Cells, Tissues, and Conversion Factors – What Gets More Cancers?

The European Bioinformatics Institute estimates that one human cell weighs about 10^{-9}g (Brazma *et al.*, 2001). How many cells does a person who weighs 190 pounds have? What would the chance be of that person suffering a cancer-causing mutation in one cell? In this exercise you will use conversion factors to figure out how many mutations a person is likely to have and investigate some possible applications to identify animals and organs that are extra-resistant and extra-susceptible to cancer.

First, you need to remind yourself of how to use conversion factors in an organized way.

The basic method of doing conversion factor problems: USE THE UNITS!!!

This method may seem like a lot of work for simple problems. However, it will get you through the most complicated problems, so it is worth learning at this point.

1. Identify what the question is asking you to figure out – what UNITS
2. Set up the question as an equation with what you want to find out on the right of the equal sign

For example: _____ = $\dfrac{\text{cells}}{\text{Human}}$

3. Look in the list of what you know for something with the units you want in your answer. Put that information on the left of the equal sign.

For example: $\dfrac{\text{cell}}{\text{10-9 gm}}$ $\dfrac{\text{190 lb}}{\text{human}}$ _____ = $\dfrac{\text{cells}}{\text{Human}}$

4. What's the difference in units between the left and right sides of the equation? Use some of the other data and conversion factors to make the units cancel out until they are the same on each side.

For example: $\dfrac{\text{cell}}{\text{10-9 ~~gm~~}}$ $\dfrac{\text{190 ~~lb~~}}{\text{human}}$ $\dfrac{\text{454 ~~gm~~}}{\text{~~lb~~}}$ = $\dfrac{\text{cells}}{\text{Human}}$

5. Now put the numbers into scientific notation and ESTIMATE the numerical answer.

For example: $\dfrac{\text{cell}}{\text{10-9 ~~gm~~}}$ $\dfrac{1.90 \times 10^2 ~~lb~~}{\text{human}}$ $\dfrac{4.54 \times 10^2 ~~gm~~}{\text{~~lb~~}}$ $\approx \dfrac{2*5* 10^{(2+2-(-9))} \text{ cells}}{\text{Human}} \approx \dfrac{10* 10^{(13)} \text{ cells}}{\text{Human}} \approx \dfrac{10^{14} \text{ cells}}{\text{Human}}$

6. Now you can use your calculator to solve the problem and get a precise answer.

If you feel rusty about these skills, here are the tutorials you should use to practice:
http://faculty.alverno.edu/bowneps/new%20quant/qmenu.htm
Tutorials at this site will generate questions in scientific notation, conversion factors, and estimation. Do them until you can get ten right in a row and you should be ready to cope with anything on this worksheet!

Conversion factors you will need:	How many mg in a gram? _____
How many grams in a kilogram? _____	How many μg in a gram?_____
How many grams in a lb? _____	How many lb in a ton? _____

The European Bioinformatics Institute estimates that one human cell weighs about 10^{-9}g (Brazma et al., 2001). The cells of all eukaryotic animals are about the same size, so you should be able to calculate how many cells are in different organisms and fill in the table below:

Animal	Weight	Number of cells
Human	190 lbs	
Mouse[1]	.009kg	
Rotifer [2]	0.9 μg	
Horse[1]	650 kg	
Flea[3]	0.45 mg	
Blue whale [4]	150 tons	

1 – Schmidt-Nielsen, 1997   2 – Haberman and Laugaste, 2003   3. Bennet-Clark, 1967   4. Marine Mammal Center, 2011

If a human has about 2.7 x 10-4 potentially cancer-causing mutations per year (a figure calculated based on the number of cells in a human, the number of those cells that are stem cells, and how rapidly they divide) how many potentially cancer-causing mutations would each of the other animals above have in a year? Which animals should get the most cancers?

In actual fact, whales show very low levels of cancer (Zimmer, 2011). What ideas do you have about why whales have less cancer than predicted?

Designing an Excel Spreadsheet to do conversion factor calculations

Using your conversion factor skills, you could calculate the number of cells and the theoretical number of possibly cancer-causing mutations a year in each of the following human organs. But doesn't that look like a lot of math? Make an Excel spreadsheet to do the work for you!

Human Organ	Male/female weight (g) (Narongchai & Narongchai, 2008)	Male/female Number of cells	Male/female Number of mutations/yr
Brain	1311/1170		
Pituitary gland	0.6/0.6		
Thymus	23/24		
Heart	291/246		
Thyroid	17/17		
Right lung	321/271		
Left lung	296/251		
Liver	1252/1106		
Pancreas	97/88		
Right kidney	106/97		
Left kidney	112/98		
spleen	104/77		
Right adrenal	5/7.9		
Left adrenal	6/8		

First, open Excel. You'll see a spreadsheet that looks like this:
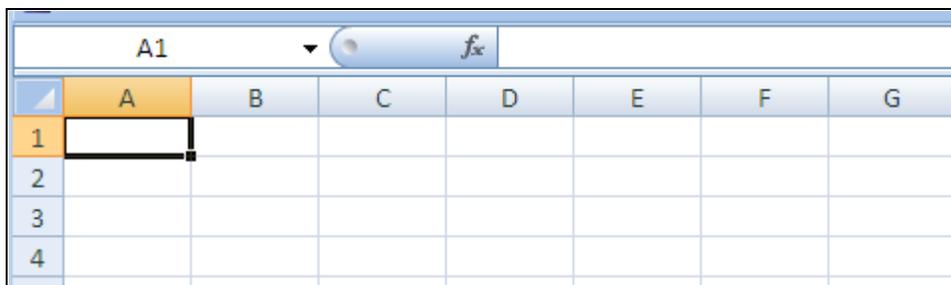
Put the cursor in Cell A1 and type '**Human Organ'.** Hit 'enter.' Go on through the top row and enter the headings from the table.

