Ventilation
Clarification of Terminology

- **Ventilation**: the mechanical process by which air is inhaled and exhaled through the lungs. It describes only the movement of air.
- **Respiration**: a term used to describe the gas exchange that occurs within the lungs (the exchange of oxygen & carbon dioxide between the lungs and blood)
- Ventilation *allows for* respiration

Mansfield, p366
Osteology of Ventilation

- The **Thoracic Cage** is bounded:
  - Anteriorly by the sternum
  - Posteriorly by the bodies of the 12 thoracic vertebrae
  - Superiorly by the clavicle
  - Inferiorly by the diaphragm

Lippert, p235
Osteology of Ventilation

- The Rib Cage attaches the vertebral column to the sternum.
- There are 12 ribs on the left and 12 on the right, for a total of 24 ribs.
- The upper 7 ribs are called True Ribs because they attach directly to both the vertebral column AND the sternum.
- Ribs 8 through 10 are called False Ribs because they attach to the sternum indirectly via the costal cartilage of the 7th rib.
- Ribs 11 & 12 are called Floating Ribs because they do not attach to the sternum.

Lippert, p235
Osteology of Ventilation

- The Rib Cage
The Thoracic and Rib Cages

- House and protect the thoracic cavity, which contains:
  - Heart
  - Lungs
  - Aorta
  - Thymus gland
  - Portion of trachea
  - Esophagus
  - Lymph nodes
Respiration

- Respiration is the exchange of oxygen and carbon dioxide between the lungs and the blood.
- **Boyle’s Law**: the volume and pressure of a gas are inversely proportional.

Mansfield, p367
Respiration continued...

- Respiration is the result of changes in thoracic volume, hence thoracic pressure (as volume and pressure are related...inversely!)
- It is important to remember that air flows from higher pressure to lower pressure until pressure is equalized
- Therefore, we need to lower the pressure in the lungs so that air will flow from higher pressure (air) to lower pressure (the lungs)
- In order to lower the pressure in the lungs, we need to increase the volume (inverse relationship)

Lippert, p236 & 238
Respiration continued...

- There are 2 ways of changing thoracic volume...
  - 1) moving the ribs
  - 2) lowering the diaphragm
Ventilation

- Ventilation is comprised of:
  - **Inhalation**: drawing air into the lungs
  - **Exhalation**: exhaling air from the lungs into the environment

Mansfield, p367
Ventilation continued...

- **Inhalation:**
  - The goal is to bring air into the lungs
  - Therefore, the pressure in the lungs needs to decrease (because air moves from high pressure to low pressure areas)
  - To decrease the pressure in the lungs, the volume needs to increase (Boyle’s Law)
  - To increase the lung volume:
    - Expansion/Elevation of the rib cage
    - Descent ion of the Diaphragm

Lippert, p236 & Mansfield, p367
Ventilation continued...

- **Exhalation:**
  - The goal is to exhale air from the lungs to the environment
  - Therefore, the pressure in the lungs needs to increase (because air moves from high pressure to low pressure areas)
  - To increase the pressure in the lungs, the volume needs to decrease (Boyle’s Law)
  - To decrease the lung volume:
    - Depression of the rib cage
    - Elevation of the Diaphragm

Lippert, p236 & Mansfield, p367
Ventilation continued...
Ventilation continued...

- **Quiet Ventilation:**
  - Occurs when an individual is resting or sitting quietly.
  - The Prime Movers of ventilation work during quiet ventilation.
  - Quiet inspiration is active, while quiet exhalation is passive.

- **Deep Inspiration:**
  - When a person needs a little bit more oxygen and breathes harder.

- **Forced Ventilation:**
  - When an individual needs to work hard to accomplish ventilation.
  - The Accessory Muscles of ventilation engage during forced ventilation.

Lippert, p239
Myology of Ventilation

- **Prime Movers:**
  - Diaphragm
  - Intercostal Muscles
    - External Intercostals
    - Internal Intercostals

Lippert, p239
## Ventilation

### Diaphragm

<table>
<thead>
<tr>
<th>Origin</th>
<th>Xiphoid process, ribs, lumbar vertebrae</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insertion</td>
<td>Central tendon near the dome of the diaphragm</td>
</tr>
<tr>
<td>Innervation</td>
<td>Phrenic n.</td>
</tr>
<tr>
<td>Action</td>
<td>Inspiration</td>
</tr>
</tbody>
</table>

Lippert, p239-240
## Ventilation

### External Intercostals

<table>
<thead>
<tr>
<th>Origin</th>
<th>11 per side; each muscle arises from the inferior border of the rib above</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insertion</td>
<td>inserts on the upper border of the rib below</td>
</tr>
<tr>
<td>Innervation</td>
<td>Intercostal nerve</td>
</tr>
<tr>
<td>Action</td>
<td>Assist with inspiration by elevating ribs and thereby expanding the thorax</td>
</tr>
</tbody>
</table>

Lippert, p240-241
**Ventilation**

**Internal Intercostals**

<table>
<thead>
<tr>
<th><strong>Origin</strong></th>
<th>11 per side, each muscle arises from the upper border of the rib below</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Insertion</strong></td>
<td>On the lower border of the rib above</td>
</tr>
<tr>
<td><strong>Innervation</strong></td>
<td>Intercostal nerve</td>
</tr>
<tr>
<td><strong>Action</strong></td>
<td>Assist with forceful expiration by depressing the ribs</td>
</tr>
</tbody>
</table>

Lippert, p240-241
### Accessory Muscles of Inspiration:

<table>
<thead>
<tr>
<th>Deep Inspiration</th>
<th>Forced Inspiration</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCM</td>
<td>Levator Scapula</td>
</tr>
<tr>
<td>Pectoralis Major</td>
<td>Upper Trapezius</td>
</tr>
<tr>
<td>Scalenies</td>
<td>Rhomboids</td>
</tr>
<tr>
<td>Levator Costarum</td>
<td>Pectoralis Minor</td>
</tr>
<tr>
<td>Serratus Posterior Superior</td>
<td></td>
</tr>
</tbody>
</table>
Accessory Muscles of Ventilation

- Accessory Muscles of Expiration:

<table>
<thead>
<tr>
<th>Forced Expiration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rectus Abdominis</td>
</tr>
<tr>
<td>External Oblique</td>
</tr>
<tr>
<td>Internal Oblique</td>
</tr>
<tr>
<td>Transverse Abdominis</td>
</tr>
<tr>
<td>Quadratus Lumborum</td>
</tr>
<tr>
<td>Serratus posterior inferior</td>
</tr>
</tbody>
</table>

Lippert, p243
Breathing

- **Diaphragmatic Breathing:**
  - The most efficient breathing method
  - Requires the least amount of energy
- **Chest Breathing:**
  - Requires greater effort
  - Much less effective than diaphragmatic breathing
  - Draws a much smaller volume of air into the lungs

Let’s Practice!
Valsalva Maneuver

• When you hold your breath and attempt to exhale
Common Pathologies

- A “stitch”:
- Hiccups:
- Rib Separation:
- Rib Dislocation:

Lippert, p245
Clinical Questions:

1) Why do we tend to elevate the head of the bed of an individual with respiratory difficulty?

2) Why do athletes who have just completed a sprint commonly put their hands on their legs while trying to “catch their breath”? 
References