Young Scientist Program: Anatomy Teaching Team

Washington University in St. Louis
School of Medicine

Module 4:
Basic Lung Pathology
"What problems can occur in the lungs?"

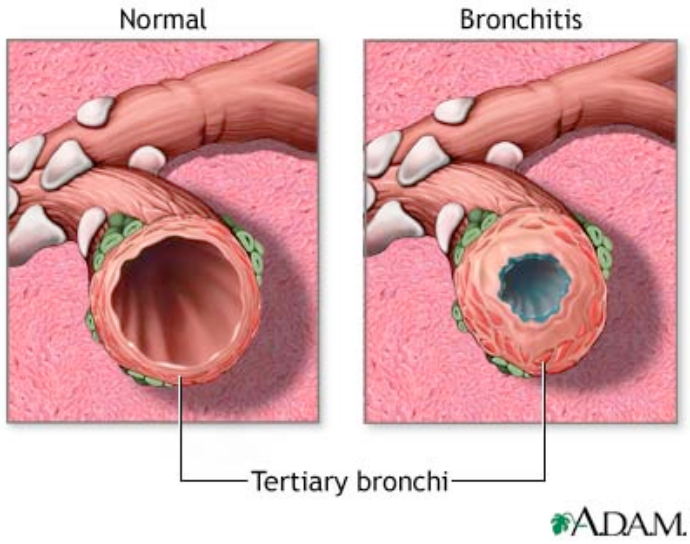
A.) Introduction

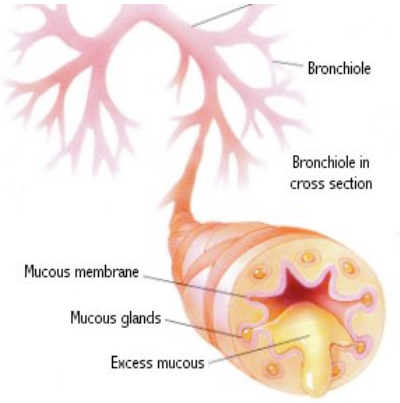
There are many things that can go wrong with the lungs. Some of these problems have been briefly mentioned in the previous modules that you have seen today, and some of these problems you have probably learned about by interacting with friends, family members, or relatives. Some problems with the lungs are very common (such as bronchitis and pneumonia) and affect a large number of people, others are very rare (such as a collapsed lung or tuberculosis) and only affect a few people. *Overall, though, the fact that the lungs are so critical to our survival (as they provide oxygen to all the tissues of our body) suggests that any problem with the lungs will have a big effect on the health and welfare of an individual.* (Even little changes in lung function can cause big problems in terms of a person's everyday health and function, being that our body is so complex and so finely balanced.) Therefore, many of the problems that doctors typically see in the hospital have to do lung/respiratory problems. This lesson will describe a handful of conditions and diseases that affect the lungs, how they present in patients, and how some can be treated through various medical interventions.

B.) Bronchitis

One of the most common problems that occur in the respiratory tract is viral and/or bacterial infections. This is due to the fact that the respiratory tract is directly exposed to the external environment, and therefore serves as the first line of defense against pathogens. Subsequently, this position causes the respiratory system to take the "brunt" of the many pathogens that enter the body. One of the most common types of respiratory infections, and one that almost everyone has experienced, is bronchitis. Bronchitis is a condition in which there is a viral or bacterial infection in the upper respiratory tract, mainly the larger bronchi/bronchioles of the lungs, that results in inflammation, mucus section, and obstruction of these airways. Patients experiencing this condition generally have a cough, fever, shortness of breathe, and/or wheezing. There are two main types of bronchitis: acute and chronic. Acute bronchitis may last for a few days and have more mild symptoms, while chronic bronchitis is more severe and sustained and generally is a result of continued exposed to some harmful agent such as tobacco smoke. Both cases can generally be diagnosed by checking the patient's symptoms, performing a bacterial culture (to determine any bacterial strains) on the

sputum, and/or taking a chest x-ray to look for consolidation (local accumulations of pus). Finally, cases involving a bacterial infection can generally be solved using antiobiotics, while cases involving viral pathogens are generally allowed to resolve on their own.

