OUTLINE OF THE AUTONOMIC NERVOUS SYSTEM

Structure:

The nervous system is composed of a **central** portion (brain and spinal cord) and a **peripheral** portion (the nerves which pass laterally thus to structures of the body.

Central: Complex structure which will not be dealt with further except to note that from the CNS 12 pairs of cranial nerves (actually portions of the PNS) arise from the brain and these are distributed to various head and neck structures as well as conveying parasympathetics to the thorax and abdomen (see below).

Peripheral: Comprised of the cranial nerves and 31 pairs of **spinal nerves** which convey sensory (**afferent**) information to the spinal cord and thus the central NS and motor impulses (**efferent**) away from the central NS.

TYPICAL SPINAL NERVE
(do not confuse with the spinal accessory nerve, i.e. XI cranial)

1). **Roots**: refers specifically to the portions attached directly to the spinal cord. The roots are not mixed, i.e. contain **only motor or sensory.** Specifically the **dorsal root** is **sensory** while the **ventral root** is **motor**.

2.) **Mixed spinal nerve**: refers to the nerve produced by the union of the **dorsal and ventral roots** thus the mixed spinal nerve contains **sensory** fibers, **motor** fibers and (as we will see later) **sympathetic** fibers (which fall under the classification of motor fibers). The mixed spinal nerve is present at the level of the intervertebral foramina. Recall that all spinal nerves with the exception of cervical pass inferior to their corresponding vertebrae. In the cervical region C1 - C7 pass superior to the corresponding vertebrae while C8 passes inferior to the 7th cervial vertebra.

3.) **Ramus**: refers specifically to the divisions of a spinal nerve which originate from the **mixed spinal nerve** and thus contain **all of the components included in the mixed spinal nerve**. Two rami arise from each spinal nerve, a **dorsal ramus** and a **ventral ramus**. The dorsal ramus passes dorsally to innervate skin, muscle and sympathetics of the posterior surface of the body (i.e. posterior to the morphological plane established by a coronal section through the intervertebral foramina. The ventral ramus passes anteriorly to supply skin, etc. (sensory) muscles (motor), and sympathetic functions ventral to the coronal morphological plane.

