KINE 648   Lab #3

Exercise Measurement of O_2 uptake and VO_2 max
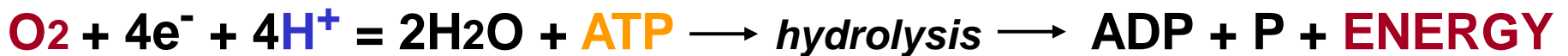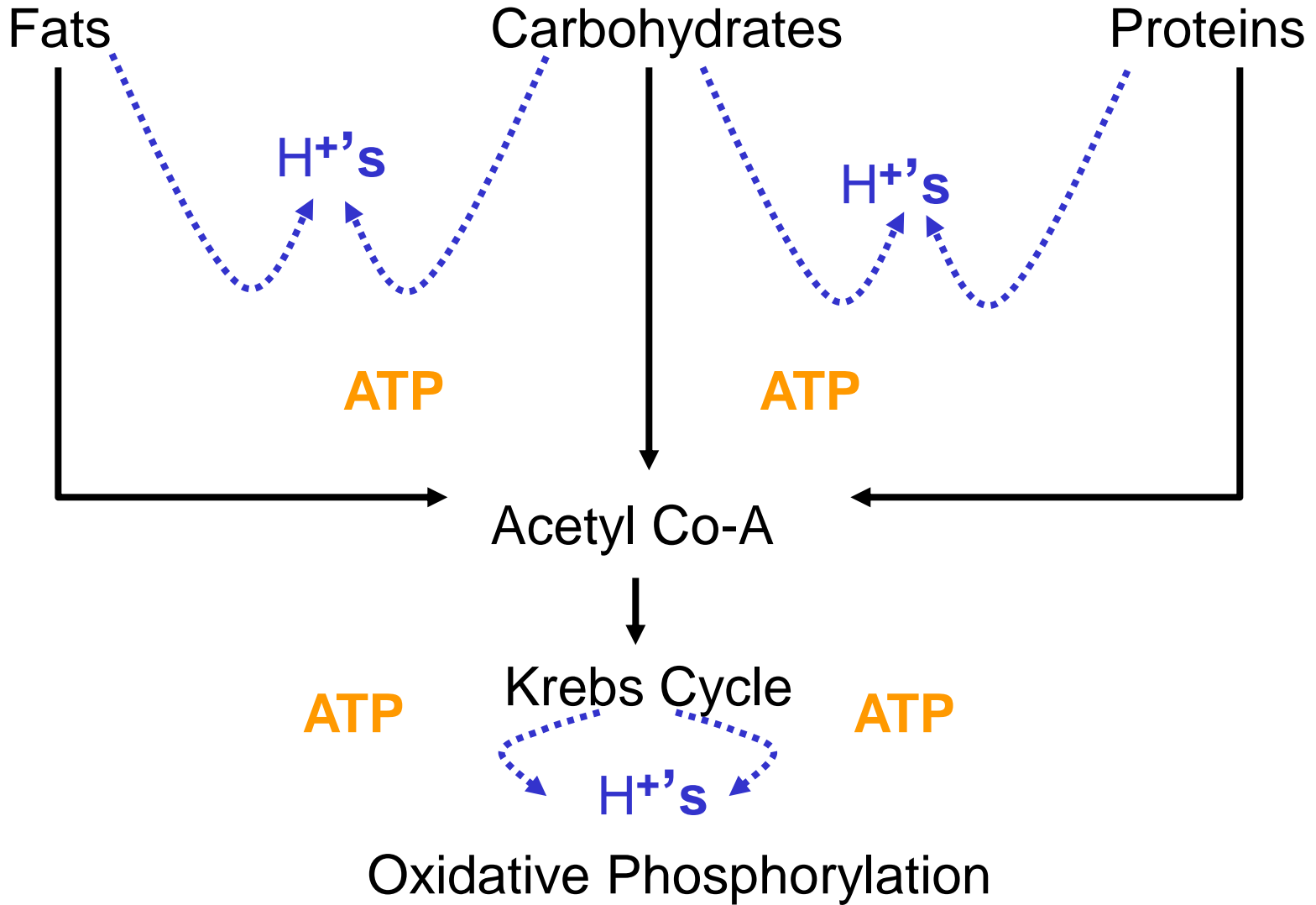
Equipment needed:

Quinton 3040 and 4500 treadmill & ECG machines
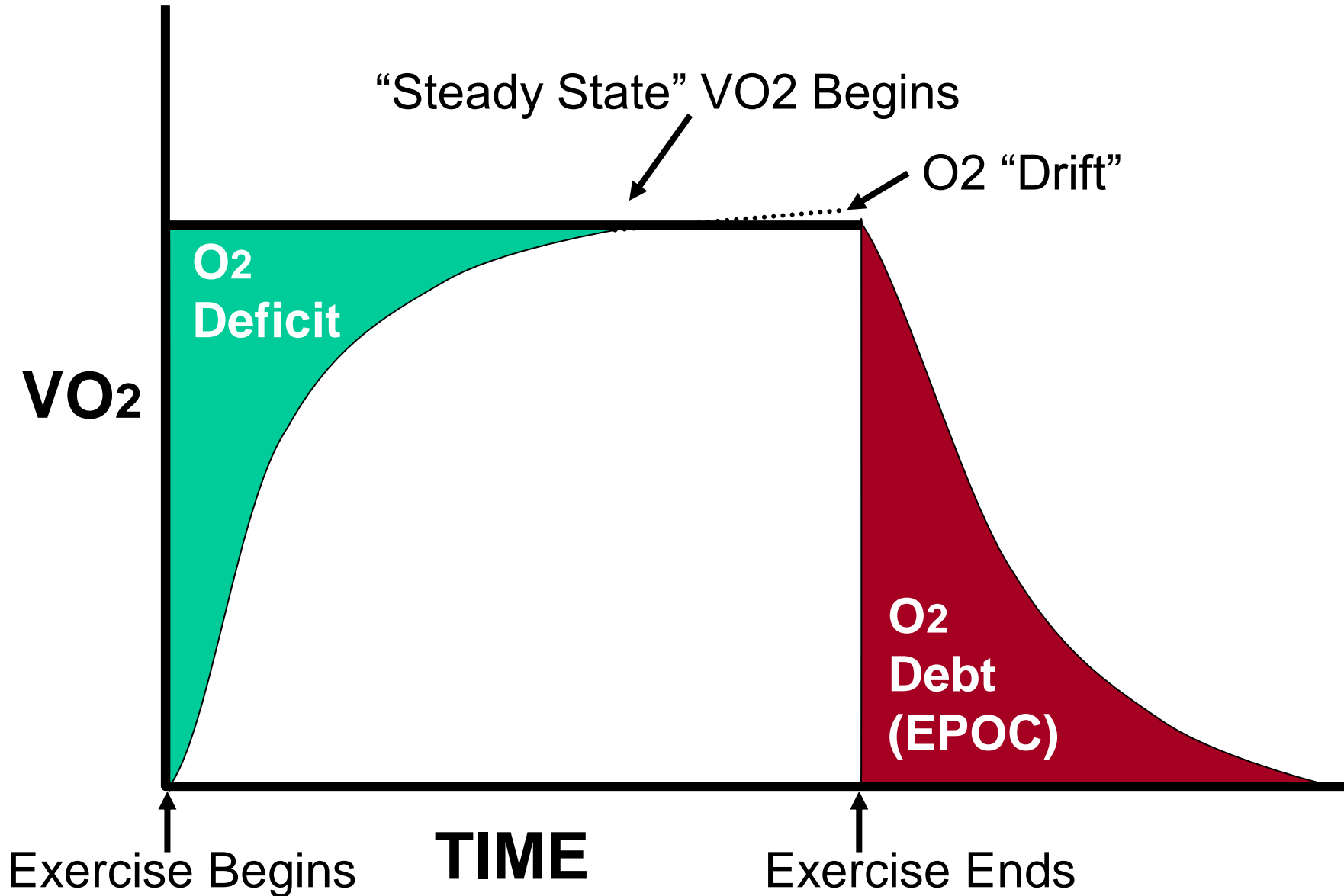Medical Graphics CPX/D gas analysis system & accessories
Handouts
Web page notes

Simplified Model of Oxidative Energy Production

Fats   Carbohydrates   Proteins

H$^+$'s   H$^+$'s

ATP   ATP

Acetyl Co-A

ATP   Krebs Cycle   ATP

H$^+$'s

Oxidative Phosphorylation

$$O_2 + 4e^- + 4H^+ = 2H_2O + ATP \longrightarrow \textit{hydrolysis} \longrightarrow ADP + P + ENERGY$$

