INTRODUCTION

The central nervous system (CNS) consists of the brain and the spinal cord. The CNS receives sensory information from other parts of the body or the body’s external environment and transmits motor information to other parts of the body by way of the peripheral nervous system (PNS). The PNS of the human includes 31 pairs of spinal nerves and 12 pairs of cranial nerves. Some nerves contain only motor nerve fibers (efferent fibers); some nerves contain only sensory nerve fibers (afferent fibers); and some nerves contain both sensory and motor nerve fibers (mixed). All spinal nerves are mixed. Cranial nerves I (olfactory), II (optic), and VIII (vestibulocochlear) are entirely sensory. Cranial nerves III (oculomotor), IV (trochlear), VI (abducens), XI (accessory), and XII (hypoglossal) are classified as motor, although they do contain proprioceptive afferent fibers. Cranial nerves V (trigeminal), VII (facial), IX (glossopharyngeal), and X (vagus) are mixed. All cranial nerves except the olfactory nerves are connected to the brain stem (medulla, pons, mesencephalon), and all are distributed in the head and neck except the vagi, which also supply structures in the thorax and abdomen. Figure 1.1a shows cranial nerves and their origins and terminations.

Cranial nerve function is commonly assessed as part of a general physical examination of the head, eyes, ears, nose, throat, and neck by a physician, physician’s assistant, nurse, or paramedic. More comprehensive examination of cranial nerve functions is usually done by specialists such as neurologists, ophthalmologists, optometrists, and audiologists. Basic cranial nerve tests are included in this book because they provide a convenient framework for reinforcing the learning of cranial nerve numbers, names, and functions. More important, they hone skills of observation and reason.

Figure 1.1 (a) Cranial Nerve Pathways
EXPERIMENTAL OBJECTIVES

1. To learn the name and number of each pair of cranial nerves and to identify the region of the brain to which each pair is attached.
2. To learn and perform simple tests of function for each pair of cranial nerves.

<table>
<thead>
<tr>
<th>Materials</th>
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<tbody>
<tr>
<td>preserved brain of human (whole) or sheep</td>
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<tr>
<td>model of human brain</td>
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<td>anatomical charts: CNS</td>
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<td>glass probe</td>
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<td>needle probe or straight pin</td>
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<td>dissecting pan</td>
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<td>tongue depressors</td>
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<td>long-stem cotton applicators</td>
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<td>cotton balls</td>
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<tr>
<td>penlight</td>
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<tr>
<td>256-Hz tuning fork</td>
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<tr>
<td>droppers</td>
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<tr>
<td>turpentine, oil of cloves, peppermint, wintergreen, and vanilla</td>
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<tr>
<td>10% glucose solution</td>
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<td>10% NaCl solution</td>
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EXPERIMENTAL METHODS

With the aid of figure 1.1b and other anatomical charts available, identify and verify the location of each of the 12 pairs of cranial nerves on a model of the human brain or a preserved brain or both. If available, the preserved brain should be placed with the anterior (ventral) surface in view in a dissecting pan for study. Use only the glass probe to study structures on the preserved brains. Do not cut, pick, probe, or tear structures with sharp or pointed instruments. The tissues have been chemically preserved and should be periodically remoistened to prevent desiccation during the period of study. After reviewing the names and locations of the cranial nerves, perform the following assessments of cranial nerve functions.

Figure 1.1 (b) Ventral aspect of the brain
Cranial Nerve 1. Olfactory Nerve (Sensory)

Olfactory nerve fibers pass from olfactory cells in the upper part of the nasal cavities through the cribiform plate of the ethmoid bone and into the olfactory bulb, where they synapse with second-order neurons. Neurons of the olfactory bulb transmit olfactory information along the olfactory tract to the olfactory cortex of the cerebrum. Damage to the olfactory epithelium, olfactory nerves, olfactory bulbs and tracts, or the olfactory cortex produces a loss of the ability to smell (anosmia).

Ask your lab partner to identify, with his or her eyes closed, each of the following common nonirritating odors: turpentine, oil of cloves, peppermint, wintergreen, and vanilla extract. Test each nostril separately. The odor should be familiar to the subject so as to differentiate between an inability to smell a substance and an inability to identify it. Record results on the data sheet at the end of the lab.

