BASIC CHEST RADIOLOGY FOR THE TB CLINICIAN

PRESENTATION GUIDE

ABOUT THIS GUIDE

This *Presentation Guide* offers slide-by-slide notes to be used as you conduct your training with the *Basic Chest Radiology for the TB Clinician Presentation* slide-set. You should be able to cover this material in about an hour.

BEFORE YOU BEGIN

Prepare Material

Download the *Basic Chest Radiology for the TB Clinician Presentation slide-set* onto your laptop computer and print the *Presentation Guide* to consult as you move through the presentation. These materials are available at: www.currytbcenter.ucsf.edu/tbradiology/

- You will connect your laptop to an LCD projector (or present from your computer screen for smaller groups) to present these slides to your learning group.
- To present the slide show, select "view" from toolbar at the top of your screen and, from the pull-down menu, select "slide show." You can also click the "slide show" icon on the toolbar at the bottom of your screen.
- To advance the slide show, click on your left mouse button or press the ↓button (alternate is → button) on your keyboard.
- Review the curriculum prior to presentation. Note that instructions for the facilitator are bolded and are not to be read to your participants. The teaching notes (or "script") are *italicized*. Your training will be most effective if you (as facilitator) have at least a basic understanding of chest anatomy—for more on this, please review Radiographic Manifestations of Tuberculosis: A Primer for Clinicians, Second Edition, Curry International Tuberculosis Center 2009. URL: http://www.currytbcenter.ucsf.edu/products/product_details.cfm?productID=EDP-04

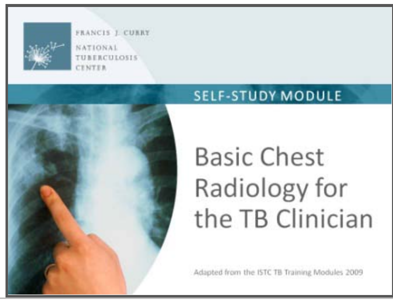
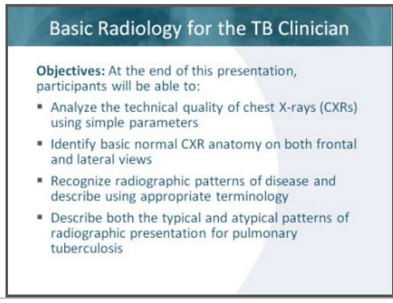
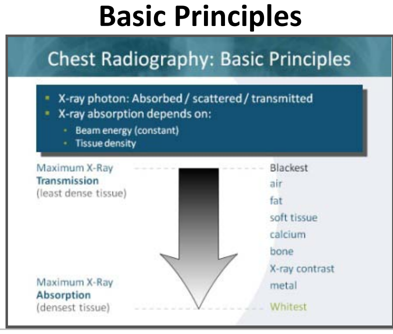
- As you conduct the presentation, keep in mind that the right/left orientation is from the patient's perspective. So the "right" lung will be on the left side of the image throughout this presentation.

Set up the Classroom

- Because of the detailed nature of these images, it is suggested that you conduct this training in a completely dark room to ensure maximum visibility.
- Use a laser pointer to highlight specific areas of radiographs.
- Set up participant seating as close to the screen as possible.
- You may wish to inform participants of Curry Center's "TB Radiology Resources" page from which they can view or order related materials.

Abbreviations used in this module

CT	Computed tomography scan
CXR	Chest x-ray
RLL/LLL	Right/left lower lobe
TB	Tuberculosis

SLIDE #	SLIDE TITLE	TEACHING NOTES
1	**Title slide**  	
2	**Basic Chest Radiology for the TB Clinician**  	**Review the learning objectives for the presentation.**
3	**Basic Chest Radiology for the TB Clinician (2)**  	**Review the key areas to be covered in this presentation (listed on the slide). If participants wish to have more detail and practice on recognizing the radiographic manifestations of tuberculosis and on reading and interpreting chest radiographs, refer them to:** **Radiographic Manifestations of Tuberculosis: A Primer for Clinicians, Second Edition. Curry International Tuberculosis Center 2009.** **www.currytbcenter.ucsf.edu/products/product_details.cfm?productID=EDP-04** **[Advance slide]**
4	**Chest Radiography: Basic Principles**  	*When x-ray photons are generated and directed at a patient, one of several interactions may occur:* • *The x-ray photon may pass completely through the patient and strike the recording medium (actual film or digital detector) unaltered.* • *The x-ray photon may strike tissue within the patient and be completely absorbed.* • *The x-ray photon may strike tissue in the patient and be scattered, but still reach the recording medium (this is the most common outcome).*

<table>
<tr><th>SLIDE #</th><th>SLIDE TITLE</th><th>TEACHING NOTES</th></tr>
<tr><td></td><td></td><td>
Whether or not an x-ray photon is absorbed by a patient’s tissue depends on several factors, the most important of which are the energy of the x-ray beam (which is relatively constant around the world) and the density of the patient’s tissue.
Seven different densities in a patient’s body may be distinguished by radiography. The least dense element is air or gas and this appears “blackest” on an x-ray (i.e., the least amount of x-ray absorption, therefore the greatest degree of x-ray transmission). Fat is slightly less dense than soft tissue and appears slightly darker than soft tissue. Note that soft tissue density includes numerous substances such as water, urine, blood, muscle, etc.—all of which appear the same density on an x-ray. Denser still is calcium, iodine-based x-ray contrast media, and bone. The densest substance an x-ray may encounter is metal, such as orthopedic hardware or shrapnel. [Advance slide]
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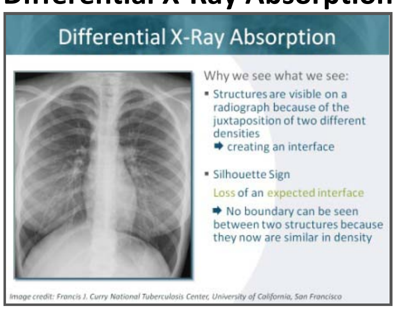
<tr><td>5</td><td>Differential X-Ray Absorption


</td><td>
Although using only tissue density as the means to differentiate structures may have its limitations, a great deal of anatomy and pathology may be recognized on radiographs. How is this accomplished? The physical principle underlying this process is referred to as “differential x-ray absorption.”
Differential x-ray absorption occurs when two structures of differing physical density are in contact with one another, but absorb differing numbers of x-ray photons due to their different densities. The difference in density therefore allows us to see a visual interface where these two structures touch. In this slide, the heart (soft tissue density) lies immediately adjacent to lung (mostly air density) [Use laser pointer to highlight]. Each organ absorbs differing numbers of photons and therefore the reviewer’s eye sees this difference as an interface or boundary–the right and left heart borders.
Knowledge of the principle of differential x-ray absorption allows the reviewer to recognize normal anatomy on radiography and to detect new, unexpected contours that reflect pathology.
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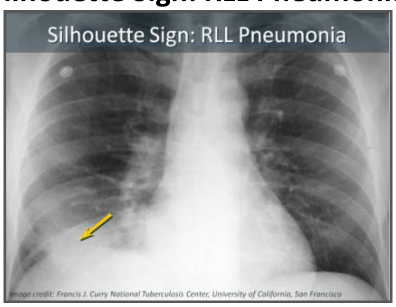
SLIDE #	SLIDE TITLE	TEACHING NOTES
		Conversely, the loss of an expected interface may also reflect an abnormal condition. In this situation, one expects an interface between two structures of differing density, but this is not seen because one of the two structures has changed density, and no boundary, or interface, can be seen when two adjacent structures are of similar density. This situation is often referred to as the "silhouette sign" (indicating the loss of an expected "silhouette") and will be discussed next. **[Advance slide]**
6	**Silhouette Sign: RLL Pneumonia** 	*In this radiograph, the left diaphragm is visible because air in the left lower lobe contacts the soft tissue density diaphragm, creating an interface that is well-defined* **[Use laser pointer to highlight].** *In contrast, look at the less well-defined right diaphragm border* **[Use laser pointer to highlight].** *The lateral portion of the border is visible, but the mid-portion* **[Advance slide to see arrow]** *is difficult to outline. This is because the air normally presents within the right lower lobe, which usually contacts the diaphragm and creates the expected interface, has been replaced by another substance (intra-alveolar inflammatory cells and debris due to pneumonia).* *The silhouette sign occurs because no interface, or boundary, can be seen between two structures of similar density. Therefore, when an expected interface is not seen, an abnormal condition is present.* *When one has a good working knowledge of normal anatomy, the silhouette sign can be used to localize the abnormal process.* **[Advance slide]**

