IV. NERVOUS SYSTEM

REFLEXES: STRETCH REFLEXES

Use light colors for A and C, and use the same colors you used on Pl. 145 for struct-
ure D-F (1) Color the upper two illustrations simultaneously, in numerical sequence 1-6,
cluding the arrows. The small arrows at the end of the muscle segments indicate con-
uation or stretch. (2) Color the lower two illustrations similarly. Note that the motor neuron
paring with the inhibitory interneuron, and the related effector, are not colored.

MONOSYNAPTIC REFLEX:

STRETCH RECEPTOR
SENSORY NEURON A
SPINAL CORD B
MOTOR NEURON C
EFFECOR C

SPINAL NERVES/ROOTS:
SPINAL NERVE:
BRANCH B
POSTERIOR ROOT C
GANGLION E
ANTERIOR ROOT F

A reflex (bend back) is an involuntary muscle response to a stimulus. It is a funda-
mental activity of the nervous system; most body movements and movement of visera
are reflexive, e.g., heart rate, respiratory rate, peristalsis of gastrointestinal motion, and
so on. Spinal reflexes involve sensory receptors, sensory neurons, interneurons of the
spinal cord, motor neurons, and effectors.
The simplest spinal reflex is a monosynaptic reflex involving two neurons and one syn-
apse (myotatic, stretch, or deep tendon reflex). The reflex is activated by stretching the
tendon of a specific muscle, such as the tendon of quadriceps femoris at the knee. This
can be done with the sharp tap of a small mallet used for such purposes (or with the
5th digit of the hand). The receptors responsive to such a stretch are the neuro-
tendinous (Golgi tendon) organ and the muscle spindle (specialized muscle fibers with
nerve endings sensitive to muscle stretch and motor nerves to those muscles which
resist stretch and "unload" the spindle). Impulses generated in these receptors (1) are
conducted by sensory neurons (2) to the spinal cord (3); these synapse in the gray mat-
er with the anterior horn motor neurons (4). The motor neuron conducts impulses to the
end plates of the effector muscle (5). The muscle contracts sufficiently, in the case of
the knee reflex ("jerk"), to extend the knee joint momentarily (6).

POLYSYNAPTIC
REFLEX:

PAIN RECEPTORS A
INTERNEURON C
FACILITATING (+) C
INHIBITING (-) C

Polysynaptic reflexes range from simple withdrawal reflexes to complex reflexes involv-
ing several segments of the spinal cord and the brain. In the withdrawal reflex shown,
extreme heat applied to the hand of an unsuspecting person induces an involuntary
hyperextension of the wrist joint by wrist extensors, associated with a simultaneous re-
laxation and stretch of the antagonist wrist flexor muscles. Obviously, the former cannot
occur without yielding of the latter. The main difference between this reflex and the
stretch reflex is the interneuron: two facilitating the withdrawal, and one inhibiting con-
traction of the antagonist (flexors) to the withdrawal.
Nervous System

PNS: Distribution of Spinal Nerves

Nerve coverings:
Epineurium
Perineurium
Endoneurium
Axon

Spinal nerves and their branches consist of axons of sensory and/or motor neurons ensheathed in fibrous connective tissue. Individual axons are surrounded by thin envelopes of fibrous tissue (endoneurium) containing nerves and capillaries that supply the living axon. Bundles (fascicles) of axons are bound by thicker, more dense coats of fibrous tissue (perineurium). Between and within the fascicles are relatively large vessels and nerve bundles. Surrounding the fascicles are circumferentially arranged loose arrays of fibrous tissue contiguous with deep or superficial fascia (epineurium). These supporting tissues stabilize the neurovascular elements and provide a framework for the nerve in its environment.

Thoracic Spinal Nerve:
Posterior Root
Anterior Root
Spinal Nerve

Posterior Ramus
Lateral Branch
Medial Branch

Anterior Ramus
Intercostal Nerve

Each spinal nerve leaves an intervertebral foramen and divides into anterior and posterior (primary) rami. The anterior rami supply all parts of the body except the deep (intrinsic) muscles and skin of the back; thus, the anterior ramus is generally larger than its posterior fellow. The anterior rami contribute to networks of interconnecting nerves (plexuses or plexi) supplying the neck, upper limb, pelvis/perineum, and lower limb. In the torso, anterior rami form the intercostal nerves. The distribution pattern of a typical thoracic spinal nerve is shown in the cross section of the thorax. Note the ramus communicantes, these will be presented in Plate 151. Note the muscular branches of the anterior ramus passing between innermost and internal intercostal muscles, as well as the lateral and anterior cutaneous branches and their distribution in the superficial fascia. Note the areas of overlap between the cutaneous branches of the anterior rami and those of the posterior ramus. This pattern occurs segmentally and bilaterally throughout the thorax; the lower thoracic spinal nerves also supply most of the abdominal wall.

