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Unit 17

Radiography of Ancient Man.....and Woman

Unit 18

The Practice of Medicine: From Wizardry to the Magic of MRI

Unit 19

The Original "X" Files: Wilhelm Konrad Roentgen

Unit 20

Madame Curie: A Woman Before Her Time

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Prepared by: Carolyn J. Frigmanski, M.A., B.S.R.T. ®
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UNIT NUMBER 17

RADIOGRAPHY OF ANCIENT MAN .... AND WOMAN

PREPARED BY: CAROL B. OKENKA, R.T. (R & MR)

INTRODUCTION

The following unit is an explanation of mummification in ancient Egypt and a series of facts relating to some of the published information of the radiography of other ancient peoples. The theme throughout is to not only make the reader aware of the special circumstances involved, but also to show the importance of radiography in the discoveries. Tha author's hope is to show and introduce paleopathology as a worthwhile science in the understanding of the evolution of modern man..

Radiography of Ancient Man...and Woman

"Mortui viventes docent" - "The dead are our teachers"
Motto of the Paleopathology Association

Mummies have been a curiosity of man for centuries. Many scientists have used mummies to study a variety of diseases and medical conditions. Many others, for profit.

The fact that the people of ancient Egypt worked formidably at preserving the bodies of their dead, does not mean they concentrated on death. Rather, they considered death a continuation of life, only in a different form. The belief was that the body in life was protected by three elements, two of those followed with the body to the next world. Those two, the *ka* and the *ba*.

The *ka* was a man's double in every way, the *ba* was similar to a soul. So, it would come as no surprise that they wanted the things that they found favorite in this life, to pass with them to the next. The answer, mummification.

Early ancestors buried their loved ones in shallow desert graves after wrapping them in linen. The bodies were placed in a near fetal position. The heat in the sand caused a natural drying process. The preservation process was made more effective when the Egyptians started building tomb chambers.

In the fifth century B.C., after visiting Egypt, the Greek historian Herodotus gave the first account of the handiwork Although some details were wrong, his account of mummification have been a major source for it's study.

Herodotus explains that the most costly mummification involves professional embalmers will show the deceased's bearers three different wooden models (coffins) for interment. After the family decides, they leave the workshop so the body can be prepared. First, by use of an iron hook, they remove some of the brain through the nostrils, the rest by infusion of drugs. Then the abdominal contents are removed by using a sharp stone. The empty abdomen is cleansed with wine, and aromatics. They then fill the cavity with every kind of spice, except frankincense. The body cavity is stitched shut. The body is then "cured" for seventy days, no more, no less. The corpse is then washed, and wrapped in linens, smeared with a gum that replaced glue. Family members by now have the body model, they place the body in it, seal it shut, and place it upright in the burial chamber.

The mid-priced style involves injecting the abdomen via syringes, with cedar oil. Again the body is cured for seventy days, then the oil is removed, and the remains of the internal organs. The family then receives the body, and the burial is completed.

The last, and least expensive way, is to simply remove the organs, cure the body and return it to the family for burial.

With the writings in the first century BC of another Greek historian, Diodorus Siculus, we find the customs of burial very similar. There is greater detail about the cutting of the abdomen however, in that the "cutter" is cursed and stoned after the cutting ritual. This takes place because in the ancient civilization of Egypt, anyone who inflicted wounds on another was hated. The actual embalmers on the other hand were held in high esteem, since they prepared the body for the afterlife.

There is belief that mummification was stopped about 1900 BC because of foreigners establishing settlements in the Nile Valley. The Egyptians had never been invaded before and because of fighting there was no time to complete the procedure. Mummification was started again around 1600 BC with little or no change in procedure.

Ceremonies at the time of burial were performed to restore the deceased's senses. The Egyptians felt this necessary to complete the passing to the afterlife. Perhaps these beliefs are why graves were later desecrated. [1]

Historic Travels of Mummies

Egypt began exporting large numbers of mummies in the 1400's to supply Europe with "mummia". This fine powder was produced by grinding mummy bones. Apothecaries would sell it as a cure for a variety of diseases. Mummia was used as a treatment for epilepsy, heart murmurs, nausea, poisoning, paralysis, tuberculosis, cuts and bruises. The practice eventually slowed, but until recently shops that catered to witches would still sell powdered mummy.

Mummies also became a fashionable curiosity for museums as well as private collectors. A French monk remarked in 1833: "It would be hardly respectable, on one's return from Egypt, to present oneself in Europe without a mummy in one hand and a crocodile in another".

During the 19th century, Canada had a shortage of rags needed to manufacture high quality paper. Paper companies responded by importing thousands of mummies and used the wrappings to make paper. Mark Twain, in "Innocents Abroad", wrote that mummies were burned in place of coal in the boilers of steam locomotives.

Egyptian law now forbids the export of mummies or biological material from mummies.

Since shortly after Wilhelm Conrad Roentgen produced the first x-ray image, man has been using x-rays to peer into the past. Nine years after the discovery, Armond Ruffer, among others, used x-rays to image a mummy. It is believed the first detailed dissection of a mummy was performed in 1820 by Augustus Bozzi Granville, an English physician, but that was only visual autopsy.

Paleopathology is the study of disease in ancient times in an effort to understand how diseases have evolved and to apply that knowledge to modern medical problems. Persons interested in this science are called paleopathologists.

The completion of the first Aswan Dam on the Nile River in 1902, made thousands of mummies available for study. The Egyptian government mounted a massive effort to save the ancients that would have been flooded by the dam. About the same time, the British established a medical school in Cairo, where Armand Ruffer was a bacteriologist. He, Alfred Lucas, and Grafton Smith, pioneered modern research on mummies. Ruffer also developed a solution for restoring water to mummy tissue so it can be examined under a microscope. The solution, named for Ruffer, is still used today.

The three scientists found that the ancient Egyptians suffered from Tuberculosis, smallpox, parasitic infections, and other conditions that still plague modern society. [2]

Research You Can Sink Your Teeth Into

A revival occurred in the mid-1960's, that was not led by paleopathologists or anthropologists. A orthodontist from the University of Michigan was responsible for the rebirth. Dr. James Harris, a geneticist and orthodontist at the University of Michigan, had been working with associates to improve the treatment of malocclusion, the misalignment of teeth.

Malocclusion occurs in more than half of all children, requiring braces or other treatment. Dr. Harris and his associates wanted to develop procedures that would permit orthodontists to determine whether a child's badly aligned teeth will straighten naturally with time or will require corrective intervention.

The dentist conducted a study of Michigan schoolchildren to establish the roles of age, family history, population trends, and genetic factors in facial growth. The research improved the precision with which orthodontists can predict how a child's face will grow and how well the teeth will fit into its bone structure.

The theories needed to be tested and refined. The need to compare dental development within a population over several centuries led researchers to Egypt.

In 1965, in the Nile Valley, a crash program was under way to salvage skeletons, natural mummies, and other archaeological remains buried in the Nubian sands over a span of almost 20 centuries. Construction of a second dam (Aswan High Dam), threatened to flood the area, including the famed temple of Abu Simbel. The temple was being moved to higher ground which afforded the researchers their opportunity.

Dr. Harris and his associates used special x-rays called cephalograms on about 1,000 skulls and compared them with X-rays of more than 2,000 schoolchildren at Aswan.

Research documented more than 2,000 years of human skull and facial evolution. It supported the theory that malocclusion is occurring because man's jaw is becoming smaller while the teeth are remaining large. The result is crowding of the teeth.

Because of his research, the Egyptian Department of Antiquities invited Dr. Harris to examine the entire royal mummy collection in Cairo - the first such examination since 1912. [1,4]

An Arctic Mystery

In May of 1845, 129 fearless British soldiers in two ships set off to chart the Northwest Passage. Britannia was the greatest force on the seas, so if anyone was to complete this task, it would be the Brits.

The brave sailors were led by Sir John Franklin, a captain that was a veteran of two expeditions in the North American Arctic.

Charting of the Passage was first thought to be important in the hopes of discovering a swift shipping route between Europe and the profitable markets of the Orient. Soon, European seamen realized that the Arctic was too treacherous for commercial shipping. Still, the lure to explore and colonize the territories of the New World continued.

The Franklin expedition began full of promise, but over the next three years something went catastrophically wrong. The two ships, the *HMS Terror* and the *HMS*

Erebus, were trapped in the ice off King William Island in 1846. There was no summer thaw that year or in 1847. Without the thaw, the ships were unable to move on.

After Sir John Franklin died in 1847, the sailors planned to travel over land the 1,000 miles to a Hudson Bay trading post on the Back River. None, however, survived the journey.

Despite massive investigations by the British, the demise of the crew remained a mystery.

Nearly 150 years after the tragedy, a team of scientific researchers traveled to the Arctic in 1986 to try and uncover clues that could explain the sailors' tragic end.

The team leader was Owen Beattie, Ph.D., a widely respected forensic anthropologist from the University of Alberta in Edmonton. Beginning in 1981, Dr. Beattie had attempted to solve the riddle by collecting bone and tissue samples, but to no resolution. Derek Notman, MD, a radiologist at Park Nicollet Medical Center in Minneapolis, MN was also included on the team. Additional team members included several historians, a pathologist and Brian Spencely, a professor of physics. One of Spencely's ancestors, John Hartnell, would be exhumed during the investigation.

"Very little information lives on after the final sighting of the two ships off the coast of Greenland in 1845" Dr. Notman related. "The members of Franklin's expedition are still heroes to the British public and they have a strong place in British history".

Obtaining a permit from the British government - who still controls the Northwest Territories - for yet another investigation was not an easy task. Well aware of the British sensitivity to the project, the researchers submitted carefully detailed plans and kept the information about the proposed trip out of the hands of the media.

Approval eventually came and Dr. Notman and the others headed for Canada's Beechey Island, only 900 nautical miles from the North Pole. Their focus was on two of the ill-fated sailors buried there.

Dr. Beattie's research led many to believe that the men may have died from lead poisoning caused by the leaking of lead used to seal provisions in tin cans. Because of the positive radiologic findings with lead poisoning, Dr. Notman brought along a portable X-ray unit and the supplies necessary to develop on-site radiographs.

Lead poisoning can have disastrous effects on the body and mind including muscle paralysis, nerve and brain inflammation, anorexia, neuroses and disorientation.

The theory of lead poisoning could explain why many of the expedition members' actions seemed illogical and inexplicable. The ships for example, were not abandoned until dozens of men had died in the rat-infested holds. When the men finally left, they dragged heavy cargo of little use on a thousand-mile trek to the south, despite the fact that well-provisioned whaling ships frequented the north end of the passage.

The radiologist and the team's other medical experts flew from Minneapolis to Edmonton, accompanied by a Port-a-Ray Manual 100MA portable X-ray unit, radiographic film, processing chemicals, and other assorted pieces of machinery necessary to the project.

Because of Federal Aviation Administration regulations, the portable x-ray machine had to occupy a seat right behind the bulkhead. The portable x-ray unit rode in first class while the rest of the team rode in the tourist section. From Edmonton, the team boarded a Pacific Western plane for a flight to Resolute Bay, stopping at Yellow Knife, the capitol of the Northwest Passage. A small DeHavilland Twin Otter seaplane then met the team and carried them to Beechey Island.

With only a week long permit for onsite research, the company had no time to waste. After unloading the equipment from the Twin Otter, which quickly zoomed away because of the changeable weather, the researchers set up several longhouse-style tents that were to serve as their temporary laboratory. Their own quarters were small domed tents that could be carried on backpacks.

The researchers also realized that the Beechey Island area was a migratory route for polar bears. Fortunately, the team had Keena, a dog specially trained to be on the lookout for bears.

The Arctic summer is as bright as its winter is dark. Midnight seemed like midday. This meant the darkroom never saw darkness either. To solve the dilemma, a double layer of black landscape plastic was placed over a steel conduit frame.

Snow was melted to make the water necessary to mix the developer, fixer, and wash water. Using GBX chemistry, the developing and fixing time for each film was about three to five minutes. The wash cycle was about 15 minutes. Films were then hung in a tent for the two hour dry time.

An aquarium heater plugged into one of the generators kept the darkroom water supply at 75 degrees and the air temperature at about 50 degrees.

The complicated set up of the darkroom was important because with only one week to complete all tests, it was necessary to know as quickly as possible if the x-rays were good and if they showed anything else that needed to be investigated.

Kodak Corporation supplied the team with a 200 speed system. Originally, Dr. Notman had considered a 400 speed system, but company experts felt the higher film speed would be too sensitive to the cold conditions.

The first test film was made of a whale bone found on the beach. The film turned out well, and Dr. Notman knew the rigged system worked.

Another task that had to begin right away was the exhumation of the bodies of two sailors whose graves were marked by flagstones, the only structures on Beechey Island.

At first, the excavation went easy since only snow and gravel covered the surface. But soon the diggers hit the dense, hard permafrost. Twenty four hours of digging shaped a trench.

To respect the dignity of the dead, British regulations mandated that the burial sites be covered by tents. This way, planes flying overhead could not see the open graves of their fallen heroes.

The first body exhumed was that of John Hartnell. The coffin was ice filled, and researchers feared that use of a pick would cause damage so a bucket brigade of warm water was formed. The body slowly thawed and soon they were staring at a 25 year old who had died so many cold nights ago.

After the body thawed, the limbs became fully flexible and lifelike, allowing the team to position them as you would any patient.

Dr. Notman took a full series of X-rays over a period lasting almost 14 hours. It was at this time that Keena started barking. Soon the shouts of "BEAR" started ringing through the camp.

A polar bear had been attracted to the odor from the body. Eventually, gunshots into the air scared the bear off.

A review of all the films showed no evidence of the suspected lead poisoning and all of John Hartnell's bones appeared normal. Dr. Notman did admit wanting a CT scanner to help in the possible diagnosis.

The other body, that of William Braine, was in much worse condition. There had been postmortem deterioration before his burial. Braine's body was discolored and emaciated. There were cuts over the left iliac crest at the anterior superior spine which Dr. Notman determined was the result of rat bites.

The radiographs of Braine appeared normal until Dr. Notman conducted his lower thoracic series. At the level of T11, the radiologist noticed a wedge-shaped abnormality. Angular kyphosis of this type is typical of spinal tuberculosis. TB was a common ailment of expeditions of this era, and the sailors would transmit it among each other. It is not believed to have caused his death.

The cause of the sailor's death remained elusive, although the medical experts suspect Hartnell and Braine died of pneumonia.

After a week of examination, the team returned the bodies to the carefully reconstructed graves so that no trace of the investigation remained.
The British heroes were finally at rest. [6]

Learning The Mummy's Secret

The winter of 1987 brought scientists to Toledo, Ohio to the Medical College Hospital. The reason to travel to the snowy Midwest was a paleopathologist's dream. The opportunity to examine a 1,300 year old American Indian mummy.

The preserved body was buried around 730 A.D. in a cave in the Absaroka Mountains of northwest Wyoming. The body was mummified naturally, in a drying process that left some tissue for modern scientists to examine. Estimates before the autopsy indicated that he died at about age 55.

The mummy was excavated in 1963 by the Buffalo Bill Historical Center in Cody, Wyoming. It was brought to Toledo with the approval of Native American officials who hoped the autopsy would yield information about life and death among early American populations.

The host from MCO was Dr. Frank Saul, an authority on disease in ancient civilizations. Dr. Saul and his wife, Julie, an associate in anatomy, arranged the postmortem. The MCO departments of radiology, pathology, dentistry, surgery, and anatomy cooperated in the project.

Others participants included:

- Dr. James Harris, an orthodontist (previously mentioned);
- Dr. Derek Notman, a Minneapolis radiologist (previously mentioned);
- Dr. Jaime Benitez, Director of Otoneurology at William Beaumont Hospital in Royal Oak, Michigan;
- Dr. Howard Duncan, Chief of Rheumatology at Henry Ford Hospital in Detroit
- Dr. Arthur Aufderheide, a pathologist at the University of Minnesota School of Medicine;

- Dr. Theodore Reyman, Director of Pathology at Mount Carmel Mercy Hospital in Detroit;
- Dr. Michael Zimmerman, Director of Pathology at Hahnemann University School of Medicine in Philadelphia;
- Dr. Jeanne Riddle, an electron microscopist at Henry Ford Hospital in Detroit;
- Dr. Ray Brinker, Chairman of the Department of Radiology at MCO;
- Roberta Easter, R.T.-R, Technical Director of the Department of Radiology at MCO.