When you put the cursor on the line between cells A and B, you can drag that line right to make the cells wider so that you can see everything you typed in them.

Now enter values from the table above in cells A2 and B2.

Can you figure out the value that should go in cell C2, from just the value in cell B2? How? Write it down below.

C2 (number of cells) = B2 (weight) * _____

If you know how to figure it out, you can tell the computer to do it. Put the cursor in cell C2 and type the equal sign. Then enter the equation you developed above. (if you need scientific notation, type it as 10^4 or 10E4) Hit 'enter.' Do you see the correct value appear in cell C2?

Now look at cell D2. How can you use the answer in cell C2 to calculate the value for cell D2? What should the equation be?

D2 (theoretical number of mutations) = C2(number of cells) * _____

Enter that equation into cell D2.

Now look at the columns about females on your spreadsheet. They use the same math, don't they? So you can copy the equations you typed into cells C2 and D2, and paste them into cells F2 and G2.

Use your spreadsheet to solve more problems! Fill in columns A, B, and E with the values from the table above. Now select cell C2. See the little box in the lower right corner of the cell?

A	B	C	
		Male number of	Male
Human Organ	Male weight (g)	cells	mutat
Brain	1311	1.311E+13	

Put your cursor in that little box and drag it downwards. It will copy the equation you entered in cell C2 into the cells you drag it across. Do the same thing for cells D2, F2, and G2.

Do your answers agree with the ones you figured out manually?

These calculations are very rough predictions of how many cancer-causing mutations different organs might suffer in a year. What are some of the assumptions made in this kind of a model?

Come up with ONE hypothesis about cancer based on your calculations and find out whether it is correct or not.

Literature Cited

Bennet-Clark, H. C., 1967. The jump of the flea: a study of the energetics and a model of the mechanism Jf. Exp. Biol. (1967), 47. 59-76 59. Retrieved from http://jeb.biologists.org/content/47/1/59.full.pdf

Brazma, A., Parkinson, H., Schlitt,T., Shojatala, M. (2001). European Bioinformatics Institute. A quick introduction to elements of biology - cells, molecules, genes, functional genomics, microarrays. http://www.ebi.ac.uk/microarray/biology_intro.html

Haberman, J. and Laugaste, R. (2003) On characteristics reflecting the trophic state of large and shallow Estonian lakes (L. Peipsi, L. Võrtsjärv). Hydrobiologia 506-509(1-3):737-744. Abstract retrieved from http://www.springerlink.com/content/u471162l74n422v1/

Marine Mammal Center (2011). Blue Whale. Retrieved from http://www.marinemammalcenter.org/education/marine-mammal-information/cetaceans/blue-whale.html

Narongchai P, Narongchai S.(2008). Study of the normal internal organ weights in Thai population. J Med Assoc Thai. 2008 May;91(5):747-53. Abstract retrieved from http://www.ncbi.nlm.nih.gov/pubmed/18672642

Schmidt-Nielsen, K., 1997. Animal Physiology, 5th ed. University of Cambridge Press

Zimmer, C. (2011). The mere existence of whales. The Loom, Discover Magazine February 28th, 2011. Retrieved from http://blogs.discovermagazine.com/loom/2011/02/28/the-mere-existence-of-whales/

Nervous System -- Use a predictive equation to calculate cell resting potential

Plasma

3 mM K$^+$

Concentration gradient

90 mM K$^+$

116 mM A-

Attraction to Anions
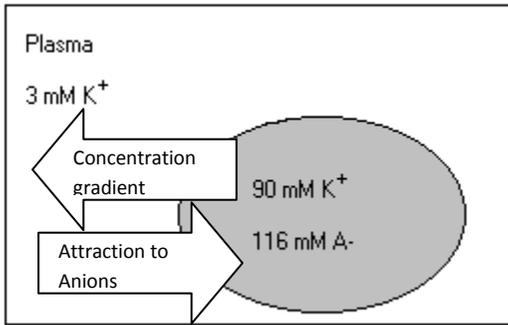
In lecture, you heard that the cell has lots of K$^+$ inside but there is not much K$^+$ in the blood around it. Doesn't that seem weird? Why wouldn't the K$^+$ diffuse out into the blood until the concentrations are equal?

One reason is that there are proteins inside the cell. They are too big to get out, but they are negatively charged (Anions, or A-).

