc*), and Wrapup.

4.1.3 Model math

HumMod.DES contains <model> and <math> elements. The <math> element has four (optional) children: <context>, <parms>, <dervs>, and <wrapup>. In HumMod, these children point to blocks in Structure.DES where the majority of the model calculation blocks are called. These correspond to four types of math that show up in the model, distinguished by when the blocks are called.

1. <context> is called only when the model parses, or when particular parameters are altered. Examples include changing the sex or body composition of the model. Context sizes the model, ensuring that the amount of water, electrolytes, etc., matches the expected values obtained from the body size description.

2. The <parms> block is called whenever any parameter's value is changed by a user or script, and when the model is finished parsing after <context>. Parms blocks instantiate any user interaction in the model.

3. The <dervs> blocks calculate the model derivatives and other values. This is the workhorse block for the model.   Because <implicitmath> blocks may be run many times to achieve a stable solution for a given timestep, and <implicitmath> may call <dervs> blocks, a single <dervs> block may be executed multiple times for each time step. Because of this, it is important that model interactions are not instantiated within a dervs block.

4. <wrapup> blocks are executed at the end of each calculation interval. Typical actions in <wrapup> blocks are the calculation of concentrations, calculation of interval lengths used in <timervars>, and other "housecleaning" functions within the model.

4.1.4 Variables

All variables in HumMod have the following naming convention: file_name.variable_name. Examples include Symptoms.Number, Heart-Pacemaker.Setting and Heart-Asystole.Is_Asystole. If a variable is being used within the same .DES file that it was defined, it can be called using only the variable_name, however for any calls outside of that .DES file, the entire name must be used.

HumMod has three types of numbers that are defined in .DES files; constants, variables, and parameters. Constants, which are represented as <constant>, are defined and are not changeable. Variables, which are represented as <var>, are changeable, but only internally in the code. Parameters, which are represented as <parm> are changeable, and are meant to be modified by the user though the HumMod user interface. Constants, variables, and parameters are single precision floating-point numbers.

In addition, HumMod uses Curves, Blocks, Integrals, and Implicits (to define implicit algebraic equations), all of which are defined in .DES files and are based on constants, variable, and parameters.

Variables, constants and parameters are defined in the following way:

```
<constant><name> BodyDensity </name></constant>

<var><name> Gain </name></var>
```

```
<parm><name> Temp(F) </name></parm>
```

Initial values may be defined (for constants, vars and parms) in the following way:

```
<parm><name> InitialTemp(F) </name><val> 98.6 </val></parm>
```

There are seven types of variables that appear in HumMod. Each of these will be described below. In all cases, optional children elements of the model objects are denoted in italics.

1. <var><name> ___ </name>*<val>* ___*</val>*</var>. The <variable> type is intended to describe dependent variables, the outputs of model equations. As such, users cannot affect their values directly: they are calculated in blocks. They can optionally be assigned an initial value, but it will be replaced the first time their value is calculated.

   The following examples are from \Structure\Catechols\Alpha1Pool.DES

   ```
   <var><name> ReceptorActivity </name><val> 1 </val></var>
   <var><name> Effect </name></var>
   ```

2. <parm><name> ___</name><val>____</val></parm>. The <parm> type is intended to describe independent variables, for instance switches, clamp values, medication dosages, or other controls the user is allowed to set. They must be initialized with a value. They can be calculated as the output of some equation, but this overwrites user control invisibly, and should be avoided.

   The following example is from \Structure\Catechols\Alpha1Pool.DES

   ```
   <parm><name> TotalAlpha1 </name><val> 4. </val></parm>
   ```

3. <constant><name>_____</name><val>____</val></constant>. The <constant> type is intended to describe values that will not change in simulation, and as such, must be initialized upon definition. This value cannot be overwritten by calculation or by a user except by changing the XML code itself.

   The following example is from \Structure\Catechols\Alpha1Pool.DES

   ```
   <constant><name> kd_epi </name><val> 5  </val></constant>
   ```

4. <whitenoise><name>___</name><lowerlim>____</lowerlim><upperlim>____</upperlim></whitenoise >. The <whitenoise> type defines a variable that gets its value from a white noise distribution.

   The following example is from \Structure\Acidosis\CardiacArrest.DES

   ```
   <whitenoise>
     <name> Chance </name>
     <lowerlim> 0 </lowerlim>
     <upperlim> 1 </upperlim>
   </whitenoise>
   ```

5. <normaldist><name> ___</name><mean>____</mean><sddev>____</sddev></ normaldist >. The < normaldist > type is used if a user wants a normal distribution to sample from.

   The following example is from \Structure\Context\Context-Height.DES

```
<normaldist>
  <name> Normal </name>
  <mean> 0 </mean>
  <stddev> 25 </stddev>
</normaldist>
```

6. <fixedparm><name> ___</name><val>____</val></fixedparm>. The <fixedparm> type is the same as <parm> however its value does not get reset to initial conditions at solution restart. This type of variable is not used in HumMod-Salt.

7. <fixedvar><name> ___</name><val>____</val></fixedvar>. The <fixedvar> type is the same as <var> however its value does not get reset to initial conditions at solution restart. This type of variable is not used in HumMod-Salt.

8. <timervar><name> ___</name><val>____</val><state>____</state></timervar >. The <timervar> type is used to track elapsed time and can count up or down. Val and State are optional fields.

   The following example is from \Structure\Drugs\Phenylephrine\PhenylephrineOral.DES

```
<timervar><name> Timer </name><val> 0.0 </val><state> OFF
</state></timervar>
```

All variables are described in more detail in the Schema.

4.1.5 Booleans

Booleans are binary logic variables which can only have 0 or 1. While commonly used, HumMod does not have a separate variable type for Booleans. Therefore, True values are represented by 1 and False is represented by 0. Alternatively, "TRUE" and "FALSE" may be used, however those just represent 1 and 0 respectively. Interestingly, one may use "TRUE" and "FALSE" in place of integers, for example TRUE + TRUE = 2.

Booleans may be set by the user from the user interface or by comparison tests. Available comparisons are "LT" for less than and "GT" for greater than, "GE" for greater or equal to, "LE" for less than or equal to and "EQ" for equals to. The syntax is:

Variable_1 GT variable_2

```
<test>
      ( Ovaries.Phase EQ Ovaries.IS_OVULATORY )
  AND ( Progesterone.[Conc(nMol/L)] GE 8.0 )
</test>
```

```
<test> ( NOT RightHeart-Pain.HasPain ) AND ( NOT LeftHeart-
Pain.HasPain ) </test>

<test>
    ( ( HeatCore.Temp(C) LT 41.5 )
      OR
      ( HeatCore.Temp(C) GT 44.5 )
    )
    AND
    ( ( Brain-Fuel.FractUseDelay GT 0.85 )
      OR
      ( Brain-Fuel.FractUseDelay LT 0.40 )
    )
</test>
```

4.1.6 Stochastic or Monte-Carlo Simulations

Stochastic or Monte-Carlo methods can be implemented in HumMod however HumMod-Salt only uses it once, with System.Random (which generates a random number between -1 and 1). HumMod Version 3.0.4 calls System.Random, in \Structure\Heart\Heart-Defibrillator.DES in an attempt to have the defibrillation work or fail based on a probability value that is decreasing depending on how long the person has been out. However, given the same conditions, the defibrillation always works or fails.

4.2 Exploring HumMod

4.2.1 HumMod-Tech

It can be difficult to navigate and explore HumMod given its large number of .DES files and even larger number of constants, variables, parameters and functions. HumMod comes with two tools that assist with understanding it. One is the HumMod-Tech window, which can be found on the menu bar inside HumMod and a screen shot is shown as Figure 4.2. HumMod-Tech is useful for exploring the variables, curves and other mathematical parts of HumMod. The variables are easy to find, they are organized by file name (Structure Name) and then by variable name (Local Name). The HumMod-Tech window is useful for observing all the information on any variable and non-variable, such as curves, as shown in Figure 4.3.

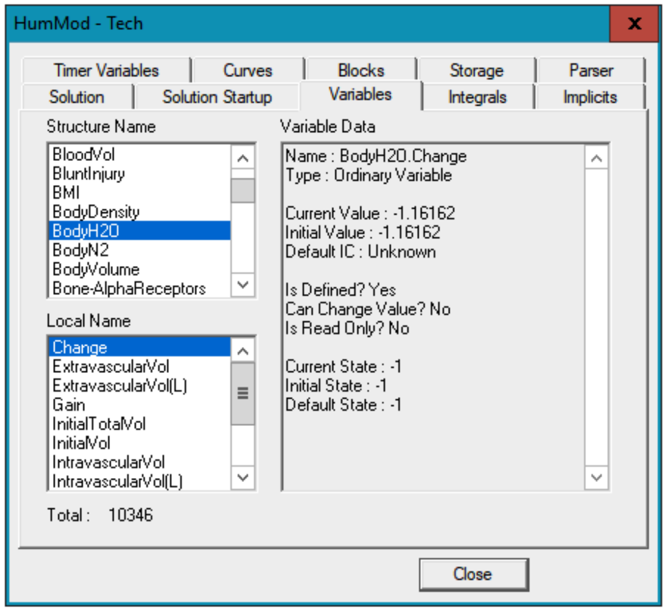

Figure 4.2: HumMod-Tech window showing a variable in BodyH2O.

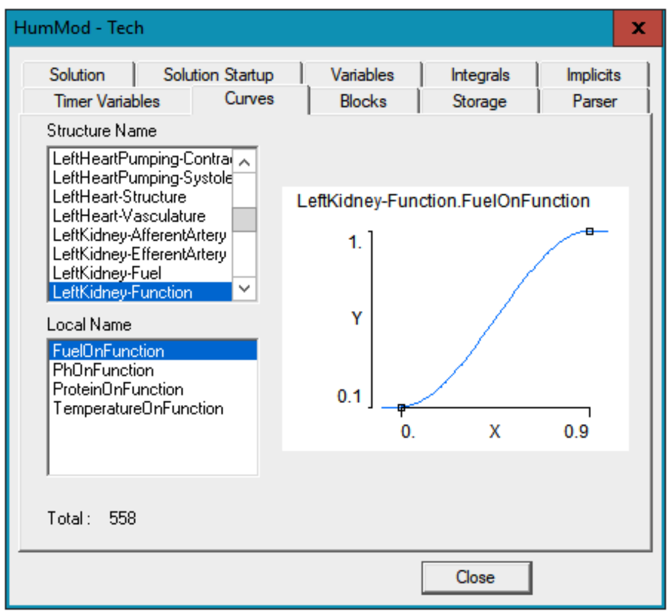

Figure 4.3: HumMod-Tech window showing a data curve on Kidney function.

4.2.2 HumMod Model Navigator

The HumMod Model Navigator, as shown in Figure 4.4, is also a useful tool, but it is more difficult to use then the HumMod Tech window. Its main use is to view and navigate the interactions between all the variables across the entire library of .DES files. Once you choose the .DES file (Structure Name) and select a variable, it will display the .DES file, show where it is defined, what other variables use it, and what variables it uses. It will also show you the related .Docs file, what displays output the variable and other information.

To obtain and use the Model Navigator, you must download the HumMod package from hummod.org. Then move the file Model Navigator.EXE and the entire Docs directory to the HumMod-Salt directory. Open Model Navigator.EXE and tell it to open HumMod.DES.

The HumMod Model Navigator often gives an error message, clicking on “Continue” will prevent HumMod Model Navigator from exiting.

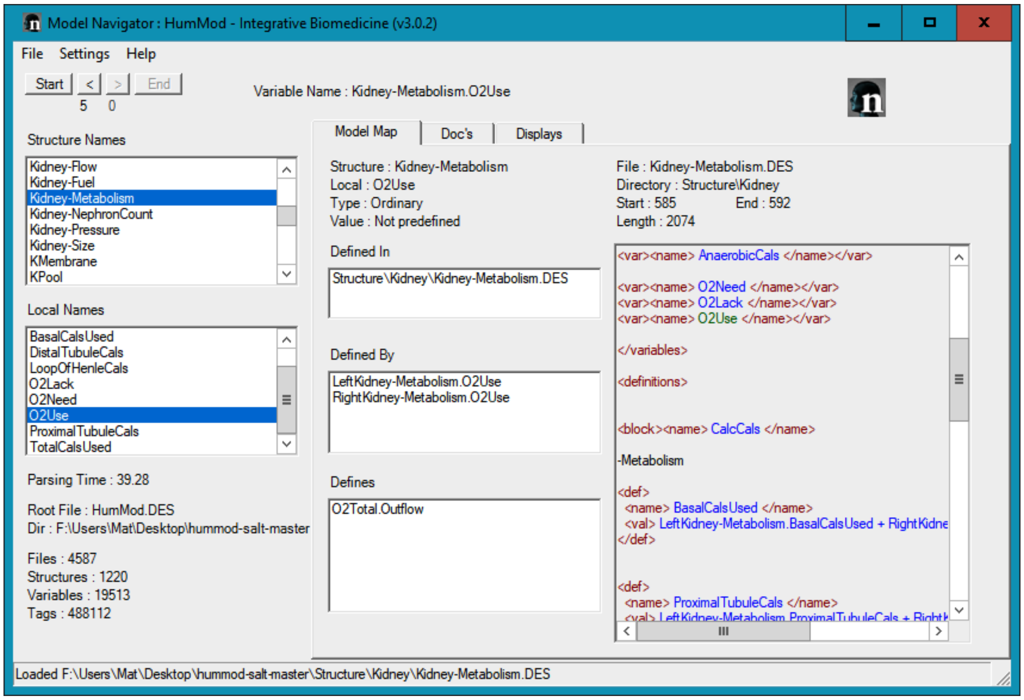

Figure 4.4: HumMod Model Navigator Screen.

4.3 Blocks

Blocks are named groups that hold specifications of related variables and equations. The information in the blocks describes the calculations and much of the calculation sequence.

4.4 Understanding and Editing the User Interface

All the .DES files that control the User Interface (UI) reside in the \Display directory. These files do not control the mathematics of HumMod and only provide the UI. This section will present the types of elements that are used in the UI and provide a starting point for UI customization.

When creating a custom UI, it is recommended that you start with a UI that is similar to what you want and modify it rather than write a .DES file from scratch.

4.4.1 Numeric Displays

Numerical displays are one of the simplest types of UI element and simply display the current value of a variable. The following code was used to create: Temperature (F) = 98.6 and was taken from \Display\Diagnosis\Chart\Temperature.DES.

```
<showvalue>
   <row> 7.8 </row><col> 28 </col>
   <name> HeatCore.Temp(F) </name>
   <format><decimal> 1 </decimal></format>
   <label> Temperature (F) </label>
</showvalue>
```

4.4.2 Text Displays

The HumMod UI can display a string from a pre-defined list. First the list of strings must be defined and each string associated with a number. A good example of a Text Display is the "- I'm Feeling OK. -" line on the main chart display which changes as the status of the subject changes. The following example is from \Display\Diagnosis\Chart\Symptoms.DES. Note that in this example, "Symptoms.Number" is a variable that is defined and set elsewhere, <maplist> simply defines an alternative way of displaying the value.

```
<maplist>
  <name> Symptoms.Number </name>
  <map><val>  0 </val><img> - I'm feeling OK. - </img></map>
  <map><val>  1 </val><img> - Your patient is not responding. -
</img></map>
  <map><val>  2 </val><img> - I've got a bad chest pain. -
</img></map>
  <map><val>  3 </val><img> - I can't get enough air. -
</img></map>
...
  <map><val> 23 </val><img> - Still no heartbeat - </img></map>
  <map><val> 24 </val><img> - Ovulation just occurred -
</img></map>
</maplist>
```

Next the code for the UI element is

```
<showvalue>
  <row> 6.4 </row><col> 1.0 </col>
  <name> Symptoms.Number </name>
  <nolabel/>
  <format>
    <list> Symptoms.Number </list>
    <fieldwidth> 26 </fieldwidth>
  </format>
</showvalue>
```

4.4.3 Call Boxes

The call box command will display a custom message in a pop-up dialog box like the one shown in Figure 4.5 and is generated from the following code.

```
<page> Put custom message here. </page>
```

Call boxes are commonly used in HumMod inside If Statements as a warning to the user that the subject is at risk of dying, or to make the user aware of some other important condition. Most, if not all, of the call boxes are commented out in HumMod 3.0.4 because they appeared quite often and interfered with the flow of the simulation.

Note: Unlike the rest of the UI elements, the Call Boxes must be coded into the .DES files in the \Structures directory.

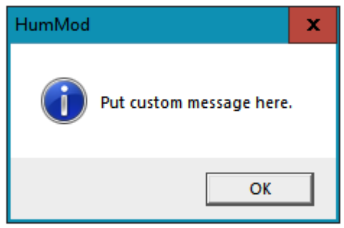

Figure 4.5: Example of a Call Box.

4.4.4 Info Buttons

Information buttons () are used to provide secondary information to the user that appears only when they click on the button.

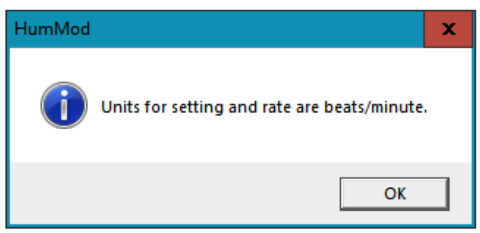

Figure 4.6: An example call box that appears when the info button is clicked.

The following code was used to generate the info button as shown in Figure 4.6 and is from \Display\Intervention\CardiacPacemaker\Control.DES.

```
<infobutton>
  <row> 1.2 </row><col> 26.0 </col>
  <line> Units for setting and rate are beats/minute. </line>
</infobutton>
```

4.4.5 Boxes

Parts of the display screen may be enclosed by a box. The following code was used to create the box (not the contents) shown in Figure 4.7 and is from \Display\Intervention\Defibrillator\Control.DES.

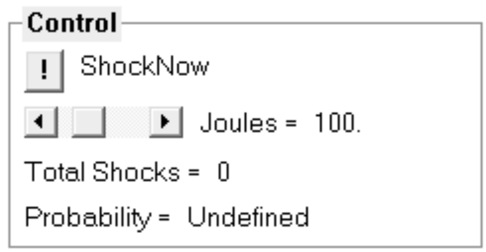

Figure 4.7: Group Box example.

```
<groupbox>
   <row> 2.0 </row>
   <col> 1.0 </col>
   <high> 7.8 </high>
   <wide> 30.0 </wide>
   <title> Control </title>
```

And after all the code for the elements are defined, a final line is added to close the box.

```
</groupbox>
```

4.4.6 Check Marks

Checkmarks are a basic Boolean indicator. The following code below will display ✓ OK and is from \Display\Intervention\Defibrillator\Status.DES.

```
<checkmark>
  <row> 2.4 </row><col> 1.0 </col>
  <name> Is_OK </name>
  <label> OK </label>
</checkmark>
```

If the variable *Is_OK* is 0 (False), there will be no checkmark, and if the variable is 1 (True), there will be a checkmark.

