The Respiratory System

HASPI Medical Anatomy & Physiology 14a

Lab Activity

Name(s): _____

Period: _____ Date: _____

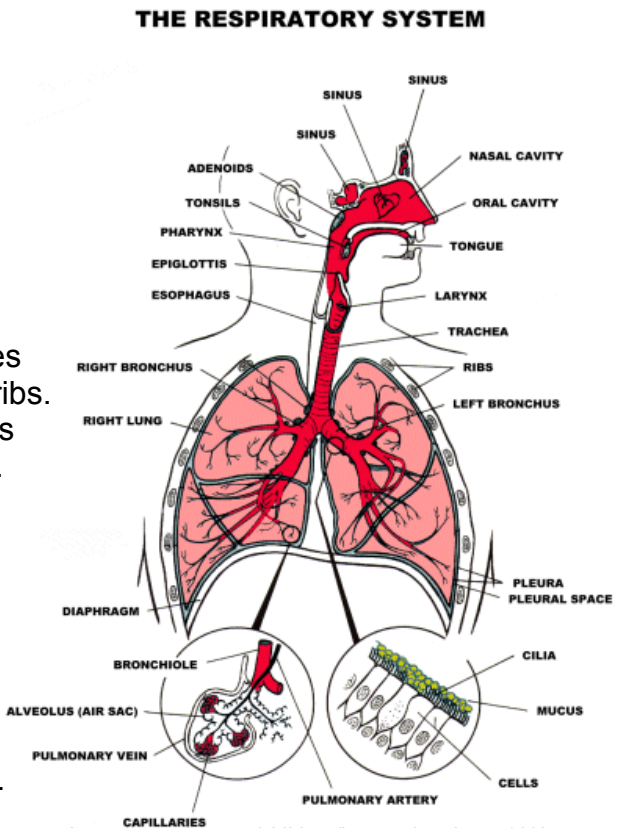
Background

The Respiratory System

A healthy respiratory system is crucial to an individual's overall health, and respiratory distress is often one of the first indicators of a life-threatening illness. The function of the respiratory system is to exchange gases between the external air and the body. The lungs are the primary organ of the respiratory system that performs this function.

The lungs take up a large portion of the thoracic cavity and are actually attached to the surface of the thoracic cavity by a sticky pleural membrane. The pleural membrane produces a liquid called surfactant that allows the lung to stick to the ribs. On occasion, air gets caught in the space between the lungs and the thoracic cavity and can cause the lungs to collapse. This may be caused by trauma, infection, or can occur spontaneously.

The amount of oxygen needed by the body, and carbon dioxide produced by the body, can vary greatly depending on an individual's activity level. Exercise can increase the need for energy produced by cellular respiration, and therefore the oxygen demanded by the body, by 25 times. An increase in the rate of respiration can meet this demand.



https://www.lung.ca/children/images/grades7_12/the_respitatory_system.gif

Process of Respiration

Step	Process
1	The **intercostal muscles** contract, pulling the ribs up, and the **diaphragm** contracts and moves down, pulling air into the body through the mouth or nostrils.
2	Air passes through the **nasopharynx** or **oral pharynx** through the **epiglottis,** which prevents food from entering the trachea.
3	The **trachea** contains tiny hair-like cilia and mucus that catch any particles in the air that could be harmful to the lungs, and moves them back up the trachea to be spit out.
4	Air moves down the trachea, which branches into the right and left **bronchi.**
5	Right and left bronchi continue to branch, much like an upside-down tree, into smaller limbs called **bronchioles**.
6	The bronchioles end in tiny clusters of air sacs called **alveoli.** where gas exchange will occur.
7	Alveoli have extremely thin membranes surrounded by **pulmonary capillaries** from the cardiovascular system. An adult has approximately 300 million alveoli in the lungs for gas exchange.
8	**Oxygen** that has been pulled into the alveoli diffuse through the alveoli membrane and into the capillaries to be circulated throughout the body for cellular respiration.
9	**Carbon dioxide** that has been created by the body through cellular respiration is brought by the capillaries to the alveoli and diffuses into the alveoli.
10	The diaphragm relaxes, moving up and causing air in the alveoli to be exhaled.