Oxygen Consumption During a Submaximal Bout of Exercise

"Steady State" VO2 Begins

O2 "Drift"

O₂ Deficit

VO₂

O₂ Debt (EPOC)

Exercise Begins

TIME

Exercise Ends

Changes to O2 and CO2 Values up to Max Exercise

OBLA T-vent

Respiratory Compensation

PaO2

PAO2

PaCO2   PACO2

Hyperventilation

Isocapnic Buffering

NC in $\dfrac{V_E}{VCO_2}$

VE

VCO2

VO2

VO2 max

The VO2 max Plateau (no further u in VO2 with an increase in workload)

pH and HCO3⁻

Exercise Begins

Increasing Workload
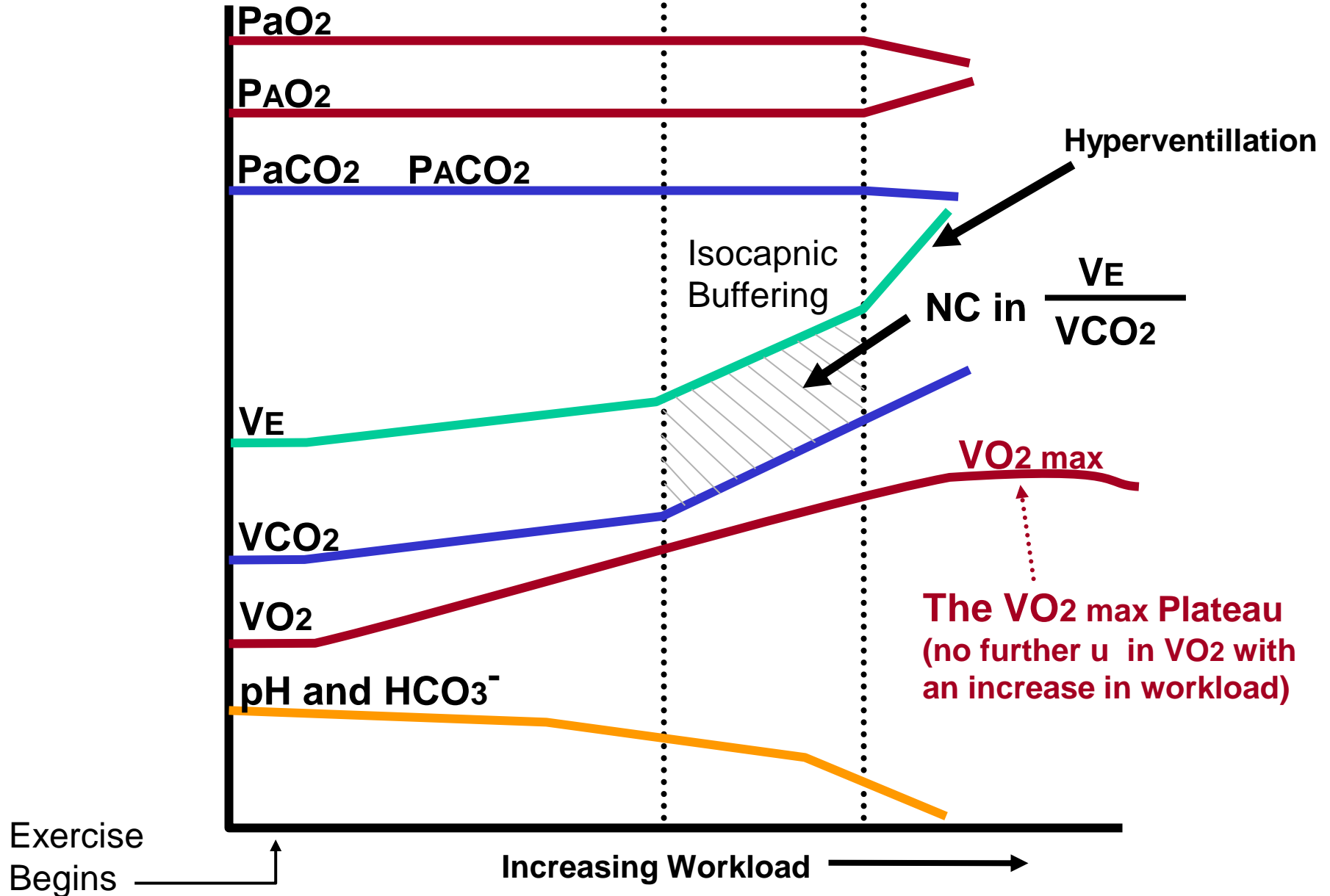
Medical Graphics Gas Analysis System (CPX/D)