Dr. Benitez studies ancient ear diseases and hopes to remove the three tiny bones inside the ears as part of that research. Dr. Duncan is looking for indications of arthritis in ancients.

Dr. Aufderheide will use tissue samples to help him reconstruct the diet of ancient people.

Drs. Reyman and Zimmerman hope to reconstitute tissue using a solution specially developed to restore water.

Dr. Riddle will examine a wide range of specimens, from tissues to insects found with the body.

The length of study was three days. The autopsy is conducted within a context of respect for the dead individual, almost in solemnity. Museum officials placed a religious token inside the elaborate plastic container specially built to transport the mummy. The token remains along side the mummy throughout the procedure.

Many noninvasive tools are used in the autopsy. The scientists use X-rays, CT scans, electron microscopes, and other esoteric procedures.

The CT scanner probes Medical College of Ohio's Mummy's (MCOM) skull in 86 slices, each a fraction of an inch thick. Dr. Notman notes "Even a patient being prepared for plastic surgery to reconstruct the face would not get this detailed a CT study".

The mummy's position in its specially built transportation crate led to concern that some of the X-rays would be of poor quality, or even impossible. Based on the X-rays taken by Roberta Easter, the researchers were able to determine the signs of arthritis for information about MCOM's sex, height, and age at death.

The scientists have quickly agreed, based on the evidence shown, that MCOM was much younger than the original estimate of 55. The joints show a lack of arthritic changes that occur normally with age. The teeth also prove the younger age.

After months of review of tissue samples and x-rays, the researchers were able to find out many things about the ancient. Scientists have, for example, identified one of the last meals consumed by the individual. They have found evidence that he suffered from an infestation with parasitic intestinal worms. [2,3]

The paleopathologists are fairly certain, however, that he did not suffer from scurvy and a number of other diseases that leave characteristic marks on the bones. Tests even have pinpointed the time of death to a two-month period in the spring.

Researchers cannot explain how this person avoided the typical signs of osteoarthritis, common to early peoples. This individual, who was in his mid- or late- 30s, who presumably lived a rugged existence, avoided joint changes.

Some of the most revealing information came from examination of coprolites, pieces of fossilized fecal material, found inside the mummy. Researchers in Toronto used a rehydrating process to restore it to natural consistency so that it could be examined microscopically. The examination showed that the individual had consumed a diet high in vegetable matter. Undigested muscle fibers suggested meat consumption, and small quantities of fine carbon particles, suggested that at least part of the food had been cooked.

The presence of bone splinters may indicate that the individual was healthy enough a few days prior to death to chew and crush bones. On the other hand, Dr. Saul notes, the splinters may indicate that he was sick and could not chew adequately.

In summary, researchers believe the information received from this autopsy has opened doors for further research of ancient America. [5]

The Soap Man and Woman Mummies

In 1875 two mummified individuals, a woman and a man, were exhumed somewhere in Philadelphia. There names were listed as having the last name of Ellenbogen. The exact location was not clearly documented, but descriptions accompanying the bodies stated that they died in 1792 of yellow fever.

The female cadaver, now known as "Soap Lady", was presented to the Mutter Museum, College of Physicians in Philadelphia, on Nov. 18, 1875. The male cadaver, named "The Soap Man", was initially presented to the Wistar and Horner Museum of the Medical Department of the University of Pennsylvania, but is now located at the Smithsonian Institution in Washington, DC.

The name "Soap" comes from a process that involves the nitrogenous tissue giving off ammonia which attacks the fat of the body and forms a hard ammonia soap, or adipocere. The form of the body stays well preserved.

In 1942, Dr. Joseph McFarland, curator of the Mutter Museum, raised several questions concerning the story surrounding the two cadavers, including their names, the date and causes of death and the exact location of the exhumation. His archival research indicated:

- No individuals named Ellenbogen were in Philadelphia prior to 1836;
- No one by that name died of yellow fever in 1792;
- Yellow fever was not reported in Philadelphia in 1792;
- There was no cemetery located in the neighborhood of Fourth and Race streets.

Renewed interest in the female cadaver at the Mutter Museum resulted in a radiographic examination in 1987. Because of it's fragile nature, the female cadaver could not be moved. The answer was to obtain the necessary images with a portable unit. The radiographs provided evidence that refuted information provided in the museum records and by McFarland.

For example, the radiographs revealed straight pins that after removal were found to have been manufactured after 1824. Although McFarland stated that the body was that of a "toothless old woman", the radiographs of the suture closures of the head, as well as other bones, show that "Soap Lady" was premenapausal, possibly not older than 40.

Because it was on display, the male cadaver could not be examined in the same time frame. In 1991, the Smithsonian took "Soap Man" off exhibit and placed in a climatically controlled attic storage area of the Natural History Museum. Prior to the radiographs, the research team inspected the approach to the room, including elevators and passageways, to determine the type of portable unit that could be transported to the area. To formulate a plan, photographs and measurements were taken of the body, the board and shelf on which it rested, and of the attic room.

Diagonal beams extending from floor to ceiling in the approach to the storage area precluded the use of a "fixed tower" mobile x-ray unit. To overcome this problem, a unit was brought in pieces into the attic area and reassembled. A tunnel was built under the body for the AP projections, and a vertical cassette holder was built of ring stands and tape.

A 400-speed screen system was used because of the output of the mobile x-ray unit. All exposures were done at 60 kVp. The techniques follow:

Technical Factors for Soap Man Radiographs

Region	Projection	SID	mAs
Skull	AP	40"	18.0
	30° caudal	51"	29.3
	Lat	56"	26.8
Thorax	AP	40"	18.0
	Lat	56"	40.8
Abdomen	AP	40"	23.0
	Lat	56"	26.4
Femur	AP	40"	15.0
	Lat	56"	26.4
Tibia-Fibula	AP	40"	18.0
	Lat	56"	26.4
Feet	AP	40"	12.0
Humerus, radius-ulna	AP	40"	23.8

The first results noted were a number of artifacts, found to be nails, that were proven to be below the body by relocating the central ray thus moving the nails. Organs noted in the body included shrunken cerebral hemispheres, the heart and aorta, and dilated portions of small and large intestines. The skeleton reveals few abnormalities. Degenerative changes were visible in the lower cervical and upper thoracic spines, suggesting "Soap Man" was some type of manual laborer such as a bricklayer, farmer, sailor or dockworker.

Again, the use of pins in the body refute the 1792 death claim. The degree of closure of the cranial sutures also placed his mean age at 40.

Other museum records concerning the cause of death could not be proven or refuted by this examination. However, the 1942 study leaves little doubt that information was fabricated to hide the true identity of both individuals.

The value of the radiographs produced by the research team aided in providing information to scientists that could not be revealed any other way and was used to refute historical documentation. [7]

Conclusion

Over the years, radiology has played an important part in unraveling some of the mysteries of ancient peoples. With the advancements occurring in medicine today, it should become easier to explain some of those mysteries. One drawback for such an endeavor may be the expense involved. It would take dedication by a radiology department willing to absorb the expense of such an endeavor. The cost of film, chemistry, room and personnel time in business today make this practice prohibitive. Hopefully, interest in the past will prevail, and soon we can learn more of our past.

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UNIT NUMBER 18

THE PRACTICE OF MEDICINE:

FROM WIZARDRY TO THE MAGIC OF MRI

PREPARED BY: MARY TELEHA PARKS, B.S., R.T. (R & CT & M)

INTRODUCTION

In this unit we will review the transformation of medicine from earliest man's system of religion and magic to tiday's scientific biomedical format. The contributions of many cultures will be discussed, as well as ancient laws, treatments and surgery. A chronology of many of our most important medical discoveries will be presented.

NEOLITHIC MAN, A MAGIC BEGINNING

In the dawning of civilization, during the period known as the Old Stone Age, human beings have left evidence of their lives and artistry in carvings in bone and cave paintings. We would like to imagine that there were also healers in these early times, but we have no evidence to support their existence. Yet ancient man suffered from many of the diseases we know today. Rheumatoid arthritis was not uncommon. Evidence of arthritis has been found in the fossils of some of our earliest ancestors and many of the animals that lived millions of years ago. There is evidence in fossil finds, specifically, a dinosaur tail vertebra discovered in a Wyoming plateau.

About 9,000 B.C., the New Stone Age began. It lasted in northwestern Europe until about 2,000 B.C. Our earliest ancestors lived in caves and had brains as large as or larger than later generations. Neolithic Man believed that everything in nature was inhabited by gods They worshiped the sun, moon and stars. The wind, the trees and the animals were things to be revered as gifts from the gods. There is a cave drawing in the Pyrenees that shows a medicine man dressed in animal skins with his legs striped with colored earth and having a pair of deer antlers on his head. It is easy to conjure up a picture of a sacred ceremony in a dark cave around a fire. The costume of the medicine man represented all that was sacred to his people and a symbol of his power. The ceremony was performed to bring rain, win a battle or cure disease.

This era has provided us with evidence that at least one surgical operation called trephination was frequently performed. Trephination is the process of cutting an opening through the cranium. The opening was often circular, but sometimes square, and varied in size from a tiny hole up to an opening about two inches in diameter. Man, in this era, did not have sophisticated tools yet so the process was achieved by the use of a flint knife or scraper. The knife was used to mark a circle on the outer surface of the skull and then deeper cuts were made until a groove was formed and the piece of skull could be removed. This procedure was performed on men, women, and children and sometimes more than once. We know many of these patients survived this surgery because of a large number of fossils that have been found showed healing of the wound.

The question is why was this operation performed? Modern surgeons perform this same operation on people who have skull fractures or have increased pressure on the brain. Few of the discovered fossils show any signs of fracture. Therefore, there must be another reason. In the lives of primitive man, there were no delineated borders between magic, religion, and medicine. Man could cause illness in his enemies by sending, through magic, a demon to inhabit the victim's body. A deity could punish a man with illness by introducing a foreign object or abducting his soul. In the New Stone Age, nervous or mental conditions could be attributed to possession by demons. Of course,the priest, shaman or sorcerer would try to let the demon escape. In some cases, the symptoms were relieved and the practice continued. Evidence of trephining has been found in Peru and various places in Europe and Asia.

Another ancient operation was the amputation of fingers. Cave paintings in France and Spain, from around 7,000 years ago, show many silhouettes of hands with amputated fingers. Evidence has also been found in California, Arizona, Peru, Africa and Australia. Imprints in Egypt, Palestine, Arabia, Babylonia, India, Phoenicia and Mexico also attest to this surgery. Amputation persists even today among certain aboriginal tribes. It is believed this procedure is even older than trephining and was done to appease a god, to drive out demons or as a symbol of mourning.

Among the earliest prehistoric peoples, amulets to ward off diseases have been found. These amulets were often crude representations of the sun, moon or stars. Archeologists have even found evidence that the piece of skull removed during trephination was also used as an amulet. All things that happened in nature were signs from the gods. Drought, storms and fires would be looked upon as bad omens. Good weather, abundant crops and game would mean the gods were pleased with them.

Because they had no written alphabet, prehistoric man left no record of his religious beliefs, medical theories or practices. Observance of the North American Indians, at the time of the discovery of America, has bridged this gap. Many tribes of that period were still living in the Stone Age. Death was accepted as a normal occurrence in war, accidents and in old age. Diseases were caused by anger or bad humor of the gods. The religious beliefs of the North American Indian resemble the religious beliefs of primitive cultures everywhere as a mixture of magic, religion and medicine. The Great Spirit was the lord of the earth and all lesser gods, humans and animals, owed him allegiance. These gods had to be appeased and the medicine man was the logical person to accomplish that task. The medicine man was often chosen through a miraculous dream or by surviving an accident that was considered to be a clear sign from the gods. The medicine man played a leading role in these primitive societies. They were asked for rain for their crops, good hunting, victory in war and were called upon to treat the sick by driving away evil spirits. To accomplish these tasks, they used elaborate masks, effigies, charms, necklaces, amulets and rattles. If these techniques were not successful, they could turn to drugs, some of which had a definite therapeutic benefit. For reducing fever, they used willow bark; for an emetic, they used a concoction of holly; and for surgical procedures, they were familiar with narcotics such as datura that could put a person to sleep. Datura was also used in their ceremonies to induce a trance and to encourage visions from the gods. In many cultures when a boy was becoming a man, he had to go on his own to the desert, mountains or forest to fast and pray. He did not give up until he reached a state in which he was given a vision that would be his guidance in life. Usually, there was some animal in the dream that would be his protector in life.

Even without a written account of medicine from Neolithic Man, there can be no doubt that some of the early superstitions and treatments were passed from generation to generation and used for hundreds of years.

MESOPOTAMIA, CRADLE OF CIVILIZATION

Mesopotamia, the land lying between the Tigris and Euphrates Rivers, has been called the cradle of civilization because some of the earliest myths of the origination of mankind have developed here. The Garden of Eden was in the plain of Eden near Babylon with the Euphrates River flowing nearby. The ancient Babylonians told of a serpent tempting the woman with an apple in the garden that is similar to a story found in the Book of Genesis.

About 3,500 years ago, this land was inhabited by groups of people called Sumerians. They attained a high degree of civilization. They developed a system of pictorial hieroglyphs that later turned into cuneiform writing. They built large cities that had sewers into which toilets and refuse drained. Their system of religion and medicine was based on the belief in many gods and in evil spirits. When a person would fall ill, his family first tried home remedies to cure him. The patient's recovery meant that the gods were to blame for the illness. The patient that did not recover quickly with home remedies needed more drastic measures. A priest/physician was summoned from the temple. The physician questioned the patient to determine the cause of the sickness. The patient was asked if he had broken any taboos of their society. Did he fail to give proper homage to their ancestors? Had he seen a dog barking outside the city gates? Did he know anyone that would have reason to put a curse on him? The answers to his questions determined the physician's course of treatment.

The physician used incantations that appealed to the various gods for forgiveness and mercy. Bribes of food and delicacies were offered to entice evil demons from the body. Offerings were burnt and the smoke was used to chase away demons. Disgusting concoctions were given to drive out the evil spirits. When all the physician's efforts failed, the patient was placed on the street and all who passed had to stop and give advice to effect a cure. Persons that had been afflicted with the same symptoms imparted the circumstances of their cure. This process was probably the most scientific treatment of disease in this period. The Sumerians eventually disappeared from history, but their system of religion and writing was retained.

Babylon became the chief city and gave its name to the whole country. The Babylonians developed agriculture, commerce, art and science, especially mathematics and astronomy. The medicine of Mesopotamia was primarily magico-religious. The people worshipped many gods. The priests were chosen by the gods and dealt with illness and disease with elaborate ceremonies. The ancient incantations and practices of the Sumerians were still used with only the names of the gods changed. There was a great deal of secrecy to these ceremonies. Herbal treatments used were handed down from each priest to his successor. At some point, these priests began to write their incantations and treatments down on clay tablets.

The Babylonian priests were divided into three classes:

> The diviners, who interpreted omens and foretold the course of the disease; the exorcists, who drove out the evil spirits that caused diseases; and the physicians, who performed the operations and administered drugs(Sigerist, 1967).

Each one had their part in the ceremony to cure an illness or drive away hard times. Each one had a basis in the superstitions and practices of primitive man.

King Hammurabi (2123-2081 B.C.) was responsible for an elaborate code of laws, including laws for those who practiced surgery. There is a section that specifies the fees surgeons were to receive and also the penalties for surgical failures. The fees are in accordance with the status of the patient:

> 218. "If a physician operate on a man (i.e., gentleman) for a severe wound with a bronze lancet and cause the man's death; or open an abscess (in the eye) of a man with a bronze lancet and destroy the man's eye, they shall cut off his fingers."
> 219. "If a physician operate on a slave of a freeman with a bronze lancet and cause his death, he shall restore a slave of equal value."
> 221. "If a physician set a broken bone for a man or cure his diseased bowels, the patient shall give five shekels of silver to the physician."
> 222. "If he be a freeman, he shall give three shekels of silver."
> 223. "If it be a man's slave, the owner of the slave shall give two shekels of silver to the physician."
> 224. "If a veterinary physician operate on an ox or an ass for a severe wound and save its life, the owner of the ox or ass shall give to the physician, as his fee, one-sixth of a shekel of silver (Thomas, 1954)."