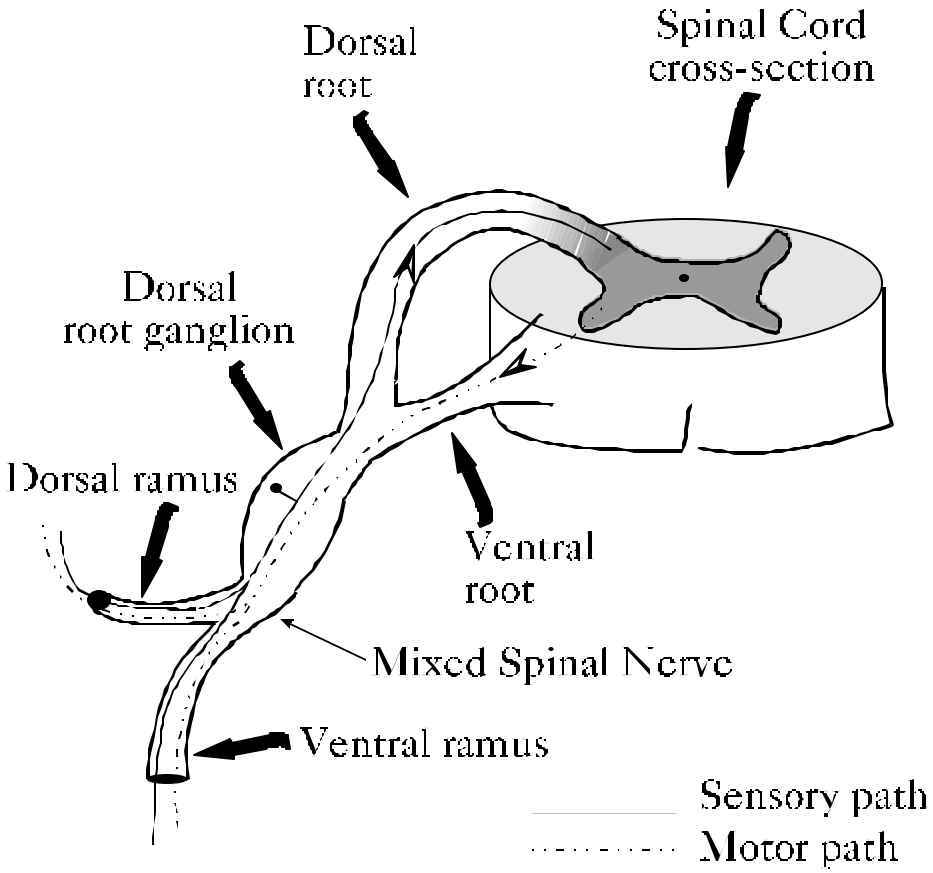

Figure 54: A typical Spinal Nerve.

AUTONOMICS

Two divisions of the autonomic system occur, the **sympathetic** and the **parasympathetic**. Both are **motor** to certain structures. Recall that the sympathetic is "fight or flight" while the parasympathetic is "vegetative functions". Since the parasympathetic is somewhat simpler than the sympathetic, we will consider it first.

Parasympathetic:

Note that the designation of this division as **para**sympathetic indicates that it originates on either side of the sympathetic, i.e. cranial and sacral but not in between since from T1 - L2 or L3 comprises the **sympathetic outflow** from the spinal cord.

Therefore parasympathetics arises from the cranial nerves (III, VII, IX and X) and from the **ventral rami of spinal cord segments S2,3 and 4.** Thus all parasympathetic innervation to the viscera originates from cranial nerve X (**vagus**) or pelvic parasympathetics (**the pelvic splanchnic nerves**).

Distribution

All the viscera with the exception of **a small terminal portion of the transverse colon, the descending colon, the sigmoid colon, rectum, bladder and reproductive organs** receive parasympathetics from the **vagus.** Those structures listed above receive parasympathetics from the **pelvic splanchnics.**

Structure

Parasympathetics generally display the following structure:

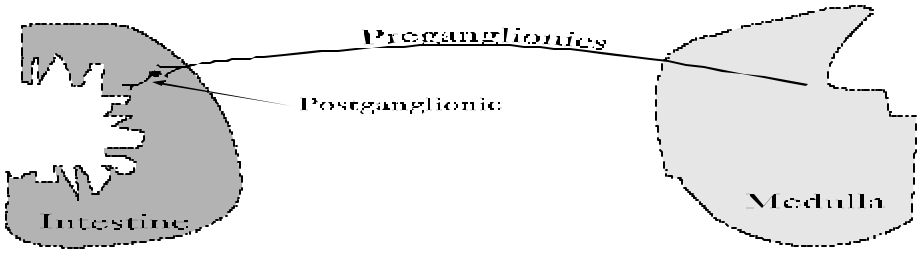

Figure 55: Parasympathetic arrangement of pre- and post-ganglionics.

Note that the **preganglionics** are very long while the **postganglionics are very short**. Furthermore the synapse between **pre-** and **post-** occurs very near the site of termination. Thus in the vagus, parasympathetics destined for the stomach originate in the medulla where long axons extend throughout the course of the vagus **(preganglionics**), finally terminating on nerve cell bodies **within the wall of the viscera. Note that in head and neck termination of preganglionics occurs in ganglia displaced from their site of termination.** Thus the picture is slightly different in this region. Note also the **all** synaptic transmission in the parasympathetic system is **cholinergic.**

Sympathetics:

In contrast to the parasympathetic system the sympathetics are very widely distributed and much more complex in arrangement. In addition the preganglionics are **cholinergic** while the postganglionics are **adrenergic** except concerning the suprarenal glands which receive preganglionics only and are therefore cholinergic.