4.4.7 Charts

Charts are the only method in HumMod for graphical representation of data. Typically, the X-axis will be the time variable (System.X). The size of the chart can be modified by changing the <high> and <wide> parameters. Multiple lines may be on the same chart simply by adding more <yvar> </yvar> commands. See BloodPressure.DES for an example of a multiline chart. Available colors include BLACK, BLUE, RED, YELLOW, and GREEN.

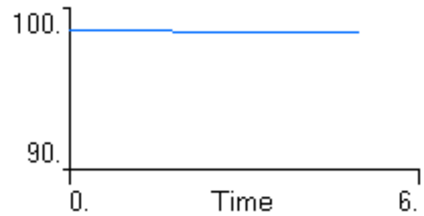

Figure 4.8: The Temperature chart from the main chart screen.

The code below was used to create the chart shown in Figure 4.8 and is from \Display\Diagnosis\Chart\Temperature.DES.

```
<showgraph>
  <row> 8.8 </row><col> 28 </col><high> 7 </high><wide> 26
</wide>
  <leftmargin> 4 </leftmargin>
  <xaxis>
    <name> System.X </name>
    <label> Time </label>
    <scale><min> 0 </min><max> 6 </max></scale>
  </xaxis>
  <yaxis>
    <yvar>
      <name> HeatCore.Temp(F) </name>
      <nolabel/>
      <linecolor> BLUE </linecolor>
    </yvar>
    <scale><min> 90 </min><max> 100 </max></scale>
  </yaxis>
</showgraph>
```

4.4.8 Sliders

Sliders are the only method in the HumMod user interface to change numerical values of a parameter. To use a slider, you must first create a list of possible slider values. Once that is done, you may put place the slider on your page. The following example was taken from \Display\Intervention\CardiacPacemaker\Control.DES and will produce this slider. In this example the slider will have values from 0 to 200 in increments of 1. The current value is 20. Here is an inline example of the display and code.


```
<repeatlist>
  <name> Heart-Pacemaker.Setting </name>
  <repeat><reps> 200 </reps><stepsize> 1.0 </stepsize></repeat>
</repeatlist>

<slidebar>
  <row> 2.8 </row><col> 1.0 </col>
```

```
    <name> Setting </name>
    <listname> Heart-Pacemaker.Setting </listname>
    <label> Setting </label>
  </slidebar>
```

4.4.9 Action Buttons

Action buttons are used in the UI to force HumMod to run a specific block of code immediately. The block may or may not have been included in the calculation sequence. Typical usage includes “Take Now” which forces the model to “take” a pharmaceutical.

The following was taken from \Display\Intervention\Drugs\Isoproterenol\Dosing\Inhaler.DES. It will run the block “Inhale”, which is found in \Structure\Drugs\Isoproterenol\IsoproterenolInhaler.DES.

```
<actionbutton>
  <row> 1.4 </row><col> 1.0 </col>
  <blockname> Inhale </blockname>
  <label> Use Inhaler Now </label>
</actionbutton>
```

4.4.10 Radio Buttons

Radio buttons in HumMod serve as a Boolean OR control in the user interface. The following example was taken from \Display\Intervention\CardiacPacemaker\Control.DES. Here is an inline example of the display and code.


```
<radiobuttons>
  <row> 1.4 </row><col> 1.0 </col>
  <name> Switch </name>
  <listname> Common.Switch </listname>
  <nolabel/>
</radiobuttons>
```

4.4.11 Check Boxes

Check boxes are used as a Boolean input.

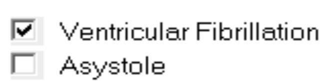

Figure 4.9: Example of check boxes.

The code below was used to create the upper check box shown in Figure 4.9. This example was taken from .\Display\Intervention\CPR\Heart.DES.

```
<checkbox>
  <row> 5.4 </row><col> 2.0 </col>
  <name> ActivateOnFibrillation </name>
  <label> Ventricular Fibrillation </label>
</checkbox>
```

4.4.12 Menu Items

The lower menu bar is completely user editable. You may add, delete or move menu items around at will. This is useful if you want to create your own display panels, or just want commonly used panels easily accessible.

From the .DES file that defines the display panel there is a <name> Panel_name </name> command. The name listed there is placed in the <name> </name> space on the menu definition files. Note that you may only call a specific panel once in the entire menu tree and the names must be unique.

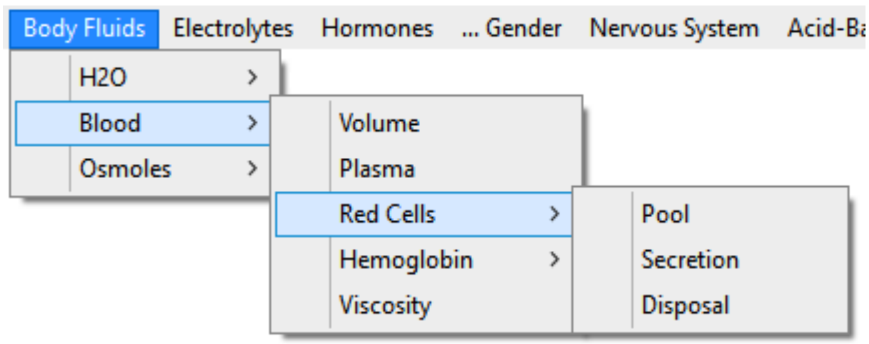

Figure 4.10: An example of an editable menu.

The menu in Figure 4.10 was created by the following code from \Display\Tree\BodyFluids\Blood.DES.

```
<branch>
  <name> Blood </name>
  <label> Blood </label>
  <parent> BODYFLUIDS </parent>
</branch>

<leaf>
  <name> Blood_Volume </name>
  <label> Volume </label>
  <parent> Blood </parent>
</leaf>

<leaf>
  <name> Blood_Plasma </name>
  <label> Plasma </label>
  <parent> Blood </parent>
</leaf>

<branch>
  <name> Blood_RedCells </name>
  <label> Red Cells </label>
  <parent> Blood </parent>
</branch>

<leaf>
```

```
    <name> RedCells_Pool </name>
    <label> Pool </label>
    <parent> Blood_RedCells </parent>
  </leaf>

  <leaf>
    <name> RedCells_Secretion </name>
    <label> Secretion </label>
    <parent> Blood_RedCells </parent>
  </leaf>

  <leaf>
    <name> RedCells_Disposal </name>
    <label> Disposal </label>
    <parent> Blood_RedCells </parent>
  </leaf>

  <branch>
    <name> Blood_Hemoglobin </name>
    <label> Hemoglobin </label>
    <parent> Blood </parent>
  </branch>

  . . .

  End
```

And its parent file \Display\Tree\BodyFluids\BodyFluids.DES calls the file as such:

```
  <branch>
    <name> BODYFLUIDS </name>
    <label> Body Fluids </label>
    <parent> MAINMENU </parent>
  </branch>

  <?path Display\Tree\BodyFluids\ ?>

  <?include H2O.DES ?>
  <?include Blood.DES ?>
  <?include Osmoles.DES ?>

  End
```

In addition the following line must be in \Display\Tree\Tree.DES.

```
  <?include BodyFluids\BodyFluids.DES ?>
```

You can set the default screen that HumMod opens first by using the following command in \Display\Display.DES.

```
<common>
  <displayfirst> Chart </displayfirst>
</common>
```

4.5 Math and Algorithms

HumMod is capable of a wide variety of mathematical calculations and algorithms, however some of them are implemented in manner that is not intuitive. This section provides an overview of the mathematics of HumMod.

4.5.1 Basic Arithmetic

HumMod can do basic arithmetic using the standard +, -, * and / operators. Be aware that HumMod evaluates the arithmetic in strict left to right order and thus does not use standard order of operations. For example, in HumMod:

6 + 6 * 4 = 48

If you want it to equal 30, you must use parentheses and enter it in like:

6 + (6 * 4) = 30 or 6 * 4 + 6 = 30

Any further math such as trigonometric functions, logarithms or exponents cannot be done without using curves or implicits.

It is important to note that there must be a white space before and after each number and operator or HumMod will generate an error message and not load. This only is true for arithmetic operations.

4.5.2 If Statements

If Statements are used with the following syntax.

```
<if>
<test> Boolean_Test </test>
<true>
****Commands to execute for true***

</true>
<false>
****Commands to execute for false***

</false>
</if>
```

For the Boolean_Test, either a simple Boolean variable or a comparison test may be used. An example of an If Statement can be found in \Structure\Heart\Heart-Defibrillator.DES.

There is also the <andif> command, which is used to imbed an if statement inside of an if statement. An example of an <andif> command from \Structure\Heart\Heart-VFib.DES is below.

```
<if>
<test> Heart-Asystole.Is_Asystole </test>
<true>
  <andif>
  <test> Is_Fibrillating </test>
  <true><call> Stop </call></true>
  </andif>
</true>
<false>
  <call> TestStart </call>
</false>
</if>
```

4.5.3 Curves

Curves are user-defined continuous functions of a single variable. Curves are useful when the exact mathematical function for a particular physiological relationship is not known, but the curve is. HumMod takes data points and their first derivative (slope) as specified in the .DES file and fits the points to a cubic spline to generate the curve. The slope is necessary to create the correct curve using a small number of points. At least two points are required to define a curve.

As an example, the SweatAccumulation.TemperatureEffect curve is shown as Figure 4.11. The code defining it in \Structure\Insulin\InsulinSynthesis.DES is shown below.

```
<curve>
  <name> TemperatureEffect </name>
  <point><x>  60 </x><y> 0.5 </y><slope> 0.0 </slope></point>
  <point><x>  85 </x><y> 1.0 </y><slope> 0.05 </slope></point>
  <point><x> 100 </x><y> 2.0 </y><slope> 0.0 </slope></point>
</curve>
```

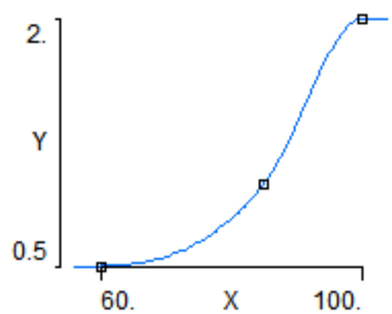

Figure 4.11: The SweatAccumulation.TemperatureEffect curve.

Once the curve is defined, it can be called using the following code. In this example HeatSkin.Temp(F) is the independent variable (X) and the dependent variable (Y) will be saved as TemperatureEffect.

```
<def>
  <name> TemperatureEffect </name>
  <val> TemperatureEffect [ HeatSkin.Temp(F) ] </val>
</def>
```

4.5.4 Equations

Equations cover seven types of numerical analysis, of which three are seen repeatedly in HumMod. The common ones are <diffeq>, <delay>, and <impliciteq>. The uncommon ones are <stablediffeq>, <backwardeuler>, <lag> and <stabledelay>.

<diffeq>, <stablediffeq>, and <backwardeuler> are types of differential equations. <delay>, <stabledelay>, and <lag> are time delay equations, and <impliciteq> is an implicit algebraic equation.

Equations must be in the <equations> element part of the .DES file.

4.5.5 Differential Equations

These equations are integral solved with Euler's method, i.e. the approximation that $y_{new} = y_{current} + y' \cdot h$, where h is the step size (time step) of the integration interval. Each differential equation is associated with an error tolerance (below), and the approximation of the second derivative of the function, along with the error tolerance, define a maximum step size that guarantees y_{new} will be within $error - tolerance$ of the actual value of y. HumMod chooses the minimum step size that satisfies all of its <diffeq> elements simultaneously. The child elements of <diffeq> are <name>, <integralname> (both variable declarations for the output value), <dervname> (variable declaration for the derivative), <initialval> (optional value that initializes the integral; alternately can be set automatically in Context, described below), and <errorlim> (error tolerance, usually set as 3% of the starting value of the integral). The variable referenced in <dervname> is assigned a value (usually via equation) in one of the calculation blocks in <definitions>.

An example of a differential equations is found in \Structure\Heat\HeatCore.DES

```
<diffeq>
  <name> Mass </name>
  <integralname> Mass </integralname>
  <dervname> Change </dervname>
  <errorlim> 123.0 </errorlim>
</diffeq>
```

Further information about differential equations can be found in the Schema. HumMod uses numerical solutions to the differential equations, and thus they are differential equations, not difference equations.

4.5.6 Delay

Delay is used when the output should slowly follow the input, as shown in Figure 4.12.

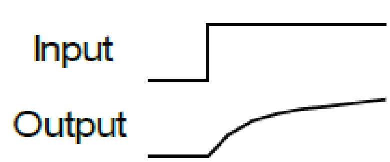

Figure 4.12: An illustration of the use of <delay>. From *HumMod 2010 Schema*.

An example of the use of a delay equation is shown below and is taken from \Structure\Exercise\Exercise-Metabolism.DES.

```
<delay>
  <name> ContractionRate </name>
  <outputname> ContractionRate </outputname>
  <initialval> 0.0 </initialval>
  <inputname> TargetContractionRate </inputname>
  <rateconstname> ContractionsK </rateconstname>
  <dervname> ContractionRateDerv </dervname>
  <errorlim> 0.5 </errorlim>
</delay>
```

Further information about differential equations can be found in the Schema.

4.5.7 Other equations

The details of other equations can be found in the Schema.

4.5.8 Commenting Out Code

To comment out code that you do not want to use, but do not want to delete, put <!-- before the code and --> after.

4.6 Timing in HumMod

Timing in HumMod is done though two key variables, <solutionint>, which describes the length of time you are simulating for a run, and <displayint> controls the size of each time step. There is a variable, <storageint>, which is no longer used but references to it may still be found. Both variables use minutes as their base unit (thus one second is represented by 0.016666).

Variables which control timing are all found in the \Control directory. GoFor.DES sets the available options for how long to run HumMod. GoTo.DES gives the user an interesting option, it tells HumMod to run until the start of the next hour, day, week or 30 days, regardless of how long that takes.

To create your own custom time step in HumMod, simply modify the following and add it to \Control\GoFor.DES. This example goes for five minutes in 10 second increments. Be warned that HumMod will crash if you attempt to run for too long using small time increments. This is due to HumMod only allocating a limited amount of memory for variables during each time step.

```
<gofor>
  <solutionint> 5 </solutionint>
  <displayint> 0.166666 </displayint>
  <menuitem> 5 Mins (slow) </menuitem>
</gofor>
```

4.6.1 Timesteps

Choosing the timestep for displaying a simulation requires experimentation on the part of the user. It requires thinking about what timescale the physiological changes of interest will occur on, and a decision about how much detail the user would like to see. Changing the timescale can alter the outputs of a simulation. One can imagine a simulation with a periodic (sine wave) solution for some variable. If the timestep is chosen poorly, the user may only see the peaks or troughs of the output and the behavior appears constant, while another timestep might show transient behavior. HumMod's solution is built on the timestep forced by its error tolerances, which is not affected in any way by the user choice of solution interval, or the programmer's choice of <displayinterval>. However, the construction of HumMod limits the amount of data that can be stored for display. Currently, asking for more than 25 displayed points in a single solution interval may cause the program to crash. Recall in the Control code, a <gofor> element has the following syntax:

```
<gofor>
      <solutionint> N </solutionint>
      <displayint> n </displayint>
</gofor>
```

This requirement states that the ratio $\frac{N}{n}$ should be less than 25 to ensure the display can handle the output.

4.6.2 Technical Note About Order of Calculation

The solver handles calculations in a one-in-one-out manner. An order has to be established on the equations. This is done by carving up the equations into pieces called blocks/calculation. Blocks are contained within physiological structures, for instance, GITract-BloodFlow or SkeletalMuscle-Metabolism, although a given structure may contain multiple blocks. To call a block, all references within it must be defined (via variable declaration) and endowed with a value (through previous calculation step or by definition in the variable declaration). Adding to the difficulty, there are four types of calculation blocks:

1. Context blocks give all variables that depend on user choice a value. These include body water, electrolyte masses, hormone masses, etc. These depend on choice of body size, muscularity, adiposity, male/female, etc. Context blocks are called at model instantiation, and whenever a model assumption, such as gender, is changed.

2. Parms blocks instantiate values from the scripted controller or user interface, handling the jump discontinuities that happen when a parameter is given a new value. Parms blocks are called whenever a parameter is changed. If you move a slide bar two times in a row parms blocks are called twice.

3. Dervs blocks evaluate the derivatives that are fed (by the solver) into the differential equation methods. Most of the algebra in the model is taken care of in dervs blocks. Dervs blocks are called automatically in the evaluation of the integrals over a solution interval. Because of the mathematical methods, it is impossible to predict how many times a dervs block will be called in a solution.

4. Wrapup occurs at the end of a solution interval and is used for step-counts and other model manipulations that keep track of what has been done. Since wrapup is called at the end of each solution interval exactly once, it is the only place in the model where enumeration can be performed with confidence.

The model.DES file calls structure.context, structure.parms, etc. The structure.DES file contains the linear ordering of all model blocks. In many cases a block called in structure.DES will in turn call multiple blocks within a local folder.

5 Discussion and Conclusion

HumMod is a flexible human physiology simulation that takes into account thousands of variables to replicate the body's response to changing conditions. HumMod is heavily based on the book *Guyton and Hall Textbook of Medical Physiology* (Hall 2011). Elements of body chemistry such as blood chemistry, hormones, and respiration are detailed. The cardio-vascular system and its response to stresses such as exercise and injuries is modeled. HumMod also includes the effects of a variety of medications and can replicate an increasing range of emergency situations and traumas.

All of the data, equations, and relations that make up HumMod are readily available to the user and can be modified at will to take into account better understandings of the physiology or even to add entire new systems and relations. The user interface is equally customizable and new screens, plots, and controls can be added to meet the needs of a specific research project.

This document guides the user through the installation and basic use of HumMod so that the simulation can be utilized with a minimal learning curve. In addition this document provides a detailed look into the inner workings of HumMod so that a more advanced user will have the tools to modify HumMod themselves. The appendices provide a glimpse into the depth and complexity of HumMod.

HumMod has many strengths, including heart, blood, endocrine system, medical interventions, kidney functions, and blood chemistry. It is also expandable by the user, has full algorithm transparency, and is interoperable with other programs.

Limitations and Omissions

We note here some criticisms and omissions we found while creating this manual. They are inculded to give potential users a realistic sense of the edges of what is availible. HumMod's interface often lacks variables' units, and for someone who is unfamiliar with human physiology, it can be difficult to know the units of the variables. Many information buttons on the display screens do not have information. The information icons are an opportunity to provide helpful and useful information to the user who may not be familiar with the terms and variables. It would be useful for the user to have information about the system they are viewing. Some systems had to be looked up in *Guyton and Hall* because of unfamiliarity with human physiology. Some information icons for displays with heat loss instead display the units for heat gain. It would be clearer if the information icon said heat flux instead of heat gain or loss, just for clarity and consistency.