As K+ diffuses out, leaving the Anions behind inside the cell, the inside of the cell becomes more negative relative to the outside. K+ is attracted to the negative charge and this attraction to the negative Anions pulls it back in. The cell reaches equilibrium when the concentration gradient causing K+ to leave the cell is equal to the electrical attraction causing K+ to go back into the cell. Usually this happens when the cell's internal charge is around -70 to -90 mV. That is the **resting potential**, or **Em**.

If the concentration gradient between the inside and outside of the cell were smaller, K+ would not move out of the cell as much and the cell would not have be so negative at equilibrium.

You can predict the cell's resting potential (E$_m$) from the amounts of K$^+$ inside and outside the cell, using the Nernst Equation:

$$E_m = 61 \text{ x log } ([K^+ \text{ outside}]/ [K^+ \text{ inside}])$$

([K$^+$] means 'the concentration of K^{+}')

For the cell in the picture above, what would the Em be? First make some estimations. Is ([K$^+$ outside]/ [K$^+$ inside]) larger than 1 or smaller? _____

The logarithm of a value larger than 1 is positive. The logarithm of a value smaller than 1 is negative. Is log ([K$^+$ outside]/ [K$^+$ inside]) going to be positive or negative? _____

Is the resting potential (Em) going to be positive or negative?_____

What is the value of Em you get from the equation?_____

Now, suppose we give the person an injection of K$^+$ and raise blood K$^+$ to 10 mM. What will the resting potential be?

Will this person's nerves fire more or less than normal?

Use an Excel worksheet to predict cell potential and graph it

Set up your spreadsheet:

	A	B	C
1	K+ inside (mEq/L)	K+ outside (mEq/L)	Calculated Resting Potential (mV)
2	90	3	??????
3			
4			

What should the equation be for calculating the resting potential? _____

Enter it in cell C2. When you hit enter, the answer should appear in cell C2. Was it the right answer? If not, doublecheck your equation and how you typed it in.

Now use your spreadsheet to solve more problems! Fill in columns A and B to follow the changes in this cell if internal K+ remains at 90 mEq/L but external K+ changes. Enter at least 10 different values for external K+ into cells B3-B12.

Now to make a chart –

Drag the cursor to select the cells in columns B and C. These are the data you will chart. Now go to the **Insert** tab and choose '**Scatter** .' You'll have several options: choose a scatter plot with a line drawn through it. Then go to the **Layout** tab and add axis labels and a title to your chart.

The title should explain what the chart shows. Put your name in the title as well, since you'll be handing in a printout of it. The axis labels should include units. Make your title and labels informative, so somebody reading this chart could understand what it was without seeing anything else about it!

When you have your chart the way you want it, print the spreadsheet and the chart to turn in.

ADVANCED WORK - OPTIONAL
You can make your spreadsheet more realistic ---

From class, you know that if the resting potential meets the threshold, the cell will fire and depolarize up to its action potential, which is +35 mV. The threshold potential of a human neuron is around -55 mV. So in real life, if your calculated resting potential was above –55 mV, you'd predict that the cell would have fired and the real cell charge would be +35 mV.
Let's put in a new column to reflect that. In Cell D1, type **Predicted actual cell charge**

Select cell D2 and click on the icon that looks like *fx*.
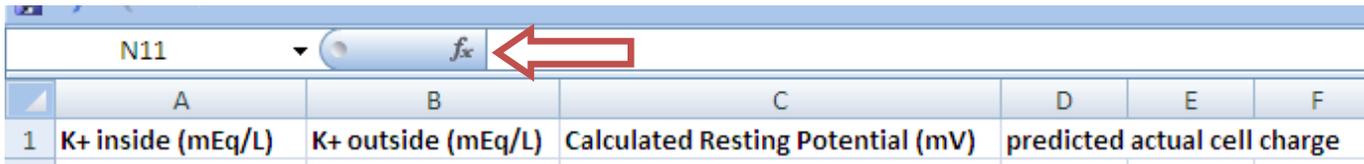
	A	B	C	D	E	F
	N11		f_x			
1	K+ inside (mEq/L)	K+ outside (mEq/L)	Calculated Resting Potential (mV)	predicted actual cell charge		

From the list provided, choose **IF** and click on **OK**

In the dialog box:

The logical argument you want to put in is that if the calculated resting potential in cell C2 is higher than –55, then the predicted actual cell charge in cell D2 will be +35.

So for **logical argument**, enter **C2>-55**

For **Value if true**, enter **+35**

If the calculated resting potential in cell C2 is not higher than –55, then we predict that the actual cell charge in cell D2 will equal the calculated resting potential. So for **Value if false**, enter **C2**.

When you hit enter, you should see the answer. Now calculate the predicted actual cell charge for all the values of external K+ in your spreadsheet.
Now select the values in columns B and D and insert a scatter plot of them. (To select two different columns that are not next to each other, select the cells from first column and then hold 'ctrl' while you select the cells from second column.)