Structure:

All sympathetic outflow from the spinal cord originates from spinal levels **T1 through L2 or 3**. Thus sympathetics for the head and neck, upper limbs and lower limbs must be derived from sympathetics in this region (T1 -L2). However the **sympathetic trunk is longer extending from the base of the skull inferiorly to the**

anterior surface of the coccyx where the trunks end by fusing as the ganglion impar.

Unlike the parasympathetics, the sympathetics can be considered to display **preganglionics and postganglionics of more equal length**. In actual fact, the preganglionics and postganglionics are of variable lengths but **do not synapse in the walls of viscera as do the parasympathetics.**

Preganglionics:

Arise in the lateral column within the spinal cord (T1 - L2). They exit the cord via the **ventral roots**, pass into the spinal nerves, pass from these nerves almost immediately via **white rami communicantes** (white since they appear this way due to their myelination) into the **sympathetic trunks** arranged along the lateral aspect of the vertebral bodies.

In a **"typical"** situation, the preganglionics end on postganglionics within the ganglia of the sympathetic trunk. The **postganglionics** return to the spinal nerve as **grey rami communicantes** (grey since they are not myelinated) and are distributed via the **dorsal and ventral rami** to all parts of the body. This "typical" situation is illustrated below:

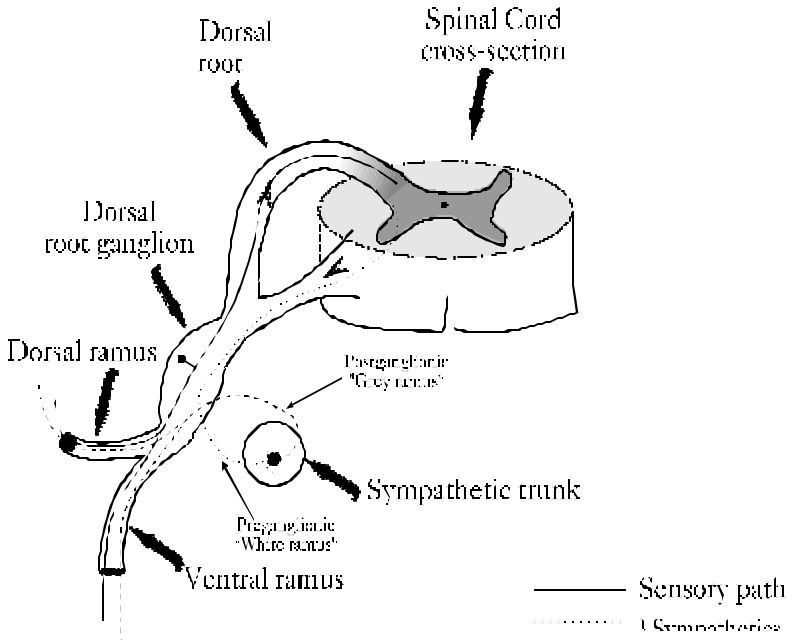

Figure 56: Sympathetic origin from the spinal cord.

In addition some **preganglionics** simply pass right through the sympathetic trunk ganglia, unite with similar preganglionics from other levels and pass towards subsidiary (prevertebral) ganglia of the sympathetic system (see diagram following). This is the case with the **greater splanchnic, lesser splanchnic and least splanchnic nerves** which are derived from T5 -T9, T10 & 11, and T12 respectively and pass to abdominal ganglia

which are located roughly adjacent to the major arterial vessels of the abdomen. Here the **preganglionics** enter the ganglion and synapse (at least some of them). **Postganglionics then pass to the appropriate viscus.** The **prevertebral ganglia** of this type of sympathetic are the 2 **coeliac ganglia,** a **superior mesenteric ganglion, and an inferior mesenteric ganglion**.

