CHAPTER - 1

INTRODUCTION

Life is a constant vacillation between happiness and sorrow. Life is too sweet to be spent worrying. Health is the very foundation of life. Health implies both mental and physical well being and not mere absence of disease. Good health needs both sound mind and sound body as sound mind requires sound body. Health is not merely a bodily phenomenon. Health of an individual depends on the genre of a host of factors like: Genetic factors, intrauterine growth, nutrition of foetus, mother's health, nutrition (particularly in the early age), pollution due to environmental factors, air and food intake, and aging. The importance of health is realized only when it is lost partly/totally. Health should be as sacredly guarded as the character [1].

"Once you embrace nature's laws you have solved your health problems".
- Henry Lindlahr

Feeling sick is far more harmful than being sick. There is only one cause of disease, although the disease may manifest itself in various forms and in different degrees of severity. Barring trauma (injury) and
surroundings uncongenial to human life, the primary cause of all diseases is violation of Nature's laws. Violation of Nature's laws in thinking, breathing, eating, drinking, dressing, working, resting, as well as in moral, social and sexual conduct results in certain primary and secondary manifestations of disease. Whatever be the malady, the disease is the result of transgression, whether such transgression has been conscious or unconscious. All diseases are in reality self-purifying efforts on the part of nature.

Diseases are either caused or aggravated by the deficiency of positive alkaline mineral elements in blood and tissues. The body, therefore, is provided with the necessary mineral substances in a well-balanced Nature Cure diet. All disorders can be traced to three primary manifestations, namely: Lowered vitality; Abnormal composition of blood and lymph; Accumulation of waste material, morbid matter and poisons. It then follows that whoever succeeds in correcting these three underlying causes, the "by removes whatever disease originates from them [2]. It is said that, "It is important to know what man has the disease, than to know what disease a man has".  

"WHY DOES MAN want to eat, to drink, and to breathe but because he is related to the elements of the earth, water, and air, and must attract these to his constitution? Why does he need warmth but because he is related to the elements of
fire and cannot do without it? AND all these elements may produce diseases. There is no disease in the elements, but the disease starts from the centers. The origin of disease is man, and not outside of man; but outside influences act upon the inside and cause disease to grow. Man himself is a Cosmos. A physician who knows nothing about Cosmology will know little about diseases. He should know what exists in heaven and upon the earth, what lives in the four elements, and how they act upon man. In short, he should know what man is, his origin and his constitution; he should know the whole man, and not merely his external body. If man were in possession of a perfect knowledge of self he would not need to be sick at all".  

- PARACELSUS

There appears to be a competition between the human beings and the diseases. Moreover, modernization has given rise to additional diseases due to pollution, etc. Thus the age-old adage 'Health is Wealth' is more apt now than ever before. The constant pursuit of man to keep himself healthy has resulted in several methods of treatment.

1.1 KEYS TO GOOD HEALTH


* A Minimum program of exercise is essential.
Sedentary life leads to ill health.

* Drinking/Eating with regard to Time, Place and Need.

* Successful Elimination is the key to health. Proper exercise helps better elimination.

Moderate stress / competition is essential. Else the life will be dull and drab making the person docile. Excess stress causes physical and chemical changes in the body which can trigger stress induced diabetes, stress seizures (epilepsy) and renal problems. Blood Pressure and Diabetes can kill a person [1].

Exercises release the (mental) tension and enable keep oneself fit. It is said that healthy people alone can be beautiful. Health is thus a prerequisite for beauty.

Death is a natural end of life. One ought to reconcile to the process of aging. Man's greed to occupy more space and time in the world leads to problems galore.

1.2 HISTORY OF MEDICINE AND SURGERY [3]

The history of Medicine and Surgery is the account of man's efforts to deal with human illness and disease, from the primitive attempts of pre-literate man to the present complex array of specialists and treatments. It seems probable that man, as soon as he had reached the state of reasoning, discovered by the process of trial and error,
which plants might be used as foods, which of them were poisonous, and which of them had some medicinal value. Folk Medicine consisting largely in the use of herbs had originated in this manner and is still in vogue.

Man did not at first regard death and disease as the natural phenomena. He accepted common maladies, such as colds and constipation, as a part of existence and dealt those by means of herbal remedies. He placed serious and disabling diseases, in a different category. These were thought of as having supernatural origin, the work of a malevolent demon or of an offended God who had either projected some object - a dart, a stone or a worm - into the body of the victim who had abstracted some thing, usually the soul of the patient. The treatment then applied was to lure the errant soul back to its proper habitat or to extract the evil intruder, by suction or other means. One curious method of providing the disease with means of escape from the body was by making a hole in the skull of the victim.

Magic and religion played a large part in the medicine of prehistoric or primitive man. Administration of the vegetable drug was accompanied by dancing and all other tricks of the magician. Thus, the first doctors, or 'medicine men' were witch doctors or sorcerers. However, primitive physicians showed their wisdom by treating the whole man, soul as well as body. The clues to the early
knowledge are scanty. The code of Hammurabi, an early king of Babylon (3000 BC), had laws relating to medical practices. The penalties for the defaulters were severe.

1.3 TRADITIONAL MEDICINE AND SURGERY IN INDIA [4]

Indian medicine is ancient. Its earliest concepts are set out in the sacred writings called Vedas. The golden age of Indian Medicine was from 800 BC to 1000 AD. It is marked especially by the production of the medical treatises, known as 'Charaka Samhita', and 'Susruta Samhita' attributed to Charaka, the physician, and Susruta, the surgeon, respectively.