Musculoskeletal System: use a simplifying model to calculate muscle strength
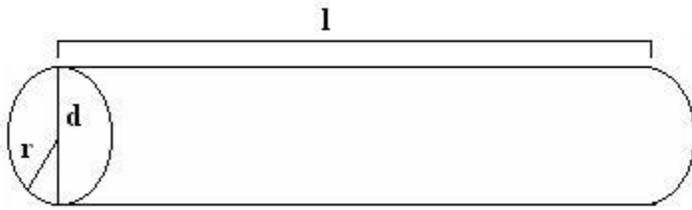
Cross-sectional area of a cylinder = πr^2	Conversion factors you will need: How many μm in 1cm? _____ How many $μm^2$ in $1cm^2$? _____ How many $μm^3$ in $1cm^3$? _____

If the cylinder above is a muscle fiber, its diameter might be 100 micrometers (100 μm). What would its cross-sectional area be?

A human muscle can exert about 6 kg of force per square centimeter of muscle cross section (McArdle, Katch and Katch, 1991). How much force could the muscle cell above exert if it were a strong muscle?

Use your skill with Excel spreadsheets to create a spreadsheet that will do these calculations for you. Here's a possible set of headings:

	A	B	C
1	muscle cell diameter (micrometers)	muscle cell cross-sectional area (square micrometers)	muscle cell strength (kg)
2			
3			

Use your spreadsheet to calculate muscle strength for 10 different muscle diameters and graph them.

By lifting up on a table edge while feeling your upper arm, identify your biceps brachii and estimate its diameter. How strong should it be, if the entire muscle is composed of muscle cells?

Test your strength by doing arm curls with the arm ergometer, or in the fitness center. Is your biceps brachii as strong as you predicted? If not, what factors could explain the inaccuracy of your prediction?

Literature Cited

McArdle, W.D., Katch, F. I., and Katch, V. L. (1991). Exercise Physiology, 3rd edition. Lea & Febiger, Philadelphia Pa. p. 457, fig. 22-3.

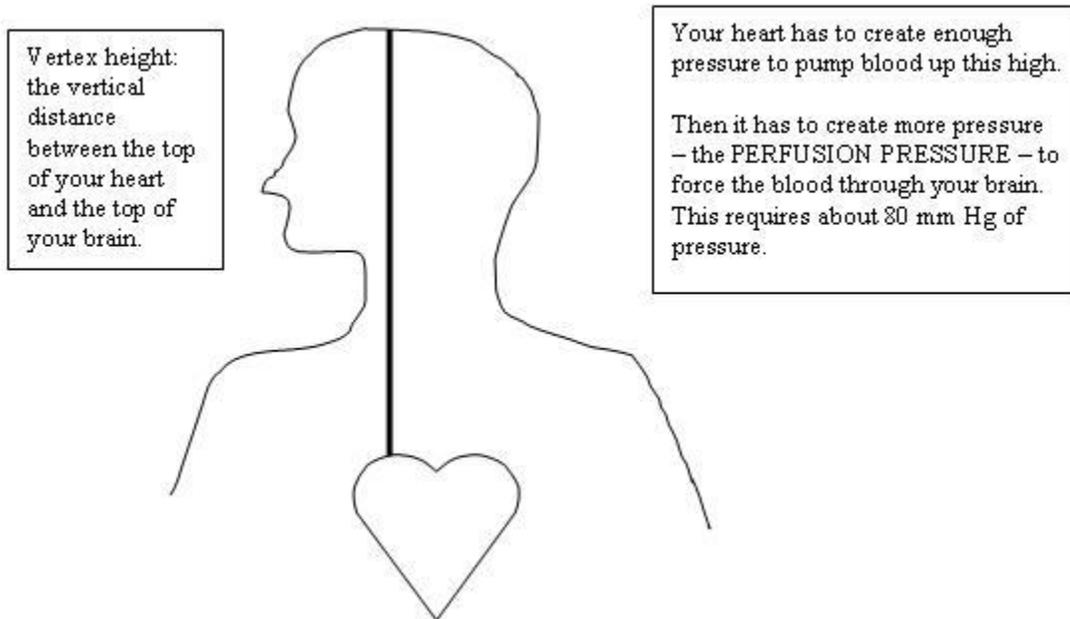### Cardiovascular System: use a deductive equation to predict blood pressure
Based on Schmidt-Nielsen, K (1997)

Deduction means working from what we know is true. You say to yourself, IF 12 inches=1 foot and 2.5 cm= 1 inch, THEN 30 cm must equal 1 foot. You could use the same kind of reasoning to create physiological equations. In this exercise, you'll predict systolic blood pressure from the vertex height – the vertical distance from the heart to the top of the head. Why would you want to do this? An immediate application is to tell whether a child or a very short or tall person has high blood pressure.

What you know; you know that blood has to be pumped from the heart to the top of the head, or the brain won't get enough blood and the person will die. And you know (because I'm telling you) that just getting the blood to the top of the head isn't enough; it takes some pressure to push the blood through the capillaries in the brain (perfusing the brain). So systolic BP has to equal at least the pressure to get blood up to the top of the head plus the pressure to push it through the capillaries in the brain.

Predicted minimum Systolic BP = pressure to reach top of head + pressure to perfuse the brain

For purposes of this exercise, let's assume that the **pressure needed to perfuse the brain is about 80 mm Hg**.