Respiration Control

How does the body recognize the need for more oxygen? Actually, it is the increase in the amount of carbon dioxide that signals the brain to increase the rate of respiration. A cluster of cells located in the medulla oblongata of the brain quickly recognizes the drop in pH of the body that occurs when there is more carbon dioxide present. This causes the medulla oblongata to send nerve impulses to increase the activity of the diaphragm and intercostal muscles, which causes an increase in respiration. Once the level of carbon dioxide decreases, and therefore the pH level, the medulla oblongata stops sending these impulses. A normal adult has a respiratory rate of 12-24 breaths per minute that can increase dramatically with heavy exercise.

Respiratory Disorders

Open airways are important for overall health. Inflammation, swelling, excess mucus, and a variety of other abnormalities caused by disease or disorders can affect the ability of the lungs to provide enough oxygen and/or remove carbon dioxide from the body. The following table summarizes only a few common disorders. Prevalence and mortality is based on annual numbers from 2008.

Respiratory Disorder	Description	Symptoms	Prevalence	Annual Mortality Rate
Chronic Obstructive Pulmonary Disorder (COPD)	Progressive disease that makes it more difficult to breath; includes emphysema and chronic bronchitis	Cough, infections, dyspnea, wheezing, fatigue	24 million	120,970
Emphysema	Alveoli become weak and lose ability to stretch	Dyspnea, chest pain, cough, wheezing	9.8 million	10,878
Tuberculosis	Bacterial infection by *Mycobacterium tuberculosis*	Cough with blood or mucus, fatigue, fever, chills, night sweat, weight loss	10,528	529
Chronic Bronchitis	Thickening and inflammation of the bronchi	Cough, mucus, fatigue, chills, fever, chest pain	3.8 million	639
Pneumonia	Inflammation and fluid in the lungs	Cough, muscle ache, nausea, vomiting, dyspnea, chills, fever	3 million	60,000
Lung Cancer	Mass of uncontrolled cell growth in the lungs	Recurrent cough, chest pain, dyspnea, wheezing, headache, weight loss	208,493	158,592
Cystic Fibrosis	Recessive genetic disease that causes mucus to build up in the lungs	Salty skin, infections, weight loss, cough, bowel abnormalities	30,000	3,708
Asthma	Inflammation of the bronchial tubes	Cough, dyspnea, chest pain, wheezing	24.6 million	3,647

Diagnostic Tests for Respiratory Disorders

There are many tests that can be performed to assess and treat respiratory distress and/or disorders. The following list summarizes a few common procedures.

- **Pulse Oximetry** - Tests the percentage of oxygen in the blood. 95% or more is a normal level, and any less would indicate a lack of perfusion (oxygen circulating around the blood).
- **Arterial Blood Gas Levels** - A blood sample is taken and the amounts of oxygen and carbon dioxide found in the blood are measured.
- **Chest X-ray** – Used to visualize any masses, congestion, or infection that has accumulated in the lungs or thoracic cavity.
- **Pulmonary Function Tests (PFTs)** - Tests the lung capacity, volume, speed of airflow, and the overall functioning of the lungs.
- **Spirometry** – Part of a PFT that specifically assesses lung capacity and volume.

NIH. 2011. How is Respiratory Failure Diagnosed? National Institutes of Health, National Heart Lung and Blood Institute, www.nhibi.nih.gov.

Carter, J. 2004. Respiratory System. http://biology.clc.uc.edu/courses/bio105/respirat.htm.