Because Hindus were prohibited by their religion from cutting the dead body, their knowledge of anatomy was limited. The Susruta Samhita recommends that a body be placed in a basket and sunk in a river for 7 days. On its removal, the parts could be easily separated without cutting. As a result of these crude methods, the emphasis in Hindu anatomy was given to the bones, muscles, ligaments, and joints. The nerves, blood vessels, and internal organs were very imperfectly known.

The Hindus believed that the body contains three elementary substances, microcosmic representatives of the three divine universal forces, which they called Spirit.
(air), Fle, and Bile. Health depends on normal balance of these three elementary substances. The seven preliminary constituents of the body - blood, flesh, fat, bone, marrow, chyle, and semen - are produced by the action of the elementary substances.

In diagnosis the Hindu Physicians used all five senses. Hearing was used to distinguish the nature of breathing, alteration in voice, and the grinding sound produced by the rubbing together of broken ends of bones. They appeared to have had a good clinical sense. Magical beliefs still persisted. The prognosis could be affected by such fortuitous factors as the cleanliness of the messenger sent to the physician, the nature of his conveyance, or the types of the persons with whom the physician met on his journey to the patient.

Indian therapeutics was largely dietetic and medicinal. Dietetic treatment was important and preceded any medical treatment. The Indian Materia Medica was extensive and consisted mainly of vegetable drugs, all of which were from indigenous plants. Charaka knew 500 plants and Susruta knew 760. But animal remedies such as milk of various animals, bones, gallstones, and minerals - sulphur, arsenic, lead, copper sulphate, gold - were also employed. The physicians collected their own vegetable drugs. Among this 'Cardamom' and 'Cinnamon' appear with western medicine.
In surgery, ancient Hindu medicine reached its zenith. Detailed instructions about the choice of instruments and the different operations are given in the classical texts. Ancient Hindus could perform excision of tumours, incision of abscesses, punctures of collection of fluid in the abdomen, extraction of foreign bodies, pressing out of the contents of the abscesses and stitching of wounds. The surgical instruments used by the Hindus have received special attention in modern times. According to Susruta, the surgeon should be equipped with 20 sharp and 101 blunt instruments. These instruments were largely of steel. Alcohol seems to have been used as narcotic during operations. In two types of operations especially, the ancient Hindus were outstanding. Stone in the bladder (Vesical calculus) was common in India, and the surgeons frequently carried out the operation of lateral lithotomy for removal of stones. They also introduced plastic surgery. Amputation of the nose was one of the prescribed punishments for adultery, and repair was carried out by cutting from the patients' cheek a piece of tissue of the required size and shape and applying it to the stump of the nose. The results appear to have been tolerably satisfactory, and the modern operation is certainly derived indirectly from this ancient source.
William Harvey's discovery of the circulation of the blood (1616) was the most important landmark of medical progress. He drew the truth from experience and not authority, following the method described by the philosopher Francis Bacon. His book 'An Anatomical Experiment Concerning the Movement of the Heart and Blood in Animals' (1628) aroused much controversy as was expected. Harvey's work was the result of many careful experiments, but few of his critics took the trouble to repeat the experiments; instead, they simply argued in favour of the older view, in their bookish and scholastic fashion.

After Robert Boyle had shown that air is essential for animal life, it was Richard Lower who traced the interaction between air and blood. The importance of oxygen was established by AL Lavoisier in 1775. The invention of Microscope is usually attributed to a spectacle maker named Zacharias Janssen, in Holland, but its development, like that of telescope, was the work of Galileo, who was the first to lay stress upon the value of measurement in science and medicine, thus replacing the theory and guess work with accuracy.

In the 17th Century one group - adapting the explanation that human body is a machine - called themselves the iatrophysicists. Another group preferring to view life as a
series of chemical processes, were called iatrochemists. Sanctorious, an early exponent of the iatrophysical view, did pioneering work on what is now called metabolism. Giovanni Alfonso Bolelli, a Professor of Mathematics worked on the mechanics and statics of the body and the physical laws that govern its movements. Thomas Willis, a leading exponent of iatrochemistry, is known for his description of brain in his 'Anatomy of Brain and Descriptions and Functions of the Nerves' published in 1664. Even in the 18th century the search for a simple way of healing the sick continued. In Edinburgh, a writer and lecturer named John Brown expounded, at the Royal medical society, his Brinonian system. In his view, there were only two diseases - strong and weak - and two treatments - stimulant and sedative - unfortunately Brown became the victim of his own system, his end hastened by his two chief remedies opium and alcohol.

At the opposite end of the scale, at least in regard to dosage, was Samuel Hahnemann, the originator of Homoeopathy, a system of treatment involving the administration of minute doses of drugs, whose effects resemble the effects of the disease being treated. His ideas had a salutary effect upon medical thought at a time when prescriptions were lengthy and doses were large; his system had many followers.
Before the 18th Century, there was little organized teaching in Britain. Those who wished to become doctors first became apprentices; they could then also attend classes in anatomy, botany and chemistry - the tripod of learning upon which medicine was founded.

1.5 THE RISE OF SCIENTIFIC MEDICINE IN THE 19th CENTURY [4]

By the beginning of the 19th Century, the structure of human body was almost fully known, thanks to the new methods of Microscopy and of Injections. Even the minute structure of the body was understood. Much more important than anatomical knowledge was the knowledge of physiological processes that was becoming rapidly elucidated. Sir Charles Bell's research on the nervous system yielded notable advances. His idea of new anatomy of brain expounded in 1811, has been called the 'Magna Carta' of neurology. This gives a picture of the functions of motor and sensory nerves.