Vertex height: the vertical distance between the top of your heart and the top of your brain.

Your heart has to create enough pressure to pump blood up this high.

Then it has to create more pressure – the PERFUSION PRESSURE – to force the blood through your brain. This requires about 80 mm Hg of pressure.

The first sphygmomanometers were just tubes inserted into the artery of a living animal. Then the blood pressure would be measured by looking at how high blood rose in the tube. This is why blood pressure is measured in units of distance (like mm). So you could measure the blood pressure required to move blood from your heart to your head in units of distance.

What is your height? _____

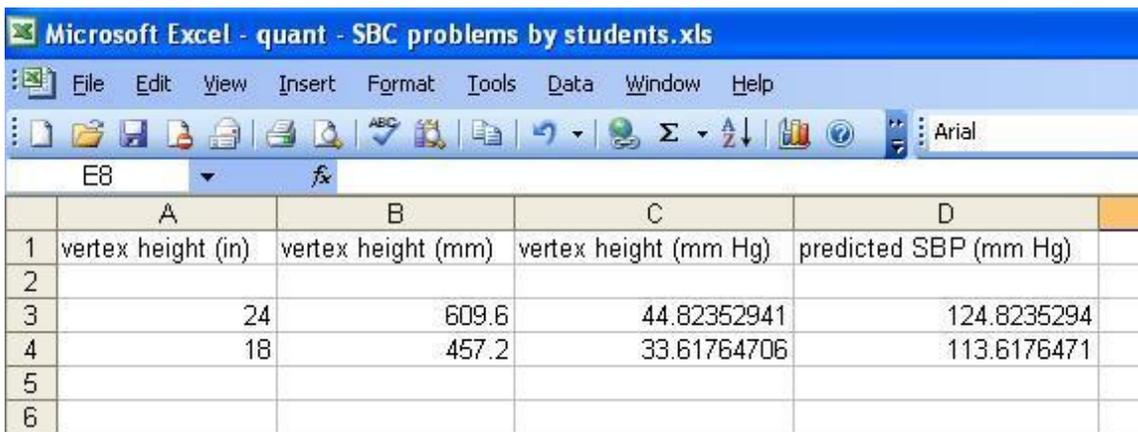Use the tape measure provided. What is your vertex height? _____

You'll notice that pressure measurements don't just say how high the pressure is pushing a fluid, they say what the fluid is. After all, different fluids have different weights, so it would take more pressure to push a heavier fluid. While blood pressure is really measuring how high blood can be pumped, the convention is to use the units "millimeters of mercury" or "mm Hg". This is done because Mercury is heavier than blood or water, so it doesn't rise as high in the tube for the same amount of pressure. **The pressure needed to raise Mercury one millimeter is the same as the pressure needed to raise water 13.6 millimeters.** Therefore, the people using old-fashioned tube manometers could use shorter tubes if they filled them with Mercury.

Convert your vertex height into mm Hg.

Now add the perfusion pressure. What is your predicted minimum Systolic Blood Pressure in mm Hg?

Suppose you were really tall, like a giraffe. If you were a giraffe 18 feet tall, with your heart situated halfway up your body, what would your predicted minimum systolic blood pressure be in mm Hg? (you should be able to solve this in one step by lining up the units!)

Make up an Excel spreadsheet for predicting systolic blood pressure from vertex height and use it to predict systolic blood pressure for people (or animals) with four different vertex heights. Here's a possible setup:

Use your spreadsheet to answer the following question:

A normally proportioned boy 4 feet 2 inches tall has a systolic blood pressure of 100 mm Hg. Is his blood pressure high, low, or what you would expect for his height? What assumptions did you have to make to solve this problem?

Literature Cited

Schmidt-Nielsen, K (1997). Animal Physiology, 5th ed. Cambridge University Press. p.109

Cardiovascular System: calculate clinically important cardiac variables

Cardiac Output (CO) = heart rate x stroke volume SHOULD BE 3-6 L/min
But people are different sizes, so that will change their CO. To account for this, we measure:
Cardiac Index (CI) = Cardiac output / body surface area SHOULD BE 2.8-5.5 L/min/m2

Pulse pressure (PP) = the difference between systolic and diastolic pressures
Mean Arterial Pressure (MAP) = diastolic pressure + 1/3 pulse pressure (Why? Because the heart spends 2/3 of its time in diastole. The pulse pressure estimates the perfusion pressure, or the flow of blood into the tissues. It should be at least 60 mm Hg.)
Central Venous Pressure (CVP) = the pressure in the veins. This is measured by putting a catheter into the vena cava, so we won't do it in this lab...
Peripheral Resistance or Systemic Vascular Resistance (SVR) = **80 x (MAP - CVP) / CO in L/min** (normally 800-1200. This reflects whether blood vessels are dilated or constricted. If they are constricted, the resistance will go up and less blood will flow into the tissues.)

