Many organs throughout the body receive dual innervation from the sympathetic and parasympathetic divisions of the autonomic nervous system. Within the thorax the organs of particular importance are the heart, lungs and esophagus. This lesson will describe how autonomic fibers reach their target organs and what responses can be expected upon stimulation by either sympathetic or parasympathetic fibers.
The intrinsic rhythmicity of the heart is produced by its dual innervation with sympathetic and parasympathetic cardiac nerves. This collection of autonomic fibers forms the CARDIAC PLEXUS. It is located at the base of the heart behind and within the concavity of the arch of the aorta. Stimulation of these fibers can dramatically alter the pace and force of contraction of the heart.
HEART - SYMPATHETIC

The sympathetic innervation of the heart originates from the thoracic portion (T1-T4 or T5) of the spinal cord. These presynaptic fibers first travel to either the cervical (superior, middle or inferior) or the thoracic ganglia of the sympathetic chain, where they synapse. The postsynaptic fibers emerging from the ganglia will then travel to the heart in small cervical or thoracic cardiac nerves (a.k.a. thoracic visceral nerves) to innervate it. Stimulation of the sympathetic nervous system within this target organ causes an INCREASE in heart rate and contractility.

Why do the cardiac nerves bother to ascend into the neck, simply to descend back down into the chest? It's because the heart initially develops in the general vicinity of the neck, and then descends into the chest, drawing its nerves down with it. This is a recurrent theme in anatomy - when the adult anatomy seems illogical, look to embryology to help explain it.
The parasympathetic innervation of the heart is supplied by the right and left vagus (CN X) nerves which provide cervical cardiac nerves to the cardiac plexus. Additional cardiac branches are provided by the right and left recurrent laryngeal nerves, branches of the vagus nerve.

Unlike the sympathetic innervation, which must first synapse within chain ganglia to supply the heart with postsynaptic fibers, the parasympathetic fibers synapse at ganglia located directly on the heart and short postsynaptic fibers then supply the target organ. Parasympathetic stimulation acts to DECREASE its rate and contractility.
The lungs are supplied by both the sympathetic and parasympathetic divisions of the autonomic nervous system, arranged as the PULMONARY PLEXI. These paired autonomic plexi lie on the anterior and posterior surfaces of the roots of both lungs. The pulmonary plexi are directly continuous with the cardiac plexus at the tracheal bifurcation, and communicate with the esophageal plexus and autonomic fibers on the aorta. Fibers from the pulmonary plexi distribute to smooth muscle and glands of the bronchi and pulmonary blood vessels.
The sympathetic innervation of the lungs originates from the thoracic portion (T1-T4 or T5) of the spinal cord. The presynaptic fibers pass through white rami communicantes to reach the sympathetic trunk, where they synapse in the upper thoracic chain ganglia. The postsynaptic fibers then pass via slender thoracic visceral nerves into the pulmonary plexus to innervate the vasculature of the lungs, while epinephrine released from the suprarenal cortex acts upon the bronchial smooth muscle. Stimulation of the sympathetic nervous system acts to VASOCONSTRICT and BRONCHODILATE.
LUNGS - PARASYMPATHETIC

The parasympathetic innervation of the lung is supplied by the right and left vagus nerves. Some parasympathetic fibers reach the pulmonary plexus from the cardiac plexus, and many additional fibers are supplied directly from the vagus nerve as it passes posterior to the root of each lung. Just as with the heart, vagal fibers synapse directly within the pulmonary plexus on ganglia located on bronchi and pulmonary vessels. Parasympathetic stimulation within the plexuses causes VASODILATION and BRONCHOCONSTRICTION.
LUNGS - ASTHMA

Bronchial asthma is a chronic disorder characterized by hyperreactive airways leading to episodic, reversible bronchoconstriction due to an increased sensitivity to irritating stimuli. Clinically patients will present with increased mucus secretions (mucus plugs) and show a tremendous and rapid bronchoconstriction in response to moderate stimulation. Prescription medications aimed at managing asthma are designed to mimic a sympathetic response (sympathomimetic) of bronchodilation.
The sympathetic innervation of the esophagus arises from the thoracic sympathetic trunk. Presynaptic fibers will first synapse within the chain ganglia before traveling to the esophageal plexus via small thoracic visceral nerves to supply the esophageal vascular smooth muscle. Stimulation of these fibers will result in vasoconstriction.
ESOPHAGUS - PARASYMPATHETIC

The esophageal plexus of nerves is formed primarily by the right and left vagus nerves and supplies the lower two-thirds of this organ. In forming the plexus, the right vagus will pass primarily to the back of the esophagus to become the POSTERIOR VAGAL TRUNK as it passes through the diaphragm, while the left vagus will pass to the front to become the ANTERIOR VAGAL TRUNK. These trunks will pass through the esophageal hiatus of the diaphragm to supply parasympathetics to abdominal viscera. As with the cardiac and pulmonary plexuses, presynaptic parasympathetic fibers will synapse within ganglia located in the wall of the esophagus and short postsynaptic fibers will innervate the organ. Parasympathetic stimulation of the esophagus results in the rhythmic contraction of esophageal smooth muscle, or peristalsis, allowing food to pass into the stomach.
Presynaptic sympathetic fibers from chain ganglia between T5-T12 leave the thoracic sympathetic trunk to form the greater, lesser and least thoracic splanchnic nerves, which will innervate abdominal organs. Branches from chain ganglia at T5-9 travel anteroinferiorly on the surface of the vertebral bodies, uniting to form the greater thoracic splanchnic nerve, which can be easily identified within the posterior mediastinum. Similar branches from T10-11 form the lesser thoracic splanchnic nerve, and T12 provides the least thoracic splanchnic, but these are more difficult to identify within the thorax due to the dome of the diaphragm. The details of the thoracic splanchnic nerves will be covered later.

Remember as well that the thoracic sympathetic trunk gives off gray rami communicantes carrying fibers to the thoracic spinal nerves. Of course, each thoracic ventral primary ramus (otherwise known as an intercostal nerve) is also connected to
the sympathetic trunk
by a **white ramus communicans**,
carrying the
presynaptic fibers
that form the
sympathetic trunk.

Above and below - posterior chest wall, right lateral view
In summary, the autonomic innervation of thoracic viscera is derived from both parasympathetic and sympathetic systems. Autonomic fibers form the cardiac, pulmonary and esophageal plexuses.

Sympathetic fibers supplying thoracic viscera arise from the lateral horn of the upper thoracic spinal cord segments as preganglionic fibers, some of which ascend in the cervical sympathetic trunk and synapse in cervical ganglia. Postganglionic fibers then descend through the neck as cardiac branches and end in the cardiac plexus of the heart. Other sympathetic fibers synapse in the upper thoracic sympathetic trunk and the postganglionic fibers travel to the thoracic viscera as small thoracic visceral nerves ending in the cardiac, pulmonary and esophageal plexuses. The sympathetics speed the heart, increase its output, constrict blood vessels and dilate bronchi.

The parasympathetic supply to thoracic viscera is carried via the vagus nerve (CN X), which descends through the neck and into the chest. It gives rise to branches that reach the cardiac, pulmonary and esophageal plexuses. The parasympathetics slow the heart and decrease its output, constrict bronchioles in the lungs and provide for contraction (peristalsis) of the esophagus.