Perhaps the greatest medical advance of the 19th century, certainly the most spectacular, was the conclusive demonstration, that certain diseases as well as the infections of surgical wounds, were directly caused by minute living organisms. This discovery changed the whole face of pathology and effected a complete revolution in the practice of surgery. The main credit for the establishment of the science of bacteriology must be accorded to Louis Pasteur.
He solved the problem of rabies in man and dogs. This led to the widespread establishment of Pasteur institutes.

The most famous contribution of United States to medical progress at this period was undoubtedly the introduction of general anaesthesia, a discovery that was marred by controversy. Some used nitrous oxide gas, others employed ether. Simpson discovered chloroform in November 1847 with complete success. It was soon tested in an operation. It was preferred to ether and became the anaesthetic of choice. Spectacular advances in diagnosis and treatment followed the discovery of X-ray by W.C. Rontgen in 1895, and of radium by Pierre and Marie Curie in 1898.

The battlefields of the 20th Century stimulated the progress of surgery and taught the surgeon innumerable lessons, which he subsequently applied in civilian practice. Perhaps the most worthwhile and enduring benefit to flow from the war was rehabilitation. For almost the first time, surgeons realized that their work did not end with healed wound. The years between wars may conveniently be regarded as the time when surgery consolidated its position. The two outstanding phenomena of 1950's and 1960's - heart surgery and organ transplantation - have taken a proper shape. Plastics were used for almost everything from suture material to heart valves. Heart-lung machine has come to stay since 1953. In 1967, surgery arrived at a climax when
1.6 MEDICAL ELECTRONICS \[4,5,6,7\]

Medical Electronics is not the replacement of the doctor, the nurse, or the laboratory technician; it is an additional tool, perhaps most accurate and reliable, for diagnosis and treatment. Medical Electronics is a widely discussed subject today. For the manufacturing community it provides a new market. For the researcher it is an opportunity to try out what had been once only ideas. For the physician it is an additional tool. For the engineer it is a new area for applying technology. For the administrator, it is a new department to be integrated into a hospital's operation. But most important, for the patient it is a better health care.

Unlike 'medicine', engineering has had only a brief history though the art has been practised from time immemorial. Engineering was an empirical art and remained so till 19th century. Even in the 19th century, the engineering inventor was a mechanical genius, a mechanic. Neither James Watt, nor Wright brothers, nor Henry Ford had gone to the University. In the last century, the term civil engineering was used for what was not directly connected with the defence of the country. Later, with the rapid strides made, the mechanical and electrical engineering branches emerged. Modern electronic science can be
considered to have been born in 1883 with the discovery of Edison effect. The development of vacuum diode in 1897 by Fleming, the triode in 1906 by Lee De Forest and the pentode in 1930 have made it possible to realize modulation, demodulation, amplification etc. The invention of transistor by Bardeen and others in 1948 has culminated in the minia-
turization of electronic equipment. Subsequent develop-
ments of integrated circuits have led to the successful
launching of sophisticated high speed digital computers and
automated systems. In fact, as of today, the utility of
electronics in any walk of life is limited only by one's
imagination. The galloping technology of electronics forced
permeation of electronics into the medical sciences for both
diagnosis, therapy and rehabilitation.

Although, medicine and surgery have had a very long
existence and electronics engineering had been in vogue
for only a few decades, the interaction between these fields
has culminated in yet another potential field - 'Medical
Electronics'. The progress in the field of Medical Electron-
ics is solely due to the technology available and the
consequent simplification of the tools for diagnosis.
Even the treatment part has made tremendous advances.
These facts are amply justified by the widespread usage of
ECG, EEG, Pacemaker, CT scan and irradiation treatments, to
name a few.
Electronics in medicine has enabled the medical community to enlarge its operation because of the plethora of procedures that are available now. Thus Medical Electronics is an extension of a physician's ability to diagnose an ailment and to treat it [4].

Evolutionary trends are obvious in biomedical instrumentation. Microelectronics and computers have now come into use in virtually every aspect of human life. At the lower end of this complex spectrum, basic daily usage instruments such as Thermometer and Stethoscope have remained unchanged since their inception. Temperatures can now be measured using more conductive to continuously monitoring instruments such as digital-display electronic thermometers which can be interfaced into a larger automated system. For monitoring routine heart and chest sounds the rubber tube Stethoscope is adequate. An Ultrasonic Doppler instrument is used to monitor sensitive sounds. This shows that automation in medicine will be most successful when introduced in an evolutionary manner. Introduction, acceptance, and utilization of sophisticated, large-scale computer-based systems is being accomplished in a natural way after the small-scale, simple electronic systems are becoming common place in the daily activities of health care delivery.

The rapid strides of progress made in the subject of electronics have had a high impact on the tools of physicians, surgeons and paramedical personnel. The succeeding
paragraphs present a brief exposure of the principles of diagnostic and therapeutic instruments. That should indicate the stand that Medical Electronics is really a marvel which deserves an in-depth study and favours implementation of these gadgets for the welfare of mankind.

1.6.1 Diagnostic Instruments [4]

To be able to look inside the human body has always been the goal of physicians. Ancient medical men and medical healers saw exterior lumps and coloured veins that signalled deeper trouble. Exploratory surgery was a common technique for a better view of internal damage. But the risk involved was high.