Equations from MedicineWorld (n.d) Online Medical Calculators. http://medicineworld.org/online-medical-calculators.html

A man has been brought into the ICU after cardiac surgery. Fill in the chart:

HR = 94 bpm
SV = 37 mL/beat
Systolic BP (SBP) = 78 mm Hg
Diastolic BP (DBP) = 52 mm Hg
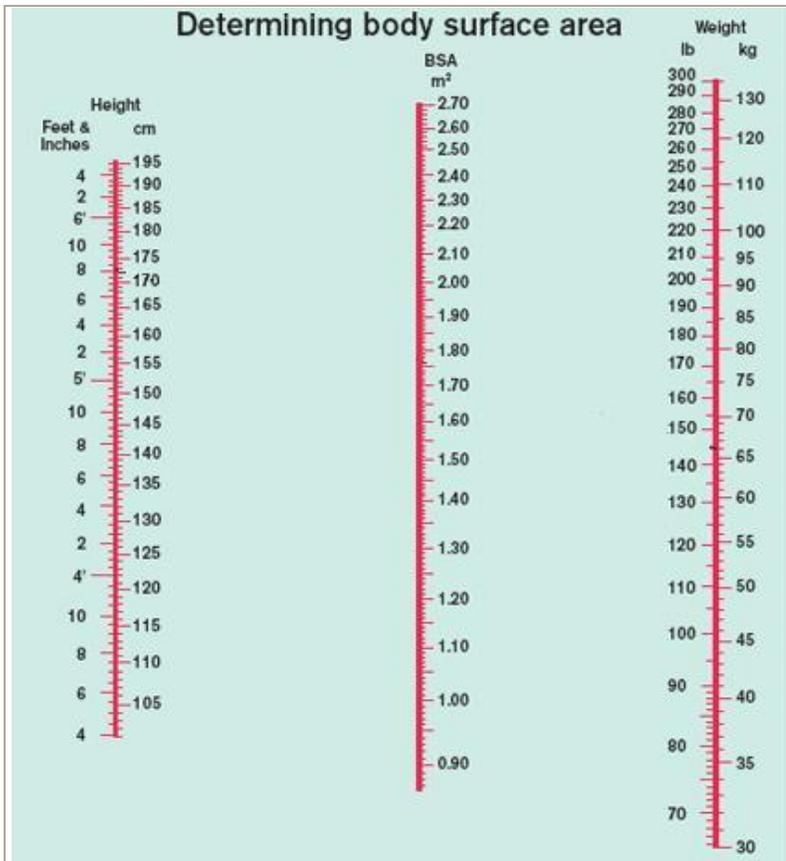CVP = 6 mm Hg

Weight 204 lb
Height 6'1"

CO = _____

CI = _____

PP = _____

MAP = _____

SVR = _____

Is this patient doing OK, or would you call his doctor? Give your rationale.

Nomogram (modified from epgoonline.com). To find body surface area, first find the person's weight and height on the scales to right and left. Then lay a straight edge between the weight and height. Where the straight edge crosses the center scale, you will find the person's Body Surface Area.

Respiratory System: calculate ventilation/perfusion ratios

Ventilation
If you were helping someone measure their respiration, how would you explain the following terms to them?
**Tidal Volume** _____
Respiratory Rate _____
Minute Ventilation _____
If you measured their Tidal Volume and Respiratory Rate and got
TV = 500 mL/ breath and RR = 14 breaths/minute, what would their Minute Ventilation be in mL/minute?

Alveolar Ventilation is the amount of that air that actually gets down to the alveoli. If it takes 150 mL of air just to fill this person's trachea and bronchioles (their **anatomical dead space)**, how much air gets into their alveoli on one 500 mL breath?