It may be important to specify how the temperatures are being measured. Through reading *Guyton and Hall* we have found that the temperature measured can change depending on how it is being taken (e.g. K, F, C). There has been confusion as to what the mass in kCal and the mass in kG correspond to. It would be helpful to see these clarified on the interface.

While compiling the manual, a few spelling mistakes were found in the HumMod displays. Table 5.1 is a list of the spelling mistakes found so far.

It is important to understand both HumMod's strengths and limitations. Through testing and speaking with people working with HumMod, we have found that HumMod becomes more inaccurate in larger time increments. Through the exercises in Example Exercises, specifically "Aerobic Exercise Until Exhaustion", we see how the use of different time increments can create drastically different results.

Table 5.1: Spelling mistakes in variables on the HumMod display.

Where	**Mistake**
Heat Summary	"Skeletal Muscle" is spelled as one word
Metabolism->Amino Acids	"Lysine" is spelled "Lycine" in both the menu and in ECFV
Circulation-> Blood Vessels->Lungs	"Left Ventricle" is spelled as one word
Heat->Oral Intake->Food Temp (deg K))	Has an extra ")" at the end

References

Clemmer, J. S., Pruett, W. A., Coleman, T. G., Hall, J. E., & Hester, R. L. (2017). Mechanisms of blood pressure salt sensitivity: New insights from mathematical modeling. *American Journal of Physiology-Regulatory, Integrative and Comparative Physiology, 312*(4), R451-R466.

Coleman, T., et. al. (2010). *HumMod 2010 Schema.* University of Mississippi Medical Center.

Dancy, C. L., & Kim, J. W. (2018). Towards a physio-cognitive model of slow-breathing. *In proceedings of the 40th Annual Conference of the Cognitive Science Society*, Madison, WI, USA, 1587-1592.

Dancy, C. L., Ritter, F. E., Berry, K. A., & Klein, L. C. (2015). Using a cognitive architecture with a physiological substrate to represent effects of a psychological stressor on cognition. *Computational and Mathematical Organization Theory, 21*(1), 90-114.

Hall, J. E. (2011). *Guyton and Hall Textbook of Medical Physiology (12th ed.).* Philadelphia, PA: Saunders.

Hester, R. L., Brown, A. J., Husband, L., Illescu, R., Pruett, D., Summers, R., et al. (2011a). HumMod: A modeling environment for the simulation of integrative human physiology. *Frontiers in Physiology, 2*, Article 12.

Hester, R. L., Iliescu, R., Summers, R., & Coleman, T. G. (2011b). Systems biology and integrative physiological modelling. *Journal of Physiology, 589*(5), 1053-1060.

Mateják, M., & Kofránek, J. (2015). Physiomodel - an integrative physiology in Modelica. *In proceedings of the 37th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)*, 1464-1467.

Appendix A A Detailed Look at an Example Module: Heat

This appendix provides a detailed look at the user interface of an example system in HumMod. We examine the Heat system, as listed in Table A.1. This is an important system: according to Guyton and Hall, "heat is the end product of almost all energy released in the body" (Hall, 2011, p. 862).

"Most of the heat produced in the body is generated in the deep organs especially in the liver, brain, and heart, and in the skeletal muscle during exercise. Then this heat is transferred from the deep organs and tissue to the skin where it is lost to the air and other surroundings. The rate of heat loss is determined by two factors: (a) how rapidly heat can be conducted from where it is produced in the body core to the skin and (b) how rapidly heat can be transferred from the skin to the surroundings" (p. 268).

Insensible refers to insensible water loss that is the water lost from the body that cannot be precisely regulated or sensed by instruments. Insensible water loss can come from the lungs, skin, respiratory tract, and feces. We will go into further detail in section A.6.13 Insensible LungA.6.13.

The most relevant chapter in Guyton and Hall (2011) is Chapter 73: Body Temperature Regulation, and Fever (p. 867).

Table A.1: All the subsystems in the HumMod Heat system.

Systems	
Core	Movement (continued)
Skin	Conduction
Skeletal Muscle	Sweating
GI Lumen	Insensible Skin
Movement	Insensible Lung
Oral Intake	Vomitus
Metabolism	Sweating
IV Drip	Diarrhea
Transfusion	Sweat
Shivering	Gland
Urine	Duct
Hemorrhage	Acclimation
Dialysis	Fuel
Radiation	

A.1 Heat Summary Display

The Summary display is the initial option in the Heat drop-down menu. The summary screen displays a complete summary of the Heat system to the user and is shown in Figure A.1. It is organized into three sections: Storage, Temperatures, and Compartments; Table A.2, Table A.3, and Table A.4 list the variables from those sections respectively. The variables used correspond to the systems in Heat, such as Skeletal Muscle. Most of the systems in Heat are organized using Storage and Temperature as well. The temperature values found in Table A.3 are the default values and can be adjusted or set in the Sizing module, the last module in the top menu shown in Figure 3.1

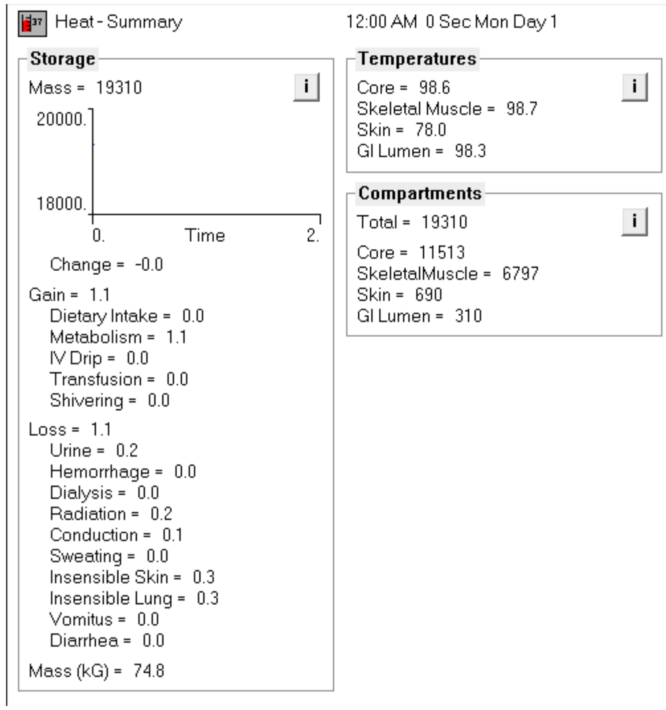

Figure A.1: HumMod Heat-Summary. The initial display of the summary of the Heat system.

In Storage there are two variables Gain and Loss. These variables refer to the heat gained, and the heat lost from the body. Each one is broken down into what systems make up heat gain and loss. We will be exploring those systems further in upcoming sections.

The temperature values are default temperature values and can be set in Sizing, the last module on the top-level menu shown in Figure 3.1.

Table A.2: HumMod Heat Summary variables under Storage with units and comments.

Variable	Units	Comments
Mass	kCal	This is the mass of the body.
Change	kCal	Change in heat.
Gain	kCal	Heat gain.
Dietary Intake	kCal	
Metabolism	kCal	
IV Drip	kCal	
Transfusion	kCal	
Shivering	kCal	
Loss	kCal	Heat loss.
Urine	kCal	
Hemorrhage	kCal	
Radiation	kCal	
Conduction	kCal	
Sweating	kCal	
Insensible Skin	kCal	
Insensible Lung	kCal	
Vomitus	kCal	
Diarrhea	kCal	
Mass	kG	

Table A.3: HumMod Heat Summary variables under Temperatures with units and comments.

Variables	Units	Comments
Core	deg F	Default value: 98.6
Skeletal Muscle	deg F	Default value: 98.7
Skin	deg F	Default value: 78.0
GI Lumen	deg F	Default value: 98.3

Table A.4: HumMod Heat Summary variables under Compartments with units and comments.

Variables	Units	Comments
Total	kCal	
Core	kCal	
SkeletalMuscle	kCal	
Skin	kCal	
GI Lumen	kCal	

A.2 Core

Core refers to the core of the human body or the deep tissue of the body. According to Guyton and Hall, "the temperature of the core remains very constant within ±1 deg F (±0.6 deg C) except when the person develops a febrile illness" (Hall, 2011, p. 867). There is no single normal core temperature, but rather a range of normal temperatures. The average core temperature is between 98.0 deg F and 98.6 deg F when measured orally.

The information icons are boxes with an "i" in them. When selected a pop-up message will appear on screen. In the display shown in Figure A.2, the information icon in temperature tells us the typical core temperature (98.6 deg F, 37.0 deg C, 310.1 deg K). The other information icon on this display are blank and do not show information. The variables in the Core system under storage and temperature are found in Table A.5 and Table A.6 respectively.

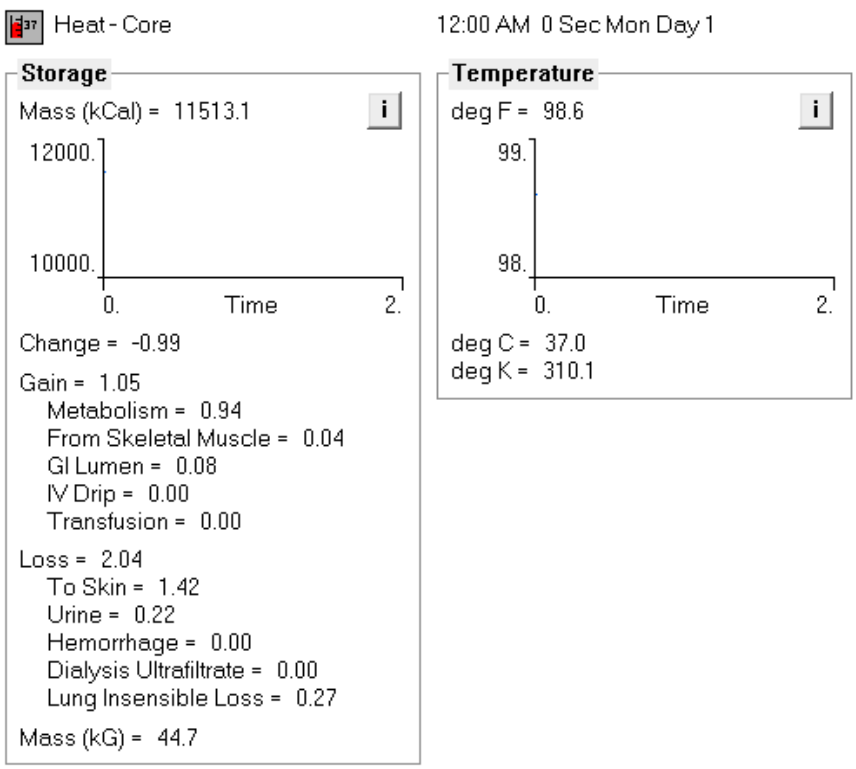

Figure A.2: HumMod Core. The initial display of the Core system under Heat.

Table A.5: Variables in HumMod Core system under Storage.

Variables	Units	Comments
Mass	kCal	
Change	kCal/min	
Gain	kCal/min	
Metabolism	kCal/min	
From Skeletal Muscle	kCal/min	
GI Lumen	kCal/min	
IV Drip	kCal/min	
Transfusion	kCal/min	
Loss	kCal/min	
To Skin	kCal/min	
Urine	kCal/min	
Hemorrhage	kCal/min	
Dialysis Ultrafiltrate	kCal/min	
Lung Insensible Loss	kCal/min	
Mass	kg	
GI Lumen	kCal/min	
IV Drip	kCal/min	
Transfusion	kCal/min	

Table A.6: Variables in Core system under Temperatures.

Variables	Units	Comments
deg F	Degrees Fahrenheit	
deg C	Degrees Celsius	
deg K	Degrees Kelvin	

A.3 Skin

Skin temperature often rises and falls, unlike the mostly constant core temperature. Most of the heat in the human body is produced by deep organs and then transferred to the skin where it is lost to the air and other surroundings. The skin is an effective controlled heat radiator system. The flow of blood to the skin is an effective way to transfer heat from the body core to the skin. Sweating is also an effective way for transferring heat away from the body core.

The initial display for Skin is shown in Figure A.3. The variables in the Skin system for storage and temperature are listed in Table A.7 and Table A.8 respectively.

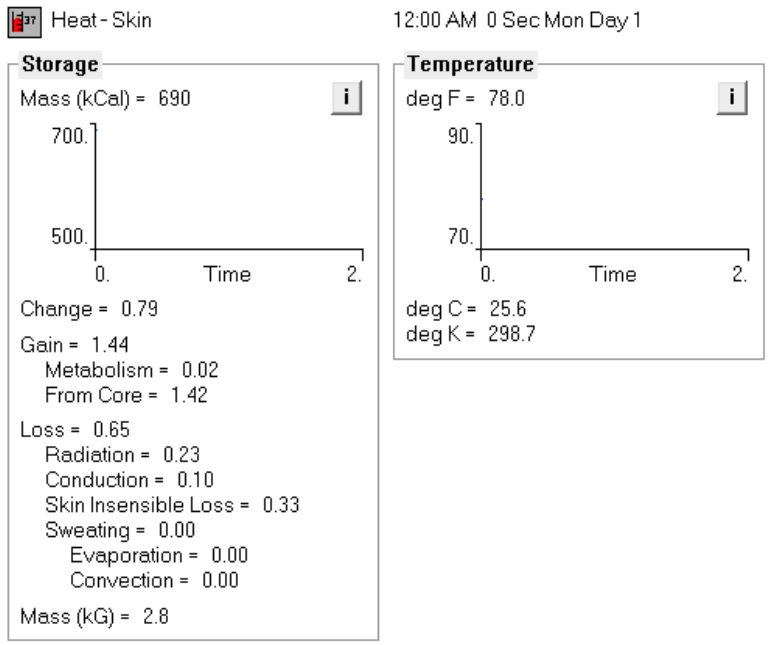

Figure A.3: HumMod Skin. The initial display of the Skin system under Heat.

Table A.7: Variables in HumMod Skin system under Storage.

Variables	Units	Comments
Mass	kCal	
Change	No units given	
Gain	No units given	
Metabolism	No units given	
From Core	No units given	
Loss	No units given	
Radiation	No units given	
Conduction	No units given	
Skin Insensible Loss	No units given	
Sweating	No units given	
Evaporation	No units given	
Convection	No units given	
Mass	kG	

Table A.8: Variables under Skin under Temperature.

Variables	Units	Comments
deg F	Degrees Fahrenheit	
deg C	Degrees Celsius	
deg K	Degrees Kelvin	

A.4 Skeletal Muscle

HumMod does not have a dedicated muscle system with smooth muscle, cardiac muscle and skeletal muscle in it, but instead has skeletal muscle under Heat. Skeletal muscle is also found under the Organs interface and menu, which displays different information. According to HumMod, the typical skeletal muscle temperature is 99.0 deg F (37.2 deg C or 310.4 deg K). The Heat display is shown in Figure A.4. and Table A.9. list the variables with their units and comments in storage and temperature respectively. In this system, the information icon in temperature tells us that the typical skeletal muscle temperatures (99.0 deg F, 37. 2 deg C, 310.4 deg K). The other information icon on this display does not show any information.

Guyton and Hall (2011) includes skeletal muscle as well as cardiac muscle and smooth muscle. According to the textbook, 40% of the human body mass is skeletal muscle, and another 10% is smooth and cardiac muscle (Hall, 2011, p. 71).

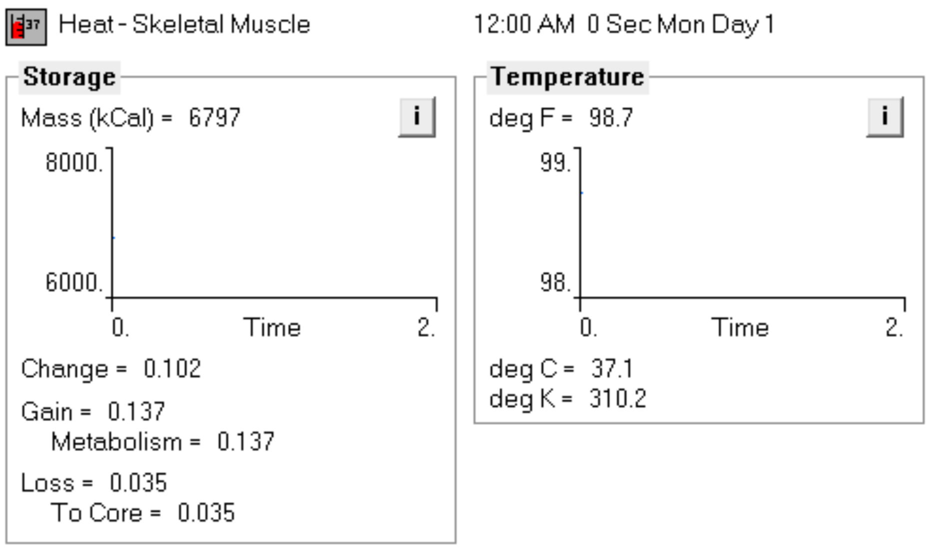

Figure A.4: HumMod Heat-Skeletal Muscle. The initial display of the Skeletal Muscle system under Heat.

Table A.9: Variables in HumMod Skeletal Muscle system under Storage.

Variables	Units	Comments
Mass	kCal	
Change	No units given	The change of heat.
Gain	No units given	Heat loss.
Metabolism	No units given	According to Guyton and Hall (2011), "The metabolism of the body simply means all the chemical reactions in all the cells of the body, and the metabolic rate is normally expressed in terms of **rate of heat liberation** during chemical reactions" (p. 862).
Loss	No units given	Heat loss.
To Core	kCal	

Table A.10: Variables in HumMod Skeletal Muscle system under Temperatures

Variables	Units	Comments
deg F	Degrees Fahrenheit	
deg C	Degrees Celsius	
deg K	Degrees Kelvin	

A.5 GI Lumen

The gastrointestinal lumen refers to the open space inside the gastrointestinal tract's tubular structure. This includes, for example, the food and processed food inside the gastrointestinal tract. The initial GI Lumen display is shown in Figure A.5. This system has one parameter "Cond" (conduction to core) that can be changed using a slider. A list of the variables in the GI Lumen system under Storage and Temperature can be found in Table A.11: Variables in HumMod GI Lumen system under Storage.Table A.11 and Table A.13 respectively. Table A.14 shows the "Cond" parameter.

