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Section One: Reading Comprehension

Electromyography

Electromyography is the technique of recording the electrical responses (action potentials) generated by muscle as a result of either voluntary muscular contraction or spontaneous muscle-fiber activity, or in response to stimulation of the nerve supplying the muscle. The principal application of electromyography is in clinical neurophysiology but it is also employed in kinesiology (the study of limb movement) and in the provision of control signals for prosthetic devices.

A recording system or electromyograph (Figure 1-1) consists of electrodes applied to the patient, high-impedance amplifiers, an oscilloscope display, a loudspeaker and, in most cases, a chart-recording device, which produces an electromyogram (EMG). A voltage or current pulse generator is also provided to permit external stimulation of nerves.

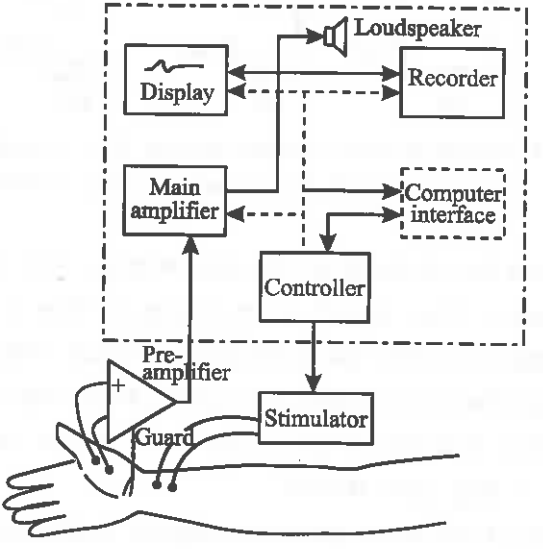


Figure 1-1. Schematic Representation of an Electromyograph.

Two main types of electrodes are used in clinical electromyography: needle electrodes, which are inserted into the muscle through the skin, and surface electrodes, which are placed on the skin (Figure 1-2). The amplitude and shape of the action potentials detected (Figure 1-3) depend on the configuration of the electrode, the number of active muscle fibers, and the

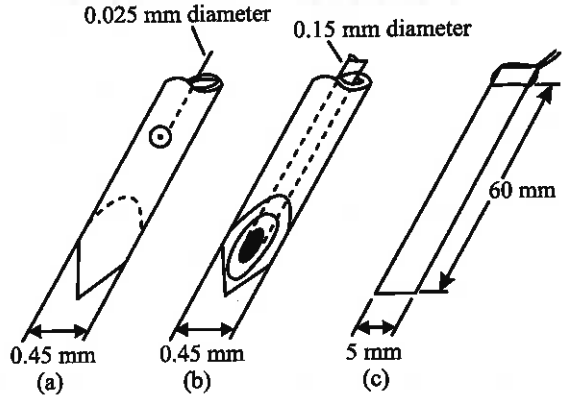


Figure 1-2. Main Types of Electrodes Used in Electromyography: (a) single-fiber needle electrode, (b) concentric needle electrode used in clinical electromyography, and (c) surface electrode (silver foil, 0.1 mm thick).

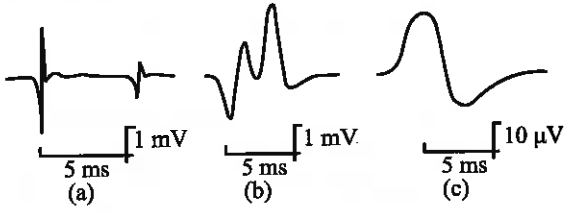


Figure 1-3. Example of Action Potentials Recorded With: (a) single-fiber needle electrode, (b) concentric needle electrode, and (c) surface electrode.

distance between the electrode and the muscle fibers. Fine single-fiber needle electrodes (Figure 1-2a) record action potentials from only a few muscle fibers. The larger concentric needle electrodes (Figure 1-2b), more commonly used in clinical electromyography, can record from some 50 to 200 muscle fibers. A surface electrode (Figure 1-2c) is capable of recording from the whole muscle or large parts thereof.

Recording of the action potentials requires a differential amplifier with high input impedance, high common-mode rejection ratio, and low noise

level. The frequency bandwidth of the amplifier should be variable in the range 2 Hz to 20 kHz. Some electromyographs include preamplifiers in which the patient electrodes are isolated electrically from the rest of the mains-powered equipment, further reducing unwanted interference signals (e.g., from the mains supply) and increasing patient safety. The amplified signal is displayed on an oscilloscope and drives a loudspeaker. In clinical practice the audio signal can be as useful as the displayed signal. The nerve stimulator included in the electromyograph generates voltage or current pulses of variable amplitude (0-400 V or 0-100 mA, respectively) and variable width (0.05-1 ms). The stimulator output is synchronized with the oscilloscope sweep and its transformer coupled in order to reduce stimulus artefact resulting from conduction of the stimulus pulse through the tissue fluids and to provide greater safety for the patient.

Permanent recordings are produced on ultraviolet or electrostatic recorders. For many applications short-term storage (as provided by a storage oscilloscope) is sufficient. The displayed action potentials may then be measured or a Polaroid photograph taken from the oscilloscope display.

Most electromyographs now incorporate digital recording and measuring facilities ranging from a signal averager to a microprocessor-based system that can store and analyze action potentials.

Hansen, S, Sutton, D.L, & Ballantyne, J.P. (pp. 305-306).

Part I. Comprehension Exercises

A. Put "T" for true and "F" for false statements. Justify your answers.

..... 1. Electromyography is employed in the provision of control signals for prosthetic devices.

..... 2. A current pulse generator is provided to permit internal stimulation of nerves.

..... 3. Needle electrodes are placed on the skin.

..... 4. Single-fiber needle electrodes can record from some 50 to 200 muscle fibers.

..... 5. The nerve stimulator produces current pulses of variable amplitude and variable width.

..... 6. The amplified signal is displayed on an oscilloscope and drives a chart-recording device.

B. Choose a, b, c, or d which best completes each item.

1. The technique of recording the action potentials generated by muscles is called ..... .
   a. electroencephalography
   b. electromyography
   c. electrocardiography
   d. electroretinography
2. The amplitude and shape of the action potentials detected depend on ..... .
   a. the configuration of the muscle, the number of active muscle fibers, and the distance between electrode and the muscle fibers
   b. the configuration of the electrode, the number of active muscle fibers, and the distance between the electrode and the muscle fibers
   c. the configuration of the electrode, the number of active muscle fibers, and the distance between the electrode and the amplifier
   d. the configuration of the stimulator, the number of active muscle fibers, and the distance between the electrode and the muscle fibers
3. Permanent recordings are produced on ultraviolet or electrostatic .....
   a. amplifiers
   b. stimulators
   c. electrodes
   d. recorders
4. A ..... electrode is capable of recording from the whole muscle or large parts thereof.
   a. surface
   b. concentric needle
   c. single-fiber needle
   d. needle
5. A microprocessor-based system can ..... action potentials.
   a. detect and analyze
   b. generate and store
   c. produce and display
   d. store and analyze
6. The study of limb movement is called ..... .
   a. neurophysiology
   b. kinesiology
   c. physiology
   d. neurology

C. Answer the following questions orally.

1. What is the principal application of electromyography?
2. What does an electromyograph consist of?
3. What does the recording of the action potentials require?
4. What are the advantages of using preamplifiers in electromyographs?
5. What should be done in order to reduce stimulus artefact and to provide greater safety for the patient?

Part II. Language Practice

A. Choose a, b, c, or d which best completes each item.

1. The word **voluntary** as used in the text means ..... .
   a. done willingly without being forced
   b. done without intention
   c. produced unwillingly
   d. made without any purpose
2. An **amplifier** is an instrument which ..... .
   a. receives sound waves and changes them into electrical waves
   b. makes electrical current or power stronger
   c. receives sounds and passes them on over a further distance
   d. turns electrical energy into sound
3. To **synchronize** as used in the text means ..... .
   a. to record with the same speed
   b. to provide a high voltage
   c. to measure the strength of an electric current
   d. to happen at the same time
4. The word **artefact** as used in the text is best described as ..... .
   a. the artificial response
   b. the voluntary process
   c. the artificial product
   d. the spontaneous activity
5. **Concentric** needle electrodes have ..... .
   a. the same motor units
   b. a common center
   c. a different center
   d. a common amplitude

B. Fill in the blanks with the appropriate form of the words given.

1. Apply

a. Intensity and frequency of malformation induction depend on the ..... dose.

b. The major ..... of bone scans has been in searching for the spread of malignant tumors to bone.

c. Biomechanics is the branch of biology that ..... engineering mechanics to the study of living organisms.

2. Differ

a. There is also a ..... in frequency range between normal and abnormal heart sounds.

b. Blood consists of a fluid, called the plasma, in which are suspended three ..... types of formed elements or blood cells.

c. Clinically, field potentials are recorded using high-gain, high-input-impedance ..... preamplifiers with good common-mode rejection capability, and low inherent amplifier noise.

3. Measure

a. The ..... of bone density employs a monoenergetic beam of photons.

b. Efforts have been made to ..... the thicknesses of the tooth layers.

c. A ..... of the blood pressure can help to illustrate the effectiveness of the heart in pumping blood and the peripheral resistance of the circulation.

4. Produce

a. The overall transfer function of linear elements connected in series is the ..... of the transfer functions for the individual elements.

b. Many combinations of nonlinear elements can ..... the overall linear transfer function required.

5. Insert

a. Filters are frequently ..... in the optical system to control the distribution of radiant power or wavelength.

b. Visual examination of the interior of a hollow organ of the body by the ..... of an illuminating instrument, usually through a natural channel is called endoscopy.

C. Fill in the blanks with the following words.

potentials	needle	sensitive
inserted	regions	employed
disadvantages	multipolar	area

One of the ..... of recording the EMG by using the convenient surface electrodes is that they can be used only with superficial muscles and are ..... to electrical activity over too wide a/an ..... . Various types of monopolar, bipolar, and ..... insertion-type electrodes are commonly used in electromyography for recording from deep muscles and from SMUs (single motor units). These types of electrodes generally record local activity from small ..... within the muscle in which they are ..... . Often a simple fine-tipped monopolar ..... electrode can be used to record SMU field ..... even during powerful voluntary contractions. Bipolar recordings are also ..... .

D. Put the following sentences in the right order to form a paragraph. Write the corresponding letters in the boxes provided.

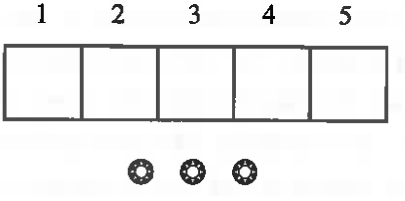
a. The component fibers of the motor units extend lengthwise in loose bundles along the muscle.

b. Skeletal muscle is organized functionally on the basis of the *motor unit*.

c. In cross section, however, the fibers of a given motor unit are interspersed with fibers of other motor units.

d. The motor unit is the smallest unit that can be activated by a volitional effort, in which case all constituent muscle fibers are activated synchronously.

e. Thus the component muscle fibers of the *single motor unit* constitute a distributed, unit bioelectric source located in a volume conductor consisting of all other muscle fibers, both active and inactive.



More About Electromyography

Clinical Applications

Muscle fibers are organized in functional units called motor units, each motor unit consisting of a neuron, its axon, and the muscle fibers it supplies (Figure 1-4). Electromyographic measurements of motor unit activity and nerve conduction velocity are used clinically in the investigation of neuromuscular disease.

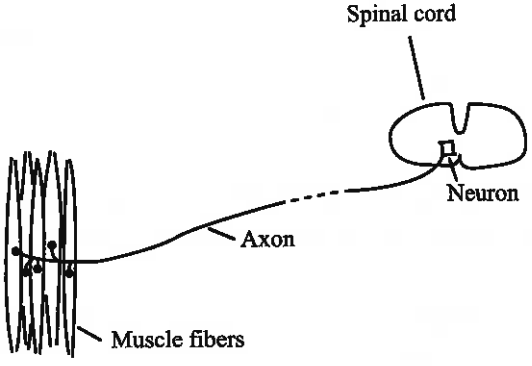


Figure 1-4. Schematic Diagram of a Motor Unit.

At rest, no motor-unit potentials (MUPs) are generated by normal, healthy muscle, but low-amplitude, short-duration action potentials (fibrillations) may be detected in diseased muscle if the muscle fibers have lost their nerve supply. The presence of abnormally large or small MUPs or a high incidence of MUPs with more than four phases all indicate neuromuscular disease when generated during weak voluntary muscular contraction. The abundance of motor-unit activity at maximal voluntary contraction is used as an index of the motor-unit complement in the muscle.

Measurement of nerve-conduction velocity is used to detect slowing in the propagation of nerve pulses. The nerve is stimulated at two separate sites and the times between the stimuli and the onset of the evoked muscle responses – latencies – are measured. The latency difference and the distance between the two sites determine the nerve-conduction velocity. Repetitive

nerve stimulation at frequencies of 3 or 10 Hz, or sometimes up to 50 Hz is used to test neuromuscular transmission.

Quantitative Electromyography

Quantification of the qualitative changes noted in conventional electromyography has been attempted. Amplitude and duration of MUPs recorded with concentric needle electrodes have been measured.

The single-fiber electrode (Figure 1-2a) can record from two muscle fibers belonging to the same motor unit. The variability in the time interval – jitter – between the action potentials from the two muscle fibers is measured. Increased jitter is caused by defects in neuromuscular transmission or nerve conduction. Single-fiber electromyography can also give a measure of muscle density in the motor unit.

The number of functioning motor units in a muscle can be estimated by an on-line computerized method. A small sample of motor units are recruited sequentially by increasing the intensity of a series of electrical stimuli to the nerve supplying the muscle. The computer records the summated MUPs and by comparison with the supramaximally evoked muscle action potential (all motor units responding together) the number of motor units is estimated. An extension of this technique allows the MUPs from the sample to be analyzed in detail. Some neuromuscular diseases (e.g., the neuropathies) show a decrease in the number of motor units and exhibit changes in the MUP parameters.

Over the years, a number of automated methods for diagnosis of neuromuscular diseases have been introduced. One example is frequency analysis of the EMG, whereby the signal is passed through a series of electronic filters and the result plotted as a histogram of frequency distribution. Another method provides a smoothed spectrum using a digital computer. Some disease processes in the muscle have been shown to alter the frequency spectrum of the EMG. Another technique measures the mean amplitude and the number of changes in the sign of the slope of the EMG recorded at constant muscle tension. Few of these automated techniques have proved to be of value in clinical electromyography.

Hansen, S., Sutton, D.L., & Ballantyne, J.P. (pp. 306-307).

Comprehension Exercises

A. Put "T" for true and "F" for false statements. Justify your answers.

..... 1. At rest, motor-unit potentials are generated by normal, healthy muscle.

..... 2. Defects in neuromuscular transmission or nerve conduction result in increased jitter.

..... 3. All of the automated methods have proved to be of value in clinical electromyography.

..... 4. Automated methods are used for diagnosis of neuromuscular diseases.

..... 5. The single-fiber electrode can record from two muscle fibers belonging to a different motor unit.

..... 6. For testing neuromuscular transmission, repetitive nerve stimulation at frequencies of 3 or 10 Hz is used.

B. Write the answers to the following questions.

1. What are motor units?
2. What does a motor unit consist of?
3. How is the nerve-conduction velocity determined?
4. How is the number of functioning motor units in a muscle estimated?
5. What are the automated methods?
6. What are the evoked muscle responses called?

Section Three: Translation Activities

A. Translate the following passage into Persian.

Internal Electrodes

Electrodes can also be used within the body to detect biopotentials. They can take the form of *percutaneous electrodes*, in which the electrode itself or the

lead wire crosses the skin, or they may be entirely *internal electrodes*, in which the connection is to an implanted electronic circuit such as a radiotelemetry transmitter. These electrodes differ from body-surface electrodes in that they do not have to contend with the electrolyte-skin interface and its associated limitations. Instead, the electrode behaves in the way dictated entirely by the electrode-electrolyte interface. No electrolyte gel is required to maintain this interface, because extracellular fluid is present.

There are different types of percutaneous needle and wire electrodes. The basic needle electrode consists of a solid needle, usually made of stainless steel, with a sharp point. The shank of the needle is insulated with a coating such as an insulating varnish; only the tip is left exposed. A lead wire is attached to the other end of the needle, and the joint is encapsulated in a plastic hub to protect it. This kind of electrode is frequently used in electromyography. When it is placed in a particular muscle, it obtains an EMG from that muscle acutely and can then be removed.

A variation of this type of electrode is used on patients undergoing surgery to monitor the ECG continuously. The electrode consists of stainless steel hypodermic needles placed subcutaneously on each limb. Lead wires with special connectors attached to the needle at the hub connect the electrodes to the cardioscope. These electrodes remain in place as the patient is manipulated during the surgical procedure. They are away from the surgical field. Electrolyte gel is not necessary.

B. Find the Persian equivalents of the following terms and expressions and write them in the spaces provided.

1. biopotentials .....
2. cardioscope .....
3. electrolyte gel .....
4. electrolyte-skin interface .....
5. encapsulate .....
6. extracellular fluid .....
7. hypodermic .....
8. implanted electronic circuit .....
9. jitter .....

10. latencies .....
11. motor units .....
12. muscle fibers .....
13. muscle tension .....
14. nerve conduction .....
15. neuromuscular disease .....
16. oscilloscope display .....
17. percutaneous electrodes .....
18. stimulation .....
19. subcutaneously .....
20. voluntary .....

Unit 2

Section One: Reading Comprehension

Bioelectricity

Animal electricity is a concept with a long, if somewhat murky, history. Commentators have remarked upon the lifelike features of many electrostatic and discharge phenomena. In turn, these electrical phenomena were often capable of potent biological effects; furthermore, some of these effects were identical to those produced by the attacks of certain fish. Thus the links were numerous, yet for many centuries they were too intricate for clear interpretation; even the seminal observations of Galvani (1737-98) upon the dancing of frogs' legs, touched by heterogeneous metals in salted water, were contemporarily explained by the flow through the metal of Vital Spirit, not mere electricity. The foundations of a modern understanding were only laid down – by du Bois-Reymond, Helmholtz, and Bernstein – in mid-nineteenth century Germany.

The great majority of bioelectric phenomena have their origin in the potential differences which exist across cell membranes. These arise from inequalities of ionic concentration between the intracellular and extracellular fluids, which are themselves caused as follows.

Metabolic energy, made available by the hydrolysis of adenosine triphosphate (ATP), fuels a mechanism not yet fully understood but known to reside in macromolecular complexes embedded within the cell membrane. This drives out from the cell the most common cation of biological fluids, sodium (Na^+), and is termed the 'sodium pump'. The charge deficit which would arise if the outward pumping process went on unchecked – the inside of the cell being left massively negative with respect to the outside – is largely compensated by the inflow of the second most common cation, potassium (K^+). This ion permeates freely through cell membranes, and in the simplest instances is passively drawn in to make up the electrical deficit.

The chief anionic constituents of intracellular fluids are organic species,

synthesized metabolically from small precursors, but themselves too large to diffuse back through the membrane. Extracellularly, the principal anion is chloride (Cl^-); this, though able to pass freely through many cell membranes, is repelled electrically from achieving a comparable concentration intracellularly. Thus, all cells contain predominantly K^+ and organic anions, in electrochemically comprarable amounts, while the extracellular fluid contains chiefly Na^+ and Cl^-.

Membrane Potentials

A transmembrane potential difference (PD), known to physiologists as a 'membrane potential', results from the cationic separation just described. To see that this must happen, suppose that the internal negativity produced by the pump were completely cancelled by K^+ uptake. This would eliminate the force tending to hold K^+ ions within the cell. Being freely permeating, they would diffuse out, leaving the inside negative again.

The thermodynamic equilibrium condition, for an ion under a concentration gradient, was derived by Nernst in the 1890s as:

$$E_j = \frac{RT}{z_j F} \ln \frac{[j]_o}{[j]_i}$$

Where $[j]_i$ and $[j]_o$ represent concentrations of the ion j inside and outside the cell, respectively; z_j is the algebraic valency of j; E_j is the equilibrium membrane potential, measured inside relative to out (i.e., it is negative for a cation having higher concentration inside); F is the Faraday constant; R is the gas constant; and T is the absolute temperature. At 310 K (mammalian body temperature), RT/F equals 26.7. Thus, for a monovalent cation 30 times more concentrated inside the cell than out, the equilibrium internal potential would be about −90 mV. An approximately 30-fold concentration ratio characterizes K^+ distribution across the membranes of the principal electrically excitable cells, nerve and skeletal muscle; in these cells membrane potentials in the vicinity of 90 mV are in fact observed (note that as the membrane is only about 7 nm thick, this PD implies a transmembrane field > 10^5 Vcm^{-1}).

Strictly, the membrane potential of a living cell in a normal environment is not a pure K^+ equilibrium potential, for at least two reasons. First, other ions have finite, though commonly small, permeabilities. In particular Na^+,

with a steep inwardly directed concentration gradient and therefore an inside-positive equilibrium potential, has permeability one to two orders of magnitude less than that of K^+ in a resting (i.e., electrically unexcited) cell, but this suffices for it to reduce the inside-negative polarization by ~ 10 mV. Secondly, however, no quantitative allowance has been made for the continuing electrogenic (current-generating) effect of the Na^+ pump. Yet the kind of pump described above, steadily transporting positively charged ions out of the cell, contributes an emf which summates algebraically with the Nernstian influences, and acts in the hyperpolarizing direction (i.e., tends to drive the inside still more negative). Normally this effect contributes only a few millivolts but, in a cell recovering from Na^+ load, the figure may be tens of millivolts. A final complication is that a pure Na^+ pump is probably a rarity. Most pumps, in most conditions, appear to transport K^+ ions into the cell at the same time as transporting Na^+ out. (This is active transport, not passive diffusion; it apparently occurs through different membrane channels from those involved in thermodynamic equilibration, and the ions transported become free to participate in the Nernstian process only when released into the intracellular fluid.) Nevertheless, the coupling ratio, (Na^+ active efflux)/(K^+ active influx), is usually more than unity, so pumping is still electrogenic, though less markedly so than in the simple case.

Spurway, N. (pp. 34-35).

Part I. Comprehension Exercises

A. Put "T" for true and "F" for false statements. Justify your answers.

..... 1. PDs exist across the cell membranes.

..... 2. The charge deficit is compensated by the most common cation of biological fluids, sodium (Na^+).

..... 3. Some of the biological effects produced by the attacks of certain fish were identical to those produced by electrical phenomena.

..... 4. Some cells contain predominantly Na^+ and organic anions.

..... 5. In the Nernst equation, $[j]_o$ represents concentrations of the ion j.

..... 6. The algebraic valency of j in the thermodynamic equilibrium is z_j.

..... 7. The permeability of K^+ is less than that of Na^+ in a resting cell.

B. Choose a, b, c, or d which best completes each item.

1. PDs arise from inequalities of ionic concentration ..... .
   a. within the cell membrane
   b. through different membrane channels
   c. between inside and outside of the cell membrane
   d. between the intracellular and extracellular fluids
2. Organic species are ..... .
   a. able to pass freely through many cell membranes
   b. drawn inside the cell to make up the electrical deficit
   c. too large to diffuse back through the membrane
   d. released into the intracellular fluid
3. Chloride (Cl^-) is repelled electrically from achieving ..... .
   a. an ionic concentration intracellularly
   b. a comparable concentration intracellularly
   c. an ionic concentration extracellularly
   d. a comparable concentration extracellularly
4. The membrane potential of a living cell in a normal environment is ..... .
   a. a pure K^+ equilibrium membrane potential
   b. not a pure K equilibrium potential
   c. not a pure K^+ equilibrium potential
   d. a pure K^+ equilibrium internal potential
5. Most pumps transport ..... .
   a. K^+ ions into the cell at the same time as transporting Na^+ out
   b. Na^+ ions into the cell at the same time as transporting K^+ out
   c. K^+ ions into the cell after transporting Na^+ out
   d. Na^+ ions into the cell after transporting K^+ out

C. Answer the following questions orally.

1. What are the chief anionic constituents of intracellular fluids?
2. What does the extracellular fluid contain?
3. What does $[j]_i$ represent in the thermodynamic equilibrium?
4. What characterizes K^+ distribution across the membranes of the principal electrically excitable cells?
5. Why is pumping still electrogenic?

Part II. Language Practice

A. Choose a, b, c, or d which best completes each item.

1. **Concentration gradient** is a gradient that exists across a membrane separating a high concentration of ..... .
   a. a particular ion from a low concentration of a positive ion
   b. a particular ion from a low concentration of the same ion
   c. a negative ion from a high concentration of a positive ion
   d. a positive ion from a low concentration of a negative ion
2. **Constituent** as used in the text means ..... .
   a. transmembrane field
   b. membrane potential
   c. membrane channel
   d. component part
3. **Hydrolysis** refers to ..... .
   a. decomposition of a chemical compound by reaction with acid
   b. reaction of a chemical compound with a weak acid
   c. decomposition of a chemical compound by reaction with water
   d. reaction of a chemical compound with a weak base
4. To **diffuse** means ..... .
   a. to spread
   b. to reduce
   c. to eliminate
   d. to repel
5. An **anion** is a negatively charged ion that ..... .
   a. migrates to a positively charged ion
   b. repeles another negatively charged ion
   c. repeles an anode
   d. migrates to an anode

B. Fill in the blanks with the appropriate form of the words given.

1. **Capable**
   a. Stem cells are ..... both of long-term self renewal and of supplying cells to other compartments.
   b. The range of purpose-built or dedicated electronic communication aids now available is very wide, in terms of both ..... and price.

2. Effect

a. In recent years, numerous studies of the ..... of sound on biological systems have been carried out.

b. Evaluation is composed of a number of interrelated activities designed to determine the characteristics of the device and its clinical ..... .

c. The electrical conduction system of the heart governs the heart rate and the ..... sequencing of the atrial and ventricular pumps.

d. Ultraviolet radiation of wavelengths shorter than 200 nm is ..... absorbed by all common materials including air and does not represent an external radiation hazard.

3. Organ

a. Special senses are each located in one or two specialized ..... within the head.

b. ..... chemistry deals with the nature and products of animal and plant bodies.

c. Exposure to a high level of radiation to living ....., mammals in particular, induces pathological conditions and even death.

4. Separate

a. In the general senses, ... membrane specializations at the nerve terminal must be presumed to be part of each distinct form of sensitivity.

b. The importance of membranes to extracorporeal blood purification is derived from the fact that they permit ..... and purification processes under conditions appropriate to the nature and properties of blood.

c. The left and right eyes are ....., and consequently receive slightly different images of three-dimensional objects.

5. Diffuse

a. In a multisolute system, each solute ..... across the membrane under the influence of its particular concentration gradient.

b. ..... rates of protons, acid radicals and mineral ions are important rate-determining factors in tooth decay.

c. The use of water as the ..... blood flow trace is attractive in that it is not lipophilic.

C. Fill in the blanks with the following words.

saline	transmembrane	capillary
peak	fiber	penetrating
axially	mechanism	connection

The key to understanding the AP (action potential) ..... was the intracellular electrode. This consisted first of a/an ....., about 50 μm in diameter, filled with ..... solution and inserted ..... along an exceptionally large nerve ..... from a cut end. A little later, glass tubes drawn down to tip diameters < 1 μm (microelectrodes) were found capable of ..... radially through the membranes of a variety of cell types, and giving well-sealed electrical ..... to the inside. The absolute values of ..... potential difference, in a resting cell and at the AP ....., were revealed by these two forms of intracellular electrode.

D. Put the following sentences in the right order to form a paragraph. Write the corresponding letters in the boxes provided.

a. Plant cells, like those of animals, have sodium pumps: they thus contain high concentrations of K^+ relative to extracellular fluids and display membrane potentials.

b. Instances where the essential biological mechanism is electrical do not, however, appear to be nearly as numerous in plants as in animals.

c. In plants, as in animals, potential differences of tens of millivolts can often be recorded which appear to be secondary consequences of concentration differences, of pumping or of streaming phenomena.

d. Roots take up ions by vigorous active-transport mechanisms, analogous to those of epithelia.

e. Plant biophysicists frequently use electrical methods as tools for studying these processes.

1	2	3	4	5

Action Potentials

An action potential (AP) is a rapid swing of intracellular potential in the depolarizing direction, followed – typically within about 1 ms -- by an almost equally rapid return towards resting condition. Although smaller, less reproducible 'spikes' of depolarization do occur in some tissues, a true AP is of an amplitude that is dependent only on the ionic gradients across the cell membrane, and not on the stimulus strength. This property is represented by the classical physiological term, an 'all-or-nothing' response.

Except where cell geometry changes significantly, APs propagate without decrement along the length of the cell. They are the means by which rapid and relatively interference-free conveyance of information is achieved down long, cablelike cells such as nerve and skeletal-muscle fibers. The all-or-nothing feature implies that signalling in such fibers is frequency coded: AP frequency commonly, but not always, increases with stimulus intensity. Also implicit in the all-or-nothing property, and crucial to the avoidance of interference, is the existence of a threshold stimulus strength, below which no response occurs.

Stimulation can be achieved by many forms of energy input (e.g., mechanical, chemical, or thermal), but all have it in common that, if adequate to produce an AP, they achieve, as an immediate consequence of their application, a depolarization of not less than 15 mV or so. Nerve, muscle, and sensory cells rapidly follow this stimulating depolarization with the much larger all-or-nothing response which constitutes the AP. (To distinguish between stimulus and response, note that an otherwise similar, but inexcitable, cell would show only the first of the two stages of depolarization just described.) Alternatively, the stimulating depolarization can be produced directly at the cathode of a pair of electrodes laid against the outside of the cell. Such direct, electrical excitation is the preferred tool for both experimental and clinical nerve excitation. It also simulates the natural excitation process over the main length of a fiber, for ahead of any point at which the peak of an AP is occurring, local current spread produces

depolarization, and triggers the response in the new region. This is how propagation takes place.