Dead space = 150 mL air/ breath

Tidal volume = 500 mL air/breath

Air to alveoli = ???
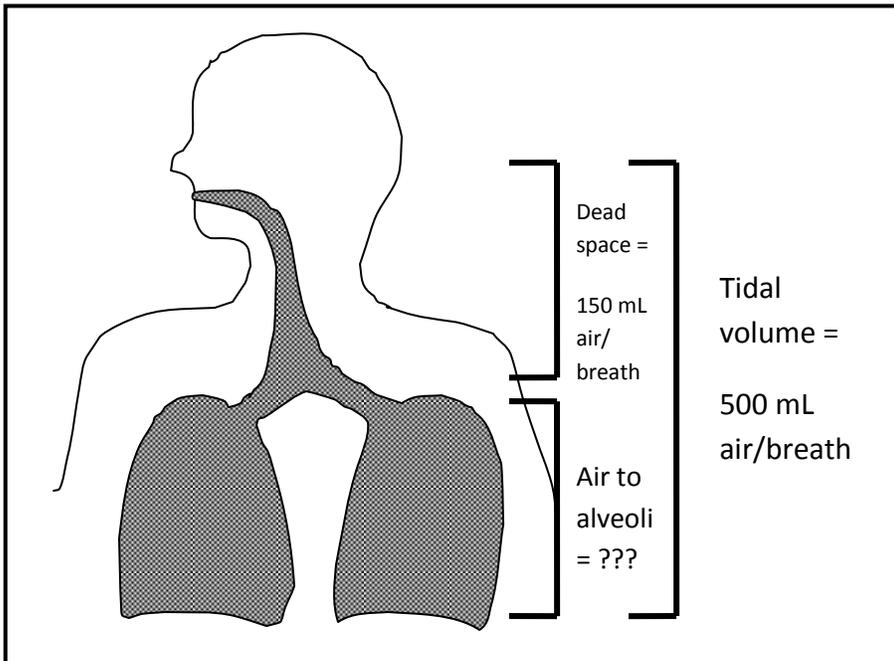
This person is breathing 14 breaths/min. How much air gets into their alveoli in one minute? This is **alveolar ventilation** or **VA.**
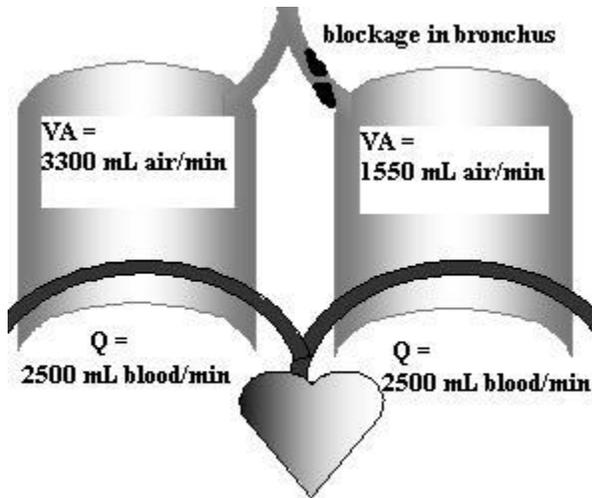
Application:
If this person were breathing through a snorkel two cm across and 20 cm long, how would it affect their alveolar ventilation? What if the snorkel were 2 meters long? (Hint – draw a diagram to set up this question. The equation for volume of a tube is $\pi r^2 l$.

Perfusion (Q) is how much blood the heart sends through the lungs per minute. It has to be just the same as the amount that goes through the body each minute. So **perfusion** for the two lungs, put together, is the same as cardiac output.

The lungs work best if they get both adequate air flow and adequate blood flow. This is expressed by the **Ventilation: Perfusion ratio (VA/Q).** Its units are **mL air/mL blood.**

For the person in the first question, if perfusion is 5000 mL/minute, what is the ventilation: perfusion ratio for the lungs?

In a normal lung, the Ventilation: Perfusion ratio has a mean of 0.85. Here's a diagram of two lungs and the blood flow through them. Calculate the Ventilation: Perfusion ratio for each lung.

blockage in bronchus

VA = 3300 mL air/min

VA = 1550 mL air/min

Q = 2500 mL blood/min

Q = 2500 mL blood/min

If the ratio is too low, it means that the lung is getting enough blood but not enough air. The blood going through this lung isn't able to pick up Oxygen. This is **wasted blood flow**, because the heart had to work to pump it but the body doesn't get any Oxygen from it.

If the ratio is too high, the lung is getting enough air but not enough blood. Most of the Oxygen inhaled is going back out, because there isn't enough blood going through the lung to pick it up. This is **wasted ventilation**; the body has to work to inhale, but doesn't benefit from the air inhaled. It is also called **physiological dead space.**

If you were in charge of blood flow to these two lungs, how would you adjust it?

You can demonstrate your understanding of these calculations by turning in a problem from the web page respiratory volumes quant problem.

Respiratory System: how much Oxygen is in your blood?

Equations from MedicineWorld (n.d) Online Medical Calculators. http://medicineworld.org/online-medical-calculators.html

Your Oxygen Capacity is the total amount of oxygen in your blood. You have Oxygen attached to your hemoglobin and dissolved in your plasma. But how much?

The O2 attached to your hemoglobin:

When your hemoglobin is 100% saturated, each gm of Hb can hold 1.36 mL of O_2.

That is: 1.36 mL O_2/gm Hb 100% sat

The O2 dissolved in your plasma:

When oxygen is dissolved in your plasma, 3.1×10^{-3} mL O_2 per 100 mL blood will raise the pO2 by 1 mm.

That is: 3.1×10^{-3} mL O2/1 mm pO_2 100 mL blood.

Try it out:

A woman has 13 g Hb/100 mL blood. Her Oxygen saturation is 96%. How much O2 is attached to her hemoglobin in mL O2/100 mL blood?

The woman's arterial pO2 is 87 mm Hg. How much O2 is dissolved in each 100 mL of her blood?

What is her total arterial O2 content per 100 mL blood?

The woman develops GI bleeding and her hemoglobin levels go down to 8 g Hb/100 mL blood. She is hyperventilating. Her pO2 is 89 mm Hg and her Oxygen saturation is 99%. Has her total arterial O2 content increased or decreased?

Respiratory/circulatory systems: calculate allowable blood loss values

How much blood loss is too much?

Average blood volumes from MedicineWorld (n.d) Online Medical Calculators. http://www.manuelsweb.com/blood_loss.htm	
Age	**Blood volume**
Premature Neonates	95 mL/kg
Full Term Neonates	85 mL/kg
Infants	80 mL/kg
Adult Men	75 mL/kg
Adult Women	65 mL/kg

When you lose blood, you can replace the lost volume quickly. It takes a while to replace the lost RBCs, though – and in the meantime, you have to get along with a lower hematocrit.