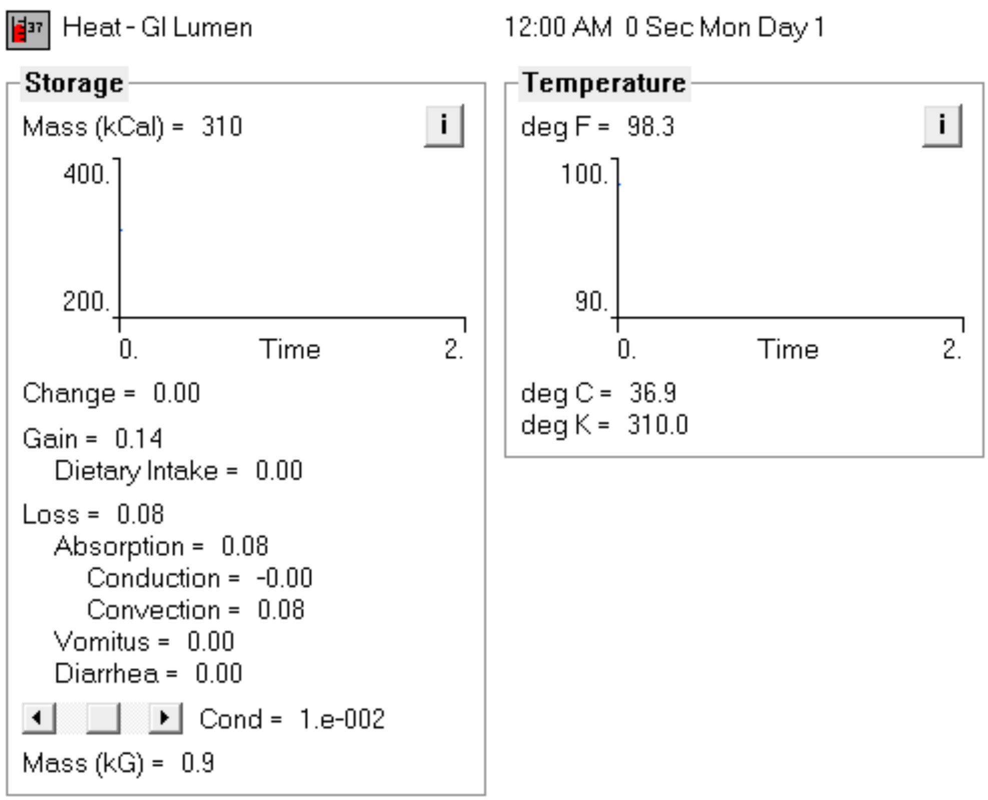

Figure A.5: HumMod GI Lumen screen. The initial display of the GI Lumen system under Heat.

Table A.11: Variables in HumMod GI Lumen system under Storage.

Variables	Units	Comments
Mass	kCal	
Change	kCal	
Gain	kCal	
Dietary Intake	kCal	
Loss	kCal	
Absorption	kCal	
Conduction	kCal	
Convection	kCal	
Vomitus	kCal	
Diarrhea	kCal	

Table A.13: Variables in HumMod GI Lumen system under Temperatures

Variables	Units	Comments
deg F	Degrees Fahrenheit	
deg C	Degrees Celsius	
deg K	Degrees Kelvin	

Table A.14: Parameters in HumMod GI Lumen system

Parameter	Units	Comments
Cond	No units given	This is a parameter that uses a slider.

A.6 Movement

The Movement sub-module under Heat looks at the movement of things coming in and out of the body, and its effects on heat. In Figure A.6, we see the subsystems of Movement separated into two sections in the menu, which represent gain and loss from the system, respectively. The top section represents heat gain, while the bottom section is heat loss. In Figure A.7, we see a daily intake and output of water table from Guyton and Hall (2016) with some of the subsystems found in the Movement module, such as fluid ingested, insensible skin, insensible lung, sweat, and urine. There is no default summary screen for Movement, but each sub-module, or subsystem, has a default screen.

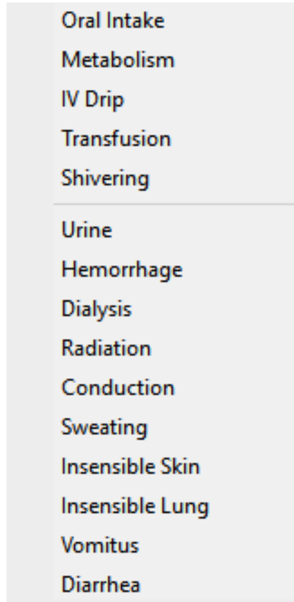

Figure A.6: HumMod Movement submenu under the Heat menu tab.

	Normal	Prolonged, Heavy Exercise
Intake		
Fluids ingested	2100	?
From metabolism	200	200
Total intake	2300	?
Output		
Insensible: skin	350	350
Insensible: lungs	350	650
Sweat	100	5000
Feces	100	100
Urine	1400	500
Total output	2300	6600

Figure A.7: Daily intake and output of water (ml/day) from Guyton and Hall 13th edition, Table 25-1, page 306 (page 286 in 12th edition).

A.6.1 Oral Intake

Oral intake looks at the temperature as well as amount of water and food intaken orally. Oral intake focuses on heat gain. As food is being digested, absorbed, and stored, energy is being consumed, and heat is being generated. The initial default screen for oral intake is shown in Figure A.8. The information icon tells us that the units for heat gain are in kCal/min. There are no parameters on this screen that the user can change.

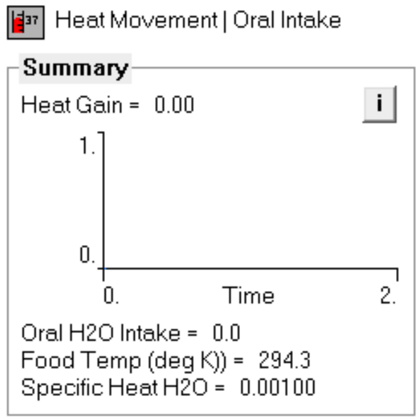

Figure A.8: HumMod Oral Intake summary initial default screen. This system is found under Movement that is under Heat.

Table A.15: Variables in HumMod Oral Intake system under Movement that is under Heat.

Variables	Units	Comments
Heat Gain	kCal/min	
Oral H2O Intake	No units given	
Food Temp (deg K))	Degrees Kelvin	Has an extra ")" at the end
Specific Heat H20	No units given	No units given, but assuming kCal or kCal/min

A.6.2 Metabolism

According to Guyton and Hall (2011), "The metabolism of the body simply means all the chemical reactions in all the cells of the body, and the metabolic rate is normally expressed in terms of rate of heat liberation during chemical reactions" (p. 862). Heat production is a by-product of metabolism. According to Guyton and Hall (2011), there are six key factors that determine the rate of heat production in the body: (a) the basal rate of metabolism of all the cells of the body; (b) the extra rate of metabolism caused by muscle activity; (c) the extra metabolism caused by the effects of hormones on the cells; (d) the extra metabolism caused by the effects of epinephrine, norepinephrine, and sympathetic stimulation on the cells; (e) the extra metabolism caused by the increased chemical activity in the cells; (f) the extra metabolism needed to digest, absorb, and store food (p. 867).

The initial screen for metabolism is shown in Figure A.9. The information icon tells us that the units for heat gain are in kCal/min. All the variables in Metabolism are listed in Table A.15.

In the structure files for Metabolism, there is a text file called "Insulin and Tissue Glucose Uptake." According to this document in the Metabolism structure files, "Guyton and Hall tell us that in the absence of insulin, tissue glucose uptake is inadequate." This means that insulin levels exert a tonic effect on glucose absorption in all tissues. Removing insulin reduces glucose absorption.

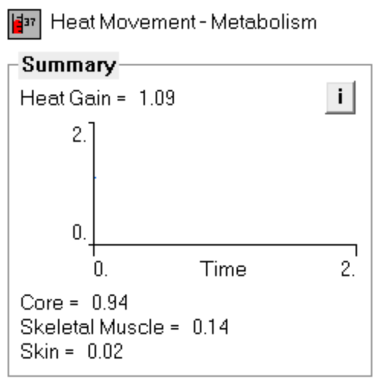

Figure A.9: HumMod Metabolism initial screen. This system is a subsystem in Movement and can be found under the Heat system.

Table A.16: Variables in HumMod Metabolism system in Movement which is under the Heat system.

Variables	Units	Comments
Heat Gain	kCal/min	
Core	No units given	Possibly kCal or kCal/min
Skeletal Muscle	No units given	Possibly kCal or kCal/min
Skin	No units given	Possibly kCal or kCal/min

A.6.3 IV Drip

Intravenous therapy, or IV drip, is a therapy where liquid substances are administered through the veins. This is usually done to replace fluids or deliver medication quickly because the venous system can carry it through the body via circulation. The user has full control over what is administered in the module. Water rate is established, and the contents of the fluid are set by manually adjusting sliders for electrolytes and protein constituents, or by activating premixed compounds such as Ringer's lactate. The initial IV Drip display is shown in Figure A.10. The information icon tells us that the units for heat gain are in kCal/min. The variables and their units are listed in Table A.16.

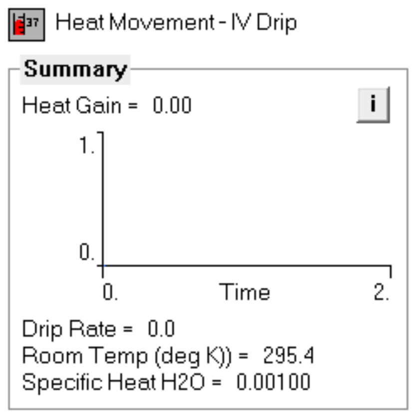

Figure A.10: HumMod IV Drip initial screen. This system is a subsystem in Movement and can be found under the Heat system.

Table A.17: Variables in HumMod IV Drip system in Movement which is under the Heat system.

Variables	Units	Comments
Heat Gain	kCal/min	
Drip Rate	No units given	
Room Temp (deg K))	Degrees Kelvin	Has an extra ")" at the end
Specific Heat H2O	No units given	

A.6.4 Transfusion

Blood transfusion is transferring blood into the body. The initial screen is shown in Figure A.11. The information icon tells us that the units for heat gain are in kCal/min. The variables and their units are listed in Table A.17. There are no parameters that the user can change on this screen.

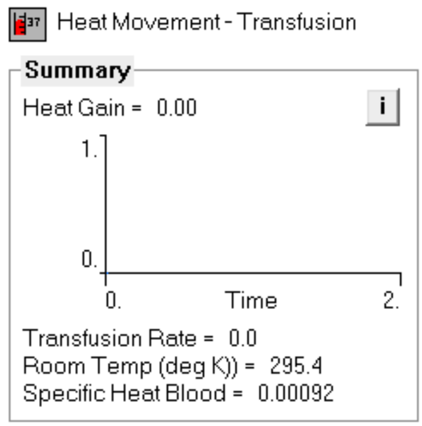

Figure A.11: HumMod Transfusion initial screen. This system is found under Movement in the Heat module.

Table A.18: Variables in HumMod Transfusion screen. This system is found under Movement in the Heat module.

Variables	Units	Comments
Heat Gain	kCal/min	
Transfusion Rate	No units given	
Room Temp (deg K))	Degrees Kelvin	Has an extra ")" at the end
Specific Heat Blood	No units given	

A.6.5 Shivering

Muscle activity is present when shivering. Shivering is used to increase the temperature of the body and promotes heat production. The initial screen display for Shivering, found in Figure A.12. displays two graphs: heat gain over time and calories over nerve activity. Nerve activity from the hypothalamus can cause shivering to occur regardless of temperature, such as during a fever. Shivering is measured in calories. The units for heat gain are in kCal/min. The variables in the initial Shivering display are listed in Table A.18. There are no parameters the user can change in this Shivering display.

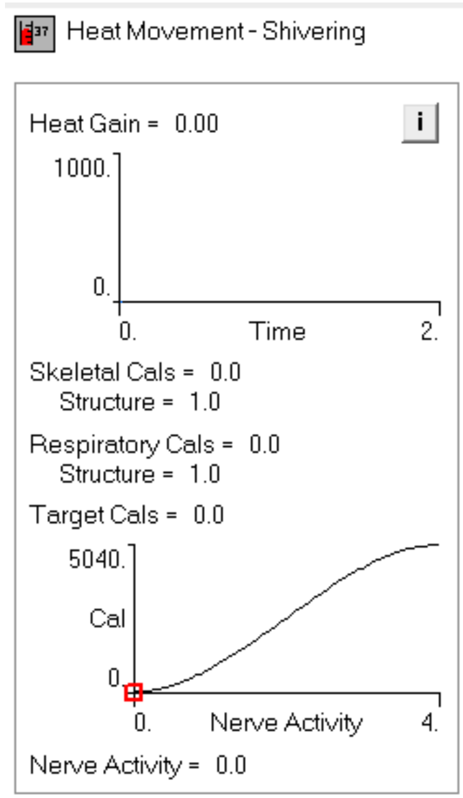

Figure A.12: HumMod Shivering initial screen. This screen is available in the Movement tab which is found in Heat files.

Table A.19: Variables in HumMod Shivering system found under Movement in Heat module.

Variables	Units	Comments
Heat Gain	kCal/min	
Skeletal Cals	Cal	
Structure	No units given	Default value is 1.0
Respiratory Cals	Cal	
Structure	No units given	Default value is 1.0
Target Cals	Cal	
Nerve Activity	No units given	

A.6.6 Urine

Aside from insensible water loss, sweat, and feces, the remainder of water loss comes from the urine excreted by the kidneys. The body maintains the balance between water intake and output by controlling the rate the kidneys excrete water, which is also true for most electrolytes as well. The kidneys adjust the excretion rate of water and electrolytes to match the intake of those substances. The initial screen in Figure A.13 focuses on heat loss. The variables in Urine are found in Table A.19. There are no parameters the user can change on this screen. The information icon tells us that the units for heat gain are in kCal/min, which can be inferred as the same units for heat loss.

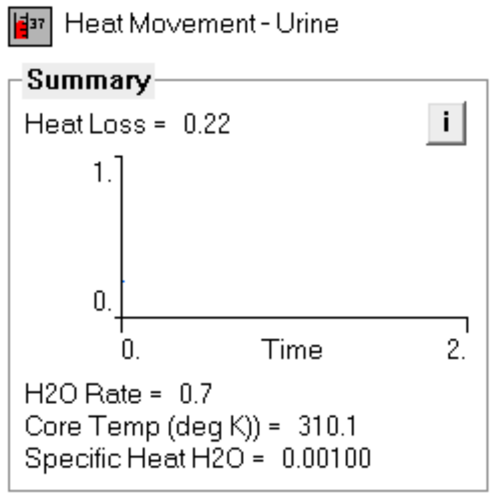

Figure A.13: HumMod Urine system initial display found under Movement in Heat module.

Table A.20: Variables in HumMod Urine system found under Movement in Heat.

Variables	Units	Comments
Heat Loss	kCal/min	
H2O Rate	No units given	
Core Temp (deg K))	Degrees Kelvin	Has an extra ")" at the end
Specific Heat H2O	No units given	

A.6.7 Hemorrhage

A hemorrhage is the escape of blood from a blood vessel, which decreases the filling pressure of circulation and decreases venous return which can lead to hemorrhagic shock from blood loss. Figure A.14 shows the initial display for Hemorrhage, and it is only a summary screen. The variables are listed in Table A.20. There are no parameters on this screen that the user can change. The information icon tells us that the units of heat gain are in kCal/min.

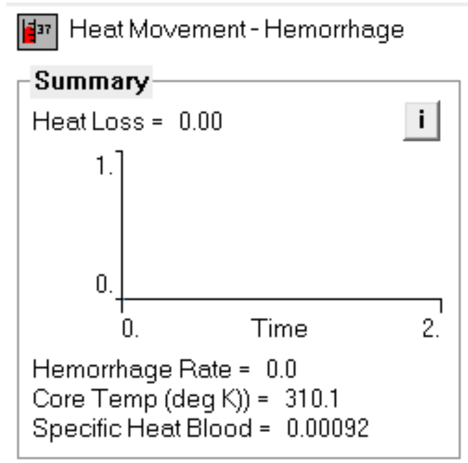

Figure A.14: HumMod Hemorrhage initial display. This system is in Movement under the Heat module.

Table A.21: Variables in HumMod Hemorrhage.

Variables	Units	Comments
Heat Loss	kCal/min	
Hemorrhage Rate	No units given	
Core Temp (deg K))	Degrees Kelvin	Has an extra ")" at the end
Specific Heat Blood	kCal	

A.6.8 Dialysis

Dialysis is a substitute for a normal functioning kidney. It purifies the blood, acting like an artificial kidney. The initial display screen is just a summary screen and is shown in Figure A.15. The variables on this screen are listed in Table A.21. There are no parameters that the user can change on this screen. The information icon tells us that the units for heat gain are in kCal/min.

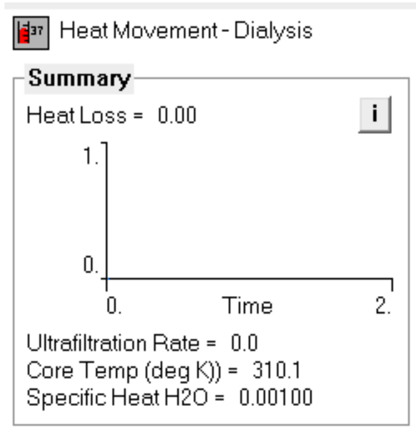

Figure A.15: HumMod Dialysis initial screen found in Movement under the Heat module.

Table A.22: Variables in HumMod Dialysis found in the Movement under the Heat module.

Variables	Units	Comments
Heat Loss	kCal/min	
Ultrafiltration Rate	No units given	
Core Temp (deg K))	Degrees Kelvin	Has an extra ")" at the end
Specific Heat H2O	kCal	

A.6.9 Radiation

Heat is lost from the skin through radiation, conduction, and evaporation. Anything that doesn't have an absolute temperature of zero radiates infrared heat away, this includes the human body. According to Guyton and Hall (2011), "about 60 percent of total heat loss is by radiation" (p. 868). The initial display screen found in Figure A.16 is just a summary screen. The variables and their units are listed in Table A.22. There are no parameters the user can change on this screen. The information icon tells us that the units for heat flux are kCal/min, and temperature difference is skin minus ambient in degrees Kelvin.

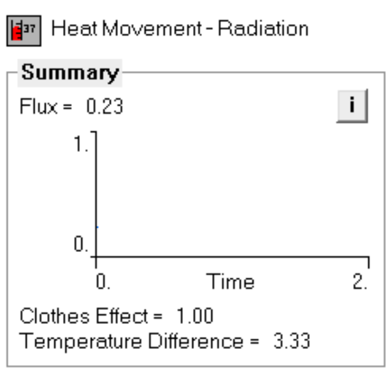

Figure A.16: HumMod Radiation initial display found in Movement under the Heat module.

Table A.23: Variables in HumMod Radiation found in Movement under the heat Module.

Variables	Units	Comments
Flux	kCal/min	
Clothes Effect	No units given	
Temperature Difference	Degrees Kelvin	= skin - ambient

A.6.10 Conduction

According to Guyton and Hall (2011), about three percent of total heat lost is from direct conduction from the surface of the body to a solid object, but about fifteen percent of total heat lost is from conduction from the surface of the body to air (p. 869). The initial screen is a summary screen and is shown in Figure A.17 below. The variables and their units are listed in Table A.23. There are no parameters the user can change on this screen. The information icon tells us that the units for heat flux are kCal/min, and temperature difference is skin minus ambient in degrees Kelvin.