The modern day approach is to make non-invasive diagnostics to the extent possible. To achieve appreciable success towards this goal, monitoring of the electrical activity of the parts of the body is essential. In case of non-electrical quantities, appropriate transducers have to be employed. The biological potentials are often band limited to 100 Hz. Hence the problem of low frequency amplification is common to all biomedical amplifiers. Since the potentials themselves are quite low, very efficient electrode systems have to be used, as otherwise noise artifacts tend to obliterate the signal. The heated stylus recorder is generally preferred to conven-
narrowing of arteries. Angiogram is a painful and dangerous invasive procedure involving injection of a dye through a Catheter. At higher power levels the ultrasonic vibrations literally shake the tissue to death. Thus the ultrasound can be useful in destroying the malignant tissue.

Since the discovery of X-rays by Wilhelm Rontgen in 1895, various types of radiation have been used in medical diagnosis and treatment to probe the human body noninvasively. These include X-rays, Ultrasound, Computerized Tomography (CT) and Positron Emission Tomography (PET). The CT scanners have expanded the diagnostic imaging research area. The technology has led to the development of several other non-invasive imaging systems that provide functional or biochemical data as well as structural information. The basic principle underlying PET is that any abnormal biological process results from an abnormal biochemical activity. The image reconstruction algorithms, problems of data storage and image presentation are similar for both CT and PET scanners. Another diagnostic imaging system that has a great promise relies on Nuclear Magnetic Resonance (NMR) to generate data. The advantage of such a system is two fold. It does not subject the patient to ionizing radiation and it can provide information about the chemistry of the tissue in addition to the tissue structure.
1.6.2 Therapeutic Instruments [4]

Just as the percolation of electronics into medicine has culminated in the growth of a variety of diagnostic instruments, it had also resulted in the invention of several therapeutic instruments.

Diathermy equipment is employed to produce deep heating in the tissue of the body. The metal pads of the equipment act as the plates of a capacitor with the body tissue serving the role of a dielectric. The dielectric losses cause the heating of the tissues. Diathermy improves circulation and promotes healing of injured tissues. The short wave diathermy employs frequencies of 13.56 MHz and 27.12 MHz. The microwave diathermy equipment operates at 2450 MHz. The unit is compact. Microwave diathermy produces an even rise of temperature. This method is hazard-free since no physical contact is required. Microwave diathermy is used for making incisions. Inductothermy envisages usage of a coil around the body and passage of a current through it. The induced current in the body causes the healing through heating.

The muscle stimulators are essentially pulse generators. The use of this enhances the recovery of a muscle after a sprain, dislocation, etc. As mentioned earlier ultrasonic therapy is useful in the selective destruction of cancerous tissue. It can also be of avail in the treat-
merit of arthritis and disorders of the muscle, nerve and bones. X-rays are extremely penetrating. The bones being opaque, appear as a light area against a dark background. In angiography, a radio opaque liquid is swallowed by or injected into the patient. The obstruction of the passage can be filmed using X-rays. X-rays can be of avail in destroying malignant growth. Over-exposure to X-rays can cause destruction of the tissues. Hence lead shielding is mandatory around the X-ray installation to protect technicians.

 Certain radio isotopes are preferentially selected by the kidneys, others by the liver, etc. The condition of these organs is studied by injecting an appropriate dose of radio isotope and monitoring the degree of accumulation with a Geiger counter.

 Defibrillators and pacemakers would be of immense utility for cardiac emergencies.

 1.7 IMPACT OF COMPUTERS ON BIOMEDICAL ENGINEERING

 Over the past two decades, the techniques of computer modelling and simulation have become increasingly important to the fields of bioengineering and medicine. The reasons for this are numerous. As in the other areas of science and engineering, mathematical modelling lets biomedical re-
searchers subject increasingly complex hypotheses to quantitative examination. Furthermore, the sophistication of computer hardware configurations, particularly the increase in memory capacity and CPU speed, have produced a parallel increase in the level of biological complexity that realistically can be modelled.

Although biological complexity outstrips the capabilities of even the largest computational systems, and will for some time to come, the computational methodology has taken hold in biology and medicine and has been used successfully to suggest physiologically and clinically important scenarios and results [8].

Computers contribute to medical care in three basic, interrelated ways: they detect and communicate data about the patient's physical condition; they interpret the data; and they actively assist in treating the patient.

1.7.1 Electronic Monitoring

Electronic monitoring units provide fast and accurate information about the patient's vital function without having to enter the body. Obstetrics departments in most of the advanced hospitals use non-invasive monitors that show foetal heart beat to detect potential problems with the birth process enabling the physician to determine when to take emergency steps, such as Caesarean section.
Infants in high risk categories, particularly premature babies, can now be monitored for symptoms associated with Sudden Infant Death Syndrome (SIDS). Respiratory monitoring units feature computerized alarms programmed to signal apnea (cessation of breathing) and bradycardia (abnormally slow heart beat), alerting medical staff to begin emergency resuscitation. Designed for easy operation, these self-adjusting systems record and store data on respiration and heart muscle movement, and require no supervision.

Microprocessor technology also permits more effective monitoring of coronary patients such as upgraded models of the cardiac monitor. Ambulatory ECG monitors specially programmed to keep a constant check of heart and pace maker functions are effective in both preventive treatment and the rehabilitation of heart attack victims.

Total patient monitors that keep a running account of vital physiological functions have reduced the risk of major surgery. Capable of complex, multiple calculation, these units provide the anaesthesiologist with the data relating to heart rate, blood pressure, and endoviability.