Flow module analyzes the information from the pneumotach, a device that measure the rate of airflow across a membrane and converts it to a digital signal. **(VE)**

The O_2 analyzer contains a heated zirconium electrode, one side of which is exposed to room air. The other side is exposed to the exhaled sample gas. The amount of gradient induced O_2 migration from the room air, through the zirconium electrode, to the sample air can be converted to a digital signal representing the amount of O_2 consumed **(VO2)**

The CO_2 analyzer contains two infrared light chambers, one with room air, the other with sample gas. Since CO_2 absorbs infrared light, the more infrared light absorbed in the sample chamber (compared to the room air chamber), the greater the CO_2 content in expired air. The amount of infrared light absorbed in the sample chamber can be converted into a digital signal representing the amount of CO_2 in the sample air. **(VCO2)**

Flow Module

Gas Analyzers
(O2 and CO2)

Computer
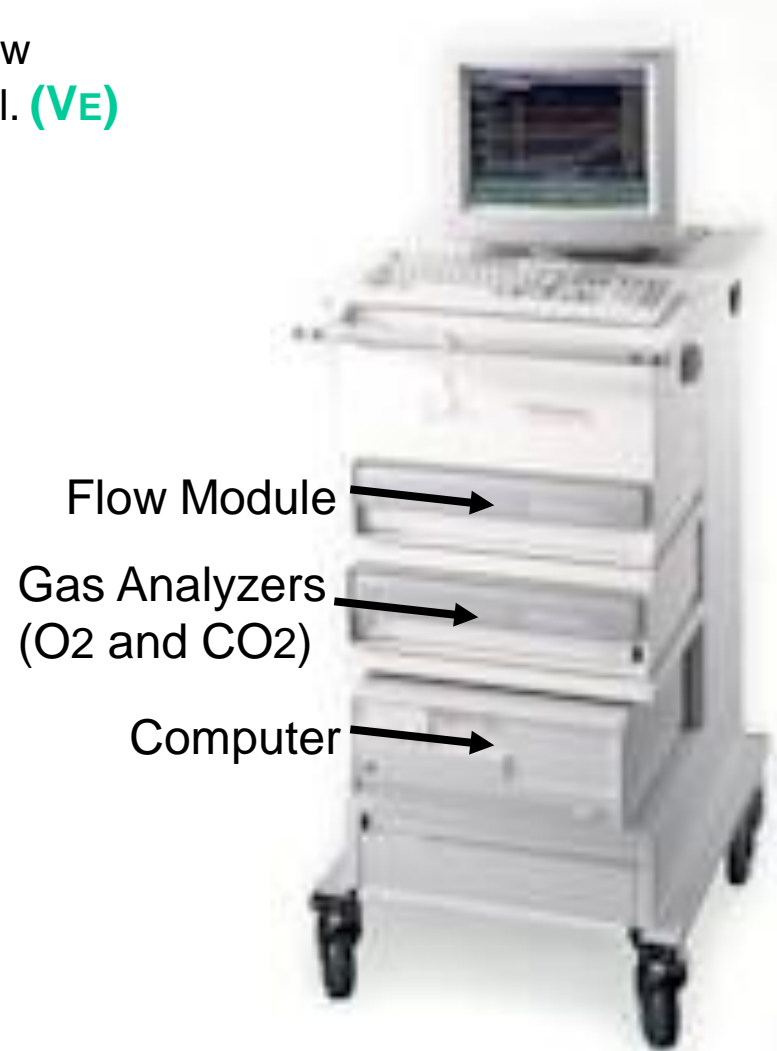
Lab Assignment for Data Collection #3

Directions: Students should work in groups of 3 – 4 depending on how many test can be done in two of the lab class periods (lab instructor must be present to supervise the use of the Med Graphics CPX/D)

1. **Calibrate the CPX/D system.** Follow the instructions given by your lab instructor and those on the next 4 slides to calibrate the pneumotach and gas analyzers and prepare the mouthpiece.