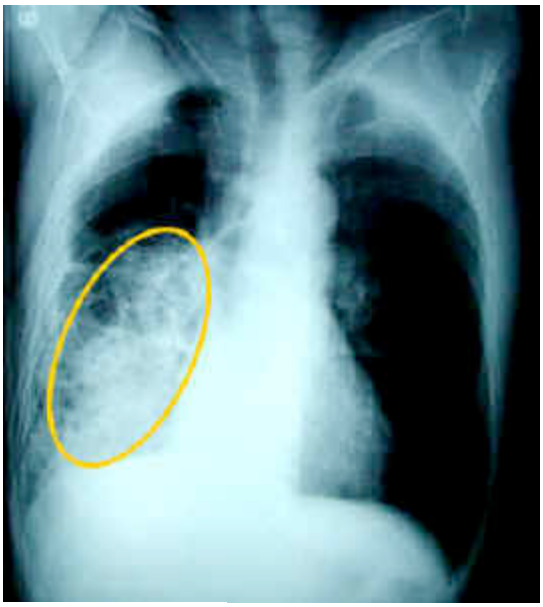




C.) Pneumonia

Another common, and more serious, infection of the respiratory system is pneumonia. Pneumonia is characterized by a bacterial, viral, fungal, or parasitic infection in the smaller diameter airways in the peripheral regions of the lungs, rather than the larger diameter airways in the central region of the lungs. In general, pneumonia can be very serious because the infection can occupy a great deal of alveoli and dramatically effect the amount of functional lung tissue. Also, that deep into the lungs there are few large scale immune mechanisms, making it even harder to clear/counter the infection. Patients who are suffering from pneumonia typically have a fever, chills/shakes, shortness of breath, chest pain, and either some/no sputum production (due to the infection being so far into the lungs). While there are many causes of pneumonia, and many types of pneumonia [ranging from community acquired to immuno-compromised types] the most common causes are the bacteria: *Streptococcus pneumoniae* , *Haemophilus influenzae* , or *Moraxella catarrhalis*, or also S. Aureus. Pneumonia can be diagnosed by examining the patient's symptoms, culturing the sputum for bacteria, taking a chest ray (which may show lobar consolidation [pus filling up one whole lobe of the lung], and performing a CBC [blood cell count] to check the number of WBCs. If the cause is bacterial antibiotics can be an effective treatment, similarly fungal and parasitic infections can generally be treated. Viral causes generally have fewer treatment options.

Suppurative bronchitis: lung



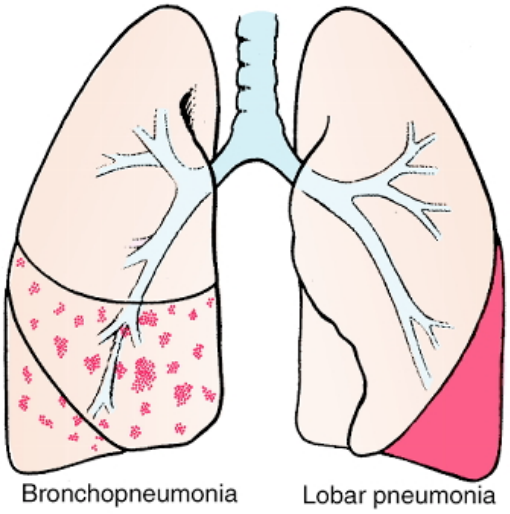
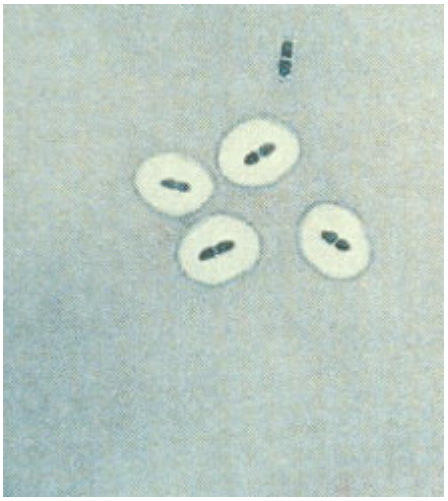


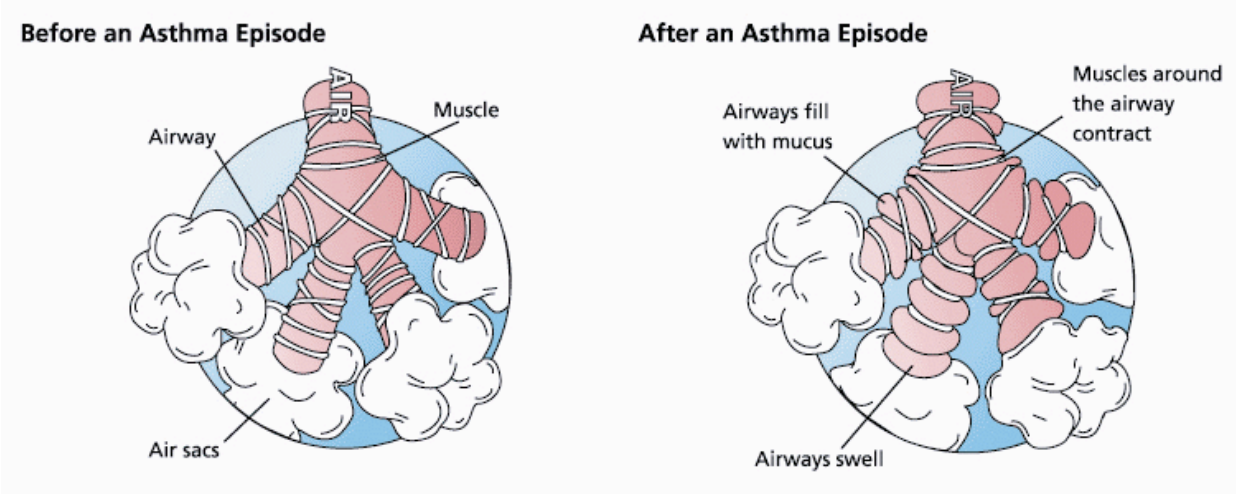
Figure 23-2 Distribution of lung involvement in bronchial and lobar pneumonia. In bronchopneumonia (left), patchy areas of consolidation occur. In lobar pneumonia (right), an entire lobe is consolidated.