Materials

Station 1: Anatomy Posters (4)
Station 2: Spirometers (3), alcohol wipes
Station 3: Histology Posters (4)
Station 4: Stethoscopes (3), Timer
Station 5: Disease Posters (5)
Station 6: Patient Question Cards (3 sets)

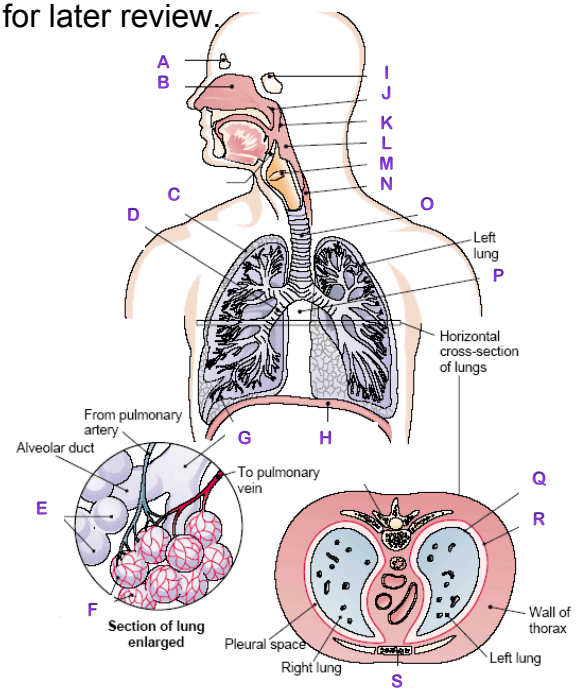
Procedure

This is a station lab activity. There are 6 stations set up around the classroom. Each station will take approximately 10-15 minutes.

Station 1: The Respiratory System

Respiratory System Anatomy – Using the "Respiratory System" chart, identify the labeled organs or parts of the organ A-S in **Table 1** below. If there are any that you cannot identify, use a textbook or online resource. A smaller version of the charts are included for later review.

Table 1: The Respiratory System	
A	K
B	L
C	M
D	N
E	O
F	P
G	Q
H	R
I	S
J	



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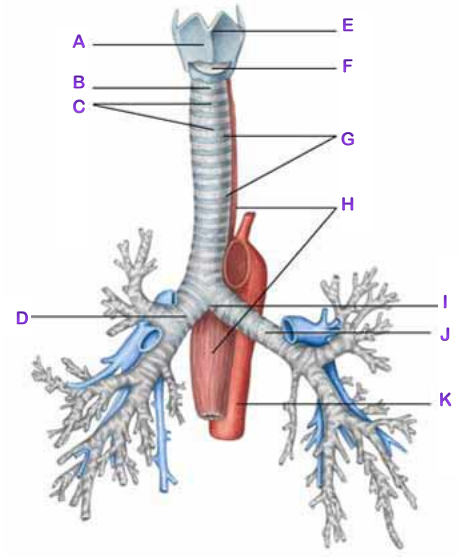

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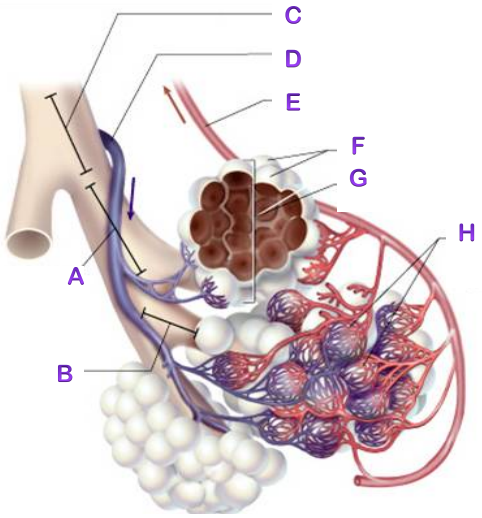
Table 2: The Trachea	
A	G
B	H
C	I
D	J
E	K
F	