2. **Resting measurements:** Have your subject to lie in a supine position with his/her feet elevated for about 5 minutes. Insert the mouthpiece, attach nose clip and record resting O_2 and CO_2 values for 2:30. At the end of the 2:30, Use a sphygmomanometer to record the BP and label it "supine". Have the subject straddle the treadmill belt and continue recording for an additional 2:30, noting the time he went from supine to standing. At the end of this 2:30, record the BP and label it "pre-exercise".

3. **Exercise measurements:** Make sure the Bruce Protocol is selected on the treadmill that you are using. Start the treadmill belt and have the subject start walking. When the subject is ready, simultaneously click the "start exercise" tab on the CPX/D and push the start exercise button on the treadmill control. Watch and record the VO_2, RER, and BP at 15 seconds before the end of each stage of the protocol. Refer to the handout on treadmill/ECG and metabolic cart operation for the machines you are working on for data entry specifics. Hook up the oximeter (if available) and record the oxygen saturation of your subject near the end of his maximal effort (when he is close to volitional fatigue).

   Encourage your subject to stay with the increasing workloads as long as they can, however, have them let you know when they only have a few seconds left before fatigue so that you can push "stop exercise " on the treadmill control (and the CPX/D simultaneously) and let them walk the belt down as opposed to jumping off the belt. Have the subject sit on the side of the patient table and continue collecting all post-exercise data for 3:00, then click the "stop test" tab on the CPX/D. Remove the mouthpiece from the subject (have a towel ready to collect the spit when the mouthpiece comes out) then clean and store all equipment as indicated by your lab instructor.

Lab Work-up for Assignment #3

1. In this laboratory, we measured maximum oxygen consumption (VO2max). In a healthy person, what physiological mechanism(s) limits VO2max. Be sure to construct and reference your answer as outlined in the syllabus.

2. Compare the actual measured VO2 values for the standing pre-exercise stage and the last minute of each stage of the Bruce Protocol with those yielded by the estimation equations in Lab 1. Make and label a table of the measured VO2 values for each stage of rest and exercise and the estimated values. Discuss whether or not significant differences exist between measured and calculated values, if significant differences are present, speculate as to why they exist.

3. Use Microsoft EXCEL to correlate the actual measured VO2 values for each stage of the Bruce Protocol with those yielded by the estimation equations presented in Lab 1.   Include a copy of the correlation output sheet in your lab write-up.

4. Get the VO2max values from all of your class mates and use Microsoft EXCEL to compute the mean, median, mode and standard deviation. Include a copy of these statistics in your lab write-up.

VO2max using MedGraphics CPX/D with Breeze Ex 3.06 software

- The metabolic cart needs to be on for at least 30 minutes and the pump needs to be on for at least 10 minutes before beginning. The switch is located on the right side of the bottom module.
- Turn the gauges on top of the calibration and reference gas tanks to the left (open) to allow for gas to flow to the system for analysis.
- To begin, double click Breeze Ex icon to open the program.
- Once the Breeze program is open, click **Enter New Patient** icon.
- Enter the **Required** information that is highlighted in white: last name, identification, age, height, and weight. Under **Optional** information, it may be necessary to change the patient's **Race** (the default is **Caucasian**).
- After the information is entered click **Return**.
- Click **Calibration Menu**. Be sure to check the environmental conditions and make the appropriate changes. The thermometer, barometer and humidity instrument are located on the North wall near the back doors.
- Click **Pneumotach**. Insert saddle into pneumotach so that the knobs are aligned properly. Insert the honeycomb end of the pneumotach into the 3-L syringe. Click **Start** and follow the **Withdraw/Insert** prompts on the screen. Vary the speed of the strokes when calibrating the pneumotach (I.e. follow the dashed lines). Once the pneumotach calibration has passed, click **Return.** Also, remove the pneumotach from the 3L syringe.
- Click **O2 and CO2 Analyzers**. Make sure the pink sample line is inserted about ¼" into the home port on the pneumotach. Open the door on the pump module to expose the knobs.
- Click **Coach.** Follow the instructions to calibrate the O2 and CO2 analyzers. Adjust the knobs as necessary. Once the calibration is successful, click **Return.** Turn off gas tanks as soon as the gas analyzer calibration is finished**. Click **Print Calibration Report.** Click **Return.**

VO2max using MedGraphics CPX/D with Breeze Ex 3.06 software (cont.)