Spurway, N. (p. 36).

Comprehension Exercises

A. Put "T" for true and "F" for false statements. Justify your answers.

..... 1. A true AP is of an amplitude that is not dependent on the stimulus strength.

..... 2. Below the threshold stimulus strength, no response occurs.

..... 3. AP frequency always increases with stimulus intensity.

..... 4. APs can be produced without decrement along the length of the fiber.

..... 5. The stimulating depolarization can be produced throughout the membranes of a variety of cell types.

..... 6. Smaller and less reproducible 'spikes' of depolarization occur in excitable cells.

B. Write the answers to the following questions.

1. What is an AP?
2. What does all-or-nothing feature imply?
3. How do APs propagate?
4. Where can the stimulating depolarization be produced?
5. What does a true AP depend on?

Section Three: Translation Activities

A. Translate the following passage into Persian.

Ionic Mechanism in the Cells First Studied

Earlier thinking, dating from the turn of the century, but based only on

recordings from extracellular electrodes, had assumed that the AP consisted simply of a depolarization from resting potential towards zero; this was ascribed to a moment of general, ionic leakiness. The newly observed 'overshoot' to positive potential required, instead, a switch of permselectivity: K^+ dominated the resting state and an ion for which the Nernst potential was inside-positive must transiently dominate the active one. To carry the currents involved, it could only be an ion present in bulk, and the obvious candidate was Na^+. In the late 1940s, Hodgkin, Huxley, and Katz found that reducing Na^+ concentration in the fluid bathing the nerve duly diminished both the rate and extent of the overshoot, and the essential mechanism of this class of AP was established. In terms of the E_m (membrane potential), P_{Na^+} swings briefly from a value of one to two orders of magnitude lower than P_{K^+} to a value about two orders greater.

B. Find the Persian equivalents of the following terms and expressions and write them in the spaces provided.

1. active efflux .....
2. active influx .....
3. cation .....
4. cationic separation .....
5. depolarizing direction .....
6. electrical deficit .....
7. electrogenic .....
8. excitable cells .....
9. hyperpolarizing direction .....
10. inexcitable .....
11. inside-negative polarization .....
12. intracellular fluids .....
13. overshoot .....
14. permselectivity .....
15. precursor .....
16. stimulating depolarization .....
17. thermodynamic equilibration .....
18. transmembrane .....

Section One: Reading Comprehension

Blood Flow: Invasive and Noninvasive Measurement

Accurate measurement of blood flow to organs or tissues is necessary in many areas of medical and biological research. The clinical value of flow measurements, particularly in cardiology and in cardiac and vascular surgery, is well recognized. The ability to detect blood flow, even if it cannot be precisely measured, has also proved invaluable to obstetricians for the measurement of fetal heart rate and to other clinicians for investigation of the circulation.

Many methods for measuring blood flow are available. These include:

- venous occlusion plethysmography, whereby the rate of increase in volume of a part of the body is measured as blood flows into it while the outflow (venous return) is temporarily cut off;
- techniques using ultrasound and the Doppler effect in order to derive blood velocity from the change in frequency (due to the Doppler effect) which occurs when a beam of ultrasound is scattered by moving red cells in the blood;
- electromagnetic induction techniques, in which the blood flow is determined from the voltage induced when blood (an electrical conductor) flows through a magnetic field;
- indicator dilution methods, in which an indicator is added and its concentration is measured after thorough mixing with the flowing blood; and
- indicator clearance methods, whereby blood flow is determined from the rate at which an indicator is carried away from the site of measurement by the flowing blood.

Venous occlusion plethysmography is one of the oldest methods of blood-flow measurement. It is noninvasive and can yield highly accurate

results. The limb (or part of a limb) is enclosed in a rigid container filled with warm water, and an inflatable cuff encircles the limb close to where it enters the container at a waterproof seal (Figure 3-1). The cuff is inflated rapidly to

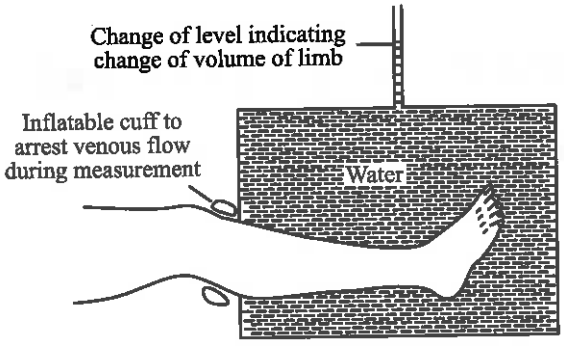


Figure 3-1. Venous Occlusion Plethysmograph for Measuring Blood Flow in a Limb or Part of a Limb.

a pressure which just exceeds the pressure in the veins, preventing blood from leaving the limb, but not restricting the arterial inflow. During each measurement, which takes a few seconds, arterial blood continues to flow into the limb, distending the veins, and displacing an equal volume of water from the container. The rate at which water is displaced is measured electronically and recorded. After each measurement, the cuff is deflated to allow the veins to return to their normal volume.

Terry, H.J. (pp. 85-86).

Part I. Comprehension Exercises

A. Put "T" for true and "F" for false statements. Justify your answers.

..... 1. Blood flow can be measured only invasively.

..... 2. Venous occlusion plethysmography can yield highly accurate results.

..... 3. In indicator dilution method, the blood flow is determined from the change in voltage.

..... 4. In electromagnetic induction technique, the indicator is diluted by flowing blood.

..... 5. In cardiac surgery, the importance of blood flow measurements is well recognized.

..... 6. In indicator clearance method, the flowing blood can carry away an indicator from the site of measurement.

B. Choose a, b, c, or d which best completes each item.

1. Blood-flow measurement has proved invaluable to obstetricians for .....
   a. the measurement of fetal heart frequency
   b. the investigation of the circulation
   c. the investigation of fetal heart volume
   d. the measurement of fetal heart rate
2. A change in frequency occurs when .....
   a. the outflow is temporarily cut off
   b. a beam of ultrasound is scattered
   c. the volume of a part of the body is measured
   d. the veins are returned to their normal volume
3. Both ultrasound and the Doppler effect methods rely on red cells .....
   a. movement b. charge
   c. size d. shape
4. In indicator clearance method, blood flow is determined from ..... .
   a. the applied voltage b. the blood concentration
   c. the carrying away rate d. the applied current
5. For measuring blood flow in a limb, an inflatable cuff is used .....
   a. to encircle the limb close to where it enters the container
   b. to prevent blood from entering the limb
   c. to enclose the limb in a rigid container
   d. to restrict the arterial inflow in the limb

C. Answer the following questions orally.

1. How is a beam of ultrasound scattered?
2. How is blood flow determined in electromagnetic induction technique?
3. What is the oldest method of blood-flow measurement?
4. How is blood flow measured in a limb?
5. Why is the cuff deflated after measuring blood flow in a limb?

Part II. Language Practice

A. Choose a, b, c, or d which best completes each item.

1. The word **occlusion** can be described as ..... .
   a. a blockage in a muscle of the body
   b. a blockage in a canal, vessel, or passage of the body
   c. a short ultrasonic pulse in a tissue
   d. a beam of ultrasound across a blood vessel
2. **Circulation** refers to the movement of an object or substance through ..... .
   a. a direct course so that it detects blood flow
   b. a direct course so that it returns to its starting point
   c. a circular course so that it returns to its starting point
   d. a circular course so that it moves in all directions
3. **Electromagnetic induction** is the production of electric current in a circuit when the circuit is ..... .
   a. directed obliquely through an electrical conductor
   b. passed through a changing magnetic field
   c. held against an electrical conductor
   d. added to a changing magnetic field
4. To **distend** means ..... .
   a. to combine
   b. to reject
   c. to remove
   d. to enlarge
5. **Noninvasive** is a diagnostic or therapeutic technique that ..... .
   a. requires entering a body cavity or an interruption of normal body functions
   b. indicates the blood velocity in the veins of the heart
   c. does not require the skin to be broken or a cavity or organ of the body to be entered
   d. determines the direction of blood flow in the tissues of the body

B. Fill in the blanks with the appropriate form of the words given.

1. **Accurate**
   a. All tests of cardiac function as well as the interpretations that are

put on them should be examined and analyzed with respect to their sensitivity, specificity, and ..... .

b. Photogrammetry may be defined as the science of obtaining ..... and precise measurements from conventional photographs that are taken under strictly controlled conditions.

c. With the advent of new machines that can measure blood viscosity and its determinants rapidly and ..... the relevance and importance of such measurements have become apparent.

2. Necessary

a. In order to produce an image of the inside of the body in a nonrestrictive way, it is ..... to use radiation to which the body is semitransparent, for example, the sound waves used in ultrasonic imaging.

b. The steady expansion of scientific and technological innovations has ..... specialization for all health professionals and the housing of advanced technology within the walls of the modern hospital.

3. Investigate

a. Computers have an advanced diagnostic role in cardiac ..... .

b. Many materials have been ..... from implant use, but very few have proved suitable.

c. Positron emission tomography (PET) is a noninvasive, ... procedure used in clinical research for the study of regional tissue physiology and biochemistry and pharmacology.

4. Ability

a. The body consumes oxygen and generates carbon dioxide continuously but it is only ..... to store these gases in amounts sufficient for at most a few minutes of metabolism.

b. If a general-purpose piece of equipment such as a home computer is to be used as a communication aid, a prerequisite is that it should have the ..... to run the appropriate program; as soon as it is switched on.

5. Normal

a. Cancer researchers have for decades been confronted with the problem of devising a hypothesis which could explain how so many

diverse chemical and physical agents can exert the same effect in transforming a ..... cell into a tumor cell.

b. The ECG ..... consists of a presentation of twelve different recordings of cardiac electrical activity.

C. Fill in the blanks with the following words.

transducer	drawback	noninvasive
equipment	probe	electromagnetic
principles	catheter	pulsatility

Plethysmography and Doppler ultrasound techniques have the important advantage of being ..... . While plethysmography provides an accurate measurement of mean flow, it has the ..... of requiring the subject to remain still, in a suitable position, while measurements are made. Ultrasonic methods provide clinically valuable information on the velocity and ..... of blood flow, but elaborate ..... is necessary for precise measurements. If a vessel is exposed during surgery, the choice lies between the ultrasonic and ..... methods. Further, either technique can be used for long-term flow measurement using a surgically-implanted ..... placed round an artery, ultrasonic flowmeters having the advantages of lower power consumption in the ..... and freedom from baseline drift.

Blood flow through the heart and the major vessels can be measured by indicator dilution techniques, if a needle or a/an ..... can be inserted into the appropriate artery or vein. A great variety of techniques, based mainly on dilution or clearance ....., are available for flow measurements in the various organs and tissues of the body.

D. Put the following sentences in the right order to form a paragraph. Write the corresponding letters in the boxes provided.

a. A similar technique, hot-film anemometry, is used to determine the velocity profile in the larger blood vessels.

b. In another method, known as thermal clearance, a thermistor is embedded in tissue and maintained at a temperature a few degrees

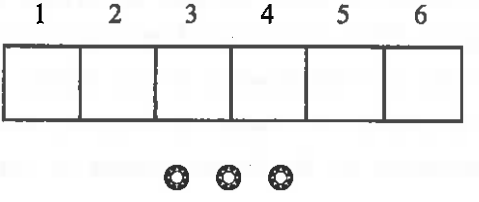
above body temperature; the electrical power supplied, which is directly proportional to tissue perfusion, is measured.

c. A number of very different methods of flow measurement are based on the simple principle that the rate at which an indicator is removed from a point or a region in the body is proportional to the flow, provided that certain conditions are met.

d. The varying blood velocity is determined from the power supplied, as the needle is advanced across the vessel.

e. For example, if a bolus of the radioisotope ^{133}Xe, dissolved in saline, is injected into tissue, the perfusion of the tissue can be determined from the rate of decay of radioactivity at the site of the injection.

f. A thin-film resistor, a fraction of a millimeter across, is mounted at the tip of a needle which is inserted in a blood vessel.



Section Two: Further Reading

Use of Backscattered Ultrasound and the Doppler Effect

The use of ultrasound and the Doppler effect for the investigation of circulation has increased rapidly in the last decade and research is in progress on many aspects of this technique. A beam of ultrasound at a frequency between 2 and 10 MHz is directed obliquely across a blood vessel (Figure 3-2). The red cells in the blood scatter the ultrasound in all directions. Some of the backscattered ultrasound impinges on a receiver crystal which is adjacent to the transmitter crystal. In practice, both crystals are often fixed in juxtaposition in a single probe which can be held against the surface of the

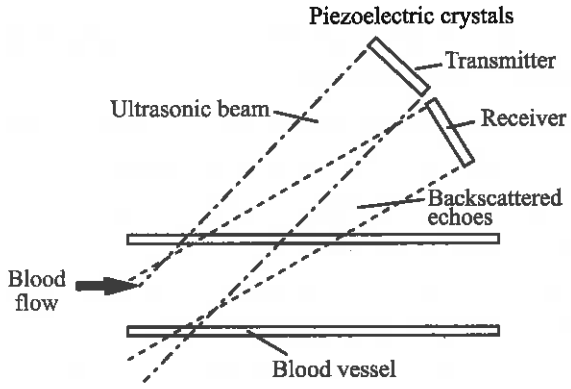


Figure 3-2. Measurement of Blood Flow by Ultrasound. A probe in which the crystals are mounted is applied to a blood vessel at operation, or held against the skin for transcutaneous measurements on an underlying vessel.

skin in the vicinity of a blood vessel. A gel or oil is used as an ultrasound coupling medium, filling the space between the crystal faces and the skin. Owing to the Doppler effect, movement of the blood towards, or away from, the crystals causes the received sound to be at a higher, or lower, frequency than the transmitted sound, the change in frequency being directly proportional to the component of the blood velocity in the direction of the ultrasonic beam.

Since normal blood velocities give rise to changes in frequency which are within the human audible range, many simple inexpensive instruments have been produced which allow the operator to hear a signal which varies in pitch with the velocity of the blood. Such instruments are in common use for the detection and qualitative assessment of arterial and venous flow, and the confirmation of pregnancy by the detection of the fetal pulse. More elaborate machines have been developed for the imaging of blood vessels and the monitoring of fetal heart rate during labor.

In order to obtain a quantitative measurement of blood flow, rather than an indication of blood velocity, it is necessary to know the area of cross section of the vessel and the mean velocity over that area. Two methods have been used to determine the velocity distribution across the vessel. One approach is to analyze the frequency spectrum of the Doppler signals, since the proportion of the received signal within a certain frequency band indicates

the proportion of blood flowing at a corresponding range of velocities. Alternatively, if the transmitter output consists of short ultrasonic pulses, signals from different parts of the blood vessel can be separated according to the time interval between transmission and reception of a pulse. This is known as a range-gated Doppler system. Whichever method is used, it is also necessary to know the angle between the ultrasonic beam and the blood vessel, and the cross-sectional area. Ultrasonic instruments which combine pulse-echo techniques for imaging the vessel and the Doppler effect for velocity measurements have recently been developed.

Terry, H.J. (pp. 86-87).

Comprehension Exercises

A. Put "T" for true and "F" for false statements. Justify your answers.

..... 1. The red cells in the blood scatter the ultrasound in one direction.

..... 2. The frequency of a beam of ultrasound across a blood vessel is between 2 and 10 MHz.

..... 3. The receiver crystal is adjacent to the transmitter crystal.

..... 4. Normal blood velocities cause changes in volume.

..... 5. The proportion of the transmitted signal determines the proportion of blood flowing at a corresponding range of velocities.

..... 6. Pulse-echo techniques are used for velocity measurement.

..... 7. The signal which the operator hears varies in frequency with the velocity of the blood.

B. Write the answers to the following questions.

1. What should be held against the surface of the skin in the vicinity of a blood vessel?
2. Where does some of the backscattered ultrasound impinge on?
3. What fills the space between the crystal faces and the skin?
4. What causes the received sound to be at a higher, or lower, frequency than the transmitted sound?
5. Where are the receiver and transmitter crystals mounted?
6. When can signals be separated from different parts of the blood vessel?

7. What should one know in order to obtain a quantitative measurement of blood flow?

Section Three: Translation Activities

A. Translate the following passage into Persian.

Indicator Dilution Methods

The use of indicators for measurements on the circulation was introduced by Stewart (1897) and developed for the measurement of blood flow by Hamilton et al. (1928). Many different methods based on this technique are now in use. They can be divided into two groups, depending on whether the indicator is injected at a constant rate (for long enough for a steady state to be reached) or in the form of a rapid injection of a single bolus of the indicator.

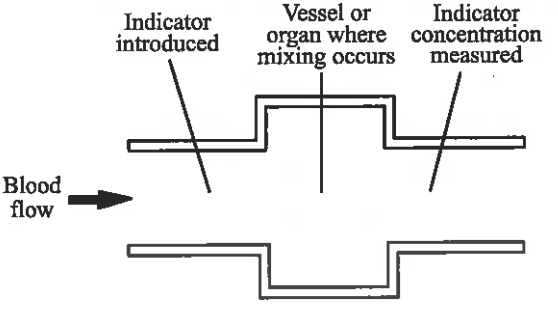


Figure 3-3. Principle of Flow Measurement by Indicator Dilution.

If an indicator is added to the flowing blood at a known, steady rate (Figure 3-3) and its concentration is measured after thorough mixing has occurred, the indicator will reach the site of measurement at the same rate at which it is injected, i.e., $\dot{Q}C=X$, where $\dot{Q}$ is the blood flow, C is the indicator concentration, and X is the rate of injection of indicator. Hence the blood flow is calculated from the indicator concentration and the injection rate.

The second group of methods is based on the principle that all the

indicator, injected in a bolus, will reach the site of measurement, after dilution and mixing with the blood. Hence,

$$\int_{t=0}^{\infty} \dot{Q}C(t)\mathrm{d}t = Y$$

where $\dot{Q}$ is the blood flow, $C(t)$ is the concentration of the indicator at time t, Y is the total quantity of indicator injected, and t is the time from the start of the injection.

If the blood flow is constant, the equation can be rearranged as follows:

$$\dot{Q} = \frac{Y}{\int_0^{\infty} C(t)\mathrm{d}t}$$

This is known as the Stewart-Hamilton equation.

Blood flow through the heart is commonly measured by dye dilution, for example, by measuring the concentration of a dye such as indocyanine green in the blood photometrically. Thermal dilution, using cold saline, can also be used. Here, saline is injected through a catheter into the blood entering the heart. A temperature sensor at the tip of a second catheter measures the temperature of the blood after mixing in the heart. Equipment is available, using each of these methods, for both measuring and calculating the blood flow automatically.

B. Find the Persian equivalents of the following terms and expressions and write them in the spaces provided.

1. arterial inflow .....
2. audible range .....
3. backscattered ultrasound .....
4. bolus .....
5. cardiology .....
6. catheter .....
7. cross section .....
8. dye dilution .....
9. indicator concentration .....

10. indocyanine green .....
11. inflatable cuff .....
12. invasive measurement .....
13. obstetrician .....
14. piezoelectric crystals .....
15. probe .....
16. pulse-echo techniques .....
17. range-gated Doppler system .....
18. temperature sensor .....
19. transcutaneous measurements .....
20. vascular surgery .....
21. venous occlusion plethysmography .....

Section One: Reading Comprehension

Electroretinography

An electroretinogram (ERG) is a recording of the pattern of transient electrical signals that develop across the retina of the eye when it is stimulated by light. Although the first ERG was made more than a century ago and an extensive body of information regarding the electrical activity of the retina now exists, the phenomenon is still not completely understood.

In vertebrates, the electrical activity of the retina is characterized by three prominent deflections, termed the a-, b-, and c-waves (Figure 4-1a). An upward displacement indicates a positive shift in the electrical potential of the

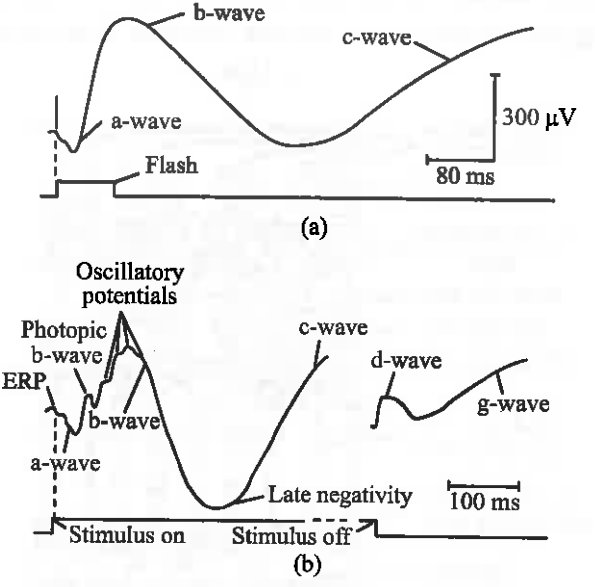


Figure 4-1. (a) Principal and (b) Additional Components of the Electroretinogram.

front surface of the retina with respect to the back. The ERG is, however, more complicated that this simple nomenclature suggests, since under

particular circumstances, additional (either more or less prominent) peaks appear. In Figure 4-1b, the appearance of some of these peaks relative to the position of the a- and b-waves is shown. Included are the early receptor potential (ERP), the photopic b-wave, and the oscillatory potentials, as well as peaks termed the d-wave, the g-wave, the late negative or after potential, and others. Each peak stands out only in response to an appropriate stimulus. The peaks are not all seen simultaneously. The e-wave, which has been most extensively studied in the frog, may be essentially the same signal as the human g-wave.

Various analyses have been undertaken to determine whether these individual waves can be considered as separate components that are related to specific retinal processes. It has been found that the early receptor potential arises from the outer segments of the retinal receptors, in response, and with virtually no delay, to stimulation with very intense light. The initial part (negative going) of the a-wave is believed to come from the inner part of the retinal receptors. Because of the time delay between the appearance of this negative-going part of the a-wave and the stimulus, it is known as the late

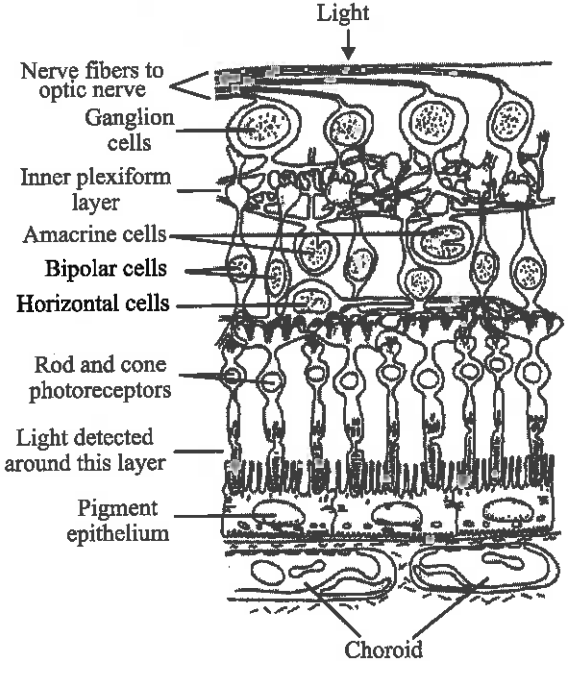


Figure 4-2. The Structure of the Retina.

receptor potential. A release of potassium ions, taking place near the inner plexiform layer of the retina (Figure 4-2) and also at a more distal site, activates cells (Mü ller cells) that extend through the retina and which generate the b-wave. The c-wave is produced by the pigment epithelial cells at the back of the retina as a result of a local decrease in potassium concentration. The individual wavelets that make up the oscillatory potential apparently have their origins at different depths within the layers of the retinal bipolar cells. Despite the tentativeness and incompleteness of current knowledge, it is clear that these waves are indicative of the transmission of visual information through the retina.

Armington, J.C. (pp. 316-317).

Part I. Comprehension Exercises

A. Put "T" for true and "F" for false statements. Justify your answers.

..... 1. The peaks are all seen simultaneously.

..... 2. The b-wave is generated by the cells that extend through the retina.

..... 3. The pigment epithelial cells are located near the inner layer of the retina.

..... 4. The oscillatory potential is made up by the individual wavelets.

..... 5. Each peak stands out only in response to an appropriate segment.

B. Choose a, b, c, or d which best completes each item.

1. The negative going of the a-wave comes from ..... .
   a. the outer part of the retinal receptors
   b. the outer plexiform layer of the retina
   c. the inner part of the retinal receptors
   d. the outer segments of the retinal receptors
2. The release of potassium ions takes place near ..... .
   a. the inner plexiform layer of the retina and at a more distal site
   b. the front surface of the retina
   c. the inner surface of the retinal receptors
   d. the outer components of the retina

3. The individual wavelets have their origins at different depths within ..... .
   a. the layers of the retinal horizontal cells
   b. the components of the retinal amacrine cells
   c. the inner part of the retinal ganglion cells
   d. the layers of the retinal bipolar cells
4. The c-wave is produced because of a local ..... .
   a. increase in potassium concentration
   b. increase in potassium volume
   c. decrease in potassium concentration
   d. decrease in potassium volume
5. It is understood from the passage that ..... .
   a. the ERG is still not completely understood
   b. there isn't much information regarding the electrical activity of the retina
   c. there exists an extensive body of information regarding the inner layers of the retina
   d. the ERG is a very simple process

C. Answer the following questions orally.

1. What is an ERG?
2. How is the electrical activity of the retina characterized in vertebrates?
3. What does an upward displacement indicate?
4. How is the c-wave produced?
5. How are the Mü ller cells activated?

Part II. Language Practice

A. Choose a, b, c, or d which best completes each item.

1. To **oscillate** means to vary ..... .
   a. regularly between two segments
   b. satisfactorily the ERG signals
   c. rapidly the electrodes on the retina
   d. regularly between high and low values
2. **Pigment** refers to ..... .
   a. any organic coloring material produced in the body

b. any inorganic coloring material produced near the retina

c. any electrical activity of the retina characterized by light

d. any recording electrode placed directly on the retina

3. **Epithelium** is ..... tissue composed of closely arranged cells.

a. a membranous b. a hard

c. a soft d. a bony

4. The word **stimulus** is best described as anything that .....

a. excites or incites an organism to function, become active, or respond

b. changes the amplitude of the ERG signals

c. determines the electrical activity of the retina

d. arises from the outer segments of the retinal receptors

5. **Transient** means .....

a. simultaneous b. temporary

c. permanent d. progressive

B. Fill in the blanks with the appropriate form of the words given.

1. Extend

a. Texture analyses have been most ..... employed in computer classification of pneumoconiosis.

b. The most ..... trials of fast-neutron therapy have been for cancer in the mouth and throat.

c. Ultraviolet radiation wavelengths ..... from 14 nm to 4000 nm.

2. Exist

a. Most ..... neturon-therapy installations produce beams fixed in a horizontal direction and of rather poor penetration into the body.

b. A study of the movement of a dye in rabbit eye showed that a posterior flow may ..... across the retina.

c. The objective of cardiac catheterization is to establish the ..... and exact location of cardiac disease or defect and to quantify its severity.

3. Add

a. The ECG is monitored for all patients and, depending on the patient's conditions, ... parameters such as blood pressure, temperature and respiration are also monitored.

b. An isolated power system can be compromised by the ..... capacitance to ground of the devices that are plugged into it.

4. Specify

a. The electrical output of a hearing aid of ..... design worn behind the ear is inductively coupled to the electrodes.

b. The clinical engineer acts as a technical advisor to the medical and paramedical staff on matters of ....., capabilities, and so on, and in the design or purchase of instruments and electrical and electronic devices.

c. Because the frequency response of the catheter-transducer system is important in determining whether a system is suitable use, many manufacturers ..... the frequency response of their transducers with common-size catheters attached.

d. The term biomechanics often notes that area of biomedical engineering concerned ..... with human biodynamics.

5. Appear

a. The best known color ..... system based on principles of color perception is the Munsell system.

b. Even though ultrasound ..... to be safe to use, some scientists suggest limited use of ultrasound during early pregnancy.

C. Fill in the blanks with the following words.

mixed	onset	conditions
rod	retinal	segments
split	stimulus	initiated

The components of the ERG may also be separated with respect to ..... function, most usefully in terms of photopic and scotopic action. Under some ....., the b-wave breaks up into two smaller waves, one ..... by the action of the cone system of the retina and the other by the ..... system. The a-wave can also be ..... into photopic and scotopic ..... . Two of the components, the d- and e-waves, are produced by the termination of a/an ....., whereas the others are produced by its ..... . The e-wave is believed to be a scotopic off-effect and the d-wave a/an ..... photopic-scotopic off-effect.

D. Put the following sentences in the right order to form a paragraph. Write the corresponding letters in the boxes provided.

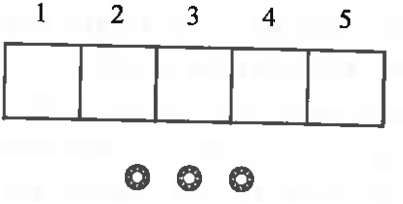
a. It will test retinal acuity over more widespread areas of the retina than can conventional methods of testing which deal only with the central visual field.

b. In amblyopia, the late negative potential and the b-wave are reduced in amplitude in response to patterned stimulation.

c. Patterned stimulation, although a recent development, is already finding clinical uses.

d. There is also some evidence to indicate that in optic-nerve disease the ERG derived in response to patterned stimulation is attenuated or absent, whereas the response to flashes of light is unchanged.

e. Since sharpness of focus on the retina determines the effectiveness of a pattern, electroretinography can be used to test visual acuity.