1.7.2 Digital Diagnosis

In addition to ensuring efficient monitoring, computers now aid in detecting a wide range of
conditions, eliminating much of the slow, costly laboratory work traditionally involved in diagnosis. The trend is toward non-invasive, microprocessor-based instruments that quickly pinpoint potential trouble spots in time to allow for effective treatment or preventive measures. Computers facilitate the diagnosis of a number of major brain, nerve and eye diseases, as well as certain kidney and metabolic disorders.

Some of the most dramatic technological innovations use telecommunications to aid diagnosis in emergency situations. Doctors can now analyze emergency cases from a screen in their office or home, thanks to slow scan television systems that instantly send internal pictures of the patient, along with such information as CT scans and ECG waveform images, over telephone lines or on satellite, microwave or radio channels. This technique enables doctors who cannot be in the emergency room to perform diagnosis and direct life-saving measures as rapidly and efficiently as possible.

1.7.3 Safer Surgery

In addition to the monitoring and diagnosing, computers enabled improvement of a variety of both new and traditional surgical procedures. For example, electrical cauterization, a technique used to stop bleeding during surgery, has been made safer by a small computerized control unit that determines the intensity of the charge released to
coagulate the blood. This saves the valuable time in the operating room and narrows the margin of error based on a more subjective application of the electrode, thus reducing the possibility of burning.

1.7.4 Home Health Care

One of the major goals of modern medical technology is to reduce costly time spent in the hospital while enabling effective treatment to continue in the most humane environment possible. All aspects of health care, from preventive treatment to rehabilitation therapy, are represented by the growing number of easy-to-use computerized devices designed for simple operation by one individual.

Some of the monitoring units found in hospitals are already adaptable for home use. The tendency toward increasingly simple operation in home monitoring equipment may prove to be a life saver for many people. These include automatic digital electronic thermometers, portable pulse and blood pressure meters, desk top electronic digital blood pressure monitors, and compact automatic pulse meters. Other monitors are capable of checking several physiological functions such as fluctuations in GSR (Galvanic Skin Resistance), EMG (Electromyograph) and skin temperature at the same time.

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Specialized computers now enable people to make quick, preliminary diagnoses of certain conditions in their own homes such as compact electronic monitors to analyze the glucose levels in the blood and computerized fertility calculators. Some new devices directly administer home treatment to the patient. Of particular interest to the millions who suffer from diabetes is the automatic insulin pump.

1.7.5 Computerized Health Care System

Our present system of health care has grown greatly more complex in recent years. Like society, the health care system is in a constant change, adapting to those same cultural, technical and commercial forces that are motivating social changes in other settings. As the underlying balance of social factors changes, the health care system changes. In recent years, many elements in the health care equation have changed and others show signs of impending change. The economics of health care, social factors, the rising tide of clinical data, engineering technology, the structure of physician-patient encounter and the role of the computer in medicine are the processes that are currently shaping the health care system [9].

Economics and technology are key factors in restructuring the health care system, aided by a rapidly emerging acceptance and use of computers. The computer provides ways
to control the cost, improve the quality of care and analyze the data in ways not previously possible. New technologies for patient care and testing, such as Nuclear Magnetic Resonance imaging, are fundamentally computer based instruments whose operation, design and interpretation is becoming increasingly the province of non-clinical technical personnel. The cost and quality of medical education has also been greatly influenced by the significant advances in computer-aided instruction that were made possible by microcomputers and inexpensive mass storage devices. Finally, information handling systems are evolving as a result of the introduction of new hardware and software technologies, including specialized languages and developments in distributed data bases and expert systems.

The essential nonfiscal applications of computers to the health care system are: automated interviewing systems, automated multiphasic screening systems, total hospital information systems, automated instrumentation, clinical laboratory systems, transverse axial tomography and automated diagnostic and clinical consultation systems [10].

Computer Aided Design has revolutionized biomedical engineering. The key to linking human cognition, judgement, and experience with computer memory, speed, and reliability is the graphics interface. This is particularly true for visualizing an emerging idea in three dimensions or defining
and analyzing a device. Physicians and surgeons are constantly confronted with such problems - envisioning the location, size, and shape of a cancerous tumour; the geometry of a skeletal fracture; or the location and structure of an aneurysm in the brain's circulatory system.

Computers are also being used in the area of the Medical Information Systems. The Medical Information System is the root of information processing in the health sciences. It draws from many resources, both human and machine, and provides the foundation for many uses: patient care, finance, education, research and many others. Lindberg [11] identifies the following 14 functional dimensions of a Medical Information System.

1) **Admissions Office**

An admissions office collects patient demographic and financial information, schedules admissions, keeps track of patient transfers and discharges, and administers the hospital census. The patient is often tracked for future visits and follow-up care. It handles gathering summary data upon patient discharge. In some cases, the patients' pre-admission and family histories are collected. The needs of the admissions office are primarily in the area of data-base services, including on-line inquiry capability and various forms of on-line data entry. A particular problem of the admissions office concerns identification and linkage of
members of a family or guarantor group.

ii) **Ambulatory Care Department**

An outpatient department has information needs in patient scheduling, multiphasic screening, medical record keeping and other functions such as quality-of-care audit. Since ambulatory visits are more predictable, requirements for preparation of patient data summaries and data entry are less stringent than those for admitted patients, but constraints upon the overhead costs of computer services as a percentage of total costs are tighter. The ambulatory care information systems must be able to access financial as well as clinical data. In multi-clinic groups, the system must function with distributed data-base requirements. In prepaid or other group plans, an ambulatory data base in conjunction with multiphasic screening can provide the basis for early detection and invention in areas such as cancer and cardiovascular diseases.

