In Class Exercises (ICE) - 3/14/01

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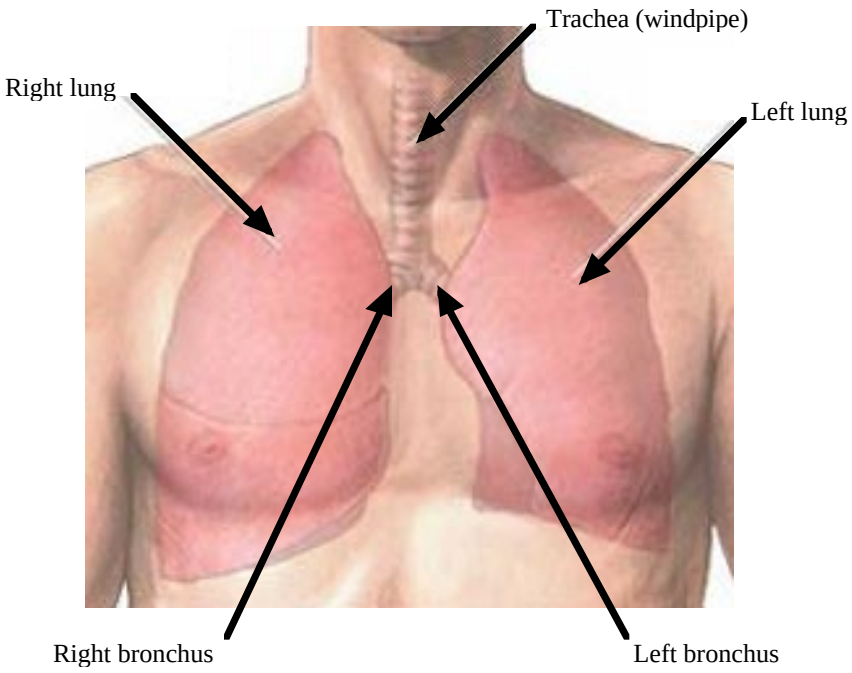

Figure 1: Basic anatomy of the human respiratory system.

When you breathe, air is drawn down the trachea, which splits into two tubes called the left bronchus and the right bronchus.

As you can see from the CT scan in Figure 3, the left bronchus is a narrow offshoot of the right bronchus.

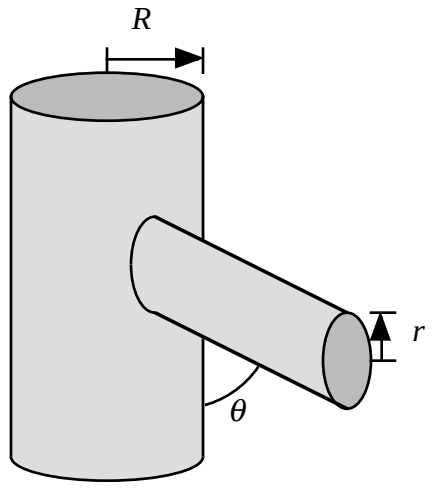

Figure 2: The small tube (radius = r) leaves the large tube (radius = R) at an angle of θ.

When a pipe branches off, the air flow becomes disorganized and turbulent, causing resistance to the smooth flow of air. Poiseuille's Law predicts that the total resistance (T) is given by:

$$T = \frac{-\cos(\theta)}{R^4 \cdot \sin(\theta)} + \frac{1}{r^4 \cdot \sin(\theta)}$$

In order to overcome this resistance to air flow, the person's muscles have to work harder when drawing or expelling breath.

[1] The source of the image used in Figure 1 is: www.webmd.lycos.com

- ***Assume that the radii of the pipes (r and R) are fixed and that only the angle θ can change. Use Poiseuille's Law to show that total resistance to air flow (T) is minimized when:***

$$\cos(\theta) = \left(\frac{r}{R}\right)^4.$$

Figure 3 shows a CT[2] scan of the trachea and bronchi of a patient at the University of Iowa College of Medicine[3].

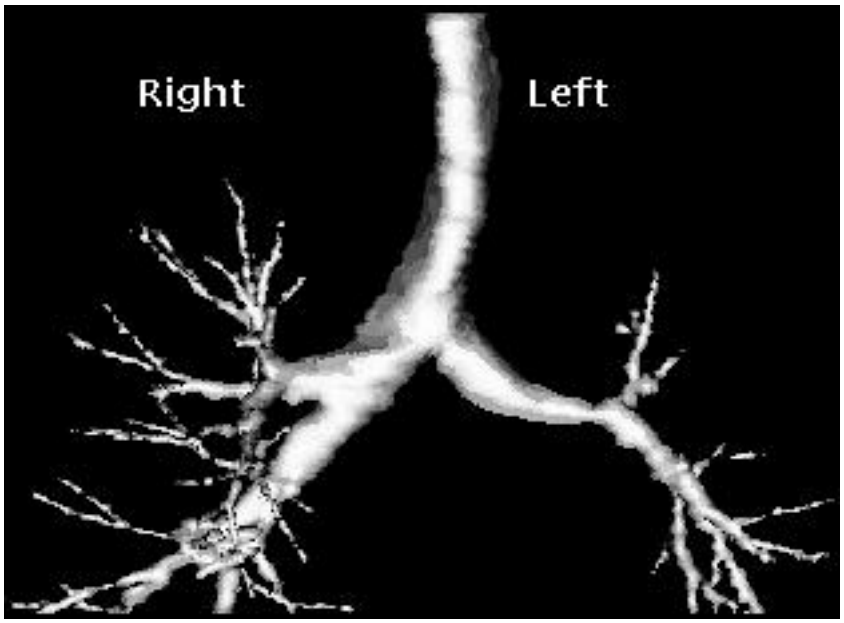

Figure 3: CT scan of patient showing trachea, left and right major bronchi and secondary bronchi.

- ***Measure the radii of the left and right bronchi for the patient in the CT scan.***

According to Poiseuille's Law, what angle will minimize resistance to air flow?

- ***Use a protractor to measure the angle between the left and right bronchi in Figure 3. Is it consistent with the predictions of Poiseuille's Law?***

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[2] "CT" stands for "Computer Tomography." This is a technique that uses an x-ray scanner and a computer to create a three dimensional picture of structures inside the human body.

[3] This CT scan was made on February 16, 2001. Image source: The Division of Physiological Imaging, Department of Radiology, University of Iowa College of Medicine.