Section Two: Further Reading

Recording Methods of ERG

The ERG is readily made from a human subject using standard electrophysiological equipment. A recording electrode cannot be placed directly on the retina, but the ERG signals can be detected satisfactorily via an electrode built into a contact lens worn by the subject (Figure 4-3). The electrode is referenced electrically to the cheek or forehead. Under many recording conditions the retinal electrical activity is quite small and not easily distinguished from a background of electrical interference. Here, the technique of signal averaging is useful for isolating the ERG signals from

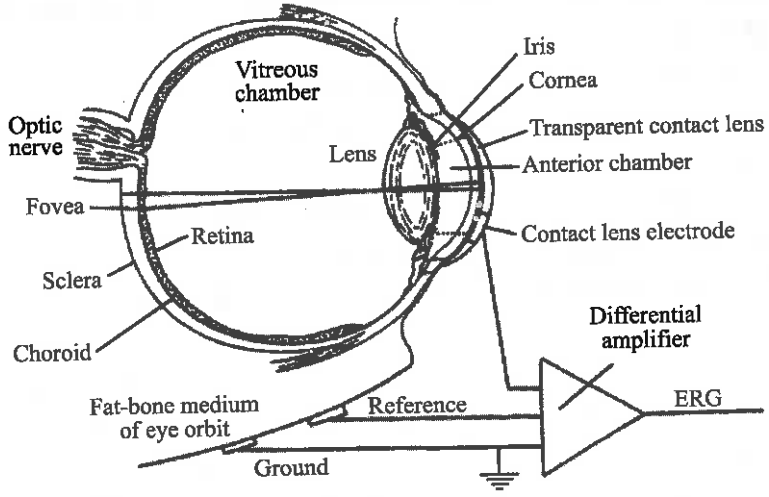


Figure 4-3. Transparent Contact Lens Containing One Electrode, Shown on Horizontal Section of Right Eye. Reference electrode is placed on right temple.

background noise. The character of an elicited response may be entirely dependent on the form of stimulus that is used. Two classes of stimulus used are flashing light stimuli and pattern reversal. A flash stimulus, even though imaged on a small local area of the retina, is distributed broadly as stray light scattered and reflected within the eye. Flashes are used when a simple technique of stimulation is needed for the investigation of the retina as a whole. Responses elicited by single flashes preferentially elicit scotopic activity; flashes flickering at a rate of 20 Hz or more elicit photopic activity. Pattern-reversal stimuli are used for the investigation of local retinal areas. The subject views a recurrent pattern of stripes or checks (Figure 4-4). The light and dark areas are interchanged periodically, and this light and dark reversal produces stimulation within the image area. Because the stray light produced by an alternating pattern is steady, there is no stimulation of the retina outside the area of the image. Only a local response is obtained. Responses to patterned stimuli are photopic.

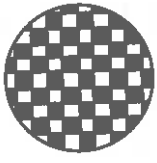


Figure 4-4. A Patterned Stimulus.

The magnitude of the ERG signals is dependent on the recording conditions. A single flash presented to the dark-adapted eye may elicit a response of the order of 500 μV or more. With light adaptation the same stimulus may produce a response too small to be detected without signal averaging. The amplitude of the the ERG signals increases with stimulus luminance until saturation for the particular testing condition is achieved. The amplitude of the response increases also in proportion to the size of retinal area stimulated. Patterned stimuli subtend small visual angles at the retina in proportion to the total visual field. Thus, since only a small fraction of the retina is stimulated, the responses generated are small (~ 10 μV). With signal averaging, responses can be obtained with fields that subtend angles at the retina of as little as 2°. Even with signal averaging, however, responses of amplitude less than 1 μV are difficult to investigate.

Armington, J.C. (pp. 317-318).

Comprehension Exercises

A. Put "T" for True and "F" for false statements. Justify your answers.

..... 1. The ERG signals can be detected via an electrode which is referenced electrically to the cheek or forehead.

..... 2. The technique of signal averaging is useful for detecting the ERG signals.

..... 3. Flashes flickering at a rate of 20 Hz or more elicit scotopic activity.

..... 4. The magnitude of the ERG signals is dependent on the alternating patterns.

..... 5. It is difficult to investigate the responses of amplitude less than 1 μV using signal averaging technique.

..... 6. The amplitude of the ERG signals increases in proportion to the size of retinal area stimulated.

..... 7. For the investigation of local retinal areas, pattern-reversal stimuli are used.

B. Write the answers to the following questions.

1. What does the character of an elicited response depend on?

2. What are pattern-reversal stimuli used for?
3. Where does a flash stimulus image on?
4. Why is there no stimulation of the retina outside the area of the image?
5. What does a single flash presented to the dark-adapted eye elicit?
6. What do patterned stimuli subtend?
7. What does the light and dark reversal produce?

Section Three: Translation Activities

A. Translate the following passage into Persian.

Applications of Electroretinography

Electroretinography has both practical and research applications. It has been used as a tool to investigate the physiological mechanisms that underlie various psychophysical processes, and knowledge obtained from such basic studies has been useful for evaluating the results of various clinical investigations.

The human ERG is a useful tool for following visual development. Electrical activity is barely detectable at birth, but develops rapidly soon thereafter and virtually full amplitude is reached at twelve months. The ERG finds its chief clinical applications, however, in the diagnosis of visual disorders. By taking into account the different origins of the electro-retinographic waves and the specific physical characteristics of the stimulus, it is often possible to reach conclusions on these disorders that are attainable in no other way.

Stimulus flashes, covering the full retina, are useful in distinguishing various forms of retinal degeneration. In progressive degeneration (retinitis pigmentosa) the a- and b-waves are severely reduced in amplitude, the response often being too small to be recorded at all (extinguished) even in the early stages of the disease. Thus, the ERG is clearly abnormal. Since retinitis

pigmentosa is hereditary in origin, electroretinography (which can detect retinal impairment at an earlier age than any other method of detection) is of particular value for testing children who may suffer from the disease although its symptoms have not yet developed. In other conditions, specific components of the ERG may be absent. For example, the scotopic components of the ERG are absent in subjects afflicted with congenital night blindness. In color blindness, the photopic components of the ERG are affected. Indeed, the principal forms of color blindness can be distinguished from one another by using colored stimuli and appropriate recording conditions. In the early phases of developing retinopathy in diabetics, a reduction in the oscillatory potentials can be observed before other components of the ERG are affected.

B. Find the Persian equivalents of the following terms and expressions and write them in the spaces provided.

1. bipolar cells .....
2. congenital .....
3. contact lens .....
4. deflection .....
5. electrical interference .....
6. elicited response .....
7. individual wavelets .....
8. oscillatory potentials .....
9. pattern-reversal stimuli .....
10. photopic activity .....
11. physiological mechanisms .....
12. plexiform layer .....
13. receptor potential .....
14. retinal degeneration .....
15. retinal receptors .....
16. retinitis pigmentosa .....
17. saturation .....
18. scotopic activity .....
19. vertebrates .....
20. visual angles .....

Section One: Reading Comprehension

Ultrasound in Medicine

Ultrasonic methods are important in medicine because their use provides the best solution to certain problems in diagnosis, therapy, and surgery. This is because ultrasound differs from other forms of radiation in its interactions with living systems. Compared with other imaging techniques, such as radiography, computerized tomography, and nuclear magnetic resonance imaging, ultrasonic instruments are relatively inexpensive. Moreover, in contemporary diagnostic examinations using ultrasound, any hazard seems to be much less than that associated with ionizing radiation.

Most medical applications of ultrasound employ frequencies in the range 1-15 MHz. The most commonly used transducer is a disk of polarized lead zirconate titanate, which has piezoelectric properties. (Plastic transducer materials such as poly (vinylidene difluoride) and its derivatives are beginning to show promise for medical applications of ultrasound, but improvements in their properties are still needed.) For continuous-wave applications, the transducer may be air-backed and so mounted that the restriction of its vibration is minimized. For applications involving the use of short pulses, however, the bandwidth of the transducer is usually increased by the attachment of a matched absorbent backing to its rear surface.

In the steady state, a circular piston of radius a vibrating cophasally generates a field similar to that shown diagrammatically in Figure 5-1. The central axial distribution is given by

$$\frac{I_z}{I_o} = \sin^2 \left\{\frac{k}{2}[(a^2+z^2)^{1/2}-z]\right\}$$

where I_o is the intensity at the source, I_z is the intensity at any distance z from the source, and $k=2\pi/\lambda$, where λ is the wavelength ($\lambda=c/f$, where c is the propagation speed and f is the frequency). If $a^2 \gg \lambda^2$, then

$$z'_{max}=a^2/\lambda$$

where z'_{max} is the position of the last axial maximum moving away from the source. The last axial maximum marks the transition between the near and far fields of the ultrasonic beam. In the near field, the energy is mainly confined within a cylinder. In the far field, however, the beam diverges conically and may have side lobes; the central lobe is reduced to zero at angles of $\pm\theta$ given by

$$\sin\theta = 0.61\ \lambda/a$$

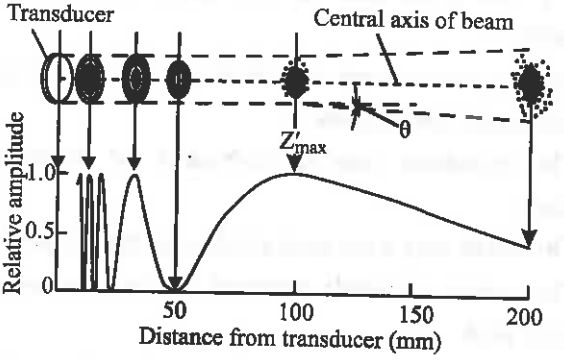


Figure 5-1. The Ultrasonic Field Produced by a 1.5 MHz Transducer of Radius a=10 mm. The ultrasonic beam normal to the central axis is circular in section, and the elliptical diagrams represent such sections, in the planes indicated on the graph. The graph shows the relative energy distribution along the central axis of the beam.

A transient ultrasonic beam, which has a wide frequency spectrum, becomes increasingly homogenous in the near field, the shorter the pulse duration.

The ultrasonic beam may be focused in the near field by means of a lens, a mirror, or a curved transducer. Ray optics may be used to a first approximation in calculating the position of the focus; more accurate theory involves consideration of the wavelength. Lenses are usually fabricated from plastics, in which the speed is greater than that in soft tissues, so concave profiles are needed for focusing. Since in some applications it is desirable to have a flat front surface to the probe, strongly focusing concave transducers are often combined with weakly defocusing convex lenses.

The power P of an ultrasonic beam may be measured by determination

of the vector force F associated with 'radiation pressure'. In the case of complete absorption, the relationship is $F=P/C$.

Ultrasonic power may also be measured by calorimetry, although this is technically difficult for very low powers produced by inefficient transducers.

Wells, P.N.T. (pp. 834-835).

Part I. Comprehension Exercises

A. Put "T" for true and "F" for false statements. Justify your answers.

..... 1. Imaging instruments are relatively inexpensive as compared with ultrasonic instruments.

..... 2. The transducer may be air-backed for continuous-wave applications.

..... 3. The beam may have central lobes in the far field.

..... 4. The energy is mainly confined within a curved transducer in the near field.

..... 5. By using a curved transducer, the ultrasonic beam may be concentrated in the near field.

B. Choose a, b, c, or d which best completes each item.

1. The difference between ultrasound and the other forms of radiation is in its ..... .
   a. transitions in soft tissues
   b. applications through living tissues
   c. interactions with living systems
   d. vibrations through soft tissues
2. The transition between the near and far fields of the ultrasonic beam is marked by ..... .
   a. the central axis of the beam
   b. the last axial maximum
   c. the last axial minimum
   d. the first axial maximum
3. In order to have a flat front surface to the probe, strongly focusing concave transducers are often combined with ..... .
   a. strongly defocusing convex lenses
   b. weakly defocusing convex transducers

c. weakly defocusing convex lenses

d. strongly defocusing concave transducers

4. A circular piston of radius a vibrating cophasally generates a field in ..... .

a. the central lobe

b. the circular state

c. the side lobes

d. the steady state

5. In the far field, ... at angles of $\pm \theta$.

a. the side lobes are reduced to zero

b. the central lobe is reduced to zero

c. the side lobes are reduced to one

d. the central lobe is reduced to one

C. Answer the following questions orally.

1. How is the bandwidth of the transducer increased?
2. Why are ultrasonic methods important in medicine?
3. How does the beam diverge in the far field?
4. How is the power P of an ultrasonic beam measured?
5. What are concave profiles used for?

Part II. Language Practice

A. Choose a, b, c, or d which best completes each item.

1. **Transducer** is a hand-held device that ..... a sound-wave signal.

a. measures and amplifies

b. receives and reflects

c. sends and receives

d. amplifies and sends

2. **Absorbent** is a product of substance that can ..... .

a. produce gas bubbles

b. absorb liquids or gases

c. combine liquids with gases

d. measure pulses of ultrasonic energy

3. **Resonance** refers to the process of energy absorption by an object that is tuned ..... .

a. to diverge ultrasonic beams from their origins

b. to spread short pulses of ultrasonic beams

c. to transmit sound waves to soft tissues

d. to absorb energy of a specific frequency only

4. **Concave** as used in the text means .....
   a. resembling or shaped like a cone
   b. curved like the inner surface of a sphere
   c. curving outward like the surface of a sphere
   d. having the shape of a square
5. The word **homogenous** means .....
   a. similar
   b. dissimilar
   c. complete
   d. incomplete

B. Fill in the blanks with the appropriate form of the words given.

1. **Approximate**
   a. It is known that proteins are composed of ..... 20 different types of amino acid, where as DNA contains only four types of base.
   b. A-scan systems can determine whether there is a foreign body in the eye and the ..... distance behind the lens it is located.
   c. An ..... is a medical instrument used to draw together the edges of divided tissues.
2. **Depend**
   a. The mechanical properties of bone ..... on its composition and structure, and strength and stiffness increase with increasing mineralization.
   b. Plasma viscosity is ..... on temperature, a fall in temperature causing a rise in viscosity.
3. **Improve**
   a. Image analysis with a computer involves the development of complex models intended to stimulate and ..... upon human analytical performance.
   b. Despite significant ..... in cardiac diagnosis and treatment in recent years, heart disease remains the leading cause of death and significant disability in some countries.
   c. Several of the presently available automatic analyzers include small built-in microprocessors that allow computations and ..... data presentation.

4. Absorb

a. The ..... and emission of radiation are the bases of several instrumental methods of analysis.

b. The dose ..... by the tissues from interally administered radioactive material is determined by several factors.

c. Fluorescence spectroscopy uses the property of some molecules to reemit ..... energy.

5. Sense

a. The human ear is extremely ..... to sound.

b. The radiation ..... of cell varies for x-rays, depending on the position of the cells in the cell cycle.

c. Medical personnel should be ..... to observing the physical condition and performance of the devices they use.

C. Fill in the blanks with the following words.

inhomogeneous	spatial	reflections
analogous	coherent	dynamic
propagation	unfortunate	diagnosis

The earliest attempts to use ultrasound in medical ..... were based on transmission methods ..... to those used in x radiology. These attempts failed, chiefly because of large ..... variations in transmission even in the normal. (It was ..... that this work concentrated on the brain: acoustically, the skull is particularly ..... .) The performance of continuous-wave transmission imaging is also limited by multiple ..... and standing waves, and these prevented the continuous-wave, ... ultrasound image camera from being used except for crude ..... studies. Holography also failed, partly because of variations in ..... speed degrading the phase information on which the process depends.

D. Put the following sentences in the right order to form a paragraph. Write the corresponding letters in the boxes provided.

a. For physiological values of v, f_D lies in the audible range if f is in the low-megahertz-frequency range.

b. It is also possible to sample the target volume, for example, to measure blood-flow profiles, by pulsing the transmitter and range-gating receiver.

c. Simple Doppler systems indicate only target velocity, and the operator may merely listen to the output signals.

d. If two coplanar transducers are arranged so that one receives reflected ultrasonic energy transmitted by the other, the received signal is shifted in frequency by the Doppler effect if the reflector (or ensemble of scatterers) is moving with respect to the transducers.

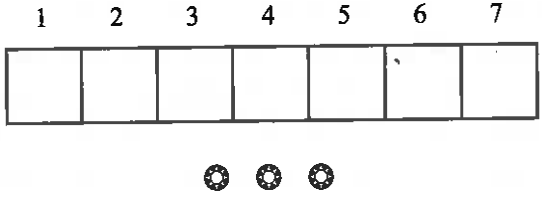
e. In many specialized applications, however, electronic methods of analysis give valuable additional information.

f. The difference f_D between the transmitted and received frequencies is given by

$$f_D = 2vf/c$$

where v is the velocity of the reflector along the ultrasonic beam, f is the transmitted frequency, and $v \ll c$.

g. The direction of movement may be indicated, and, especially in the case of blood flow, the frequency spectrum and the maximum and mean values of velocity may be displayed and subjected to further analysis.



Section Two: Further Reading

Ultrasonic Characteristics of Biological Tissues & Biological Effects of Ultrasound

The propagation speeds, characteristic impedances (equal to ρc, where ρ is the density), and attenuation coefficients for some materials of importance in biomedical ultrasonics are given in Table 5-1. The propagation speed is

Table 5-1. Ultrasonic Characteristics of Some Materials of Biomedical Importance.

Material	Propagation Speed (ms^{-1})	Characteristic Impedance ($10^6 kg\ m^{-2}\ s^{-1}$)	Attenuation Coefficient at 1 MHz ($dB\ mm^{-1}$)
Air	330	0.0004	0.12
Blood	1560	1.6	0.02
Muscle	1545-1630	1.7	0.2
Soft tissue*	1450-1600	1.4-1.7	0.03-0.17
Water	1523	1.5	0.0002

* Except muscle

practically independent of the frequency. The attenuation in air and in water results from absorption due to viscosity, and is proportional to the square of the frequency. In soft tissues, however, the attenuation is mainly due to relaxation, and is approximately proportional to the frequency.

Absorption of ultrasound may heat tissue sufficiently to cause damage. Many tissues are irreversibly damaged by exposure to temperatures in excess of 50° C; at lower temperatures, the effects of heat are usually noninjurious and reversible.

Ultrasound may also affect biological materials by mechanical action. Shearing forces due to velocity gradients may be sufficiently large to break macromolecules. The velocity gradient is amplified by the presence of gas-filled bubbles, due either to stable or transient cavitation.

Some biological effects of ultrasound, such as the acceleration of wound healing, do not seem to be explicable on the basis of thermal or mechanical actions. Research aimed at discovering their origins is continuing.

There is no thermal hazard in contemporary diagnostic techniques. Diagnostic intensities (typically 100 Wm^{-2}) seem to be below the thresholds for all forms of mechanically induced damage so far studied. There is no statistically significant evidence of an increase in fetal abnormality following modern ultrasonic diagnostic procedures.

Wells, P.N.T. (p. 835).

Comprehension Exercises

A. Put "T" for true and "F" for false statements. Justify your answers.

..... 1. The attenuation in soft tissues is approximately proportional to the square of the frequency.

..... 2. The propagation speed depends on the frequency.

..... 3. There seems to be thermal hazard in contemporary diagnostic techniques.

..... 4. The attenuation is due to relaxation in soft tissues.

..... 5. The acceleration of wound healing cannot be explained on the basis of thermal or mechanical actions.

B. Write the answers to the following questions.

1. Where does the attenuation in air and in water result from?
2. How is the velocity gradient amplified?
3. What are the effects of heat on tissues at lower temperatures?
4. What are the three ultrasonic characteristics of biological tissues?
5. How does ultrasound affect biological materials?

Section Three: Translation Activities

A. Translate the following passage into Persian.

Pulse-Echo Imaging

Most diagnostic applications are based on the pulse-echo method which gives information about the positions of interfaces within the body, which act as reflectors and scatterers; to a lesser extent, this technique also gives clues about their characteristics. Other methods of investigation, such as x radiography, may not readily give comparable information.

Pulses of ultrasonic energy, typically 1000 s^{-1} and each of a few microseconds duration, are generated by a transducer. These pulses are

directed along a narrow beam into the patient. Echoes which return from characteristic impedance discontinuities within the patient may be detected by the transducer, delayed (following the transmission of each pulse) by times corresponding to depths along the ultrasonic beam. In the ideal case of normal incidence on a plane interface,

$$\frac{I_r}{I_i} = \left(\frac{Z_t - Z_i}{Z_t + Z_i}\right)^2$$

where I_i and I_r are the incident and reflected intensities, and Z_i and Z_t are the characteristic impedances on the incident and transmitting sides of the interface, respectively.

In practice, few interfaces between biological structures can be considered to be extensive plane boundaries. Most characteristic impedance discontinuities have dimensions of the order of a few wavelengths or less, and specular reflection is a less appropriate concept than scattering.

Pulse-echo methods depend on the satisfactory detection of ultrasonic signals. This requirement often prevents their application in the examination of structures surrounded by, or containing, gas or bone. This is because both gas and bone present large mismatches in characteristic impedance (and hence large reflections) at interfaces with soft tissues, and they also have relatively high attenuations and dissimilar propagation speeds. In soft tissues, compensation for attenuation may be provided by swept (time-varied) gain in the receiver amplifier.

Since the attenuation of ultrasound by biological tissue increases with increasing frequency, the frequency of ultrasound is limited by the required penetration. The attenuation in soft tissues is around 1 dB cm^{-1} MHz^{-1}. About 70 dB of attenuation can be tolerated in the compromise between frequency and noise, corresponding to a maximum penetration of about 230 wavelengths. For example, for abdominal and cardiac studies, penetrations of 100-200 mm are required, so that frequencies of 2-3.5 MHz are generally used. Proportionately higher frequencies are used for examining smaller structures.

B. Find the Persian equivalents of the following terms and expressions and write them in the spaces provided.

1. attenuation coefficients .....

2. cavitation .....
3. compromise .....
4. defocusing convex lenses .....
5. diagnostic intensities .....
6. diagnostic procedures .....
7. diverge .....
8. incident intensities .....
9. ionizing radiation .....
10. ray optics .....
11. reflected intensities .....
12. shearing forces .....
13. specular reflection .....
14. transducer .....
15. velocity gradient .....
16. viscosity .....

Unit 6

Section One: Reading Comprehension

Electroencephalography

The intact brain may be studied by recording its electrical activity. The activity of the individual neurons is recorded using microelectrodes placed within a few micrometers of the cell body by advancing the electrode through the cortex. The mass action of a large number of cells can be recorded using electrodes that are relatively large compared with the individual cells. These electrodes can be placed within the tissue, on the surface of the cortex, or on the scalp. The recording of the scalp activity is known as an electroencephalogram (EEG); such activity is quasirhythmic and in the frequency band of about 0-100 Hz. The amplitude is of the order of tens of microvolts and the activity varies from place to place on the head. The EEG changes with the mental state of the subject and shows characteristic patterns of activity during sleep, coma, epileptic seizures, and other disturbances of cerebral origin. The activity can be changed by external stimuli and characteristic waveform patterns are evoked which reflect both the physical characteristics and the significance or meaning of the stimulus.

The EEG is obtained by amplifying the electrical activity derived from the electrodes placed on the scalp. The electrodes are usually disks of chlorided silver held in place by an adhesive or elastic harness. Good contact with the tissue is obtained by cleaning or abrading the skin beneath the electrode. Twenty or more electrodes are placed at preset sites; many channels of activity are recorded simultaneously. Because of the small amplitude of the signal and the presence of external electrical and magnetic fields in the frequency band of interest (usually 50 or 60 Hz mains interference) high-gain differential amplifiers with a high common-mode rejection ratio are used. The data are usually displayed on a multichannel pen recorder.

One of the main objectives of conventional recordings is to measure the distribution of electrical potential over the scalp and to infer the location of the source or sources giving rise to it. Since the electrical activities are

widespread over the scalp there is no 'neutral point' on the head against which the potentials can be measured. The presence of the electrical activity of the heart (millivolts compared with microvolts) restricts the use of a noncephalic electrode that might be assumed to be undisturbed by brain activity. This electrocardiogram may be reduced by subtraction techniques.

Cooper, R. (pp. 304-305).

Part I. Comprehension Exercises

A. Put "T" for true and "F" for false statements. Justify your answers.

..... 1. Macroelectrodes are used to record the activity of the individual neurons.

..... 2. The scalp activity is quasirhythmic.

..... 3. By amplifying the electrical activity derived from the electrodes, the EEG is obtained.

..... 4. More than twenty electrodes are placed at preset sites.

..... 5. The EEG data are normally displayed on a multichannel pen recorder.

..... 6. The potentials can be measured against a 'neutral point' on the head.

B. Choose a, b, c, or d which best completes each item.

1. The ..... activity is of the order of tens of microvolts.
   a. frequency band of the scalp
   b. amplitude of the cortex
   c. amplitude of the scalp
   d. frequency band of the cortex
2. The EEG ..... .
   a. is a disk of chlorided silver
   b. can be changed by internal stimuli
   c. is placed on the surface of the skin
   d. changes with the mental state of the subject
3. The electrodes are held in place by ..... .
   a. a multichannel pen recorder
   b. an adhesive or elastic harness
   c. disks of chlorided silver
   d. magnetic fields

4. The presence of the electrical activity of the heart ..... .
   a. causes a good contact with the tissue
   b. evokes characteristic waveform patterns
   c. restricts the use of a noncephalic electrode
   d. distributes the electrical potential over the scalp
5. By using electrodes that are relatively large, ...
   a. the mass action of a large number of cells can be recorded
   b. the activity of the individual neurons can be recorded
   c. the physical characteristic of the stimulus are amplified
   d. the distribution of electrical potential over the scalp is restricted

C. Answer the following questions orally.

1. What is EEG?
2. Where are the electrodes placed?
3. What do characteristic waveform patterns reflect?
4. Why are high-gain differential amplifiers used with a high common-mode rejection ratio?
5. Why is there no 'neutral point' on the head?
6. What is the main objeetive of conventional recordings?

Part II. Language Practice

A. Choose a, b, c, or d which best completes each item.

1. **Adhesive** refers to the quality of a substance that enables it ..... .
   a. to measure the distribution of electrical potential
   b. to become attached to another substance
   c. to amplify the electrical activity
   d. to generate the electrical potential
2. **Evoked potential** is an electrical response in the brainstem or cerebral cortex which is ..... .
   a. produced by a specific frequency
   b. derived from a specific electrode
   c. displayed on a specific pen recorder
   d. elicited by a specific stimulus

3. In electricity, a **neutral state** is one in which there is ..... charge.
   a. either a positive or a negative
   b. both a positive and a negative
   c. neither a positive nor a negative
   d. only a positive
4. To **abrade** means .....
   a. to remove the epidermis or other skin layers by scraping or rubbing
   b. to record the mass action of a large number of cells by using electrodes
   c. to change the electrical activity on the scalp by using external stimuli
   d. to obtain ECG by amplifying the electrical activity on the cortex
5. **Intact** as used in the text means ..... .
   a. impaired
   b. injured
   c. damaged
   d. unimpaired

B. Fill in the blanks with the appropriate form of the words given.

1. **Act**
   a. Computers have figured in various models of the electrical ..... of the heart.
   b. Thermal neutron ..... analysis is a useful method of analysis for about two-thirds of the chemical elements.
   c. If the calculated value of the heart rate is above or below a preselected value, the computer ..... an alarm to alert the attending staff that a problem exists.
2. **Character**
   a. Although the conversion of sound into nerve impulses occurs in the inner ear, mechanisms which modify the ..... of the incoming sound begin to operate in the external part of the ear.
   b. The presence of particular substances in the bacterial cell wall or membrane can be ..... by the effect of specific enzymes on the mobility of the whole particle.
   c. Clinical microbiology involves blood band operations limited to the collection and preservation of blood and its ..... for compatibility and therapeutic use.

3. Reflect

a. In ..... ultraviolet photography, it is essential that only ultraviolet radiation reaches the film.

b. In ultrasonography, the intensity of the ..... is related to the ratio of the characterisitic acoustic impedance across the interface.

c. Cinemagraphic cameras and interrupted-light photography record the displacement of ..... body segment markers.

4. Magnet

a. Oxygen is strongly paramagnetic and has a ..... susceptibility several hundred times that of other medical gases.

b. A tape recorder consists of a transport mechanism which moves a tape coated with a ..... medium past record and replay heads.

c. The magnetic polarization of a material produced by a magnetic field, is called ..... .

5. Distribute

a. The foundation for brain scans was the observation that although most foreign materials injected intravenously had wide ..... on the body, they entered into the brain.

b. The principal positive ion within muscle is potassium. When radioactive potassium is given intravenously, it is widely ..... and largely passes intracellularly.

C. Fill in the blanks with the following words.

qualitative	spiking	oscilloscope
bandwidth	integral	constant
interpreters	permanent	multichannel

Different types of recording instruments obtain a temporary or ..... record of the EEG. The most common recording device is a pen or chart recorder (usually multichannel) that is a/an ..... part of most commercially available EEG instruments. The ..... of interest in clinical EEGs is relatively low (less than 40 Hz) and therefore within the frequency response capabilities of these devices. Recordings are on a long sheet of continuous paper (from a folded stack), fed past the moving pen at one of several selectable ..... speeds. The paper speed translates into distance per unit time or cycles per

unit time, to allow EEG ..... to identify different frequency components or patterns within the EEG. Paper speed is selected according to the monitoring situation at hand: slow speeds (10 mm/s) for observing the ..... characteristically associated with seizures and faster speeds (up to 120 mm/s) for the presence or absence of individual frequency bands in the EEG.

