NEURAL REGULATION OF BREATHING
Section 4, Part A

NEUROGENESIS OF BREATHING

I. Medullary Respiratory Center
   A. Medulla isolated from cranial nerves and higher centers can drive respiratory muscles
      1. rhythm appears "ataxic"
   B. Integration of neural centers
      1. nucleus of the tractus solitarius (NTS) or dorsal resp. group
         a. appears to receive and integrate sensory information and to initiate
            motor response
         b. receives input from lungs, pharynx, larynx, and peripheral chemoreceptors
         c. afferent connection -
         d. may be the source of rhythm for breathing
         e. axons from inspiratory neurons appear to innervate the phrenic nerves
            and ventral respiratory group
      2. nucleus ambiguous (NA) and nucleus retroambigualis (NRA)
         a. contains both inspiratory and expiratory neurons
         b. rostral neurons in NA -
         c. rostral neurons in NRA -
         d. spatial separation occurs -
      3. separation of descending tracts from medullary resp. groups
         and tracts from cortex
         a. spinal lesions -
         b. Ondine's curse -

II. Pontine Respiratory Centers
   A. Pons is not necessary for rhythmic breathing
      1. removal of upper portion of pons -
   B. Nucleus parabrachialis medialis (NPBM) aka. pneumotaxic center
      1. at the beginning of inspiration -
      2. toward end inspiration -
         a. activity of stretch receptors are involved
      3. cutting of the vagus with NPBM intact -
         a. inhibits stretch impulses from affecting NPBM
      4. higher centers must play an important role in rhythmic breathing
      5. cats can survive NPBM lesions and subsequent bilateral vagotomy
         a. anesthesia will cause apneusis

III. Respiratory Switching
   A. Inspiration
      1. impulses are discharged from the medulla -
         a. gradual crescendo of impulses
         b. intensity is nearly linear; cessation is abrupt
      2. no impulses are seen during exhalation -
B. Factors affecting breathing patterns
   1. vagal stimulation shortens duration of inspiration
      a. has no effect on rate of phrenic discharge
   2. lung volumes and NPBM activity are additive -
   3. high PCO$_2$ levels, inspiratory effort increases
      a. diaphragm contracts more rapidly
   4. low PCO$_2$ levels -
   5. duration of expiration appears set by length of previous insp.

C. Modification of breathing by higher CNS centers
   1. modified by conscious control -
      a. limited ability to override medullary centers -
      b. one alters breathing pattern to talk
   2. conscious control is in turn subject to:
      a. emotions -
      b. autonomic nervous system -
      c. special senses -
      d. acts that directly control breathing -