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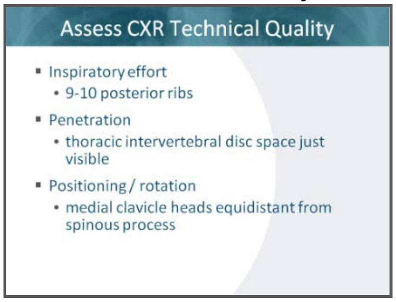
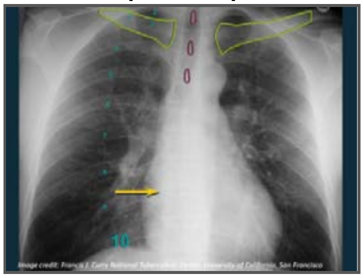
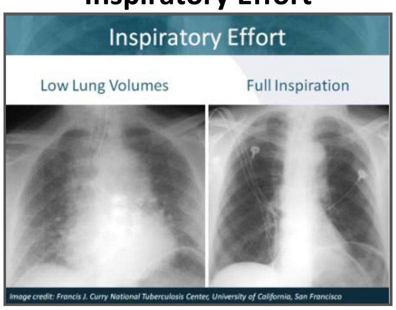
SLIDE #	SLIDE TITLE	TEACHING NOTES
7	**Assess CXR Technical Quality**  	*When reviewing imaging studies, it is vital to assess the technical quality of the study before providing an interpretation. When the study is technically suboptimal, it may be necessary to qualify the interpretation by noting that the reliability of the reading is limited by the quality of the film, and in some cases repeat imaging may be necessary.* *Several technical factors are important for interpreting chest radiography. Three of the most common technical factors that should be assessed include:* - *<u>Patient's inspiratory effort</u>: In general, the patient's inspiratory effort is considered adequate when approximately the 10^{th} posterior rib is visible above the diaphragm. When only the 8^{th} rib is visible, the lung volumes are diminished. This may reflect poor inspiratory effort, although restrictive lung diseases may produce such a finding as well. When the diaphragm is visible below the 11^{th} rib, the lung volumes are abnormally large, which usually reflects obstructive lung disease or air trapping.* - *<u>Degree of penetration, or "film blackening"</u>: A film is considered adequately "penetrated" when the thoracic intervertebral discs are just visible. Also, the lungs, particularly the upper lobes, should not appear excessively "black," and peripheral pulmonary vessels should be visible.* - *<u>Adequacy of patient positioning/rotation</u>: A patient is properly positioned for radiograph in the frontal plain when the distance between the medial heads of the clavicles is approximately equidistant from the spinous processes.* **[Advance slide]**

SLIDE #	SLIDE TITLE	TEACHING NOTES
8	**(no title)** 	*We will now practice reviewing the technical quality of this chest radiograph:* - <u>*Inspiratory Effort*</u>*: Let the numbers guide you in counting the rib* **[Advance slide to see numbers]**. *The 10th posterior rib is visible just above the right diaphragm* **[Use laser pointer to highlight]***; therefore, the inspiratory effort is adequate.* - <u>*The intervertebral disc spaces*</u> **[Advance slide to see yellow arrow]** *are just visible through the mediastinum, and pulmonary vessels are readily visible in the upper lobes and peripherally; therefore, the "penetration" is adequate.* - <u>*The medial heads of the clavicles*</u> *(yellow outlines)* **[Advance slide to see green outlines, purple ovals]** *are approximately equidistant from the spinous processes (purple ovals); therefore, the positioning is appropriate.* **[Advance slide]**
9	**Inspiratory Effort** 	*Let's review these two images for technical adequacy:* <u>*Low lung volumes*</u>*:* **[left side of screen]** *The patient is intubated. Only the posterior 7th rib is visible above the diaphragm* **[Use laser pointer to highlight]***; therefore, the inspiratory effort is suboptimal and the lung volumes are low. This is a nearly expiratory image.* *When lung volumes are low, basilar opacities resulting from atelectasis and "vascular crowding" are often evident and limit diagnostic accuracy in the lung bases. Often the mediastinum appears abnormally wide as well, simulating cardiovascular disease.* <u>*Full inspiration*</u> **[Advance slide to see right image]:** *Now review the repeat radiograph on the right, taken only moments after the radiograph on the left. Lung volumes are improved (the 10th posterior rib on the right is visible* **[Use laser pointer to highlight]***.) Note how the basilar opacities have cleared and the cardiomediastinal contours are now sharply defined and the "edema-like" appearance has resolved.* **[Note additional findings on images]:** *there are metal*

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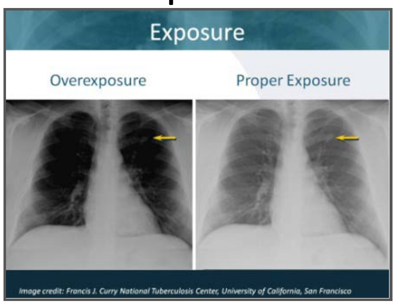
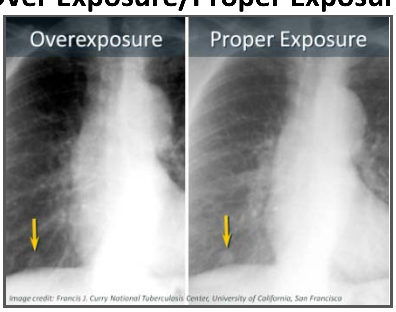
		fasteners and keys with a safety pin attached to the patient's clothing. Both images also reveal an elevated right hemi-diaphragm with prominent gastric air. **[Advance slide]**
10	**Exposure** 	*We will now review these x-rays for technical adequacy.* *<u>Left image:</u> Note how the upper lungs appear excessively "black,"* **[Use laser pointer to highlight]** *and the small peripheral pulmonary arteries are not visible. Also, the thoracic intervertebral discs spaces are readily visible. This image is "over-exposed" or "too penetrated" and is technically inadequate. Significant findings may be missed on such a radiograph.* *<u>Right image:</u> Pulmonary vessels are readily visible in the lung apices and lung periphery and the thoracic intervertebral disc spaces are just visible* **[Use laser pointer to highlight]**. *This image is properly exposed or "penetrated" and is technically adequate.* *Note how the left apical nodule* **[Advance slide to see arrow]** *is readily visible on the image on the right, yet the lesion* **[Advance slide to see arrow]** *is inconspicuous on the image on the left.* **[Advance slide]**
11	**Over Exposure/Proper Exposure** 	*Let's review the film above for technical adequacy:* *<u>Left image</u>: Similar to the prior example, the upper lungs appear excessively "black," and the small peripheral pulmonary arteries are not readily visible. This image is "over-exposed," hiding an abnormality missed at the time due to the poor technical image quality.* *<u>Now review the right image</u>:* **[Advance slide to see right image]** *Pulmonary vessels are more readily visible than the image on the left, and the right image appears less contrasted (the "white and black" differences are less pronounced). This image is properly exposed, now revealing a well-defined nodule* **[Advance slide to see arrow on right image].**

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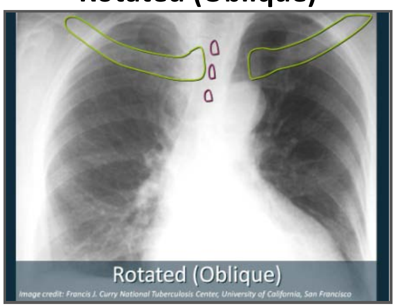
		In retrospect, the nodule was faintly present in the prior film **[Advance slide to see arrow on left image]** *but missed initially due to image over-exposure.* **[Advance slide]**
12	**Rotated (Oblique)** 	*Here is an example of a rotated image.* *Note the position of the medial heads of the clavicles with respect to the spinous processes and trachea* **[Advance slide to see green outlines (clavicles) and purple ovals (spinous processes/trachea)]**. *The medial head of the right clavicle is significantly closer to the spinous processes and also overlaps the right aspect of the trachea.* *In contrast, the medial head of the left clavicle* **[Use laser pointer to highlight]** *is positioned much farther from the spinous processes and trachea than is the medial head of the right clavicle. This indicates that the patient was rotated at the time the radiograph was performed.* *In this example, the medial end of the right clavicle is approaching midline which indicates the patient is turned to a "right anterior oblique" position. When the medial head of the left clavicle approaches or crosses midline on a frontal chest radiograph, the patient is in a "left anterior oblique" position.* *While a rotated image is often still readily interpretable, the changes that accompany rotation may result in misdiagnosis if the rotated position is not recognized. In this example, the right anterior oblique rotation renders the left hilum less visible than in a properly positioned image* **[Use laser pointer to highlight]** *and, conversely, the right hilum often appears more pronounced. The opposite is true with left anterior oblique positioning.* **[Advance slide]**

<table>
<tr><th>SLIDE #</th><th>SLIDE TITLE</th><th>TEACHING NOTES</th></tr>
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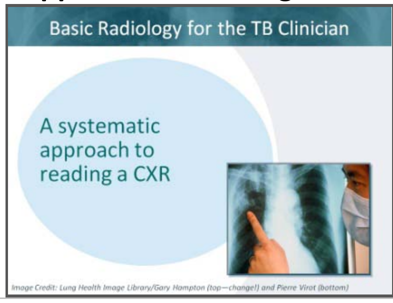
<td>13</td>
<td>Basic Radiology for the TB Clinician: A systematic approach to reading a CXR

</td>
<td>We now move on to the topic of how to develop a systematic approach to reading chest radiographs.

It is vitally important to be systematic when interpreting chest radiographs. Consistency in one’s approach to image interpretation is key to avoiding misdiagnosis.
[Advance slide]</td>
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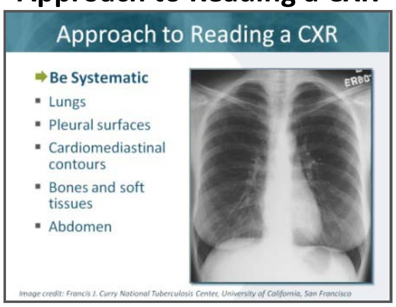
<td>14</td>
<td>Approach to Reading a CXR

</td>
<td>When reviewing a frontal chest radiograph, certain anatomic landmarks are usually readily visible and should be sought on every image reviewed. Being systematic in this approach allows the reviewer to gain familiarity with normal anatomy, which facilitates recognition of an abnormal condition.

The major organ systems that should be recognized and analyzed include [Use laser pointer to highlight] the lungs, pleural surfaces, cardiomediastinal contours (including the heart, great vessels, and hila), bones and soft tissues of the thorax, and the visualized portions of the abdomen.