Table 3: The Alveoli	
A	E
B	F
C	G
D	H



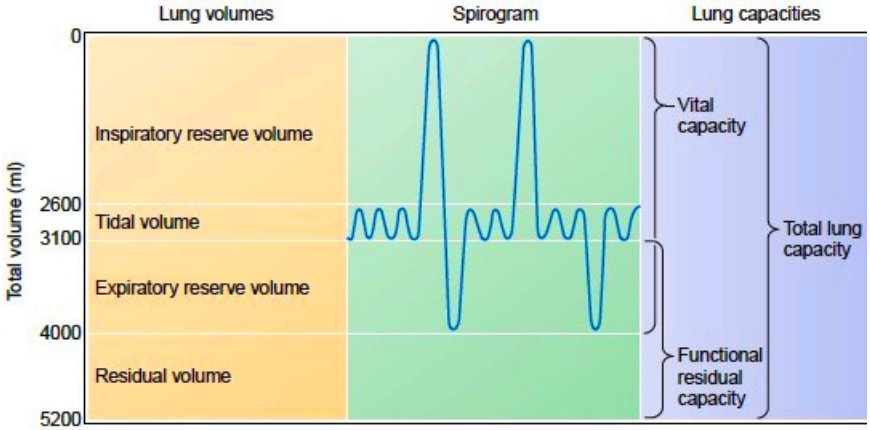
http://www.pc.maricopa.edu/Biology/pfinkenstadt/BIO202/202LessonBuilder/Respiratory/alveoli.jpg

Inhalation and Exhalation – Using the "Inhalation and Exhalation" chart, fill in the muscles involved in inhalation and exhalation as well as the movements they perform in Table 4.

Table 4. Inhalation	
Accessory Muscle	**Function**
Principal Muscle	**Function**
Exhalation	
Active Muscles	**Function**

Station 2: Spirometry

Measuring the capacity of the lungs is an important indication of possible respiratory distress. A pulmonary function test (PFT) measures lung function, and one of the most common tools to measure volume and capacity is the spirometer. The capacity and volume of the lungs differ according to sex, age, body type, and fitness level.



http://encyclopedia.lubopitko-bg.com/images/A%20spirogram.jpg

For regular day-to-day activities only about 30-40% of the lung capacity is used. With regular aerobic exercise, it is possible to increase the overall capacity of the lungs. Through disease, environmental factors, or lifestyle choices it is also possible to reduce the capacity of the lungs. For example, asthma, emphysema, air pollution, altitude, weather, and/or smoking can all reduce lung capacity and volume.

Directions

1. There are three spirometers located at this station. Use an alcohol wipe to clean off the mouthpiece on one of the spirometers.
2. Using Table 5 below, determine your tidal volume, expiratory reserve volume, inspiratory reserve volume, and vital capacity using the spirometer. The "How is it Measured?" column gives directions on how to conduct each measurement.
3. Calculate the residual volume and total lung capacity from the measurements you collect.
4. Record your measurements in the "Your Results" column.

Spirometer Measurement	How is it Measured?	Average	Your Results
Tidal Volume *Amount of air exhaled or inhaled in a normal breath*	Exhale normally into the spirometer	**500 ml**	
Expiratory Reserve Volume *Amount of air that can be exhaled forcefully*	Inhale normally and exhale ALL of your breath into the spirometer	**1000-1200 ml**	
Inspiratory Reserve Volume *Amount of air that can be inhaled forcefully*	Inhale as much air as possible and exhale ALL of your breath into the spirometer. Subtract your tidal volume from this amount.	**2000-3000 ml**	
Vital Capacity *The total usable capacity of the lungs*	Add your tidal volume, expiratory reserve volume, and inspiratory reserve volume together	**4800 ml**	
Residual Volume *Amount of air left in lungs after you forcefully exhale*	Cannot be measured through spirometry; if you are female write 900 ml in your results, if you are male write 1200 ml in your results	*female* **900 ml** *male* **1200 ml**	
Total Lung Capacity *The total capacity of the lungs*	Vital capacity + residual volume	**5000-6000 ml**	

Station 3: Respiratory System Histology

The cell and tissue structure of respiratory organs is suited for the functions they perform. Using the charts, draw and label Image B for the following respiratory organs below. Image A on each chart is for reference!

Alveoli

Using colored pens/pencils, draw the histology Image B from the "The Alveoli" chart in the space below. Using Image A as a reference, label your drawing with the lumen of blood vessel, alveolar cells, and air space of alveolus.

Bronchus

Using colored pens/pencils, draw the histology Image B from the "The Bronchus" chart in the space below. Using Image A as a reference, label your drawing with the alveolus, muscle, and terminal bronchiole.

