ENDURANCE EXERCISE SIMULATION (*web*-HUMAN 8.1)

Introductory 2010
You have had a bit more work (e.g. high altitude, thermal biology) than most Comparative classes have usually had by this point in the course. I nevertheless have retained the full introductory material below as if this were only your second class using web_HUMAN. In class we will concentrate on the experiment itself. You can go back at your leisure(!) to fill yourselves in on background as you wish.

Introduction – general – endurance activity – 'exercise'
Although we may tend to anthropocentrically think otherwise, endurance exercise is not an activity unique to the human athlete alone. Indeed, eons before the first marathon runner, the problem of how to design a mammal that could, by sustained distance running, wear down a prey item, was successfully solved many times. Animals that hunt in packs (wolves, wild dogs, etc.) all have body physiology adjusted to run down, over long periods of time, weaker prey items (e.g. young or ill caribou). In fact, the two basic mammalian hunting strategies (short fast bursts of speed- the "cats" & long, slow sustained wearing down- the "dogs") have their direct analogs in two types of human running events, the sprint and the marathon.

Recall (SN ch. 1-4) that it is largely the responsibility of two systems, the cardiovascular and the respiratory, to insure adequate O2 flow to the working tissues. Indeed, adjustments are made in all groups of vertebrates (fish<--->mammals & birds) (SN Table 3.3) as the demand for O2 delivery rises. An ultimate goal of the physiology of the organism during endurance activity (in humans, exercise) is to supply oxygen to the working muscles at a rate sufficient to keep pace with the aerobic O_2 needs of the muscles.

In this experiment, we will have the subject exercise at three levels of intensity (light, moderate and severe). The resulting cardio-respiratory data will enable us to investigate two underlying questions:

1) [Part A] How well are the cardiovascular and respiratory systems of the organism able to supply the needed oxygen and

2) [Part B] What limits an organism's (in *web*-HUMAN, a person's) exercise endurance? That is, what factor(s) of the cardiopulmonary system is (are) the limiting factor(s), the weak link(s)? Which components first fail in the task of providing oxygen flow at a sufficient rate to meet the increased aerobic muscular demands.

The *web*-HUMAN computer model simulates exercise by specifying exercise as oxygen utilization above resting (basal metabolic) levels. For example, oxygen (**EXER**) use of 2.0 L/min. corresponds to moderate human exercise while O2 use of 3.0 L/min. constitutes more severe exercise. Also note that exercise is terminated by the model (i.e. the model quits), even if exercise duration (**XERMIN**) is set to a very large non-limiting amount of time (its default value is only 10 min.), whenever the total oxygen debt (**O2DEBT**) exceeds a total of 10 Liters.*

An overview of the activities in this document
You begin this lab by I.) teaching yourself how to exercise *web*-HUMAN, then proceed

on to II.) plotting the obtained data in Excel. III.) We then practice exercise at a high level (EXER = 3.0 L/M) analyzing the results as a class. After this we split the class into groups to IV.) store and analyze what the effects of maneuvers that aid the respiratory system (e.g. 100% O2) or the cardiovascular system (increased cardiac contractility) have on endurance exercise time to cessation. Finally, on your own you V.) investigate the effects of each of these respiratory and cardiovascular aids has on increasing endurance exercise times.

I. <u>Teaching yourself how to run an EXERcise session in *web*-HUMAN</u>

You have all had in-lab experience with running a high altitude simulation in model. We will now refresh the *web*-HUMAN skills you learned and extend them to running an exercise session.

1) Go to *web*-human at [http://placid.skidmore.edu] .

2) <u>Log in</u> (click Login for personalized features) [you already have a password from high altitude session]

3) Return to the opening screen, refresh it and <u>load the introductory tutorial</u> and run it ((may be run as an interactive class demonstration).

4) You can run the tutorial on-screen side by side with your *web*-HUMAN screen or print the tutorial out as a PDF to follow in paper. In either case do the entire tutorial in *web*-HUMAN asking your instructor questions as necessary.
BE CERTAIN TO TURN OFF YOUR BROWSER'S POPUP BLOCKER OR YOU WILL GET NO PLOTS.

II. <u>Teaching yourself how to pass web-HUMAN data into Excel for further plotting/analysis</u> – see the accompanying "Graphing web-HUMAN in Excel" sheet or download it from section 3 of the User's Manual.