The key point is to develop a system that you will follow every time when reviewing a radiograph so that no area is overlooked. As an example, some practitioners consistently begin at the top of the image and work their way down, comparing [Use laser pointer to highlight] the right and left sides for symmetry: first for the lungs, then returning to the top to evaluate the pleura carefully from the apices to the costrophrenic angles and along the diaphragm, then returning to the top once more for the mediastinal structures, and so on down the list.

By developing a set systematic inspection, the reviewer will avoid distraction by any abnormalities encountered. This is important because reviewers who are not systematic may notice one abnormality and become distracted by it, and miss a second abnormality that may be present. This phenomenon is referred to as “satisfaction of search.”
[Advance slide]</td>
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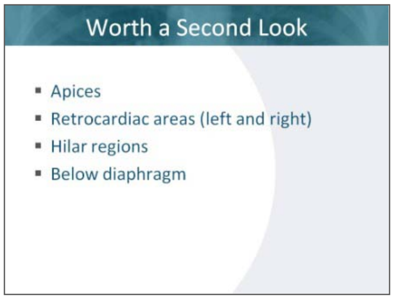
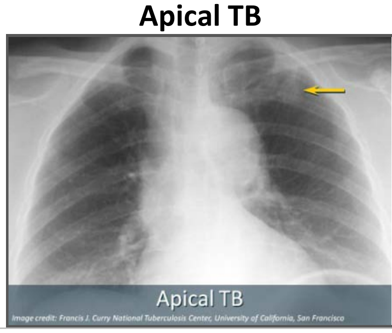
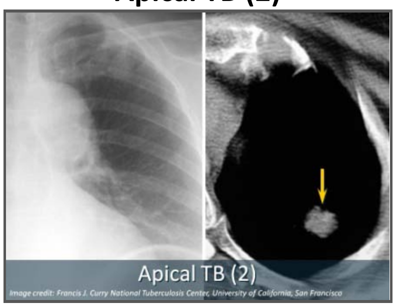
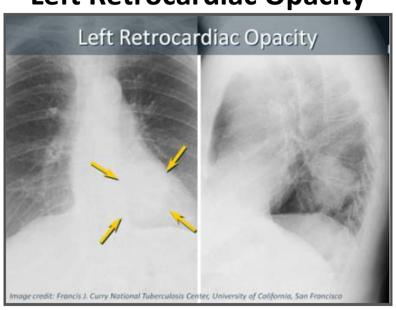
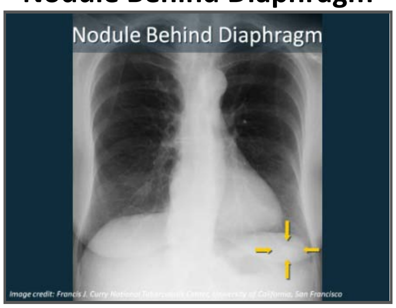
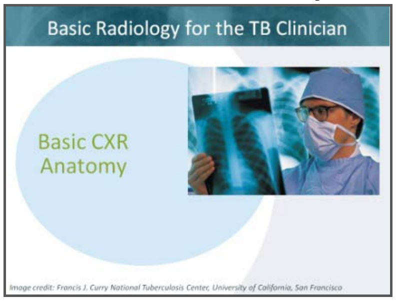
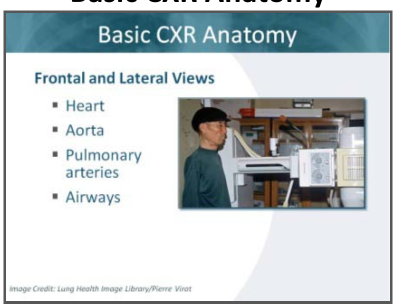
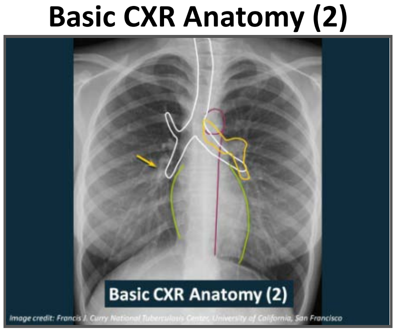
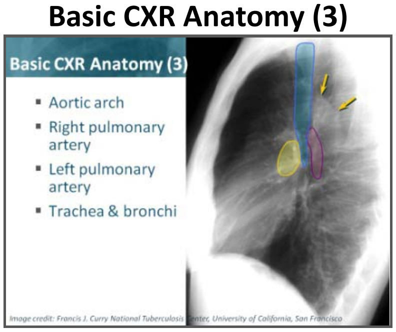
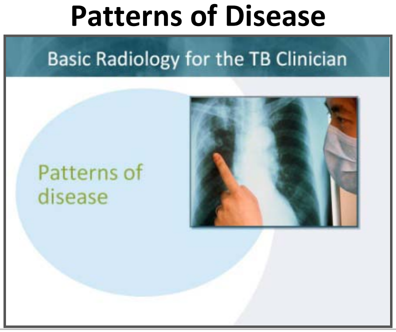
SLIDE #	SLIDE TITLE	TEACHING NOTES
15	**Worth a Second Look**  	*Certain areas of the chest radiograph are particularly vulnerable to misinterpretation, often due to the excessive overlap of structures. Problem areas worth giving a "second look" include:* - <u>Lung apices:</u> *The overlap of the first rib, clavicle, and costochondral junction may occasionally simulate the presence of disease (in particular, the artifactual appearance of a lung nodule), or may obscure disease.* - <u>Retrocardiac region</u> *(areas projecting "behind" the heart): The soft tissue opacity created by the heart may obscure pulmonary pathology residing in the lung, usually the lower lobes. A lateral radiograph may be helpful to better visualize an abnormality here.* - <u>Hilar regions</u> *are notoriously difficult to evaluate owing to rather complex anatomy in this region. Many overlapping structures occur in this region as pulmonary vessels and bronchi penetrate the lung from the mediastinum. The best methods available for avoiding misdiagnosis when reviewing hilar structures include careful attention to these regions and a firm understanding of normal hilar anatomy. The lateral chest radiograph also provides a view of the pulmonary hila from a different perspective and is therefore useful for evaluating potential hilar abnormalities.* - <u>Region below the diaphragm:</u> *Much of the lower lobes will "project" below the diaphragm on a frontal chest radiograph, sometimes obscuring the recognition of abnormalities in these areas as well.* **[Advance slide]**
16	**Apical TB**  	*Review this chest radiograph.* *Note the rounded opacity in the left lung apex* **[Advance slide to see arrow]** *partially overlapping with the left anterior first rib. This abnormality is consistent with a pulmonary nodule (in this instance found to be TB on needle biopsy).* *When evaluating chest radiographs, symmetry is an important*

SLIDE #	SLIDE TITLE	TEACHING NOTES
		consideration. The lungs and pleural surfaces are usually fairly symmetric; therefore it is wise to evaluate both sides of the thorax in search of such symmetry. When an area of increased or decreased opacity is found and is seen to be asymmetric (as in this example), an abnormal condition may be present. Using symmetry to identify subtle pulmonary abnormalities is especially useful when evaluating the pulmonary apices. **[Advance slide]**
17	**Apical TB (2)**  	*In the previous example, when the asymmetric focal opacity within the left lung apex was recognized, thoracic CT (computed tomography scan) was obtained for further characterization.* *This patient had head and neck malignancy and metastatic disease was suspected. The thoracic CT shows that the left apical nodule* **[see arrow]** *is non-calcified. Subsequent biopsy confirmed* Mycobacterium tuberculosis. **[Advance slide]**
18	**Left Retrocardiac Opacity**  	*Now we'll review this chest radiograph. Note the subtle rounded opacity in the left lower lobe, within the left retrocardiac region* **[Advance slide to see arrows].** *One must actively "look through" the heart "shadow" to detect medially located lower lobe pulmonary abnormalities behind the heart. In general, the reviewer should be able to "see" pulmonary vessels in the lower lobes "through" the heart to be confident that these regions are free of abnormalities.* *This finding is very difficult to recognize on the frontal radiograph. Please note, however, that some branching vessels are seen through the left heart (these vessels are located in normal portions of the left lower lobe)* **[Use laser pointer to highlight]** *which then disappear in the area of the mass.* **[Advance slide to see right image]** *Note that the lateral radiograph on the right image readily shows the mass. Lateral radiographs do not always add information to that obtained with frontal radiography, but in selected cases can be quite*

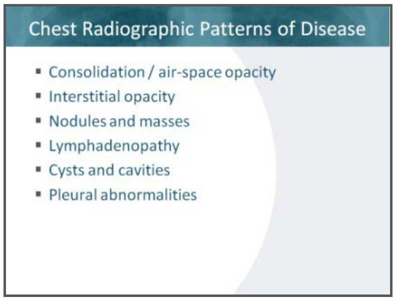
SLIDE #	SLIDE TITLE	TEACHING NOTES
		helpful. In particular, lateral radiographs are useful for localizing abnormalities detected on frontal radiographs and for the detection of lower lobe lesions which are obscured by the heart and diaphragm on the frontal radiographs. Lateral radiographs are also useful for the detection of mediastinal and hilar lesions. **[Advance slide]**
19	**Nodule Behind Diaphragm** 	*Review this chest radiograph. Note the subtle rounded opacity in the left lower lobe, projecting below the diaphragm* **[Advance slide to see arrows],** *which is barely discernable.* *This finding is exceedingly difficult to recognize on the frontal radiograph. The lesion is better appreciated when the reviewer actively "looks through" the diaphragm. Compare the appearance of the lower lobes on the right and medially on the left* **[Use laser pointer to highlight]**–*only normal branching vessels are visible.* *Actively seeking lower lobe pathology is required to maximize accuracy when reviewing frontal chest radiographs. Much of the lower lobes will "project" below the diaphragm on a frontal view. Similar to evaluating the retrocardiac region, if the reviewer cannot readily discern pulmonary vessels branching within the lower lobes when actively "looking through" the diaphragm, it is likely the significant pathology within the lower lobes will not be recognized either. In such circumstances, a repeat radiograph may be obtained if technical inadequacy (often underexposure) is the cause of this situation; alternately, a lateral radiograph may be performed to visualize the lower lobes unobstructed by the diaphragm.* **[Advance slide]**