Most of these regulations refer mainly to surgery and not medical practice. Even in this early period of medicine, there seemed to be a distinction between a surgeon and a physician. It does not appear to be an atmosphere that encouraged people to become physicians.

The emblem Rx was used on prescriptions by Babylonian physicians as an invocation to the god Marduke.

The Babylonians, like primitive man, believed disease came from demons. They had an elaborate system of incantations and treatments to drive out the demons. They used poultices, bandages, plants and minerals, water was a cleansing agent with enemas mentioned many times. Before they administered any treatment, the priests used an incantation.

The Babylonians, like the Hebrews, Egyptians, and Greeks, put a great deal of importance on the meaning of dreams. Dreams were from the gods and could foretell the outcome of a harvest, a battle or disease. Starting with our earliest ancestors, this conviction appears to have been passed down through the ages.

Babylonian culture had a lasting impact on history. Many of their legends were adapted by the Jews and became a part of their religious inheritance. Early discoveries in archaeology, astrology, history, mathematics, medicine and philosophy were implemented by the Greeks. The Greeks spread much of this knowledge throughout the known world.

The Babylonians were succeeded by the Assyrians. The religious and medical practices dating to the Sumerians were still in use. Ashurbanipal, the last of the great Assyrian kings, established a library in his name. He collected the ancient medical tablets and stored them in his library. This was the first written record of the spells, incantations and remedies to cure illness (Shippen, 1957).

EGYPTIANS, MASTER HEALERS

Egyptian medicine, like many cultures, began with the priests. The Egyptians were polytheistic. There were certain gods concerned with the heavens, others for vegetation and some for reproduction. The sun was the god Ra, the chief god in Egyptian theology. Ptah looked after the people's health just as Yahweh did for the Hebrews and Apollo for the Greeks. Later, Ptah shared this responsibility with Imhotep. Imhotep was an official of King Zoser who was deified during the Greco-Roman period. The Egyptians had strong religious beliefs, but magic was inseparable from religion in their use of medicine. They used incantations and amulets in their cures. They had secret ceremonies and believed in evil spirits. The Egyptians also had an empirico-rational system of medicine. They treated illness with drugs. There was surgical intervention. The Egyptians were the first to try to explain the process of health and disease philosophically instead of mythically(Sigerist, 1957).

Egyptian religion emphasized immortality. Every year, the Nile would flood and all vegetation would die and rise again. Could not man do the same? This ancient belief in immortality is probably what led to the practice of mummification. It was earlier thought that the practice of mummification gave the priests a certain knowledge of anatomy. However, it is now believed that the priests had very little to do with the actual process of preparing the body. The process of mummification was carried out by technicians. The representation of organs found on amulets and other figures makes us believe that the Egyptians did have a basic knowledge of anatomy.

The basis of our knowledge of Egyptian medicine is found in Medical Papyri. Only a few of these have been discovered. The Edwin Smith Papyri describes Egyptian surgical practices. The best known is the Ebers Papyrus which was written about 1570 B.C. It was copied from much earlier books and was a series of prescriptions for diseases that affected the body. The papyri are arranged starting with diseases that affected the head and then in descending order. They seem to be much freer from magic than previous papers. The Egyptian physician used knowledge and religious beliefs to call upon the gods to **assist** him in his efforts. This practice was different from using incantations to cast out demons and pleas of intervention by the gods.

A large part of the Ebers Papyrus contains remedies for a condition that has plagued man for thousands of years, constipation. The following remedy for an overtaxed bowel was certainly effective:

Take thou:

Fresh dates	one part

Sea salt	one part
Sebbet juice	one part

Signa:

Mix in water, place in an earthen receptacle, and put therein: crushed gengent beans, cook together, cool, and let the patient drink warm. Thereafter let him drink sweet beer (Atkinson, 1958).

Egypt is considered the birthplace of medical science. From the first dynasty, Egypt had a system of medicine more rational than the world was to see again for thousands of years. Egyptian physicians were famous as teachers and taught in Arabia, Persia and Greece. Hippocrates, grandfather of the great physician by that name, was taught by an Egyptian. Physicians from Egypt were summoned to attend to the needs of most of the monarchs of the ancient world. Many others traveled widely for their profession. Medical knowledge in Greece was fused with Egyptian knowledge and handed down from father to son to become the basis for Greek medicine. This act of sharing knowledge with other cultures opened the door of secrecy and made room for the science of medicine to grow.

The Egyptians were very skilled in their practice of medicine. If a person became ill, they sent a description of their illness to the temple of health. A physician, who specialized in the area of the illness, was sent to him. Many surgeries were performed. The bladder was opened for the removal of stones. Amputations were performed. Diseases of the eye got special attention and operations for cataracts were performed. Circumcision was carried out as a ritual by the priests, not the physicians. Egyptian papyri gives us some of the earliest descriptions of contraceptive practices. The Kahun Papyrus recommends:

> "the insertion of a vaginal suppository containing crocodile's dung and honey mixed with sodium carbonate (Atkinson, 1958)."

The Papyrus of Ebers prescribes;

> "the vaginal insertion of acacia tips. These tips contain gum arabic, which dissolves in water, forming lactic acid. Many contraceptive jellies, widely used today contain lactic acid (Atkinson, 1958)."

The Egyptian physician used an astonishing variety of drugs from the mineral, vegetable and animal kingdom. Drugs were given in a variety of ways such as potions, mixed in milk, wine or beer or made into pills with dough. They used suppositories, purgatives and emetics. Diseases of the chest were sometimes treated with inhalations and diseases of the skin with ointments. The Egyptians discovered the value of drugs still used in our pharmacopoeia. The Egyptians were also known for their knowledge and use of poisons.

HEBREW INFLUENCES

Most of our knowledge of Hebrew medicine comes from the ***Bible***, especially the first five books of the ***Old Testament***, called by the Jews the ***Torah*** or the ***Law***. The Hebrews were the first culture that was monotheistic. Disease was considered to be a result of the wrath of the Divine Being, Yahweh. Relief from suffering was accomplished through prayer, fasting and the observance of the moral laws. The basic attitude in the Scriptures seems to have been dependent upon Divine help rather than medical treatment.

In the ***Bible***, greater stress was placed upon the prevention rather than treatment of disease. Because of this belief, no other population in the history of man has left us such a wealth of laws relative to sanitation and hygiene. These important laws have come down through the ages. They are still in use, to some degree, in every country in the world that is enlightened enough to use them. The book of Leviticus, which contains the admonitions of Moses, set the groundwork for most of today's sanitary laws to protect health. These laws were far advanced from any that existed at the time and have had little improvement today.

GREECE, THE BEGINNING OF SCIENCE

It was the Greeks who put the practice of medicine on its now widely accepted course. From the Greeks, we received the basic elements of anatomy, physiology and pathology. Most of our medical nomenclature came from the Greek. Many of our medical traditions show a clear connection to the ancient Greeks. Greek medicine did not just appear fully formed. There were years of learning and incorporating the medical practices of Babylonia and Egypt into their own system. Many scholars insist that the story of Asklepios is the Greek version of Imhotep.

Asklepios, while practicing his profession in Thessaly, was hit by lightning and killed. While this is a perfectly natural phenomenon, the Greeks saw in it something supernatural. Legend says that Pluto, Lord of the Underworld, was angry. His realm was being depopulated because of Asklepios' skill. He begged Zeus to strike down Asklepios. Zeus agreed and hurled the fatal thunderbolt that killed Asklepios. Later, he was remorseful and elevated Asklepios to the rank of a god.

The earliest Greek practitioners of medicine were the Asklepians or priest-physicians. They treated the sick with a mixture of superstitious rites and practical means. Their treatment protocols came from the belief that dieseases was caused by demons. The early Greek culture continued the belief of many gods. Their ideas are associated with the sign of the serpent. The serpent on the caduceus has Greek origins. Many of the physicians of the time had come to believe that the physical condition of a patient would respond to mental states. Therefore, the function of the priest-healer was to direct the patient's mind into wholesome, relaxing channels that helped the body to heal. Next came the art of dietetics in treating the sick. All Greek schools of medicine taught the sick to select their food well, to eat less and thus live longer. These ideas continue to be very important today. Their temples were usually in a healthful location where fresh air abounded and the surrounding countryside presented a quiet and cheerful environment.

The ancient Greeks were known for their intellectual curiosity. They showed interest in all things and they sought explanations for all phenomena. Above all, they sought wisdom. One of the most distinguished members of this group was Pythagoras, who coined the phrase ***philosophia*** (lover of wisdom). Pythagoras influenced medicine with his belief that life was composed of four elements -- earth, air, fire and water. Each element was given a quality -- dry, cold, hot and moist. These four elements with their qualities formed the four humors of the body: blood that is hot and moist, yellow bile that is hot and dry, phlegm that is cold and moist and black bile that is cold and dry. The proportions of these humors determined a man's disposition, mental qualities and his state of health. Pythagoras's theory dominated medical thinking from about 500 B.C. until it was finally overturned in 1858.

Hippocrates, known as the Father of Medicine, helped Greek medicine to reach its greatest heights. Hippocrates was born on the Isle of Cos about 460 B.C. He was the son of a physician and trained his sons to be physicians. Because of Hippocrates, medicine became an art, a science and a profession. Hippocrates was the first physician to separate medicine from philosophy. He separated the priest from the physician by disassociating himself from all the techniques using

Greek magic in healing. The Hippocratic Oath, with its highly ethical code, has had a great influence on medicine through the centuries.

HIPPOCRATIC OATH

The Hippocratic Oath is provided below for your review.

I swear by Apollo the physician and Asklepius and Hygia and Panacea and all the gods and goddesses, making them my witnesses, that I will fulfill according to my ability and judgement this oath and this covenant:

To hold him who has taught me this art as equal to my parents and to live my life in partnership with him, and if he is in need of money to give him a share of mine, and to regard his offspring as equal to my brothers in male lineage and to teach them this art—if they desire to learn it—without fee and covenant; to give a share of precepts and oral instruction and all the other learning to my sons and the sons of him who has instructed me and to pupils who have signed the covenant and have taken an oath according to the medical law, but to no one else.

I will apply dietetic measures for the benefit of the sick according to my ability and judgment; I will keep them from harm and injustice.

I will neither give deadly drug to anybody if asked for it, nor will I make a suggestion to this effect. Similarly I will not give to a woman an abortive remedy. In purity and holiness I will guard my life and my art.

I will not use the knife, not even sufferers from stone, but will withdraw in favor of such men as are engaged in this work.

Whatever houses I may visit, I will come for the benefit of the sick, remaining free of all intentional injustice, of all mischief and in particular of sexual relations with both female and male persons, be they free or slaves.

What I may see or hear in the course of the treatment or even outside of the treatment in regard to the life of men, which on no account one must spread abroad, I will keep to myself holding such things shameful to be spoken about.

If I fulfill this oath and do not violate it, may it be granted to me to enjoy life and art, being honored with fame among all men for all time to come; if I transgress it and swear falsely, may the opposite of all this be my lot.

Today most medical students recite a form of the oath at their graduation. In recent years, there has been discussion of changing the oath to be more relevant. Many schools develop their own oath according to their beliefs.

Hippocrates relied on the curative effect of rest and relaxation. He used hot baths as therapeutic measures, he prescribed purgatives and emetics, he set and splinted fractures and he reduced dislocations. Most of all, he was a keen observer. His writings describe the symptoms of disease with such great clarity that even physicians today can identify them.

Aristotle (384-322 B.C.) was the son of a physician. In his biological works, he discussed many problems that exist to this very day. Many naturalists still read Aristotle's works. He formulated the basis of organic evolution with his teaching about the Ladder of Nature. He developed theories concerning generation and heredity. He founded comparative anatomy and he dissected many animals. He did not make any distinctions between arteries and veins. He did not correlate any relation between the sense organs, the nerves and the brain.

Around 300 B.C., a great medical school was founded at Alexandria in Egypt. It is believed that the medical school at Alexandria was guided by the style of Imhotep. The Greeks at Alexandria were knowledgeable of the ideas of Hippocrates. By following in his footsteps, they made many discoveries that were put into practice. Herophilos, considered the Father of Anatomy, was the first to dissect both human and animal bodies. Erasistratos, a younger contemporary of Herophilos, was called the Father of Physiology. He separated the cerebrum from the cerebellum and discovered that veins carried deoxygenated blood and the arteries carried oxygenated blood.

The School of Alexandria played an important role in the history of medical education. For the first time, a systematic system for instruction of anatomy was developed. For the first time, the doors were open to students throughout the world. Medicine was becoming more scientific in nature rather than based on superstitions and incantations. New knowledge was shared among people from other countries and each group could then build upon that knowledge.

THE ROMAN CONQUERORS

The original Roman medical system was a system of the more primitive people almost totally without scientific elements. It. As with all primitive medicines, it combined the domains of religion and magic. There were many gods to be pleased and sacrifices were dedicated to these gods. Rome did not have any professional physicians, but it was inundated with amateur doctors and herb doctors who treated patients with folk remedies, amulets and incantations. With the fall of Greece to the Romans, Greek medicine invaded the Roman Empire. The Romans shunned the medicine of the Greeks because they regarded it as a tool to destroy them. As their knowledge grew, the Greek system was incorporated into Roman life and it became indistin-guishable from the Roman system.

The Romans were advanced in promoting public sanitation and health. They had two notable accomplishments that were unequaled in the ancient world and in some countries of the modern world today. One of their accomplishments was the construction of the 10 Roman aqueducts that could supply 250,000,000 gallons of water daily. Today, four of the aqueducts have been repaired and are sufficient to meet the needs of Rome. Roman baths were soon established throughout the empire and were of great hygienic importance. The second notable accomplishment was the Cloaca Maxima or greatest sewer. It gradually assumed all the functions of a modern sewer. There is evidence of an extensive waterworks system with waterclosets flushed by running water. This sanitary device was unknown to continental Europe and the British Isles until 1,000 years later.

Celsus, a notable Roman writer, promoted the therapeutic value of bleeding that continued to be practiced for 1900 years. Bleeding has some proponents extolling its virtues today.

Galan was a great Roman writer on medical and surgical subjects of the Roman world. Galan looked upon the human body only as a receptacle of the soul. This view was respected by both Mohammedans and Christians for several centuries. Galan's theory was based on the fundamental thesis of Pythagoras and Hippocrates that life was composed of four elements -- earth, air, fire and water. The proportions of these humors determined a man's disposition, mental qualities and his state of health. Galan elaborated on this combined theory and gave it much more importance. For about 1500 years, the humoral theory had to be studied and understood by doctors before they could practice medicine. They believed that you could not diagnose and treat patients without it.

Although the Romans did little to advance the cause of medicine, they did establish great sanitary systems. The Romans were still visited by plagues and epidemics that may have contributed to the fall of Rome. It became necessary to send for the Roman Legions in Briton. Their return to Rome opened Briton to the Anglo-Saxon invaders. Many of us can trace our ancestry to these invaders.

INFLUENCE OF THE MIDDLE AGES

The Middle Ages (Dark Ages) describes the period between the downfall of classical civilization and the revival of learning. Some believe this period lasted from about 476 until 1440 when printing was invented. Only classical standards were accepted and new discoveries and theories were looked upon with suspicion and fear. All achievements during the millennium were disparaged. It was one of the greatest periods of construction of our time. The great Cathedrals of Europe were built, great epic poems were written and universities were founded. By this time, most people had converted to a system of monotheism. The Church was supreme. It continued to practice secret rituals and elaborate ceremonies. Classical learning and classical science survived mainly in monasteries. Knowledge was only valid when it fit in the master plan of the Church. Sterility of thought and lack of intellectual initiative resulted. Studies of the disease process and of patients' symptoms were neglected. The ambition of the physician was not to study the disease, but to study what was already written and make commentary on it. Astrology had a profound influence upon medicine. Superstitions and fears from previous generations were again paramount. Physicians were helpless during the the Black plague and leprosy epidemics of the Middle Ages. People again sought supernatural aid. It was a period when experimentation and the birth of new ideas were discouraged and punished.

ARABIC ENLIGHTENMENT

During the time of the Dark Ages, Nestor was the Bishop of Constantinople. He was excommunicated because he had developed some new beliefs which were considered heretical. Nestor and his band of followers (the first Unitarians) traveled eastward. Some reached China, others stopped in Palestine, but most of them settled in Arabia. They carried with them many precious documents such as the writings of Hippocrates, Galan and Celsus, among others. They inspired the Arabians to copy these documents into Arabic. They became the most learned people of the time on Egyptian, Greek and Roman medicine.