III. <u>Running an exercise session of high intensity</u> – you learn the limits of endurance exercise in HUMAN.

<u>Basic Response of the Cardio-respiratory System to Intense Levels of Exercise</u>
(may be run as an interactive class demonstration or as a self-run tutorial)

Run individually and then (stop!) analyzed as a class
A trial at EXER = 3.0; simulated 'heavy' exercise
We will eventually (Part V) have the subject exercise at various levels for as long as s/he is able. In *web*-HUMAN, the level of exercise is controlled by the variable **EXER**, which specifies the level of exercise in O2 usage above the basal level (i.e. rate of O2 use during exercise).

<u>Instructions</u> Set the *exercise duration* (**XERMIN,** default is 10 min**.**) parameter for some very large time (such as 100 minutes) This will allow exercise to proceed until some critical, limiting *physiological* value has been exceeded. Set **EXER** = 3.0 L/min. (heavy exercise). Run for *30 minutes* with *5 minutes between printouts*. Has the subject ceased to exercise due to an O2DEBT of > 10L? If so between what times eyeball time and EXER columns)?

To get a more exact time of cessation (to the minute) mouse Patient's Charts in the **View** section and select Your Patient's Chart . Note the report of the exact time of exercise cessation. *STOP FOR CLASS DISCUSSION!*

IV. <u>Exercise at various levels</u>
Run as class groups (see below)

<u>Gathering Data- instructions</u>
Start over thus initializing again, reset View output as necessary, and run a 30 minute simulation for the exercise intensity level assigned to your lab group (see below). Remember to set XERMIN high (and hence out of the way. Determine the time to exercise cessation and <u>rerun</u> a newly initialized model *for only that exact amount of time.*

Note that two groups will also be changing respiratory and cardiovascular variables. Look up each (FO2AT, RHSB, LHSB) in Help info on: under the **Help** section to make certain you understand each.

Save your group's run in the folder ==>CompVertSp10<== for use in class discussion.

Class groups

	variable changed				
<u>Group name</u>	<u>Exercise level</u>	<u>Cessation time</u>	<u>VENT</u>	<u>CO</u>	Possible name [-:
_____	____3.50____	_____ _____ _____			*Bluefin tunas*
_____	____2.75___	_____ _____ _____			*Mako sharks*
_____	____1.25___	_____ _____ _____			*Arctic foxes*
_____	____0.75___	_____ _____ _____			*Pigmy possums*
_____	__FO2AT=1**_	_____ _____ _____			*High O2's*
_____	__R&LHSB=1.2*	_____ _____ _____			*strong hearts*

* set EXER = 1.5 AND LHSB & RHSB = 1.2   ** set EXER = 1.5 AND FO2AT=1.0

Wait for class viewing and discussion of the results which will be called up from your stored files by the instructor. [Note that more than 2 variables can be changed before running exercise by 1) changing EXER & XERMIN 2) running for 0 min. with 0 min. between printouts and 3) changing one or two more variables]

V. <u>INCREASING EXERCISE ENDURANCE</u> (<==done independently)

Which part of the cardiopulmonary system is the limiting factor in supplying oxygen to the exercising muscles (that is, why does the model run up an O2DEBT)? Is it due to an *insufficient <u>respiratory</u> O_2 intake rate* or to an *insufficient <u>circulatory</u> O_2 transport rate*? Which of these two *serial* legs of the O_2 transport system gives in first and fails to meet the needs of the aerobic muscles?

We investgate this via 3 separate runs, each time keep our eye on the exercise cessation times.

Run 1 – baseline

Run EXER = 2.0 XERMIN=100 for 30 minutes at 5 min. intervals using Patients Charts as previously to determine exact exercise cessation time. Copy data as you wish to Excel.

Runs 2 & 3 – respiratory and cardiovascular strengthening

We try to increase the subject's tolerance (time to 10 L debt) during moderate exercise (EXER=2.0) in two ways.

First, have him/her *breathe 100% oxygen* while exercising. This removes as much as possible any *respiratory* restraint. Then, restoring the inhaled O2 to its normal value (always Start over), instead *increase the model's basic heart strength* (i.e. simulate a cardiac muscle training effect). This 'conditions' the CV system & tends to remove the circulatory restraint. Whichever of these maneuvers works best (gives the longer increase in exercise time) indicates that that particular system was the most limiting one originally.