SLIDE #	SLIDE TITLE	TEACHING NOTES
20	**Basic Radiology for the TB Clinician: Basic CXR Anatomy**  	*Now let's move on to learn about basic CXR anatomy.* **[Advance slide.]**
21	**Basic CXR Anatomy**  	*A number of anatomic structures are readily visible on frontal and lateral chest radiography and should be actively sought on every image reviewed. One must practice identifying normal anatomy (and normal variants) of these structures in order to accurately recognize when abnormalities are present.* *In this section, identifying the specific anatomic detail visible on a radiograph for the heart, aorta, central pulmonary arteries, and central airways will be reviewed.* *Other structures, such as the bones, soft tissues, diaphragm contours, costophrenic angles, and upper abdominal viscera are also readily visible on frontal and lateral chest radiography and should be examined as well but will not be covered in specific detail here.* **[Advance slide]**
22	**Basic CXR Anatomy (2)**  	*Review this chest radiograph. Try to identify as much normal anatomy as possible. <u>Remember to be systematic</u>.* *The interface along the right inferior mediastinum is created by the lateral margin of the right atrium (a soft tissue or water density structure) contacting the aerated medial segment of the right middle lobe–this is the so-called "right heart border."* **[Advance slide to see "right heart border" highlighted]** *Similarly, the inferior left mediastinal contour is created by the*

SLIDE #	SLIDE TITLE	TEACHING NOTES
		contact between the left ventricle and air within the lingula–the "left heart border." **[Advance slide to see "left heart border" highlighted]** *The main and left pulmonary arteries are routinely visible on most frontal chest radiographs.* **[Advance slide to see pulmonary arteries highlighted]** *The main pulmonary artery is located medially, and the left pulmonary artery courses slightly superiorly, laterally, and then turns inferiorly. The right main pulmonary is often only barely visible on the frontal chest radiograph centrally, but the right interlobar and lower lobe pulmonary artery* **[Advance slide to see arrow]** *is virtually always seen.* *The aorta* **[Advance slide to see aorta highlighted]** *is routinely visible on frontal chest radiographs. The aortic arch is a rounded structure located superiorly, with the lateral margin of the descending thoracic aorta variably seen extending inferiorly from the arch. The aortic contour is not as readily seen in younger patients, but as this structure often distorts (becomes "tortuous") with aging, the aortic arch and descending thoracic aortic contours become more prominent and readily visible.* *The central airways* **[Advance slide to see central airways highlighted]** *, including the trachea and main bronchi, are usually visible as air lucency seen through the mediastinum and medial lung.* **[Advance slide]**
23	**Basic CXR Anatomy (3)** 	*Lateral radiographic anatomy is often challenging because the anatomy of both lungs and the mediastinum overlap in this projection. Regardless, much like the frontal radiograph, several anatomic structures are routinely visible on lateral chest radiographs and should be sought upon every review.* *The aortic arch is usually visible along the cranial aspect of the image* **[Advance slide to see arrows, highlighting aortic arch].** *As on the frontal image, as patients age, more of the ascending*

SLIDE #	SLIDE TITLE	TEACHING NOTES
		and descending aortic contours may be visible on the lateral chest radiograph. *Due to its right lateral orientation, the right pulmonary artery* **[Advance slide to see right pulmonary artery highlighted]** *is seen as a round or oval structure in the anterior hilum on the lateral chest radiograph.* *The left pulmonary artery* **[Advance slide to see left pulmonary artery highlighted]** *is often visible in the posterior aspect of the hilum on the lateral chest radiograph, making a small arch that parallels the larger arch described by the thoracic aorta.* *The trachea and main bronchi are often visible on the lateral chest radiograph* **[Advance slide to see trachea and main bronchi highlighted]**. *The trachea is seen as a tubular lucent structure extending downward in the center of the thorax. The tracheal carina is located where the caudal aspect of the trachea appears to narrow. The orifices of the right upper lobe bronchus and the combination of the left main bronchus and left upper lobe bronchus are occasionally seen as circular or oval lucencies projected over the tracheal air column; the right upper lobe bronchial orifice is the more cranially located of the two.* **[Advance slide]**
24	**Basic Radiology for the TB Clinician: Patterns of Disease**  	*With an understanding of chest radiographic anatomy, the manner of generating radiographic images, and technical factors that influence interpretation, you--the reviewer--are now prepared to gain an appreciation of the various patterns of disease that may be seen with chest radiography.* **[Advance slide]**

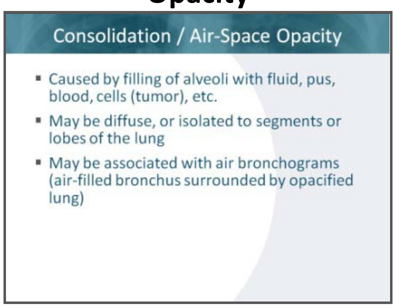
<table>
<tr><th>SLIDE #</th><th>SLIDE TITLE</th><th>TEACHING NOTES</th></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>25</td><td>Chest Radiographic Patterns of Disease



</td><td>Broadly classified, a number of abnormal patterns may be recognized on chest radiography. These patterns include:

Air-space opacity or consolidation, often referred to as air-space disease
Interstitial opacity
Nodules or masses
Thoracic lymphadenopathy
Pulmonary cysts or cavities
Pleural space abnormalities
Each of these abnormal patterns (which are recognizable on chest radiography) will be reviewed.

[Advance slide]</td></tr>
<tr><td>26</td><td>Consolidation / Air-Space Opacity



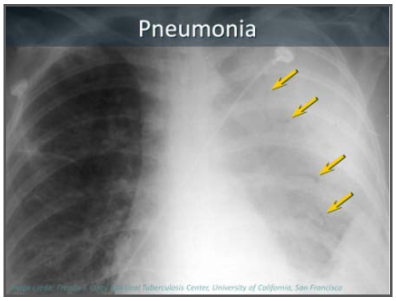
</td><td>Consolidation, or air-space opacity, represents a condition in which the air within the pulmonary alveoli has been replaced by another substance. Such substances can include pus (pneumonia), blood (pulmonary hemorrhage), edema fluid, or tumor.

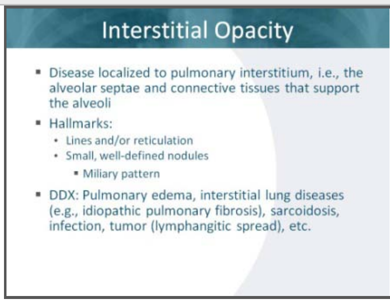
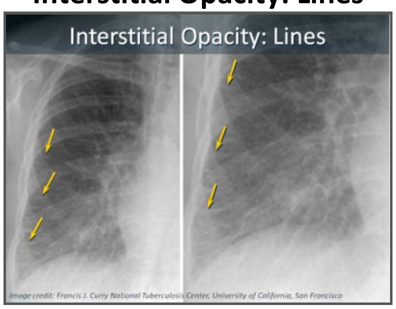
Pulmonary consolidation may be focal (i.e., limited to a small region of the lung) or more widespread.

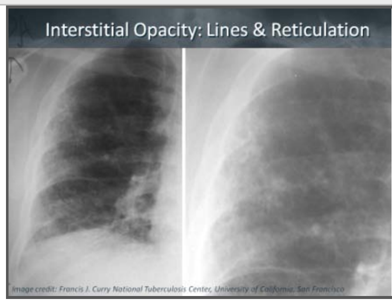
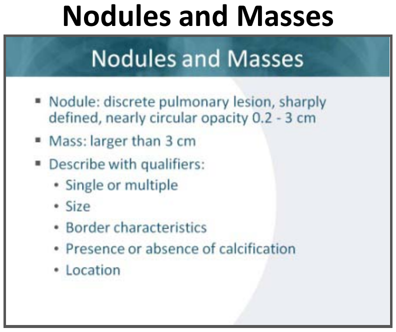
Consolidation, or air-space opacity, is recognized on a chest radiograph when one or more of the following features are seen:

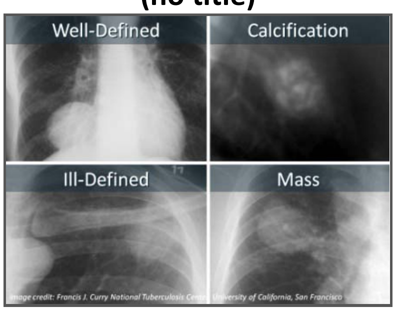
Homogeneous increased pulmonary opacity that obscures the margins of pulmonary vessels and airway walls
Air bronchograms (or small lucencies within the areas of increased opacity, often referred to as “air alveolograms”)
Pulmonary opacities with ill-defined margins, often patchy in appearance
Extension to pleural surfaces
Small nodules, often referred to as “air-space nodules” or “acinar nodules”