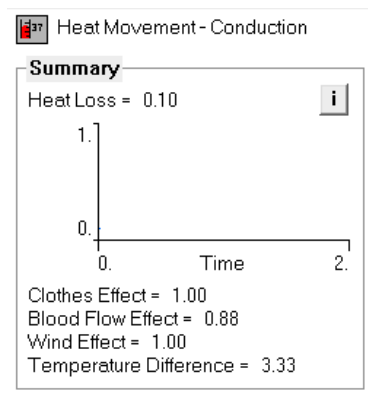

Figure A.17: HumMod Conduction initial display found in Movement under the Heat module.

Table A.24: Variables in HumMod Conduction initial display, found in Movement under the Heat module.

Variables	Units	Comments
Heat Loss	kCal/min	
Clothes Effect	No units given	
Blood Flow Effect	No units given	
Wind Effect	No units given	
Temperature Difference	Degrees Kelvin	= (skin temp.- ambient temp.)

A.6.11 Sweating

Sweating is a subsystem of Movement in Heat, but it is also its own system called Sweat in Heat. The difference is that Sweating focuses on the heat loss from sweating and the evaporation rate, while Sweat focuses on the different parts, such as the sweat gland and duct.

According to Guyton and Hall (2011), the amount of water lost by sweating depends on physical activity and environmental temperature. The volume of sweat normally is about 100ml/day, but in very hot weather or during heavy exercise fluid loss in sweat occasionally increases to 1 to 2L/hour (p. 285).

Figure A.18 shows the initial display for Sweating. The display screen is divided into three sections: Summary, Convection, and Evaporation. The Summary sections summarizes the heat loss, total convection, and total evaporation. The information icon in the Summary window tells us that the units for heat flux are in kCal/min, and units for H2O loss are in mL/min.

The Convection sections tells us about the heat loss from convection, sweat rate, and skin temperature in degrees Kelvin. The information icon repeats the same information as the information icon in the Summary.

The Evaporation sections tells us the heat loss from evaporation, evaporation information, wind effect, and vapor pressure. There are graphs for wind effect and basic evaporation. The information icon repeats the same information from the Summary section information icon. The variables and their units are listed in Tables A.24 through A.26.

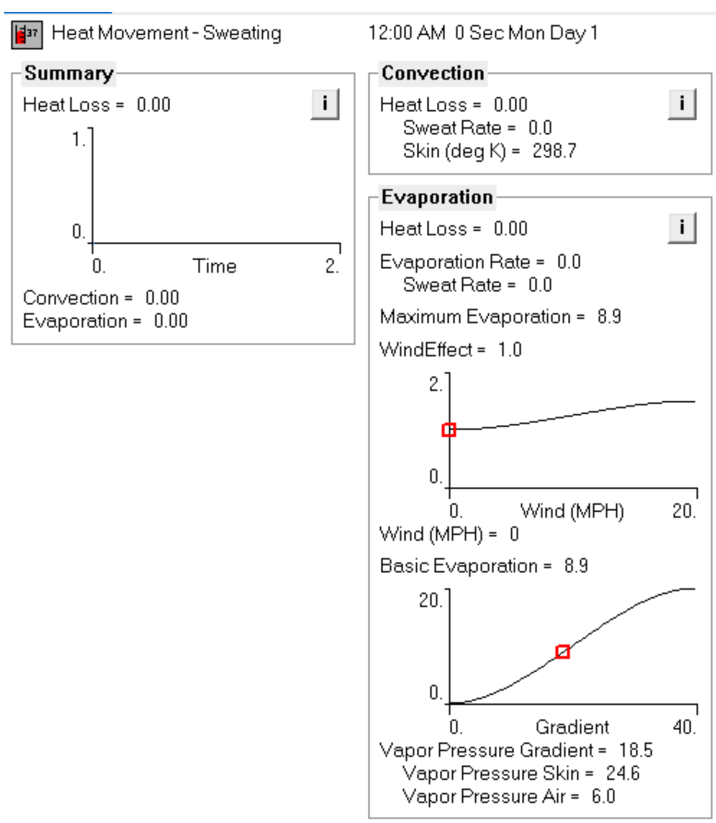

Figure A.18: HumMod Sweating initial display. This system is under Movement in the Heat module.

Table A.25: Variables in HumMod Sweating Summary.

Variables	Units	Comments
Heat Loss	kCal/min	
Convection	No units given	
Evaporation	No units given	
Specific Heat H2O	No units given	

Table A.26: Variables in HumMod Sweating Convection.

Variables	Units	Comments
Heat Loss	kCal/min	
Sweat Rate	No units given	
Skin (deg K))	Degrees Kelvin	Extra “)”

Table A.26: Variables in HumMod Sweating Evaporation

Variables	Units	Comments
Heat Loss	kCal/min	
Evaporation Rate	No units given	
Sweat Rate	No units given	
Maximum Evaporation	No units given	
Wind Effect	No units given	
Wind (MPH)	MPH	
Basic Evaporation	No units given	
Vapor Pressure Gradient	No units given	
Vapor Pressure Skin	No units given	
Vapor Pressure Air	No units given	

A.6.12 Insensible Skin

Insensible skin is the water loss that cannot be precisely regulated (i.e., is not able to be sensed). This occurs independently of sweating and is also present in people who were born without sweat glands. The initial display is a summary screen and is shown in Figure A.19. The variables are listed in Table A.27. There are no parameters the user can change on this screen. The information icon tells us that the units of flux are in kCal/min.

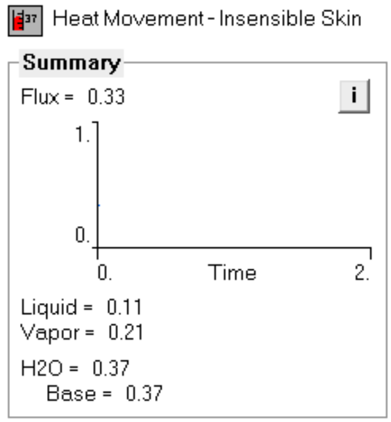

Figure A.19: HumMod Insensible Skin initial display screen.

Table A.27 : Variables in HumMod Insensible Skin found in Movement under the Heat module.

Variables	Units	Comments
Flux	kCal/min	
Liquid	No units given	
Vapor	No units given	
H2O	No units given	
Base	No units given	

A.6.13 Insensible Lung

Insensible water loss through the lung happens as the air enters the respiratory tract and it becomes saturated with moisture. There is more insensible water loss during cold weather. The initial display is a summary display and is shown in Figure A.20. The variables are listed in Table A.28. There are no parameters that the user can change on this screen. The information icon tells us that the units of flux are in kCal/min.

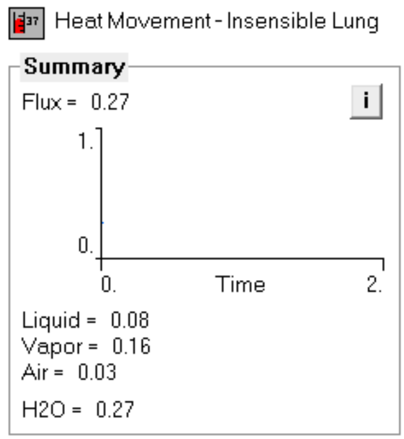

Figure A.20: HumMod Insensible Lung initial display.

Table A.28: Variables in HumMod Insensible Lung found in Movement under the Heat module.

Variables	Units	Comments
Flux	kCal/min	
Liquid	No units given	
Vapor	No units given	
Air	No units given	
H2O	No units given	

A.6.14 Vomitus

Vomiting is how the upper gastrointestinal tract rids itself of contents when the it becomes excessively irritated, distended, or excited. The initial display for Vomitus is a summary display shown in Figure A.21. The variables in the display are listed in Table A.29. The information icon says the units of heat loss are kCal/min.

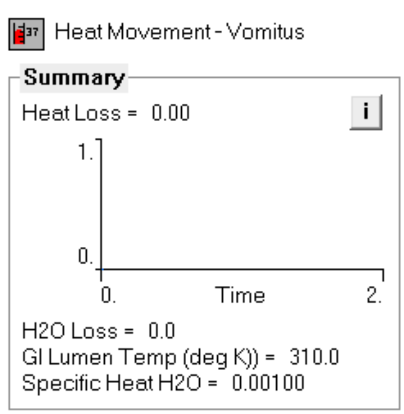

Figure A.21: HumMod Vomitus initial display.

Table A.279: Variables in HumMod Vomitus module.

Variables	Units	Comments
Heat Loss	kCal/min	
H2O Loss	No units given	
GI Lumen Temp (degK))	Degrees Kelvin	Extra “)”
Specific Heat H2O	No units given	

A.6.15 Diarrhea

According to Guyton and Hall (2011), only a small amount of water (100ml/day) is lost in feces, but can increase to several liters a day in people with severe diarrhea, which is why severe diarrhea can be life threatening if not corrected within a few days (p. 286). The initial display, shown in Figure A.22, is a summary display. The variables in the Diarrhea initial display are listed in Table A.30. Heat loss is in kCal/min.

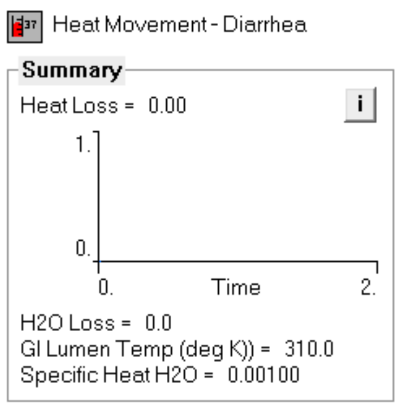

Figure A.22: HumMod Diarrhea initial display.

Table A.30 : Variables in HumMod Diarrhea initial display.

Variables	Units	Comments
Heat Loss	kCal/min	
H2O Loss	No units given	
GI Lumen Temp (degK))	Degrees Kelvin	Extra “)”
Specific Heat H2O	No units given	

A.7 Sweat

The submodule Sweat covers the sweat gland and duct, acclimation to heat, and fuel.

A.7.1 Gland

According to Guyton and Hall (2011), sweat glands have cholinergic nerve fibers that run in the sympathetic nerve and secrete acetylcholine. The sweat gland is made of two parts: a deep subdermal coiled portion that secretes the sweat and a duct portion that passes outward through the dermis and epidermis of the skin (p. 870).

The initial display for Sweat Gland is shown in Figure A.23. This display shows the Precursor Secretion. There are two graphs that display information, three parameters the user can change, and seven variables the user cannot change. The variables are listed in Table A.31 and the parameters are listed in Table A.32.

The information icon tells us three things: (1) the units for H2O flow are in mL/min, (2) the units for effects are times normal value, and (3) the units for electrolyte concentration and flow are mEq/mL and mEq/min.

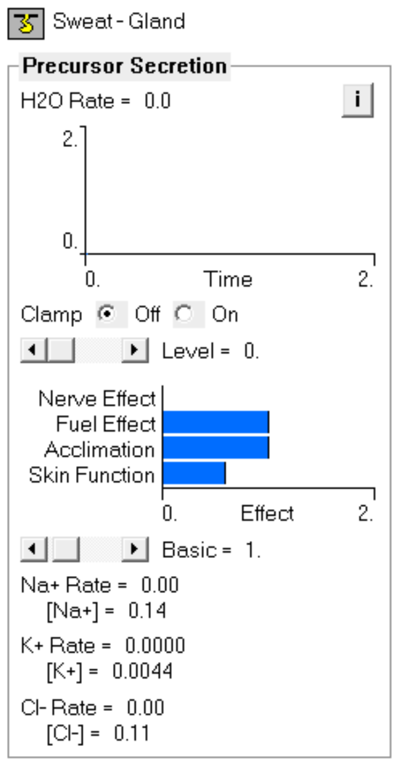

Figure A.23: HumMod Sweat-Gland initial display.

Table A.31: Variables in HumMod Sweat-Gland.

Variables	Units	Comments
H2O Rate	mL/min	
Na+ Rate	mEq/min	Electrolyte flow rate
[Na+]	mEq/mL	Electrolyte concentration
K+ Rate	mEq/min	Electrolyte flow rate
[K+]	mEq/mL	Electrolyte concentration
Cl- Rate	mEq/min	Electrolyte flow rate
[Cl-]	mEq/mL	Electrolyte concentration

Table A.32 : Parameters in HumMod Sweat-Gland.

Variables	Units	Comments
Clamp		Off/On
Level		Slider
Basic		Slider

There is an available clamp that sets the sweating level at a particular point ("Level", in ml/min) or by altering the basic level of sweating ("Basic"). Sweat is calculated as Basic*Modifiers where Modifiers are multiplier functions incorporating temperature, work, nervous activation, etc.

A.7.2 Duct

The Sweat-Duct initial display has two sections, shown in Figure A.24, Reabsorption and Balance. The information icons contain no information. The variables are parameters are listed in Tables A.33 through A.35.

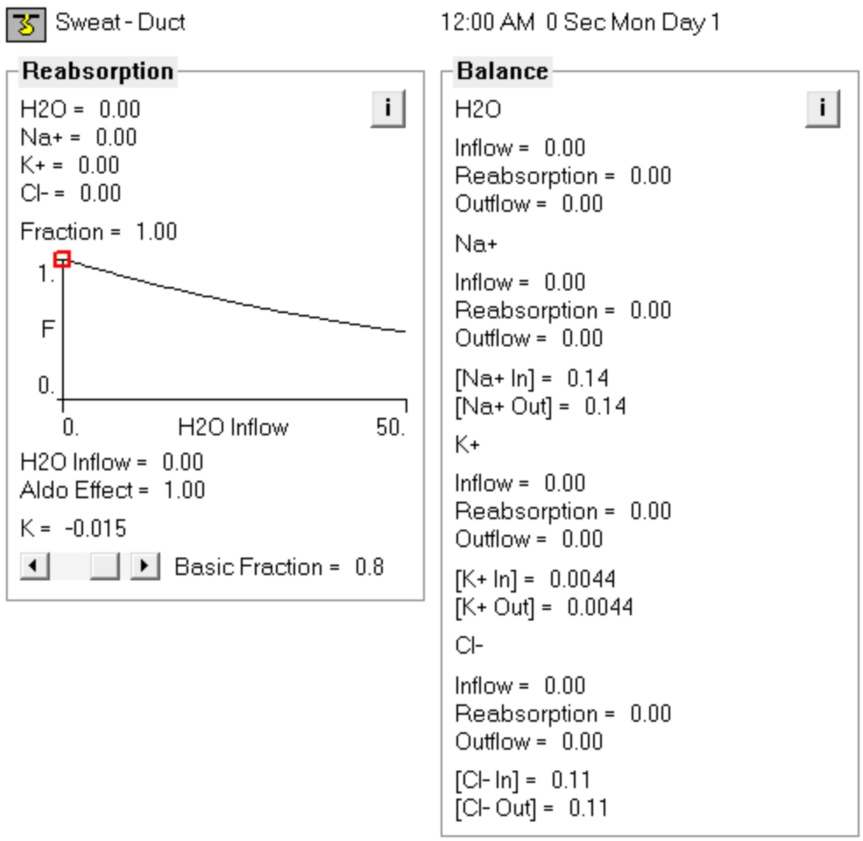

Figure A.24: HumMod Sweat-Duct initial screen.

Table A.33: Variables in HumMod Sweat-Duct Reabsorptions

Variables	Units	Comments
H2O	mL/min	H2O flow rate
Na	mEq/min	Electrolyte flow rate
K+	mEq/min	Electrolyte flow rate
Cl-	mEq/min	Electrolyte flow rate
Fraction		
H2O Inflow	Ml/min	
Aldo Effect	No units given	
K		

Table A.34: Parameters in HumMod Sweat-Duct Reabsorption.

Variables	Units	Comments
Basic Fraction		Slider

Table A.35 : Variables in HumMod Sweat-Duct Balance.

Variables	Units	Comments
H_2O		
Inflow	mL/min	
Reabsorption	mL/min	
Outflow	mL/min	
Na+		
Inflow		
Reabsorption	mEq/min	
Outflow		
[Na+ In]		
[Na+ Out]		
K+	mEq/min	
Inflow		
Reabsorption		
Outflow		
[K+ In]		
[K+ Out]		
C-	mEq/min	
Inflow		
Reabsorption		
Outflow		
[C- In]		
[C- Out]		

A.7.3 Acclimation

Acclimation is the sweating mechanism for acclimating to heat. According to Guyton and Hall (2011), a normal acclimatized person seldom produces more than about 1 liter of sweat per hour. When this person is exposed to hot weather, for the first one to six weeks, he or she begins to sweat more profusely as much as two to three L/hour. The info box says "K is the delay rate constant (in Min). Tau is the delay time constant, typically 6 days".

The initial display, shown in Figure A.25, is a summary display. This display has two graphs, six variables the user cannot change, and two parameters the user can change. The variables are listed with units in Table A.36, and the parameters are listed in Table A.37.

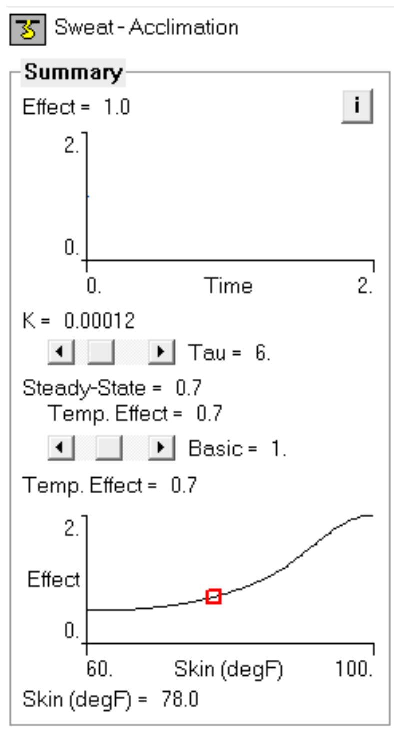

Figure A.25: HumMod Sweat-Acclimation initial display.

Table A.36 : Variables in HumMod Sweat-Acclimation.

Variables	Units	Comments
Effect		
K	min	Decay Rate Constant
Steady-State		
Temp. Effect		
Temp. Effect		
Skin (degF)	Degrees Fahrenheit	

Table A.37: Parameters in HumMod Sweat-Acclimation

Variables	Units	Comments
Tau		Slider
Basic		Slider

A.7.4 Fuel

The structure file for fuel is organ-Fuel.DES, where “organ” is bone, adipose, skeletal muscle, etc. The display is shown in Figure A.26. The information icon does not have additional information. Variables and parameters are listed in Tables A.38 and A.39 respectively.

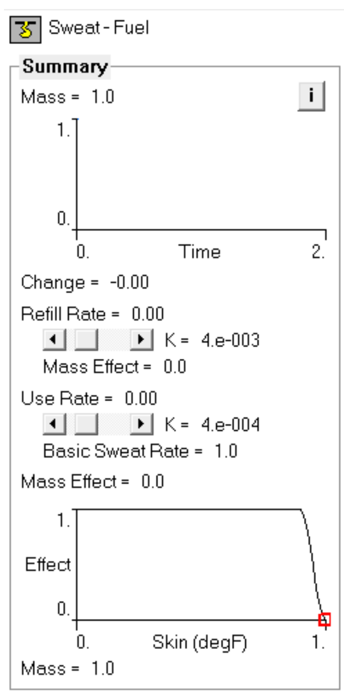

Figure A.26: HumMod Sweat-Fuel initial display.