 Run 2- respiratory strengthening
To breathe 100% O2, set the fractional concentration of O2 in the atmosphere (**FO2AT**) to 1.0 (this may be varied between 0.0 <-> 1.0; it is, of course, normally 0.21). Remember to initialize ('Start over') and reset the View Output column headers, substituting **O2V** for EXER (you already know how EXER will behave, when it will turn off, etc.) before you start. Run for *100 min.* with 5 min between printouts and check your Patients chart. Record data as before.

 Run 3- cardiovascular strengthening
To increase basic heart strength (normally = 1.0) you must set the values of right heart strength (**RHSB**) *and* left heart strength (**LHSB**) to higher (yet equal) values. A recommended value is 1.25. (What would happen if you raise the strength of only one side of the heart?) Use the same **View output:** tables as in the 100% O2 section above.

Reminder: One way to set up an experiment that requires changing 3 or 4 variables is to first change two (e.g. EXER & XERMIN) then run for 0 min. with 0 min. between printouts, then change the third and finally run the experiment itself.

☞   The Lab Writeup
☞   Factors Determining Endurance Time
required   1) Which maneuver, the 100% O2 or the heart conditioning, increased endurance time more? Which system is then normally the limiting one? Select data from this section and graph it (one plot page only) in a way that supports your conclusion.

extra credit   2) Ultimately, O2 flow to the muscles must be adequate in order to support aerobic exercise and prevent anaerobiasis & lactate buildup. Think about how to *calculate*** O2 flow or O2 flow to the muscles (ml/min. of O2). You have enough data in your tables to do it [hint: review the lectures on O2 flow, cardiac output]. Under which condition is O2 flow to the muscles highest? *(extra credit means with NO consultation with you instructor at all.)*
** Not to be derived from Patient Charts.

<u>Lab Writeup Checklist</u>:

Your writeup should include the following:

1) A data <u>graph</u> and supporting *very* brief <u>analysis</u> (1 page <u>MAXIMUM</u>-10 point type) showing which system, cardiac or respiratory, is the limiting one in endurance exercise.
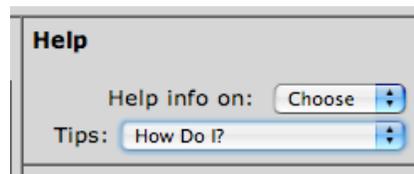
2) This write-up is due at the beginning of lab next week.

3) The O2 Flow analysis above is for extra credit (10 points) and optional.

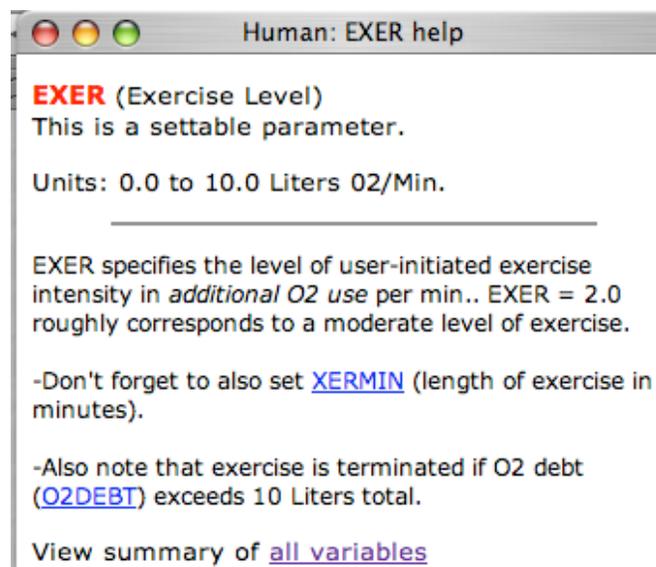# Quick summary- Using web-HUMAN's on-line Help features

Note well: Make certain your popup blocker is OFF before using the functions below

1) Find the **Help** section on the screen right. Notice that it allows you to a) look up information on a variable (Help Info on: <Choose>) and 2) look up how to run a procedure (Tips: <How Do I?>)

2) To check a variable, select Help Info on: <Choose> with your mouse & roll down to the variable of interest. e.g. Help info on: EXER A window pops open with information on that variable & links to related variables (see below).

3) To learn how to run a procedure (e.g. exercise, infusion, etc.), mouse down to your procedure under Tips: <How Do I?> and a window will open detailing how to run the procedure.