[Advance slide]</td></tr>
</table>

SLIDE #	SLIDE TITLE	TEACHING NOTES
27	**Pneumonia**  	*Review the chest radiograph. How should the abnormalities be characterized? What <u>pattern of disease</u> is present?* *The chest radiograph shows homogeneous increased opacity throughout the left lung. Several tubular lucencies are present* **[Advance slide to see arrows]***–these lucencies represent air bronchograms. The presence of air bronchograms and homogenous pulmonary opacity extending to the pleural surface suggests that the pattern of disease present is consolidation or air-space opacity. This patient has left lung bacterial pneumonia.* *The presence of air bronchograms is really a reverse manifestation of the silhouette sign. Normally air-filled bronchi are not readily visible within the lung parenchyma because the lung also contains air, and therefore there is virtually no density difference to create a perceptible interface (the silhouette sign). Only the bronchial wall–a soft tissue/ water density structure–is sufficiently different in density enough to provide the contrast required to distinguish aerated lung parenchyma from air-filled bronchi, and because bronchial walls are relatively thin, they are only normally seen in the central lung. However, when air in the pulmonary parenchyma is replaced by another substance–pus in this example of this patient with pneumonia–the air within bronchi becomes contrasted with the water density of the pulmonary parenchyma, creating the appearance of air bronchograms.* **[Advance slide]**
28	**Interstitial Opacity**	*Abnormalities involving the pulmonary interstitium affect the connective tissue framework of the lung, such as the interlobular septae. As a result, interstitial diseases tend to produce fairly well-defined pulmonary findings such as:* • *Linear abnormalities ("lines")* • *Small, well-defined nodules (miliary disease is an example of*

SLIDE #	SLIDE TITLE	TEACHING NOTES
		*an interstitial process producing small nodules)* • *Lines that intersect, or "criss-cross" with one another, creating a net-like pattern referred to as "reticulation" (one way to visualize this is to think of the reticular pattern on the hide of a giraffe).* *The differential diagnosis (DDX) of interstitial pulmonary diseases is extensive, and includes pulmonary edema, infections (including* Mycobacterium tuberculosis*), the idiopathic interstitial pneumonias (including fibrotic lung diseases), a number of other non-infectious inflammatory diseases (such as sarcoidosis), and tumors, among other rarer diseases.* *Many diseases will show both interstitial and air space disease patterns on chest radiography, and it is not uncommon to see both patterns on a chest radiograph.* **[Advance slide]**
29	**Interstitial Opacity: Lines** 	*Review the chest radiograph. What pattern of disease is present?* *There are a number of small, well-defined linear opacities ("lines") best seen in the lung periphery where they intersect the pleural surface* **[Advance slide to see arrows]**. *These linear opacities are the hallmark of an interstitial process. These findings are easier to see on the magnified, detail image on the right.* **[Advance slide to see magnified view on right]** *This patient has congestive heart failure producing hydrostatic pulmonary edema. The heart failure has produced "thickening" of the pulmonary interstitium, resulting in linear opacities on the chest radiograph sometimes referred to as Kerley B lines.* **[Advance slide]**
30	**Interstitial Opacity: Lines & Reticulation**	*Review the chest radiograph. What pattern of disease is present?* *Areas of increased opacity are seen in the peripheral right lung, immediately adjacent to the pleural surface. These opacities consist of intersecting linear opacities, creating a "net-like," or reticular, pattern. These findings may be more easily seen on*

SLIDE #	SLIDE TITLE	TEACHING NOTES
	 	*the magnified, detailed image.* **[Advance slide to see magnified view on right]** *Reticular patterns are another major manifestation of interstitial lung diseases on chest radiography.* *The interobserver agreement of various interstitial pulmonary opacities on chest radiography is rather low. That is, it can be difficult to distinguish whether a particular pattern is linear, nodular, or reticular, and different reviewers may have different impressions. This variability has given rise to widespread use of the term "reticulonodular" when describing interstitial opacities on chest radiography. Ultimately it is best to attempt to classify the interstitial pattern present as linear, nodular, or reticular, based on the predominant type of opacity present because the differential diagnosis of each of these three opacities is slightly different. Regardless, this exercise can be challenging and proper characterization often requires further evaluation with thoracic CT if available.* *The patient in the example has idiopathic pulmonary fibrosis, an interstitial lung disease frequently characterized by reticular opacities on chest radiography.* **[Advance slide]**
31	**Nodules and Masses**  	*Nodules and masses on chest radiography may represent air-space disease, interstitial disease, or a combination of these two phenomena.* *A <u>nodule</u> is defined as a discrete, nearly circular opacity on a chest radiograph ranging up to 3 cm in size.* *A <u>mass</u> is essentially the same as a nodule but is greater than 3 cm in size.* *Nodules and masses should be characterized as thoroughly as possible to provide an accurate differential diagnosis and properly direct patient management.* **[Advance slide]** *In particular, when the reviewer finds a nodule or mass on chest radiography, the reviewer should first decide whether or not the lesion is single or if multiple lesions are present. Next, the*

SLIDE #	SLIDE TITLE	TEACHING NOTES
		reviewer should note the size of the lesion, as certain processes may be more or less associated with certain nodule size ranges. Additionally, the reviewer should describe the border characteristics of the nodule: • *Is the border circumscribed (i.e., can the border be easily traced with a pencil tip), or is it ill defined?* • *Is the contour smooth, lobulated (i.e., a "lumpy" margin), or is the lesion spiculated (i.e., has sharp, "spiny" protrusions)?* *The reviewer should also search for areas of increased opacity within the nodule or mass. These areas may represent calcification. Calcification within a nodule or mass is usually associated with a benign etiology, although not always. Calcification is also characteristic of granulomatous inflammation (particularly tuberculous and fungal infections and sarcoidosis).* **[Advance slide]**
32	**(no title)**  	*Characterize the nodules or masses in each of these examples:* *The mass in the upper left image has circumscribed, or well-defined, margins.* **[Use laser pointer to highlight]** *Compare the lesion in the upper left with the lesion in the lower left image. Note how the margins, or border characteristics, of this lesion are difficult to trace because they are "fuzzy."* **[Use laser pointer to highlight]** *This is typical of an ill-defined mass or nodule.* *Look at the image on the upper right. Note how this nodule contains areas of increased opacity.* **[Use laser pointer to highlight]** *These areas of increased opacity must be denser than soft tissue and in fact represent irregular calcification within the lesion (example is a hamartoma).* *Finally, consider the lesion in the lower right image. This lesion is classified as a mass because it measures nearly 6 cm in size. Its borders are mostly circumscribed. There is a small focus of increased opacity within the center of the mass, which*

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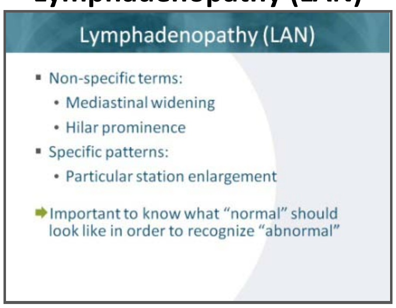
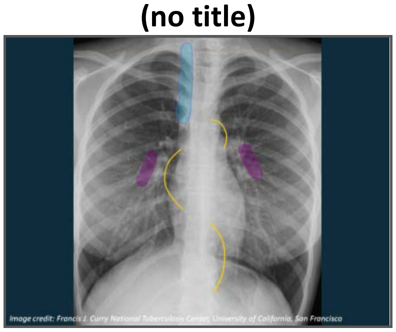
		represents calcification. **[Use laser pointer to highlight]** *This mass is a lung cancer. This lesion illustrates the point that, while calcification within a pulmonary nodule is usually associated within a benign process, the mere presence of calcification within a nodule or mass usually does not guarantee that the nodule is benign.* **[Advance slide]**
33	**Lymphadenopathy (LAN)** 	*Evidence for abnormal intrathoracic lymphadenopathy should be sought on every chest radiograph reviewed.* *Often reviewers of chest radiography will use fairly non-specific terms when describing the possible presence of intrathoracic lymphadenopathy. Such terms include "mediastinal widening" or "hilar prominence." These terms are non-specific descriptors that do not provide the clinician with a clear indication of whether a finding is normal or abnormal and are therefore discouraged by many radiologists. Defining enlarged nodes by the lymph node station (location) is preferred.* *Again, it is particularly important to train the eyes to recognize what normal structures should look like in order to reliably recognize when abnormalities exist.* *Although identifying suspected lymphadenopathy can be quite challenging for many clinicians, it is helpful to know where to expect to see enlarged intrathoracic lymph nodes. Intrathoracic lymph nodes are usually encountered in specific areas, and these areas will be highlighted on the next slide.* **[Advance slide]**
34	**(no title)** 	*Normal frontal chest radiograph highlighting areas to routinely look for lymphadenopathy:* *<u>Right paratracheal region:</u> The right paratracheal stripe* **[Advance slide to see this highlighted]** *is a thin structure, usually not greater than 4 mm, along the right lateral wall of the trachea. This stripe is formed by the right lateral tracheal wall, some mediastinal fat, and small lymph nodes. When right paratracheal lymphadenopathy is present the stripe "thickens"*