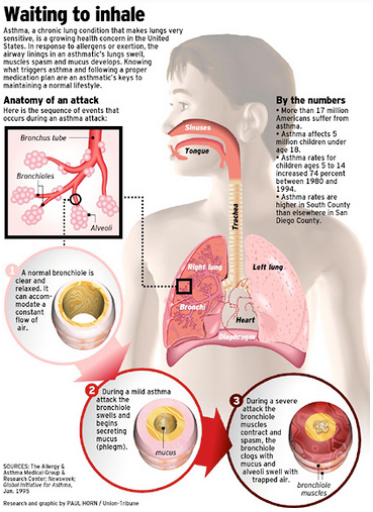


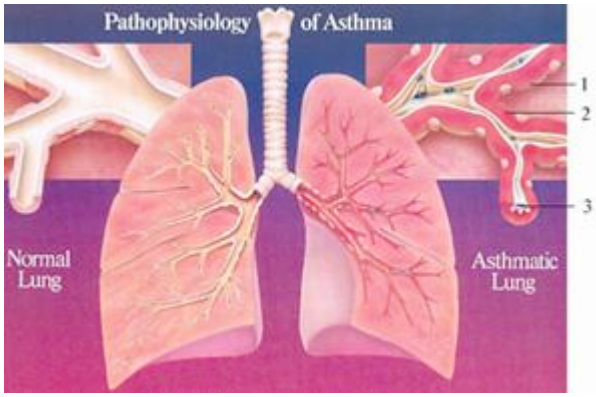
D.) Asthma

Another very common respiratory condition, and getting more and more common [now rates as high as 1 in 4 children in urban areas], is that of asthma. Unlike the previous conditions asthma is not an infection and is not acute. Asthma is a long term (chronic) condition in which the airways in the lungs (bronchi/bronchioles) are hypersensitive to various environmental stimuli (such as dust, allergens, cold/heat, moisture, etc.). Upon exposure to these triggers the airways spasm and constrict, due to stimulation of the smooth muscle surrounding the airways, become inflamed, and

increase mucus production, all of which may lead to airway obstruction. This type of event is known as an asthma attack. The actual mechanism causing this "hypersensitivity" is still unclear and a topic of much debate. Currently, researchers have figured out that individuals with asthma possesses certain type of "overactive" immune cells that are more sensitive to particular antigens and more efficient at "turning on" the immune reaction inside the airways. In general, individuals with asthma will have problems breathing, shortness of breath, and wheezing which typically comes and goes from time to time. Luckily, there are many type of effective treatments for asthma. The most common treatment for asthma are inhalers, which are mainly a mixture of gas and drugs that are inhaled into the lungs. The most common by far is albuterol. Albuterol is a bronchodilator and a B_2-adrenergic receptor agonist. Specifically, albuterol binds to B_2-adrenergic receptors on the smooth muscle cells surrounding the constricted airways causing the cells to relax, therefore dilating the affected airways and allowing air to pass. Recently a large number of new medications have come out for the treatment of asthma. Some utilize powdered steriods that are inhaled into the lungs (Advair, a steroid), or drugs that inhibit leukotrienes [inflammatory molecules] (Singulair), or general adrenergic agonists (for emergencies) such as epinephrine in an "Epi Pen." Untreated asthma can lead to a condition known as bronchiectasis, or death.