The most common cause of anosmia is damage to the nasal olfactory epithelium as from excessive smoking, cocaine use, or inflammation due to infection. Neurologic causes include tumors of the frontal lobe near the olfactory bulbs and tracts and head injuries. As do other special senses (e.g., vision, hearing), the sense of smell diminishes with increasing age.

Cranial Nerve II. Optic Nerve (Sensory)

The optic nerve arises from cells in the retina of the eye and conveys visual information to the brain. Fibers from the nasal half of each retina cross at the optic chiasma and are distributed to the contralateral brain stem, thalamus, and occipital cerebrum along with fibers from the ipsilateral temporal retina (see figure 1.2). Both eyes are represented in the occipital cortex of each cerebral hemisphere. In addition to providing sensory information regarding vision, the optic nerve provides the sensory component of visual reflexes such as the pupillary light reflex or accommodation of the lens.

Examination of the optic nerve involves determination of visual acuity, peripheral vision, and appearance of the optic fundus.

Ask the subject if there has been any change in his or her vision. Visual acuity or sharpness of vision when looking at near as well as distant objects can best be tested with a standardized chart such as a Snellen Test Letter Chart. If a chart is not available, you may use any printed material (e.g., newspaper, magazine, etc.) and compare the subject’s visual acuity with your own. If the subject normally wears eyeglasses or contact lenses, these should be worn during the test. If a subject’s visual acuity is diminished to the point where even large print cannot be read, ask the subject to count extended fingers at various distances from the eye. Test the subject’s ability to detect motion and to distinguish light from dark.

Assess the subject’s peripheral vision by asking him or her to sit in front of you, at about the same height, and about 2 feet away. Have subject cover one eye, and with the other eye look straight into your eye. Cover your eye opposite the subject’s covered eye. In a plane perpendicular to the gaze and midway between your eye and the subject’s, slowly bring a pencil or a cotton applicator into view. As the test object is moved toward the line of gaze, the subject will let you know when he or she first sees it. Compare your visual field (assuming it is normal) with the subject’s visual field. All four quadrants should be tested at a 45-degree angle from the vertical and horizontal (figure 1.2 below). Test each eye separately.
When recording your results, place a check mark for the eye and quadrant in which you and the subject had common results. Place a minus mark for any eye or quadrant in which your fields did not match.

Loss of vision in all or part of the visual field is caused by specific lesions in the visual pathway (figure 1.3). Blindness in one half of each visual field is called hemianopia. Lesions of the optic tract or optic radiation produce the same hemianopia (homonymous hemianopia) for both eyes. A tumor of the pituitary gland may exert pressure on the optic chiasma (see figure 1.3) causing bilateral loss of the temporal fields of vision.

Figure 1.3  Visual pathways, lesions, and defects in the visual field

Cranial Nerves: III (Oculomotor), IV Trochlear, VI Abducens

Six extrinsic muscles move the eyeball within the orbit (figure 1.4). The inferior, superior, and medial recti muscles and the inferior oblique muscle are controlled by the oculomotor nerve. The lateral rectus is controlled by the abducens nerve, and the superior oblique muscle is controlled by the trochlear nerve.

The oculomotor nerve also controls the elevator muscle of the upper eyelid and the involuntary internal muscles of the eye that control pupil diameter and lens thickness. Because the oculomotor, trochlear, and abducens nerves control related functions of the eye, they are tested as a unit.
First, observe how much of the subject's iris (colored part around pupil) is covered by the eyelid. Normally about one-third will be covered. Drooping of the eyelid (ptosis) occurs in paralysis of the oculomotor nerve, myasthenia gravis, and other diseases. Record observations.

Second, examine the pupils. Are they both the same size? Are they round or oval? Are they in the center of the eye facing forward, or are they deviated to the side? Normally the pupils should be round, equal in size (about 2-3 mm in diameter), and in the center of the eye. Unequal pupils (anisocoria) may be congenital and have no pathologic significance or may occur as a result of a variety of abnormalities, including syphilis, multiple sclerosis, and sympathetic paralysis. If both pupils are markedly smaller or larger than normal, medication may be the cause. Ask the subject if he or she is taking any medication that affects the eye (glaucoma medicines, anticholinergic medicines, etc.). A unilateral dilated pupil often occurs with increased intracranial pressure. The pupil becomes fixed and unresponsive to light on the side of the brain where the pressure has increased. Record observations.