Because of the zeal of its followers in the seventh century A.D., Islam swept the land. By the ninth century, a great Muslim empire was established. Their initial rejection of the infidel writings yielded to the value of this knowledge. Unfettered by the constraints of western Europe, specifically the constrictions of the Church, science and education moved forward.

In 1160 A.D., one of the first great hospitals was founded in Damascus on the principle that all persons could be treated. The poor were treated for free. The hospital also had a laboratory where tinctures and decoctions were made up and dispensed to the people. Medicine had reached far beyond superstition and magic. New discoveries were constantly being made and accepted by other physicians. Men worked together to cure the diseases of the world. Hospitals and physicians began to evolve into what we know today (Singer, 1962).

The chroniclers of Islam kept very detailed records on the administration of the hospitals in Baghdad. Records are in existence of their budgets, salaries of physicians, oculists and attendants. In the year 931, a medical board was formed for the examination of physicians who wanted to practice medicine. A physician could not practice until he passed the examination. It was the beginning of the regulation of knowledge needed to practice medicine.

ANGLO-SAXON PRACTICES

After the Anglo-Saxons overran England, they had many documents written in the eleventh and twelfth centuries in their possession. These documents consisted of a mixture of magic and herbal practices used to charm away the diseases of the time. The Anglo-Saxons believed that disease was the result of elves, demons or was due to worms invading the body. Many of their remedies were wholly magical. For example:

> "For a woman bewitched: Take at night, while fasting, a root of a radish. After this the unseen cannot harm her (Atkinson, 1958)."

Or this cure for warts:

> "Take seven little wafers and write upon each the names: Maximianus, Malchus, Marche, Johannes, Martianius, Dionysius, Constaninius. As a charm sing their names into the right ear, then into the left ear; then let one who is a maiden go to him and hang the charm upon his neck. He will be well in three days (Atkinson, 1958)."

In order to disgust the elfish enemies and drive them away, the herbal remedies given to patients were often nauseating and repulsive.

These superstitious ideas persisted for centuries until new drugs from America helped to dispel them. They still persist in some areas of the New England and Canada. The droppings of cattle are still a favorite remedy for painful inflammations that came to these areas over three hundred years ago.

Pillories were invented to punish people who had committed a crime not serious enough to be punished by death or by a long term in prison. There was quite a surge of unlicensed apothecaries and barber surgeons at this time. The pillories came to the New World with the pilgrims and were used well into the 1800's. The law in Delaware regarding pillories was not abolished until 1905.

THE MEDICAL SCHOOL AT SALERNO

During the Middle Ages, there was a hospital and school established at Salerno, Italy. Salerno had long been known for its reputation as a health resort. Patients and doctors flocked to Salerno. It became a center for trade and learning, as well as, a medical center. The hospital and school built a reputation famous for its cures . Pilgrims came from throughout the land. Robert, the son of William the Conqueror, came to be treated for an arrow wound received during a crusade. Before he left, a poem was written in his honor. The poem, ***Regimen Sanitatis Salernitanum,*** was widely translated and published over the next four centuries. This poem not only kept alive the work done at Salerno, but also functioned as a code of health with many verses extolling the virtues of diet, exercise and general hygiene. Here are two separate verses of the poem which are applicable today.

Advice to the Layman
If thou would have health and vigor
Shun cares and avoid anger.
Be temperate in eating
And in the use of wine.
After a heavy meal
Rise and take the air
Sleep not with an overloaded stomach
And above all thou must
Respond to Nature when she calls.

Another verse was written by a doctor for other doctors:

Let doctors array themselves well.
Sparkling jewels are not amiss.
When you have them show them.
Ride in a well-attired vehicle
For when you are well dressed
You may charge a higher fee.
Patients always pay a doctor best
If he appears to be well dressed.
While those who go in shabby clothes
Must put up with small fees.
There always will be poor doctors
Who get a pittance for their work (Atkinson,1958).

Even in the Middle Ages, the doctors were concerned about their fee. It is an example of the way things were starting to evolve. Even during the time of primitive man, the medicine man was considered special and had a place above the rest of the group. As we can see the physicians did not want to part with that perk.

THE RENAISSANCE - PERIOD OF TRANSITION

Although this period is difficult to place chronologically, the Renaissance was a period of transition from the Middle Ages. Many believe it began in 1453 with the fall of Constantinople. Others believe it was 1454 with the invention of the printing press. The discovery of America in 1492 is also considered a plausible date because of the great impact the discovery had on Europe. It was a rebirth of the dignity of the individual and a desire for spiritual freedom. It was a time when experimentation, exploration and new ideas were applauded. The Renaissance began in Italy and spread across Europe. Many great men lived and worked during this time. The sciences flourished. Some of the great artists were studying the human form very closely. They soon came to realize that they had to study anatomy, especially of the bones and muscles, to reproduce the human form accurately. They began to dissect the human body. Leonardo Da Vinci (1452-1519) was the most important artist in contributing to the advancement of scientific medical knowledge based on anatomical structure.

CONTRIBUTIONS OF LEONARDO DA VINCI

Da Vinci practiced anatomical dissection for years and was preparing a medical text book with the help of a medical teacher. Unfortunately, the medical teacher died and the book was never finished, but many of Leonardo's exquisitely illustrated drawings still survive today.

Leonardo Da Vinci was one of the first to question the philosophy of Galan and his humors (Singer, 1962). He conducted many first hand investigations of the bodies of men and animals. He was especially interested in the heart and its blood vessels. He examined the structure and form of the heart and prepared the most accurate drawings available at the time. He came to understand how the valves of the heart allowed the blood to pass only in one direction to prevent regurgitation. He was especially interested in how the individual muscles moved bones. He dissected and experimented with groups of muscles and the bones to which they were attached. He was interested in fetal development. He even studied the brain.

Da Vinci never published any of these works. His notebooks remained hidden for over two centuries.

ANDREAS VESALIUS, UNCONVENTIONAL BREAK

Andreas Vesalius of Brussels was only four years old when DaVinci died. He was the first man to write and anatomical textbook based on direct observation.

Vesalius was appointed professor of anatomy and surgery at Padua. His earliest writings reflected the teachings of Galan and Aristotle. As Vesalius did more and more research, he soon found that Galan and Aristotle's teachings could not always be trusted. He began to question every teaching they had made and soon found himself in total disagreement. He threw himself into the study of anatomy. In 1543, his book titled ***De humani corporis fabrica*** (The Fabric of the Human Body) was printed. It was a landmark in the history of science and an unconventional way of thinking. Since Vesalius's teachings were in conflict with the teachings of Galan and Aristotle, he soon encountered repercussions. He was brought before the Inquisition and charged with dissecting a living body. He escaped with a promise of atonement and the promise to make a pilgrimage to the Holy Land. On his way back from Jerusalem, he was shipwrecked and died.

THE REFORMATION

In 1517, Martin Luther had posted his 95 theses in Wittenberg and the Reformation was begun. The Renaissance was largely secular and religiously tolerant. The Reformation was mainly religious and intolerant. The door was opened for men to study current beliefs and to question, experiment and find new answers of their own. Research and experimentation fluorished. It was no longer dangerous to question the status quo. Scientists became an honorable occupation. The domination of magic and of religion in medicine had ended. Scientific research began to evolve into what we know today. Scientists, free of the constraints of magic and religion, were finally able to make great strides in their fields.

EVOLUTION OF TECHNOLOGY

Instruments were invented to help with experiments such as microscopes, thermometers, surgical instruments and the Crookes tube. From this time on, the history of medicine moved rather quickly with new discoveries. Medicine began to follow the emprico-rational model.

Roentgen's discovery of x-rays changed the face of medicine and has evolved into a high tech modern miracle. As we all know, Roentgen discovered x-rays in 1895 by accident. It was a major breakthrough for the diagnosis of illness. It was heralded as the beginning of an era where uncertainty and empiricism gave way to knowledge. Fluoroscopy was performed within a year of Roentgen's discovery. Radiographic tubes were improved to allow better production of x-rays. The benefits of radiation therapy were discovered. Radiation protection devices and practices were being employed. In 1906, a lead bowl was used to surround the x-ray tube. In 1913, protective gloves and shields came into use. By 1929, pictures of radiographic equipment show all the basic elements we still use today: enclosed tube, cones, bucky, stationary tables and control panels with mA, time and kVp selectors. The image intensifier came into use in the 1960's.

One of the greatest advances in x-ray was the pairing of x-rays with computers. Computed tomography (CT) was developed in the early 1970's. This modality has moved forward to become one of the most useful diagnostic tools that we posess.

Computed axial tomography consists of a narrow beam of x-rays that move in a 360 degree circular motion. The x-rays are picked up by an array of detectors. CT provides cross sectional images of the part being examined. The images are displayed on a cathode ray tube or monitor.

The images can be stored or printed. In the early days, exams could take as long as one hour to complete.

CT scanning is able to detect small changes in organs. It has been most useful in the brain and abdominal regions. The development of CT has provided us with a non-invasive method for diagnosis of many disease processes that would ordinarily have required surgery for detection (Piotrowski, 1996).

A patient that complains of headaches or dizziness could have several diagnoses: migraine headaches, tumors, stroke, etc.. They would have to undergo several tests, many quite painful, for confirmation of a diagnosis. One early test that has now been discontinued was the pneumoencephalogram. The procedure required replacement of some of the cerebral spinal fluid with a gas to delineate the ventricles of the brain. It was not only extremely painful, but it was also dangerous.

In the 1980's, CT was combined with the procedure of stereotaxic surgery to provide an added dimension to diagnostic and clinical medicine (Hatfield, 1998). The combination of techniques allowed for pinpoint accuracy. Today, we have computer mediated stereotaxic radiosurgery. Missile tracking technology, robotics and powerful x-ray machines are used to safely destroy cancerous tumors in the brain and spine. These procedures can be performed without opening the skull or risking the partial paralysis that may occur in spinal surgeries. We have multislice CT scanners that can display multiple images of a patient's anatomy "6 times faster" than traditional single slice scanners (Hatfield, 1998). The electric beam computed tomography fast scanner was developed by Imatron. It is able to give a more complete diagnosis of heart disease than the more conventional indicators used. At the Cooper Aerobics Center in Dallas, Texas, the EBCT scanner is used in their comprehensive health screening program. The speed of the EBCT scanner allows them to measure the heart and vessels between beats. Calcium deposits can be visualized in three dimension. The bone density of the lumbar spine can be measured and used to determine the risk of osteoporosis.

Future uses of computed tomography in the prevention and diagnosis of disease are only limited to our imaginations.

Angiography is the injection of a radiopaque contrast media into the vascular system for the x-ray analysis of an organ (Piotrowski,1996). New CT scanning technology is able to replace conventional angiography with non-invasive imaging. The lightspeed scanner can "extend the exam and create images of the anatomy of the leg vessels down to the toes" according to Dr. Gary Glazer, MD, professor and chairman of the department of Radiology at Stanford University in Stanford, California.

The principles of Magnetic Resonance Imaging were discovered in the 1940s by Edward M. Purcell and Felix Bloch. They were awarded the Nobel Prize of Physics for their work in 1952.

MRI is fundamentally different than x-rays. A magnetic field is created by a powerful magnet. This magnetic field aligns the body's hydrogen protons. Hydrogen protons are used because there are so many. The protons are knocked out of alignment by radio wave pulses. As the protons realign, they emit radio signals that are detected and converted to visual cross-sectional images (Pietrowsky,1996).

During the 1970's, many innovative changes were made to MRI scanners that broadened the use of this modality. Two dimensional MRI made it possible to gain information on the structure of large molecules of biological importance (Pietrowski, 1996). Today, we have three dimensional and four dimensional magnetic resonance imaging equipment used in important protein studies.

MRI has come to the forefront in the area of cardiac anatomy and function. MRI is able to evaluate cardiac valves, cardiac output and cardiac mass. Pericardial abnormalities and wall thickening of the heart can be detected. Flow imaging technique enables the use of MRI in studies of the vascular system(Ward, 1998).

There are some limitations for patients having an MRI. Patients with pacemakers, certain aneurysm clips, prosthetic devices and patients that may have metal splinters in their eyes may not be candidates for MRI examination.

CONCLUSION

After the end of World War I, the United States and Canada experienced a prolific growth of medical schools and hospitals. A key component to this growth was the Rockefeller Foundation that was established in 1913. It gave generous gifts of money and personnel for the fight of disease and to aid in the development of medical, public health and nursing education. There were many fine schools that benefited from this aid. Johns Hopkins, The Columbia - Presbyterian Medical Center and Cornell Medical Center are just a few that made great strides in improving medical education.

Another striking feature of the early 20th century was the development of private clinics in various parts of the country. A few of these famous clinics are Mayo Clinic in Rochester, Minnesota, Cleveland Clinic in Cleveland, Ohio and the Lahey Clinic in Boston.

Many procedures are becoming less invasive because of new developments and equipment today. We have virtual reality programs that help teach students interventional procedures. We have color doppler sonography. We are able to observe the fetus with 3-D ultrasound. Doctors do laser surgery and angioplasty. We have spiral CT angiography and 3-D reconstruction.

Positive Emission Tomography (PET) scanners and Single Photon Emission Computed Tomography (SPECT) scanners have made great advances in nuclear scanning (Ward, 1998).

MRI, with its roots in the early Greek interest in properties of magnetism and electrostatics, has become on of our foremost diagnostic tools.

By the twentieth century, important advances were made in chemistry, bacteriology, pathology, physiology, physics and pharmacology. Achievements in medicine had grown steadily. Medical equipment had become developed to a point that could only have been imagined in science fiction such as the development of 3-D imaging of tumors, organ transplants and artificial hearts. We have ended one of the most scientific and technologically based eras in history as we begin the new millenium with great anticipation of even more spectacular achievements.

Today, more than ever, the ancient Greek philosophy still applies as the best medicine we can give our bodies: To live a good life avoid stress, watch your diet and exercise.

A SHORT, SYNOPSIZED CHRONOLOGY OF MAJOR SCIENTIFIC ACCOMPLISHMENTS

William Turner - (1520-1568) He was a physician, naturalist and considered the Father of English Botany who wrote ***A new Herball,*** in 1551 (only English herbal written in the 16th century).
Julius Caesar Aranzio - (1530-1589) He published his first book in 1564 entitled ***De humano foetu*** to explain the pregnant uterus that included the most complete description of the human fetus up to that time.
Giambasta Cortesi - (1554-1636) He became a professor of surgery and performed rhinoplasty.
William Harvey - (1578-1657) He gave the first demonstration of the circulation of blood and also described pulmonary circulation. He is considered to be one of the greatest scientific geniuses of the British nation.
Rene Descartes - (1590-1650) He was a French philosopher and author of the first ***"text-book of physiology".*** He did many studies on the anatomy and physiology of the eye.
Santorio Santorio - (1561-1636) He invented three types of thermometers and a pulsiologium. He weighed himself after eating and also weighed his body wastes and found that food ingested was not all excreted in body wastes.
Marco Aurelio Severino - (1580-1656) He was a professor of anatomy in Naples in 1610 who is said to have been the first to have ligated the femoral artery. He performed tracheotomy suffocation in diphtheria.
Conrad Victor Schneider - (1614-1680) He was a professor of medicine at Wittenberg in 1639. He proved by dissection that there was no opening between the brain and the nose. Following his discovery, physicians stopped "purging the brain" in cases of asthma.
Anton van Leeuwenhoek - (1632-1723) He spent much of his time grinding lenses and making microscopes. He was known as the Father of "Protozoology and Bacteriology."
Richard Lower - (1631-1691) He performed the first successful blood transfusion in February, 1665.
John Louis Petit - (1674-1760) He was one of the greatest surgeons of his time and developed many new operations. He was the first to perform a cholecystecomy.
William Smellie - (1697-1763) "One of the most important obstetricians of all times and all countries." He was born in Scotland and eventually moved to London where he taught midwifery. He invented several obstetrical instruments, including forceps.
Jean Baptiste Senac - (1693-1770) He published the first comprehensive systematic book on the anatomy, physiology and pathology of the heart and on heart disease.
Matthew Dobson - (1784) He first described and demonstrated sugar in the urine of a diabetic.
James Lind - (1716-1794) He discovered the nature of scurvy and found that scurvy did not occur when given lemon juice. Within two years after his death, scurvy disappeared from the sailors in the British navy.
Caspar Friedrich Wolff - (1733-1794) He became known as "the Father of Modern Embryology."
Edward Jenner - (1749-1823) He discovered the vaccination for small pox that is considered to be one of the greatest discoveries in medicine.