Trachea

Using colored pens/pencils, draw the histology Image B from the "The Trachea" chart in the space below. Using Image A as a reference, label your drawing with the tracheal lumen, respiratory epithelium, mucosal serous glands, and hyaline cartilage.

Tracheal Cross-section

Using colored pens/pencils, draw the histology Image B from the "Tracheal Cross-section" chart in the space below. Using Image A as a reference, label your drawing with the esophagus, folded mucosa, posterior cartilage, trachealis muscle, trachea, mucosa, submocosa, and thyroid gland.

Station 4: Lung Sounds & Respiratory Rate

Analysis of the lungs and respiration is important when determining general respiratory health and the possibility of respiratory distress. Auscultation of the lungs and measuring the respiratory rate are common steps when taking vital signs of a patient. Practice these procedures using the directions below.

Lung Sounds Directions

		✔when complete
Step 1	Infection or injury can be isolated to a single lobe or portion of the lung, so it is important to listen to multiple lobes. During an actual exam, auscultation would be performed on the skin, but for this activity ONLY use the stethoscope on the outside of any clothing.	
Step 2	Select a partner of the same sex. One partner will be listening to lung sounds and the other partner will be the patient.	
Step 3	Have the patient sit quietly and breathe normally.	
Step 4	Place the stethoscope on the upper right chest and ask the patient to take a deep breath and release. You should hear a normal "swishing" sound of air moving in/out, indicating clear lungs.	
Step 5	Record in Table 6 whether the lungs were clear, or whether any abnormal sounds were heard.	
Step 6	Figure A shows all of the positions that need to be auscultated. Listen to each lobe and record the results in Table 6.	
Step 7	Switch roles and repeat steps 3 – 6.	

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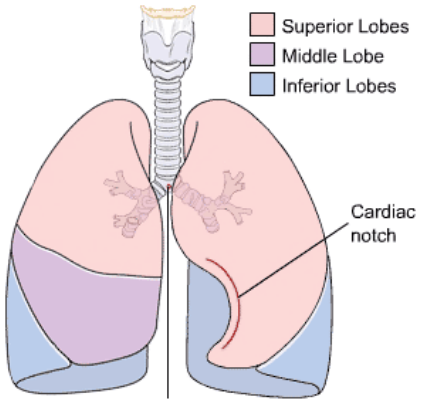
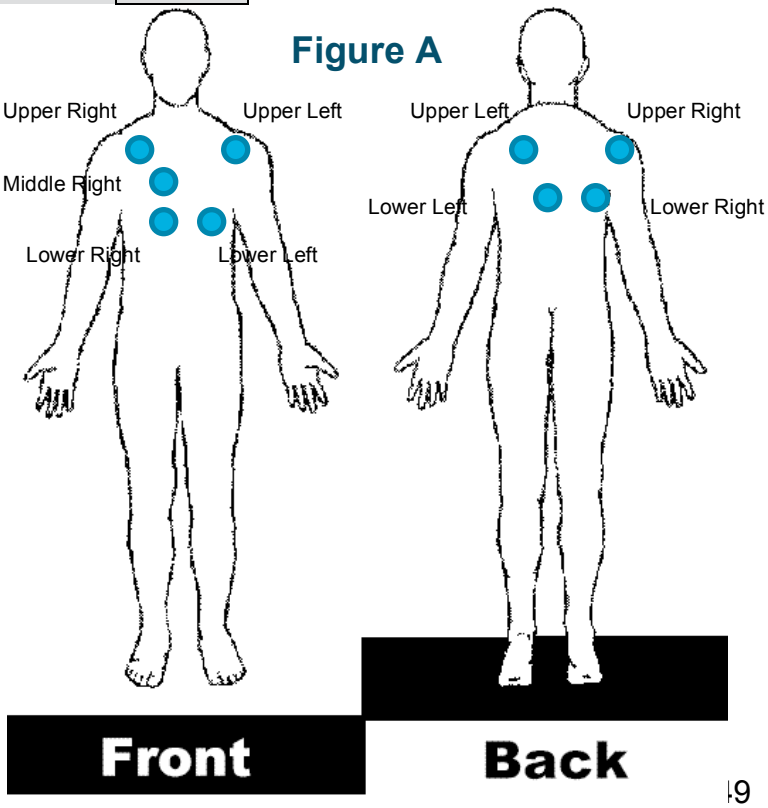