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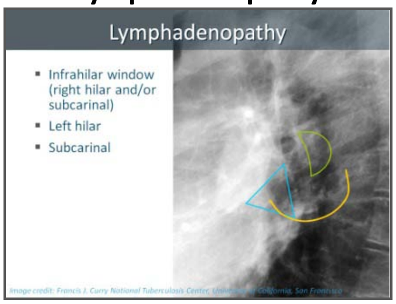
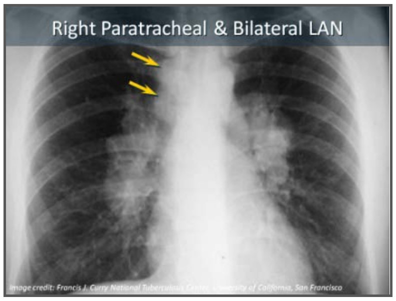
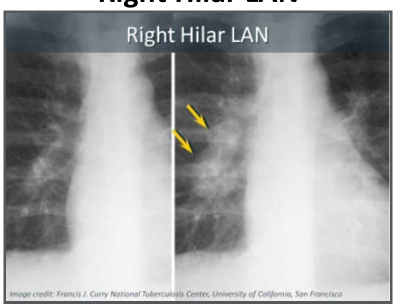
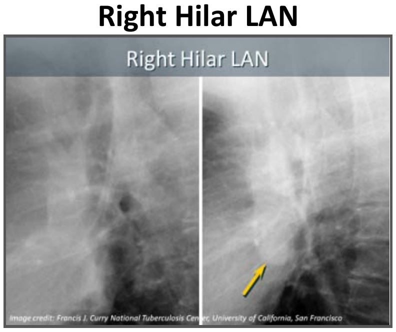
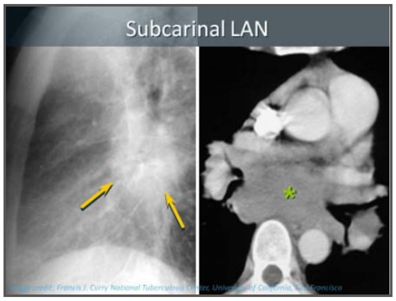
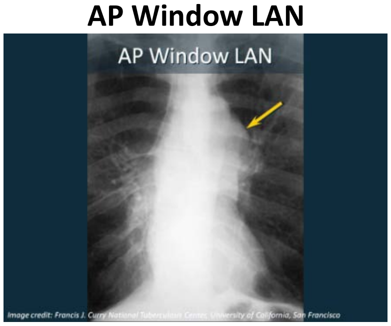
		and often appears lobulated. *Hilar region:* *Hilar lymph nodes are located immediately adjacent to the pulmonary arteries.* **[Advance slide to see these highlighted]** *When hilar lymph nodes enlarge, the pulmonary arteries will appear larger, denser, and often lobulated or "lumpy-bumpy."* *Aorto-pulmonary (AP) window:* *The AP window* **[Advance slide to see this highlighted]** *is the region of the mediastinum located inferior to the arch of the aorta and above the main and left pulmonary artery. This area is usually concave or straight. When a convexity is encountered in the AP window, lymphadenopathy should be suspected.* *Subcarinal region:* *Masses in the subcarinal space* **[Advance slide to see this highlighted]** *can achieve a rather large size before they are readily detectable on frontal chest radiography. Once they achieve a sufficient size, such masses will "push" into the medial right lung and create a contour that is convex laterally (note that the presence of the thoracic aorta restricts subcarinal lesion growth on the left). If large enough, subcarinal masses will displace the right pulmonary artery laterally. Lesions in this region are often most easily detected on the lateral radiograph.* *Paravertebral space:* *Posterior mediastinal lymphadenopathy* **[Advance slide to see this highlighted]** *usually presents on frontal chest radiography as a paravertebral mass. Such masses will "push" into the adjacent lung and create a convex, laterally-facing contour along the thoracic spine. On the left side, paravertebral masses may disrupt the stripe created by the descending thoracic aorta as it runs along the left lower lobe.* **[Advance slide]**

SLIDE #	SLIDE TITLE	TEACHING NOTES
35	**Lymphadenopathy** 	*The lateral chest radiograph is well-suited to the detection of lymphadenopathy in the hilar regions and subcarinal space. A firm understanding of anatomy is required to effectively recognize enlarged intrathoracic lymph nodes on the lateral chest radiograph.* *Recall that the right hilar vessels (mostly the right pulmonary artery and to a lesser extent the right upper lobe pulmonary vein) create the round or oval-shaped structure seen in the anterior aspect of the hilum on the lateral chest radiograph; the left pulmonary artery appears as a comma-shaped structure comprising the posterior superior aspect of the hilum. Just inferior to the shadow created by the right pulmonary artery, no major vessels or contours are usually present–this area is often referred to as the "inferior hilar window."* **[Advance slide to highlight inferior hilar window]** *The presence of a soft tissue opacity or unexpected contour in this area often indicates the presence of lymphadenopathy.* *Left hilar lymphadenopathy* **[Advance slide to highlight left hilar lymphadenopathy]** *often appears as a contour or interface that increases the density of or appears to enlarge the left pulmonary artery.* *Subcarinal lymphadenopathy* **[Advance slide to highlight left subcarinal lymphadenopathy]** *on the lateral chest radiograph is often detected as a contour or interface that faces inferiorly, often located at, or just below, the level of the right pulmonary artery.* *Hilar lymphadenopathy on the lateral radiograph may be seen as an increase in hilar size, a focal mass, lobulation of the hilar contours, or alteration in the normal hilar contours.* **[Advance slide]**

SLIDE #	SLIDE TITLE	TEACHING NOTES
36	**Right Paratracheal & Bilateral LAN** 	*This chest radiograph shows increased density and lobulation in the right paratracheal region* **[Advance slide to see arrows]** *and hila bilaterally–this finding is characteristic of lymphadenopathy in these regions.* *The patient in this example has sarcoidosis, a condition often associated with intrathoracic lymphadenopathy.* **[Advance slide]**
37	**Right Hilar LAN** 	*These two images are of the same patient. The image on the left was taken prior to the development of right hilar lymphadenopathy (shown on the right).* *Note how the abnormal right hilum appears denser than on the normal image, and how, in the later image, there is lobulation* **[Advance slide to see arrows]**. *In the normal situation, the lateral margin of the hilum and pulmonary artery is either straight or minimally convex. Lobulation is an abnormal condition.* **[Advance slide]**
38	**Right Hilar LAN** 	*Here is the same patient (before and after development of right hilar lymphadenopathy) in the lateral view.* *The image on the left is a cropped image of the central lung and hilum showing the appearance of the normal right hilum. (Anterior is to the left of the image, and posterior is to the right. Posteriorly the thoracic spine is just visible.)* *On the image on the right, after the patient has developed right hilar lymphadenopathy, note how a new contour* **[Advance slide to see arrow]** *has developed just below the right pulmonary artery–this area is the inferior hilar window. The inferior hilar window is normally a relatively avascular area projecting just inferior to the right pulmonary artery. When right hilar lymphadenopathy is present, a contour abnormality*

SLIDE #	SLIDE TITLE	TEACHING NOTES
		or new, unexpected interface may be found in this region. **[Advance slide]**
39	**Subcarinal LAN** 	*Review this lateral chest radiograph. What abnormality is present on this image?* *Find the right pulmonary artery shadow* **[Use laser pointer to highlight** *–recall that it is a soft tissue structure located in the anterior hilum. In this patient, note how the density of the right pulmonary artery appears contiguous with the increased opacity seen inferiorly in the infrahilar window, and that a contour abnormality, or a new unexpected interface, is now seen in the inferior aspect of the hilum* **[Advance slide to see arrows]**. *Note how this abnormality creates an inferiorly facing interface.* *This appearance is typical of a subcarinal mass. Such masses may be caused by several different processes, but lymphadenopathy is one of the more important causes.* *The thoracic CT image* **[Advance slide to see CT image]** *on the right shows a soft tissue mass located between the lower lobe bronchi, filling the subcarinal space* **[Use laser pointer to highlight.]**. *This mass was due to lymphadenopathy resulting from lymphoma.* **[Advance slide]**
40	**AP Window LAN** 	*Review this frontal chest radiograph. What abnormality is present?* *Recall that the normal AP window creates an outwardly concave or straight interface with the adjacent left lung. Note that the AP window in this patient pushes outward creating a convex contour with the adjacent left lung* **[Advance slide to see arrow]**. *This is an abnormal condition.* *When a convex contour is present in the AP window, lymphadenopathy* **[Advance slide]** *should be strongly suspected. Rarely other processes could be responsible for this appearance, but lymph node enlargement is most often responsible.*