In addition to a pen recorder, the EEG may be recorded on a/an ..... *frequency modulated* (FM) analog tape recorder. During such recordings, a visual output device such as a/an ..... or video display usually displays the EEG with each of *N* channels, switch-selected for display. This nonpermanent display is necessary or at least desirable to allow visual ..... monitoring of recorded signals, so that corrective action (reapplying electrodes and so on) can take place immediately if necessary.

D. Put the following sentences in the right order to form a paragraph. Write the corresponding letters in the boxes provided.

a. The A/D converter is interfaced to a computer system so that each sample can be saved in the computer's memory.

b. Since physically realizable filters do not have ideal characteristics, the sampling rate is usually greater than two times the filter's cutoff frequency.

c. Computers can also be recording devices, digitizing (converting to digital form) one or several amplified EEG channels at a fixed rate.

d. To ensure that the signal is band-limited, a low pass filter with a cutoff frequency equal to the highest frequency of interest is used.

e. In such *sampled data systems*, each channel is repeatedly sampled at a fixed time interval (*sample* interval) and this sample is converted into a binary number representation by an *analog-to-digital (A/D) converter.*

f. A set of such samples, acquired at a sufficient sampling rate (at least two times the highest frequency component in the sampled signal), is sufficient to represent all the information in the waveform.

1	2	3	4	5	6

Methods of Deriving Electrical Signals

There are three basic methods of deriving electrical signals from a certain type of electrode array. These are commonly described as bipolar, common reference, and average reference. In the bipolar derivation, each channel is connected between two (usually adjacent) electrodes, both of which are likely to be affected by appreciable brain potentials. When using the common reference derivation, one electrode, usually chosen to minimize the possibility of picking up potentials from the brain, is common to all channels. In the average reference system, the average potential of all (or most) of the electrodes in the array is generated by connecting all electrodes to a 'star point' through high resistors. This star point is then used as a common reference for all channels. In a modification of the average reference system (called source derivation), the activity of a particular electrode in the array is referred to the average of those electrodes immediately surrounding it.

Although the data arising from a set of electrodes are obviously the same whatever the method of derivation, the various techniques can be used to emphasize particular features. For example, the bipolar technique, which measures local gradient of the potential field, gives a different result from the common reference system that measures the potentials against the common (often incorrectly presumed inactive) point. The combination, in the input circuit of the amplifier, of time-displaced rhythmic activity from two electrodes can give rise to ambiguities that make interpretation in terms of sources very difficult.

The EEG is often contaminated by artefacts from extracerebral sources; for example, the presence of relatively large potentials from eye movements and blinks (because of the change of the corneal-retinal potential field), and from the electrical activity generated by the musculature of the scalp. Fortunately this latter effect is of relatively high frequency (50 Hz or more) and can be reduced by restricting the upper limit of the amplifier bandwidth to 30 Hz. The measurement of the steady potentials between parts of the brain is difficult because of differences in electrode potentials and steady

potentials generated in the skin. Thus, for routine recording, the bandwidth of the amplifiers is usually restricted at the lower end to approximately 1 Hz by high-pass filters.

The outer layer of cortex beneath the scalp electrodes is the main source of the electrical potentials recorded. If the activity in the deep structures is evoked by, for example, auditory stimuli it can be detected on the scalp by signal enhancement techniques such as the averaging of signals.

Cooper, R. (p. 305).

Comprehension Exercises

A. Put "T" for true and "F" for false statements. Justify your answers.

..... 1. Average reference is one of the methods of deriving electrical signals.

..... 2. In the bipolar derivation, two electrodes are used to minimize the possibility of picking up potentials from the brain.

..... 3. The average reference system measures the potentials against the star point.

..... 4. The result obtained from the bipolar derivation is different from that obtained from the common reference derivation.

..... 5. In the common reference system, the star point is used as a common reference for all channels.

..... 6. Source derivation is a modified version of the average reference system.

B. Write the answers to the following questions.

1. How is the average potential of all of the electrodes generated in the average reference system?
2. What does the bipolar technique measure?
3. Why is the measurement of the steady potentials between parts of the brain difficult?
4. How is the activity in the deep structures detected on the scalp?
5. What is the main source of the electrical potentials recorded?

A. Translate the following passage into Persian.

Electroencephalography Techniques

Scalp recordings of spontaneous neuronal activity of the brain, identified as the EEG, allow measurement of potential changes over time (brain waves) between a signal electrode and a reference electrode. Compared to other biopotentials, such as the electrocardiogram, the EEG is extremely difficult for an untrained observer to interpret. As might be expected, partially as a result of the spatial mapping of functions onto different regions of the brain, correspondingly different waveforms are visible, depending on electrode placement. Recognizing that some standardization was necessary for comparison of research as well as clinical EEG records, the International Federation in Electroencephalography and Clinical Neurophysiology adopted the 10-20 *electrode placement system*. The system is so named because it divides the linear distances between temples (right-left) and between the masion and inion (fore-aft), across the top of the head, into two 10 percent and four 20 percent regions. The points of intersection formed by drawing perpendicular lines to the anterior-posterior and right-left lines at each 10 or 20 percent demarcation represent the standard electrode placement sites. Each site is designated with a standard label for easy reporting purposes (C_z, P_3, and so forth).

B. Find the Persian equivalents of the following terms and expressions and write them in the spaces provided.

1. abrasion .....
2. anterior-posterior .....
3. auditory stimuli .....
4. average reference .....
5. cerebral origin .....
6. common reference .....
7. conductive electrode paste .....

8. corneal-retinal potential field .....
9. demarcation .....
10. epileptic seizures .....
11. masion .....
12. noncephalic electrode .....
13. perpendicular lines .....
14. preset sites .....
15. quasirhythmic .....
16. sinusoidal .....
17. temples .....

Unit 7

Section One: Reading Comprehension

Electrocardiography

Electrocardiography is the recording on a voltage-time graph of potentials existing on the skin as a result of the electrical activity of the heart. The standard electrocardiogram (ECG) consists of twelve recordings of voltages between various pairs of electrodes placed on the skin of the limbs and chest. The basic methods of electrocardiography have remained unchanged for over 40 years, but advances in technology have greatly simplified the procedure so that ECG can be recorded quickly in the patient's home or in a health center, as well as in hospitals. The analysis of ECGs remains largely an empirical exercise although increasing understanding of the genesis of the ECG has allowed a scientific approach to be adopted in some areas of the subject. Electrocardiography is one of the commonest medical investigations. It can give valuable information to the clinician in widely varying pathological conditions, such as disturbances of blood electrolytes, endocrine diseases, and pulmonary disease, as well as in all aspects of heart disease.

Von Kö lliker and Muller investigated the electrical activity of isolated frogs' hearts in 1856, and in 1887, A.D. Waller 'discovered that one can detect this electrical activity on the surface of the body in man, using bowls of saline in which the right hand and left foot were immersed. Einthoven measured the activity in 1912, using a string galvanometer in conjunction with an optical recording device. He described three 'lead' connections, between right

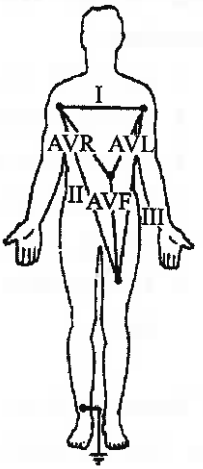


Figure 7-1. The Standard and Unipolar Limb Leads and Einthoven's Triangle.

arm and left arm (standard lead I), between right arm and left leg (standard lead II), and between left arm and left leg (standard lead III). He postulated that the heart was in the center of the triangle formed by these 'leads', and that conduction to the surface of the body was uniform in all directions (Figure 7-1). Wilson (1934) added further lead connections termed unipolar or V leads. He used an exploring terminal placed at one of six positions on the chest over the heart and a central terminal achieved by connecting the leads from the limbs together, having inserted a 5000 Ω resistance into each (Figure 7-2). Three unipolar limb leads introduced by Goldberger complete the 12-lead ECG. These are obtained by connecting the exploring electrode to the right arm (AVR), left arm (AVL), and left leg (AVF), and measuring the potential difference between the exploring electrode and the central terminal.

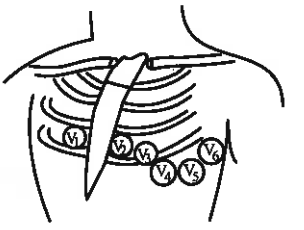


Figure 7-2. The Positions on the Chest for the Unipolar Chest Leads.

Robinson, J.F. (p. 301).

Part I. Comprehension Exercises

A. Put "T" for true and "F" for false statements. Justify your answers.

..... 1. The ECG can give information in pulmonary disease.

..... 2. Twelve recordings of voltages are used in the standard ECG.

..... 3. Wilson used an exploring terminal and a central terminal.

..... 4. The exploring electrode should be connected to the right arm, left leg, and right leg.

..... 5. The standard lead I makes a connection between right leg and left leg.

B. Choose a, b, c, or d which best completes each item.

1. In the standard electrocardiogram, various pairs of electrodes are placed ..... .

a. on the skin of the legs and arms

b. on the skin of the limbs and chest

c. between left arm and left leg

d. on the right hand and left foot

2. In order to measure the electrical activity of the heart, Einthoven used ..... .

a. bowls of saline

b. three unipolar chest leads

c. 5000 Ω resistance

d. a string galvanometer in conjunction with an optical recording device

3. The standard lead III is placed between ..... .

a. right arm and left leg

b. right arm and left arm

c. left arm and left leg

d. left arm and right leg

4. In order to complete the 12-lead ECG, ... are used.

a. three lead connections

b. three unipolar limb leads

c. two unipolar chest leads

d. six lead connections

5. Electrocardiography ..... .

a. is the recording of the electrical activity of the muscles

b. is the recording of the electrical activity of the brain

c. provides clinician with valuable information

d. is the investigation of heart related diseases

C. Answer the following questions orally.

1. What is electrocardiography?
2. What does the standard electrocardiogram consist of?
3. What was in the center of the Einthoven's triangle?
4. What did Von Kö llikerand Muller investigate?
5. Where is an exploring terminal placed?

Part II. Language Practice

A. Choose a, b, c, or d which best completes each item.

1. **Electrolyte** is an element or compound that, when melted or dissolved in water or other solvents, ...

a. separates positive ions and can become attached to another element

b. spreads across the membranes and can produce an electric current

c. dissociates into ions and can conduct an electric current

d. neutralizes the potential difference and can detect the electrical activity

2. **Endocrine** refers to a process in which a group of cells secrete into the blood or lymph circulation a substance that has a specific effect on ..... .

a. heart muscles
b. brain
c. blood vessels
d. tissues in another part of the body

3. **Saline** is a substance that ..... .

a. absorbs liquids and gases
b. contains a salt of an alkali metal
c. conducts an electrical activity
d. decreases electrical activities on the surface of the body

4. **Galvanometer** is a device that indicates or measures ..... .

a. electrical current by its effects on needle or coil in a magnetic field
b. electrical activity by its effects on an exploring electrode in a magnetic field
c. potential difference by its effect on a unipolar lead
d. electrical activity by its effects on a multichannel pen recorder

5. The word **genesis** means ..... .

a. segment
b. diagnosis
c. origin
d. design

B. Fill in the blanks with the appropriate form of the words given.

1. **Simple**

a. Many useful clinical applications of the Doppler method depend on the user ..... listening to the signals.
b. More recently, with the introduction of micro-processor technology, both instrument operation and data acquisition and processing have been considerably ..... .
c. ..... single-beam spectrophotometers have wide-ranging application in clinical and pharmaceutical laboratories.

2. **Conduct**

a. Some people who have ..... deafness can hear better through the bones of the skull than through the ears, the sound being transmitted

by vibration.

b. The first trial of fast-neutron therapy was ..... in California from 1938 to 1943.

c. Natural contractions of the chambers of the heart are controlled by the ..... of electrical impulses through specialized muscle fibers.

3. Center

a. A ..... theory of molecular biology states that the flow of genetic information is from DNA to RNA to protein.

b. Dentistry is ..... concerned with the state of health of the teeth and supporting structures as well as any related anatomical or physiological features.

c. The arm lengths of the chromosomes are the distances between the ..... of the centromere and the ends of the arms.

4. Resist

a. Every muscle, even when unstimulated, ... stretch when it has been extended beyond a certain length.

b. The ratio of blood pressure to cardiac output is called the vascular ..... .

c. Thermistors have a negative coefficient of ..... as a function of temperature.

5. Large

a. The outer part of bone is composed of a protein and ..... amounts of calcium and phosphorus.

b. Some of the most serious problems in cervical cytology automation stem ..... from the nature of the specimen.

C. Fill in the blanks with the following words.

terminology	widespread	record	arrhythmias
cardiac	angiography	valves	benefited
information	days		

An instrument used to obtain and ..... the electrocardiogram is called an *electrocardiograph*. The electrocardiograph was the first electrical device to find ..... use in medical diagnostics, and it still remains the most important

tool for the diagnosis of ..... disorders. Although it provides invaluable diagnostic information, especially in the case of ..... and myocardial infarction, certain disorders – for instance, those involving the heart ..... – cannot be diagnosed from the electrocardiogram. Other diagnostic techniques, however, such as ..... and echocardiography, can provide the ..... not available in the electrocardiogram. The first electrocardiographs appeared in hospitals around 1910, and while ECG machines have ..... from technological innovations over the years, little has actually changed in the basic technique. Most of the ..... and several of the methods still employed date back to the early ..... of electrocardiography and can be understood best in a historical context.

D. Put the following sentences in the right order to form a paragraph. Write the corresponding letters in the boxes provided.

a. That this set of electrical events is intrinsic to the heart itself is well demonstrated when the heart (particularly that of cold-blooded vertebrates such as the frog or turtle) is removed from the body and placed in a nutrient medium (such as glucose-ringer solution).

b. The main pumping function is supplied by the ventricles, and the atria are merely antechambers to store blood during the time the ventricles are pumping.

c. The heart serves as a four-chambered pump for the circulatory system.

d. The resting or filling phase of the heart cycle is referred to as *diastole.*

e. The smooth, rhythmic contraction of the atria and ventricles has an underlying electrical precursor in the form of a well-coordinated series of electrical events that takes place within the heart.

f. The contractile or pumping phase is called *systole.*

1	2	3	4	5	6

Source of Electrical Activity of the Heart

The electrical activity of the heart results from a process of electrical depolarization and repolarization of the surface membrane of the cardiac muscle cells. In the resting state, the outside of the membrane is positively charged while the inside is negatively charged – the potential difference being 90 mV across the membrane. This potential is due to the relative concentration of potassium, sodium, and chloride ions inside and outside the cell. Movement of these ions across the membrane neutralizes the potential difference (depolarization). The process of depolarization starts in the right atrium and spreads throughout the atria to the ventricular septum and thence to the walls of the left and right ventricles. This process precedes, and is a prerequisite for, mechanical contraction of the heart.

These events produce on the ECG a series of deflections from the baseline. The first deflection is a low amplitude, broad deflection due to atrial depolarization (P wave). After an interval of 0.1-0.2 s from the onset of this wave there is a bigger deflection due to ventricular depolarization (QRS complex) followed by a lower broader deflection (T wave) due to ventricular repolarization (Figure 7-3a).

Analysis of the ECG is invaluable in the diagnosis of disturbances of cardiac rhythm and conduction (passage of electrical stimuli), enlargement of the cardiac chambers, ischemia or necrosis of heart muscle, disease of the myocardium owing to infections, toxic chemicals or drugs, and disease of the pericardium. The ECG also shows characteristic changes in the presence of excess or deficiency of potassium, calcium, and magnesium. Hypothyroidism produces a characteristic ECG waveform.

Perhaps the most important use of the ECG is in the diagnosis of coronary artery disease. Within a short time of a coronary artery occluding and producing myocardial infarction, the ST segments of the ECG become elevated (up to 10 mm above the baseline). Thereafter the Q waves deepen and the T waves become inverted (Figure 7-3b). The cause of these changes is a current of injury passing between the damaged heart muscle and the

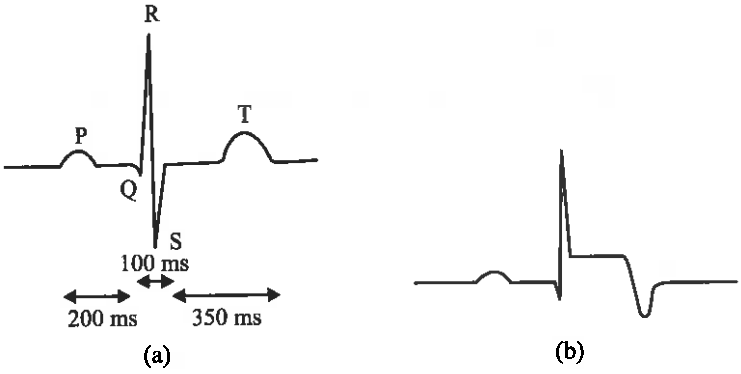


Figure 7-3. (a) Appearances and Time Relationships of the ECG and (b) The ECG in Acute Myocardial Infarction Showing Elevation of the ST Segment and Inversion of the T Wave.

surrounding undamaged muscle giving rise to ST segment elevation. The damaged area transmits the intracavity ECG giving rise to the Q wave. The pattern of repolarization is interrupted by the damaged tissue resulting in the inverted T wave. The leads in which these changes appear indicate the area of the heart that is damaged. Although these abnormalities subside to some extent, the ECG usually retains some signs of damage indefinitely.

Myocardial infarction is frequently complicated by disturbances of cardiac rhythm and conduction which may be fatal if not detected and treated immediately. It is important therefore to monitor one lead of the ECG continuously by means of an oscilloscope when a patient is at risk.

Robinson, J.F. (pp. 301-302).

Comprehension Exercises

A. Put "T" for true and "F" for false statements. Justify your answers.

..... 1. The inside of the membrane of the cardiac muscle cells is negatively charged in the resting state.

..... 2. Analysis of the ECG is invaluable in the diagnosis of the disease of the pericardium.

..... 3. The first deflection on the ECG is a low amplitude, broad deflection due to ventricular repolarization.

..... 4. The ECG only shows characteristic changes in the presence of excess of magnesium.

..... 5. Depolarization is neutralized by the movement of potassium, sodium, and chloride ions across the membrane of the cardiac muscle cells.

..... 6. The undamaged heart muscle transmits the intracavity ECG giving rise to the T wave.

..... 7. Myocardial infarction is frequently complicated by the enlargement of the cardiac chambers.

B. Write the answers to the following questions.

1. What is the most important use of the ECG?
2. What is the cause of the potential difference across the membrane of the cardiac muscle cells?
3. Where does the process of depolarization start from?
4. What does hypothyroidism produce?
5. How is the pattern of depolarization interrupted?

Section Three: Translation Activities

A. Translate the following passage into Persian.

ECG Waveform

The electrocardiogram is used clinically in diagnosing various diseases and conditions associated with the heart. It also serves as a timing reference for other measurements. To the clinician, the shape and duration of each feature of the ECG are significant. The waveform, however, depends greatly upon the lead configuration used, as discussed below. In general, the cardiologist looks critically at the various time intervals, polarities, and amplitudes to arrive at his diagnosis.

Some normal values for amplitudes and durations of important ECG parameters are as follows:

Amplitude:	P	wave	0.25 mV
	R	wave	1.60 mV
	Q	wave	25% of R wave
	T	wave	0.1 to 0.5 mV
Duration:	P-R	interval	0.12 to 0.20 s
	Q-T	interval	0.35 to 0.44 s
	S-T	segment	0.05 to 0.15 s
	P	wave interval	0.11 s
	QRS	interval	0.09 s

For his diagnosis, a cardiologist would typically look first at the heart rate. The normal value lies in the range of 60 to 100 beats per minute. A slower rate than this is called *bradycardia* (slow heart) and a higher rate, *tachycardia* (fast heart). He would then see if the cycles are evenly spaced. If not an *arrhythmia* may be indicated. If the P-R interval is greater than 0.2 s, it

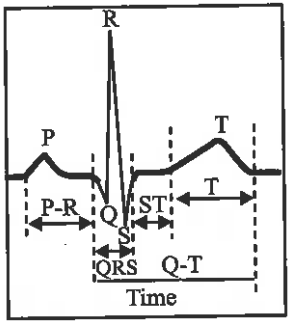


Figure 7-4. The Electrocardiogram in Detail.

can suggest blockage of the AV node. If one or more of the basic features of the ECG should be missing, a heart block of some sort might be indicated.

In healthy individuals, the electrocardiogram remains reasonably constant, even though the heart rate changes with the demands of the body. It should be noted that the position of the heart within the thoracic region of the body, as well as the position of the body itself (whether erect or recumbent), influences the 'electrical axis' of the heart. The *electrical axis* (which parallels the anatomical axis) is defined as the line along which the

greatest electromotive force is developed at a given instant during the cardiac cycle. The electrical axis shifts continually through a repeatable pattern during every cardiac cycle.

Under pathological conditions, several changes may occur in the ECG. These include (1) altered paths of excitation in the heart, (2) changed origin of waves (ectopic beats), (3) altered relationships (sequences) of features, (4) changed magnitudes of one or more features, and (5) differing durations of waves or intervals.

B. Find the Persian equivalents of the following terms and expressions and write them in the spaces provided.

1. arrhythmia .....
2. atrium .....
3. blood electrolytes .....
4. bradycardia .....
5. coronary artery disease .....
6. disturbances .....
7. ectopic beats .....
8. endocrine disease .....
9. hypothyroidism .....
10. ischemia .....
11. myocardial infarction .....
12. myocardium .....
13. necrosis of heart muscle .....
14. pericardium .....
15. pulmonary disease .....
16. repolarization .....
17. tachycardia .....
18. unipolar chest leads .....
19. ventricular septum .....

Unit 8

Section One: Reading Comprehension

Computerized Axial Tomography

Computerized axial tomography (CAT) is a radiographic technique in which x-ray images representing slices through a patient are reconstructed by means of computer programs. An x-ray tube moves in a circular path with the patient on the axis of rotation and detectors either rotate simultaneously about the same axis or are fixed in position around the plane of rotation. Earlier systems used a complex movement called rotate-translate in order to economize on the number of detectors needed, but they have been mainly superseded because of their slower scan times and patient throughput. Electronic detectors are used to collect arrays of x-ray absorption data; the much wider linear dynamic range of electronic detectors compared to film enables a higher but still low and clinically acceptable dose to be given to the patient which can be converted into vastly improved detection of soft-tissue lesions. The additional advantage of tomography is that overlaying organ structure from the images, which would otherwise obscure the subtle low-contrast differences, is removed.

The first practical clinical demonstration of CAT was in 1971. The superior imaging of cerebral lesions revolutionized neuroradiological practice and the CAT scanner rapidly became a standard item of equipment worldwide in all major hospitals which had neuroradiological departments. The inventor, Godfrey N. Hounsfield, has received over 40 honors and decorations for his contribution to medical diagnostic imaging, which he worked out while studying pattern recognition and information transfer systems at the Central Research Laboratories of EMI Ltd (now Thorn-EMI).

The neuroradiological application was extended from the brain to the spinal cord as soon as whole-body systems were available that had a large enough scanning aperture, and disposed of the 'water bag', which earlier systems used for coupling the head to the detectors.

The need for improved soft-tissue discrimination in oncology (cancer studies) has led to the CAT scanner being used for staging cancer disease progression and managing patient treatment. An important benefit of CT (computed tomography) images is that the use of high-intensity beams in radiotherapy can be accurately planned using the digital data which comprise the image. Indeed, a variety of programs and specialist display systems now available allow the radiotherapist to plan multiple-beam treatments which optimize radiation to the tumor site while minimizing damage to neighboring sensitive tissues.

CAT Technology

The key technology elements necessary for the CAT scanner are:

- high-output x-ray tubes;
- compact, reliable electronic x-ray detectors;
- cost-efficient digital computers;
- cost-efficient digital storage computer peripherals; and
- clinically oriented image-display systems.

The ready availability of all these in the 1970s allowed numerous manufacturers to offer systems to the world healthcare market.

A variety of system-design concepts were developed which differed mainly in the data gathering and coding method. These were named first, second, third, and fourth generation designs by their manufacturers as they were announced. The key differences between the designs are given in Table 8-1.

The minimum clinical requirements which are acceptable for current applications are given in Table 8-2. System performance within these

Table 8-1. Design Differences Between First to Fourth Generation CT Systems.

	Generation			
Feature	**First**	**Second**	**Third**	**Fourth**
Typical number of detectors	1(+1)	10-30	250-700	500-2000
Scan mechanism	rotate-translate	rotate-translate	rotate only	rotate-stationary
Typical scan time(s)	240	20-60	3-10	2-30

Table 8-2. Minimum Clinical Requirements for Current CT Systems.

Area of Study	Minimum Scan Time (s)	Resolution (mm)	Contrast Discrimination (%)
Brain	10-20	1-2	0.5
Spinal cord	10-20	0.5-1	0.5
Chest	2-5	1-2	2
Abdomen	1-5	2-4	5
Heart (gated multiple scans)	ideally 0.01	0.5-2	0.5

boundaries is now met by all manufacturers, although perfect spinal-cord imaging has not yet been achieved. Heart imaging is difficult and many compromises have to be made. Gating from ECG signals and addition of multiple scans remains the only method of data gathering since a single scan is not technically possible within one heart beat at the resolution or contrast-discrimination levels required, because of x-ray tube power limitation. Cardiac research work is proceeding, however, to determine the optimum compromise for clinical validity in the resulting images. It is important that heart muscle is imaged clearly as well as the major blood vessels supplying the heart wall.

Ridyard, J.N.A. (p. 214).

Part I. Comprehension Exercises

A. Put "T" for true and "F" for false statements. Justify your answers.

..... 1. Earlier CAT systems utilized rotate-translate movement to reduce the number of required detectors.

..... 2. Hounsfield was the inventor of CAT scanner.

..... 3. High-output x-ray tubes are necessary for the CAT scanner.

..... 4. System design concepts were different from each other in the data gathering and coding method.

..... 5. Perfect heart imaging has not yet been achieved.

B. Choose a, b, c, or d which best completes each item.

1. A rotate-translate was used in earlier systems in order to ..... .
   a. economize on the number of x-ray tubes needed
   b. move an x-ray tube in a straight path
   c. economize on the number of detectors needed
   d. collect arrays of x-ray absorption data
2. CAT scanner can be used for ..... .
   a. minimizing damage to neighboring sensitive tissues
   b. imaging of cerebral lesions
   c. overlaying organ structure from the images
   d. staging cancer disease progression
3. A variety of programs and specialist display systems let ..... .
   a. the detector rotate simultaneously about the same axis
   b. the radiotherapist plan multiple-beam treatments
   c. the manufacturer offer CT systems to the world healthcare market
   d. the neurologist study information transfer systems
4. A single scan is not technically possible because of x-ray ..... .
   a. tube movement in a circular path
   b. detector power limitation
   c. tube power limitation
   d. detector movement in a straight path
5. Earlier systems of CAT have been superseded because of their ..... .
   a. faster scan times and reliable electronic x-ray detectors
   b. multiple scans and electronic detectors
   c. multiple scans and clinically oriented image-display systems
   d. slower scan times and patient throughput

C. Answer the following questions orally.

1. What is CAT?
2. Why are electronic detectors used?
3. What is an important benefit of CT images?
4. What are the necessary elements for the CAT scanner?
5. What is the only method of data gathering?

Part II. Language Practice

A. Choose a, b, c, or d which best completes each item.

1. **Lesion** refers to ..... .
   a. an abnormal condition of the respiratory system
   b. a wound, injury, or pathologic change in the body tissue
   c. a blockage in the major blood vessels of the body
   d. a physical examination of an organ or cavity of the body
2. **Aperture** is an opening or hole in ..... .
   a. an object or anatomic structure
   b. a soft tissue
   c. a circular path
   d. a heart muscle
3. **Rotate** means ..... .
   a. to move around a magnetic field
   b. to spin around an object
   c. to revolve around an x-ray beam
   d. to turn around an axis
4. **Oncology** is a branch of ..... .
   a. radiography dealing with images
   b. medicine dealing with tumors
   c. physics dealing with electricity
   d. medicine dealing with heart diseases
5. **Supersede** as used in the text means ..... .
   a. to represent
   b. to insert
   c. to replace
   d. to influence

B. Fill in the blanks with the appropriate form of the words given.

1. **Reconstruct**
   a. As with CT scanning, the computer processing consists of machine control, data collection, image ....., and image analysis.
   b. Kuhl and Edwards were the first to produce ..... tomograms of living patients.
2. **Accept**
   a. Flow measurements using volume displacement and strain-gauge techniques are ..... in routine clinical use.

b. Fortunately the human body can, to a certain degree, ... the accumulation of waste products within it without marked effect on general health.

c. The fully automatic, modular, multichannel, selective, programmable, microprocessor-controlled clinical chemistry analyzer is now an ..... part of laboratory life.

3. Develop

a. The greatest area of ..... and use of centrifuges in the research field has involved the use of centrifugation on what is essentially a preparative scale.

b. Most prescreeners that have so far been ..... are based on one of the two technologies: image analysis and flow cytometry systems.

4. Require

a. The main ..... for visual inspection of the dental tissues are ready access and good illumination.

b. Three-dimensional images ..... the use of three-dimensional shape descriptors.

5. Limit

a. The details of the metabolism in the body of a ..... number of substances are reasonably well known from studies on patients and on healthy volunteers.

b. Since the attenuation of ultrasound by biological tissue increases with increasing frequency, the frequency of ultrasound is ..... by the required penetration.

C. Fill in the blanks with the following words.

isolated	irradiated	advantages	visualize
motion	radiographic	reconstruct	intervening

Computerized axial tomography or computer-assisted tomography (CAT) scanners provide the ability to ..... cross-sectional images of the body from x-ray attenuation data. One of the major ..... of this technique is that since ..... cross-sectional images can be produced, ... structures do not diminish the contrast of the desired planes as in ..... tomography. Also, since only the section of interest is ....., patient x-ray dosage can be reduced.