iii) **Business Office**

The business office information system must tie together all financial aspects of the clinical encounter. These functions include calculation of room rates and charge postings in accordance with allowed procedures, patient billing, preparation of insurance statements, accounts receivable, aging of accounts, general ledgers, accounts payable, inventory, payroll, workload analysis, productivity
iv) Clinical Laboratory

The clinical laboratories were one of the earliest areas of the hospital to be computerized, as complex instrumentation was developed with computerized control systems. These evolved or were supplemented with more general-purpose information processing capabilities. A typical clinical laboratory system processes physicians' orders, handles direct data acquisition from laboratory instruments, generates reports, produces work sheets for specimen collection, schedules standardized instrument test to be run at regular intervals, and monitors length of service of chemicals and other replenishment items. The volume of data and procedures even in a small hospital laboratory can be daunting.

v) Dietetics Department

This is an area often overlooked in which well designed software, interacting with patient records can result in considerable cost savings and improvement in quality of care. Studies have indicated that nutrition can reduce the length of stay in many cases. Functions of dietetics system include food inventory control, institution menu standardization and planning, nutrient analysis, patient menu selection, menu item forecasting in terms of seasonal changes in
price and availability of items, and other food service management functions. The complexity of such a system in a large hospital should not be underestimated. A fully automated dietetics system interacts with patient medical records and physicians' orders for special diet restrictions, generates menus based on patient preferences, variety, cost, and ingredient availability (seasonal items), and schedules the preparation and distribution of the final product.

vi) EKG Units

Many examinations are processed by computerized techniques. In some systems, this includes the collection of examination requests, data acquisition from both fixed and portable units, processing and interpretation of results including processing of lengthy 24-hour monitoring tapes to seek irregularities, report generation, preparation and management of physical records, and cardiac pacemaker surveillance. Related to EKG units are laboratories that process EEGs for the interpretation of brain waves. Another related technology is Electromyography (EMG), which involves electrical stimulation and measurement of muscle tissue.

vii) Intensive Care Units

There are a number of computer-based functions performed in intensive care wards whose purpose is to free personnel for actual patient care, reduce costs and improve outcome. Basic functions include acquisition of data signals
in coronary, surgical or pulmonary ICUs, detecting and warning personnel of abnormal developments, and on-line control of infusions and medication delivery.

viii) **Medical Records Department**

The medical records information system ties together all the data from other sources into a patient record. The medical records department is responsible for maintaining a diagnosis registry which contains for each patient a numerically coded admission diagnosis, a clinical diagnosis, interpretations of surgical pathology, cytology or autopsy examinations, laboratory results, nursing and physician notes and narratives including results from physical examinations, vital signs and medications administered, physical therapy procedures, patient and family history, interpretation of radiological and EKG diagnoses, length-of-stay data, outcomes and survival rate data, and other information. The medical record department prepares a number of reports that are used to monitor the overall quality of care and maintain institutional accreditation such as cancer registers.

ix) **Mental Health Centre**

These functions include interpretation of psychological tests, hospital administrative and management activities, collection of nurses' and physicians' narratives, medication records, standardized coding of diagnoses prob-
lems and conditions, analysis and interpretation of hospital records, and predictions of patient behaviour.

x) Operating Room

A computer system can aid in the maintenance of operating room logs and scheduling, analysis of utilization including case mix, resident experience, duration of procedures, blood bank usage, optimization of case instrumental control functions, and interpretation of data (for example, perfusion pump control and other activities associated with open heart surgery).

xi) Pharmacy

Pharmaceutical systems are used to acquire and record prescriptions (often from terminals located in the clinical wards), prepare labels, and analyze drug selection in terms of patient diagnosis, concomitant conditions, age, usual dosage, compatibility with other drugs, allergy, and sensitivity. This requires access to patient medical records, and a full scale system would be a very complex expert system. Computer systems for the hospital pharmacy also aid in the preparation of drug profiles, inventory, and planning.

xii) Radiology

These systems collect examination requests, schedule patients, and acquire report summaries from the interpreter.
A number of computerized aids exist to help in generating standardized narratives including diagnostic codes. These systems involve the development of intricate user-friendly man-machine interfaces. Radiology systems are also used in the calculation of radiation treatment plans, report generation, management of the film library, cost analysis, and other management functions.

xiii) Education

The medical record is an important tool for education in that it can be used critically to evaluate the delivery of health care as well as form the basis for a number of computer-assisted instruction applications involving simulated patient encounters.

xiv) Research

Research based usage of the medical information system includes epidemiology, evaluation of experimental procedures and drugs, public health planning, and preventive medicine. A number of promising developments have surfaced in the past few years, including such applications as computer-assisted rehabilitation therapy, especially applied to paralysis [12].
1.7.6 *Emerging Trends in Computer Applications to Health Care System*

This section presents a gist of some other areas of health care system that have been subject to the impact of computerization and the emerging trends.

**Applications to the Hearing Impaired**

These have included systems to permit real-time close-captioned television, computer networks for communication, voice recognition and speech synthesis, and training in sign language and lip reading. Work has also been done on highly miniaturized systems which present visual displays of sounds on eyeglasses and other related techniques [13].