John Morgan - (1735-1789) He was a pioneer in American medical education. He stressed the need to raise the qualifications for medical students.
Benjamin Rush - (1746-1813) He was one of the most famous physicians of Revolutionary times. He studied fevers (scarlet, typhoid, yellow) and wrote the first American textbook on psychiatry.
Joseph Priestly - (1894-1984) He discovered the anesthetic effects of nitrous oxide in 1772.
Charles Darwin - (1809-1882) He published ***On the Origin of the Species*** in 1859. Few books in the history of science have had more influence on biology, sociology, philosophy and religion.
Joseph Lister - (1827- 1912) As a surgeon, he practiced antisepsis on his patients and found that they did not get secondary infections.
Agostino Bassi - (1771-1856) He is considered "The Founder of the Parasitic Theory of Infection."
Louis Pasteur - (1822-1895) He discovered "pasteurization." (a method of destroying bacteria by heating milk for a few moments at a temperature of 50 to 60 degrees C.).
Robert Koch - (1843-1910) He discovered Anthrax bacillus and how it developed. He is considered one of the greatest bacteriologists of history.
Walter Reed - (1851-1902) He worked on Yellow Fever Commission and discovered yellow fever spread by mosquito bites.
Wilhelm Konrad Roentgen - (1845-1923) He discovered X-rays on November 8, 1895.
Pierre and Marie Curie - They collectively discovered radium in 1898.
Sigmund Freud - (1856-1939) He investigated psycho neurosis and his theories have had a powerful impact on psychiatry.
Paul Ehrlich -(1854-1915) He devised a procedure for staining blood that served as the beginning of modern hematology. He did the most prolific work in infectious diseases since Koch and Pasteur. He created a new science called chemotherapy.
James Herrick - (1861-1954) He described the first clinical description of coronary occlusion in 1912 and he described the first case of sickle cell anemia.
Rudolf Matas - (1860-1957) He pioneered work on nerve blocking, spinal anesthesia, and laryngeal intubation. He was the first to make advances in the surgery of aneurysms.
Ivan Pavlov - (1849-1936) He is considered one of the greatest physiologist of modern times. He studied the relationship of psychic stimuli to digestion and to investigate the field of conditioned response.
Frederic Banting - (1891-1944) He and Charles Best announced the discovery of insulin in 1922. It revolutionized the treatment of diabetes mellitus.
Alexander Fleming - (1881-1955) He discovered penicillin in 1928 that saved millions of lives.
Jonas Salk - (1914 -1995) He introduced his polio vaccine in 1954. Millions of children were vaccinated and avoided the crippling disease.
Albert Sabin - (1906-1993) He introduced his oral vaccine in 1961 that became the vaccine of choice for polio.
Dr. Michael Debakey - (1908-) In 1965, he implanted the first mechanical heart devices to help a diseased heart.
Christiaan Barnard - (1922-) He is a South African surgeon who performed the first whole heart transplant from one person to another in 1967.
Willem DeVries - (1943-) He is an American surgeon who performed the first artificial heart transplant in 1982 at the University of Utah Medical Center. The patient lived 112 days.

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UNIT NUMBER __19__

THE ORIGINAL X- FILES: WILHELM KONRAD ROENTGEN

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INTRODUCTION

In this unit we will review the life of Wilhelm Konrad Roentgen from his early childhood to his amazing discovery of x-rays and his Nobel Prize. We will continue to review some of the advances in Radiology and also some of the different applications of x-rays.

EARLY LIFE

Wilhelm Konrad Rontgen was born in Lennep, Germany (Prussia) on March 27, 1845. The spelling of his last name is often Anglicized to Roentgen. His father was a German textile merchant and his mother was Dutch. During the early years of Wilhelm's life, there was much political instability in Germany. In 1848, his father moved the family to Appeldoorn, Holland. The family gave up its Prussian citizenship in favor of Dutch citizenship. In later years Wilhelm would again be given his German citizenship(Stehling,1995).

Wilhelm was an only child and was brought up in the comfortable and secure life of the well to do. He was much loved and probably slightly spoiled. He was considered to be somewhat of a "problem" child. Because Wilhelm found the strict discipline of the Dutch education system to be difficult to adhere to, his elementary school performance was less than admirable. He did, however, show an enthusiasm for some of the science classes he attended.

By 1862, 17 year old Wilhelm had completed his secondary education. He looked forward to attending a technical school in Utrecht, Holland. His days at Utrecht were not much different from his days in secondary school. His performance was hardly remarkable and he only did enough to get by. One day towards the end of his career at Utrecht, another student had drawn a caricature of the professor on a decorative stove screen. Wilhelm, never one to pass up a good time, was among the students standing around congratulating the artist and laughing. Unfortunately, Wilhelm did not hear the teacher coming down the hall. He was soon looking into the same disagreeable face at which he had just been laughing. He sobered instantly and when he looked around, he realized he was alone at the stove. The other students had all taken their seats. Not known for his artistic ability, the professor knew Wilhelm had not drawn the caricature, but demanded to know who had done the artwork. Wilhelm, looking at his fellow students, answered: "I can not tell you, sir." The professor was enraged. Determined to punish someone for this practical joke, the professor went before the school board and demanded that something be done (McClafferty, 1997). As a result, Wilhelm was made the example. He was expelled from the Utrecht Technical School. He failed his two years without matriculating. He received final grades of "very poor" in physics and "failed" both the ancient languages of Latin and Greek (Stehling, 1995).

His father, as most fathers would, interceded on Wilhelm's behalf. He won the right for Wilhelm to take a private examination that would give him the credits he needed to attend college. Wilhelm studied laboriously for the exam. He worked diligently with the teacher in his effort to pass. Unfortunately, the day before the exam was to be given, his teacher fell ill and had to be replaced. The replacement was one of the instructors who had urged Wilhelm's expulsion from school. Wilhelm failed the exam and was devastated because he could not attend the University at Utrecht to earn a degree.

It was not only the "poor" in physics that bothered him, but his failure of the ancient languages of Latin and Greek. In the Dutch system of education, the knowledge of these languages was mandatory to attend the Universities. Wilhelm was allowed to attend the University of Utrecht as a "visiting" student. This status allowed him to attend classes and lectures, but he received no grades. His continued failure of Latin and Greek also plagued him. Wilhelm was at loose ends (Thomas, 1948).

GOOD ADVICE

Carl Thormann, a friend of Wilhelm's from the technical school, was concerned about Wilhelm's discouragement. He went to his father and pleaded with him to talk to Wilhelm. Mr. Thormann, who was born in Switzerland, urged Wilhelm to transfer to the Polytechnic Institute in Zurich. The famous institute did not require a diploma or proficiency in the ancient languages (Stehling, 1995).

Roentgen was elated. He rushed home to convince his parents that this was what he wanted to do. He promised that this relocation would be the end of his problems and that this opportunity would put him on the road to his career as an engineer. Roentgen's parents gave in. With their blessing, Wilhelm applied and was accepted to the Polytechnic Institute. In November, 1865, Roentgen entered the hallowed halls of the Polytechnic Institute.

POLYTECHNIC INSTITUTE

Unfortunately, Wilhelm continued with his poor study habits. He was erratic at attending classes. He much preferred the beauty of the Swiss lakes and mountains to the classroom. He reveled in the frequent social gatherings. He attended picnics and parties and did not let his studies interfere.

Wilhelm was a tall man and he dressed very fashionably due to the continuous generosity of his parents. He was well liked by his fellow students who nicknamed him "Appeldoorn" for his hometown. With his friends and schoolmates, Wilhelm enjoyed frequenting the coffee bars and taverns. At one of these inns, Wilhelm met and became very good friends with the innkeeper, Gottfried Ludwig. Ludwig was a very colorful individual and was very popular with the students from the Institute. Ludwig was a former revolutionary and had been forced to leave his home in the 1830's. He was excellent at fencing and taught many of the students its finer points. He was able to translate their theses into Latin for them and was always able to quench their thirst with wine and beer.

Ludwig's tavern became Wilhelm's favorite social spot. His enjoyment was only enhanced by the presence of Ludwig's daughter, Anna Bertha. Roentgen fell in love with Anna Bertha and began to court her seriously. They went on picnics by the beautiful lakes and in the mountains. He finally asked Anna Bertha to marry him and she accepted. In 1868, their engagement was announced. Before Anna Bertha could marry Roentgen, she went to live in Appeldoorn with Wilhelm's mother to learn the finer points of her intricate ways of cooking and other domestic duties (Thomas, 1948).

Wilhelm spent three years at the Polytechnic Institute. He studied both engineering and theoretical physics. His studies included steam engines, machine design, and thermodynamics. His grades varied from "excellent" in analytical mechanics to "poor" in more practical subjects. His professors, aware of his haphazard ways, did not think he would ever earn his diploma. Roentgen persevered and by August, 1868, he had passed his "exit" exams. He became classified as a mechanical engineer. Roentgen's future was still not clear. He knew he did not want to spend his life as an engineer.

A NEW CAREER

In the fall of 1868, a young physicist from the Polytechnic Institute, August Kundt, was about to change Roentgen's life forever. Kundt had noticed Roentgen's aptitude in certain subjects. He came to Roentgen and tried to persuade him to abandon engineering and follow the path of physics. He came with the offer of an unpaid position as his assistant. Roentgen readily accepted. At the age of 24, he began to study physics seriously and started on his long journey to his discovery.

His relationship with Kundt flourished. Wilhelm's work schedule was light in the beginning. Kundt was only five years older than Roentgen and they worked well together. They liked to flirt with the girls in a store across the street when they took breaks from their work (Roentgen had not married Bertha yet).

Roentgen began to pursue a career in physics with uncharacteristic zeal. He experimented and studied gas behavior. He discovered some interesting new facts. Kundt was so impressed with Wilhelm's professionalism and the caliber of his experiments that he submitted his name as a candidate for a Ph.D. at the University of Zurich.

Roentgen worked with a former professor from the Polytechnic Institute, Professor Gustav Zeuner (Stehling, 1995). Roentgen committed himself to receiving his Ph.D. He worked with a zest that his professors had only rarely seen. In June, 1869, Roentgen received his Ph.D. from the University of Zurich.

Now that he had achieved his Ph.D., Roentgen hoped to be recognized as an academician. This did not happen. Roentgen, continuing his work with Kundt, still unpaid, became senior assistant. He began working with the electrical and acoustic phenomena in gas-filled glass tubes.

In April 1870, Kundt was offered a professorship at the University of Wurzburg in Germany. Impressed with Roentgen's work with the properties of gases and the congenial relationship they enjoyed, Kundt asked Roentgen to accompany him and continue as his assistant. This time Roentgen was paid 1,000 marks a year as a stipend. Roentgen mournfully noted that he made less than a common laborer. At the University of Wurzburg, Roentgen received a small amount of academic recognition. Yet he was not raised to the level of academician because of his failure to pass secondary school Greek and Latin even though he had his Ph.D.

Roentgen began to acquire a tremendous knowledge of physics by reading any journals and papers he could find. On many nights, he stayed up late into the night. He was exploring various fields, finding solutions for one problem and moving to the next, without advertising the success of his investigations. His success was not hindered by the fact that as a result of a childhood illness, he had clear vision in only one eye and was also color-blind (Thomas, 1948).

As a boy, Wilhelm had shown that he had a knack for developing mechanical gadgets. As a scientist he was able to construct his own experimental apparatus. He usually worked alone without a lab assistant and felt that a physicist should be able to accomplish great things with just a pocketknife.

Roentgen was doing important work. He determined rigorous values for the specific heat of gases, particularly that of air. He did this work on an apparatus of his own design. This exciting discovery led to the publishing of his first paper in the Annals of Physics and Chemistry, an eminent scientific journal, in October 1870. His article explained his findings on the specific heats of gases. This research helped to bring down the walls of resistance to becoming a member in the ranks of the academicians (Thomass, 1948).

On July 19, 1870, France declared war on Prussia. It was a disastrous move on France's part and they suffered defeat in a few weeks. Because Roentgen held Dutch citizenship he was not involved in the fray. The Prussians demanded millions of marks in gold for reparations. This was a boon to Germany's universities and research facilities, which received a part of the money. The University of Strassburg was established at this time (Stehling, 1998).

In 1871, as Kundt's assistant, Roentgen was doing much more in helping Kundt prepare for classes and was even teaching some of the elementary physics classes. His salary was raised to 5,000 marks per year. He was still considered Kundt's assistant and not a member of the faculty. His salary was paid by Kundt. His raise in salary allowed him to fulfill a long hoped for dream, to marry Anna Bertha who was still living in Appeldoorn. On January 19,1872 they became man and wife.

During this same period Kundt had become quite dissatisfied with the poor equipment and lecture facilities at Wurzburg. He was offered a position at the new University of Strassburg. Roentgen accompanied him, still as his assistant. The University was trying to build a reputation as a major academic institution and was offering excellent teaching and research positions. Roentgen's continuing prominence in research and publishing finally made him eligible for his "union card" that allowed him to be considered as an upper level German academic, without ever having passed Latin and Greek.

Roentgen attained the rank of private lecturer and was well on his way to a full professorship. Finally given a salary and some research space of his own, his scientific reputation grew rapidly over the next two years. With a colleague, Franz Exner, Wilhelm published five papers during that time. The papers discussed the electric properties of gases, polarization of light in gas columns and heated gas radiation phenomena.

PROFESSOR ROENTGEN

In 1875, Roentgen was finally offered a position as a professor in math and physics at the Academy of Hohenheim near Stuttgart, Germany. His German citizenship was also restored at this time. He excitedly accepted the position. Kundt was disappointed to see Roentgen go. They had worked well together for many years. He realized that Roentgen was leaving him to establish his own career.

Roentgen was pleased with the atmosphere at Hohenheim and his new status. He was, however, discouraged with his light teaching schedule of elementary algebra and basic physics. They also wanted him to teach a class on zoology. He wanted to become more involved in the in depth courses in physics and experimentation.

In 1876, the University of Strassburg offered him a position as "Extraordinary Professor of Physics." Roentgen jumped at the chance to work with the upper level classes and resigned his position at Hohenheim. He was also given the opportunity to renew his relationship with Kundt at Strassburg (Thomas, 1948).

He and Anna Bertha found a pleasant house near the university and life was very comfortable for them. Roentgen threw himself into his new research with Kundt. He was becoming more interested in the phenomena of electric discharges in gas filled containers. Between 1876 and 1879, he and Kundt published more papers on the process of light polarization in gases when subjected to electric fields. Roentgen discovered a way to measure the conductivity of heat in crystals. He researched the absorption of heat rays in water vapor. He also contributed information on the electromagnetic rotation of the planes of light on the polarization in gases (Thomas, 1948).

In 1879, at the age of 34, Roentgen was offered the senior professorship of physics at the University of Giessen. Several of the leaders in the German scientific community recommended his appointment. The Ordinarius (senior) position was quite a prize. The small, but famous, university offered Roentgen both social and academic prominence. He received a large salary. Wilhelm and his family rented a large house and had domestic servants. Roentgen's parents also moved to Giessen. They enjoyed the company of their son and daughter-in-law, in addition to, enjoying the benefits of his social standing.

The University at Giessen was famous for its chemistry department. It was Roentgen's desire to make physics just as famous and important. He developed a physics program worthy of the serious physics student. Roentgen stayed in Giessen for ten years continuing his research.

Roentgen hoped to advance from the already distinguished status of professor to the director of an institute. Giessen did not hold that promise for him. In 1888, Wurzburg offered him the position of professor of physics and director of its Physics Institute.

Roentgen accepted immediately. He had no binding ties to Giessen. His parents had died earlier. Wurzburg offered him comfortable quarters over his well-equipped lab. In 1894, Roentgen began a series of experiments based on Lenard's work on electric discharges in vacuum tubes. By October 1895, Roentgen's career was about to reach its peak.