Additionally, tissue attenuation differences of less than 1 percent can be seen, which is much smaller than that of other ..... imaging systems, which typically require a 10 percent or greater tissue attenuation difference to ..... a structure.

D. Put the following sentences in the right order to form a paragraph. Write the corresponding letters in the boxes provided.

a. The xenon gas detectors are essentially ionization chambers whereby x-ray photons entering the chamber cause ionization of the xenon gas.

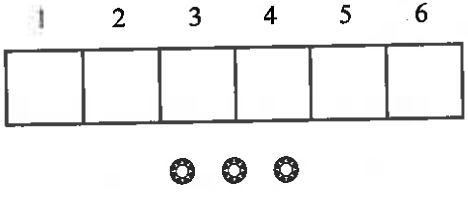
b. Third-generation scanners used a fan beam x-ray source and a ring of detectors to acquire attenuation data.

c. This increases the current flowing between two electrodes maintained at a high voltage so that detector current is directly proportional to x-ray intensity.

d. In this scanner, both the source and the detector are rotated about an axis centered within the patient.

e. Since the source and detector rotate together, the detectors can be relatively deep and positioned along the rays radiating from the source.

f. The x-ray source produces a beam with a divergence angle between 30° and 45° ,and the detector ring consists of 300 to 700 continuous xenon gas detectors.



Section Two: Further Reading

Principle of Image Reconstruction & Data Sampling

If an angular array of projections of x-ray beam attenuation readings is taken

over at least 180° around an object such that each part of the object is sampled in two orthogonal dimensions, then it is possible to reconstruct an image of the object represented by the map of attenuation in the plane of the sampled readings. The mathematical basis for this was first documented by Radon (1917).

Figure 8-1 shows a single detector being used to measure the x-ray attenuation of an object such that only the central element is common to all the sample readings taken – only this element can thus be determined accurately. If an offset is used and the experiment repeated, a second element is now common to all readings. Repeating this for the full diameter of the object enables all the diameter elements to be determined. If this is repeated for all the angles necessary to fill the circumference with picture elements, then every element is fully determined – with central elements significantly over-sampled but the periphery correctly sampled.

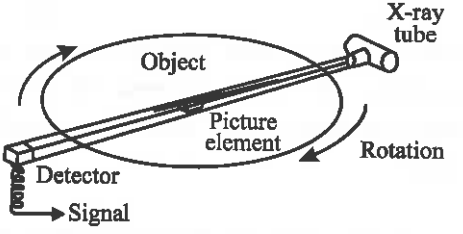


Figure 8-1. Single Detector Sampling.

When discrete sampling theorem rules are observed, the minimum number of samples necessary to determine an object diameter D, with resolution d, is:

$$D/2 \text{ (angles)} \times 2D/d \text{ (views)} = D^2/d \text{ (readings)}$$

A 500 mm diameter object thus requires 785398 readings for a 1 mm resolution accuracy.

The single-detector systems first developed used a linear translation of the framework holding the x-ray tube and detector to create samples across the diameter (Figure 8-2a). The framework then rotated a small angle (1°) before translating in the reverse direction. A total of 180 angular steps was

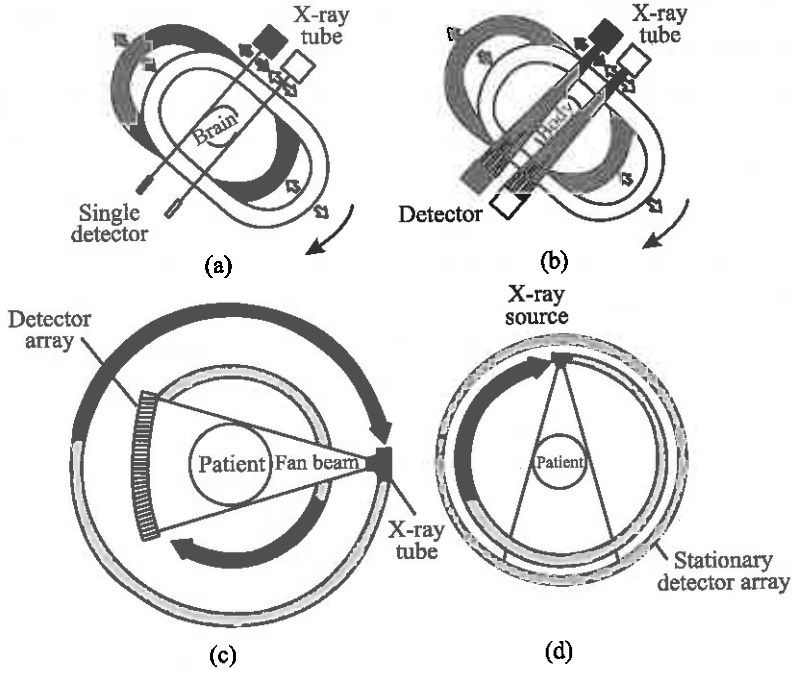


Figure 8-2. Systems Used for Data Sampling: (a) first generation, single detector, rotate-translate, (b) second generation, fan beam, rotation only, (c) third generation, fan beam, rotation only, and (d) fourth generation, fan beam, rotation only.

taken with diametric sample intervals determined by a fine graticule on the translation framework. Due to the masses involved, there was a mechanical speed limit of 3-4 min for a 180° rotation.

The second generation of CAT scanner systems (Figure 8-2b) added additional detectors so that multiple angles were recorded simultaneously. The speed improvement was in direct proportion to the number of detectors, although a resolution improvement was usually introduced by increasing the number of detectors per degree. The practical scan time limit for body-sized apertures was about 20 s per 180° scan.

Third generation systems use a bank of detectors large enough to include the whole patient in the subtended angle (Figure 8-2c). Over 200 detectors were initially used, but 500-700 are now common. The cost of each detector channel including the necessary electronics has to be considerably reduced

over the first and second generation designs for this type of system to be practical.

No movement other than rotation is necessary, since the required diametric sample interval is given by the detector arc itself — each detector viewing one particular radius only.

A much-improved level of detector stability is necessary with this design concept, and many manufacturers withdrew from the market due to technical difficulties in achieving this. The scan speed is limited by x-ray tube flux output and computer data-transfer rates. Scan times as low as 1 s are possible.

Fourth generation designs (Figure 8-2d) were developed in order to overcome the need for the high level of stability in third generation system detectors. Only the x-ray tube rotates, with a stationary detector bank occupying the full 360° scan plane. A much larger number of detectors are necessary for this type of system, other things being equal, but not in direct proportion to that apparently needed based on the third generation since the diametric sample interval is now obtained from the number of readings taken as the x-ray tube rotates, while the angular samples are determined by the detector geometry (the opposite to third generation). The scan speed is again limited by flux output and computer data-transfer rates, the latter tending to dominate in this design. Scan times as low as 1 s are possible.

Ridyard, J.N.A. (pp. 215-216).

Comprehension Exercises

A. Put "T" for true and "F" for false statements. Justify your answers.

..... 1. A 200 mm diameter object requires 785398 readings for a 1 mm resolution accuracy.

..... 2. First generation systems use a bank of detectors.

..... 3. A much larger number of detectors are required for the fourth generation systems.

..... 4. Scan times as low as 1 s are possible both for the third and fourth generation systems.

..... 5. The practical scan time limit for brain-sized apertures was about 20 s per 180° scan.

..... 6.The detector geometry determines the angular samples in the fourth generation systems.

B. Write the answers to the following questions.

1. What is a single detector used for?
2. Why did the single-detector systems use a linear translation of the framework?
3. Why did the second generation of CAT scanner systems add additional detectors?
4. How is the diametric sample interval obtained in the fourth generation systems?
5. Why were the fourth generation systems developed?
6. How are the diametric sample intervals determined in the first generation systems?

Section Three: Translation Activities

A. Translate the following passage into Persian.

Solid-State Detectors

Solid-state scintillators give a pulse of light in the visible spectrum from each x-ray photon absorbed. This light pulse is then converted into an electrical signal by a photomultiplier or silicon photodiode. The afterglow of the scintillation pulse must be low enough to prevent signal distortion since pulse counting is not possible due to the high rates involved (1×10^6 Hz) per channel and direct integration into charge is used. The linear dynamic range must be sufficient to record accurately both the highest count rate as well as the lowest – the latter in particular since reciprocals of logarithms are taken during computation and a small error is therefore magnified. Sodium iodide crystals doped with thallium were used in the first scanners since these give a high light output for each x-ray photon and are readily available. They have to

be totally sealed since the material is hygroscopic and cost effective designs with large arrays of multiple detectors are not possible. The afterglow is also rather high which restricts the dynamic range.

Bismuth germanate and cesium iodide became favored materials as they could be obtained in commercial quantity. Cadmium tungstate, now available in quantity, is an ideal material for use with silicon photodiodes since the light output is high, of the correct spectral color to match the response of silicon, and it has excellent mechanical properties as well as low afterglow. All these materials are easily fabricated into small detector elements of the required size and cost in large arrays.

B. Find the Persian equivalents of the following terms and expressions and write them in the spaces provided.

1. abdomen .....
2. circumference .....
3. contrast-discrimination levels .....
4. distortion .....
5. graticule .....
6. hygroscopic .....
7. integration .....
8. linear translation .....
9. neuroradiological practice .....
10. orthogonal dimensions .....
11. photodiode .....
12. photomultiplier .....
13. reciprocal .....
14. resolution .....
15. rotate-translate .....
16. subtended angle .....
17. x-ray flux output .....

Section One: Reading Comprehension

Biomechanics

Biomechanics is the branch of biology that applies engineering mechanics to the study of living organisms. The term is often applied specifically to studies of man but is more correctly used to include studies of all living organisms. Many different branches of mechanics have been applied to biological systems.

The earliest book on biomechanics is Giovanni Borelli's *De Motu Animalium* (1680), which discusses the movements of mammals, birds, and fishes. Borelli tackled several simple mechanical problems; for example, he used the principle of levers to estimate the forces which certain human muscles can exert, and Archimedes' principle in a discussion of the buoyancy of fish. A little later Stephen Hales published *Vegetable Staticks* (1727) and *Haemastaticks* (1733). The former describes a remarkable series of experiments on water movement in plants, and the latter some experiments using manometers to measure the blood pressure of farm animals. Little progress was made thereafter until the rise of the nineteenth century German school of physiologists. Johannes Mü ller (1801-58) carried out experiments with vocal cords from human corpses, relating his results to the physics of stretched strings. Human biomechanics has continued without interruption since then, but relatively little was done on the mechanics of other animals until the pioneering work of Sir James Gray (1891-1975) on mechanisms of locomotion.

The principal structural materials of organisms are polymers (either proteins or polysaccharides), sometimes with inorganic crystalline fillers. Some, such as the mesogloea of jellyfish, are dilute aqueous gels. Others, such as the insect protein resilin, are amorphous elastomers with elastic and thermodynamic properties very like soft rubbers. Many biological materials are oriented semicrystalline polymers, for example, cellulose, a polymer of glucose and the principal constituent of plant cell walls and fibers, including

cotton and hemp. Tendons consist of fibers of the protein collagen, and silk and wool are also protein fibers.

Many skeletal materials are composites. Insect cuticle, for instance, consists of polysaccharide fibrils in a protein matrix. Bone is a composite of 70% inorganic crystals (mainly calcium phosphate) and 30% collagen fibers. Mollusc shell consists of calcium carbonate crystals cemented together by protein. The composite structure of these materials makes them tough, like fiberglass and other man-made composites.

Study of biological materials has been greatly assisted by earlier work on rubber and plastics, but most biological materials are much more complex than man-made materials. Most man-made polymers are built from a single monomer but proteins consist of about 20 amino acids which polymerize in precisely controlled sequences to form long chains. The vast range of possible structures enables subtly different materials to evolve where slightly different properties are required. Structure at supramolecular level can also be very precisely controlled. One form of insect cuticle has microfibrils oriented in the manner of the molecules of a cholesteric liquid crystal. One of the principal types of bone consists of small cylindrical units, each built up of layers in which the fibers run alternately in left- and right-handed helices. The anisotropy of bone and of other natural materials is often nicely matched to the stresses experienced in nature.

Alexander, R. McN. (pp. 57-58).

Part I. Comprehension Exercises

A. Put "T" for true and "F" for false statements. Justify your answers.

..... 1. The principal structural materials of organisms are polymers with inorganic crystalline fillers.

..... 2. Biomechanics is not the study of all living organisms.

..... 3. Many different branches of mechanics have been used in biological systems.

..... 4. Oriented semicrystalline polymers are not biological materials.

..... 5. Collagen fibers and inorganic crystals make bone.

..... 6. The earlier work on rubber and plastics have no role in the study of biological materials.

B. Choose a, b, c, or d which best completes each item.

1. The branch of biology that applies engineering mechanics to the study of living organisms is called ..... .
   a. hemodynamics
   b. biomechanics
   c. mechanics
   d. physics
2. The earliest text on biomechanics was ..... .
   a. Vegetable Staticks
   b. Hoemastaticks
   c. Mü ller's papers
   d. De Motu Animalium
3. Borelli used the principle of levers ..... .
   a. to study engineering mechanics
   b. to include studies of all living organisms
   c. to estimate the forces which certain human muscles can exert
   d. to form long chains of molecules
4. Mollusc shell consists of ..... .
   a. calcium carbonate crystals and protein
   b. fibers, cotton, and hemp
   c. fibers of the protein and collagen
   d. inorganic crystals and collagen fibers
5. Many ..... materials are composites.
   a. rubber
   b. shell
   c. skeletal
   d. muscular
6. In man-made polymers, structure at ..... level is exactly controlled.
   a. supramolecular
   b. microstructural
   c. macrostructural
   d. micromolecular

C. Answer the following questions orally.

1. What is the major concern of the first book on biomechanics?
2. What is the construction of man-made polymers?
3. What do tendons consist of?
4. What is the construction of bone?
5. What is the history of biomechanics?

Part II. Language Practice

A. Choose a, b, c, or d which best completes each item.

1. **Biomechanics** is the study of ..... .

a. biology and mechanics
b. living creatures and their mechanics
c. mechanical laws and their application to living organisms
d. structural materials of organisms

2. The word **inorganic** means ..... .
a. a chemical compound that does not contain carbon
b. a substance with carbon composition
c. a matter made of inorganic acids
d. a chemical compound containing carbon composition

3. The word **amorphous** is best described as ..... .
a. shaped
b. shapeless
c. well-formed
d. well-defined

4. The word **buoyancy** is best described as the tendency to remain ..... .
a. fixed in a bone
b. stationary in a liquid
c. afloat in a liquid
d. stationary in a gas

5. **Mesogloea** are ..... .
a. cells of central nervous system
b. skeletal materials
c. muscle cells
d. blood components

B. Fill in the blanks with the appropriate form of the words given.

1. Structure

a. The principles of deformable body mechanics have important applications in the design of ..... and machine elements.
b. Bone is the primary ..... element of the human body.
c. Decompression chambers are very variable in size, and are made ..... much stronger than hyperbaric oxygen chambers.

2. Stretch

a. Since tendons and ligaments are viscoelastic, some of the energy supplied to ..... them is dissipated by causing the flow of the fluid within the ground substance, and the rest of the energy is stored in the ..... tissue.
b. Muscles are elastic in the sense that when a muscle is ..... and released, it will resume its original size and shape.

c. Every muscle resists ..... when it has been extended beyond a certain length.

d. Elastomers or rubbers are polymers that exhibit large ..... at room temperature and can snap back to their original dimensions when the load is released.

3. Continue

a. A ..... applied force on a fluid body will cause a ..... deformation.

b. For patients who are critically ill and require ..... measurement of blood pressure, a direct assessment is necessary.

c. The central nervous system (CNS) consists of the spinal cord lying within the bony vertebral column and its ....., the brain, lying within the skull.

d. Stethoscopes are used for ..... monitoring the heart sounds of surgical patients and providing a direct early warning of cardiac problems.

4. Biology

a. Biomechanics combines the field of engineering mechanics with the field of ..... and physiology.

b. In ..... terms, bone is a connective tissue which binds together various structures of the body.

c. The ..... active units of living tissues are the cells of which they are composed.

5. Great

a. The measurement of blood flow has had ..... interest for biomedical engineers.

b. The brain is the ..... modified and enlarged portion of the central nervous system.

C. Fill in the blanks with the following words.

mechanism	strain	accelerates	muscle
muscular	elastic	state	wings

Elastic ..... energy is important in many activities of animals. A flea taking off for a jump ..... from rest to a speed of 1 ms^{-1} in a distance of

0.5 mm. To do this it must extend its legs in 1 ms. No ..... can contract so fast (except in a peculiar ..... of oscillation which enables small insects to beat their ..... at high frequencies), but the flea has a built-in catapult made of the ..... protein resilin. Strain energy is stored in the resilin by a relatively slow ..... contraction and released rapidly by the trigger ..... which initiates the jump.

D. Put the following sentences in the right order to form a paragraph. Write the corresponding letters in the boxes provided.

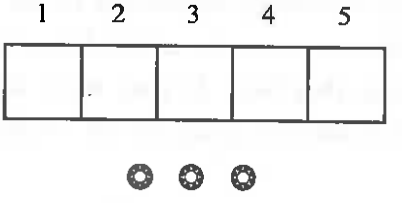
a. Statics is the study of systems that are in a state of constant motion, that is, either at rest (with no motion) or moving with a constant velocity.

b. The field of mechanics is composed of two major subbranches known as *statics* and *dynamics*.

c. The study of a moving body may involve *kinematics* and/or *kinetics*.

d. Whereas kinematics describes the appearance of motion, kinetics is the study of forces associated with motion.

e. Dynamics is the study of systems in motion in which acceleration is present.



Section Two: Further Reading

Statics, Kinematics, & Dynamics

Some complex problems of statics arise in biomechanics. Consider, for instance, the forces the leg muscles must exert in human standing. One analysis has treated the body as an assembly of seven rigid segments (two feet,

two shanks, two thighs and a trunk). Accordingly, the conditions for equilibrium in three dimensions gave 42 simultaneous equations. However, as there are 29 major muscles in each leg and there are also unknown forces at joints and ligaments, the problem is indeterminate. This is a recurring difficulty in biomechanics, which cannot easily be overcome by measuring internal forces in the body. Limited use has been made of transducers implanted in the bodies of men and animals to measure tension in tendons and strain in bones, but it is not feasible to implant many transducers in any one person or animal. Indirect evidence of muscle activity can be obtained fromt fine electrodes inserted into muscles, but it does not seem possible to calculate forces reliably from records of electrical activity.

The human hip is a simple ball and socket joint and the elbow is a hinge (with a second hinge between the two parallel bones of the forearm). Some other joints are more complex. The human knee behaves much like a hinge but consists of the spiral end surface of the femur rolling and sliding on the much flatter end of the tibia. The two are held together by ligaments, notably two ligaments which cross like an x in a gap in the middle of the joint. If slight play is ignored, there is just one degree of freedom of relative movement. The movement of the shin is approximately planar motion for most of its travel, but it rotates about a moving instantaneous center. As the knee approaches full extension, its movement becomes three-dimensional.

There are several interesting mechanisms in the skeletons of animals. Some of the most elaborate occur in certain fishes that extend the mouth forward as a tube when they feed. At least three radically different space linkages have evolved in different groups of fish, to give essentially the same movements.

Animal locomotion raises many problems in dynamics. Why, for instance, do men change from walking to running at a particular speed?

Consider first a man walking with speed u on legs of length l. If each leg is kept straight while its foot is on the ground the man's trunk advances in a series of circular arcs of radius l. This implies an acceleration u^2/l downwards, towards the supporting foot, but unless the man walks on adhesive ground his downward acceleration cannot exceed the acceleration of free fall, g. Hence u cannot exceed $(gl)^{1/2}$, or about 3 ms^{-1} for an adult man. The maximum speed

will be less for a child (smaller *l*) and on the moon (smaller *g*). Observations agree quite well with these predictions. Men normally break into a run at 2.5 ms^{-1}, and the faster racing walk involves a peculiar hip movement which reduces the vertical excursion of the center of mass.

More sophisticated models of human walking have been devised. Some are designed to explore the energy costs of different walking techniques, and seem to show that normal walking minimizes costs. Others are designed to estimate forces in individual muscles.

Many investigations of animal dynamics require knowledge of the external forces acting on the body. Various types of transducers have been used to measure these forces, including force platforms set into the floor.

Alexander, R. McN. (p. 58).

Comprehension Exercises

A. Put "T" for true and "F" for false statements. Justify your answers.

..... 1. There seems to be unknown forces at tendons and ligaments.

..... 2. Many transducers can be implanted in any person or animal.

..... 3. Transducers used for measuring tension in tendons and strain in bones are of limited use.

..... 4. The femur and the tibia are held together by ligaments.

..... 5. The human hip behaves like a simple ball and socket joint.

..... 6. It is impossible to calculate forces reliably from records of electrical activity of the muscles.

B. Write the answers to the following questions.

1. How many major muscles are found in each leg?
2. How can indirect evidence of muscle activity be achieved?
3. What does the human knee consist of?
4. When does the knee movement become three-dimensional?
5. How is the movement of the shin?

A. Translate the following passage into Persian.

Hydrostatics & Hydrodynamics

Plants lose water by evaporation and this must be replaced by water from the soil. Such water as there is in dry soil is at a low potential because it is held by capillarity in narrow spaces or adsorbed to clay particles. If water is to move from soil to plant, the water potential in the plant must be even lower. Plant sap is a dilute aqueous solution and achieves a low water potential by having a low pressure. Indirect measurements have shown that in conditions of drought, the pressure of the sap of the creosote bush (a desert plant) falls to -80 atm. This pressure is apparently reached without cavitation, in the fine tubes which contain the sap.

Surface tension is important in some biomechanical problems. Lungs, for example, are spongy structures with air-filled pores and pockets of diameter 0.1 mm or less. Air is pumped in and out of the pockets, making them enlarge and contract as the animal breathes. If the inner surfaces of the lungs were coated with water, the pressure in the pockets would increase as their size decreased. They would tend to collapse completely, and very large pressures would be needed to reinflate them. This happens in a dangerous disease of newborn babies. The inner surface of the healthy lung is coated with a surfactant, which has a low surface tension when it forms a complete film, as in the contracted lung.

The application of hydrodynamics can be illustrated by considering the motion of aquatic animals. An estimate of the power needed to propel a fish can be made by assuming the drag on the fish is the same as on a rigid body of the same size, moving at the same speed. Alternatively the power can be estimated from tail movements shown in films, by calculating the rate at which kinetic energy is added to the wake. The latter method gives estimates about five times as high as the former. The discrepancy is believed to be due to thinning of the boundary layer by the undulation of the body, making the former estimate unrealistic.

B. Find the Persian equivalents of the following terms and expressions and write them in the spaces provided.

1. anisotropy .....
2. aqueous .....
3. composite .....
4. crystalline filler .....
5. cuticle .....
6. equilibrium .....
7. femur .....
8. helices .....
9. ligament .....
10. locomotion .....
11. manometer .....
12. monomer .....
13. shin .....
14. surface tension .....
15. tendon .....
16. tibia .....

Section One: Reading Comprehension

Bone: Mechanical Properties

The bones of the skeleton play an important part in the support and movement of the body, and also provide mechanical protection for vital organs. These functions are possible because bone is both stiff and strong. Bones and bone material are not homogeneous but have clearly defined structures. In the typical long bone, such as the femur, the central portion or shaft consists of a cylinder of compact cortical bone, but the ends are filled with a spongy, cancellous bone consisting of a three-dimensional lattice made up of bony trabeculae.

The basic microstructural unit of adult human bone is the Haversian system or osteon, which forms a roughly cylindrical elongated structure (Figure 10-1). The osteon has a central Haversian canal containing blood vessels, lymphatics, and nerves. Concentric lamellae surround the Haversian

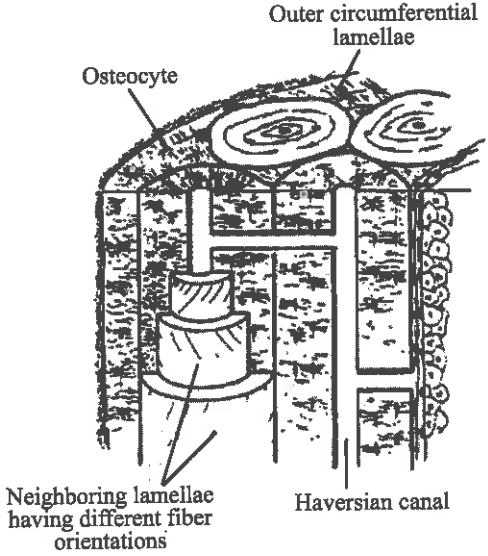


Figure 10-1. The Structure of Compact Bone: Each Haversian System May Contain up to 30 Lamellae, and Have a Diameter of up to 0.1 mm.

canal, and the outer limit of the osteon is delineated by a cement line of calcified mucopolysaccharide ground substance.

The mechanical properties of bone have been extensively investigated. The aims have been to relate the mechanical properties to the composition of bone and structure of bone in health and disease, to provide basic information on the mechanics of skeletal support and locomotion, and to provide parameters for the analysis of the effects of abnormal loads, and the presence of implants.

Bone, like other biological materials, shows wide variation in composition and structure, and this is reflected in the range of values of the mechanical parameters reported in the literature. The conditions under which the specimens are prepared and tested are important, for example, dry bone has a significantly higher strength than wet bone.

Bone shows a linear load-deformation response, from which a modulus of elasticity may be calculated; yield typically occurs at strains of ~ 1%. After yield, the bone undergoes plastic deformation, followed by failure. Time-dependent behavior is also observed.

Barbenel, J.C. (pp. 107-108).

Part I. Comprehension Exercises

A. Put "T" for true and "F" for false statements. Justify your answers.

..... 1. Osteon has an oval shape or structure.

..... 2. Bones and bone material are homogeneous with clearly defined structures.

..... 3. Blood vessels are contained in the central Haversian canal of osteon.

..... 4. The Haversian canal is surrounded by lamellae.

..... 5. The bones of the skeleton play more than one crucial role for the body.

B. Choose a, b, c, or d which best completes each item.

1. The protection of vital organs is one of ..... functions of the bones of the skeleton.

a. the typical
b. the mechanical
c. the chemical
d. the medical

2. The crucial functions of the bones are possible because bone is both ..... .
a. stiff and strong
b. solid and spongy
c. rigid and stiff
d. strong and spongy

3. The central Haversian canal contains ..... .
a. femur, protein, and nerves
b. nerves, osteon, and lymphatics
c. lymphatics, blood vessels, and nerves
d. blood vessels, osteon, and nerves

4. Like all biological materials, bone shows wide variation in ..... .
a. composition and structure
b. structure and form
c. structure and formula
d. size and structure

5. One of the aims of extensive investigation of bones has been ..... .
a. to calculate the modulus of elasticity in different directions
b. to provide basic information about the effects of abnormal loads
c. to find out the results of the presence of implants
d. to relate the mechanical properties to the composition of bones

C. Answer the following questions orally.

1. What are the various functions of the bone?
2. What is the basic construction of human bone and what shape it has?
3. How is the construction of osteon?
4. What are the aims of studying the mechanical properties of the bone?
5. What is the difference between a dry bone and a wet bone?

Part II. Language Practice

A. Choose a, b, c, or d which best completes each item.

1. **Lamellae** are ..... .
a. fat cells
b. collagen fibers
c. thin layers
d. waste products

2. The word **lymphatic** refers to a vessel that ..... .
a. produces collagen
b. transports plasma
c. removes nutrient
d. conveys lymph

3. The word **elongate** means ..... .

a. to become longer
b. to reduce strain
c. to decrease compression
d. to increase strength

4. The word **femur** refers to ..... .

a. the thigh bone extending from pelvis to the knee
b. the bone between the foot and the ankle
c. the bones extending from the skull to the hip
d. thin part of the leg between ankle and the calf

5. The word **osteon** is best described as ..... .

a. the elastic behavior of the compact bone
b. the radial and tangential strength of the compact bone
c. the nonlinear viscoelastic behavior of the compact bone
d. the basic structural unit of the compact bone

B. Fill in the blanks with the appropriate form of the words given.

1. Protect

a. The principle functions of the spinal column are to ..... the spinal cord; to support the head, neck, and upper extremities; to transfer loads from the head and trunk to the pelvis; and to permit a variety of movements.

b. Skin, with its relatively high electrical resistance, normally affords a measure of ..... to susceptible internal organs.

2. Connect

a. The extravascular sensor system is made up of a catheter ..... to a three-way stopcock and then to the dome of the pressure sensor.

b. The microshock current can flow either into or out of the electric ..... to the heart.

c. The nerves that ..... directly to the brain are called cranial nerves.

d. Small potentials between any two ..... surfaces near the patient can cause a microshock.

3. Direct

a. There exist both ..... and indirect methods of measuring blood pressure.

b. The mechanical response of bone is dependent upon the ..... as well as the magnitude of the applied load.

c. Blood flow can be measured by using the Doppler technique either transcutaneously or by placing a transducer ..... on a vessel.

4. Base

a. The ..... use of Doppler systems is the measurement of blood flow or the motion of heart valves or walls.

b. Artificial lungs, commonly termed oxygenators, are ..... oxygen and carbon dioxide gas exchangers.

5. Strength

a. The presence of the minerals imparts ..... to bone and also gives it a density that is apparent on an x-ray of an extremity.

b. Oxygen is ..... paramagnetic and has a magnetic susceptibility several hundred times that of other medical gases.

c. Many hormones affect the metabolism of skeletal muscle but none have ..... influences on its contraction.