**Applications to Imaging and Diagnosis**

Ultrasound applications, based on a pulse-echo ranging technique similar to sonar or radar, have been used to generate real time images for diagnosis. Applications have included three-dimensional digital displays in stereo pairs, tissue characterization and blood flow measurements, detection of eye and liver abnormalities, doppler techniques for cardiology, obstetrics, and gynaecology. The same basic techniques have been applied to renal calculi removal and tumour removal [14]. Other imaging techniques include Positron Emission Tomography (PET), and Nuclear Magnetic Resonance (NMR) tomography, more recently referred to as 'Magnetic Resonance Imaging' or MRI [15].
Patient Interviewing by Computer

The earliest application of computers to health care consisted of attempts to capture patient interviews. Early techniques used semi-automated approaches, while recent cost reductions have made fully interactive systems possible [16].

Applications to Aid in Nursing

These include features such as those embedded in the IBM Patient Care System, which provides for nursing order entry, patient assessment protocols, discharge planning guides, and reference information for pharmacy and dietetics [17].

Applications to Dispatching Emergency Medical Services

These systems manage location, time of call, list of responding units, map coordinates, and assignment of radio channels, and consist of base stations and remote digital radio terminals operating on an 800 MHz channel.

Applications involving Local Area Networks

Developments in the area of microcomputers and powerful work stations have eroded the traditional centralized view of computing in the health care setting. Local Area Networks are becoming more common as systems local to certain hospital specialties develop.
Over the past two decades, the field of artificial intelligence has made great progress towards computerizing human reasoning. Nevertheless, the tools of AI have been mostly restricted to sequential processing and only certain representations of knowledge and logic. A different approach to intelligent system involves constructing computers with architectures and processing capabilities that mimic some processing capabilities of the brain [18]. The results may be knowledge representations based on massive parallel processing, fast retrieval of large amounts of information, and the ability to recognize patterns based on experience. The technology that attempts to achieve these results is called Neural Computing [19].

Twenty years ago, the research on neuro systems and neuro engineering was carried out with the goal of describing the basic building blocks of neural systems architecture. The motivation underlying the research was to gain an understanding of neural systems with the intent of advancing medical technology. Even in 1988 it was still accepted as one of the goals of the discipline of biomedical engineering; however, researchers are also excited by the 'inverse' goal of using the models of neural systems in order to solve problems in other disciplines which have proven untenable using more classic methods. Both of these goals have led to
increased interest by investigators in what is today termed 'Neuro Engineering'.

Neuro Engineering, which is inherently multidisciplinary, requires a convergence of knowledge, methodologies, and experience from diverse disciplines including biophysics, computer science, engineering, mathematics, neurophysiology, physics, and psychology. The vast increase in computer power over the past few years has provided the tools needed by investigators to approach the challenges offered by the complexities of neural systems. In turn, the understanding of the nervous system has led to the development of new mathematical and methodological techniques to analyze and simulate how large numbers of simple numbers interact with each other. Thus, the growth in neuro engineering can be attributed not only to the insight gained into biological neural systems, but also to the usefulness of its methodologies in fields as diverse as signal processing, robotics, artificial intelligence, and computer science [20].

The Artificial Neural System technology represents a universalization among the various sciences working towards a common goal of building intelligent systems. The primary interest is to explore and reproduce human information processing tasks such as speech, vision, olfaction, touch, knowledge processing and motor control.
The biological applications of neural networks include providing insight into how the brain works and modelling various parts of the nervous system. The medical applications of the neural networks include reading X-rays, ECG and EEG patterns, predicting drug reactions and adaptive blood pressure regulation.

1.9 EXPERT SYSTEMS AND THEIR APPLICATIONS IN BIOMEDICAL ENGINEERING

Expert systems are a subset of the field of artificial intelligence. They utilize knowledge and inference procedures to solve problems which require human expertise due to their degree of difficulty. Knowledge is the major factor in the performance of the system. However, knowledge is not merely a collection of facts as would be found in a database; it also includes assumptions, beliefs and rules for dealing with these bits of information. These rules of thumb are called "heuristic", and they form a second type of information within the knowledge base and provide the rules connecting how the basic facts are utilized. Heuristics provide the "Common Sense" or expertise that is part of the system [21].

The basic structure of an Expert System includes three fundamental system elements. These include: a "Knowledge database consisting of facts and heuristic knowledge associated with the problem; a problem-solving inference and
reasoning processor to utilize the knowledge base in the solution of the problem; and a user interface that provides working memory for keeping track of the problem status, the input data for the specific problem, and the relevant history of what has thus far been done" [22].

Integration of these three functions produces an Expert System that "performs a specialized and usually difficult professional task at the level of a human expert. Once the system has been developed, in addition to solving problems, it can also be used to instruct others enabling them develop their own expertise".

The medical science has been, for artificial intelligence in general and knowledge engineering in particular, a kind of laboratory in which, apart from solving specific problems, efficient solutions are searched for in areas of similar characteristics. The domain is thus ideal to put to test most of the ideas that occur to a large number of artificial intelligence researchers as well as specialists in knowledge engineering.

Now a days, in the medical science arena, or better, in the clinical domain, medical instrumentation outputs are combined with knowledge to obtain correct diagnoses. At this stage, one would find the first difficulty: how to define models to treat information coming from the outside world and incorporate them to a reasoning scheme suitable for its
individual and global interpretation in order to provide adequate diagnoses and therapies [23].

Even within this subdomain there appear differential characteristics. For instance, are the temporal aspects of a given information important? Will we have to process previously the numeric information coming from outside and/or define interpretation contexts? Can we assure that one or several diagnoses or therapeutic schemes are clearly and precisely derived from the data?