Table A.38 : Variables in HumMod Sweat-Fuel in the Heat module.

Variables	Units	Comments
Mass		
Change		
Refill Rate		
Mass Effect		
Use Rate		
Base sweat rate		
Mass Effect		
Mass		

Table A.39: Parameters in HumMod Sweat-Fuel in the Heat module.

Variables	Units	Comments
UseK		Slider
RefillK		Slider

Appendix B Files in the Heat Module

How HumMod does calculations and displays data on the GUI is dictated by the structure and display folders. The structure folder is responsible for storing the files that establish how the model works. The display folder is responsible for storing the files that establish how the data is displayed on the GUI. The DES files are the definition of structure and display information. REF files refer to the documentation of where variables and equations came from.

Heat Files

Table B.1: Structure files for HumMod Heat system

DES	DES	REF
Convulsion.DES	Heat.DES	Heat.REF
HeatConduction.DES	HeatCore.DES	HeatInsensibleLung.REF
HeatDialyzer.DES	HeatHemorrhage.DES	HeatShivering.REF
HeatInsensibleLung.DES	HeatIVDrip.DES	HeatSweatConvection.REF
HeatMetabolism.DES	HeatRadiation.DES	HeatSweatEvaporation.REF
HeatShivering.DES	HeatSkeletalMuscle.DES	SpecificHeat.REF
HeatSkin.DES	HeatStorage.DES	
HeatSweatConvection.DES	HeatSweatEvaporation.DES	
HeatSweating.DES	HeatTransfusion.DES	
HeatUrine.DES	SpecificHeat.DES	
TempTools.DES		

Table B.2: Display files for HumMod Heat system

DES
Heat.DES

Summary Display Files

Table B.3: Display files for HumMod Summary display

DES	DES
Compartments.DES	Storage.DES
Summary.DES	Temperatures.DES

Skeletal Muscle Files

Table B.4: Structure files for HumMod Skeletal Muscle system

DES	DES	REF
SkeletalMuscle-Glycogen.DES	SkeletalMuscle-MetabolicVasodilation.DES	SkeletalMuscle-Glycogen.REF
SkeletalMuscle-AlphaReceptors.DES	SkeletalMuscle-Metabolism.DES	SkeletalMuscle-Flow.REF
SkeletalMuscle-BetaReceptors.DES	SkeletalMuscle-Metaboreflex.DES	SkeletalMuscle-MetabolicVasodilation.REF
SkeletalMuscle-CO2.DES	SkeletalMuscle-MusclePumping.DES	SkeletalMuscle-Metaboreflex.REF
SkeletalMuscle-ContractileProtein.DES	SkeletalMuscle-Ph.DES	SkeletalMuscle-MusclePumping.REF
SkeletalMuscle-Energy.DES	SkeletalMuscle-Pressure.DES	
SkeletalMuscle-Flow - original.DES	SkeletalMuscle-Size.DES	
SkeletalMuscle-Flow.DES	SkeletalMuscle-Structure.DES	
SkeletalMuscle-Fuel.DES	SkeletalMuscle-Vasculature.DES	
SkeletalMuscle-Function.DES	SkeletalMuscle-Work.DES	
SkeletalMuscle-Lactate.DES	SkeletalMuscle.DES	

Table B.5: Display files for HumMod Skeletal Muscle system

DES	DES	DES
Fluxes.DES	Storage.DES	Temperature.DES
SkeletalMuscle.DES	Summary.DES	

Core Files

No structure files were found.

Table B.6: Display files for HumMod Core system

DES	DES	DES
Core.DES	Storage.DES	Temperature.DES

Skin Files

Table B.7: Structure files for HumMod Skin system

DES	DES	DES
Skin-AlphaReceptors.DES	Skin-Lactate.DES	Skin-Size.DES
Skin-CO2.DES	Skin-Metabolism.DES	Skin-Structure.DES
Skin-Flow.DES	Skin-Ph.DES	Skin-Vasculature.DES
Skin-Fuel.DES	Skin-Pressure.DES	Skin.DES

Table B.8: Display files for HumMod Skin system

DES	DES	DES
Skin.DES	Storage.DES	Temperature.DES

GI Lumen Files

Table B.9: Structure Files for HumMod GI Lumen system

DES	DES	REF
GILumen.DES	GILumenFood.DES	GILumen.REF
GILumenCalcium.DES	GILumenProtein.DES	GILumenElectrolytes.REF
GILumenChloride.DES	GILumenH20.DES	GILumenFood.REF
GILumenElectrolytes.DES	GILumenHeat.DES	GILumenOther.REF
GILumenPotassium.DES	GILumenDiarrhea.DES	GILumenVolume.REF
GILumenSodium.DES	GILumenOther.DES	
GILumenCarbohydrates.DES	GILumenVomitus.DES	
GILumenFat.DES	GILumenVolume.DES	

Table B.10: Display files for HumMod GI Lumen system

DES	DES	DES
GILumen.DES	Storage.DES	Temperature.DES

Movement Files

Table B.11: Display files for HumMod Movement system

DES
Movement.DES

Oral Intake Files

Table B.12: Display files for HumMod Oral Intake subsystem under Movement.

DES	DES
OralIntake.DES	Summary.DES

Metabolism Files

Table B.13: Display files for HumMod Metabolism system under Movement.

DES	DES
Metabolism.DES	Summary.DES

Table B.14: Structure files for HumMod Metabolism system under Movement.

DES	DES	REF
Metabolism.DES	Metabolism-CaloriesUsed.DES	CaloriesUsed.REF
Metabolism-FattyAcid.DES	Metabolism-FuelUse.DES	Metabolism-Tools.REF
Metabolism-Glucose.DES	Metabolism-MetabolicRate.DES	
Metabolism-RespiratoryQuotient.DES	Metabolism-Tools.DES	
Thyroid.DES		

Table B.15: Text files in Structure files for HumMod Metabolism system.

TXT
Insulin And Tissue Glucose Uptake.TXT

IV Drip Files

Table B.16: Display files for HumMod IV Drip system under Movement

DES	DES
IVDrip.DES	Summary.DES

Table B.17: Structure files for HumMod IV Drip ystem under Movement.

DES
IVDrip.DES

Transfusion Files

Table B.18: Display files for HumMod Transfusion system under Movement.

DES	DES
Transfusion.DES	Summary.DES

Table B.19: Structure files for HumMod Transfusion system under Movement.

DES
Transfusion.DES

Shivering Files

Table B.20: Display files for HumMod Shivering system under Movement.

DES	DES
Box.DES	Shivering.DES

Urine Files

Table B.21: Display files for Urine system under Movement.

DES	DES
Urine.DES	SummaryDES

Hemorrhage Files

Table B.22: Display files for Hemorrhage system under Movement.

DES	DES
Hemorrhage.DES	Summary.DES

Table B.23: Structure files for HumMod Hemorrhage system under Movement.

DES	DES
Hemorrhage.DES	ThoraxHemorrhage.DES

Dialysis Files

Table B.24: Display files for HumMod Dialysis system under Movement.

DES	DES
Dialysis.DES	Summary.DES

Radiation Files

Table B.25: Display files for HumMod Radiation system under Movement.

DES	DES
Radiation.DES	Summary.DES

Conduction Files

Table B.26: Display files for HumMod Conduction system under Movement.

DES	DES
Conduction.DES	Summary.DES

Sweating Files

Table B.27: Display files for HumMod Sweating system under Movement.

DES	DES
Convection.DES	Evaporation.DES
Summary.DES	Sweating.DES

Insensible Skin Files

Table B.28: Display files for HumMod Insensible Skin system under Movement.

DES	DES
InsensibleSkin.DES	Summary.DES

Insensible Lung Files

Table B.29: Display files for HumMod Insensible Lung system under Movement.

DES	DES
InsensibleLung.DES	Summary.DES

Vomitus Files

Table B.30: Display files for HumMod Vomitus under Movement.

DES	DES
Vomitus.DES	Summary.DES

Diarrhea Files

Table B.31: Display files for HumMod Diarrhea under Movement.

DES	DES
Diarrhea.DES	Summary.DES

Sweat Files

Table B.32: Display files for HumMod Sweat system in Heat.

DES
Sweat.DES

Table B.33: Display file for HumMod Sweat Gland system under Sweat.

DES	DES
PrecursorSecretion.DES	SweatGland.DES

Table B.34: Display files for HumMod Sweat Duct system under Sweat.

DES	DES	DES
Balance.DES	Reabsorption.DES	SweatDuct.DES

Table B.35: Display files for HumMod Sweat Acclimation system under Sweat.

DES	DES
SweatAcclimation.DES	Summary.DES

Table B.36: Display files for HumMod Sweat Fuel system under Sweat.

DES	DES
SweatFuel.DES	Summary.DES

Table B.37: Structure files for HumMod Sweat system in Heat.

DES	DES	REF
Sweat.DES	SweatAcclimation.DES	SweatAcclimation.REF
SweatDuct.DES	SweatFuel.DES	SweatDuct.REF
SweatGland.DES		SweatFuel.REF
		SweatGland.REF

Appendix C List of Directories and Files in the \Structure Directory

This Appendix lists all the files in the \Structure directory. These files contain all the mathematics and logic of the HumMod simulation. By browsing these files, the user can see what specific parts of human physiology that HumMod incorporates, and those that it does not. Listing the directories in full also gives the user an understanding of the complexity of HumMod.

```
│ Structure.DES
│
├───A-VFistula
│     A-VFistula-Flow.DES
│     A-VFistula-Pressure.DES
│     A-VFistula.DES
│     A-VFistula.REF
│
├───Acetoacetate
│     Acetoacetate.DES
│
├───Acetone
│     Acetone.DES
│
├───AcidBase
│     AcidBase.DES
│     AcidTools.REF
│     BloodPhValues.DES
│     PhBlood.DES
│     PhCells.DES
│     PhGeneral.DES
│     PhUrine.DES
│     PhUrine.REF
│
├───Acidosis
│     Acidosis.DES
│     CardiacArrest.DES
│
├───ACTH
│     ACTH.DES
│     ACTH.REF
│     ACTHTest.DES
│
├───ADH
│     ADH.DES
│     ADH.REF
│     ADHClearance.DES
│     ADHFastMass.DES
│     ADHPool.DES
│     ADHPump.DES
│     ADHSecretion.DES
│     ADHSlowMass.DES
│     ADHSynthesis.DES
│
├───AdrenalGland
│     AdrenalGland-Flow.DES
│     AdrenalGland-Insufficiency.DES
│     AdrenalGland-Size.DES
│     AdrenalGland-Size.REF
│     AdrenalGland.DES
│
├───Age
│     Age.DES
│
├───AirSupply
│     AirSupply-GasTanks.DES
│     AirSupply-InspiredAir.DES
│     AirSupply-PressureChamber.DES
│     AirSupply.DES
│     AirSupply.REF
│
├───Aldosterone
│     AldoDisposal.DES
│     AldoPool.DES
│     AldoPump.DES
│     AldoSecretion.DES
│     Aldosterone.DES
│     Aldosterone.REF
│     AldoTumor.DES
│
├───AminoAcid
│   │ AA-Alanine.DES
│   │ AA-Alanine.REF
│   │ AA-Arginine.DES
│   │ AA-Arginine.REF
│   │ AA-Asparagine.DES
│   │ AA-Asparagine.REF
│   │ AA-Aspartate.DES
│   │ AA-Aspartate.REF
│   │ AA-Cysteine.DES
│   │ AA-Cysteine.REF
│   │ AA-Glutamate.DES
│   │ AA-Glutamate.REF
│   │ AA-Glutamine.DES
│   │ AA-Glutamine.REF
│   │ AA-Glycine.DES
│   │ AA-Glycine.REF
│   │ AA-Histidine.DES
│   │ AA-Histidine.REF
│   │ AA-Isoleucine.DES
│   │ AA-Isoleucine.REF
│   │ AA-Leucine.DES
│   │ AA-Leucine.REF
│   │ AA-Lysine.DES
│   │ AA-Lysine.REF
│   │ AA-Methionine.DES
```

AA-Methionine.REF
AA-Phenylalanine.DES
AA-Phenylalanine.REF
AA-Proline.DES
AA-Proline.REF
AA-Serine.DES
AA-Serine.REF
AA-Threonine.DES
AA-Threonine.REF
AA-Tryptophan.DES
AA-Tryptophan.REF
AA-Tyrosine.DES
AA-Tyrosine.REF
AA-Valine.DES
AA-Valine.REF
AAPool.DES
AAPool.REF
AminoAcid.DES
AminoAcid.TXT
MAEP data.xlsx

—TissueH2O
Circulatory Protein Notes.TXT
TissueH2O.DES
Torso_Lower_H2O.DES
Torso_Middle_H2O.DES
Torso_Upper_H2O.DES

—CapillaryProtein
CapillaryProtein.DES
Torso_Lower_CapillaryProtein.DES
Torso_Middle_CapillaryProtein.DES
Torso_Upper_CapillaryProtein.DES

—CapillaryWater
CapillaryWater.DES
Torso_Lower_CapillaryWater.DES
Torso_Middle_CapillaryWater.DES
Torso_Upper_CapillaryWater.DES

—CellH2O
CellH2O.DES

—InterstitialProtein
InterstitialProtein.DES
Torso_Lower_InterstitialProtein.DES
Torso_Middle_InterstitialProtein.DES
Torso_Upper_InterstitialProtein.DES

—InterstitialWater
InterstitialWater.DES
Torso_Lower_InterstitialWater.DES
Torso_Middle_InterstitialWater.DES
Torso_Upper_InterstitialWater.DES

—LymphProtein
LymphProtein.DES
Torso_Lower_LymphProtein.DES
Torso_Middle_LymphProtein.DES
Torso_Upper_LymphProtein.DES

—LymphWater
LymphWater.DES
Torso_Lower_LymphWater.DES
Torso_Middle_LymphWater.DES
Torso_Upper_LymphWater.DES

—Anesthesia
Anesthesia.DES
NoAnesthesia.DES

—AnesthesiaGas
AnesthesiaGas.DES
AnesthesiaGasArty.DES
AnesthesiaGasArty.REF
AnesthesiaGasBone.DES
AnesthesiaGasBrain.DES
AnesthesiaGasFat.DES
AnesthesiaGasGITract.DES
AnesthesiaGasKidney.DES
AnesthesiaGasLeftHeart.DES
AnesthesiaGasLiver.DES
AnesthesiaGasLung.REF
AnesthesiaGasOrgan.REF
AnesthesiaGasOtherTissue.DES
AnesthesiaGasRespiratoryMuscle.DES
AnesthesiaGasRightHeart.DES
AnesthesiaGasSkeletalMuscle.DES
AnesthesiaGasSkin.DES
AnesthesiaGasSolubility.DES
AnesthesiaGasVein.DES
AnesthesiaGasVein.REF

—AnesthesiaIV
AnesthesiaIV.DES
AnesthesiaIV.REF
AnesthesiaIVBlood.DES
AnesthesiaIVBone.DES
AnesthesiaIVBrain.DES
AnesthesiaIVFat.DES
AnesthesiaIVGITract.DES
AnesthesiaIVInfusion.DES
AnesthesiaIVInjection.DES
AnesthesiaIVKidney.DES
AnesthesiaIVLeftHeart.DES
AnesthesiaIVLiver.DES
AnesthesiaIVOrgan.REF
AnesthesiaIVOtherTissue.DES
AnesthesiaIVRespiratoryMuscle.DES
AnesthesiaIVRightHeart.DES
AnesthesiaIVSkeletalMuscle.DES
AnesthesiaIVSkin.DES
AnesthesiaIVSolubility.DES

—ANP
ANP.DES
ANP.REF
ANPClearance.DES
ANPPool.DES
ANPPump.DES
ANPSecretion.DES

—Apnea
Apnea.DES

—AutopsyReport
Autopsy-Chemistry.DES
Autopsy-Examination.DES
AutopsyReport.DES
AutopsyReport.REF

BetaHydoxyButyrate
BetaHydoxyButyrate.DES

Bladder
Bladder.DES
BladderAmmonia.DES
BladderBicarbonate.DES
BladderChloride.DES
BladderCreatinine.DES
BladderGlucose.DES
BladderKetoacid.DES
BladderPh.DES
BladderPhosphate.DES
BladderPotassium.DES
BladderProtein.DES
BladderSodium.DES
BladderSulphate.DES
BladderUrea.DES
BladderVolume.DES

BloodChemistry
BloodChemistry-BloodGases.DES
BloodChemistry-Consult.DES
BloodChemistry-Potassium.DES
BloodChemistry-Sample.DES
BloodChemistry-Sodium.DES
BloodChemistry.DES

BloodIons
BloodIons.DES
BloodIons.REF

BloodVessels
BloodVessels.DES
BloodVessels.REF
LeftAtrium.DES
LeftVentricle.DES
PulmArty.DES
PulmArty.REF
PulmCapys.DES
PulmCapys.REF
PulmVeins.DES
PulmVessels.DES
RightAtrium.DES
RightVentricle.DES
SplanchnicVeins.DES
SystemicArtys.DES
SystemicVeins.DES
Ventricles.REF

BloodVolume
BloodVol.DES
BloodVolume.DES
PlasmaVol.DES
RBCClearance.DES
RBCH2O.DES
RBCSecretion.DES
RBCSolids.DES
RBCVol.DES
RBCVol.REF
[EPO]Delay.DES

BMI
BMI.DES
BMI.REF

BodyDensity
BodyDensity.DES

BodyN2
BodyN2.DES
BodyN2.REF

BodyVolume
BodyVolume.DES

Bone
Bone-AlphaReceptors.DES
Bone-CO2.DES
Bone-Composition.DES
Bone-ExchangeableCalcium.DES
Bone-FixedCalcium.DES
Bone-Flow.DES
Bone-Fuel.DES
Bone-Function.DES
Bone-Lactate.DES
Bone-Metabolism.DES
Bone-Mineral.DES
Bone-Ph.DES
Bone-Pressure.DES
Bone-Size.DES
Bone-Structure.DES
Bone-Vasculature.DES
Bone.DES

Brain
Brain-CO2.DES
Brain-CO2.REF
Brain-Flow.DES
Brain-Fuel.DES
Brain-Fuel.REF
Brain-Function.DES
Brain-Function.REF
Brain-Lactate.DES
Brain-Metabolism.DES
Brain-Ph.DES
Brain-Ph.REF
Brain-Pressure.DES
Brain-Size.DES
Brain-Structure.DES
Brain-Vasculature.DES
Brain.DES
GlasgowComaScale.DES
GlasgowComaScale.REF
Seizure.DES