C. Fill in the blanks with the following words.

move	osteons	approximately
lamellae	fluid	cancellous
bones	Haversian	trabeculae

In the shaft of long ..... the osteons are packed in parallel array, with their long axes ..... directed along the shaft of the bone. The ..... on the outer and inner surfaces of the shaft do not form ..... systems but are parallel to the bone surface. The Haversian canals of adjacent ..... are connected by lateral Volkmann's canals. The canals and the lacunae contain ..... which transports nutrients and waste products, and are also free to ..... in response to stress.

The open-textured ..... bone at the ends of the long bones consists of ..... made up of rods and plates.

D. Put the following sentences in the right order to form a paragraph. Write the corresponding letters in the boxes provided.

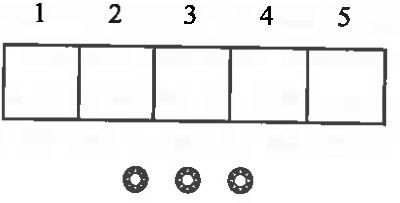
a. Bone from which organic material has been removed retains its shape and some of its strength which suggests that mineral phase is continuous.

b. The major mineral component is hydroxy-apatite, most of which occurs as crystals having plate or needle shapes.

c. Each lamella has a predominant fiber orientation, which differs in adjacent lamellae.

d. Bone is a living material and cells, called osteocytes, are found in lacunae between the lamellae.

e. The crystals are deposited at specific sites on the collagen and their growth is aligned with the fiber, the crystallographic *c* axes being parallel to the fiber.



Section Two: Further Reading

Load-Deformation and Time-Dependence Behavior of Bone

The structural alignment of osteons in compact bone is reflected in anisotropy of mechanical properties. The modulus of elasticity in the longitudinal direction is about 1.5-2 times that measured tangentially. There is less information on the radial modulus, but it probably lies between the values for the other directions. It has been suggested that the anisotropy is such that the bone can be considered as orthotropic.

The value of the longitudinal modulus for slow tensile tests on wet specimens commonly falls in the range 15-20 GPa. Compression tests show a much wider variation; Fung (1981) ascribes the variability to the nonhomogeneous, anisotropic composite structure of bone, but it may be due to the difficulty inherent in compression tests.

Anisotropy is also apparent in the shear modulus. Specimens in torsion along the axis of the bone have a shear modulus of about 5-6 GPa, but tangential specimens are about twice as stiff. The load-deformation response of cancellous bone consists of an initial linear phase, followed by deformation at almost constant load and finally an increasingly stiff response. It is both weaker and less stiff than cortical bone.

Strain-rate dependence has been demonstrated in both tension and compression. The elastic modulus becomes higher with increasing strain rate, the modulus being a logarithmic function of the rate. Ultrasonic methods have been used to demonstrate anisotropy and produce values of the modulus of elasticity which may be in excess of 20 GPa.

Both stress relaxation and creep have been demonstrated. The data of Lakes et al. (1979) suggest that the isochronous relaxation modulus is strain dependent, implying nonlinear viscoelastic behavior. The dynamic response also shows time-dependent effects. Specimens tested over the frequency range 0.002-100 Hz showed progressive changes in modulus and phase angle.

Barbenel, J.C. (p. 108).

Comprehension Exercises

A. Put "T" for true and "F" for false statements. Justify your answers.

..... 1. Cortical bone is stronger and less stiff than cancellous bone.

..... 2. With increasing strain rate, the radial modulus becomes higher.

..... 3. The elastic modulus acts as a logarithmic function of the rate.

..... 4. Compression tests as compared with slow tensile tests demonstrate a much wider variation.

..... 5. Ultrasonic methods generate values of the modulus of elasticity which falls in the range 15-20 GPa.

..... 6. The shear modulus on specimens in torsion along the axis of the bone is about 5-6 GPa.

B. Write the answers to the following questions.

1. How is the modulus of elasticity in the longitudinal direction measured?
2. What does Lakes suggest about isochronous relaxation modulus?
3. What is the range of the value of the longitudinal modulus for slow tensile tests on wet specimens?
4. What does the load-deformation response of cancellous bone consist of?
5. What did specimens tested over the frequency range 0.002-100 Hz demonstrate?
6. What does Fung ascribe the variability of the compression tests results to?

Section Three: Translation Activities

A. Translate the following passage into Persian.

Bone Failure and Elastic Model

The values of the failure parameters reported in the literature show a wide variation.

The stress at failure appears to be directionally dependent. For wet bone the stress at failure for both tension and compression is about 100 MPa in the longitudinal direction, but the radial and tangential strength is less. The strength is rate dependent, with the stress at failure increasing with increasing strain rate.

Impact strength has been investigated using Charpy-type tests in which the energy lost by a weighted pendulum in fracturing the specimen is measured. The energy absorbed per unit cross-sectional area is about 14 $kNmm^{-2}$. There is also evidence that longitudinal specimens are tougher than tangential specimens. Bone is highly notch sensitive, although the root radius of the notch appears to have little effect.

The mechanical properties of bone depend on its composition and structure, and strength and stiffness increase with increasing mineralization.

Attempts have been made to model the elastic behavior of bone using composite theory.

The modulus of bone has been calculated using Voigt (equal strain in each component) and Reuss (equal stress) models. The resulting predictions gave upper and lower bounds of the modulus-mineral content relationship which are widely separated, the experimental results falling between them. A combined model produces better agreement between experiment and prediction, but this may be due to the presence of an additional adjustable parameter. A microstructural model based on a near-hexagonal array of osteons leads to predictions of the angular variation of modulus which closely simulates the experimental behavior of bone.

Bone is a living material, which will respond to force by modifying its composition. A model incorporating such adaptation has been developed and applied to the problem of the response of bone to a medullary pin, but experimental validation is still lacking.

B. Find the Persian equivalents of the following terms and expressions and write them in the spaces provided.

1. abnormal .....
2. calcify .....
3. cancellous .....
4. composition .....
5. compression .....
6. cortical .....
7. elongate .....
8. lamellae .....
9. notch .....
10. stiffness .....

Unit 11

Section One: Reading Comprehension

Colorimetry

Colorimetry is any technique for measuring the color of objects and lights. The technique may be qualitative or quantitative, visual or photoelectric, direct or indirect.

The simplest and most straightforward techniques of color measurement involve direct visual comparisons. The observer compares an unknown color with physical standards appropriate to the color dimension being evaluated. For specific purposes, the range of standards need only be large enough to encompass the unknown color, and the individual standards can be realized in any convenient form (e.g., colored paints, papers, filters, or solutions). However, for general purposes, the choice of standards is decided by additional considerations. They should (a) have permanent color characteristics, (b) represent the widest range of possible colors, and (c) be organized according to some color plan or set of principles allowing the precise specification of any color chosen at random. Since it is impossible to produce an infinite variety of standards, most matches will not be perfect. Some logical scheme must be introduced, therefore, to organize the standards so that visual interpolation of the exact match is possible. Visual interpolation is easiest when the standards are arranged in a series of small, approximately equal intervals.

Sets of color standards having the properties outlined above are called color-order systems. Plans for scaling color standards which are based on the principles of color perception are called color-appearance systems. These are the most useful systems provided that their scales are used under carefully controlled conditions. This proviso is necessary because the appearance of colors changes with lighting and viewing conditions. An explanation of the perceptual or psychological attributes of color will help illustrate what uniform scales of color appearance are.

Perceptually, color may be conceived as varying along three separate dimensions: hue, saturation, and brightness (lightness). Hue is the color dimension corresponding to the isolated sections of the visible electromagnetic spectrum: violet (wavelength ~390-455 nm), blue (455-492 nm), green (492-577 nm), yellow (577-597 nm), orange (597-622 nm), and red (622-770 nm). Purple is also a hue although it comprises energy from the two opposite ends of the spectrum (violet plus red). The inclusion of purple enables hue to be treated as a continuous dimension running from red to orange, yellow, green, blue, violet, and back again through the purples to red. White, grays, and black are missing from this continuum because they are not hues. They are achromatic colors, i.e., colors without a hue assignable to a specific region of the spectrum. They either have energy simultaneously present from more than one section of the spectrum (grays and white) or none at all (black). Whites may also be formed by mixing complementary wavelengths. In these special cases, the white will have energy present from two isolated regions or one spectral region plus purple.

Sharpe, L.T. (pp. 201-202).

Part I. Comprehension Exercises

A. Put "T" for true and "F" for false statements. Justify your answers.

..... 1. Measuring the color of objects and lights is called colorimetry.

..... 2. Colorimetry is only a qualitative techinque.

..... 3. Direct visual comparison is among the most difficult techniques of colorimetry.

..... 4. Visual interpolation is exact when the standards are arranged in a special manner.

..... 5. White, grays, and black are achromatic colors.

..... 6. It is impossible to generate an infinite variety of color standards.

B. Choose a, b, c, or d which best completes each item.

1. During direct visual comparison, the observer compares an unknown color with ..... appropriate to the color dimension being evaluated.

a. real properties b. general qualities

c. physical standards d. physical structures

2. Color-appearance systems are the plans for .....
   a. scaling color standards
   b. interpolating unknown colors
   c. arranging known colors
   d. mixing complementary wavelengths
3. Color may be conceived as varying along three ..... .
   a. equal intervals
   b. separate dimensions
   c. horizontal axes
   d. vertical axes
4. Sets of color standards are called ..... systems.
   a. color-appearance
   b. colorimetric
   c. achromatic
   d. color-order
5. Achromatic colors are those ..... .
   a. with a hue assignable to a specific region of the electromagnetic spectrum
   b. without a hue assignable to a specific region of the spectrum
   c. without a perfect color of the spectrum
   d. with continuous dimension running from red to violet

C. Answer the following questions orally.

1. What is colorimetry?
2. What are the criteria for selecting standards for general purposes of colorimetry?
3. What is hue?
4. What are the dimensions of color variation?
5. What are the colors of the hue and which colors are excluded?
6. What do the plans for scaling color standards depend on?

Part II. Language Practice

A. Choose a, b, c, or d which best completes each item.

1. **Colorimetry** is the measurement of .....
   a. the number of red cells in blood
   b. the intensity of light in a substance
   c. the blood flow in a vessel
   d. the electrical activity of the retina
2. The word **perception** means .....
   a. justification
   b. evaluation
   c. suggestion
   d. recognition

3. A **spectrum** is a series of colored bands diffracted and arranged in ..... .

a. terms of their appearance

b. order of their respective wavelengths

c. terms of hue, saturation, and lightness

d. order of their brightness

4. **Achromatic** refers to color .....

a. standards

b. dimensions

c. properties

d. plans

5. The word **saturation** means .....

a. a condition in which a solution contains as much solute that can remain dissolved

b. a measure to which oxygen is combined with hemoglobin

c. a chemical compound in which all the valency bonds have not been filled

d. a condition in which the mixture color will appear less bright than the unknown color

B. Fill in the blanks with the appropriate form of the words given.

1. Arrange

a. The complete analysis of muscle forces required to sustain various postural positions is difficult because of the complex ..... of muscles within the human body.

b. The cortex is generally ..... in six layers consisting mainly of pyramidal cells and granule cells.

2. Observe

a. When looking at photographs of a patient taken over a period of time the differences that are ..... should result only from changes in the patient's condition.

b. Biometry serves as a tool for the description of biological samples in terms of the location and dispersion of ..... variables.

c. The modern intensive care unit depends on microprocessor-controlled monitors and central ..... stations.

d. Cross-sectional ..... studies analyze characteristics of patients at one particular time to determine the status of a disease or condition.

3. Organize

a. The human brain can be divided ..... into three general regions: the brain stem, cerebellum, and cerebral cortex.

b. An intensive care unit is usually ..... to treat a wider spectrum of diseases than the coronary care unit, but is mainly used for the treatment of circulatory and respiratory conditions.

4. Evaluate

a. ..... is a complex procedure which combines physical testing, functional testing, clinical trials, and cost assessments.

b. The technique of electric response audiometry (ERA) is used to ..... the function of the auditory system objectively by measurement of electrophysiological activity evoked by a transient acoustic stimulus.

5. Illustrate

a. The application of hydrodynamics can be ..... by considering the motion of aquatic animals.

b. The development of the Starr-Edwards prosthesis is a good ..... of the practical problems encountered in prosthetic heart-valve design.

C. Fill in the blanks with the following words.

radiant	brightness	achromatic
object	hue	luminosity

The combined ..... and saturation dimensions are called the chromaticness attribute of a color as distinguished from its ..... or lightness attribute. Brightness or ..... refers to self-luminous colors (lights). It is the attribute permitting a color to be judged similar to one of a series of ..... colors ranging from dim to dazzling bright. Generally, a color appears brighter as ..... energy is increased. Lightness, on the other hand, refers to non-selfluminous or ..... colors which are either light-reflecting (surface colors) or light-transmitting (volume colors).

D. Put the following sentences in the right order to form a paragraph. Write the corresponding letters in the boxes provided.

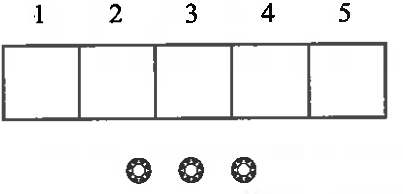
a. Similarly, value is related to the lightness of an object, although it is actually a compressive function of an object color's reflectance.

b. Hue as defined in the Munsell system requires no further explanation.

c. The best known color appearance system based on principles of color perception is the Munsell system.

d. Chroma corresponds closely to the saturation of a color: low chroma colors appear achromatic, high chroma colors appear saturated.

e. It uniquely classifies colors according to three dimensions: hue, chroma, and value.



Section Two: Further Reading

Trichromatic Colorimetry

As well as being matched to physical standards, unknown colors may be specified by metameric color matching. This technique exploits a fundamental fact of human physiology: of the four types of photon absorbing pigment in the normal eye, only three – those residing in the cone photoreceptors – are responsible for color vision. These cone pigments are maximally sensitive to different regions of the electromagnetic spectrum, but their sensitivities overlap. For convenience they are referred to as short-wavelength, middle-wavelength, and long-wavelength absorbing, although this description is correct only insofar as it refers to their relative wavelengths of maximum absorption.

The sensitivities of the cone pigments differ; for example, short-wavelength (high-energy) photons are most likely to be absorbed by short-

wavelength absorbing cones and least likely to be absorbed by long-wavelength absorbing cones. The reverse is true for long-wavelength (low-energy) photons. However, once a photopigment absorbs a photon all information about its wavelength and energy is lost. Thus, even though a cone's input is multivariant, its output is univariant, and depends solely upon how many quanta are caught by its pigment, not upon which quanta are caught (this assumes that quantum efficiency is constant). The limitation of cone output to a single dimension of change is fundamental because it means that any color can be specified by only three values: the relative quantum catches of the three cone classes. Obviously this will change with the wavelength characteristics of the color.

At present, quantum catches cannot be counted. To do so, it is necessary to know exactly the fractional absorption spectrum of the cones, as well as the optical density of several ocular screening pigments. Fortunately these shortcomings can be bypassed by invoking a corollary of cone univariance (i.e., metamerism). Metameric colors are matching colors with dissimilar spectral energy distributions. They may be contrasted to isomeric colors, i.e., matching colors with identical spectral energy distributions. Metamerism between colors holds only for a given illuminant and a given observer. Despite these restrictions, it holds under a wide variety of experimental conditions that may alter the appearance of metameric colors, e.g., preexposure to bright adapting lights, the introduction of strongly colored surrounds, or concomitant changes in the radiance (irradiance) or the spectral composition of both colors. The reason that metamerism occurs (i.e., why physically distinct colors can appear identical) is physiologically straightforward: their disparate spectral energy distributions produce identical quantum catches. (This is only true if the distributions have at least three crossovers, one in each area of maximum response of the cones.) Metamerism thus provides a way of completely specifying an unknown color by three values other than the cone outputs. Any color can be matched in appearance, but not in physical composition, by known amounts of arbitrarily chosen color stimuli or primaries – color stimuli whose mixture produces the same quantum catches as the unknown color. Only three independent ways of varying these primaries are needed so that the quantum catches of the three cone classes can be altered independently.

Sharpe, L.T. (pp. 203-204).

Comprehension Exercises

A. Put "T" for true and "F" for false statements. Justify your answers.

..... 1. Only three types of photon absorbing pigment in the normal eye are responsible for color vision.

..... 2. Short-wavelength photons are least likely to be absorbed by short-wavelength absorbing cones.

..... 3. Long-wavelength photons are most likely to be absorbed by long-wavelength absorbing cones.

..... 4. A cone's input is univariant.

..... 5. A cone's output is not based on which quanta are caught.

..... 6. Isomeric colors are matching colors with similar spectral energy distributions.

..... 7. The relative quantum catches of the three cone classes can be calculated.

B. Write the answers to the following questions.

1. What does happen when a photopigment absorbs a photon?
2. What does a cone's output depend upon?
3. What are metameric colors?
4. Why do distinct colors physically seem identical?
5. How can any color be matched in appearance?
6. How can an unknown color be specified?

Section Three: Translation Activities

A. Translate the following passage into Persian.

Indirect Colorimetry

Visual colorimetry is elegant, straightforward and precise. It reduces the vast array of color appearance to three dimensions of input. However, its

generality is limited: different observers make different metameric matches for the same unknown color. In fact, the variability between two observers is often larger than their individual standard deviations. For visual colorimetry to have validity for a large population the color matches of many observers must be averaged, often an impractical and time-consuming task. A different but related approach is to develop a system of color measurement based upon the immutable characteristics of a standard or hypothetically ideal observer. The standard observer can be defined by a set of color-matching functions: three independent functions of wavelength which weight the quantal flux of an unknown color in the same way as the cone spectral sensitivity functions. Conveniently, these functions can be derived by using the principles of univariance and metameric color matching. Three primary colors are chosen, preferably of monochromatic wavelengths spectrally separated as much as possible, and then the amounts (which may be positive or negative) required to match the wavelength of an equal-energy spectrum are determined, in radiometric or photometric units. These amounts are called the spectral tristimulus values, from which the amounts required to match any heterogeneous mixture of wavelengths (i.e., the amounts needed to match any unknown color) can be computed. This is done by first multiplying the unknown color's relative spectral distribution curve $S(\lambda)$ by the spectral tristimulus values then by integrating these products over the whole spectrum:

$$X = k\int_{\lambda} S(\lambda)\bar{x}(\lambda)\mathrm{d}\lambda$$
$$Y = k\int_{\lambda} S(\lambda)\bar{y}(\lambda)\mathrm{d}\lambda$$
$$Z = k\int_{\lambda} S(\lambda)\bar{z}(\lambda)\mathrm{d}\lambda$$

where X, Y, and Z are the tristimulus values of the unknown color, $\bar{x}(\lambda)$, $\bar{y}(\lambda)$, and $\bar{z}(\lambda)$ are the color-matching functions (or spectral tristimulus values), and k is a normalizing factor usually set equal to

$$100 / \int_{\lambda} S(\lambda)\bar{y}(\lambda)\mathrm{d}\lambda$$

B. Find the Persian equivalents of the following terms and expressions and write them in the spaces provided.

1. hue .....

2. immutable characteristic .....
3. interpolation .....
4. interval .....
5. isomeric colors .....
6. metamerism .....
7. monochromatic wavelengths .....
8. perception .....
9. photometric units .....
10. photoreceptors .....
11. qualitative .....
12. quantitative .....
13. random .....
14. scaling .....
15. spectral tristimulus values .....
16. univariant .....

Unit 12

Section One: Reading Comprehension

Artificial Pacemaker Unit

Many of the abnormalities of the heart can be treated by drugs. If drugs alone are not sufficient, then temporary (artificial) pacing is considered. If the disease is not chronic, in many cases a combination of temporary pacing and drugs helps the patient. But if temporary pacing is inconvenient and the patient needs regular pacing, an (artificial) permanent pacemaker is considered. This option involves a surgical operation and the related cost. Implantable pacemakers improve the quality of life and give the patients near normal life functionality.

The pacemaker unit delivers an electrical pulse with the proper intensity to the proper location in the heart to stimulate the heart at a desired rate and thus provides the patient with a functional heart. Figure 12-1 shows a functional diagram of an artificial pacemaker, which requires a pulse generator and a lead. The pulse generator houses electrical components responsible for generating the pulse (via output circuits) at the proper time (via (timing) control circuits) based on events sensed (via sensing circuits). It

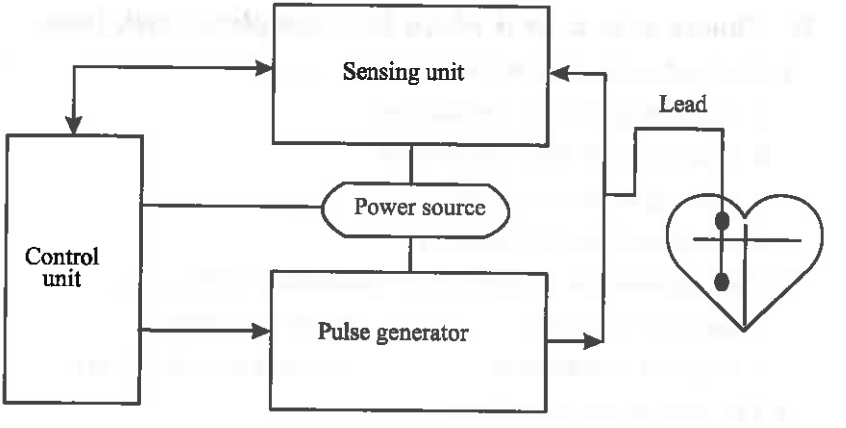


Figure 12-1. A Functional Diagram of Heart and Pacemaker.

also contains the power supply and may include other elements such as telemetry for testability and programmability and ROM (read only memory) or RAM (random access memory) to store data for diagnostic purposes. The lead contains a wire to deliver the pulse to its destination in the heart and to sense and carry back information to the sensing units in the pulse generator. It electrically connects the pulse generator to the myocardium of choice. The lead delivers the pulse from the pulse generator unit to the site of excitation. In addition, it carries the myocardial potentials back to the sensing portion of the pulse generator. The lead consists of three portions: a connecting portion to the pulse generator, an electrode for attachment to the myocardium and a wire connecting the two connectors.

Asgarian, M.H. (pp. 105-106).

Part I. Comprehension Exercises

A. Put "T" for ture and "F" for false statements. Justify your answers.

..... 1. The pulse generator unit consists of three portions.

..... 2. The lead consists of a wire connecting the sensing unit and the pulse generator unit.

..... 3. The pacemaker unit does not need any pulse generator.

..... 4. Heart disease can be either chronic or not.

..... 5. Artificial pacemaker unit is an aid for heart disease.

B. Choose a, b, c, or d which best completes each item.

1. The lead consists of an electrode for ..... .
   a. connecting the two connectors
   b. attachment to the myocardium
   c. creating an electric field
   d. attachment to the batteries
2. The implantation of permanent pacemaker needs ..... .
   a. surgical operation
   b. drug therapy
   c. long run of medicine
   d. occupational therapy
3. The wire in the lead ..... .
   a. delivers the pulse to its destination in the heart

b. sends the processed information to the control unit

c. carries back information to the pulse generator in the sensing units

d. carries back accurate signals to the control unit

4. ROM or RAM are used to ..... .

a. test data

b. program data

c. store data

d. terminate the activity

5. Implantable pacemakers ..... .

a. generate irregular heart beats

b. transfer magnetic currents

c. improve the quality of life

d. amplify electrical signals

C. Answer the following questions orally.

1. What is the pacemaker unit?
2. When is an (artificial) permanent pacemaker used?
3. What are the choices for the treatment of the heart diseases?
4. What is the function of a pacemaker unit?
5. What are the three portions of the lead?
6. What is the lead used for?

Part II. Language Practice

A. Choose a, b, c, or d which best completes each item.

1. **Pacing** is best described as ..... .

a. an electrode of the pacemaker system

b. an agent that soothes or comforts

c. the sinoatrial nod of specialized nervous tissue

d. the artificial, electrical stimulation of a heart rhythm

2. The word **chronic** refers to ..... .

a. a disease developing slowly and persisting for a long time

b. a type of pulmonary disorder lasting for a long time

c. a substance containing long chains of molecules

d. a tissue consisting of protein and collagen

3. The word **implant** means ..... .

a. to stimulate

b. to insert

c. to deliver

d. to discharge

4. **Myocardium** are muscle cells that ..... .
   a. require a pulse generator unit b. send accurate signals
   c. form the bulk of the heart wall d. create a wave of action potentials
5. The word **telemetry** refers to ..... .
   a. the stimulation of nerve cells
   b. the combination of temporary pacing
   c. the transmission of data between distant points
   d. the production of sinusodial waves

B. Fill in the blanks with the appropriate form of the words given.

1. **Generate**
   a. There is ..... agreement that engineering methods and technology offer significant potential for increasing the effectiveness and efficiency of health care.
   b. ....., the term transducer is defined as a device that converts one form of energy to another.
   c. It is possible to ..... the basic imaging sequences to three dimensions by using two-phase encoding gradients prior to the read period.
   d. The Moro reflex is a ..... startle response observed in neonates.
2. **Stimulate**
   a. Excitable cells can be ..... by a variety of stimuli depending on the type of cell.
   b. The history of pacing began with the work of Galvani in 1780, when he did experiments dealing with electrical ..... of living tissue.
3. **Function**
   a. The primary ..... of the lungs is to oxygenate blood and to eliminate carbon dioxide in a controlled manner.
   b. A neuron, or nerve cell, is the basic anatomical and ..... unit of the peripheral nervous system (PNS), as well as the central nervous system (CNS).
   c. Eye implants are used to restore the ..... of the cornea and lens when they are damaged or diseased.

d. Proliferative cells in organized tissues are important because of the phenomenon of cell loss (the loss of ..... competent cells).

4. Select

a. Spectrophotometry is based on the fact that substances of clinical interest ..... absorb or emit electromagnetic energy at different wavelengths.

b. It is believed at first that statistical methodology will solve most, if not all, the problems involved in the ..... of the most appropriate treatment for a disease, or even the problem of placing a disease in a particular diagnostic category.

5. Consider

a. Biomechanics ..... the applications of classical mechanics, including statics, dynamics, solid mechanics, and fluid mechanics to biological problems.

b. The shape of single motor unit (SMU) potentials is ..... modified by disease.

c. ..... interest has developed around the medical use of low-energy electric and magnetic fields to promote healing, particularly the healing of ununited bone fractures.

C. Fill in the blanks with the following words.

bradycardia	conduction	implanted	risk
speed up	cardiovascular	pacemakers	blood

The use of artificial cardiac ..... is well established in medical practice. More than 500,000 pacemakers have been ..... into patients in the USA alone, making this the most common of all ..... therapeutic procedures. The most common indication for a pacemaker is a very slow heart rate or ..... due to a failure of the natural pacemaker or a component of the ..... system. Patients who have bradycardia are at ..... for loss of consciousness as their hearts cannot ..... in response to stress and their brains do not receive adequate ..... flow.

D. Put the following sentences in the right order to form a paragraph. Write the corresponding letters in the boxes provided.

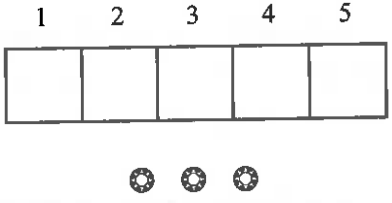
a. When the natural heart rate fell below the preset rate, the pacemaker would be instructed to send an electrical impulse to cause the heart to beat.

b. The next generation of pacemakers was developed to sense the heart's own rhythm and would suppress the artificial pacemaker's output to avoid this dangerous situation.

c. Thus, this more intelligent unit could 'sense' or detect the heart's activity and 'pace' as needed.

d. This 'demand' pacemaker had electronic circuits to detect the heart's own native rhythm through the electrodes.

e. If the heart were beating above a certain rate, typically 60 beats per minute, the pacemaker would not stimulate the heart.



Section Two: Further Reading

Power Source and Sensing Unit in Artificial Pacemakers

The power source provides the energy required for the operation of the circuitry of a pacemaker, which includes the control, sensing, and pulse-generating units. For implantable pacemakers, at present the power source is usually a chemical battery. Several other sources (such as a nuclear battery and a biological battery) have been developed, but their use in pacemakers is considered less practical. Modern pacemakers typically use batteries with

lithium as the anode element and iodine as the cathode. These form a battery that does not produce gas and can be hermetically sealed to protect the battery from body tissues. A main concern in using a battery is its longevity. Longevity of a battery can be determined knowing battery capacity and current drain. Battery capacity is usually defined in term of ampere-hours while current drain is in terms of microamperes. The current drain is dependent on the type of electrode as well as the circuitry and type of pulse generation of the pacemaker.

The sensing unit amplifies and filters the information received via the electrode and lead from activities inside the heart. To avoid attenuation of signals, op amps with a high input impedance amplify the signal. Bandpass filtering removes unwanted signals. A comparator determines whether the QRS is detected in order to reset a timing circuit. Modern pacemakers also include noise reversion circuits to change the pulse generator to an asynchronous pacing mode when the noise level surpasses the noise reversion threshold. This prevents inhibition of pacing in the presence of noise. The sensing circuits also include circuits for protection of the electronic circuitry of the pulse generator in the clinical situations where excessive voltage may be applied to the sensing circuit. Such a case would happen in the presence of defibrillation. The sensing element relays the processed information to the control unit where it is analyzed and decisions are made.

Asgarian, M.H. (pp. 106-107).

Comprehension Exercises

A. Put "T" for true and "F" for false statements. Justify your answers.

..... 1. The power source for implantable pacemakers is usually a nuclear battery.

..... 2. Iodine serves as the cathode element in batteries used for modern pacemakers.