Suppose you gave 500 mL of blood. If your initial hematocrit was 42%, what will your final hematocrit be after you have donated the blood and replaced the lost volume with water?

You solve a problem like this by using a simplifying model. Think of your blood as containing only fluid and RBCs.

First, figure out how much blood you had before you gave blood.

Now take away the 500 mL you donated. How much blood do you have left?

Your hematocrit was 42%, which means 42% of your remaining blood is RBCs. How many mL of RBCs do you have left?

Now you will retain fluids to bring your blood volume back up to its initial value. If you put the RBCs you have left into the initial blood volume, what's your new hematocrit?

Calculating **Allowable Blood Loss** is important when planning surgery. This is because the doctors would like to avoid giving blood transfusions. During surgery, they will keep blood volume constant by giving fluids. But the bleeding patient is losing both fluids and RBCs – so hematocrit is going down. How much blood can the patient lose, before hematocrit is dangerously low?

1. If a 70-kg man goes into surgery with a hematocrit of 45%, and the doctors have decided that he will be OK if his hematocrit goes down as low as 30%, how much blood can he lose before they have to stop maintaining his blood volume with fluids and give him more RBCs?

Wondering how they can tell how much blood a surgery patient lost? One way is by keeping track of how many sponges get soaked, and estimating how much blood each sponge can hold. But it's not always accurate. Eipe and Ponniah (2006) found that anesthesiologists often under- or over-estimated the amount of bleeding during an operation. They discovered this by comparing the patient's hematocrit before and after surgery and calculating how much blood was actually lost.

2. A 67-kg woman went into surgery with a hematocrit of 38%. After surgery, her hematocrit was 29%. The anesthesiologist said he had not given her a transfusion because she had only lost 600 mL of blood during the surgery. Was the anesthesiologist's estimate correct?

Literature Cited

Eipe, M., and Ponniah, N. (2006). Perioperative blood loss assessment – how accurate? Indian Journal of Anesthesiology 50(1):35-38. http://medind.nic.in/iad/t06/i1/iadt06i1p35.pdf

Urogenital System: calculate renal clearance rates and relate them to kidney function

Use the unit conversion method to solve these problems.

1.   Ms. B came into the hospital after losing a lot of blood in a motorcycle accident. After her condition was stabilized she was given a creatinine clearance test to estimate her glomerular filtration rate. Creatinine is a substance that is filtered into the urine but neither reabsorbed nor secreted, so you can tell how much blood was filtered by how much creatinine goes out in the urine.

   Plasma creatinine levels = 0.1 mg creatinine/mL blood
   Urine creatinine levels = 16 mg creatinine/mL urine
   Urine production = 0.5 mL urine/ min

What was her creatinine clearance rate (mL blood /min)? You should be able to solve this in one step by lining up the conversion factors to cancel out all except the units you want. To see how, use the practice page at http://faculty.alverno.edu/bowneps/new%20quant/renalclearance.htm

Are her kidneys working properly? Explain how you reached your conclusion.

2. Ms. B was given several blood transfusions and the next day the results of her creatinine test were:

   Plasma creatinine levels = 0.2 mg creatinine/mL blood
   Urine creatinine levels = 1.2 mg creatinine/mL urine
   Urine production = 5 mL urine/ min

What was her creatinine clearance rate (mL blood /min)?

Are her kidneys working properly? Explain how you reached your conclusion.

You can calculate clearance rates of any substance, if you measure how much of it is in the blood and the urine. We usually don't bother to do this, because most substances are not simply filtered into the urine and therefore they are not very useful for estimating renal filtration. If a substance is secreted into the urine, its clearance rate will look as if more blood was filtered than the kidney actually filtered; if the substance is reabsorbed, its clearance rate will look as if very little blood was filtered.

3. At the same time as question 2, Ms. B's urine urea and glucose levels were taken. Calculate her urea and glucose clearance rates, in mL blood/min.

       Plasma urea levels = 0.2 mg urea/mL blood
       Urine urea levels = 2 mg urea/mL urine
       Plasma glucose levels = 80 mg glucose/100 mL blood
       Urine glucose levels = 0.4 mg glucose/mL urine
       Urine production = 5 mL urine/ min

Which compound is being secreted into the urine? Which is being reabsorbed from the urine? Explain how you know.

4. Ms. B had some fluctuations in blood pressure during her stay in the hospital. Two sets of measurements were:

	Day 6	Day 8
Blood pressure	90/50	125/80
Plasma creatinine (mg/mL)	0.2	0.1
Urine creatinine (mg/mL)	24	5
Urine production (mL/min)	0.5	3
Plasma K+ (mEq/mL)	3×10^{-3}	3×10^{-3}
Urine K+ (mEq/mL)	1.44	0.1

What was her glomerular filtration rate on each day? Explain why it might have been different on the two days.

What was her K^+ clearance on each day? On which day was she secreting more K^+?

What do you think her aldosterone levels were like on each day? Why?