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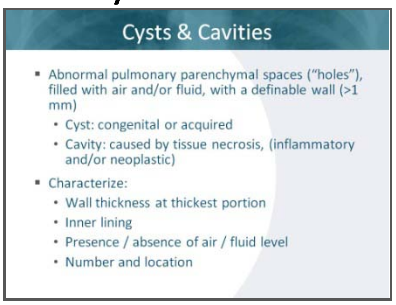
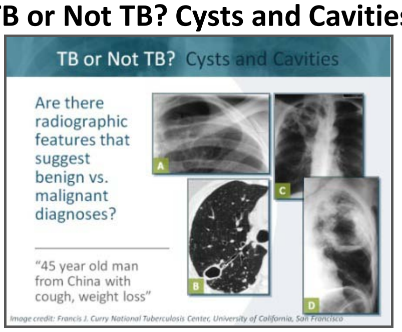
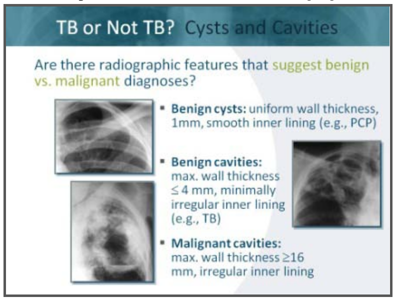
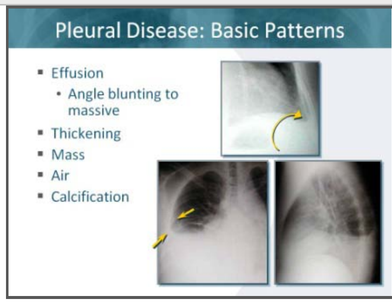
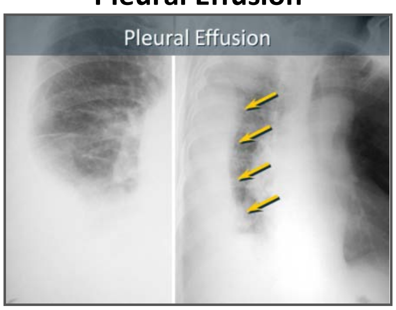
		The lymph node enlargement in the AP window in this example was due to tuberculous lymphadenitis in a severely immunocompromised patient. **[Advance slide]**
41	**Cysts & Cavities**  	*Pulmonary cysts and cavities are focal lucent areas on chest radiography that may be filled with air and/or fluid and usually possess a definable wall. They may be simplistically thought of as "holes" in the lung.* **[Advance slide]** *Pulmonary cysts are focal parenchymal spaces (again, filled with air and/or fluid) with thin walls. They may be either congenital or acquired.* **[Advance slide]** *While there are no strict criteria for defining a radiographic lesion as a "cavity", the use of this term implies visual findings suggestive of underlying pathologic tissue necrosis occurring within a nodule or mass. The wall thickness may be variable, usually at least a millimeter or thicker, composed of inflammatory or neoplastic material. Cavities may develop in cases of infection, infarction, or malignancy.* *Note that other causes of lucent areas on chest radiographs include bronchiectasis and emphysema.* **[Advance slide]** *When describing the characteristics of either a cyst or cavitary lesion, the list of characteristics above should be noted.* **[Advance slide]**
42	**TB or Not TB? Cysts and Cavities**  	*Practice describing the basic characteristics of cystic and cavitary lesions with these different images. Each of these examples (A, B, C, D)* **[Advance slide to reveal each]** *could have presented the same symptoms: "a 45-year-old man from China with cough and weight loss."* *Are there any radiographic features that would suggest benign vs. malignant diagnoses?* **[Advance slide]**

SLIDE #	SLIDE TITLE	TEACHING NOTES
43	**TB or Not TB?** **Cysts and Cavities (2)** 	*This is a good example of a benign pulmonary cyst, a "pneumatocele."* **[Advance slide]** *The uniformly thin walls and smooth inner lining are characteristics that suggest a benign etiology (the lesion here resulting from an infection with Pneumocystis jiroveci pneumonia).* **[Use laser pointer to highlight]** *Next* **[Advance slide]***, these are two different examples of benign-appearing cavities. While the walls may be somewhat irregular in thickness (perhaps as much as 3-4 millimeters in their thickest portion), they remain relatively thin-walled overall.* **[Use laser pointer to highlight]** *Benign etiology is suggested by the smooth (or only slightly irregular) internal lining, with wall thickness no more than 4 millimeters at its thickest portion (both examples here are from different cases of tuberculosis).* *Grossly malignant cavities* **[Advance slide]** *often have very nodular and irregular wall contours and internal linings. A wall thickness (at the thickest portion) greater than 16 millimeters with significant irregularity would be highly suggestive of malignancy, as in this example of a cavitary squamous cell lung cancer. Here, the right-sided borders of this lesion measure more than 20 millimeters.* **[Use laser pointer to highlight.]** *When the wall thickness of a cavity at its thickest portion measures between 5 and 15 millimeters, the lesion is considered indeterminate in regard to suggesting a benign or malignant etiology based on radiographic appearance.* **[Advance slide]**
44	**Pleural Disease: Basic Patterns**	*Abnormalities that may affect the pleural space include pleural effusion, pleural thickening, pleural masses, air within the pleural space (pneumothorax), and pleural calcification.* *The most common and familiar abnormal finding affecting the pleura is an effusion, which can range from minimal blunting to massive with total whiteout of the hemi-thorax. Fluid tends to*

SLIDE #	SLIDE TITLE	TEACHING NOTES
		*form a homogeneous density with a smooth, discrete interface that curves as it reaches the chest wall forming a meniscus* **[Advance slide to see arrows]**. *Here the arrows point to the curvilinear meniscus suggesting the presence of pleural fluid, sometimes best appreciated on a lateral view.* *Thickening of the pleura may range from nonspecific subtle findings to larger pleural plaques.* *Masses may also present in the pleural region and are often best defined by computed tomography (CT) if available.* *A pneumothorax is suspected when loss of normal "lung markings" (pulmonary vessels) is noted adjacent to the remaining lung as it falls away from the pleural surface.* *Some chronic pleural processes may calcify, particularly in prior tuberculous empyema, prior hemothorax (blood in the pleural space), and asbestos-related pleural disease.* **[Advance slide]**
45	**Pleural Effusion** 	*When fluid is suspected, as in this first film (on the left), it is useful to check for mobility of the fluid, which can be done with decubitus imaging. Defining how much of the opacity found on the frontal view is actually free-flowing fluid vs. an alternate abnormality (e.g., mass, consolidation, loculated fluid) allows for appropriate planning of invasive diagnostic procedures.* **[Advance slide to see right image]** *On the right is the decubitus film of the same patient, lying on their right side (note that the film is displayed here in the upright position). The large density seen on the frontal view has almost entirely "layered out" with the shift in position* **[Advance slide to see arrows]** *confirming a large component of mobile fluid within the pleural space.* **[Advance slide]**

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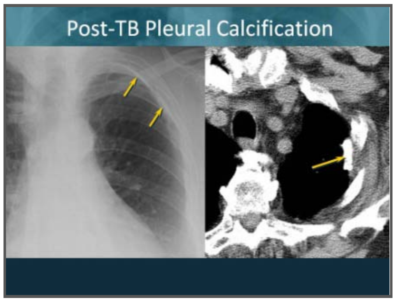
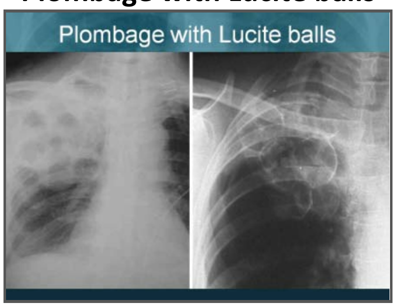
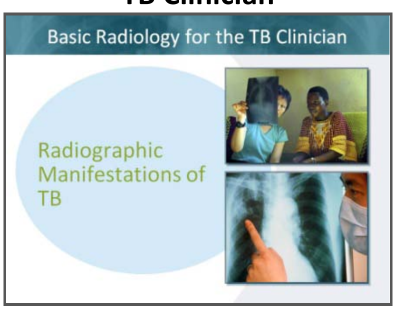
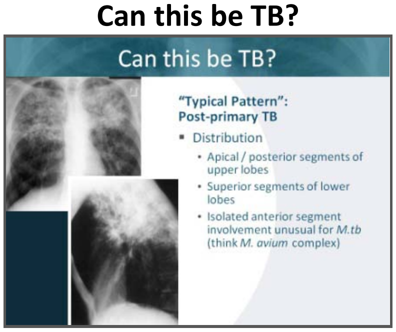
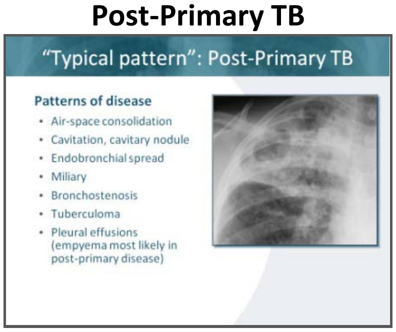
46	**Post-TB Pleural Calcification** 	*Here is an example of pleural calcification, seen as a very bright white linear opacity along the pleural surface* **[Advance slide to see arrows]**. *This same process is identified on the accompanying CT scan.* **[Advance slide]**
47	**Plombage with Lucite balls** 	*Prior to the advent of adequate pharmacologic treatment for tuberculosis, collapsing the infected lung by surgical placement of material within the pleural space (plombage) was a treatment option. Here are two examples showing multiple lucite balls placed in the right extrapleural space. [This is no longer a current practice and these images are shown for their historical interest.]* **[Advance slide]**
48	**Basic Radiology for the TB Clinician** 	*And finally, this last section will cover some of the basic radiographic manifestations of pulmonary tuberculosis.* **[Advance slide]**
49	**Can this be TB?** 	*Can this be TB?* *Describe the frontal chest radiographic findings:* *There is bilateral upper lobe consolidation (air-space opacity) with possible cavitation. The hilar structures are retracted upward suggesting some upper lobe volume loss as well.* **[Use laser pointer to highlight]** **[Advance slide to view lateral view]** *The lateral view of the same patient shows typical involvement predominating within the apical and posterior upper lobe segments of the lung.* **[Use**

<table>
<tr><th>SLIDE #</th><th>SLIDE TITLE</th><th>TEACHING NOTES</th></tr>
<tr><td></td><td></td><td>laser pointer to highlight. Advance slide to see text]

This is a classic example of what is commonly thought of as the most “typical” radiographic pattern of presentation for tuberculosis, often referred to as a “post-primary” or “reactivation” TB pattern.

This pattern of disease characteristically involves the apical and posterior segments of the upper lobes, and often the superior segment of the lower lobe. The predilection for the upper lobes is thought to be due to decreased lymph flow in the upper regions of the lung. Historically, an alternative explanation is the presence of higher oxygen tension in that region.