..... 3. The most important point in using batteries in pacemakers is their longevity.

..... 4. Current drain is defined in terms of microamperes.

..... 5. The sensing element sends the processed information to the power source.

..... 6. Unwanted signals can be removed by bandpass filtering.

..... 7. A comparator is used in order to detect the QRS.

B. Write the answers to the following questions.

1. What does a pacemaker consist of?
2. How can longevity of a battery be determined?
3. What does the current drain depend on?
4. What does the sensing unit do?
5. What is the use of noise reversion circuits in modern pacemakers?
6. What does the control unit do?

Section Three: Translation Activities

A. Translate the following passage into Persian.

Control and Pulse-Generating Units in Artificial Pacemakers

The control unit is responsible for determining when to send a pulse for pacing, to change the mode, and to save data. The control unit for the most part is a timing device. The first control units were simple timers made of resistors and capacitors. Presently the timing circuit is made of a crystal oscillator, which generates accurate signals. Using the clock pulses, the control logic determines when to trigger the output pacing pulse, the blanking and the refractory intervals and the AV (atrial-ventricular) delay and to reset the escape intervals of an inhibited pacing system or trigger initiation of an AV delay for triggered pacing modes. The control also contains a rate-limiting circuit that sets an upper limit (runaway rate) for pacing in case of a failure. In many of today's pacemakers telemetry circuits are available to allow

programming the control functions and transfer of collected information (if any) for diagnosis purposes. In addition, a magnetic field detector is included to intentionally interrupt the normal functions of a pacemaker for test purposes.

The pulse-generating circuitry (referred to as the output circuit) is responsible for generating a voltage pulse to create an electric field of adequate intensity to stimulate the myocardium and create a wave of action potentials. The minimal energy to create such a waveform is called stimulation threshold. As the duration of a pulse is increased, the voltage magnitude required to exceed stimulation threshold decreases and as the duration of a pulse is decreased, the voltage magnitude needed to exceed that stimulation threshold increases. The pulse-generating unit charges up a capacitor and the capacitor is discharged when the control (timing) circuitry requires the delivery of a pulse. The unit uses pump-up capacitors to deliver pulses of larger magnitude than the potential of the batteries. The pump up capacitors are charged in parallel and discharged into the output capacitor in series.

B. Find the Persian equivalents of the following terms and expressions and write them in the spaces provided.

1. artificial .....
2. asynchronous .....
3. capacitor .....
4. excitation .....
5. intensity .....
6. myocardium .....
7. pacemaker .....
8. programmability .....
9. pulse generator .....
10. stimulation threshold .....
11. testability .....

Unit 13

Section One: Reading Comprehension

Electrosurgery

Electrosurgery (also known as surgical diathermy) is a technique which uses high-frequency currents to cut tissue and coagulate blood. While low-frequency currents can be hazardous depending on their magnitude, the stimulating effects of electric current progressively decrease at increasing frequencies above 1 kHz and are negligible at frequencies above 100 kHz. At frequencies between 100 kHz and 10 MHz, heating is the only significant effect produced in tissue. Tissue is almost purely resistive at these frequencies.

An electrosurgery unit (Figure 13-1) is thus essentially a high-frequency current generator. The patient is connected across the output of the generator, forming its load. One pole of the generator is connected to a fleshy part of the patient via a large surface-area electrode – the neutral or patient plate. The other pole is attached to a pointed or very small surface electrode – the active electrode. This is held in a pen-like holder by the surgeon and is used to apply current to the selected site of operation. The surgeon is able to switch the generator on and off, usually by means of a foot switch. The current passing can be controlled by a front-panel control on the instrument.

Current is thus applied to the tissue through a very small surface area, and is returned to the generator via the bulk of the body and a large surface-area neutral plate. All but a very small fraction of the power developed in the patient is dissipated at the site of application of the active electrode. The heat generated there is sufficient to cut tissue and coagulate blood.

The work of d'Arsonval on the frequency-dependent effects of current on the human body laid the foundation for the use of high-frequency current in medical treatment and in surgery. Early devices produced high-voltage, low-current waveforms and were used to treat warts and skin lesions. The development of lower-voltage, higher-current generators using vacuum tubes led to

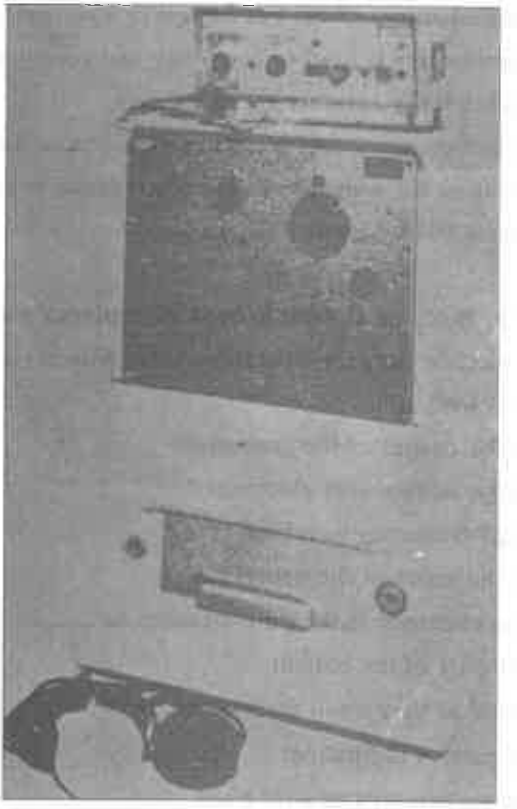


Figure 13-1. A Typical Valve/Spark-Gap Electrosurgery Unit and a Comparable Solid-State Unit (on Top).

instruments with good cutting properties. However, as these vacuum tubes were neither readily available nor cheap, the definitive development of electrosurgery and its commercialization were carried out by W. T. Bovie in the USA using spark-gap generators. Valve generators did not, however, disappear and these two types of generators, often combined into one instrument, formed the basis of all electrosurgery units until the 1970s when high-voltage power transistors became available. This led to the development of modern solid-state electrosurgery apparatus.

McCarthy, J. (pp. 319-320).

Part I. Comprehension Exercises

A. Put "T" for true and "F" for false statements. Justify your answers.

..... 1. High-frequency current has no use in electrosurgery.

..... 2. Electrosurgery is used to cut tissue and coagulate blood.

..... 3. Low-frequency currents are dangerous.

..... 4. An electrosurgery unit generates high-frequency currents.

..... 5. Heating is not a significant effect produced in tissue at frequencies between 100 kHz and 10 MHz.

B. Choose a, b, c, or d which best completes each item.

1. For an electric surgery operation, the patient is connected ....., forming its load.

a. across the output of the generator

b. to a large surface-area electrode

c. to a high-frequency waveform

d. across the input of the generator

2. The active electrode is the pole attached to ..... .

a. a fleshy part of the patient

b. a pointed or very small surface electrode

c. a bony part of the patient

d. a large surface-area neutral plate

3. ..... is used to control the current in an electrosurgery unit.

a. Foot switch b. Front switch

c. Foot panel d. Front panel

4. Current is applied to the tissue via ..... .

a. the bulk of the body b. a vacuum tube

c. a very small surface area d. a pair of electrodes

5. Instruments with good cutting properties are those with ..... .

a. high-voltage, low-current waveforms

b. low-voltage, high-current generators

c. high-voltage, high-current waveforms

d. low-voltage, low-current generators

C. Answer the following questions orally.

1. What is the use of electrosurgery?
2. How does an electrosurgery unit work?
3. What is(are) the advantage(s) of generators developed in the USA?
4. How can the surgeon switch the generator on and off?
5. How is current returned to the generator?

Part II. Language Practice

A. Choose a, b, c, or d which best completes each item.

1. The word **current** is best described as ..... .
   a. a certain physiologic electrical activity related to blood circulation
   b. a flow of electrons along a conductor in a closed circuit
   c. a flow of protons along a generator in a closed circuit
   d. the site of application of the active electrode
2. **Apparatus** refers to ..... .
   a. a device for a specific purpose b. a special type of surgery
   c. the use of electricity in surgery d. the use of output circuits
3. The word **hazardous** as used in the text means ..... .
   a. continuous b. comfortable
   c. dangerous d. available
4. **Electrosurgery** is a process of surgery performed ..... .
   a. with various electrical instruments
   b. with electronic devices
   c. without electrical instruments
   d. without optical devices
5. The word **stimulate** means ..... .
   a. to dissipate b. to amplify
   c. to strengthen d. to excite

B. Fill in the blanks with the appropriate form of the words given.

1. **Hazard**
   a. An electrically defective device becomes potentially ..... when its chassis is isolated from ground.

b. Even though the isolated power system can reduce the macroshock ....., it has little effect on microampere currents that flow in the system.

2. Essential

a. X-ray tubes are ..... vacuum tube diodes and all cathode ray tubes used in ECG monitors and consoles, computer systems, and CAT scanners are vacuum tubes.

b. Maintenance of adequate pressure is ..... for the function of vital organs and the prevention of vascular collapse.

3. Develop

a. Contraction is a unique ability of the muscle tissue, which is defined as the ..... of tension in the muscle.

b. The first imaging method ..... was the simple x-ray which is essentially a shadow image produced by illuminating the body with a point source of x-rays.

4. Resist

a. Teeth may by made more acid ..... by exposing them to the fluoride ion, preferably when they are in the precalcified, developing state.

b. Bone can ..... rapidly applied loads much better than slowly applied loads.

c. The red blood cells have a much higher electrical ..... than the blood plasma in which they are suspended.

d. The ratio of blood pressure to cardiac output is called the vascular ....., and is a useful parameter to describe the workload on the heart.

5. Progress

a. The future of the medical applications of diagnostic ultrasound is tied to the ..... of electrical and computer technology.

b. Special methods like double exposure are employed to measure the range of joint movements, e.g., the objective assessment of knee movement in ..... rheumatoid arthritis.

c. Mature cells develop from stem cells by a process of differentiation during which intermediate transit cells ..... lose their capacity for differentiation as their capacity for function increases.

d. The limited proliferation of transit cells acts as an amplifier of cell number as cells ..... toward functional maturity.

C. Fill in the blanks with the following words.

crest-factor	met	solid-state
solution	waves	transformer
cutting	peak	power

In the recent development of solid-state units, difficulties have been ..... in matching some aspects of the performance of the older valve/spark-gap instruments. Most ..... units are designed around a master oscillator running at 500 kHz which drives a ..... stage loaded by the primary coil of a step-up, high-frequency output ..... . The master oscillator produces reasonable quality sine ..... with little modulation, giving excellent, smooth results when used for ..... . The production of high ..... waveforms, effective for fulguration, is difficult. The typical ..... is to gate the master oscillator at, say, 10 μs on, 30 μs off, thus retaining a high ..... voltage but reducing total power.

D. Put the following sentences in the right order to form a paragraph. Write the corresponding letters in the boxes provided.

a. With the solid-state equipment, this is less easy since there is only the one master oscillator.

b. This retains a coagulating effect while increasing the cutting effect.

c. With the valve/spark-gap equipment the blended output is obtained by activating both high-frequency generators simultaneously and mixing the outputs from both at the output terminal.

d. The blended effect is usually achieved by gating the master oscillator with a different mark space ratio from that used for coagulation alone; typically 50 μs on, 50 μs off might be used.

1	2	3	4

High-Frequency Generators in Electrosurgery

All modern electrosurgery units use frequencies in the range 200 kHz to 10 MHz. This avoids both the low-frequency problems of unwanted stimulation and the problems of the increasingly nonohmic heating effects of very high-frequency current. Most units operate at frequencies around 1 MHz.

The precise effect of current depends on the power used, the shape of the active electrode and the output waveform. This last factor has been the subject of much empirical development over the years, although little quantitative work appears to have been done.

A fine-intensity arc from a pointed electrode produces a very rapid heating of tissue over a very small area. This causes microexplosive boiling of intracellular fluid, the energy developed being absorbed by the creation of steam. The tissue is thus cut without dissipation of heat in surrounding tissue. Sinusoidal current waveforms appear to have good cutting properties.

Coagulation of blood by heat to reduce the need for individual ligatures of many small blood vessels is a very long-established procedure. Two coagulation techniques using high-frequency current are employed and have come to be known as fulguration and desiccation. Fulguration is the destructive charring of tissue induced by sparking. Here, a fine high-intensity arc is undesirable, so flat spatula-shaped or ball electrodes are employed. In consequence high-peak voltages are necessary to establish an arc. These are of relatively low power to avoid microexplosive cutting of the tissue. The ratio of peak voltage to rms (root-mean square) voltage in a waveform is known as the crest factor. Waveforms with a high-crest factor produce good fulguration.

The other method of coagulation, desiccation, is the straightforward ohmic heating of tissue resulting from contact between the active electrode and tissue. Here, the active electrode is often a pair of forceps clamping a blood vessel through which high-frequency current is passed. In these cases,

while the power used must be adequate, the current waveform is not significant.

Many general-purpose electrosurgery units provide a blended or 'cutting with hemostasis' output which combines cutting properties with a fixed or variable amount of coagulating effect.

McCarthy, J. (p. 320).

Comprehension Exercises

A. Put "T" for True and "F" for false statements. Justify your answers.

..... 1. Most electrosurgery units act at frequencies around 1 MHz.

..... 2. Desiccation is one of the techniques of coagulation.

..... 3. Flat spatula-shaped or ball electrodes are used in desiccation.

..... 4. Sinusoidal current waveforms with a low-crest factor generate good desiccation.

..... 5. The low-frequency problems of unwanted stimulation are removed by using frequencies in the range 200 kHz to 10 MHz in electrosurgery units.

..... 6. High-frequency current is used in both coagulation techniques.

..... 7. A pair of forceps serves as the active electrode in fulguration.

B. Write the answers to the following questions.

1. What is the range of frequencies used in all modern electrosurgery units?
2. What does a fine-intensity arc from a pointed electrode generate?
3. What is fulguration?
4. What is the crest factor?
5. What is desiccation?
6. What is the use of a blended output in general-purpose electrosurgery units?

A. Translate the following passage into Persian.

Neutral Electrodes in Electrosurgery

The neutral electrode used in electrosurgery is known by a variety of other names: neutral plate, patient plate, electrosurgery grounding pad, and earth plate are common alternatives. It plays a vital role in ensuring patient safety whatever type of output circuit is chosen. Various materials and designs have been used for neutral electrodes. The most common in the early days was a soft lead plate which could be bent to follow the curve of the patient at the site of application. In order to increase contact with the patient, the plate was usually wrapped in a saline-soaked bandage. If this dried out during the course of a long operation, all contact between patient and plate was lost. In use with the older earthed or earth-referred equipment, this has been a significant cause of burns at alternative contact sites and at monitoring electrodes. Lead neutral plates have almost completely disappeared in current practice.

There are three main types of neutral plate in use today. The first type is a large surface area (say 600 cm^2) semirigid stainless-steel plate on which the patient is placed. Good contact is ensured by the patient's weight, though contact area is significantly less than the total plate area. The plate cannot be molded to match patient contour, so sites of application are limited.

The second type are semidisposable flexible foil electrodes of around 250 cm^2 area. These are usually made of aluminum foil, in some cases plastic backed, and are held in an appropriate neutral-plate holder. They are used dry and where possible the patient is laid on them so that contact is made with a fleshy part. However, they can be strapped to, say, the upper leg because of their malleability. Approximately ten sessions per plate is a reasonable maximum usage, but if a plate has become significantly kinked it should be replaced sooner. These 'dry plate' electrodes have proved most effective in use.

Disposable electrodes are the third type of neutral plate. These are

strictly for single use only and are usually smaller in area (~ 180 cm^2) than the foil type. Many are pregelled with a conductive electrode gel and all have some type of adhesive which allows them to be stuck to any suitable site on the patient. Their cost per patient is between 50 and 100 times that of the multiuse dry plates.

B. Find the Persian equivalents of the following terms and expressions and write them in the spaces provided.

1. coagulation .....
2. commercialization .....
3. desiccation .....
4. diathermy .....
5. fulguration .....
6. hemostasis .....
7. output .....
8. magnitude .....
9. negligible .....
10. resistive .....
11. semidisposable flexible foil .....
12. sinusoidal current waveforms .....
13. spark-gap equipment .....
14. vacuum .....

Unit 14

Section One: Reading Comprehension

Static Electricity in Hospitals

Insulators or insulated solid bodies can in certain circumstances acquire electric charge and develop a high electrostatic potential with respect to their surroundings. Sparks are generated when such charged bodies are brought into close proximity to surfaces at a different electric potential. The risk of ignition of flammable anesthetic vapors in hospital operating theaters by static sparks was once very real, but has now been virtually eliminated. However, the current, extensive use of synthetic fibers has caused a less serious problem of static electrification in the hospital ward, during bed-making in particular. Here, we discusses the main mechanism of static electrification and the methods which can be employed in hospitals to overcome problems that result from it.

When two dissimilar materials are brought in contact, electrons flow from one to the other, generating a small potential difference, about 1 V, between the two contacting surfaces. If the materials are then separated, work is performed in overcoming the force of attraction between the oppositely charged surfaces. The potential difference between the surfaces increases, and tends to drive charge back across the interface. If one material or both are insulators, charge recombination is incomplete, and although the amount of residual charge after separation is small, high potentials of several thousand volts are developed due to the very small initial clearance between the surfaces. This principal mechanism of static charging is termed contact electrification. A second and more complicated mechanism, frictional electrification, sometimes operates in conjunction with contact electrification involving factors such as material transfer and local generation of heat by rubbing.

The ability of a material to develop and retain static charge depends both on its chemical constitution and on environmental factors, e.g., relative

humidity. Lyophilic materials, such as cotton and paper, absorb water vapor from damp atmospheres (relative humidity> 50%) and remain uncharged because of their relatively low electrical resistivity under these conditions. The electrical resistivity of lyophobic or water-repellant materials, such as nylon or Terylene, is less influenced by atmospheric humidity and these materials can become charged in relatively damp atmospheres. At very low relative humidities lyophilic materials are as efficient generators of static electricity as the lyophobics. [Wool, rubber, silk, nylon, and plastics such as polythene, poly (vinyl chloride) and polypropylene are examples of electrostatic materials.]

Good electrical conductors, such as metals, become charged by induction when placed in close proximity to charged insulators and retain the charge if they are insulated from earth. A charged conductor releases its entire charge, by way of a potential equalizing spark, when closely approached by another conductor at earth potential, whereas a charged insulator (because of its poor electrical conductivity) transfers its charge only in the vicinity of the contact zone. Sparks generated when conductors discharge are therefore more energetic (and hence more dangerous) than those produced by insulators discharging under the same circumstances.

Mackinnon, D.J. (p. 801).

Part I. Comprehension Exercises

A. Put "T" for true and "F" for false statements. Justify your answers.

..... 1. Acquiring electric charge may develop a high electrostatic potential.

..... 2. The risk of ignition of flammable anesthetic vapors cannot be eliminated in hospitals.

..... 3. Charge recombination is not complete when one material or both is an insulator.

..... 4. Electrons cannot flow from one material to another.

..... 5. Contact electrification refers to the principal mechanism of static charging.

..... 6. Contact electrification is more complicated than frictional electrification.

B. Choose a, b, c, or d which best completes each item.

1. A charged conductor releases its ..... .
   a. entire charge
   b. energy and light
   c. potential
   d. spark
2. Extensive use of synthetic fibers has caused ..... .
   a. a real problem during bed-making in the hospital ward
   b. a less serious problem of static electrification in the hospital ward
   c. a high electrostatic potential with respect to the surroundings
   d. a single long spark in practical circumstances
3. A charged insulator has ..... .
   a. a poor electrical conductivity
   b. a poor electrical resistivity
   c. a high electrostatic potential
   d. a high potential difference
4. Chemical constitution and environmental factors are leading factors in ..... .
   a. attracting and combining electrostatic potential
   b. regulating and equalizing static charge
   c. developing and retaining static charge
   d. absorbing and retaining water vapor from damp atmosphere
5. Lyophilics are efficient generators of static electricity at ..... .
   a. very low relative humidities
   b. high relative humidities
   c. sufficient relative humidities
   d. very low relative dryness

C. Answer the following questions orally.

1. What may happen if two dissimilar materials are brought together?
2. What is static electricity?
3. How is static electricity produced?
4. How does a charged conductor release its charge?
5. What is the difference between a charged conductor and a charged insulator?

Part II. Language Practice

A. Choose a, b, c, or d which best completes each item.

1. An **insulator** is ..... .
   a. an electrical charge
   b. a conducting substance
   c. an electrostatic material
   d. a nonconducting substance

2. The word **conductor** refers to any substance through which ..... .
   a. electrons flow easily
   b. oxygen is transferred
   c. flammable concentrations might occur
   d. potential equalizing sparks can pass
3. The word **static** means ..... .
   a. active
   b. dynamic
   c. motionless
   d. moving
4. **Lyophilic** materials are ..... .
   a. stabilizing colloids
   b. random activations
   c. flammable agents
   d. anesthetic agents
5. The word **interface** is best described as ..... .
   a. the combination of different elements
   b. the connection between different elements
   c. the order of elements in connection
   d. the connection of elements in a specific order

B. Fill in the blanks with the appropriate form of the words given.

1. **Environment**
   a. The clinical engineer in the hospital works in an ..... that is very different from the industrial sector in terms of the workplace.
   b. In some facilities, special electrically shielded rooms minimize ..... electrical noise, particularly 60-Hz alternating current (AC) line noise.
2. **Perform**
   a. The ..... characteristics of a medical instrumentation system are both static and dynamic in nature.
   b. The characteristics of a medical transducer to ..... a specific detection and conversion process are determined during a calibration cycle.
   c. ECG monitoring is routinely ..... in many departments of a modern hospital.

3. Clear

a. It is frequently desirable to measure the function of the two kidneys separately, but ..... techniques based on peripheral venous blood sampling do not allow this.

b. The first ..... human electrocardiogram (ECG) was made with a string galvanometer by Einthoven in 1903.

c. ..... is a concept used frequently in the measurement of renal function.

4. Operate

a. Photochemical injury depends on the total energy absorbed before natural repair mechanisms become ..... .

b. Heart-sound microphones ..... on the basis of either the piezoelectric effect or Faraday's principle.

c. Patients in hospital, particulary after a surgerical ....., are relatively immobile and blood clotting causes thrombosis in the veins of the legs.

d. ..... amplifier circuits may be used to measure the current in a thermistor as a function of temperature.

5. Move

a. The rate at which an action potential ..... down a fiber or is propagated from cell to cell is called the propagation rate.

b. Agonists are muscles responsible for the primary desired ..... .

C. Fill in the blanks with the following words.

electrostatic	antistatic	maintenance
castors	conductivity	sparking

More generally, the following measures are taken to prevent static ..... in the theater:

- Prohibition, when practicable, of the use of ..... materials. Cotton clothing and bedding are employed; operating tables are fitted with ..... rubber mattresses.
- The ..... of all objects and personnel at the same electrical potential

by providing flooring, foot-wear, and ..... for mobile equipment, with limited but carefully controlled electrical ..... .

D. Put the following sentences in the right order to form a paragraph. Write the corresponding letters in the boxes provided.

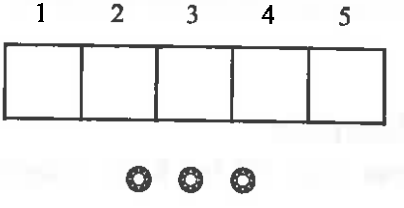
a. The only practical solution to this problem is either not to use electrostatic bedding materials or to install flooring which has a higher electrical conductivity than vinyl.

b. Charge, induced on the metal-bed frame when dissimilar electrostatic materials are separated rapidly from the mattress, is retained for some time if the electrical conductivity of the floor is low.

c. The almost universal use of man-made fibers for bedding materials in hospital wards, where the relative humidity is often low, has led to nursing staff receiving unpleasant static shocks when making beds.

d. Potential equalizing sparks then pass between bed frame and any staff in close proximity.

e. The problem is exacerbated in new or upgraded wards which have highly insulated vinyl rather than wooden floors.



Section Two: Further Reading

Explosions in the Operating Theater

Between 1947 and 1954, thirty-six explosions during anesthesia were reported to the Ministry of Health in the UK. Static sparks were the source of ignition in a substantial number of these incidents.

In order to ignite a flammable gas mixture by static spark the following conditions must be fulfilled:

a) The gas concentration must lie between certain limits. Cyclopropane, a common anesthetizing agent, ignites in air at concentrations of 2-10% by volume but the upper limit extends to 63% in mixtures with oxygen. The most violent explosions occur with stoichiometric mixtures in which the amount of available oxygen is just sufficient for complete combustion (4.5 vol.% cyclopropane for cyclopropane-air mixtures).

b) The ignition energy must exceed a critical value. Minimum ignition energies for mixtures of cyclopropane with air or with oxygen are 0.2 mJ and 0.001 mJ, respectively, but because of the inefficiency of the sparking process, stored energies at least ten times greater than these minima are required for ignition in practical circumstances.

c) A spark of adequate length is required. A single long spark is more effective than multiple small sparks with the same total energy.

Abolition of flammable agents in the operating theater is the one certain method of preventing explosions. The advent of a nonflammable anesthetic agent, halothane, in 1956 was responsible, in part, for the now very low incidence of explosions in the UK. However a total ban on the use of flammable anesthetics is not practicable and, in any case, other flammable agents (e.g., skin cleansing preparations) are also in use.

Mackinnon, D.J. (p. 801).

Comprehension Exercises

A. Put "T" for true and "F" for false statements. Justify your answers.

..... 1. Halothane is a common anesthetizing agent.

..... 2. Stoichiometric mixtures cause the most violent explosions in the operating theater.

..... 3. Multiple small sparks are more effective than a single long spark with the same total energy.

..... 4. It is impracticable to ban totally the use of flammable anesthetics in the operating theater.

..... 5. Halothane ignites in oxygen at concentrations of 2-10% by volume.

B. Write the answers to the following questions.

1. What is the minimum ignition energy for mixture of cyclopropane with oxygen?
2. What are the three conditions for igniting a flammable gas mixture by static spark?
3. What was the source ofignition in most of explosions during anesthesia?
4. What is a certain way of preventing explosions in the operating theater?
5. What is cyclopropane?

Section Three: Translation Activities

A. Translate the following passage into Persian.

Antistatic Precautions in the Theater

Prevention of fire and explosion is achieved by ensuring that anesthetic-oxidant mixturcs of flammable proportions are not in proximity with any source of ignition. A region called the zone of risk, in which flammable concentrations might occur, has been defined by Vickers (1970) to extend for 0.25 m around any part of the anesthetic machine including the patient's breathing circuit and the respiratory tract. Within this zone the risk of explosion is very real and the most stringent measures must be taken to exclude all sources of ignition including static sparks. These measures are detailed in IEC 601-1 (International Electrotechnical Commission 1977), which has been adopted as a national standard in several countries.

B. Find the Persian equivalents of the following terms and expressions and write them in the spaces provided.

1. anesthetic agent .....

2. chemical constitution .....
3. discharge .....
4. electric charge .....
5. electrification .....
6. equalizing .....
7. flammable .....
8. insulator .....
9. proximity .....
10. respiratory tract .....
11. stoichiometric mixtures .....
12. water-repellant .....

Unit 15

Section One: Reading Comprehension

Biomaterials

In the treatment of disease or injury it has been found that a variety of nonliving materials are of use. Commonplace examples include sutures and tooth fillings. A *biomaterial* is a synthetic material used to replace part of a living system or to function in intimate contact with living tissue. The Clemson University Advisory Board for Biomaterials has formally defined a biomaterial to be "a systemically and pharmacologically inert substance designed for implantation within or incorporation with living systems." By contrast, a *biological material* is a material such as bone matrix or tooth enamel, produced by a biological system. Artificial materials that simply are in contact with the skin, such as hearing aids and wearable artificial limbs are not biomaterials since the skin acts as a barrier with the external world. The uses of biomaterials, as indicated in Table 15-1, include replacement of a body part that has lost function due to disease or trauma, to assist in healing, to improve function, and to correct abnormalities. The role of biomaterials has been influenced considerably by advances in many areas of medicine. For example, with the advent of antibiotics, infectious disease is less of a threat than in former times, so that degenerative disease assumes a greater importance.

Table 15-1. Uses of Biomaterials.

Problem Area	Examples
Replacement of diseased or damaged part	Artificial hip joint, kidney dialysis machine
Assist in healing	Sutures, bone plates and screws
Improve function	Cardiac pacemaker, contact lens
Correct functional abnormality	Harrington spinal rod
Correct cosmetic problem	Augmentation mammoplasty, chin augmentation
Aid to diagnosis	Probes and catheters
Aid to treatment	Catheters, drains

Moreover, advances in surgical technique have permitted materials to be used in ways that were not possible previously.

The performance of materials in the body can be viewed from several conceptual perspectives. First, we may consider biomaterials from the point of view of the problem area that is to be solved, as in Table 15-1. Second, we may consider the body on a tissue level, an organ level (Table 15-2), or a

Table 15-2. Biomaterials in Organs.

Organ	Examples
Heart	Cardiac pacemaker, artificial heart valve
Lung	Oxygenator machine
Eye	Contact lens, eye lens replacement
Ear	Artificial stapes, cosmetic reconstruction of outer ear
Bone	Bone plate
Kidney	Kidney dialysis machine
Bladder	Catheter

system level (Table 15-3). Third, we may consider the classification of materials as metals, polymers, ceramics, and composites as is done in Table 15-4. In that vein, the role of such materials as biomaterials is governed by the interaction between the material and the body, specifically, the effect of the body environment on the material, and the effect of the material on the body.

Table 15-3. Biomaterials in Body Systems.