Next, ask the subject to focus on a distant object. Hold a penlight about 20 cm to the side of the eye and shine it directly into the pupil. Check for pupillary constriction in this eye (direct reflex) and simultaneous constriction in the untested eye (consensual reflex). Grade the pupillary response to light as brisk (4+), less than brisk (3+), slow (2+), very slow (1+), or absent (0). Record observations.

Move a test object (fingertip, pencil, cotton-tipped applicator) from a distance of 1 m in front of the subject to within 3 cm of his or her nose. As the subject gazes at the moving object, note convergence of the eyes (the eyes become crossed) and the pupillary constriction that normally accompanies the convergence. Convergence should occur smoothly and equally, as should pupillary constriction. Record observations.

Finally, ask the subject to cover one eye and keep his or her head motionless as you move an object (fingertip, pencil, cotton-tipped applicator) within the visual field about 30 cm from the eye. Ask the subject to follow the object with his or her eye as you move it to each of the following positions: up, down, right, left, up right, down right, up left, down left. Eye movement should occur smoothly and precisely. As you record your observations, use a + sign to indicate that the subject had normal results and a – sign to indicate abnormal results. Check for nystagmus (involuntary, rapid, rhythmic movement of the eyeball) and weakness of eye muscle. Test the other eye using the same procedure. There should be no nystagmus on elevation or depression of the eyes, but a small amount of nystagmus at the extreme of any lateral or medial gaze is normal.

Cranial Nerve V. Trigeminal Nerve (Mixed)

The trigeminal nerve has two roots, one motor and the other sensory, arising from the pons (figure 1.1). The motor fibers supply muscles of mastication (chewing), such as the temporalis and the masseter. The sensory fibers convey pain, temperature, touch, and pressure information from the eye, face, nasal and oral mucosa, gums, teeth, and anterior two-thirds of the tongue.
The motor function may be tested by placing your fingertips on the temporalis muscles at each temple (figure 1.5) of the subject and asking the subject to clench his or her teeth several times. Compare the strength of muscle contraction on each side. They should be the same. Test the strength of masseter muscles using the same technique. The masseter can be palpated just above and to the front of the angle of the lower jaw. Contractions should be symmetrical and equal. Circle “yes” if the muscle strength is equal on both sides and circle “no” if it’s not.

Check the strength of jaw closure by asking the subject to grip a tongue depressor with his or her teeth on each side while you try to extract the depressor. Strength of closure should be bilaterally good. Ask the subject to open his or her mouth. Note any deviation of the jaw to the right or left. Normally there is no deviation. Record observations. Ask the subject to move the lower jaw side to side to assess medial and lateral pterygoïd muscle function. Normally the mandible moves smoothly and equally to each side.

Fibers in the sensory root come from the trigeminal ganglion, which receives input from three divisions of sensory nerves: the ophthalmic (I), the maxillary (II), and the mandibular (III). The facial distribution of these divisions is shown in figure 1.6. Each division should be tested separately and bilaterally (on both sides).

First, explain to the subject that you are going to test the corneal reflexes. Then pull a small piece of cotton from a cotton ball, form it into a long thin strand, and ask the subject to look up and away from you. Lightly touch the cornea with the piece of cotton, avoiding the eyelashes. The eyes (both) should blink. Repeat the test on the other eye. Record observations.
Next, test the areas of the skin on each side of the midline supplied by the three divisions of the trigeminal nerve for their sensitivity to light touch (cotton ball) and pain (pin prick). Before stimulating the skin, ask the subject to close his or her eyes and tell you when the stimulus is applied. Record observations—mark + on areas where sensation is normal for touch and pain.

Injury to the sensory components of the trigeminal nerve causes anesthesia in the area of the affected division. Tic douloureux (trigeminal neuralgia) is caused by irritation of the trigeminal nerve and is marked by excruciating pain that follows the distribution of the sensory fibers.