1.9.1 Expert Systems for Diagnosis

Diagnosis is the process of determining the correct problem from a collection of problems given a set of symptoms that indicate the existence of a problem. Common experiences with this process include visits to the physician in order to determine the illness (disease) and visits to the local mechanic to determine the cause (fault) of a poorly operating car. In either case, we report the symptoms of the problems to the diagnostician (physician or mechanic) who determines the most likely cause that best explains these symptoms. In terms of complexity of finding the correct problem, the diagnostician must find a diagnosis from a set of possible diagnoses. That is, if a total of 10 problems are being considered where only one of these is correct, then at most 10 diagnoses will need to be evaluated.
However, in the more typical case, where several problems (diseases/faults) may occur simultaneously, the complexity of finding a proper diagnosis increases exponentially with the number of problems. For example, using the 10 problems considered above, the situation changes to where any of the 1024 possible combinations of problems may turn out to be the correct diagnosis.

In medicine as well as electronics and other domains, multiple problem diagnosis, henceforth called multiple fault diagnosis, is the identification of a set of problems (disorders, diseases, or faulty components) that best correspond to or explains some observed abnormal behaviour that is indicated by a set of symptoms (manifestations). This type of problem solving is commonly referred to as abductive inference, and automating this approach has been the focus of extensive research efforts. Common among these research efforts is the nature of their systems. Namely, these approaches to diagnosis follow the "reasoning from the first principles" paradigm where a description of some of the physical system's structure and behaviour is maintained and compared to abnormal behaviour. This is in sharp contrast with the "experimental" paradigm which is driven by the problem-solving rules of thumb or heuristics acquired from a human expert diagnostician [24].

Many researchers in the medical area are interested in developing methods for providing knowledge-based decision
support to the practicing physician. Although they demonstrated the potential to provide useful computer based consultation, they have paid little attention to the modelling of patient specific preferences and trade offs about the quantitative values obtained from physicians. Furthermore, purely symbolic (non quantitative) reasoning techniques have limited utility in the solution of many medical problems without the explicit consideration of the quantitative notions of uncertainty and trade offs [25].

There are several different approaches to knowledge representation, each of these provide appropriate symbolic structures to represent knowledge and appropriate reasoning mechanisms for answering questions and assimilating new information in accordance with the truth theory of the underlying representational language.

The choice of a suitable approach is contextual: it depends on the intrinsic characteristics of the domain of interest. There are cases in which the knowledge regarding a given context is uncertain, for example, when tasks are poorly understood and structured, or when the information available is incomplete, fragmentary or otherwise intrinsically vague.

Intrinsically vague knowledge is typical of the decision processes involved in medical diagnosis, especially
when they are based on complex and non-numeric data. Medical diagnosis usually relates a linguistic description of symptoms to diagnostic classes. A linguistic description of symptoms does not, by definition, represent a precise numeric concept, and diagnostic classes cannot be modelled in terms of crisp sets [26].

The essential steps in the diagnosis of the disease are acquisition of information, and decision or diagnosis. Diagnosis is a peculiar combination of precisely defined logic and intuitive judgements. Deployment of Expert Systems for diagnostics and therapeutics is bound to be rewarding.

1.9.2 Expert Systems for Rehabilitation

The last two decades have seen the continued expansion in scope, rigour, and maturity of the subject of human body mechanics and organ dynamics. The discipline of applied mechanics is being very skilfully employed for the analysis, design and performance evaluation of the prosthetic, orthotic, and rehabilitation systems. The restoration of effectiveness or normalcy by training etc, or the restoration of proper conditions after some illness is called as Rehabilitation.

The use of 'smart' materials for fitting prosthetics and orthotics will automatically adjust the orthotic forces as the patient regains muscle strength. Functional electri-
cal or magnetic stimulation which is presently being used in the rehabilitation research may also be used in normal individuals for such applications as the stimulation of Spinal Cord, Peripheral Nervous System etc. The availability of low cost computational power has opened flood gates for the development and introduction of new, better, more powerful and versatile equipment for diagnosis, therapy, and rehabilitation. Developing Expert System based rehabilitation equipment is therefore bound to be fascinating as well as rewarding.

1.10 SCOPE OF THE THESIS

Health had been of concern for all from times immemorial, since mere living is perhaps a sort of curse. To live with vitality and vigour, to be able to perform his functions and fulfil his obligations to the society had been the aspirations of human being.

Health depends on a myriad of factors, chief among them being, good intake of oxygen and nutritious diet and successful elimination of wastes: solid, liquid, and gaseous. Adverse congenital factors may even worsen the situation. There are several systems of medicine, the foremost being based on the dietetics. Allopathy, Homoeopathy, Ayurveda, Unani, Magnetotherapy, Acupuncture, and Acupressure are the quite popular systems. Allopathy is unique by its
life saving nature. Allopathy has gained much by adopting latest electronic and computer systems. Diagnosis is vital to any treatment. Accumulation of expertise by experience is what is known in the jargon as creation of data base. An extensive data base culminates in an Expert System. When therapy does not restore normalcy in the subject, the best of the bad situation is all that can be made—such procedures are called Rehabilitation Techniques [1].

This thesis is a fruition of efforts to develop:

a) Expert Systems for diagnosis, viz,

* an automated Homoeo diagnostic system
* an automated Coronary diagnostic system

b) Expert Systems for Rehabilitation of blind and deaf, viz,

* Character recognition
* Announcement
* Multi-user Reading systems

Artificial Neural Networks (ANNs) and parallel processing techniques have been employed in realizing the above systems.