http://www.clevelandclinic.org/thoracic/Airway/images/lung_lobes.gif

Table 6. Lung Sounds

Lung Sounds	Normal	Your Results
Front		
Upper Left Lobe	Clear	
Upper Right Lobe	Clear	
Middle Right Lobe	Clear	
Lower Left Lobe	Clear	
Lower Right Lobe	Clear	
Back		
Upper Left Lobe	Clear	
Upper Right Lobe	Clear	
Lower Left Lobe	Clear	
Lower Right Lobe	Clear	

Figure A



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Respiratory Rate Directions

		✔when complete
Step 1	Select a partner of the same sex. One partner will be taking the respiratory rate and the other partner will be the patient.	
Step 2	Have the patient sit quietly and breathe normally. If the patient is having a hard time breathing normally, have him/her close the eyes.	
Step 3	Observe the rise and fall of the patient's chest. Using a timer, count the number of breaths for 30 seconds. Multiply this number by 2 for the respiratory rate.	
Step 4	Record this number in Table 7 (on the patient's sheet).	
Step 5	It is also common to observe the rhythm, effort, depth, and/or noise associated with the patient's breathing.	
Step 6	Observe and record these in Table 7. (NOTE: It is unlikely unless your patient is sick that any of these characteristics will be abnormal.)	
Step 7	Switch roles and repeat steps 2 – 6.	

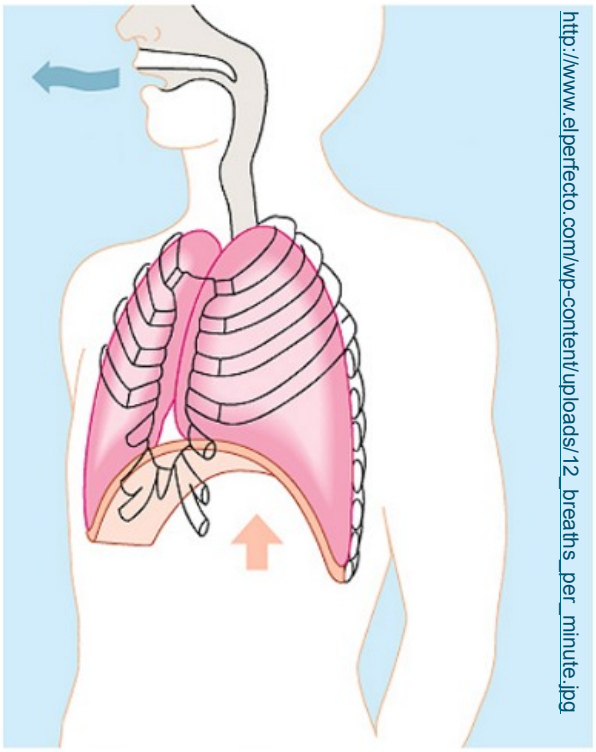

Table 7. Respiratory Rate

Respiratory Rate	Normal	Your Results *(circle one)*
Rate	12-24 breaths per minute	
Rhythm	Regular	regular irregular
Effort	Effortless	labored effortless
Depth	Normal	deep normal shallow
Noise	Clear	clear wheezing gurgling rales crackles other: _____

Station 5: Respiratory Disease

Using the "Respiratory Disease" charts, complete the following table. List ONLY THREE Causes or Risk Factors, Symptoms, and Treatment Options for each disease.