**Cranial Nerve VII. Facial Nerve (Mixed)**

The facial nerve arises from the pons lateral to the abducens nerve (figure 1.1) and contains motor and sensory fibers. The motor fibers innervate muscles of facial expression, and parasympathetic fibers stimulate salivary glands. Sensory fibers convey taste information from the anterior two-thirds of the tongue (figure 1.7).

Test for facial nerve function by asking the subject to show teeth and smile, lift the eyebrows, frown, and close the eyes tightly. Record observations. All facial movements should be equal bilaterally. Note any asymmetry of facial movements and features, but keep in mind that some persons habitually smile and talk more out of one side of the mouth than the other and that every face is somewhat asymmetrical.

Disease of the facial nerve results in peripheral facial paralysis (Bell’s palsy) on the side of the lesion. Causes of Bell’s palsy include compression of the nerve by a tumor and infections that inflame the nerve and surrounding tissue. The affected individual will be unable to close the eye on that side, wrinkle his or her forehead, or show teeth. Loss of muscle tone on the side of the lesion allows the corner of the mouth to droop.

Test taste using a sugar or salt solution. Place a few drops on half of the anterior two-thirds of the protruded tongue and instruct the subject to keep the tongue out until he or she has tasted the substance. Test each side of the tongue separately. Record results.

**Cranial Nerve VIII. Vestibulocochlear Nerve (Sensory)**

The eighth cranial nerve contains fibers of the vestibular nerve and the cochlear nerve. The vestibular nerve is sensory from receptors in the inner ear that provide information concerning movement of the body, balance, and body position in relation to gravitational force. The cochlear nerve is sensory from auditory (hearing) receptors in the cochlea of the inner ear.

Ask the subject to stopper one ear canal with his or her finger while you test hearing in the other ear. At a distance of 50 cm directly lateral to the tested ear, whisper a two-digit number (e.g., 29, 35) and ask the subject to identify the number by writing it on a sheet of paper. Repeat the test on the other ear.

The inability to hear some or all of the normally audible sounds could be caused by one or more of several disorders such as blockage of the outer ear canal (with wax, fluid, etc.); damage to the eardrum or ear ossicles; blockage of the internal auditory meatus and inflammation of the middle ear (common in upper respiratory infections); damage to the inner ear, auditory receptors, and auditory (cochlear) nerve; or damage to auditory pathways in the brain. The whisper test does not provide a means of differentiating one type of hearing loss from another.

A more useful test of hearing requires a 256-Hz tuning fork. Strike the prong of the tuning fork gently against the heel of your shoe to start it vibrating. Note the time and immediately place the tip of the tuning fork handle on the mastoid process (the bony bump behind and below the auricle) to test for bone conduction hearing. Be careful not to touch the prongs of the fork against the ear or hand. The subject should hear sound. As soon as the subject says he or she no longer can hear sound, note the time and immediately move the vibrating ends of the fork to within 3 cm of the external ear canal to test for air conduction hearing. The subject should again be able to hear the sound, note how long it take for sound to no longer be heard. Normally the subject's hearing should be equal in both ears, and air conduction hearing time should be about twice the duration as that for bone conduction. Repeat the test for the other ear. Record observations, mark + for normal hearing and – for abnormal hearing, also not if there was a difference in bone conduction and air conduction hearing for each ear.
A shortening of hearing time with air conduction coupled with preservation of hearing time with bone conduction suggests interference with sound transmission in the outer ear or the middle ear. If both the hearing time for bone conduction and the hearing time for air conduction are reduced, the hearing loss most likely involves the inner ear or the auditory nerve or both.

Strike the prong of the tuning fork gently against the heel of your shoe and place the tip of the handle on the middle of the subject’s forehead. If both ears are normal the subject will hear the sound equally in both ears. With unilateral nerve deafness, the subject will hear the tuning fork with the good ear but not the affected ear. If there is blockage or damage to the outer ear or middle ear, or both, the sound will be heard more loudly in the affected ear.