Many of his experiments were based on the research of his fellow scientists. Here are just a few who had important developments that contributed to Roentgen's success:

Heinrich Geissler, a German physicist, instrument maker and glass blower who invented a gas filled light emitting tube that produced a controlled continuous light. He also advanced the development of the modern vacuum pump that was necessary for all experiments in electron conduction through vacuum and gas tubes (Bleich, 1960).

Johann Hittorf , a German physicist, named the mysterious flow of electricity in the vacuum tubes "cathode rays."

Sir William Crooks, an English physicist, improved on the Geissler tube. He found that as air pressure in the tube was reduced by a vacuum pump, a thin bright stream of light could be seen flowing between the anode and the cathode. As the pressure in the tube was lowered farther, the stream of light became a bright column of light, filling the whole space between the electrodes. When the pressure is at about 0.001mm of mercury the wall of the tube glowed. Crooks missed his chance of discovering X-rays when photographic film in protective packaging was fogged in his lab. The science of the day could not explain this occurrence and he dismissed the incident as unimportant (Bleich, 1960).

Phillip Lenard , a French scientist, demonstrated the cathode rays could escape the aluminum window of a glass tube. Roentgen was trying to reproduce Lenard's experiment when the fateful discovery of x-rays occurred on November 8, 1895 (Electronics, 1995).

A FATEFUL DAY

On November 8, 1895, Roentgen had been studying the discharge of electrons from a Crooke's tube so he could try to explain the phenomena. Because the Crooke's tube glowed slightly when the current flowed, he darkened the room so he could see the glow better. He also covered the end of the tube with black cardboard to block the cathode rays.

Much to his annoyance, he noticed a fluorescent glow from a sheet of paper coated by platinum cyanide across the room. He looked around for the source and saw the Crooke's tube glowing. He was baffled because the end of the tube was still covered with cardboard. He shut off the power and the paper stopped glowing. He turned the tube back on and the greenish glow reappeared. He put a book in front of the tube and the paper still glowed. He replaced the book with a block of wood and then a rubber shield with the same results. He then put a box of brass lab weights in front of the tube and found that the dark silhouettes of the weights showed up on the paper (Electronics, 1995).

Finally he put his hand between the tube and the paper and was amazed to see a faint outline of his flesh and the dark outline of his bones. He realized at once that he had made a major discovery. He called the radiation "X-Rays" because "X" indicated an unknown factor in math.

Roentgen sequestered himself in his lab and worked night and day on his discovery. One night his wife went to Wilhelm's lab looking for him. She was worried because he had not been eating right and had been working so late each night. It was then that Wilhelm explained his findings to Anna Bertha and took the now famous x-ray of her hand.

It took Roentgen seven weeks to analyze his discovery and write a paper on it. He also built a collection of radiographs, not only of hands but of other objects like the box of laboratory weights and a wire hidden in a spool. In January, 1896, he presented the paper to the Physical and Medical Society of Wurzburg. He also mailed reprints of his paper and copies of the x-ray photos to many of his colleagues throughout Europe. His colleagues were swift to recognize the diagnostic potential of his x-rays after seeing Bertha's hand. Requests for data came from all over Europe and the United States. The Sunday edition of a leading Vienna newspaper proclaimed the news of the rays that penetrated solid objects. The other newspapers picked up the story and it was in headlines across Europe and the United States. Articles appeared in science weeklies, often with incorrect information.

Within a matter of weeks, the x-ray craze ballooned. Manufacturers collected the equipment needed to produce a portable x-ray set. Verses were written and cartoons were drawn. Photography shops were overwhelmed with requests for the x-ray pictures.

This new discovery brought out the charlatans and quacks (Thomas, 1948). One person proclaimed that x-rays, over a period of three hours, turned a thirteen cent piece of metal into a hundred and fifty-three dollars' worth of gold.

Frances E. Willard, the leader of the Temperance movement, announced that the x-ray would abolish vice in the world because people would be able to see deterioration of the body due to smoking and drinking.

There was one person who proclaimed that he had images of his thoughts and another proclaimed the he had several films with discharges from the human soul.

Roentgen was appalled with all the misinformation and quackery that that was being dispensed. He had also become a magnet for reporters and fans. He was unable to do any further experimentation for several weeks. He decided to take a vacation to get away from all the publicity, but found that he was hounded everywhere he went. Roentgen was a reticent individual who did not like the limelight (Thomas, 1947).

Roentgen was showered with honors and medals in Europe and the United States. The German Kaiser decorated him with the Prussian Order of the Crown. Artists sculpted several busts of him. The University of Wurzburg made him an honorary Doctor of Medicine and his students gave him a torchlight parade (Stehling, 1995).

Roentgen gave only one professional presentation on his discovery, although he did give a few non-technical talks to royal audiences. His short presentation did nothing to acknowledge the contributions of his fellow scientists to his discovery. Lenard, in particular, was quite bitter. He felt that Roentgen's discovery would not have happened without the research of other scientists. His presentation dealt mainly with the properties of x-rays and little else.

Many people advised Wilhelm to take out a patent on his new discovery and use it to increase his own wealth. He refused saying "In accordance with the tradition of German university professors, I believe that their discoveries and inventions belong to mankind and that they should not in any way be hampered by patents."

Many of his colleagues wanted to call the newly discovered rays "Roentgen rays". Wilhelm continued to call them "x-rays".

On December 10, 1901, he was awarded the first Nobel Prize of Physics. Wilhelm did not keep the prize money. He donated the money to research.

In spite of all the quacks and schemers that jumped on the x-ray bandwagon, the development of x-rays made giant steps forward. Fluoroscopes were developed that could show the beating heart and the movement of the diaphragm. All manner of medical problems were photographed such as tumors, bone fractures, dislocations, gallstones and kidney stones. Foreign objects such as bullets and their fragments could be seen and treated with fewer complications. The use of x-ray machines during the First World War saved thousands of soldiers. Roentgen was appalled by the war that separated many of the scientists that had worked together.

He accepted a position at the University of Munich in July, 1899. He remained there until he reached emeritus status and retired in 1920.

His own life was darkened by the chronic, lingering illness of his wife Bertha, his companion for almost 50 years. Toward the end of her life, he never left her side. She passed away in 1919 at the age of eighty-one (Stehling, 1995).

In his last years, Roentgen became homesick for the beautiful mountains of Switzerland. He was invited by friends to visit them in Switzerland and he joyfully made the trip. At the age of seventy-six, he made his final climb of the Alps (Thomas, 1948).

Roentgen died, at the age of 78, on February 10, 1923, of cancer. During his illness, ever the scientist, Wilhelm kept notes on the progression of his disease. He was buried beside his wife Bertha and his parents in Giessen.

THE WORK CONTINUES

Roentgen's work did not die with him. The discovery of x-rays opened a whole Pandora's box of uses. He would have been amazed at the developments that have occurred through the century. X-rays are used productively in many diversified fields.

ADVANCES AND APPLICATIONS IN RADIOLOGY

During World War I, Coolidge portable x-ray machines were used in 1918. During World War II, x-ray machines were parachuted to the front to help wounded soldiers get faster and better treatment.

X-rays are used in industry to check for defects in castings or welded metal. They are used to check the quality of steel beams and armored plates.

X-rays are used to purify food.

X-rays can be used to check for fake jewelry and for forged paintings.

X-rays are used to check the quality of all kinds of goods i.e. foods, crystal authenticity, etc.

X-rays are used for airport security.

X-rays are used to diagnose and treat a multitude of disease entities.

X-rays are used in chemical analysis. Elements give off a specific x-ray emission and absorption of wave lengths. By determining these qualities, an element may be identified.

Astronomers study x-ray emissions from distant points in space to learn about quasars, black holes and the remains of supernovas.

Archeologists use x-rays to study mummies without having to unwrap them.

The study of x-rays opened up new areas for scientists who continued to study radioactivity, cosmic rays and the electron. The whole field of nuclear physics had its beginnings with Roentgen's discovery.

Most of all, new developments in medical radiography have made the greatest strides for humanity. X-rays can relieve the pain of cancer patients with malignant tumors by shrinking the tumors.

One of the most important systems developed in the last 25 years is the combining of x-ray with a computer known as computerized tomography. The computer converts the x-ray signals to video images of a cross section of a patient. Every organ of the body can not only be x-rayed, but can be displayed in cross-section and 3-D (Electronics, 1995).

When Wilhelm Konrad Roentgen made his accidental discovery that fateful day, it has become one of the most important and widely used discoveries of our time.

A CHRONOLOGY OF IMPORTANT EVENTS IN THE LIFE OF WILHELM ROENTGEN

March 27, 1845	Roentgen was born in Lennap, Germany.
November, 1865	Roentgen entered the Polytechnic Institute in Switzerland.
1868	Roentgen was engaged to Anna Bertha Ludwig.
1868	August Kundt offered Roentgen a position as his assistant.
June, 1869	Roentgen received his Ph. D. from the University of Zurich.
April, 1870	Roentgen accompanied Kundt to the University of Wurzburg.
October, 1870	Roentgen published his first paper.
January 19, 1872	Roentgen and Bertha were married.
1872	Kundt and Roentgen moved to the University of Strassburg.
1875	Roentgen offered position as Professor in math and physics. at the Academy of Hohenheim near Stuttfgart, Germany
1876	Roentgen took a position at the University of Strassburg and again works with Kundt.
1879	Roentgen went to the University of Giessen as the senior professor of physics.
1888	Roentgen moved to the University of Wurzburg as director of its Physics Institute.
November 8, 1895	Roentgen made his accidental discovery of x-rays.
January, 1896	Roentgen presented his paper to the Physical and Medical Society of Wurzburg.
July, 1899	Roentgen accepted a position at the University of Munich.
December 10, 1901	Roentgen was awarded the first Nobel Prize of Physics.
1919	Roentgen's wife Bertha passed away after a chronic, lingering illness.
1920	Retired from the University of Munich with an emeritus status.
February 10, 1923	Roentgen died, at the age of 78, of cancer.

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Database

HANDY DISCOVERY

German physicist Wilhelm ***Roentgen*** first saw the bones of his own hand as he waved it between a radiation source and a fluorescent screen 100 years ago this November 8. He named the mysterious rays that seemed to make his flesh transparent "X" for the unknown. Today, X-rays are one of the most widely used diagnostic tools in the world.

· Number of radiologic procedures performed in 1990: 260 million to 330 million

· Dose of radiation needed for a chest X-ray in the 1920s: 20 rads, a unit of absorbed radiation; in 1995: under 0.2 rads; number of cigarettes that would produce health risk equivalent to one X-ray: less than 1

· Mammograms performed yearly: 25 million; average cost of a mammogram: $75; cancer patients who get radiation treatment: 60 percent; patients who get some radiation therapy daily: more than 60,000

· Magnetic resonance imaging (MRI) machines in the U.S. in 1977: 1; 1990: 1,500; 1995: 3,000; MRI exams performed yearly in the United States: 8 million; average cost of an MRI exam: $1,000

· Total payment for radiologic procedures performed in the U.S. in 1990: $19 billion to $22 billion; radiology's share of national spending on health care: 3.5 percent; profit ***Roentgen*** made from his discovery: none; reason: He refused to patent any part of it, viewing it as "a gift to humanity"

USN&WR -- Basic data: The American Society of Radiologic Technologists, Radiology Centennial Inc.

PHOTO (BLACK & WHITE): ***Roentgen***

S★T★A★R★S

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UNIT NUMBER __20__

MADAME CURIE: A WOMAN BEFORE HER TIME

PREPARED BY: CAROLYN J. FRIGMANSKI, M.A., B.S.R.T. (R)

INTRODUCTION

In this unit we will review some of the important life aspects, discoveries and contributions of the world's greatest woman scientist, Marie Sklodowska - Curie. It is important to note that 1998 is the centennial of the discovery of radium that saved millions of cancer patients, encouraged unprecidented research in atomic structure and phenomena and paved the way for future generations of women to pursue higher degrees of education and scientific research. Her youngest daughter, Eve wrote: "She was a woman; she belonged to an oppressed nation; she was poor; she was beautiful. A powerful vocation summoned her from her motherland, Poland, to study in Paris, where she lived through years of poverty and solitude. There she met a man whose genius was akin to hers. She married him; their happiness was unique. By the most desparate and arid effort they discovered a magic element, radium. This discovery not only gave birth to a new science and a new philosophy: it provided mankind with the means of treating a dreadful disease."

For this, we shall be eternally grateful to a shy and brilliant woman of science.

Marie's Birth & Family Life

Manya Salome Sklodowska, as her family called her, was born on November 7, 1867 in a school house on 16 Freta Street in Warsaw, Poland. Manya's mother, Bronislawa, was the eldest daughter in a family of country squires. She was the headmistress of the girl's school and taught music. Manya's father, Valdislav, was the son of a man who directed a boy's school in Lublin. Manya's father taught physics and math in a boy's school several blocks away. The school house at 16 Freta Street has now become a museum dedicated to Manya's early years and her contributions to science.

She was the youngest child and had 3 sisters and 1 brother. Zosia or "Sophia", who was 7 years older, helped raise the younger siblings. In 1876, Zosia was 13 years old and died from Typhus Fever which she contracted from one of her father's pupils who was tutored at their home. Manya was 9 years old. Her only brother, Joseph or "Jozio", wanted to become a physician and attended the University of Warsaw. Bronislava or "Bronya" wanted to become a physician too, but had to leave school early when their mother died from tuberculosis on May 9, 1878. It was many years later when Manya finally realized that her mother never gave her children kisses and hugs because she wanted to protect them from tuberculosis. After the death of her sister and mother, Manya doubted her religion and left the Church of God in her teens.

Helen or "Hela" was the closest sister in age to Manya.

Every year, the children were taken on exciting holidays and/or vacations to the countryside to visit and stay with relatives.

Marie's Education

Manya began reading books at age 4. One day, she stood in front of a polished glass case in her father's study containing glass tubes, bottles, rocks, scales, etc. She asked her father what the items were. He responded "Physics apparatus". Since both her parents were teachers, they encouraged all the Sklodowski children to love learning and that learning was very important. On Saturday evenings, Manya's father read stories out loud to his children in Polish. Manya mastered both Polish and Russian. Manya excelled in school. She was especially excited and loved physics, mathematics and chemistry the best. Academically, she was at least 2 years ahead of her classmates. Her teachers commented that she absorbed and understood large amounts of information, was unusually intelligent and possessed a powerful memory. Socially, she was introverted and loved studying more than parties. 1-1

Manya read everything possible in the original text: authors like Dostoevsky and Karl Marx, in addition to, French, German and Polish poets. She was presented with a gold medal for excellence in her high school studies - in Russian. She was physically exhausted from studies and her father sent her to stay and visit with her uncle in Skalbmierz. Her health restored, she developed a profound love of nature and of the rural, country people.

Since 1773, Poland had come under Russian rule, but had been struggling for self-determination for a century. The King of Poland was, in fact, the Tzar, The Emperor of Russia, Alexander II. The Tzar suppressed each rebellion and began to "Russianize" Poland during Manya'a childhood. To supervise the conversion, Polish courts of law were abolished and Russian bureaucrats replaced Polish officials. The Polish language was forbidden to be spoken or written and demoted as a dialect. Russian was the official language to be spoken at home or in public. Russian authors and religious practices were promoted. Poland was labeled on all new maps as the Russian province of "Vistula Land" since the Vistula River ran through it.

Manya and the members of her entire family became ardent patriots and believed they must do all they could do to free Poland of its Russian oppressors.

Bronya and Manya made plans while in their teens to work as governesses and to save money collectively for Bronya to study medicine in Paris. Marie was to follow later. Women were not allowed to attend the universities in Poland by Russian decree.