The anterior rami of the cervical spinal nerves (and T1 spinal nerve) form interconnecting networks from which the nerves to the neck and the upper limb are derived (next plate). The anterior rami of the lumbar and sacral spinal nerves form interconnecting plexuses from which the nerves to the pelvis, perineum and lower limb are derived (Plate 149). Thus, the source of an intercostal nerve can be traced to the single spinal nerve forming it, e.g., T6 spinal nerve, whereas the source of a nerve to the limbs is traced to the collection of spinal nerves that form it, e.g., C5-C8 spinal nerves.
Nervous System

Nerves to the Upper Limb

The major nerves to the structures of the upper limb arise from the brachial plexus, formed from the anterior rami of spinal nerves C5-T1 (plus or minus one level). These rami form the roots of the plexus. In the pattern illustrated, further branching and joining of fibers in the neck, supraclavicular area, and axilla result in the formation of the five major nerves of the upper limb.

The brachial plexus is subject to injury (plexopathy) from excessive stretching or traction (e.g., rapid, forceful pulling of the upper limb) and compression (e.g., long-term placement of body weight on axillary or arm pit cushions of crutches). In such injuries, there is great variation in degree of deficit, signs, and symptoms.

The musculocutaneous nerve (C5-7) supplies the anterior arm muscles and is cutaneous in the forearm. Packaged in muscle, it is rarely traumatized. C5 and/or C6 nerve root compression may weaken these muscles. The median nerve (C5-C8, T1; “carpal tunnel’s nerve”) supplies the anterior forearm muscles and the thenar muscles. It can be compressed at the carpal tunnel (recall PL 27), resulting in some degree of sensory deficit to fingers 1-3 and weakness in thumb movement (carpal tunnel syndrome). Similar complaints can be associated with a C6 nerve root compression.

The ulnar nerve (C8-T1; “musician’s nerve”) supplies certain muscles of the forearm and most intrinsic muscles of the hand. It is subject to trauma at the elbow in the cubital tunnel, possibly resulting in ulnar-side finger pain, hand weakness or abnormal little finger position. Similar complaints can be associated with a C6 nerve root compression. The axillary nerve (C5-6) wraps around the neck of the humerus to supply deltoid and teres minor. It is vulnerable to fractures of the humeral neck, possibly resulting in a weak paralyzed deltoid muscle. The radial nerve (C5-8, T1) supplies the triceps, brachioradialis, and posterior forearm (extensor) muscles moving the wrist and hand. It is subject to damage as it rounds the mid-shaft of the humerus; significant nerve loss here results in “wrist drop” and loss of ability to work the hand (try moving your fingers with your wrist flexed hard). A C7 radiculopathy is characterized by a weak triceps and loss of the triceps jerk (deep tendon reflex). See the appendix for listing of upper limb muscles and their nerve supply.
CN: Use a bright color for J. (1) Begin with the anterior view. Color the lumbar and sacral plexuses gray; note that they have been dotted for easy identification. Note the longest branch of the femoral nerve: saphenous nerve. (2) Color the posterior view which includes almost entirely the sciatic nerve and its branches.

**LUMBAR PLEXUS**

FEMORAL N. A

SAPHENOUS N. B

OBTURATOR N. C

LAT. FEMORAL CUTAN. N. D

LUMBOSACRAL TRUNK E

**SACRAL PLEXUS**

POST. FEMORAL CUTAN. N. F

SUPERIOR GLUTEAL N. G

INFERIOR GLUTEAL N. H

SCIATIC N. I

TIBIAL N. J

MEDIAL LAT. PLANTAR N. K

COMMON PERONEAL N. L

SUPERFICIAL PERON. N. M

DEEP PERON. N. N

The nerves to the lower limb arise from the lumbar (L1–L4) and sacral (S1–S3) plexuses. These plexuses are formed from anterior rami of the spinal nerves noted. The lumbar plexus is located in the retroperitoneum against the posterior abdominal wall; it is the source of two major nerves to the lower limb. The femoral nerve (L2–L4), giving forth an effusion of vessels just below the inguinal ligament, and in company with the (superficial) femoral artery and vein, innervates quadriceps femoris and sartorius and is sensory to the anterior thigh. Trauma to this nerve is most likely in the pelvis as it passes through or near the psoas muscle (hemorrhage, surgical misadventure, and so on). The obturator nerve (L2–L4) passes along the lateral pelvic wall and through the obturator foramen to break up into branches supplying the adductor muscle group. Like the femoral, it too is subject to trauma in the pelvis. Compressions of the L2–L4 nerve roots can be manifested by complaints in the anterior and medial femoral region. The sacral plexus gives rise to a number of important nerves, the most significant being the sciatic nerve (L4–S3). Roughly the size of your thumb, this nerve passes deep to gluteus maximus into the posterior thigh, innervating the "hamstring" muscles. Just above and behind the knee, it splits into peroneal and tibial components. The common peroneal nerve supplies the lateral leg muscles (superficial peroneal) and the anterolateral leg muscles (deep peroneal). The tibial nerve supplies the posterior leg muscles and the plantar muscles (sole of the foot). Compression of the L4–S1 nerve roots commonly affects the sciatic distribution (e.g., sciatica or pain in the lower limb along the sciatic distribution). More significant compression results in specific leg or foot muscle weakness and sensory loss. S1 radiculopathy is characterized by a loss of the achilles (lentocalcaneus) reflex or "ankle jerk." The sciatic can be injured as it exits the greater sciatic notch or in the buttock. The common peroneal nerve is vulnerable as it rounds the subcutaneous fibular neck; trauma to this nerve may be expressed as "foot drop" (loss of ankle/toe extensors). See the appendix for listing of lower limb muscles and their nerve supply.