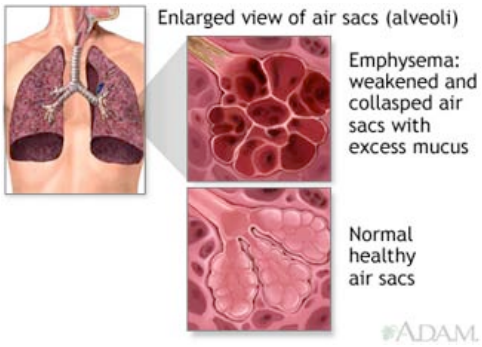


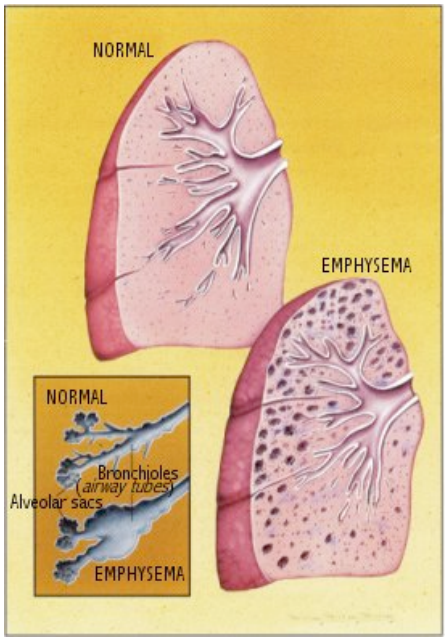


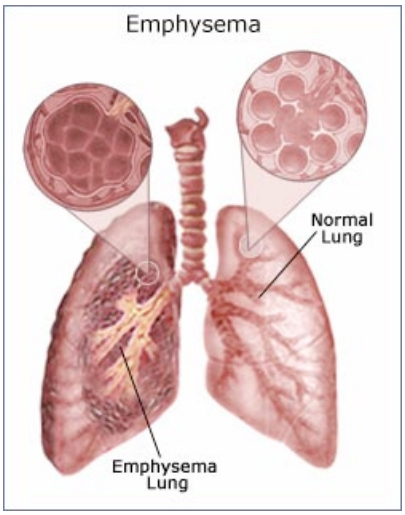
E.) Emphysema

One of the more serious lung conditions, which is overwhelmingly caused by smoking, is that of emphysema. Emphysema is one of many type of "chronic obstructive lung disease," meaning that in this condition portions of the lung become "blocked off" or obstructed, limiting airflow in and out of them. Specifically, emphysema occurs when a person is exposed to a toxic substance, mainly cigarette smoke, for a long long time. What happens when an individual inhales tobacco smoke? Well, first all of the small particulates in the smoke [thanks to the filters on the cigarettes] go deep into the lungs along with the many toxic chemicals found in the cigarettes, such as nicotine, tar, carbon monoxide, benzene, formaldehyde, and hydrogen cyanide. These particulate and chemical are then deposited along the inside of the airways in the respiratory tract and inside the alveoli. Many of these chemical damage lung cells directly and can cause many to die, other may stimulate an immune response when immune cells come and destroy/engulf the foreign particles. Either way, the tissue around these particles gets damage and the microscopic walls supporting and separating individual alveoli begin to be destroyed and replaced by scar tissue. So, over many year of this process a smoker's lung looses a large amount of flexible/stretchy tissue, and functional alveoli, and subsequently replaces it with large holes (bullae) surrounded by stiff/inflexible scar tissue. This change in the mechanical properties of the lungs (going from flexible and spongy to stiff and rigid) changes the way the lung function, specifically in that there is no "recoil / "springy-ness" left in the lung tissue to hold the airways open during expiration. This in turn causes lots of inhaled air to become trapped inside the lung, unable to leave, forming large "dead zones" where gas exchange cannot occur. Overall, this process leads to the loss of more and more functional lung tissue, making it harder and harder for the individual to breathe. Many people describe it as continuously feeling like you are suffocating. Patients who have emphysema may have shortness of breathe, hyperventilation, an greatly enlarged chest, and may breathe in a very characteristic fashion (leaning forward on something). [Why would this be? Think of the muscles of respiration.] Overall, there is little that can be done for patients with emphysema besides helping the patient to quit smoking. If the patient's condition becomes critical a lung transplant may be the patient's only hope of survival. In this procedure one or both lungs

are harvested from a brain dead donor and implanted into the patient. Simultaneously lots of immunosuppressant drugs are given to the patient to prevent their own body from attacking these foreign organs.