- You are now ready to begin the exercise test. Click **VO2 Exercise Testing.** Unscrew silver knob with pink sample line from home port and screw it onto the saddle that is attached to the pneumotach. Make sure the tip of the pink sample line is located in the middle of the upper left quadrant of the pneumotach.

- Honeycomb end of fully assembled pneumotach is then inserted into the appropriate opening of either the mouthpiece or PreVent mask. Attach noseclip to subject. Once the subject has the mouthpiece or mask on click **Start**. (This will begin collecting resting data).

- In a coordinated effort with the person running the Quinton 4500, click **Exercise** at the same time they start the exercise test.

- As the exercise tests ends (I.e. subject grabs the treadmill rail), click **Recovery** and the metabolic cart will switch to collecting recovery data.

- Before taking the mouthpiece or mask off the subject click **Stop**, to end metabolic data collection. Then click **Return**.

- Click **Exercise Report Menu**. Click on the box for **Type** and choose **Time Down.** Click **Text Report** (a preview of the report should be on the screen). Click **Print**.

- Return pink sample line knob to home port. Open calibration gas tanks as described previously. Click **Return** until you are at the **Main Menu**, and then choose **Auto Calibration**. If calibration is successful, you are ready to begin the next test.

- Remember to turn off the gas tanks and lastly turn the pump off.

- NOTE: EACH STUDENT SHOULD GO THROUGH A COMPLETE CALIBRATION PROCEDURE.

Using the CPX/D metabolic cart with Breeze 5.2 software.

1. Double click on the 'Breeze' icon.
2. When Breeze Suite 5.2 opens, click 'new' patient.
3. The data in the blue highlighted boxes is required so last name, ID, DOB, race, and sex need to be entered. Then click 'Add Visit'.
4. The 'Visit Demographics' tab should be highlighted and subject height and weight need to be entered (blue highlighted boxes).
5. Click 'calibrate' button near the top of the computer screen. Note that the machine needs to have been on for at least 30 minutes and the pump needs to have been on for at least 10 minutes before calibrating. Also, make sure to correct the environmental conditions at the bottom of the calibration screen.

    A. 'Pneumotach' tab should be highlighted first. The saddle should be clipped into the pneumotach. Click 'Zero Flow' and refrain from moving the pneumotach. Once the pneumotach has zeroed, click 'Start' to calibrate the pneumotach. Insert the honeycomb end of the pneumotach into the 3L calibration syringe. Follow the 'withdraw' and 'insert' prompts to calibrate the pneumotach. Follow the dashed lines to simulate different flow velocities.

    B. Once the pneumotach calibration has passed, click the 'O_2 and CO_2 Analyzers' tab. The gas tanks on the back of need to be turned on and the pink sample line needs to be inserted into the home port on the front of the metabolic cart about ¼". Click 'Coach' and follow the instructions to calibrate the gas analyzers, adjusting the knobs for the corresponding gasses as necessary.

Using the CPX/D metabolic cart with Breeze 5.2 software (cont'd).

C. After calibrating the pneumotach and gas analyzers, turn off the gas tanks in the back of the metabolic cart. 'Print' the calibration report then exit the calibration menu by pressing 'OK'.

D. Remove the pink sample line from the home port and insert it into the pneumotach. The end of the sample line should be located halfway into the upper left quadrant of the pneumotach.

6.   Next click the 'GX' tab at the bottom of the screen. The machine will automatically calculate the predicted values for the subject based on the demographic information that has been entered.

7.   Under 'Settings' make sure the script name is "Metabolic" and no external devices are checked. If any are checked, then click the box to the left to turn it off.

8.   Select BxB. Once the subject has put on the mask with the pneumotach attached, you are ready to begin testing. To collect data press 'Start'.

9.   Do not press 'Stop' until data collection is complete.

10.   Once finished select 'print' icon. Click 'OK' when the Microsoft Access window appears. The computer will print a summary of reports that includes 30s average and a mean 5 of 7 breaths and some other pages.

11.   Before turning off the pump remember to calibrate the gas analyzers again (refer to 5B and 5C).

12.   Exit Breeze Suites 5.2 by closing program (test is automatically saved).