Coeliac ganglia

Two in number located lateral to the origin of the coeliac artery. Receives the **greater and lesser splanchnic nerves**. Postganglionics are distributed via several plexuses (groups of nerves arranged along vessels and in relation to viscera) to the region supplied by **branches of the coeliac artery and kidney.**

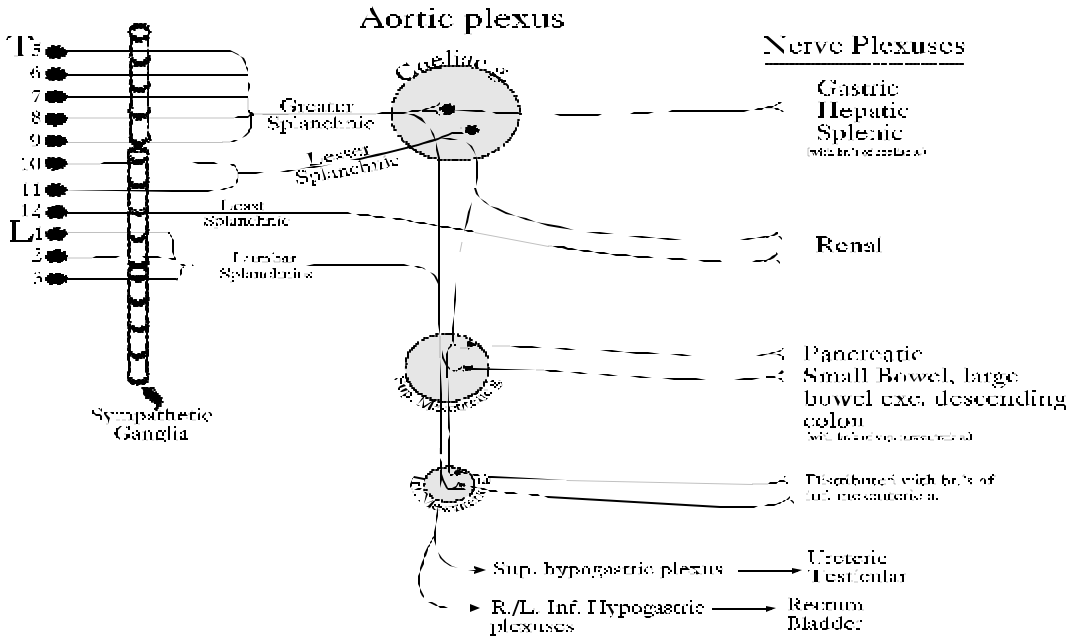

Figure 57: General arrangement and connections of sympathetics composing the splanchnic nerves.

Superior mesenteric ganglion

Located above the origin of the s. mesenteric artery. At this ganglion, preganglionics from the **lesser splanchnic nerve which have passed uninterrupted** through the coeliac ganglion synapse and **postganglionics** are distributed largely with branches of the **s. mesenteric artery**.

Inferior mesenteric ganglion

Located near the origin of the inferior mesenteric artery when present. If not present it is represented by dispersed ganglion cells. **Lumbar splanchnics** pass to the ganglion, synapse and are distributed with branches of the artery.

Note: The **least splanchnic nerve** passes to the renal plexus where small collections of nerve cells are located, synapses and continues into the kidney.

Finally some **preganglionics are derived from cord segments ~T1 - T3** and pass superiorly within the sympathetic trunk (to supply structures of the head and neck and upper limbs) while some from cord segments L1 -L2 pass to the trunk and either exit as **lumbar splanchnics** to synapse on postganglionics in the abdomen, or synapse within the sympathetic trunk and exit to supply the lower limbs.

In the case of sympathetic supply to the head and neck:

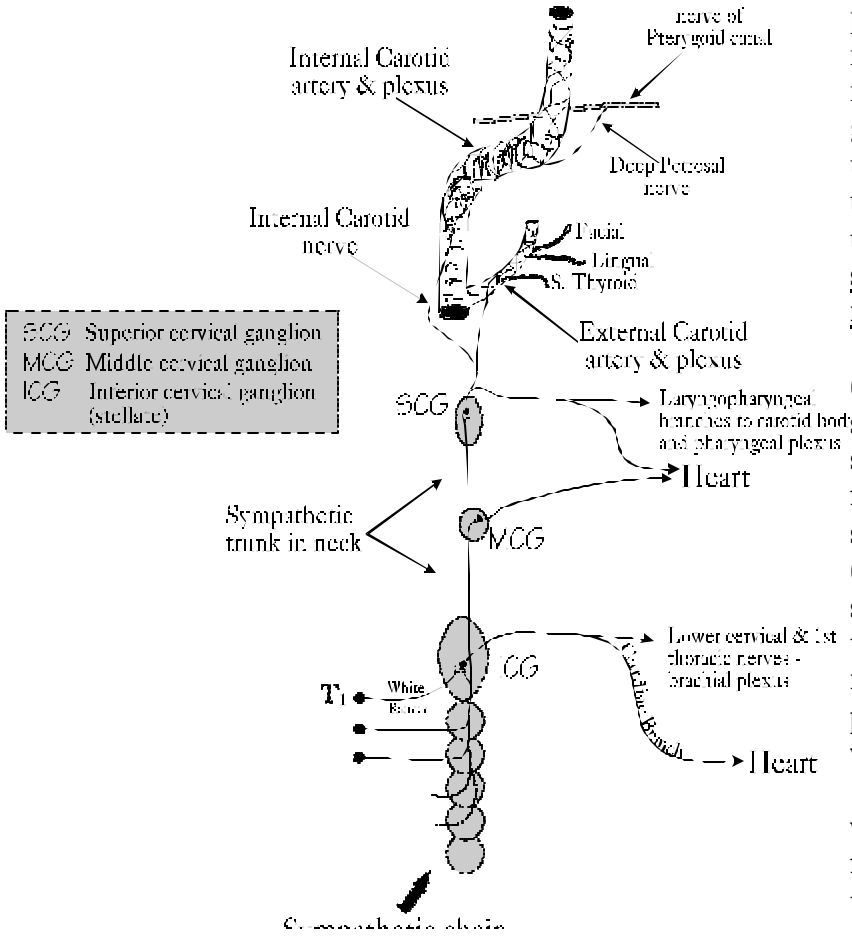

Figure 58: Distribution of sympathetics to head, neck and heart.

<u>Three</u> ganglia are present in the cervical region. These represent displaced ganglia from the upper end of the thoracic sympathetic trunk and are the **<u>superior cervical</u>, <u>middle cervical</u> and <u>cervicothoracic</u> (stellate). Note that since there is <u>no</u> sympathetic outflow from cervical segments of the cord (i.e. no white rami) sympathetics from these ganglia (grey rami) carry postganglionics on which have ended preganglionics which originated from a lower (upper thoracic) cord segments**. The connections between the superior ganglia

at T1 and the 3 cervical ganglia represent thoracic sympathetics which are passing to one or other of the cervical ganglia where they will synapse, pass to cervical spinal nerves (and thus the upper limb via the brachial plexus), innervate head and neck structures, the heart or thyroid. In addition from the superior cervical ganglion, the **internal carotid nerve** ascends with the internal carotid artery into the cranium to form the **internal carotid plexus from which sympathetics pass to the abducens, pterygopalatine ganglion, glossopharyngeal, oculomotor, trochlear and ophthalmic nerves and vessels** derived from the internal carotid artery.

In the case of the **lumbar sympathetics**:

Generally **four lumbar splanchnic nerves** (preganglionics) derived from the lumbar portion of the sympathetic trunk synapse in and contribute to the plexuses within the abdomen (see previous diagram).

In addition sympathetics derived from the lumbar and pelvic regions of the sympathetic trunk pass as grey rami (**postganglionics**) to the femoral nerve to the thigh, as well as in the tibial, pudendal and gluteal nerves to be convey with these nerves to the lower limb.

Visceral Afferents

As the name indicates these fibers are sensory to the viscera and can be regarded as the counterparts of the efferent autonomics. **Visceral afferents occur in the vagus and pelvic splanchnic nerves** as well as being distributed through the **rami communicantes of the sympathetic system**. This latter distribution is believed to be responsible for the phenomenon or **referred pain**.