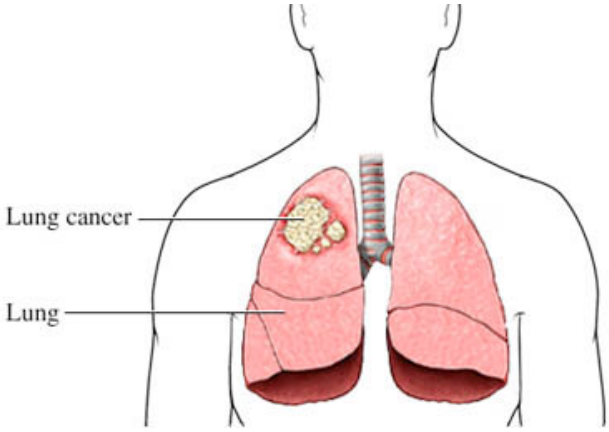


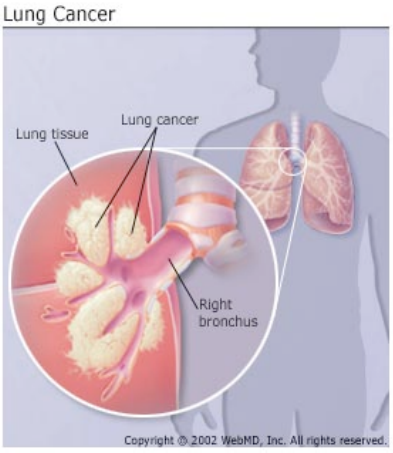
F.) Lung Cancer

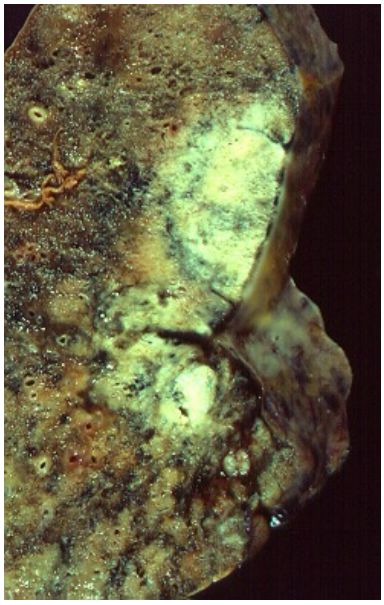
Another very common condition that is linked to smoking is that of lung cancer. As we have talked about in other sections cigarette/tobacco smoke is carcinogenic, meaning that when it is exposed to cells it has the potential to mutate cell DNA. As we also talked about before we know that mutations in cell gene/DNA can cause normal cells to "transform" into cancerous cells. Therefore, smokers who have cigarette smoke going into their lungs all the time have a very high chance of having a lot of mutated/transformed cells inside their lungs. These cancerous/"neoplastic" cells eventually begin to grow and "defy" the regular rules of tissue architecture and cell behavior. Sometime they can grow uncontrolled an form unnatural masses known as tumors. In the lungs these tumors eventually grow bigger and bigger and take up space in the lung that is needed for gas exchange. In the end this makes it harder and harder for the patient to breathe, and may eventually lead to death. Cancerous masses such as these may also generate "metastatic" cells which can spread throughout the body and cause tumors in other organs/sites as well.

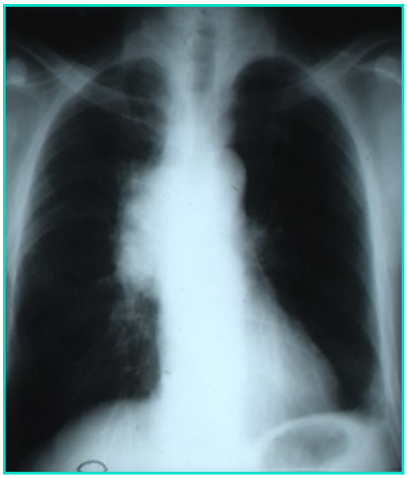
Overall there are many different types of lung cancers, all of which has different appearances and characteristics. But in general, all of the them are predominantly caused by smoking! For example, there are three main type of lung cancers: Non-small cell lung carcinoma, small cell lung carcinoma, and the other more rare types (carcinoid and sarcoma). In NSCLC the cancerous cells can arise from either cells lining the airways (squamous cells) or cells in the alveoli (adenocarcinoma). Cancer and tumors arising from different original cell types will have a different appearance and distribution throughout the lungs. By far one of the worst types is small cell lung carcinoma. SCLC is especially bag because it arises around the large airways near the hilum of the lung, so it is hard to see on x-ray and hard to diagnose, also it generally progresses and metastasizes very quickly.

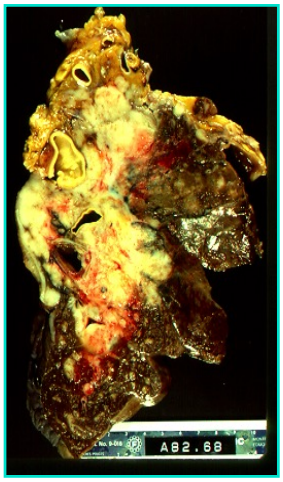
Some lung cancer can be treated with radiation therapy, chemotherapy, or surgery, but when the tumors are very large and invasive (or have metastasized) there is little that can be done. This brings up one point about cancer diagnosis. Generally you want to find these kinds of tumors early on, when they are small, because they are generally easier to treat. But as you can see in this x-rays it is very hard to determine what small dots on the x-rays are, and is therefore hard to diagnose cancer in this way. This is why many researchers are trying to develop new way to detect lung cancer/tumors when they have just begun to grow. This will help doctors diagnose cancer earlier and be able to cure more patients! By far though the most important part we can all play is reducing the number of people who get cancer by not smoking and helping those that do smoke to quit.