In September, 1885, Manya got a position as a governess to a family of lawyers in Warsaw. She worked for them for one year and in January, 1886 she gained employment with a second family named Zorawski who managed a sugarbeet estate in a small country village called Szczuki. (about 60 miles north of Warsaw). Besides teaching 2 of the 7 Zorawski children 7 hours a day, Manya organized lessons for 10-18 poor Polish children in the neighborhood who became the first to read in their town. She studied chemistry and mathematics privately at night. Casimir, the oldest son, was a mathematics student at the University of Warsaw. He fell in love and wanted to marry Manya, but his parents said no. At Easter, in 1889, Manya left when her contract expired with the family. 1-2

When she returned to Warsaw, a number of young people started a "Floating University" with meetings held in various private homes in basements and attics to elude spies. It was illegal and both students and teachers could be arrested and sent to Siberia. Lectures in anatomy, sociology, natural history, etc. were taught by various individuals. Students were encouraged to become teachers. Manya learned about positivism, originated by Auguste Comte, 50 years earlier. Positivism rejected theoretical speculation about man and his problems in favor of observable, scientific facts, their relationship to each other and the natural law. It believed in logic and reason. Charles Darwin and Louis Pasteur were 2 of its followers and Manya's "heroes." 1-3

In November, 1891 at the age of 23, Manya enrolled at the Sorbonne and changed her name to Marie - the French translation. She lived with Bronya and her physician husband, Casimir Dluski, for the first year, but later moved to the Latin Quarter in Paris to be closer to the school and laboratory. She economized with sparse furnishings in small apartments, minimal foods which required no cooking i.e. bread, fruit, tea and hot chocolate, and conserved on her heating and light expenses by staying at the library until 10 p.m. when it closed. She continued to study until 2 a.m. in a sparsely lit room at her apartment. After the first lecture, Marie realized she had difficulties with taking notes and keeping up with the lectures in French and that she was behind in her knowledge base when compared to others in her class. She mastered the French language very quickly. She always arrived early to class and sat in the front row with her tablet and pens ready.

Marie writes in a letter in 1892:

"All my mind was centered on my studies. All that I saw and learned that was new delighted me. It was like a new world opened to me, the world of science, which I was at last permitted to know in liberty." Two years later on July 28, 1893, she became the first woman in the world to receive a Master's Degree in physics at the top of her class. Marie was the recipient of the Alexandrovitch Scholarship of 600 rubles which made her life a little more comfortable. Several years after her graduation, Marie paid the scholarship back so that another deserving young woman could go to school.

The next year, she got her Master's Degree in mathematics and finished second in her class. While working on her second degree, The Society for the Encouragement of National Industry asked her to prepare a study of the magnetic properties of various steels. The acceptance of the project led to her introduction to Pierre Curie. She would never again live in her beloved Poland. 1-4

Marie began her doctoral research based on the theory of "spontaneous radioactivity" postulated by Antoine Henri Becquerel in 1897. In 1903, Marie was awarded her Doctor of Science degree.

<u>Pierre</u>

Pierre and his older brother, Jacques, were born in Paris and sons of a physician. Pierre was born on May 15, 1859. Both men became physicists. Their father recognized their exceptional intelligence and tutored them at home and later hired a personal tutor.

Pierre received his university Bachelor's Degree at age 16 and his Master's Degree at age 18. He became a laboratory assistant at age 19 to begin research. Over the next 15 years, he invented the electrometer, an apparatus used to measure small amounts of electricity, and a new ultra-sensitive scale for weighing minute amounts of material. He made important discoveries in the science of crystals. He discovered that when crystals are compressed, they developed an electric charge and that electric current could cause crystals to expand and contract. This phenomenum became known as piezoelectricity and is used today in microphones, radios and electronic circuits. He also made important discoveries in the science of magnetism. He formulated Curie's Law which states that the magnetic properties of substances change at certain temperatures identified as the "Curie point". The future development of telegraphs, radios, telephones and television is based on the knowledge of these specific temperatures. He was appointed head of the laboratory at the School of Physics and Chemistry.

In 1894, Marie met Pierre at the home of a mutual scientist named Kowalski for an afternoon tea. They discussed their separate research endeavors and discovered many common interests. Pierre was quiet and generous. Pierre wrote many letters to Marie and wanted to marry her, but she declined because she wanted to return to her beloved Poland. Pierre wrote in his diary that "women of genius are rare". In one of his letters to Marie, Pierre wrote "It would be a fine thing...to pass our lives near to each other, hypnotized by our dreams; <u>your</u> patriotic dream, <u>our</u> humanitarian dream, and <u>our</u> scientific dream". They were married on July 26, 1895 in City Hall in Sceaux. Marie refused to wear a white gown for her wedding, but chose a plain dress so she could wear it to her laboratory. They purchased 2 bicycles with some wedding money and spent their honeymoon touring the French countryside. Marie became Madame Curie of Paris and a household name in the world in less than 6 years from her date of marriage.

In 1905, Pierre was elected a member of the French Academy of Sciences and became a professor of physics at the Sorbonne.

On April 19, 1906 while crossing the street in a rain shower, Pierre stepped out from behind a cab and straight into the path of a heavy horse-drawn wagon. The driver tried to stop the wagon. The left wheel of the wagon crushed Pierre's skull in multiple fragments and he died instantly. Marie came home from her laboratory and learned the news of his death. He was 48 and they had been married for 11 years. Marie began writing letters to Pierre in a private diary for many years. "It is impossible for me to describe the misery and depth of this turning point in my life, as a result of the loss of him who was my dearest companion and friend. Crushed by the blow, I was unable to think of the future. And yet, I could not forget what my husband sometimes said that even without him I should work on."

The French government proposed an annual pension to Marie and her 2 daughters in recognition of Pierre's work. Marie refused it saying "I am young enough to earn my living and that of my children".

At the Sorbonne, the Faculty of Science voted unanimously that Marie should succeed Pierre as Professor. She accepted the position on May 1, 1906 and became the first woman professor to teach at the Sorbonne or any university in France. She resumed the lecture where Pierre had stopped.

The Le Journal published this quote on Madame Curie's first lecture in the Sorbonne: "Today has seen 'The celebration of a victory for feminism'. If a woman is allowed to teach advanced studies to both sexes, where afterwards will be the pretended superiority of man? I tell you, the time is near when women will become human beings".

In 1908, Marie published Pierre's research, notes and other data in The Works of Pierre Curie. In 1910 Marie published a 971 page account of her discoveries with radium entitled Treatise on Radioactivity. The following year Marie was awarded her second Nobel Prize for Chemistry and went to Stockholm to accept it in person. However, the presentation of the second Nobel Prize became very controversial in both the scientific community and the general public because some felt others were making important discoveries and that it was given out of pity for the loss of her husband rather than genuine admiration and respect for her work. 1-5

Marie & Pierre

Marie decided to become a physics teacher at Ecole Normale Superieure in Sevres in southwest Paris. She was interested in Becquerel's work with uranium and the "rays" that gave off light from the crystals. In 1896, Henri Poincare advanced a hypothesis called "hyperflourescence" that was created from the glass walls of a Crooke's tube when struck by cathode rays. Marie decided to work on her doctorate in these phenomena.

They conducted their experiments in an abandoned, wooden shed previously used by medical students for dissection of cadavers located on Rue Lhomond. It had a leaking roof and no ventilation. The shed contained old kitchen tables, a cast iron stove and a blackboard. Marie wrote later ..."It was in this miserable old shed that the best and happiest years of our lives were spent, entirely conseqrated to work. I sometimes passed the whole day stirring a boiling mass with an iron rod nearly as big as myself. In the evening I was entirely broken by fatigue."

In July, 1898, Pierre and Marie discovered an element they named polonium in honor of Marie's homeland of Poland. It was 400 times more radioactive than uranium. She also discovered thorium gave off radiation. Pierre gave up his teaching job to help Marie. She stirred huge pots of pitchblende while he analyzed the extracted elements.

On December 26, 1898, Pierre and Marie discovered another element they named radium from pitchblende, a stiff, tar substance which was known to contain uranium, and a new form of energy they called radioactivity.

September 12, Irene was born. Marie began her day by being up before sunrise, spending 1/2 hour or more with her daughter, going to the laboratory with Pierre, sharing a late evening meal, spending more time with her daughter, and completing more work on her doctorate, research publications, etc. 1-6

The Discoveries

In 1896, Antoine Henri Becquerel, a physics professor at the French Natural History Museum in Paris, wrapped some photographic plates in a cloth and placed them in a desk drawer. On top of the desk were some crystals containing uranium. Later, when he developed the plates, there were marks on the image which indicated where the uranium crystals had been. He decided to name these invisible rays "Becquerel rays" and considered them to be similar in nature to the rays from the sun. Marie decided to pursue Becquerel's preliminary research and investigate the origin of the mysterious "Becquerel rays" as the dissertation for her doctorate.

Marie officially began her research by studying every compound and element known at that time to find out if other substances emitted radioactivity. She found the same properties in thorium and a crude form of uranium oxide called pitchblende. She began her investigation as follows:

1. the delivery of pitchblende to the laboratory in Paris; (the pitchblende came from a mine in St. Joachimsthal, Bohemia in which a factory removed the uranium and dumped the pitchblende in a pine forest. The owners sold it cheaply and were eager to get rid of it);

2. samples of pitchblende had to have the rubbish and debri removed from it by grinding and boiling it with soda so that it separated as a solid material and a liquid: (the liquid was discarded);

3. the solid material was dissolved in an acid and treated with different chemicals in order to separate the elements they did not want by mixing, dissolving, heating, filtering, distilling, crystallizing, etc.;

4. Pierre measured each removed element with an electrometer (which he invented earlier in his career) and discovered that as the portions got smaller, the radioactivity got larger;

5. In July, 1898, Pierre and Marie extracted and discovered an element they named polonium (in honor of Marie's homeland of Poland) that was 400 x more active than uranium;

6. On December 26, 1898, Pierre and Marie discovered another element they named radium and a new form of energy they named radioactivity; and

7. 4 years later in 1902, Marie prepared 1/10 of a gram (35 ten thousandths of an ounce) of radium and went to have her sample analyzed by Eugene Demarcay, a fellow scientist. Demarcay attached a camera to the spectrometer and photographed the light patterns. He confirmed a new element on March 28, 1902 after 4 years of dedicated labor. Dr. Demarcay calculated the atomic weight as 225.93 and Marie named it radium. It was measured to be 2 million times more radioactive than uranium and gave off a faint, blue glow in the dark. 2

Marie also demonstrated that radiation had a different origin and must come from the atom itself. She discovered that it gave off 3 types of "rays", produced gas (radon), and gave off light and heat spontaneously. Other substances treated with radium became radioactive.

From 1899 - 1902, the Curies published 32 different papers on their discoveries and radioactivity. They did not patent their discovery because, in Marie's words, "It would be contrary to the scientific spirit." The Curies believed the government should work to improve the lives of the ordinary people and that science should be kept apart from commercial applications.

By 1903, both Pierre and Marie experienced symptoms which were later identified as "radiation sickness" i.e. lethargy, low blood counts, fever of unknown origin, joint and bone pain, dizzyness, etc. Both dismissed these symptoms as related to overworking rather than the biologically hazardous nature of the gamma radiation coming from the radium.

At the Radiology Congress in Brussels in September, 1910, Marie recommended a standard measurement for radium. She was given the responsibility of preparing an ampule containing 20 milligrams of radium metal to be stored at the International Bureau of Weights and Measures in Paris. The Curie (named in honor of Pierre) was defined as the quantity of emanation (radon) from or in radioactive equilibrium with 1 gram of radium.

In July, 1914, the Institute of Radium was finished on the grounds of the Sorbonne. The plan was designed by Marie with construction divided into 2 halves: one 1/2 contained laboratories for Marie's research in radioactivity with large windows for light and an elevator and the other 1/2 was equipped for biological research particularly in methods using radiology to cure sick people. In a letter to her sister, Bronya, Marie wrote "To develop science laboratories - which Pasteur called 'holy shrines' - to facilitate the tasks of those who work for science, to extend care over the young who thrist for knowledge - and thus to gain workers for the future - to create conditions in which innate and precious talents may be realized and devoted to the service of ideals....This is the way to lead society along the path of developing its power, both spiritual and material."

Marie selected plane trees and lime trees to be planted in the Institute Gardens while she herself planted the roses. 1-7

Honors and Awards

In 1902, Professor Paul Appell, one of Marie's former teachers, wanted to nominate Pierre to the Legion of Honor, one of France's most distinguished awards. Pierre declined the nomination.

In 1902, Marie was awarded the Berthelot Medal of the Academie des Sciences and for the third time, the Gegner Prize.

In 1903, Pierre was invited to London to lecture on radium. In November of the same year, Pierre and Marie were presented the Humphry Davy medal by the Royal Society, Britain's leading association of distinguished scientists.

On December 12, 1903, The Academy of Sciences in Sweden awarded the Nobel Prize for Physics jointly to Antoine Henri Becquerel and the Curies. Pierre and Marie were both too ill to travel to Sweden so Becquerel collected the gold medals for them and their prize money of 70,000 Francs. Pierre and Marie allocated their prize monies to:

fund further experiments;
release Pierre from his teaching responsibilities to concentrate on his personal research;
repay friends and family for their support over the years;
give gifts for poor Polish students pursuing scientific education and endeavors;
assist Bronya and her husband in building a TB hospital in Poland;
subscribe to scientific journals;
assist with the underground Polish Liberation Movement; and
make a few improvements to their apartment i.e. new wallpaper in one room and a modern bathroom.

In 1909, Marie received the Elliott Cresson Medal and in 1910, France offers the Legion of Honor to Marie. She declined.

In 1922, Marie was elected to the League of Nation's International Committee on Intellectual Co-operation and served as Vice-President. She believed scientists from different countries should collectively agree to:

co-ordinating publications;
standardizing scientific terms and symbols;
copyrighting their work to earn money to live and continue research;
providing international scholarships for talented people.

Marie and Pierre rarely accepted invitations to formal banquets or receptions except to honor fellow scientists from abroad. Marie owned 1 formal evening gown. Marie declined interviews unless its content was scientifically oriented and valuable.

In 1922, Marie was elected to the Academie de Medicine where she was assured contact with the medical profession to develop "Curietherapy" and to establish safety standards for workers.

In 1923, to commemmorate the 25th anniversary of the discovery of radium, the French government awarded Marie a 40,000 Francs/year pension as an expression of gratitude for her prestigious work.

From 1919-1934, scientists at the Radium Institute in Paris published 483 papers, 31 of which were written by Marie personally.

Marie served as fund raiser and administrator. By the mid 1920's, several workers at the Institute had died of cancer and doctors throughout the world had evidence that radioactivity was creating the cancer. Marie was unwilling to accept the truth and blamed the working conditions and lack of fresh air by the workers as the cause. Under her leadership, the Institute never investigated health hazards. She did not adequately protect herself.

In 1935, one year after her death, her last book was published and simply titled **Radioactivity**. In her lifetime, she had been awarded 129 prizes, medals and titles and 2 Nobel Prizes. 1-8

The Nobel Prize

The Swedish inventor of dynamite, Alfred Nobel, died in 1896 and dictated in his will that annual awards be given for peace and literature and for discoveries in physics, chemistry and physiology or medicine. It is conferred upon those elite individuals who have rendered the greatest benefit to mankind. Economics was added in 1968. The first Nobel Prize was given in 1901.

In Pierre Curie's Nobel lecture on June 6, 1905, he stated "It might even be thought that radium could become very dangerous in criminal hands, and here the question can be raised whether mankind benefits from knowing the secrets of Nature, whether it is ready to profit from it or whether this knowledge will not be harmful for it....I am one of those who believe with Nobel that mankind will derive more good than harm from the new discoveries."

There have been over 300 recipients in science. Only 9 have been women. Many believe the main reasons for so few women have been the discrimination they experienced in trying to achieve a collegiate education as students and the difficulties they encountered as researchers. There are common bonds between the 9 women: They all loved science, had sympathetic relatives who were influential, were born between 1896 and 1921 thereby existed at the right time and were passionately determined to become successful.

For 61 years, Marie was the only person to have won 2 Nobel Prizes in science. Marie wrote "I am one of those who think that science has great beauty. A scholar in his laboratory is not just a technician; he is also a child face to face with natural phenomena that impress him like a fairy tale."

Marie, Irene and The War Years

Marie used her money from her second Nobel Prize to purchase war bonds from the French government to assist in paying its military spending. She also took her personal gold items to be melted down for the war effort. The bank refused to accept her Nobel Prize gold medals for meltdown.

In August, 1914, Marie took her precious radium in a lead suitcase weighing 20 kilos to the train sation and stored the radium in a bank vault in Bordeaux to protect it from the German invaders who might reach Paris.