System	Examples
Skeletal	Bone plate, total joint replacements
Muscular	Sutures
Digestive	Sutures
Circulatory	Artificial heart valves, blood vessels
Respiratory	Oxygenator machine
Integumentary	Sutures, burn dressings, artificial skin
Urinary	Catheters, kidney dialysis machine
Nervous	Hydrocephalus drain, cardiac pacemaker
Endocrine	Microencapsulated pancreatic islet cells
Reproductive	Augmentation mammoplasty, other cosmetic replacements

Table 15-4. Materials for Use in the Body.

Materials	Advantages	Disadvantages	Examples
Polymers			
Nylon	Resilient	Not strong	Sutures, blood
Silicones	Easy to fabricate	Deform with time	vessels, hip socket,
Teflon		May degrade	ear, nose, other
Dacron			soft tissues
Metals			
Titanium	Strong, tough	May corrode	Joint replacement,
Stainless steels	Ductile	Dense	bone plates and
Co-Cr alloys			screws, dental
Gold			root implants
Ceramics			
Aluminum oxide	Very biocompatible,	Brittle	Dental; hip socket
Carbon	inert	Difficult to make	
Hydroxyapatite	Strong in	Not resilient	
	compression		
Composites			
Carbon-carbon	Strong, tailor-made	Difficult to make	Joint implants;
			heart valves

It should be evident in any of these perspectives that most current applications of biomaterials involve structural functions even in those organs and systems that are not primarily structural in their nature, or very simple chemical or electrical functions. Complex chemical functions such as those of the liver, and complex electrical or electrochemical functions such as those of the brain and sense organs, cannot be carried out by biomaterials.

Park, J.B. & Lakes, R.C. (pp. 1-3).

Part I. Comprehension Exercises

A. Put "T" for true and "F" for false statements. Justify your answers.

..... 1. Nonliving materials are of medical value.

..... 2. A material produced by a biological system is called biomaterial.

..... 3. Hearing aids and wearable artificial limbs are biomaterials.

..... 4. Replacement of a nonfunctioning body organ is a biological function.

..... 5. Infectious diseases are not fatal anymore.

..... 6. Developments in the field of surgery have facilitated the use of implantation of biomaterials.

B. Choose a, b, c, or d which best completes each item.

1. The interaction between the body and the material is governed by ..... .

a. biological materials
b. biomaterials
c. artificial materials
d. synthetic materials

2. Most of the applications of biomaterials are ..... .

a. structural
b. functional
c. biological
d. chemical

3. Certain complicated ..... functions cannot be carried out by biomaterials.

a. physical
b. electrical
c. mechanical
d. chemical

4. Materials for use in the body are generally classified as ..... .

a. catheters, drains, valves, and probes
b. composites, pacemakers, screws, and sutures
c. ceramics, composites, metals, and polymers
d. ceramics, plastics, silicones, and nylons

5. There is ..... between biomaterials and biological materials.

a. no difference
b. an exact similarity
c. a major difference
d. a trivial difference

C. Answer the following questions orally.

1. What is a biomaterial?
2. What is a biological material?
3. What are the conceptual perspectives of biomaterials?
4. What are the functions that cannot be substituted with biomaterials?
5. What are biomaterials used for?

Part II. Language Practice

A. Choose a, b, c, or d which best completes each item.

1. The word **trauma** as used in the text means ..... .
   a. a physical disorder
   b. a physical injury
   c. a psychological disorder
   d. a psychic injury
2. The word **tissue** refers to a collection of similar cells ..... .
   a. performing a particular action
   b. classifying the biomaterials
   c. replacing a synthetic material
   d. controlling a biological material
3. **Enamel** is a hard white substance that ..... .
   a. activates the muscles
   b. flows throughout the body
   c. covers the dentin of the crown
   d. stimulates the internal parts of the body
4. **Degenerative** means ..... .
   a. changing to a dysfunctional form
   b. changing the function of an organ
   c. weakening the function of a muscle
   d. strengthening the function of a muscle
5. The word **infectious** has nearly the same meaning as ..... .
   a. psychological
   b. congenital
   c. physiological
   d. contagious

B. Fill in the blanks with the appropriate form of the words given.

1. **Classify**
   a. In general, materials are ..... as either solid or fluid.
   b. To extract either a diagnostic ..... or provide information on the clinical or physiological state of the patient from an image, a severe reduction in the amount of date in the image is required.
2. **Replace**
   a. The heart valves could be ..... with artificial devices.

b. The second area of research in the area of cardiac ..... was the development of the artificial heart.

3. Treat

a. The respiratory intensive care unit (RICU) is a special-care nursing unit used to ..... patients suffering from acute respiratory insufficiency.

b. Arterial blood gas measurements are important in the ..... of respiratory disease, particularly for ventilator patients.

c. Chronic obstruction in the respiratory airways is commonly ..... with drugs administered by inhalation.

4. Influence

a. Particles which are electrically charged with respect to a suspending medium will move under the ..... of an electric field.

b. All parts of the body are ..... by mechanical stress gradients brought about by linear accelerations, and by variations thereof.

5. Record

a. Richard Caton first discovered the spontaneous electrical activity ..... from the surface of the brain of animals in 1875.

b. Hans Berger discovered that the spontaneous electrical activity of the human brain could be ....., at a much lower voltage level, from electrodes placed on the surface of the scalp.

c. Even though the phonocardiogram is a graphic ..... like the electrocardiogram, it extends to a much higher frequency range.

C. Fill in the blanks with the following words.

aneurysms	arteries	autografting	stagnant
fabricated	vascular	collapse	anastomosis

Implants have been used in various circumstances to treat ..... maladies. Examples include simple sutures for ..... after removal of vessel segments, vessel patches for ....., as well as total replacements for large arteries. Vein implants have encountered some difficulties because of the ..... of an adjacent vein or clot formation, which in turn is due to low blood pressure and ..... blood flow in veins as compared to ..... Vein

replacements have not been a major concern since ..... can be performed for the majority of cases. Nonetheless, many materials including nylon, PTFE, polyester, etc. were ..... for clinical applications.

D. Put the following sentences in the right order to form a paragraph. Write the corresponding letters in the boxes provided.

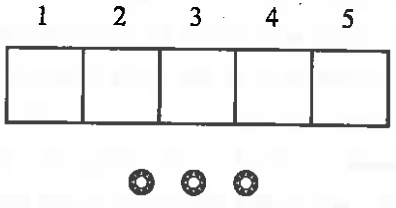
a. The new tissues interface well with blood, and thus minimize clotting.

b. Early designs for artierial replacements were solid wall tubes made of glass, aluminum, gold, silver, and PMMA.

c. Ironically, for this type of application thrombogenic materials were found to be more satisfactory.

d. In the early 1950s, porous implants made of fabrics were introduced, which allowed tissue growth into the interstices.

e. All of the implants developed clots and became useless.



Section Two: Further Reading

Historical Background and Performance of Biomaterials

The use of biomaterials did not become practical until the advent of aseptic surgical technique as developed by Lister in the 1860s. Earlier surgical procedures, whether they involved biomaterials or not, were generally unsuccessful as a result of infection. Problems of infection tend to be exacerbated in the presence of biomaterials, since the implant can provide a region inaccessible to the body's immunologically competent cells. The

earliest successful implants, as well as a large fraction of modern ones, were in the skeletal system. Bone plates were introduced in the early 1900s to aid in the fixation of fractures. Many of these early plates broke as a result of unsophisticated mechanical design: they were too thin and had stress-concentrating corners. It was also discovered that materials such as vanadium steel, which were chosen for good mechanical properties, corroded rapidly in the body. Better designs and materials soon followed. Following the introduction of stainless steels and cobalt chromium alloys in the 1930s, greater success was achieved in fracture fixation, and the first joint replacement surgeries were performed. As for polymers, it was found that warplane pilots in World War II who were injured by fragments of plastic [polymethyl methacrylate (PMMA)] aircraft canopy did not suffer adverse chronic reactions from the presence of the fragments in the body. PMMA became widely used after that time for corneal replacement and for replacements of sections of damaged skull bones. Following further advances in materials and in surgical technique, blood vessel replacements were tried in the 1950s; and heart valve replacements and cemented joint replacements in the 1960s. Recent years have seen many further advances.

The success of a biomaterial in the body depends on factors such as the material properties, design, and *biocompatibility* of the material used, as well as other factors not under control of the engineer, including the technique used by the surgeon, the health and condition of the patient, and the activities of the patient. If we can assign a numerical value f to the probability of failure of an implant, then the *reliability* can be expressed as

$$r = 1-f$$

If, as is usually the case, there are multiple modes of failure, the total reliability r_t is given by the product of the individual reliabilities $r_1=(1-f_1)$, etc.:

$$r_t=r_1r_2 \ldots r_n$$

Consequently, even if one failure mode such as implant fracture is perfectly controlled so that the corresponding reliability is unity, other failure modes such as infection could severely limit the utility represented by the total reliability of the implant.

One mode of failure that can occur in a biomaterial but not in engineering materials is an attack by the body's immune system on the implant. Another such failure mode is an unwanted effect of the implant upon the body – e.g., toxicity, inducing an inflammation, or causing cancer. Consequently, biocompatibility is included as a material requirement in addition to those requirements associated directly with the function of the implant. *Biocompatibility* involves the acceptance of an artificial implant by the surrounding tissues and by the body as a whole. Biocompatible materials do not irritate the surrounding structures, do not provoke an inflammatory response, do not incite allergic reactions, and do not cause cancer. Other characteristics that may be important in the function of an implant device made of biomaterials include adequate mechanical properties such as strength, stiffness, and fatigue properties; appropriate optical properties if the material is to be used in the eye, skin, or tooth; appropriate density; manufacturability; and appropriate engineering design.

The failure modes may differ in importance as time passes following the implant surgery. For example, consider the case of a total joint replacement in which infection is most likely soon after surgery, while loosening and implant fracture become progressively more important as time goes on, as shown in Figure 15-1. Failure modes also depend on the type of implant and its location and function in the body. For example, an artificial blood vessel is

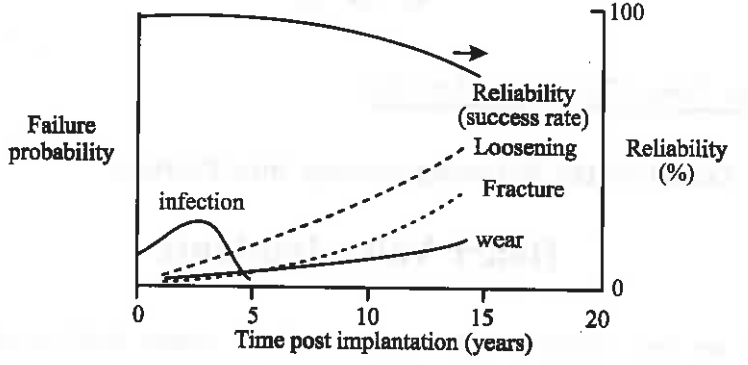


Figure 15-1. Schematic Diagram of Role of Various Failure Modes as They Depend on Time for a Joint Replacement Prosthesis. Not to scale. Failure modes of small probability, such as surgical error allergic reaction to metal, not shown.

more likely to cause problems by inducing a clot or becoming clogged with thrombus than by breaking or tearing mechanically.

Park, J.B. & Lakes, R.C. (pp. 3-4).

Comprehension Exercises

A. Put "T" for true and "F" for false statements. Justify your answers.

..... 1. Earlier surgical procedures were not successful because of infection.

..... 2. Stainless steels corroded rapidly in the body.

..... 3. Biocompatible materials do not cause cancer.

..... 4. Lister presented the total reliability of the implant in the 1860s.

..... 5. Toxicity is an example of an unwanted effect of the implant upon the body.

B. Write the answers to the following questions.

1. What were the characteristics of earlier bone plates?
2. What does the success of a biomaterial in the body depend on?
3. What are the characteristics that are important in the function of an implant device made of biomaterials?
4. What do failure modes depend on?
5. What does biocompatibility involve?

Section Three: Translation Activities

A. Translate the following passage into Persian.

Heart Valve Implants

There are four valves in the ventricles of the human heart as shown in Figure 15-2. In the majority of cases, the left ventricular valves (mitral and aortic) become incompetent more frequently than the right ventricular valves as the result of higher left ventricular pressure. Most important and frequently

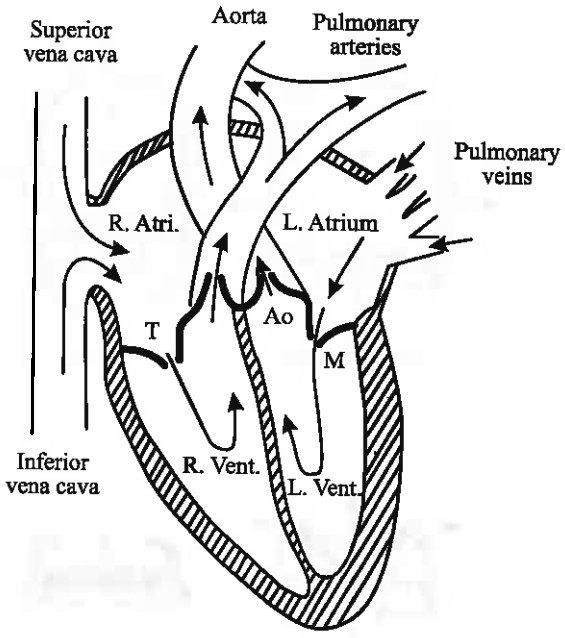


Figure 15-2. Circulation of Blood in the Heart.

critical is the aortic valve since it is the last gate the blood has to go through before being circulated in the body.

There have been many different types of valve implants. The early ones in the 1960s were made of flexible leaflets that mimicked the natural valves. Invariably the leaflets could not withstand fatigue for more than 3 years. In addition to hemolysis, regurgitation and incompetence were major problems. Later, butterfly leaflets and ball- or disk-in-the-cage were introduced. Some of them are shown in Figure 15-3. The material requirements for valve implants are the same as for vascular implants. Some additional requirements are related to the blood flow and pressure, i.e., the formed elements of blood should not be damaged and the blood pressure should not drop below a clinically significant value. Also, valve noise should be minimal, for psychological reasons.

Figure 15-4 shows a tissue valve made from collagen-rich material such as pericardial tissues. Basically the pericardium is made up of three layers of collagen fibers oriented 60° from each layer and about 0.5 mm thick in the

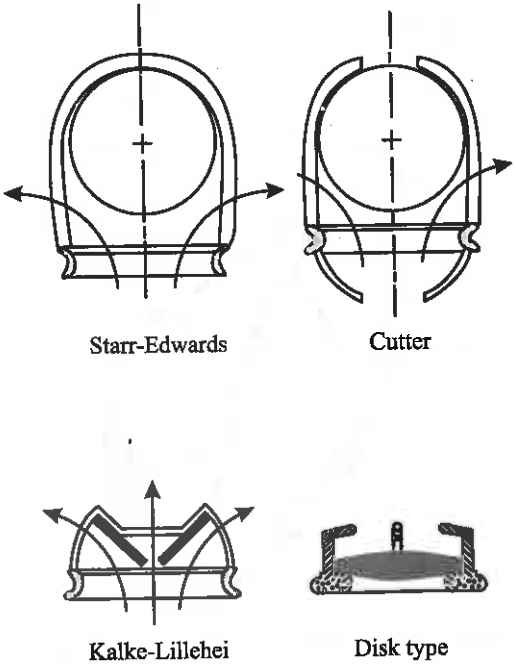


Figure 15-3. Schematic Diagram of Various Types of Heart Valves.

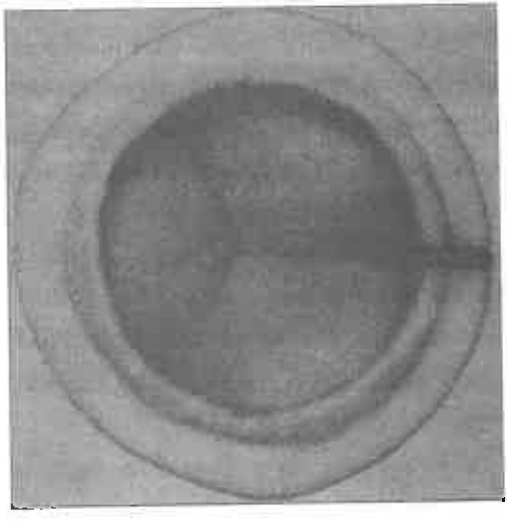


Figure 15-4. Lonescu-Shiley Pericardial Xenograft Heart Valve.

case of bovine pericardium. It can be cross-linked by formaldehyde. During this treatment, the cell viability is destroyed and the proteins are denatured. Therefore, the implant does not provoke immunological reactions. Also, porcine xenograft valves have been used. They are treated with a chemical process that denatures the proteins and kills any living cells.

B. Find the Persian equivalents of the following terms and expressions and write them in the spaces provided.

1. corneal .....
2. hemolysis .....
3. immunological reactions .....
4. infectious disease .....
5. leaflets .....
6. pericardial tissues .....
7. porcine xenograft valves .....
8. regurgitation .....
9. sutures .....
10. synthetic .....
11. vascular implants .....
12. ventricles .....

Unit 16

Section One: Reading Comprehension

Endoscopes

Endoscopes, which may be rigid or flexible, are devices which facilitate the examination of body cavities inaccessible to the human eye. They require a means of illumination and an image transmission system (Figure 16-1). Modern versions incorporate almost universally a bundle of glass fibers to conduct the illumination from an external light source to the tip of the instrument. Most rigid instruments utilize a train of lenses as an image

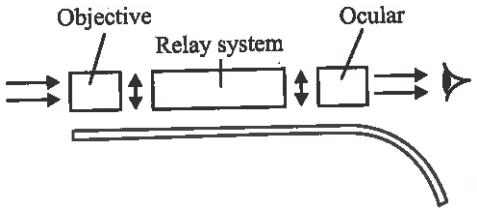


Figure 16-1. Schematic Diagram of an Endoscope.

transmission system but the fully flexible fiberoptic endoscope uses a specialized image-transmission glass-fiber bundle.

The illumination fiber bundle of a modern endoscope consists of 10-100,000 individual glass fibers, each of diameter 30-70 μm. Each fiber comprises a glass core surrounded by a thin outer coating of a glass of a lower refractive index, which insulates the core from the effects of surface contamination, defects, and contact with adjacent fibers.

The fiber transmits light by multiple total internal reflection at the interface between the core and the cladding (Figure 16-2). Total internal reflection occurs, when the angle of incidence exceeds the 'critical angle'. This results in a limited cone of acceptance with a semiangle α given by sin $\alpha=(n^2-n_1^2)^{1/2}$, where n and n_1 are the refractive indices of the core and cladding, respectively. Although each reflection is total, transmission losses

occur due to absorption by the glass and amount to approximately 30% per meter.

Glass fibers are extremely flexible by virtue of their fine diameters. The maximum bending which can be tolerated by the fiber without fracture is given by $R_F=Ed/2\sigma$, where R_F is the minimum radius of curvature, E is the modulus of elasticity, σ the ultimate failure stress, and d is the diameter of the fiber. Since glass is a brittle material, σ is critically dependent on the presence of small cracks on the surface. For bulk glass, $E/2\sigma$ is typically 1000-1500 but the relative absence of surface flaws in drawn fiber gives values in the region of 10-30, so that a single fiber of 30 μm diameter may be bent to a minimum bend radius of < 1 mm.

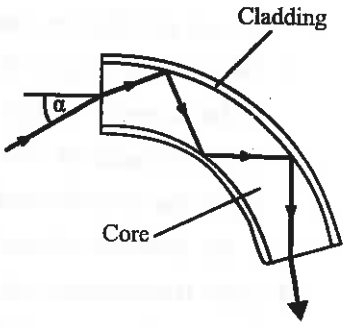


Figure 16-2. Multiple Total Internal Reflection in a Coated Fiber.

Hanwell, A.E. & Richards, J.G. (pp. 323-324).

Part I. Comprehension Exercises

A. Put "T" for true and "F" for false statements. Justify your answers.

..... 1. Endoscopes are either rigid or flexible.

..... 2. Radiotherapy is a technique used to examine the invisible cavities of the body.

..... 3. A train of lenses are used in rigid endoscopes.

..... 4. Specialized image-transmission glass-fiber bundles are used in rigid fiberoptic endoscopes.

..... 5. No flexibility can be observed in glass fibers.

..... 6. In $\sin \alpha=(n^2-n_1^2)^{1/2}$, n shows the refractive index of the core.

B. Choose a, b, c, or d which best completes each item.

1. The instruments used to examine body cavities are called .....

a. microscopes
b. endoscopes
c. radiotelescopes
d. stethoscopes

2. To conduct the illumination from an external light source to the tip of the endoscope, ... are required.

a. a bundle of glass fibers
b. a set of electric impulses
c. a set of coherent bundles
d. a bundle of coated fibers

3. The ultimate failure stress (σ) depends on .....

a. the presence of light spots on the lens
b. the diameter of fiber bundles on the surface
c. the size of individual fibers on the lens
d. the presence of small cracks on the surface

4. Light transmission takes place by multiple total ..... at the interface between the core and the cladding.

a. internal reflection
b. external reflection
c. individual coating
d. refractive index

5. Transmission losses are due to ..... by the glass.

a. fabrication
b. limitation
c. reflection
d. absorption

6. In $R_F = Ed/2\sigma$, the modulus of elasticity is shown by .....

a. σ
b. E
c. d
d. R_F

C. Answer the following questions orally.

1. What is the use of an endoscope?
2. When does total internal reflection occur?
3. How is an endoscope made?
4. What is the benefit of fiber glasses?
5. What does the illumination fiber bundle of a modern endoscope consist of?

Part II. Language Practice

A. Choose a, b, c, or d which best completes each item.

1. The word **illumination** means ..... .

a. darkening
b. lighting up
c. generating
d. constructing

2. The word **core** refers to ..... .

a. the outer layer
b. the central angle
c. the critical angle
d. the central part

3. **Brittle** refers to substances which are ..... .

a. soft and easily shaped
b. hard but easily broken
c. hard and not easily broken
d. stiff and shaped

4. The word **contamination** as used in the text means ..... .

a. impurity
b. purity
c. elasticity
d. flexibility

5. The word **cavity** refers to ..... .

a. a small area in a rigid structure
b. a thin layer in a flexible organism
c. a hollow space within a larger structure
d. a hollow tube in a larger unit

6. The word **fracture** is best described as ..... .

a. rupture
b. response
c. strain
d. string

B. Fill in the blanks with the appropriate form of the words given.

1. Utilize

a. The principles of dynamics are ..... for motion description and have many applications in sports mechanics.

b. Since a large portion of what is called 'medical electronic devices' comprises in essence different forms of instrumentation systems designed for medical use, some common aspects of instrumentation will be taken up in light of their ..... in the medical field.

c. Muscles make their own immediately ..... fuel, adenosine triphosphate (ATP).

2. Require

a. The applications of biomechanics ..... certain knowledge of mathematics.

b. A passive transducer ..... energy to be put into it for the transducer to produce the ..... transduction.

c. Physical ..... for intracardiac electrodes are electrochemical inertness, resistance to flexation fatigue, and low electrical resistance.

3. Transmit

a. Ultrasound is ..... through a medium by means of particle vibration.

b. Ultrasonic microscopy is a technique in which biological specimens are ..... scanned by high-frequency (500 MHz) sound waves.

c. There are a number of geometric factors that modify the power ..... between the source and the detector.

4. Ultimate

a. The biophysics of brain, like its physiology and biochemistry, although immensely vigorous and exciting, confronts problems which may be ..... insuperable.

b. Bone fractures when the stresses generated in any region of bone are larger than the ..... strength of bone.

5. Facilitate

a. There has been great expansion in the methods available for measurement of cardiac output. Depending on ....., any method may be appropriate.

b. The ability to direct a controlled light intensity to the back of a tooth with fiber-optic devices has ..... the emergence of tooth transillumination examinations.

C. Fill in the blanks with the following words.

radiologic	visualization	sterile	abdominal
aspiration	esophagus	lavaged	enema
diagnosis	abnormalities		

Endoscopy is the ..... of the interior of organs and cavities of the body with an endoscope. The procedure is indicated for the ..... of gastric ulcers with atypical ..... features, to locate the source of upper GI (gastrointestinal) bleeding, to establish the presence and extent of varices in the lower ..... and stomach in patient with liver disease, and to detect ..... of the lower colon. For examination of the upper GI tract, the stomach of the

patient is ..... with ice water through a large-bore gastric tube, with the patient placed on the side to reduce the chance of ..... . For examination of the lower colon, fecal material is removed by ....., laxative, or suppository. The patient is placed in the knee-chest position for the procedure and afterward is observed by the nurse for ..... pain or rectal bleeding. Aseptic rather than ..... techniques are routinely followed.

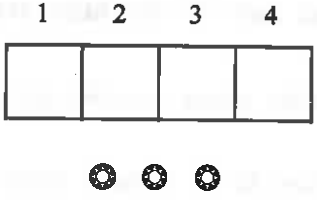
D. Put the following sentences in the right order to form a paragraph. Write the corresponding letters in the boxes provided.

a. Although the endoscope is generally introduced through a natural opening of the body, it may also be inserted through an incision.

b. Instruments are available in varying length, and the fiberoptic endoscope has great flexibility, reaching previously inaccessible areas.

c. Other instruments for viewing specific areas of the body include the bronchoscope, cystoscope, gastroscope, etc.

d. Endoscope is an illuminated optic instrument for the visualization of the interior of a body cavity or organ.



Section Two: Further Reading

Flexible Endoscopes

The modern fully flexible endoscope incorporates two types of fiber bundle. Illumination is provided from an external light source via a boundle of randomly assembled fibers (incoherent bundle), whereas a second type of fiber bundle (coherent bundle) is used to transmit the image formed by the objective lens to the eyepiece (Figure 16-3). In a coherent bundle the

individual fibers are carefully ordered, each having the same relative position on the front face of the bundle as on the back face. It is this ordering of the fibers which allows the image to be transmitted, since individual fibers only carry an average of the incident light and do not transmit image information. The outer cladding of the fibers and the spaces in between them do not transmit light, so the image is composed of spots of light, each the diameter of the inner core of the fibers. The image quality depends on the size of the fibers and the accuracy with which they are ordered.

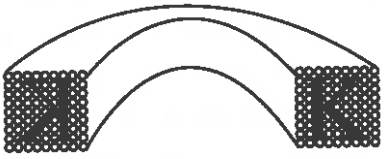


Figure 16-3. A Coherent Fiber Bundle.

The calculation of the resolution of a fiber-optic system is complex; the size of the smallest resolvable object is dependent upon the working distance. Modern endoscopes when working at their shortest range will usually resolve finer detail than that resolvable by the naked eye.

Hanwell, A.E. & Richards, J.G. (p. 324).

Comprehension Exercises

A. Put "T" for true and "F" for false statements. Justify your answers.

..... 1. An external light source provides illumination via an incoherent bundle.

..... 2. Incoherent fibers do not transmit image information.

..... 3. The individual fibers have the same relative position on the back face of the bundle as the front face.

..... 4. The ordering of the individual fibers allows the image to be assembled.

..... 5. Each spot of light has the same diameter as the inner core of the fibers.

B. Write the answers to the following questions.

1. What is a coherent bundle used for?
2. What does the image quality depend on?

3. Why is the image composed of light spots?
4. What do the individual fibers carry?
5. What does the size of the smallest resolvable object depend on?

Section Three: Translation Activities

A. Translate the following passage into Persian.

Rigid Endoscopes

There are three different types of relay systems used to transmit the image from the objective to the ocular in modern rigid endoscopes.

a) Thin-Lens Relay System. In this system, doublet lenses corrected for chromatic aberrations are employed. The diameter of the individual lenses is greater than the lens thickness and the lens separations are usually 10-20 times that of the lens thickness. The image formed by each relay stage becomes the object for the next adjacent stage and so on for as many stages as are required by the length of the endoscope (Figure 16-4a).

b) Rod-Lens Relay System. Initially developed by Hopkins, the lenses work in much the same way as a conventional thin-lens relay, but the thickness of each relay lens is typically ten times that of its diameter and the air gaps between the individual lenses are correspondingly smaller. This construction gives certain optical advantages, particularly in giving a brighter overall image (Figure 16-4b).

c) Selfoc Relay System. A solid glass rod is used which has been treated so that the refractive index at the center of the rod is greater than that at the edge. This structure continuously refracts the light as shown in Figure 16-4c. Generally, Selfoc systems have a poor image quality in comparison to other relay systems, but they have advantages for small diameter systems (< 2 mm diameter).

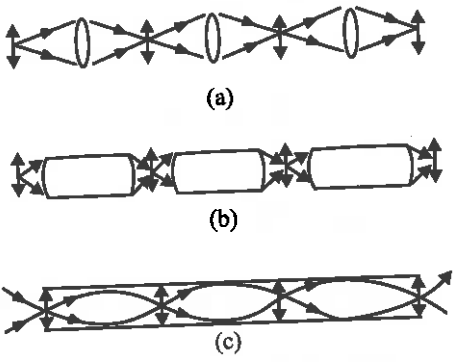


Figure 16-4. Optical Systems of Rigid Endoscopes: (a) thin-lens relay, (b) rod-lens relay, and (c) Selfoc relay.

B. Find the Persian equivalents of the following terms and expressions and write them in the spaces provided.

1. absorption .....
2. chromatic aberrations .....
3. cladding .....
4. coherent bundle .....
5. critical angle .....
6. curvature .....
7. defects .....
8. diameter .....
9. fiber-optic system .....
10. glass fiber .....
11. incoherent bundle .....
12. naked eye .....
13. ocular .....
14. refractive index .....
15. resolvable .....
16. transmission .....

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