Figure 1.7 (a) Distribution of taste receptors on the tongue (b) taste pathways on the right side of the body; pathways on the left side (not shown) are similar
Cranial Nerve IX. Glossopharyngeal Nerve (Mixed), Cranial Nerve X. Vagus Nerve (Mixed)

The glossopharyngeal nerve supplies motor fibers to the parotid salivary gland and muscles in the pharynx (throat), larynx (voice box), and soft palate. Sensory fibers convey taste information from the posterior one-third of the tongue (figure 1.7) and information pertaining to blood pressure and blood chemistry from the carotid artery.

The vagus nerve supplies motor fibers to constrictor muscles of the pharynx, intrinsic muscles of the larynx, and involuntary muscles of the bronchi, heart, esophagus, stomach, small intestine, and part of the large intestine. Secretory motor fibers of the vagus supply the pancreas and secretory glands of most of the alimentary canal. The vagus is sensory from the laryngeal mucosa, heart, lungs, esophagus, stomach, small intestine, and part of the large intestine. In addition, vagal sensory fibers convey taste from the epiglottis and blood pressure and chemistry information from the aorta. The ninth and tenth cranial nerves are tested together because their functions overlap.

Begin by asking the subject to open his or her mouth and say "ahh." Note the position of the soft palate and uvula at rest and with phonation. Normally, the uvula and palate rise in the midline with phonation (figure 1.8). Paralysis of cranial nerves IX and X on one side of the brain will cause the palate and uvula to deviate to the unparalyzed side during phonation (figure 1.8).

Next, ask if the subject has had any difficulty speaking or swallowing. Note the quality of the voice (hoarse, nasal, etc.) and ask the subject to swallow. Note any difficulty. Tell the subject you are going to test for the gag reflex. Depress the tongue and touch the back of the throat lightly on each side using a long-stem cotton applicator (figure 1.9). Absence of the gag reflex may result from a lesion of either the glossopharyngeal (sensory component) or vagus nerve (motor component) on the same side as the loss. If an abnormality is suspected, test for taste on each side of the posterior one-third of the tongue (figure 1.7).

Figure 1.8

Tests of uvular deviation (cranial nerves IX and X:
(a) normal;
(b) deviation to right, paralysis of cranial nerves IX, X on left side;
(c) deviation to left, paralysis of cranial nerves IX, X on right side;
(d) paralysis on both sides due to brain damage
Cranial Nerve XI. Spinal Accessory Nerve (Motor)

The eleventh cranial nerve supplies some motor fibers to the muscles of the larynx and pharynx via the pharyngeal plexus (C.N. IX-X-XI), but its principal distribution is motor to the sternocleidomastoid and trapezius muscles. The sternocleidomastoid turns the head to the opposite side, and the trapezius muscle elevates the shoulder on the same side. Put one hand on the subject's cheek and tell the subject to turn his or her head against your hand as you resist the movement. Meanwhile, use your other hand to palpate the opposite sternocleidomastoid. Repeat the test for the other side. The two muscles should be equal in strength, and no fasciculations (twitching) should occur.

Place both hands on the subject's shoulders and test the strength of the subject's "shrug" as he or she attempts to elevate the shoulders while you press down with both hands. Normally the strengths of the trapezius muscles are equal and there are no fasciculations.

Cranial Nerve XII. Hypoglossal Nerve (Motor)

The hypoglossal nerve supplies motor fibers to muscles of the tongue. Muscles in the right half of the tongue are supplied by the right hypoglossal nerve, and muscles in the left half are supplied by the left hypoglossal nerve.

First, assess the subject's speech by asking the subject to read aloud. Movement of the tongue is important in forming the vowel and consonant sounds of speech. Note any deficiencies.

Next, ask the subject to protrude his or her tongue in the midline. Check for deviation of the tongue tip to the right or left and for atrophy of muscle in the right or left half of the tongue. Normally the tip of the protruded tongue will not deviate from the midline and the tongue will appear symmetrical. A lesion of the hypoglossal nerve will cause the protruded tongue to deviate toward the affected side, and the appearance of the tongue will be asymmetrical owing to atrophy of muscle on the affected side (figure 12.10). Often, fasciculations of the tongue muscle occur on the affected side.