BrainInsult
BrainInsult-Fuel.DES
BrainInsult-High[Osm].DES
BrainInsult-Low[Osm].DES
BrainInsult-Ph.DES
BrainInsult-PO2.DES
BrainInsult-Seizure.REF
BrainInsult-Structure.DES
BrainInsult-Temperature.DES
BrainInsult.DES

BreathHolding
BreathHolding.DES

├──Ca
Ca.DES
Ca.REF

├──Calcitonin
Calcitonin.DES
Calcitonin.REF

├──CardiacCycle
CardiacCycle.DES
CardiacCycle.REF
DiastolicPressure.DES

├──Catechols
Acetylcholine.DES
Alpha1Pool.DES
Beta1Pool.DES
Beta2Pool.DES
Catechols.DES
EpiBolus.DES
EpiClearance.DES
Epinephrine.REF
EpiPool.DES
EpiPump.DES
EpiSecretion.DES
NEBolus.DES
NEClearance.DES
NEPool.DES
NEPump.DES
NESecretion.DES
Norepinephrine.REF
Pheochromocytoma.DES

├──CellProtein
CellProtein.DES
CellProtein.REF

├──CellSID
CellSID.DES
CellSID.REF

├──CerebrospinalFluid
CerebrospinalFluid.DES

├──Circulation
ArtysVol.DES
CardiacOutput.DES
CarotidSinus.DES
Circulation.DES
CircyManager.DES
CircyManager.REF
OrganFlow.DES
OrganFlow.REF
PeripheralResistance.DES
PeripheralResistance.REF
VeinsVol.DES
Viscosity.DES

├──CircyProtein
AGPPool.DES
AlbuminPool.DES
CircyProtein.DES
Colloids.TXT
HetaPool.DES
IgGPool.DES
PlasmaProtein.DES
PlasmaProtein.REF

├──Cl
Cl.DES
ClPool.DES

├──CO
CO.DES
CO.REF

├──CO2
CO2.DES
CO2.REF
CO2Artys.DES
CO2Blood.DES
CO2Calculator.DES
CO2Tissue.REF
CO2Tools.DES
CO2Tools.REF
CO2Total.DES
CO2Veins.DES
CO2_pCO2_To_[HCO3].DES
CO2_[HCO3]_To_pCO2.DES

├──Context
Context-Adiposity.DES
Context-Age.DES
Context-Gender.DES
Context-Height.DES
Context-Muscularity.DES
Context-OtherMass.DES
Context.DES
Context.REF
Random.DES

├──CoronarySinus
CoronarySinus.DES

├──CorticotropinReleasingFactor
CorticotropinReleasingFactor.DES
CorticotropinReleasingFactor.REF

├──Cortisol
Cortisol.DES
Cortisol.REF

├──CPR
CPR-Heart.DES
CPR-Heart.REF
CPR-Lungs.DES
CPR.DES

├──Creatine
Creatine.DES
Creatine.REF
CreatineCells.DES
CreatineSkeletalMuscle.DES

├──Creatinine
Creatinine.DES
Creatinine.REF
CreatininePool.DES

- DailyPlanner
  - DailyPlanner.DES
  - DailyPlanner.REF
  - DailyPlannerControl.DES
  - DailyPlannerSchedule.DES
- Density
  - Density.DES
- Diet
  - Diet.DES
  - Diet.REF
  - DietFeeding.DES
  - DietGoalElectrolytes.DES
  - DietGoalH2O.DES
  - DietGoalNutrition.DES
  - DietGoalNutrition.TXT
  - DietHunger-Glucose.DES
  - DietHunger-Leptin.DES
  - DietHunger.DES
  - DietIntakeElectrolytes.DES
  - DietIntakeH2O.DES
  - DietIntakeNutrition.DES
  - DietThirst.DES
- Drugs
  - Drugs.DES
  - Acetazolamide
    - Acetazolamide.DES
    - Acetazolamide.REF
    - AcetazolamideBound.DES
    - AcetazolamideDailyDose.DES
    - AcetazolamideGILumen.DES
    - AcetazolamideKidney.DES
    - AcetazolamidePool.DES
    - AcetazolamideSingleDose.DES
  - Atropine
    - Atropine.DES
    - AtropineBolus.DES
    - AtropineLiver.DES
    - AtropinePool.DES
  - Chlorothiazide
    - Chlorothiazide.DES
    - Chlorothiazide.REF
    - ThiazideDailyDose.DES
    - ThiazideGILumen.DES
    - ThiazideKidney.DES
    - ThiazidePool.DES
    - ThiazideSingleDose.DES
  - Digoxin
    - Digoxin.DES
    - Digoxin.REF
    - DigoxinDailyDose.DES
    - DigoxinGILumen.DES
    - DigoxinKidney.DES
    - DigoxinPool.DES
    - DigoxinSingleDose.DES
  - Furosemide
    - Furosemide.DES
    - Furosemide.REF
    - FurosemideDailyDose.DES
    - FurosemideGILumen.DES
    - FurosemideKidney.DES
    - FurosemidePool.DES
    - FurosemideSingleDose.DES
  - Isoproterenol
    - Isoproterenol.DES
    - IsoproterenolGILumen.DES
    - IsoproterenolInhaler.DES
    - IsoproterenolIV.DES
    - IsoproterenolIVBolus.DES
    - IsoproterenolKidney.DES
    - IsoproterenolLiver.DES
    - IsoproterenolLung.DES
    - IsoproterenolPool.DES
  - Midodrine
    - DesglymidodrineKidney.DES
    - DesglymidodrinePool.DES
    - Midodrine.DES
    - Midodrine.REF
    - MidodrineDailyDose.DES
    - MidodrineGILumen.DES
    - MidodrinePool.DES
    - MidodrineSingleDose.DES
  - Morphine
    - Morphine.DES
    - MorphineGILumen.DES
    - MorphineIMBolus.DES
    - MorphineIV.DES
    - MorphineKidney.DES
    - MorphineLiver.DES
    - MorphinePool.DES
    - MorphineSingleDose.DES
  - Narcan
    - Narcan.DES
    - NarcanBolus.DES
    - NarcanIV.DES
    - NarcanKidney.DES
    - NarcanLiver.DES
    - NarcanPool.DES
    - NarcanSingleDose.DES
  - Phenylephrine
    - Phenylephrine.DES
    - PhenylephrineGILumen.DES
    - PhenylephrineInhaler.DES
    - PhenylephrineIV.DES
    - PhenylephrineIIV.DES
    - PhenylephrineLiver.DES
    - PhenylephrineLung.DES
    - PhenylephrineOral.DES
    - PhenylephrinePool.DES
  - Propranolol
    - Propranolol.DES
    - PropranololDailyDose.DES
    - PropranololGILumen.DES
    - PropranololLiver.DES
    - PropranololPool.DES
    - PropranololSingleDose.DES

- Reserpine
  - Reserpine.DES
  - ReserpineGILumen.DES
  - ReserpineKidney.DES
  - ReserpineLiver.DES
  - ReserpineOral.DES
  - ReserpinePool.DES
- Spironolactone
  - CanrenoneKidney.DES
  - CanrenonePool.DES
  - Spironolactone.DES
  - Spironolactone.REF
  - SpironolactoneDailyDose.DES
  - SpironolactoneGILumen.DES
  - SpironolactonePool.DES
  - SpironolactoneSingleDose.DES

- Energy
  - Energy-Stores.DES
  - Energy-Tools.DES
  - Energy.DES
- Environment
  - Altitude.DES
  - AmbientTemperature.DES
  - Barometer.DES
  - Clothes.DES
  - Clothes.REF
  - Environment.DES
  - EquivalentAltitude.DES
  - EquivalentAltitude.REF
  - RelativeHumidity.DES
  - Submerged.DES
  - Wind.DES
- EPO
  - EPO-AnemiaVsHypoxia.REF
  - EPO-Disposal.REF
  - EPO-Erythropoiesis.REF
  - EPO-Pharmacokinetics.REF
  - EPO-PlasmaConcentration.REF
  - EPO-Pool.REF
  - EPO-Secretion.REF
  - EPO-Units.REF
  - EPO.DES
  - EPO.REF
  - EPO.TXT
  - EPODisposal.DES
  - EPOPool.DES
  - EPOPump.DES
  - EPOSecretion.DES
- Estradiol
  - Estradiol.DES
  - Estradiol.REF
- Exercise
  - Exercise-Bike.DES
  - Exercise-Control.DES
  - Exercise-Control.REF
  - Exercise-Metabolism.DES
  - Exercise-Metabolism.REF
  - Exercise-Motivation.DES
  - Exercise-Motivation.REF
  - Exercise-MusclePump.DES
  - Exercise-Treadmill.DES
  - Exercise-Treadmill.REF
  - Exercise.DES
  - Exercise.REF
  - TreadmillGrade.REF
- Fat
  - Fat-AlphaReceptors.DES
  - Fat-CO2.DES
  - Fat-Flow.DES
  - Fat-Fuel.DES
  - Fat-Function.DES
  - Fat-Lactate.DES
  - Fat-Metabolism.DES
  - Fat-Ph.DES
  - Fat-Pressure.DES
  - Fat-Size.DES
  - Fat-Structure.DES
  - Fat-Vasculature.DES
  - Fat.DES
- FattyAcid
  - FADecomposition.DES
  - FAPool.DES
  - FattyAcid.DES
- FSH
  - FSH-AnteriorPituitary.DES
  - FSH-Circulating.DES
  - FSH.DES
  - FSH.REF
- FuelSelector
  - FuelSelector.REF
- Gender
  - Gender.DES
- GILumen
  - GILumen.DES
  - GILumen.REF
  - GILumenElectrolytes
    - GILumenCalcium.DES
    - GILumenChloride.DES
    - GILumenElectrolytes.DES
    - GILumenElectrolytes.REF
    - GILumenPotassium.DES
    - GILumenSodium.DES
  - GILumenFood
    - GILumenCarbohydrates.DES
    - GILumenFat.DES
    - GILumenFood.DES
    - GILumenFood.REF
    - GILumenProtein.DES
  - GILumenH2O
    - GILumenH2O.DES
  - GILumenHeat
    - GILumenHeat.DES
  - GILumenOther

GILumenDiarrhea.DES
GILumenOther.DES
GILumenOther.REF
GILumenVomitus.DES

GILumenVolume
GILumenVolume.DES
GILumenVolume.REF

GITract
GITract-AlphaReceptors.DES
GITract-CO2.DES
GITract-Flow.DES
GITract-Fuel.DES
GITract-Function.DES
GITract-Lactate.DES
GITract-Metabolism.DES
GITract-Ph.DES
GITract-Pressure.DES
GITract-Size.DES
GITract-Structure.DES
GITract-Vasculature.DES
GITract.DES

Glucagon
Glucagon.DES
Glucagon.REF
GlucagonClearance.DES
GlucagonPool.DES
GlucagonSecretion.DES
GlucagonTools.DES

Glucose
Blood vs Plasma [Glucose].TXT
Glucose.DES
Glucose.REF
GlucoseDecomposition.DES
GlucosePool.DES
GlucosePump.DES
OGTT.DES

Glycerol
Glycerol.DES
Glycerol.REF
GlycerolPool.DES

GnRH
GnRH.DES
GnRH.REF

Gravity
Gravity.DES

H2O
BodyH2O.DES
BodyH2O.REF
ECFV.DES
ExternalH2O.DES
ExternalH2O.REF
H2O.DES
H2O.REF
H2ODistribution.REF
ICFV.DES
MetabolicH2O.DES

hCG
hCG.DES
hCG.REF

Heart
Heart-Arrest.DES
Heart-Asystole.DES
Heart-Defibrillator.DES
Heart-ECG.DES
Heart-ECG.REF
Heart-Intervals.DES
Heart-Pacemaker.DES
Heart-Pain.DES
Heart-Rate.DES
Heart-Rate.REF
Heart-Rhythm.DES
Heart-Rhythm.REF
Heart-Tachyarrhythmia.DES
Heart-Ventricles.DES
Heart-VFib.DES
Heart-VFib.REF
Heart.DES
LeftHeart-Pain.DES
RightHeart-Pain.DES
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Size-Inhibin.DES
Size-Insulin.DES
Size-InterstitialProtein.DES
Size-Leptin.DES
Size-LH.DES
Size-Norepinephrine.DES
Size-OrganCalories.DES
Size-OrganCalories.REF
Size-OrganCO2.DES
Size-OrganConductance.DES
Size-OrganConductance.REF
Size-OrganH2Os.DES
Size-OrganSize.DES
Size-ParathyroidHormone.DES
Size-PlasmaProtein.DES
Size-Progesterone.DES
Size-Renin.DES
Size-SkeletalMuscleSize.DES
Size-Testosterone.DES
Size-ThyroidHormone.DES
Size-Triglyceride.DES
Size-VitaminD.DES
Size-Weight.DES
Sizing-.DES
Sizing-Arteries.DES
Sizing-BloodFlow.DES
Sizing-BloodVessels.DES
Sizing-BloodVolume.DES

Sizing-BodyH2O.DES
Sizing-BodyH2O.REF
Sizing-CellH2O.DES
Sizing-ChloridePool.DES
Sizing-Composition-Bone.DES
Sizing-Composition-Brain.DES
Sizing-Composition-Fat.DES
Sizing-Composition-GITract.DES
Sizing-Composition-Kidney.DES
Sizing-Composition-LeftHeart.DES
Sizing-Composition-LeftKidney.DES
Sizing-Composition-Liver.DES
Sizing-Composition-OtherTissue.DES
Sizing-Composition-RespiratoryMuscle.DES
Sizing-Composition-RightHeart.DES
Sizing-Composition-RightKidney.DES
Sizing-Composition-SkeletalMuscle.DES
Sizing-Composition-Skin.DES
Sizing-ECFV.DES
Sizing-ExternalH2O.DES
Sizing-Glucose.DES
Sizing-HeartChambers.DES
Sizing-HeartPumping-Left-ContractileProtein.DES
Sizing-HeartPumping-Left-Diastole.DES
Sizing-HeartPumping-Left-Systole.DES
Sizing-HeartPumping-Right-ContractileProtein.DES
Sizing-HeartPumping-Right-Diastole.DES
Sizing-HeartPumping-Right-Systole.DES
Sizing-Heat.DES
Sizing-ICFV.DES
Sizing-InterstitialWater.DES
Sizing-KetoacidPool.DES
Sizing-LactatePool.DES
Sizing-LeftAtrium.DES
Sizing-LowPressureReceptors.DES
Sizing-Lungs.DES
Sizing-O2.DES
Sizing-OrganMass.DES
Sizing-OrganMass.TXT
Sizing-Osmoles-ECFV.DES
Sizing-Osmoles-ICFV.DES
Sizing-Osmoles-Total.DES
Sizing-Pericardium.DES
Sizing-PeripheralVeins.DES
Sizing-PhosphatePool.DES
Sizing-PotassiumCell.DES
Sizing-PotassiumPool.DES
Sizing-Pressures.DES
Sizing-PulmonaryArtery.DES
Sizing-PulmonaryCapillaries.DES
Sizing-PulmonaryVeins.DES
Sizing-RightAtrium.DES
Sizing-SodiumPool.DES
Sizing-SplanchnicVeins.DES
Sizing-SulfatePool.DES
Sizing-SystemicArteries.DES
Sizing-TissueH2O.DES
Sizing-UreaCell.DES
Sizing-UreaPool.DES
Sizing-Veins.DES
Sizing.DES
Sizing.REF

SkeletalMuscle
SkeletalMuscle-AlphaReceptors.DES
SkeletalMuscle-BetaReceptors.DES
SkeletalMuscle-CO2.DES
SkeletalMuscle-ContractileProtein.DES
SkeletalMuscle-Energy.DES
SkeletalMuscle-Flow - original.DES
SkeletalMuscle-Flow.DES
SkeletalMuscle-Flow.REF
SkeletalMuscle-Fuel.DES
SkeletalMuscle-Function.DES
SkeletalMuscle-Lactate.DES
SkeletalMuscle-MetabolicVasodilation.DES
SkeletalMuscle-MetabolicVasodilation.REF
SkeletalMuscle-Metabolism.DES
SkeletalMuscle-Metaboreflex.DES
SkeletalMuscle-Metaboreflex.REF
SkeletalMuscle-MusclePumping.DES
SkeletalMuscle-MusclePumping.REF
SkeletalMuscle-Ph.DES
SkeletalMuscle-Pressure.DES
SkeletalMuscle-Size.DES
SkeletalMuscle-Structure.DES
SkeletalMuscle-Vasculature.DES
SkeletalMuscle-Work.DES
SkeletalMuscle.DES

SkeletalMuscle-Glycogen
SkeletalMuscle-Glycogen.DES
SkeletalMuscle-Glycogen.REF

Skin
Skin-AlphaReceptors.DES
Skin-CO2.DES
Skin-Flow.DES
Skin-Fuel.DES
Skin-Function.DES
Skin-Lactate.DES
Skin-Metabolism.DES
Skin-Ph.DES
Skin-Pressure.DES
Skin-Size.DES
Skin-Structure.DES
Skin-Vasculature.DES
Skin.DES

SO4
SO4.DES
SO4.REF
SO4Pool.DES

Status
Status.DES
Status.REF

SurfaceArea
SurfaceArea.DES
SurfaceArea.REF

Sweat
Sweat.DES
SweatAcclimation.DES
SweatAcclimation.REF
SweatDuct.DES
SweatDuct.REF
SweatFuel.DES
SweatFuel.REF

- SweatGland.DES
- SweatGland.REF
- Symptoms
  - Symptoms.DES
  - Symptoms.REF
- Testes
  - Testes-Estradiol.DES
  - Testes-Inhibin.DES
  - Testes-Progesterone.DES
  - Testes-Testosterone.DES
  - Testes.DES
  - Testes.REF
- Testosterone
  - Testosterone.DES
  - Testosterone.REF
- ThyroidGland
  - ThyroidClearance.DES
  - ThyroidGland-Size.DES
  - ThyroidGland.DES
  - ThyroidGland.REF
  - ThyroidPool.DES
  - ThyroidPump.DES
  - ThyroidSecretion.DES
  - ThyroidTSH.DES
- TiltTable
  - TiltTable.DES
- TissueH2O
  - Circulatory Protein Notes.TXT
  - TissueH2O.DES
  - Torso_Lower_H2O.DES
  - Torso_Middle_H2O.DES
  - Torso_Upper_H2O.DES
  - CapillaryProtein
    - CapillaryProtein.DES
    - Torso_Lower_CapillaryProtein.DES
    - Torso_Middle_CapillaryProtein.DES
    - Torso_Upper_CapillaryProtein.DES
  - CapillaryWater
    - CapillaryWater.DES
    - Torso_Lower_CapillaryWater.DES
    - Torso_Middle_CapillaryWater.DES
    - Torso_Upper_CapillaryWater.DES
  - CellH2O
    - CellH2O.DES
  - InterstitialProtein
    - InterstitialProtein.DES
    - Torso_Lower_InterstitialProtein.DES
    - Torso_Middle_InterstitialProtein.DES
    - Torso_Upper_InterstitialProtein.DES
  - InterstitialWater
    - InterstitialWater.DES
    - Torso_Lower_InterstitialWater.DES
    - Torso_Middle_InterstitialWater.DES
    - Torso_Upper_InterstitialWater.DES
  - LymphProtein
    - LymphProtein.DES
    - Torso_Lower_LymphProtein.DES
    - Torso_Middle_LymphProtein.DES
    - Torso_Upper_LymphProtein.DES
  - LymphWater
    - LymphWater.DES
    - Torso_Lower_LymphWater.DES
    - Torso_Middle_LymphWater.DES
    - Torso_Upper_LymphWater.DES
- Transfusion
  - Transfusion.DES
- Trauma
  - BluntInjury.DES
  - Trauma.DES
- Triglyceride
  - Triglyceride.DES
  - Triglyceride.REF
  - TriglycerideDecomposition.DES
  - TriglycerideHydrolysis.DES
  - TriglyceridePool.DES
- Urea
  - Urea.DES
  - Urea.REF
  - UreaCell.DES
  - UreaPool.DES
- UrineAnalysis
  - UrineAnalysis.DES
- Uterus
  - Uterus.DES
- VenaeCava
  - InferiorVenaCava.DES
  - SuperiorVenaCava.DES
  - VenaeCava.DES
- VenousValves
  - VenousValves.DES
- VitaminD
  - VitaminD(1,25-Dihydroxy).DES
  - VitaminD(1,25-Dihydroxy).TXT
  - VitaminD(25-Hydroxy).DES
  - VitaminD(25-Hydroxy).TXT
  - VitaminD.DES
  - VitaminD3.DES
  - VitaminD3.TXT
  - VitaminD3Stored.DES
  - VitaminD3Stored.TXT
- Weight
  - Weight.DES
  - Weight.REF
- Weight-Fluids
  - Weight-Fluids.DES

Appendix D List of Directories and Files in the \Display Directory

This Appendix lists all the files in the \Display directory. These files contain all the files that HumMod uses to create the user interface. By browsing these files, the user can see what how the user interface is constructed and organized. Listing the directories in full also gives the user an understanding of the complexity of the HumMod user interface.