While the anterior segment of the upper lobe may be involved in addition to the other lobes, a presentation with isolated involvement of the anterior segments is unusual for tuberculosis (it is unclear why this is so). If only the anterior segment is involved, one should consider the possibility of an alternative diagnosis (disease due to M. avium complex is one example).
[Advance slide]</td></tr>
<tr><td>50</td><td>“Typical pattern”:
Post-Primary TB

</td><td>Other findings associated with the “typical pattern” (post-primary):

Air-space consolidation is the most common parenchymal finding and may be patchy or confluent in nature.

Cavitation may be more commonly seen with this pattern of TB and appears as the result of caseous necrosis. The presence of cavitation is indicative of a very high burden of mycobacteria and one would expect smear microscopy to be positive in these cases.

The more nodular appearance of the air space opacities can reflect areas of endobronchial spread of the disease (infectious material spreading within the airways).

Other findings may include miliary disease (example to follow),</td></tr>
</table>

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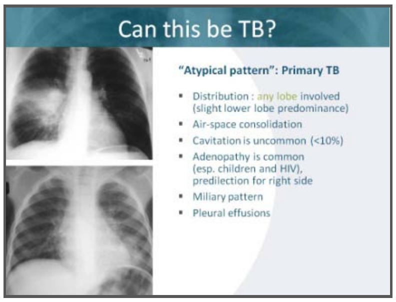
		bronchostenosis (if airways become scarred and narrowed due to disease), and focal, circumscribed, rounded pulmonary nodules referred to as "tuberculomas." *Pleural effusions may be associated with post-primary disease on occasion. Empyemas can be found in post-primary disease as well (and are unlikely in primary TB).* **[Advance slide]**
51	**Can this be TB?** 	***Can this be TB?*** *The upper film has a right mid-lung air-space opacity with right hilar lymphadenopathy, and blunting of the right costophrenic angle consistent with a small pleural effusion.* **[Use laser pointer to highlight]** *This was an HIV-negative adult with culture-confirmed pulmonary TB.* *The lower film is a child with left lower-lobe air-space consolidation with possible left hilar enlargement.* **[Use laser pointer to highlight]** *This was a child with primary TB.* *Both images represent examples of the more "atypical" or primary disease pattern of pulmonary TB.* **[Advance slide to view text]** *The distribution of air-space consolidation in patients with an "atypical" disease pattern may involve any lobe (although there may be a slight lower lobe predominance in adults).* *Cavitation, though unusual, can occur in adults with progressive primary TB.* *Lymphadenopathy is common in children and HIV-infected individuals (and may be the only radiographic abnormality, particularly in small children). There is a predilection for the right side, especially in the paratracheal and hilar areas. Lateral radiographs may be helpful in confirming the presence of suspected lymphadenopathy.* *Miliary disease and pleural effusions may also be seen with primary TB.*

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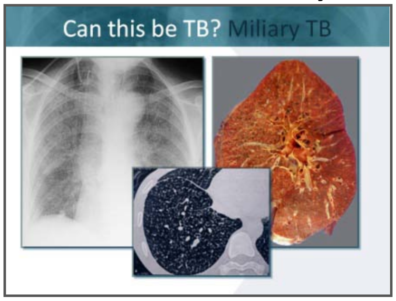
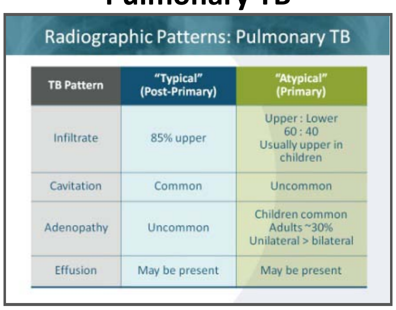
		[Advance slide]
52	**Can this be TB? Miliary TB** 	*Can this be TB?* *These are all examples of the fine, stippled pattern of small nodules seen in miliary TB on chest radiography. The small nodules seen on chest radiography correspond to the gross pathology on the right* **[Advance slide to see gross pathology]** *showing diffusely disseminated granulomatous lesions.* **[Use laser pointer to highlight]** *This pattern of nodules, which reflects the hematogenous spread of disease, can also be seen easily with chest CT.* **[Advance slide to see CT scan]** *Note that a miliary pattern may be seen in either primary or reactivation/post-primary disease.* **[Advance slide]**
53	**Radiographic Patterns: Pulmonary TB** 	*Compare the two patterns of radiographic findings associated with TB.* **[Review contents of table]** *The radiographic patterns described for pulmonary TB have been detailed in multiple studies from the 1950s through the early 1990s. While primary TB had been traditionally seen as a childhood disorder, in the era of HIV, the demographics of primary disease is changing to include a significantly greater proportion of adults, particularly the immunocompromised.* *Using the terms "primary" and "post-primary/reactivation" to describe radiographic patterns vs. actual disease pathogenesis:* • *Research studies using RFLP data (restriction fragment length polymorphism analysis), or DNA fingerprinting, have suggested that perhaps the terms "primary" vs. "post-primary/reactivation" TB to describe these radiographic patterns may be misleading. When the temporal presentation of active cases of TB have been identified as presenting <1 year after infection (indicating primary disease pathogenesis in outbreak*

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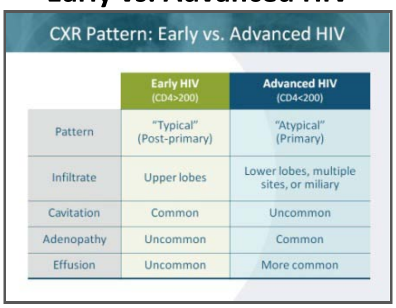
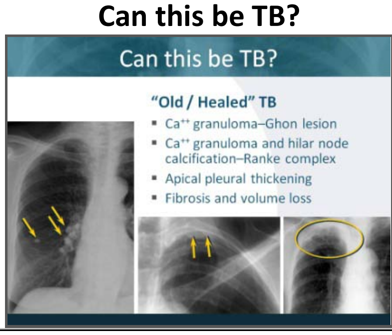
		cases linked by RFLP data) or presumed to be reactivation TB (unique DNA strains not linked to a source case within the community), both radiographic patterns have been found with either disease states. • *In other words, although the "primary" pattern may be found more often associated with true primary disease, and the "post-primary" pattern more often in true reactivation cases, it is important to recognize that either radiographic pattern may be present regardless of the actual pathogenesis of the active TB.* **[Advance slide]**
54	**CXR Pattern: Early vs. Advanced HIV**  	*How does HIV disease effect the radiographic presentation of TB?* **[Review contents of table]** *As this table suggests, the pattern of TB in HIV-infected individuals is dependent on the degree of immunosuppression. CD4 counts <200 are associated with a more atypical / primary TB disease presentation, consistent with the known rapid progression of disease in these individuals. Disseminated disease is also more common in individuals with severe immunocompromise.* *Cavitation is particularly uncommon as the CD4 drops, while lymphadenopathy and the presence of effusions increases.* *It is also important to note that the CXR may be normal in up to 10% of cases in HIV-infected individuals with culture-confirmed TB.* **[Advance slide]**
55	**Can this be TB?**  	*These chest radiographs show the commonly encountered appearances of prior, healed tuberculous infection.* *The imageon the right shows a small calcified nodule in the mid right lung, consistent with a calcified granuloma. In isolation, such calcified nodules are often referred to as "Ghon" lesions.* **[Advance slide to see arrows/associated text]**

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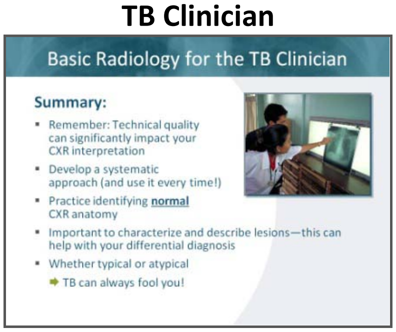
		Areas of nodular increased density are seen within the right hilum **[Advance slide to see arrows/associated text]**, *consistent with calcified lymph nodes. The combination of a calcified lung nodule and calcified hilar or mediastinal lymph nodes is often referred to as the "Ranke" complex.* *Apical pleural thickening is a very common sequela of numerous pulmonary inflammatory processes, TB included. Apical pleural thickening may be quite mild, as seen in the middle image* **[Advance slide to see arrows/associated text]**, *or more severe, as seen in the image on the right.* *When severe pulmonary inflammation has occurred and subsequently healed, apical pleural thickening may often be seen in combination with other features suggesting prior inflammation, such as volume loss, coarse linear opacities, traction bronchiectasis, and architectural distortion* **[Advance slide to see circle/associated text]**. *Such findings are illustrated in the third image on the right.* **[Advance slide]**
56	**Basic Radiology for the TB Clinician** 	*To accurately interpret chest radiographs, an appreciation of the technical factors that influence chest radiographic quality is required.* **[Advance slide to view text]** *These factors include inspiratory effort, degree of image penetration, and patient positioning. Each factor should be assessed every time an image is reviewed.* **[Advance slide to view text]** *When reviewing chest radiography, be systematic. Using the same approach every time, regardless of whether the image is normal or abnormal, will reduce error.* **[Advance slide to view text]** *Accurate chest radiography interpretation requires a firm understanding of anatomy. Review basic radiographic anatomy every time a chest radiograph is interpreted–this approach will train the reviewer to recognize what is normal and what is abnormal.* **[Advance slide to view text]** *Use a standard approach and terminology when characterizing*

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		findings on chest radiography. Describing findings in a standardized fashion facilitates accurate diagnosis and enhances communication with others. **[Advance slide to view text]** *Recognize that TB tends to be associated with particular chest radiographic presentations that tend to correlate with patient age and immune status. However, TB has a diverse appearance on chest radiography and accurate diagnosis requires a high index of suspicion.* **[End]**