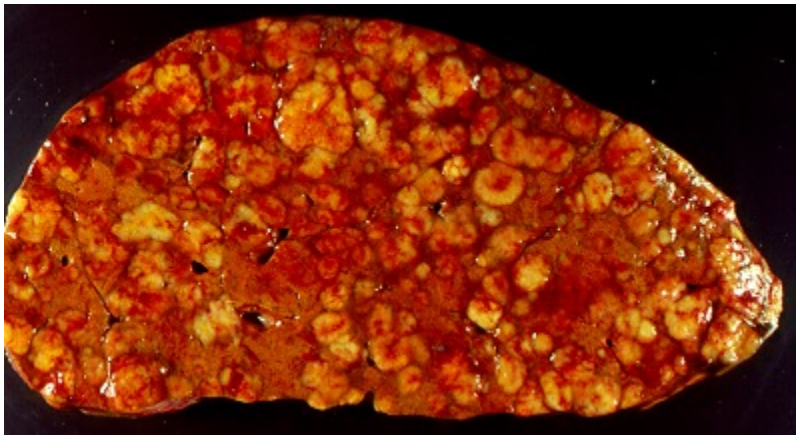


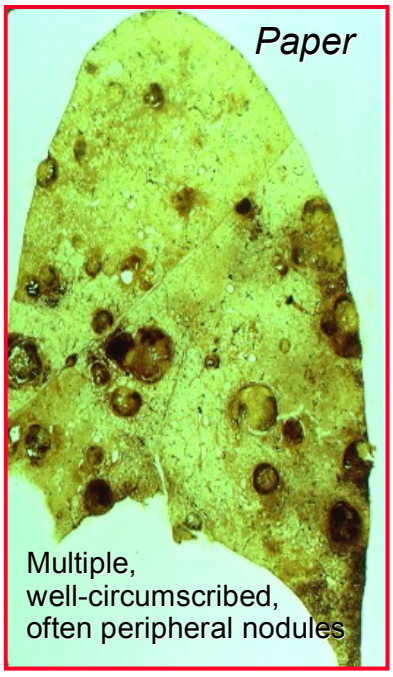




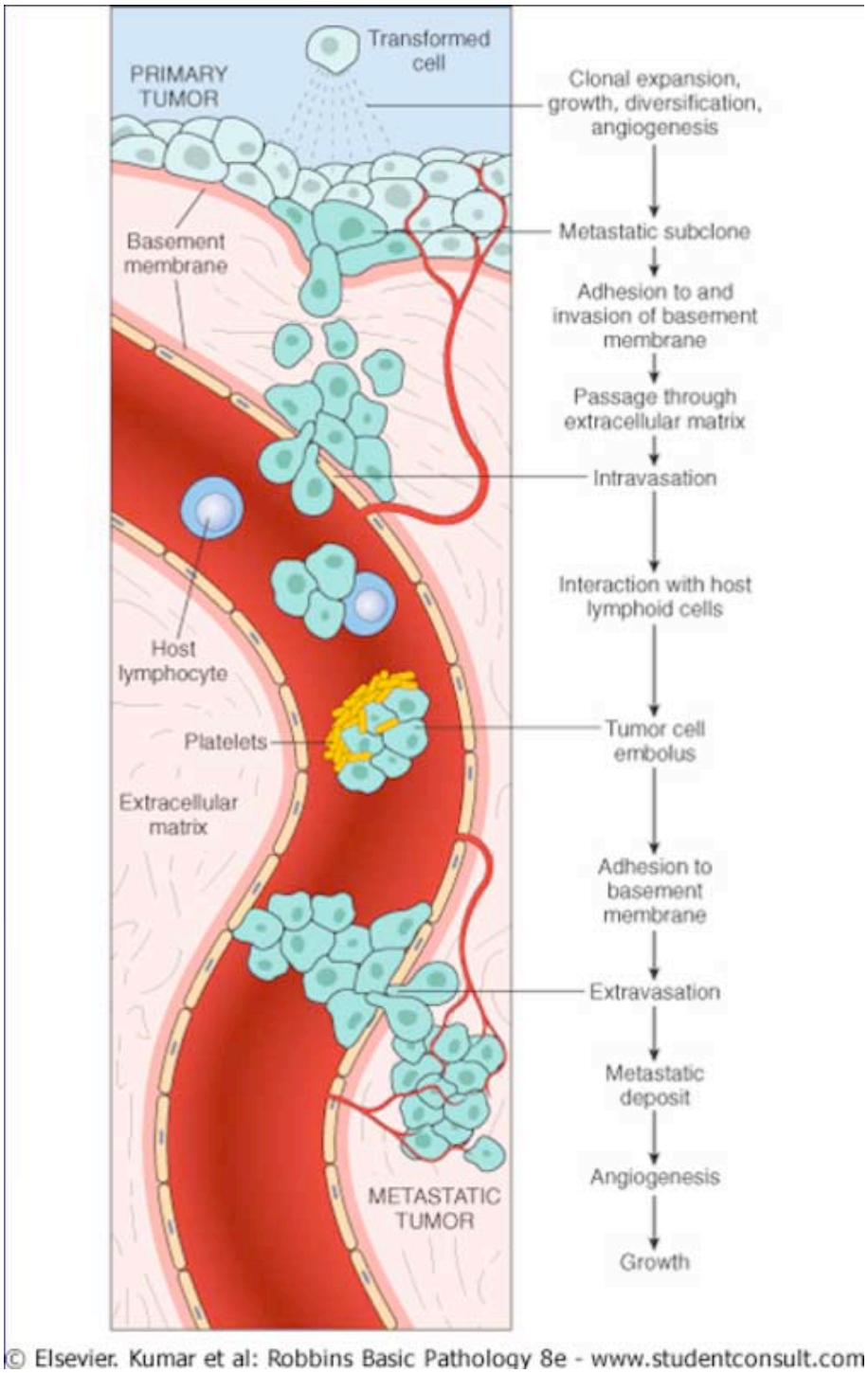








Metastatic melanoma



G.) Smoking

Estimated New Cases*

Males			Females		
Prostate	232,090	33%	Breast	211,240	32%
Lung and Bronchus	93,010	13%	Lung and Bronchus	79,560	12%
Colon and Rectum	71,820	10%	Colon and Rectum	73,470	11%
Urinary Bladder	47,010	7%	Uterine Corpus	40,880	6%
Melanoma of the Skin	33,580	5%	Non-Hodgkin Lymphoma	27,320	4%
Non-Hodgkin Lymphoma	29,070	4%	Melanoma of the Skin	26,000	4%
Kidney and Renal Pelvis	22,490	3%	Ovary	22,220	3%
Leukemia	19,640	3%	Thyroid	19,190	3%
Oral Cavity and Pharynx	19,100	3%	Urinary Bladder	16,200	2%
Pancreas	16,100	2%	Pancreas	16,080	2%
All Sites	**710,040**	100%	**All Sites**	**662,870**	**100%**

