

Comp Vert Physio 2012 ver 1.3 19 March, 2012

High Altitude Simulation

Below we investigate various aspects of high altitude adaptation and maladaptation via a *web-HUMAN* simulation.

Why simulation- This is exactly the sort of experiment simulations excel at. We get the opportunity to carry out a procedure that would be difficult to execute in the 316 lab. And we can ask for the values of and change the value of variables we would normally not be able to investigate given our current lab equipment set.

Sources- Your background in high altitude is considerable and includes a reading in Schmidt-Nielsen 209-211 plus associated hypoxia material, the first lecture in the Metabolism series and several supplementary readings on altitude as listed on the course outline.

Overview -1) We first briefly review some simple *web-HUMAN skills* you have learned. 2) We then turn to a "standard" high altitude ascent experiment in which you appear "instantly" on the top Pike's Peak, the continental USA highest mountain (summit, 12-14,000 ft. feet). The high altitude research station (Pikes Peak Research Station Florissant, CO). is somewhat lower than this. You are guided through this portion of the experiment step by step. 3) You investigate the downside of certain high altitude adaptations, especially polycythemia. Recall from lecture that high altitude dwellers die with a much higher frequency of right heart failure.

Each of these three steps plus some possible extra credit options appear below.

I. Preliminary technique review

A. *Logging in*

- log in as in the past

B. *Setting your default directory* for Saved models.

- pick Get a saved experiment to get Folder Explorer

- navigate to [CompVert2012](#) under Skidmore Courses (this is likely already your default folder)



- select the new subfolder **HighAltitude2012** and make this your default folder. All your saves, if necessary, will automatically go into this folder.

Note that you will not be required to Save during these procedures but may find saving your models useful.

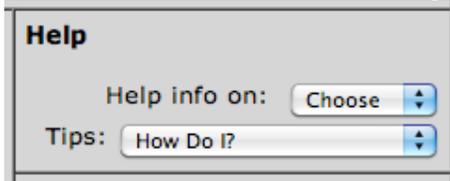
Click *Start over* (upper left)

C. *Reviewing how to get Help on variables*

Click on **[Start a Physiology Experiment](#)**

Methods available to obtain information on variables

Method 1 - use the on-line **Help** section (Help info on: <Choose>)



Use it to find the variable BAROP and examine its help screen.

What is the current value of the barometric pressure of the model at rest (spaces below are meant to be filled in)?

_____ (always list name *and* units)

Method 2 - use the *List of all variables*

On your help screen, click on View summary of [all variables](#)

You may wish to keep this screen available in the background as your work.

A]What is the *web*-HUMAN name for the " Arterial CO₂ Tension"

What is its average value at rest? _____ (include units)

B]What is the *web*-HUMAN name for the plasma bicarbonate? _____

What is its 'normal' value? _____ (include units)

II. Carrying out a high altitude experiment on Pike's Peak.

Recall, this is the highest altitude in the continental US that has an associated a large high altitude research station

For our purposes here, consider the barometric pressure at Pike's Peak to be an average of 480 mmHg.

The individual steps in carrying out this experiment are outlined below.

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1) Click to begin

- **Click [Start a Physiology Experiment](#)**

- * always remember that if you wish to Save your experiment you must log in first

This results in the typical opening *web*-HUMAN experiment screen seen in section 2 below. The model is now ready for an experiment to be set up and then run.

2) To set up your experiment

HUMAN is now ready to be set up at high altitude for a 6 day experiment while tracking the respiratory and blood gas responses in its tables. The *setup* for this experiment is shown in the figure below and *the steps* involved in this setup are then described individually.

The screen setup for the Pikes Peak experiment, One should also pick VENT to graph

a) To change the barometric pressure (BAROP) from sea level value (760 mmHg) to 12,500 ft. value (480 mmHg).

Under **Change Variable** scroll down to BAROP and enter the new desired value (480).

b) To change the output table columns to read out ventilation and blood gas variables.

Under **View Output:** (first row) mouse columns 1 (AP) through 6 (EXER) to obtain output variable names for

HUMAN Variable	Physiologic variable*
PO2A	Alveolar partial pressure O2 (m

PCO2A	Alveolar partial pressure CO2 (m
PH	Arterial blood pH
VENT	Lung ventilation (Liters/min
BICARB	Plasma bicarbonate (meq./Lit
BAROP	Barometric pressure (mmHg

* Use Help info on: <choose> for more info on any of these variables

c) To set up the graph to plot all 6 of these variables (be certain your browser popup blocking is off!)