COPD			
Description	Causes or Risk Factors (3)	Symptoms (3)	Treatment Options (3)
What age group has the highest percentage of COPD sufferers? Is it more common in men or women?			
Tuberculosis			
Description	Causes or Risk Factors (3)	Symptoms (3)	Treatment Options (3)
Where in the world are MDR-TB cases the highest? By what percentage of cases?			
Pneumonia			
Description	Causes or Risk Factors (3)	Symptoms (3)	Treatment Options (3)
How many child deaths were caused by pneumonia in 2008?			
Lung Cancer			
Description	Causes or Risk Factors (3)	Symptoms (3)	Treatment Options (3)
In what region of the U.S. can be found the most cases of lung cancer? Why do you think this is the case?			
Seasonal Flu			
Description	Causes or Risk Factors (3)	Symptoms (3)	Treatment Options (3)
How many cases of H1N1 had there been in San Diego County by 2009?			

Station 6: Respiratory Distress

Patient Scenario

A 42-year-old female patient has been admitted to the emergency room at HASPI Hospital with shortness of breath and respiratory distress. She has had a cough, fatigue, chills, and night sweats on and off for the past 3 weeks. She believes she had the flu, but the symptoms have worsened in the last few days. A chest x-ray, physical exam, and spirometry exam have been completed.

As the emergency physician on duty, it is your responsibility to quickly diagnose this patient. Asking the correct questions during a patient exam is extremely important to quickly determine the cause. Nine "Question Cards" have been laid out on the table. You only get to ask the patient THREE questions. To get the answer to the question you choose, flip the card over. Record the question/answer below.

NO CHEATING!!! You only get to formulate your diagnosis from THREE cards!

Question 1	Question 2	Question 3
Question:	**Question:**	**Question:**
Answer:	**Answer:**	**Answer:**

PLEASE make sure the QUESTION side is facing up on all of the cards for the next group.

What, if any, are important clues/indications found in the questions/answers you chose?
What do you think is causing your patients' respiratory distress?
If you are unsure of the diagnosis, what further questions could you ask to find out? If you are sure, what test(s) could be done to check that your diagnosis is correct?

Analysis Questions - *on a separate sheet of paper complete the following*

Station 1

1. What are the muscles involved in inhalation and exhalation?
2. Cobra venom contains a neurotoxin that prevents the brain from telling the diaphragm when to contract. How would this impact the respiration of an individual bit by a cobra? If there is no cobra anti-venom, what would need to be done for a cobra bite victim to survive?

Station 2

3. Why is measuring the capacity of the lungs important in indicating respiratory distress?
4. What does a spirometer measure?
5. List 5 factors that can affect the lung capacity and volume of an individual.
6. How did your tidal volume and vital capacity compare to the average numbers? If it was more than 100 ml higher or lower, what do you think caused your deviation from the average?

Station 3

7. Why are blood vessels found throughout alveolar tissue?
8. What passes through the center of the bronchus?
9. What passes through the center of the esophagus?
10. What is the purpose of the hyaline cartilage in the trachea?

Station 4

11. The respiration rate after running a 6-minute mile will naturally increase. Explain the communication that would be happening between the brain and respiratory system from the beginning of the run, during the run, and after the run.
12. What is auscultation and why is it important?

Station 5

13. What were the common causes & risk factors found between the majority of the respiratory disorders?
14. What were the common symptoms found between the majority of the respiratory disorders?

Station 6

15. What respiratory disorder was your patient suffering from? (Take a guess if you are unsure.)
16. What are the treatment options for this respiratory disorder?

Review Questions - *on a separate sheet of paper complete the following*

1. What is the function of the respiratory system?
2. Explain how the pleural membrane and surfactant keep the lungs from collapsing?
3. What could happen if air gets caught in between the space between the lungs and thoracic cavity?
4. How does exercise affect the respiration rate?
5. Explain the process of the path of air from when it enters the nose or mouth, until it diffuses into the capillaries.
6. How do the intercostal muscles and diaphragm assist in inhalation and exhalation?
7. What part of the brain controls the respiration rate? What signals this part of the brain to increase the respiration rate?
8. What is the normal respiration rate for a healthy adult?
9. From the table in the background section, what respiratory disorder was most prevalent in 2008? Least prevalent?
10. What respiratory disorder had the highest mortality rate in 2008? The lowest mortality rate?
11. Choose two of the common diagnostic procedures and summarize their use.