Estimated Deaths

Males			Females		
Lung and Bronchus	90,490	31%	Lung and Bronchus	73,020	27%
Prostate	30,350	10%	Breast	40,410	15%
Colon and Rectum	28,540	10%	Colon and Rectum	25,750	10%
Pancreas	15,820	5%	Ovary	16,210	6%
Leukemia	12,540	4%	Pancreas	15,980	6%
Esophagus	10,530	4%	Leukemia	10,030	4%
Liver and Intrahepatic Bile Duct	10,330	3%	Non-Hodgkin Lymphoma	9,050	3%
Non-Hodgkin Lymphoma	10,150	3%	Uterine Corpus	7,310	3%
Urinary Bladder	8,970	3%	Multiple Myeloma	5,640	2%
Kidney and Renal Pelvis	8,020	3%	Brain and Other Nervous System	5,480	2%
All Sites	**295,280**	100%	**All Sites**	**275,000**	**100%**

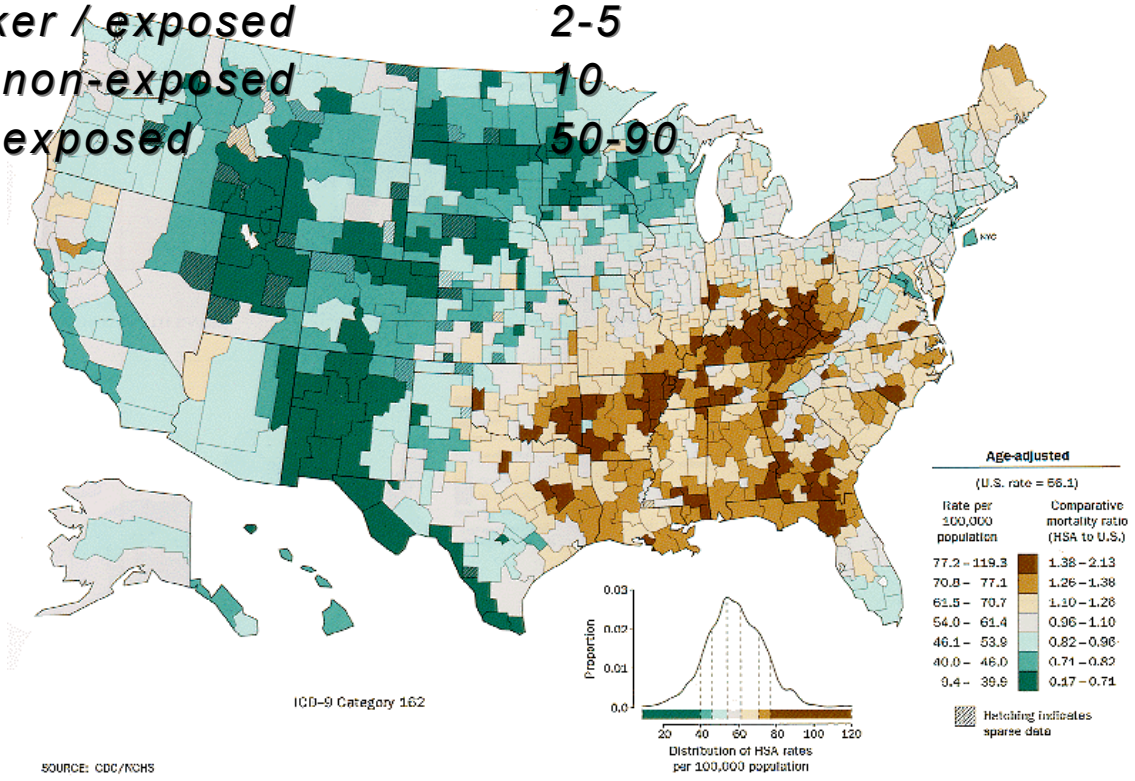
FIGURE **1** Ten Leading Cancer Types for the Estimated New Cancer Cases and Deaths, by Sex, US, 2005.

*Excludes basal and squamous cell skin cancers and in situ carcinoma except urinary bladder. Estimates are rounded to the nearest 10.

Note: Percentage may not total 100% due to rounding.