1) Under **View Output as:** (upper left, 2nd row)

change each (desired) variable to as: **graph** from its default as: **text** (see VENT as an example)(This will result in output *both* as a Table and as a Graph)

2) Under **Graph Style** (lower right) simply retain the default choices of

- a normalized plot (values will be shown as change from baseline control values) and
- one graph (all 6 values will be shown on one single plot)

d) To setup to gather data for 6 days at 12 hour intervals

Under **Run Experiment**

- for experiment duration type in 6D (default is minutes, D = days, H= hours)
- for printout intervals type in 12H to yield printouts every half

day

e) **Click** on **<Go>**- this runs the experiment resulting in a tabular and a graphic output window.

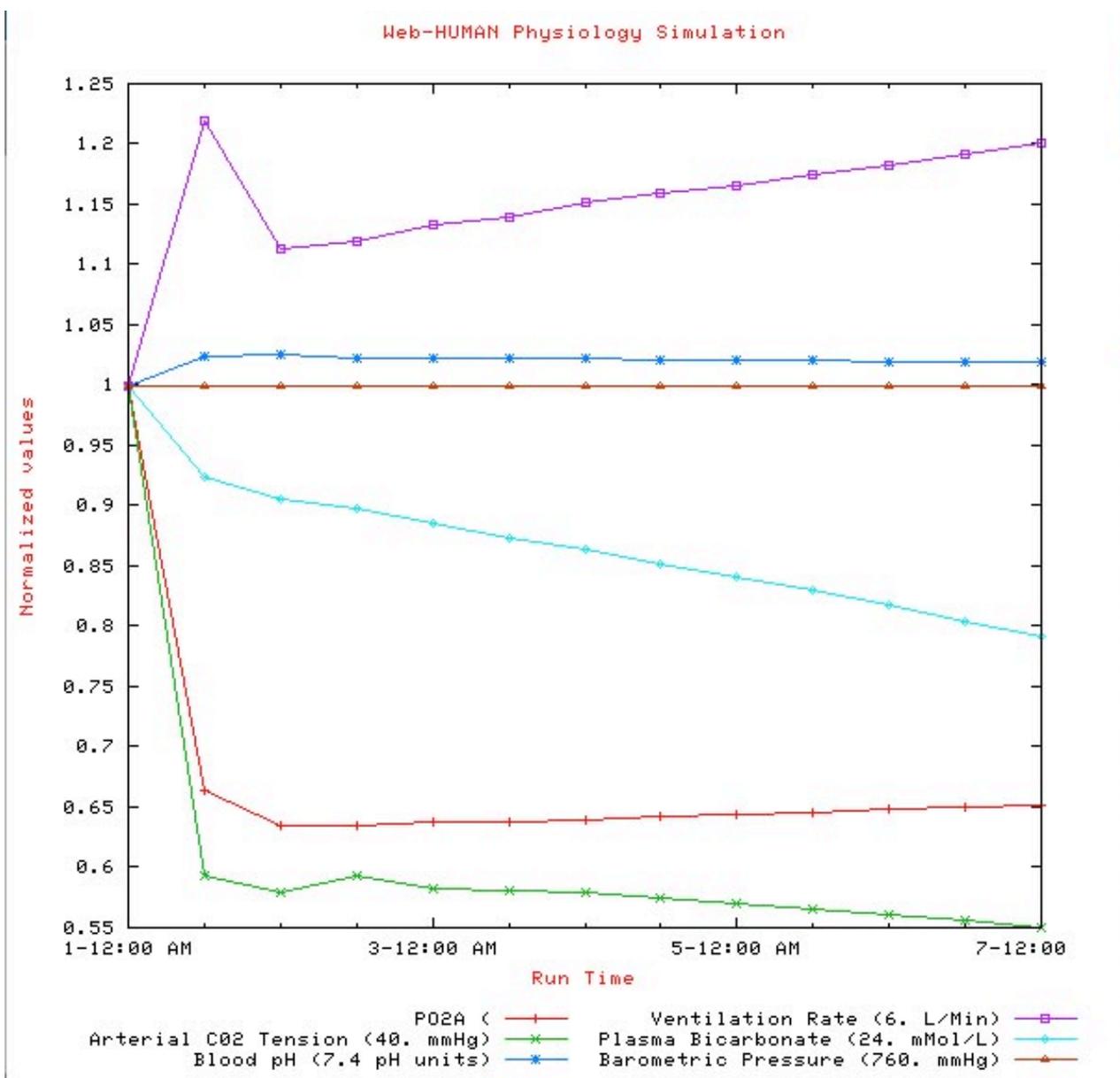
- Click on the Tabular window to bring it to the foreground as shown in the "**Output From Web-HUMAN Physiology Simulation**" below.