- Common.DES
- Display.DES
- Display.REF
- Version.DES
- AcidBase
  - AcidBase.DES
  - ArterialPh.DES
  - BloodPh.DES
  - VenousPh.DES
- BodyFluids
  - BodyFluids.DES
  - Blood
    - Blood.DES
    - Hemoglobin
      - Hemoglobin.DES
      - Calculator
        - Calculator.DES
        - O2.DES
        - P50.DES
      - Loading
        - ArteryO2.DES
        - ArteryP50.DES
        - Loading.DES
        - VeinO2.DES
        - VeinP50.DES
      - Properties
        - Concentration.DES
        - Properties.DES
        - Sensitivity.DES
    - Plasma
      - Balance.DES
      - Plasma.DES
      - Summary.DES
    - RedCells
      - RedCells.DES
      - Disposal
        - Balance.DES
        - Box.DES
        - Composition.DES
        - Disposal.DES
        - Secretion.DES
        - Summary.DES
        - [EPO]Delay.DES
      - Pool
        - LeftBox.DES
        - Pool.DES
        - RightBox.DES
      - Secretion
        - Box.DES
        - Secretion.DES
        - [EPO]Delay.DES
    - Viscosity
      - Summary.DES
      - Viscosity.DES
    - Volume
      - Compartments.DES
      - Volume.DES
      - WholeBody.DES
  - H2O
    - H2O.DES
    - Distribution
      - Distribution.DES
      - Organs.DES
      - Spaces.DES
    - Movement
      - Movement.DES
      - Dialysis
        - Dialysis.DES
        - Summary.DES
      - Diarrhea
        - Diarrhea.DES
        - Summary.DES
      - Hemorrhage
        - Hemorrhage.DES
        - Summary.DES

```
|   |   |   |---InsensibleLung
|   |   |   |     InsensibleLung.DES
|   |   |   |     Summary.DES
|   |   |   |
|   |   |   |---InsensibleSkin
|   |   |   |     InsensibleSkin.DES
|   |   |   |     Summary.DES
|   |   |   |
|   |   |   |---IVDrip
|   |   |   |     IVDrip.DES
|   |   |   |     Summary.DES
|   |   |   |
|   |   |   |---Metabolism
|   |   |   |     Metabolism.DES
|   |   |   |     Summary.DES
|   |   |   |
|   |   |   |---OralIntake
|   |   |   |     OralIntake.DES
|   |   |   |     Summary.DES
|   |   |   |
|   |   |   |---Sweating
|   |   |   |     Summary.DES
|   |   |   |     Sweating.DES
|   |   |   |
|   |   |   |---Transfusion
|   |   |   |     Summary.DES
|   |   |   |     Transfusion.DES
|   |   |   |
|   |   |   |---Urine
|   |   |   |     Summary.DES
|   |   |   |     Urine.DES
|   |   |   |
|   |   |   |---Vomitus
|   |   |         Summary.DES
|   |   |         Vomitus.DES
|   |   |
|   |   |---Storage
|   |         Storage.DES
|   |         WholeBody.DES
|   |
|   |---Osmoles
|       |   Osmoles.DES
|       |
|       |---ECFV
|       |     ECFV.DES
|       |     Osmoles.DES
|       |     [Osm].DES
|       |
|       |---Function
|       |     CellWall.DES
|       |     Function.DES
|       |     Osmoreceptors.DES
|       |
|       |---ICFV
|             ICFV.DES
|             Osmoles.DES
|             [Osm].DES
|
|---Circulation
|   |   Circulation.DES
|   |
|   |---BloodFlow
|   |     BloodFlow.DES
|   |     CardiacOutput.DES
|   |     OrganFlow.DES
|   |     OutflowSummary.DES
|   |
|   |---BloodPressure
|   |     BloodPressure.DES
|   |     Summary.DES
|   |
|   |---BloodVessels
|       |   BloodVessels.DES
|       |
|       |---Arteries
|       |   |   Arteries.DES
|       |   |
|       |   |---SystemicArteries
|       |         BloodFlow.DES
|       |         Pressure.DES
|       |         SystemicArteries.DES
|       |         Technical.DES
|       |         Volume.DES
|       |
|       |---Lungs
|       |   |   Lungs.DES
|       |   |
|       |   |---LeftAtrium
|       |   |     BloodFlow.DES
|       |   |     LeftAtrium.DES
|       |   |     Pressure.DES
|       |   |     Technical.DES
|       |   |     Volume.DES
|       |   |
|       |   |---LeftVentricle
|       |   |     BloodFlow.DES
|       |   |     BloodVolume.DES
|       |   |     LeftVentricle.DES
|       |   |
|       |   |---PulmonaryArtery
|       |   |     BloodFlow.DES
|       |   |     Pressure.DES
|       |   |     PulmonaryArtery.DES
|       |   |     Volume.DES
|       |   |
|       |   |---PulmonaryCapillaries
|       |   |     BloodFlow.DES
|       |   |     Pressure.DES
|       |   |     PulmonaryCapillaries.DES
|       |   |     Volume.DES
|       |   |
|       |   |---PulmonaryVeins
|       |         BloodFlow.DES
|       |         Pressure.DES
|       |         PulmonaryVeins.DES
|       |         Volume.DES
|       |
|       |---VascularCompliance
|       |     Summary.DES
|       |     VascularCompliance.DES
|       |
|       |---VascularConductance
|       |     PeripheralResistance.DES
|       |     Summary.DES
|       |     VascularConductance.DES
|       |
|       |---Veins
|           |   Veins.DES
|           |
|           |---RightAtrium
```

```
            BloodFlow.DES
            Pressure.DES
            RightAtrium.DES
            Technical.DES
            Volume.DES

        ──RightVentricle
            BloodFlow.DES
            BloodVolume.DES
            RightVentricle.DES

        ──SplanchnicVeins
            Pressure.DES
            SplanchnicVeins.DES
            Technical.DES
            Volume.DES

        ──SystemicVeins
            SystemicVeins.DES

            ──Conductance
                Conductance.DES
                DownstreamConductance.DES
                MusclePump.DES

            ──Summary
                BloodFlow.DES
                Pressure.DES
                Summary.DES
                UnstressedVolume.DES
                Volume.DES

    ──CirculatoryProtein
        CirculatoryProtein.DES

        ──HetaStarch
            HetaStarch.DES
            Pool.DES

        ──Interstitium
            Balance.DES
            CapillaryLeak.DES
            Interstitium.DES
            LymphTransport.DES

        ──Plasma
            Balance.DES
            Breakdown.DES
            Degradation.DES
            Plasma.DES
            Summary.DES
            Synthesis.DES

    ──GreatVeins
        GreatVeins.DES

        ──CoronarySinus
            BloodFlow.DES
            CoronarySinus.DES
            O2.DES
            PO2.DES

        ──InferiorVenaCava
            BloodFlow.DES
            InferiorVenaCava.DES

        ──SuperiorVenaCava
            BloodFlow.DES
            SuperiorVenaCava.DES

    ──HeartRate
        HeartRate.DES

        ──Atria
            Atria.DES
            BetaReceptors.DES
            Rate.DES

        ──Intervals
            Intervals.DES
            Summary.DES

        ──Tachyarrhythmia
            Summary.DES
            Tachyarrhythmia.DES

        ──Ventricles
            AVBlock.DES
            Contraction.DES
            IntrinsicRate.DES
            Status.DES
            Ventricles.DES

    ──HeartValves
        HeartValves.DES

        ──Aortic
            Aortic.DES
            Regurgitation.DES
            Stenosis.DES

        ──Mitral
            Mitral.DES
            Regurgitation.DES
            Stenosis.DES

        ──Pulmonic
            Pulmonic.DES
            Regurgitation.DES
            Stenosis.DES

        ──Tricuspid
            Regurgitation.DES
            Stenosis.DES
            Tricuspid.DES

    ──Interstitium
        Interstitium.DES

        ──Lower
            Lower.DES

            ──BloodPressure
                Arteries.DES
                BloodPressure.DES
                Capillaries.DES
                Veins.DES

            ──Capillaries-Lymph
                Capillaries-Lymph.DES
```

CapillaryLeak.DES
LymphFlow.DES

H2O
Balance.DES
H2O.DES
InterstitialPressure.DES

InterstitialProtein
Balance.DES
CapillaryLeak.DES
InterstitialProtein.DES
LymphTransport.DES

Middle
Middle.DES

BloodPressure
Arteries.DES
BloodPressure.DES
Capillaries.DES
Veins.DES

Capillaries-Lymph
Capillaries-Lymph.DES
CapillaryLeak.DES
LymphFlow.DES

H2O
Balance.DES
H2O.DES
InterstitialPressure.DES

InterstitialProtein
Balance.DES
CapillaryLeak.DES
InterstitialProtein.DES
LymphTransport.DES

Summary
Summary.DES

Upper
Upper.DES

BloodPressure
Arteries.DES
BloodPressure.DES
Capillaries.DES
Veins.DES

Capillaries-Lymph
Capillaries-Lymph.DES
CapillaryLeak.DES
LymphFlow.DES

H2O
Balance.DES
H2O.DES
InterstitialPressure.DES

InterstitialProtein
Balance.DES
CapillaryLeak.DES
InterstitialProtein.DES

LymphTransport.DES

LeftHeartPumping
LeftHeartPumping.DES

Cardiopathy
Cardiopathy.DES
Infarction.DES
Pain.DES

ContractileProtein
Box.DES
ContractileProtein.DES

Diastole
Diastole.DES
Pressure-Volume.DES
Stenosis.DES
Technical.DES

HeartStrength
Contractility.DES
HeartStrength.DES
ProgressiveFailure.DES

Output
Output.DES
StenosisAndRegurgitation.DES
Summary.DES

Systole
Pressure-Volume.DES
Systole.DES
TechnicalActive.DES
TechnicalPassive.DES
TMP.DES

LeftHeartWallStress
LeftHeartWallStress.DES

Diastole
Box.DES
Diastole.DES

Mass
Box.DES
Mass.DES

Systole
Box.DES
Systole.DES

Pericardium
FluidVolume.DES
Pericardium.DES
Pressure.DES
UnstressedVolume.DES
Volume.DES

RightHeartPumping
RightHeartPumping.DES

Cardiopathy
Cardiopathy.DES
Infarction.DES

        - Pain.DES
        - ContractileProtein
            - Box.DES
            - ContractileProtein.DES
        - Diastole
            - Diastole.DES
            - Pressure-Volume.DES
            - Stenosis.DES
            - Technical.DES
        - HeartStrength
            - Contractility.DES
            - HeartStrength.DES
            - ProgressiveFailure.DES
        - Output
            - Output.DES
            - StenosisAndRegurgitation.DES
            - Summary.DES
        - Systole
            - Pressure-Volume.DES
            - Systole.DES
            - TechnicalActive.DES
            - TechnicalPassive.DES
            - TMP.DES
    - RightHeartWallStress
        - RightHeartWallStress.DES
        - Diastole
            - Box.DES
            - Diastole.DES
        - Mass
            - Box.DES
            - Mass.DES
        - SplanchnicCirculation
            - SplanchnicCirculation.DES
            - HepaticArtery
                - Box.DES
                - HepaticArtery.DES
            - HepaticVein
                - Box.DES
                - HepaticVein.DES
            - PortalVein
                - Box.DES
                - PortalVein.DES
        - Systole
            - Box.DES
            - Systole.DES
    - SplanchnicCirculation
        - SplanchnicCirculation.DES
        - HepaticArtery
            - AlphaReceptors.DES
            - Box.DES
            - HepaticArtery.DES
        - HepaticVein
            - Box.DES
            - HepaticVein.DES
        - PortalVein
            - Box.DES
            - PortalVein.DES
- Context
    - Context.DES
    - Adiposity
        - Adiposity.DES
    - Age
        - Age.DES
    - Gender
        - Gender.DES
    - Height
        - Height.DES
    - Muscularity
        - Muscularity.DES
    - OtherMass
        - OtherMass.DES
    - Summary
        - InitialValues.DES
        - Randomness.DES
        - Summary.DES
        - Traits.DES
- Diagnosis
    - Diagnosis.DES
    - AutopsyReport
        - AutopsyReport.DES
        - AutopsyReport.REF
        - Autopsy-Chemistry
            - Autopsy-Chemistry.DES
            - LeftBox.DES
            - RightBox.DES
        - Autopsy-Examination
            - Autopsy-Examination.DES
            - Box.DES
    - BloodChemistry
        - BloodChemistry.DES
        - BloodGases
            - Artery.DES
            - BloodGases.DES
            - GetSamples.DES
            - Vein.DES
        - Consult
            - Consult.DES
            - GetConsult.DES

- LeftBox.DES
- RightBox.DES
- Sample
  - GetSample.DES
  - LeftBox.DES
  - RightBox.DES
  - Sample.DES
- Chart
  - BloodPressure.DES
  - Chart.DES
  - HeartRate.DES
  - Morphology.DES
  - RespiratoryRate.DES
  - Symptoms.DES
  - Temperature.DES
  - ThumbNail.DES
- ECG
  - Box.DES
  - ECG.DES
- Evaluation
  - CurrentState.DES
  - Evaluation.DES
  - Heart.DES
  - NeurologicalSigns.DES
- Size
  - Size.DES
  - Density
    - Density.DES
  - Mass
    - Mass.DES
  - Summary
    - Summary.DES
  - Volume
    - Volume.DES
- UrineAnalysis
  - Box.DES
  - UrineAnalysis.DES
- Electrolytes
  - Electrolytes.DES
  - Ca
    - Ca.DES
  - Cl
    - Balance.DES
    - Cl.DES
    - Concentration.DES
  - K
    - K.DES
    - Cell
      - Balance.DES
      - Cell.DES
      - Concentration.DES
    - ECFV
      - Balance.DES
      - Concentration.DES
      - ECFV.DES
    - Membrane
      - AldoEffect.DES
      - FluxToCell.DES
      - FluxToPool.DES
      - Membrane.DES
      - MembranePotential.DES
  - Lactate
    - Lactate.DES
    - Blood
      - Blood.DES
      - Pump.DES
      - Summary.DES
    - Tissue
      - Concentration.DES
      - Outflux.DES
      - Tissue.DES
  - Na
    - Balance.DES
    - Concentration.DES
    - Na.DES
  - PO4
    - Balance.DES
    - Concentration.DES
    - PO4.DES
  - SO4
    - Balance.DES
    - Concentration.DES
    - SO4.DES
  - Summary
    - Conc.DES
    - Summary.DES
- Heat
  - Heat.DES
  - Core
    - Core.DES
    - Storage.DES
    - Temperature.DES
  - GILumen
    - GILumen.DES
    - Storage.DES
    - Temperature.DES
  - Movement
    - Movement.DES
    - Conduction
      - Conduction.DES
      - Summary.DES

- Dialysis
  - Dialysis.DES
  - Summary.DES
- Diarrhea
  - Diarrhea.DES
  - Summary.DES
- Hemorrhage
  - Hemorrhage.DES
  - Summary.DES
- InsensibleLung
  - InsensibleLung.DES
  - Summary.DES
- InsensibleSkin
  - InsensibleSkin.DES
  - Summary.DES
- IVDrip
  - IVDrip.DES
  - Summary.DES
- Metabolism
  - Metabolism.DES
  - Summary.DES
- OralIntake
  - OralIntake.DES
  - Summary.DES
- Radiation
  - Radiation.DES
  - Summary.DES
- Shivering
  - Box.DES
  - Shivering.DES
- Sweating
  - Convection.DES
  - Evaporation.DES
  - Summary.DES
  - Sweating.DES
- Transfusion
  - Summary.DES
  - Transfusion.DES
- Urine
  - Summary.DES
  - Urine.DES
- Vomitus
  - Summary.DES
  - Vomitus.DES

- SkeletalMuscle
  - Fluxes.DES
  - SkeletalMuscle.DES
  - Storage.DES
  - Summary.DES
  - Temperature.DES

- Skin
  - Skin.DES
  - Storage.DES
  - Temperature.DES
- Summary
  - Compartments.DES
  - Storage.DES
  - Summary.DES
  - Temperatures.DES
- Sweat
  - Sweat.DES
  - SweatAcclimation
    - Summary.DES
    - SweatAcclimation.DES
  - SweatDuct
    - Balance.DES
    - Reabsorption.DES
    - SweatDuct.DES
  - SweatFuel
    - Summary.DES
    - SweatFuel.DES
  - SweatGland
    - PrecursorSecretion.DES
    - SweatGland.DES

- Hormones
  - Hormones.DES
  - ACTH
    - ACTH.DES
    - Box.DES
    - Disposal.DES
    - Mass.DES
    - Pump.DES
    - Secretion.DES
  - ADH
    - ADH.DES
    - Formation
      - FastMass.DES
      - Formation.DES
      - Secretion.DES
      - SlowMass.DES
      - Synthesis.DES
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