American Cancer Society, Surveillance Research, 2005

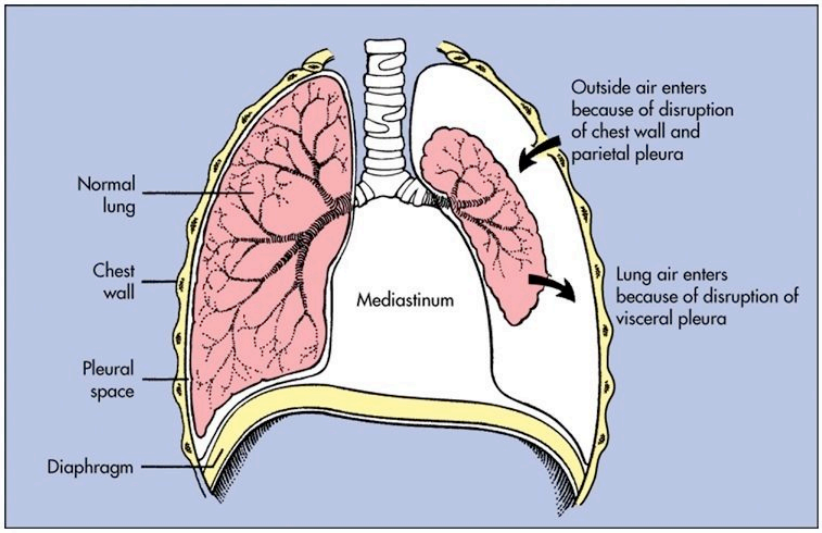
Patient Population	Relative Risk of CA
Non-smoker / non-exposed	1
Non-smoker / exposed	2-5
Smoker / non-exposed	10
Smoker / exposed	50-90



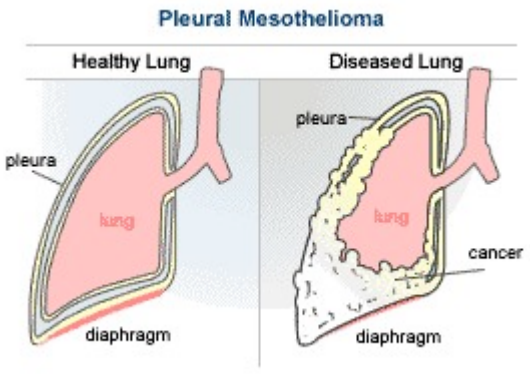
H.) Collapsed Lung

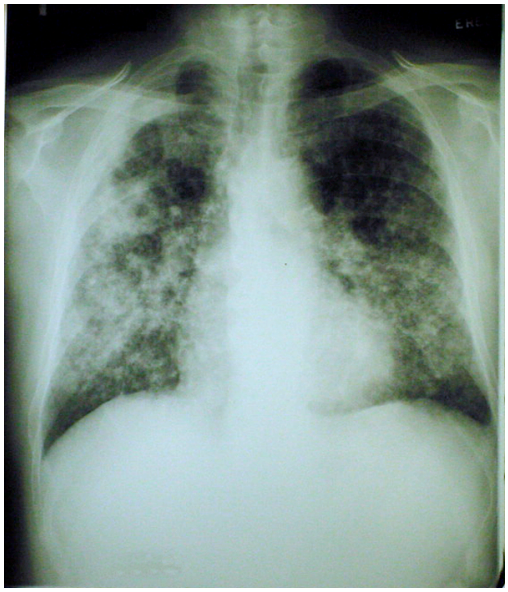
One of the more rare lung emergencies is a collapsed lung. But how does a lung "collapse"? In some cases the lung develops a leak, or "pops", and then deflates inside the chest. Another way would be a stab wound, or trauma, to the chest which causes a puncture in the tissue of the rib cage. In this case the air coming into the chest cavity will have a higher pressure than that inside the lung which causes the lung to collapse, or deflate, inside the chest. [This causes all of the alveoli in the affected lung to deflate and close, making the entire lung useless in terms of gas exchange.] In a very special instance the wound in the chest may form a sort of "one way valve" that only opens while the patient is breathing in. In this case air continuously enters the chest cavity through the wound, but does not have a chance to leave. Therefore, the pressure inside that half

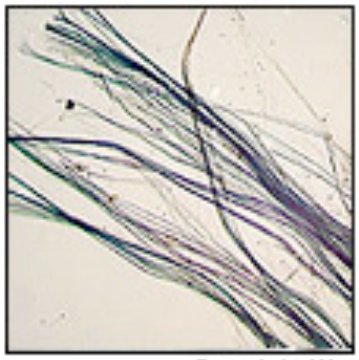
of the chest cavity builds and builds, forcing the diaphragm down on that side and pushing the mediastinum and the heart towards the opposite side of the chest. This condition is called a "**tension pneumothorax**." The only way to relieve both of these problems is to stick a tube into the chest cavity and release the air that has accumulated (along with repairing the wound in the chest wall). In general, patients with a collapsed lung with have a lot of trouble breathing, no breathing sounds over one side of the chest, and significant chest pain. Just examining the patient and doing a quick x-ray is generally enough to diagnose the problem.



I.) Asbestosis/Silicosis + Mesothelioma [Extra]







Crocidolite
Asbestos Fibers