3) The output of your experiment

- The output of the high altitude experiment, beginning on Day 1 at 12:10 a.m. (column #1)

Skidmore College		Output from Web-HUMAN Physiology Simulation				Manual	Ver. 9.1-47 (7/29/11)
DAY/HR	AP	COL	O2DEBT	MFLOL	VENT	EXER	
1-12:00 AM	99.78	5.438	0.000	1.100	5.675	0.000	
1-12:10 AM	99.69	5.425	0.000	1.089	5.673	0.000	
Barometric Pressure (760. mmHg)					=	760.00	
Barometric Pressure (760. mmHg)					=	480.00	
6.00000	Days are		8640.00	Minutes			
12.0000	Hours are		720.000	Minutes			
DAY/HR	PO2A	PCO2A	PH	VENT	BICARB	BAROP	
1-12:10 AM	97.34	38.27	7.410	5.673	23.69	480.0	
1-12:10 PM	64.68	22.67	7.584	6.916	21.87	480.0	
2-12:10 AM	61.91	22.15	7.596	6.316	21.45	480.0	
2-12:10 PM	61.88	22.67	7.581	6.352	21.25	480.0	
3-12:10 AM	62.19	22.26	7.580	6.429	20.96	480.0	
3-12:10 PM	62.24	22.24	7.576	6.467	20.70	480.0	
4-12:10 AM	62.39	22.19	7.571	6.533	20.45	480.0	
4-12:10 PM	62.60	21.99	7.568	6.579	20.19	480.0	
5-12:10 AM	62.78	21.81	7.565	6.617	19.92	480.0	
5-12:10 PM	62.97	21.61	7.561	6.664	19.66	480.0	
6-12:10 AM	63.17	21.43	7.557	6.710	19.36	480.0	
6-12:10 PM	63.36	21.26	7.553	6.761	19.06	480.0	
7-12:10 AM	63.57	21.09	7.549	6.815	18.75	480.0	

Click on the graph to bring it to the foreground. It appears as shown below.



This is a classic high altitude response.

Briefly, in the space provided, address each of the issues below

1) What happens to the arterial PO₂? Why? Can you calculate atmospheric PO₂?

2) What happens to *lung ventilation*? Explain *briefly*.

3) What happens to the alveolar *PCO₂*? Why does this change occur? (*Briefly*)

4) What response is seen in the *pH*? Why causes this change in pH? What kind of an acid base response is this (name it!)*. (*Briefly*)

* causes can be either respiratory or metabolic; pH changes can be acidotic (<7.40) or alkalotic

5) What happens to the *plasma bicarbonate*? What is causing this change (initially, at least)? Be brief!

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III. Investigating the down side of a high altitude response.

One of the adaptive responses to high altitude is a polycythemia, a sort of natural blood doping. to increase oxygen carrying capacity. This response has its downside which you will

investigate below. In this case you are more directly involved in the mechanics of setting up the experiment on your own.

Start over for a new experiment.

On your own, set up a Pike's peak experiment of equal length to the previous one that tracks the following variables. You will need to look up variables on your own.

hematocrit

blood hemoglobin

blood viscosity

vascular conductance

cardiac output (in liters/min)

sympathetic nervous system activity

Carry out your experiment for a time equal in length to your first ascent.

Examine (perhaps print out) the results.

Briefly address each of the following:

1) What is the pattern of response of *hematocrit*? How is this possibly adaptive? [Be brief!]

2) What happens to the *blood hemoglobin content*? Given the changes in [Hb] what do you expect to happen to the oxygen capacity of the blood (O_{2A})? [Be brief!]

3) What is the pattern of the *blood viscosity*? Why are these changes in viscosity occurring?

4) What is the pattern of the response of the *vascular conductance*? Explain its direction of change. [Be brief!]

5) What has happened to the *cardiac output*? Why is it changing in this direction? How might this be maladaptive? [Be brief!]

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end of the main lab simulation=====

This simulation write-up is due next week at the beginning of lab.

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Extra credit (10 points each - extra credit means *no* help from your instructor)

recall: to qualify for *any* extra credit answers must be of high quality.

1) Design and execute an experiment that asks whether *breathing 50% O₂* (atmospheric enrichment) fully relieves the hypoxia.

Submit your experiment and interpretation of the results.

2) Compare exercise duration times at our standard EXER= 2.0 XERMIN = 60

a) at sea level

b) in Denver

c) in Morococha, Peru - the world's highest residential altitude.

This section may require some web research on your part.

Here are some starter resources



morococha peru barometric pressure mmHg

Search

About 505 results (0.12 seconds)

Everything

[Animal Physiology: Adaptation and Environment - Google Books Result](#)
[books.google.com/books?isbn=0521570980...](#)

Images

[Knut Schmidt-Nielsen](#) - 1997 - Medical - 607 pages

Maps

Similar changes occur in young rats that have been exposed to low pressure during ... in native residents of Lima (sea level) and **Morococha, Peru** (4540 m altitude). ... The average **barometric pressure** at **Morococha** is 446 mm Hg, compared ...

Videos

http://www.omega.com/techref/pdf/Alt_Press_table.pdf

http://www.omega.com/techref/pdf/Alt_Press_table.pdf

2/Courses Apple Amazon News Human Weather WHO IS Tools

Web-Human http://www.omega.com/techref/...

ALTITUDE PRESSURE TABLE

Feet Altitude	inHg	Pressure torr	psia	Ambient PO ₂	mmHg		Alveolar PH ₂ O
					Alveolar PO ₂	Alveolar PCO ₂	
0	29.92	759.97	14.70	159.21	103.0	40.0	47
500	29.39	746.51	14.43	156.39	100.5	39.7	
1,000	28.86	733.04	14.17	153.57	98.2	39.4	
1,500	28.34	719.84	13.91	150.81	90.0	39.2	
2,000	27.82	706.63	13.66	143.04	93.8	39.0	
2,500	27.32	693.93	13.41	145.38	91.7	38.7	
3,000	26.82	681.23	13.17	142.72	89.5	38.4	
3,500	26.33	668.78	12.93	140.11	87.3	38.2	
4,000	25.84	656.34	12.69	137.50	85.1	38.0	
4,500	25.37	644.40	12.46	135.00	83.0	37.7	
5,000	24.90	632.46	12.23	132.50	81.0	37.4	47
5,500	24.44	620.78	12.00	130.05	78.9	37.2	
6,000	23.98	609.09	11.77	127.60	76.8	37.0	
6,500	23.53	597.66	11.55	125.21	74.8	36.7	
7,000	23.09	586.49	11.34	122.87	72.8	36.4	
7,500	22.66	575.56	11.13	120.58	70.8	36.2	
8,000	22.23	564.64	10.91	118.29	68.9	36.0	
8,500	21.81	553.97	10.71	116.06	67.0	35.7	
9,000	21.39	543.31	10.50	113.82	65.0	35.4	
9,500	20.98	532.89	10.30	111.64	63.1	35.2	
10,000	20.58	522.73	10.10	109.51	61.2	35.0	47
10,500	20.19	512.83	9.91	107.44	59.5	34.7	



mmHg pressure at 20000 ft

Search

About 69,800 results (0.26 seconds)

Everything

[Altitude Units to Pressure Units Conversion Table](#)

www.sensorone.co.uk/altitude-pressure-units-conversion.html

Images

Convert from an altitude in **feet** or metres to a **pressure** reading in millibar ... **20000, ft**, 6096.0, m, is, 465.633, mb/hPa, 6.7534, psi, 349.25, **mmHg**, 13.750, inHg ...

Maps

Videos

[Air Pressure and Altitude above Sea Level](#)

www.engineeringtoolbox.com/air-altitude-pressure-d_462.html

News

h = altitude above sea level (m). The table below indicates air **pressure** at elevations below and above sea level. ... **Pressure. feet**, meters, inches Hg, **mm Hg**, psia,