Marie approached big business and influential people to get money, vehicles and medical equipment. By late October, 1914, the first mobile x-ray unit rolled to the battlefront. It was an ordinary car carrying an x-ray machine driven by the generator off the car engine, some curtains, screens and gloves for the operator. Marie herself traveled in a Renault truck with a huge French flag painted on one side and an equally large Red Cross flag on the other side. On board with Marie was a physician, 2 assistants (one of whom was her oldest daughter, Irene), and a driver-mechanic. Marie placed Irene in charge of a unit when she was 17 years of age. Marie converted 20 cars as mobile x-ray units that soon were called "little Curie wagons" or "Radiologic Cars" and assisted in setting up 200 hospital rooms with x-ray equipment. On July 28, 1916, Marie obtained a driver's license so she would not have to rely on the chauffer.

By the end of the first day, they had filmed 30 men; by the end of World War I, they had filmed over 1 million and saved tens of thousands of lives and prevented an untold number of amputations by assisting physicians with the location of bullets/shrapnel and the severity of fracture sites!!

Marie personally visited nearly 400 French and Belgian hospitals in 4 years. From 1916 - 1918, 150 people were trained to take x-rays. When the war ended, she continued to train technicians at the Radium Institute where she established coursework and helped to define radiology as a medical practice. Irene assisted her in special courses designed for members of the American Expiditionary Forces.

Marie wrote a book titled <u>Radiology in War</u> in which she described how scientific research could be used in practical matters to save human lives and prevent needless suffering. 1-9

Marie in the United States

By 1920, Marie was known worldwide as the "Mother of Radium". Marie Meloney worked for a magazine called <u>The Delineator</u> owned by the Butterick pattern company. She was also the first woman to have a seat in the press gallery of the United States Senate. She repeatedly requested interviews with Marie in Paris and was denied. Finally, Marie agreed to an interview and the 2 women became friends. Mrs. Meloney decided to have women in the United States donate a gift of 1 gram of radium if she could have first rights to her story and a personal visit to the United States. Marie agreed.

Mrs. Meloney returned to the United States and appealed to women to raise the necessary $100,000 to buy 1 gram of pure radium for Marie's ongoing research and medical applications. In 1921, Marie and her 2 daughters sailed on board the *S.S. Olympic.* There was an enormous crowd who had waited 5 hours for her ship to dock in New York harbour. On May 20, 1921, President Warren G. Harding gave Marie a gold key with which to open the lead case containing her radium. Her reception in the United States was overwhelming. Marie had shaken so many hands that she had to wear a splint and returned to Paris earlier than originally planned.

Marie decided to become an ambassador for science by touring different countries, visiting universities and capital cities, receiving honors and speaking on the behalf of new scientific research.

In 1925, The President of Poland laid the first cornerstone and Marie the second for the Marie Sklodowska-Curie Institute in Warsaw. Women in the United States saluted her for her achievements a second time by collecting enough money to donate a second gram of radium to the Institute in Poland for its own research and therapy programs. In 1929, Marie sailed to the United States for a second visit and stayed at the White House as a guest of President Herbert Hoover for another presentation and ceremony.

Andrew Carnegie, the U.S. steel millionaire, endowed her laboratory at the Sorbonne in Paris with a gift of $50,000 in gold bonds which were used to furnish scholarships for advanced students and scientists.

During her 2 visits to the U.S., she received many honorary degrees from Ivy League schools, toured hospitals, laboratories, factories and mines. She travelled through Philadelphia, Boston, Washington, D.C., the Grand Canyon and Niagara Falls. She received gifts of cash, machinery, minerals and sentimental souvenirs. Mrs. Meloney steered influential patrons to the Curie Pavilion to donate to the Institute. In return, Marie arranged for Mrs. Meloney to receive France's highest award, the Legion of Honor. 1-10

Marie's Health

During 35 years of working with radium in an unprotected environment, she suffered "radiation burns" and scarring to her fingertips and numbness to her hands. She was extremely pale from her prolonged and chronic anemia with flushed cheeks due to her chronic low grade fever. She grew tired easily and thought periodic visits to the countryside and the Alps would remedy her health problems.

Both Pierre and Marie suffered from aching arms and legs which was diagnosed as "rheumatism" and treated with strychnine; colds, sores and blisters that never seemed to go away completely and a constant feeling of lethargy. Their bicycle trips in the countryside made them feel better.

In 1903, Marie had a child born prematurely who died hours after birth. No direct evidence was found for the cause of the child's death.

On December 29, 1911, Marie was taken to a nursing home and no one expected her to survive. By the end of February, she attended a scientific meeting. In March, she underwent kidney surgery and progressed with a slow recovery.

By 1923, Marie was considered virtually blind from radiation induced cataracts. She did not want her students and colleagues to know about this condition. She answered their questions, read their papers with difficulty in the privacy of her apartment and commented on their research verbally through discussion. Eventually, she consented to 4 surgeries from 1923 - 1930 under extreme privacy and with a false name. She enventually regained her sight well enough to drive in the streets of Paris.

She also had a known gall stone, but didn't want surgery because her father had died from his gall bladder surgery.

Emotionally, Marie endured an isolated and notorious defamation of character when she was accused of having a relationship with a married man and fellow physicist, Paul Langevin, years after Pierre's unexpected death. Mr. Langevin was unhappily married and had 4 children. He and Marie shared and discussed some of their mutual projects together. This relationship created a spectacular scandal in Paris through journalistic muckraking for several weeks which resulted in Mr. Langevin's resignation from the laboratory and his reconciliation with his wife. Marie contemplated suicide, but chose to leave Paris and recover with a trip to England and a rest in a nursing home. She failed to get elected to the Academy of Sciences by 2 votes. Some felt it was due in part to this scandal and her feminine sex. 1-11

In May, 1934, Marie felt weak while working in her Institute and told her assistant she was going home. While she was passing through the gardens surrounding the Institute, she told one of the workmen to take care of a particular rose bush that did not appear too healthy. She never returned to her beloved Institute. She took to her bed with what she considered to be "the flu". Her daughter, Eve, took her to a sanatorium in the French Alps on June 29. Many tests were conducted without a differential diagnosis. Marie was never told the truth about the seriousness of her illness. Eve read to her and assisted with her physical and emotional needs. She held her fragile, damaged hand as she died quietly on July 6, 1934 at the age of 66. She was buried near Pierre in Sceaux without any official ceremony. Eve wrote "It is impossible to inflict on her , without sacrilege, the pompous obsequies which governments give their great men. In a country graveyard, among summer flowers, she had the simplest and quietest burial, as if the life just ended had been like that of a thousand others."

Marie's Legacy to the World

Einstein said: "Marie Curie is, of all celebrated beings, the only one whom fame has not corrupted" - passing like a stranger across her own life, intact, natural and very nearly unaware of her astonishing destiny.

* Her discoveries about radiation led to a completely new area of science - nuclear physics.
* Her discovery of radium saved or prolonged the lives of millions of cancer patients.
* In 1915, "Curietherapy" involved the use of radium by physicians to treat scar tissue and arthritis and was the precursor to radiation brachytherapy.
* In 1920, the Curie Foundation was established to receive private gifts for continued research.
* She worked on the identification of the structure of the atom and helped other scientists develop nuclear power.
* She developed and supervised two Institutes of higher scientific learning that trained young scientists in her scientific procedures.
  In Paris, Marie went to the Chief of Police to inform him that the car traffic distracted scientists and disturbed her precision equipment. Within days, the streets were converted to 1 way and reordered away from the Rue Pierre so that quiet and scientific investigation could be maintained without distress.
* She remodeled the image of science by pioneering meticulous research methods.

* She was the first woman in Europe to earn a Ph.D. in Science and entered a world previously barred to women.
* She stimulated radiochemical and radiophysical research at such a phenomenal rate that 30 other radioelements were discovered from 1896-1911.
* She introduced her daughter, Irene, to scientific research. In 1926, Irene married Frederic Joliot, a scientist in his own right, and they become close working partners. He added Curie to his last name. In 1935, The Nobel Prize for Chemistry was awarded to Frederic and Irene Joliot-Curie for their discovery of artificial radioactivity. Unfortunately, both died prematurely 20 years later from the biological effects of radiation.

When Marie was approached to write her autobiography, she was genuinely surprised and said "It will not be much of a book. It is such an uneventful, simple little story. I was born in Warsaw of a family of teachers. I married Pierre Curie and had 2 children. I have done my work in France".

A book was dedicated to Marie's memory by the French Society of Physics on the centenary of her birth titled *Colloquium on Medium and Heavy Nuclei* which declared "the following generations have taken the torch she alone had carried for 28 years".

A Synopsized Chronology Of Significant Events in Madame Curie's Life
(isolated from Eva Curie's biography, Madame Curie)

1867 Marya Sklodowska, called Manya by her family, was born in Warsaw, Poland. She was the youngest of 5 children. Her parents were both teachers.

1876 Marie's oldest sister, Zosia or Sophia, died from typhus fever. Bronya survived.

1878 Marie's mother died of tuberculosis.

1883 Marie graduated from secondary school with a gold scholarship medal and spent a year resting in the country with her relatives.

1884 Marie returned to Warsaw and joined and lectured in the "Floating University".

1885 Marie and her sister, Bronya, became employed as governesses to earn money to study at the Sorbonne in Paris. Bronya left Poland first to study medicine.

1890 Marie left Poland to study mathematics, physics and chemistry at the Sorbonne in Paris. She changed her name to the French spelling

1893 Marie passed her physics exams as first in her class.

1894 Marie passed her second exams in mathematics as second in her class. She met Pierre Curie.

July 26, 1895 Pierre and Marie were married.

November 8, 1895 Wilhelm Konrad Roentgen discovered "X-rays".

February 28, 1896	Antoine Henri Becqueral discovered radioactivity.
September, 1897	Marie began researching radioactivity. Irene Curie was born.
April 12, 1898	Marie presented her first paper to the Academie des Sciences.
June 6, 1898	Marie isolated polonium.
1899	Marie began working on pitchblende to isolate radium.
1902	Marie completed the research and identified radium.
1903	Marie completed her doctorate in sciences, becoming the first woman to reach this achievement. Antoine Henri Becqueral, Pierre and Marie Curie were awarded the Nobel Prize for Physics for their work on radioactivity.
December 6, 1904	Eve Curie was born.
April 19, 1906	Pierre Cure was killed tragically and unexpectedly by a horse-drawn cart.
November 15, 1906	Marie conducted Pierre's classes and was the first woman to teach at the Sorbonne.
1911	Marie received her second Nobel Prize for Chemistry.
1912	Marie was named the Director of the Radium Institute in Paris.
July 31, 1914	The Radium Institute was completed.
August 4, 1914	World War I began.
1914-1918	Marie and her daughter, Irene, organized mobile x-ray units for use at the battlefront in addition to x-ray installations in hospitals in France and Belgium.
1921	Marie and her 2 daughters toured the United States and President Harding presented her with 1 gram of radium as a gift and sign of appreciation from the people of the United States.
1922	Marie was elected as a member of the League of Nation's International Committee on Intellectual Cooperation.
1926	Marie's first daughter, Irene, married Frederic Joliot, a French physicist.

1929	Marie returned to the United States and accepted another gram of radium from President Hoover from a grateful nation of Americans.
1934	Irene and Frederic Joliot-Curie discovered artificial radioactivity.
July 5, 1934	Marie Curie died from aplastic anemia or leukemia.
1935	Irene and Frederic Joliot-Curie received the Nobel Prize for Physics.
1937	Eve Curie published her mother's biography, *Madame Curie*.

Selected Letters of the Curie Family
(from her daughter's biography)

Marie's letter to her girlhood friend from Warsaw, Kazia in mid-July, 1895:

When you receive this letter your Manya will have changed her name. I am about to marry the man I told you about last year in Warsaw. It is a sorrow to me to have to stay forever in Paris, but what am I to do? Fate has made us deeply attached to each other and we cannot endure the idea of separating.

I haven't written, because all this was decided only a short time ago, quite suddenly. I hesitated for a whole year and could not resolve upon an answer. Finally I became reconciled to the idea of settling here. When you receive this letter, write to me: Madame Curie, School of Physics and Chemistry, 42 Rue Lhomond. ....

Marie to her brother, Joseph and his wife on July 16, 1896:

Dear ones, I should have so much liked to have come home this year and take you both in my arms! I can't think of it, alas; I have neither the time nor the money. The competitive examination for a fellowship, which I am passing now, can go on until the middle of August.....

Pierre to Marie in July, 1897 when he was detained in Paris and she went ahead with her father to Port Blanc:

My little girl, so dear, so sweet, whom I love so much, I had your letter today and was very happy....Nothing new here, except that I miss you very much: my soul flew away with you....

Marie's entry in her diary before the discovery of radium:

Life is not easy for any of us. But what of that? we must have perseverance and above all confidence in ourselves. We must believe that we are gifted for something, and that this thing, at whatever cost, must be attained.

The Curies' comments at the Proceedings of the Academy for July, 1898:

We believe the substance we have extracted from pitchblende contains a metal not yet observed, related to bismuth by its analytical properties. If the existence of this new metal is confirmed we propose to call it polonium, from the name of the original country of one of us.

The Curies' comments at the Proceedings of the Academy for December 26, 1898:

The various reasons we have just enumerated lead us to believe that the new radioactive substance contains a new element to which we propose to give the name RADIUM.

The new radioactive substance certainly contains a very strong proportion of barium; in spite of that its radioactivity is considerable. The radioactivity of radium therefore must be enormous.

Pierre's letter to Georges Gouy in January 31, 1905:

My rheumatism is leaving me alone at the moment, but I had a violent attack this summer and had to give up going to Sweden. As you can see, we are thus completely out of order with the Swedish Academy. The truth is I can only keep myself in condition by avoiding all physical fatigue. My wife is in the same state as myself, and we can't dream of the long working days we used to have.

Marie's diary entry about Irene's developmental progress on August 15, 1898:

Irene has cut her seventh tooth, on the lower left. She can stand for half a minute alone. For the past three days we have bathed her in the river. She cries, but today (fourth bath) she stopped crying and played with her hands in the water.....

Marie's diary entry about Pierre's funeral:

.... Your coffin was closed and I could see you no more. I didn't allow them to cover it with the horrible black cloth. I covered it with flowers and I sat beside it....

Marie's letter to Irene on August 28, 1914 regarding the possible German invasion of Paris:

......They are beginning to face the possibility of a siege of Paris, in which case we might be cut off. If that should happen, endure it with courage, for our personal desires are nothing in comparison with the great struggle that is now under way. You must feel responsible for your sister and take care of her if we should be separated for a longer time than I expected.

Marie's letter to her sister, Bronya on November 10, 1920:

My greatest troubles come from my eyes and ears. My eyes have grown much weaker, and probably very little can be done about them. As for the ears, an almost continuous humming, sometimes very intense, persecutes me. I am very worried about it: my work may be interfered with - or even become impossible. Perhaps radium has something to do with these troubles, but it cannot be affirmed with certainty.

These are my troubles. Don't speak of them to anybody, above all things.....

Marie's letter to Bronyaion September, 1927:

Sometimes my courage fails me and I think I ought to stop working, live in the country and devote myself to gardening. But I am held by a thousand bonds, and I don't know when I shall be able to arrange things otherwise. ***Nor do I know whether, even by writing scientific books, I could live without the laboratory.***

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1-1 pages 1-16	1-7 pages 285-288
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Unit 17

Radiography of Ancient Man.....and Woman

Unit 18

The Practice of Medicine: From Wizardry to the Magic of MRI

Unit 19

The Original "X" Files: Wilhelm Konrad Roentgen

Unit 20

Madame Curie: A Woman Before Her Time

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Unit Number 17
Title: Radiography of Ancient Man...and Woman

Please circle the correct answer

1. Ancient Egyptians believed that death was the end of life. True False

2. Herodotus describes ____________ different levels of mummification.

   a. five (5) b. three (3) c. four (4) d. two (2)

3. The reason for ending mummification in the 19th century BC is believed to be:

   a. fighting
   b. change in beliefs
   c. cost
   d. lack of burial room

4. Which of the following was a common use for "mummia"?

   a. cooking additive
   b. medicinal cure
   c. plant food
   d. paste for mummifying

5. The study of disease in ancient times is called:

   a. Anthropology
   b. Paleontology
   c. Pathology
   d. Paleopathology

6. What event, in 1902, allowed many mummies available for study?

   a. massive sand storm
   b. building of 1st Aswan Dam
   c. Smallpox epidemic
   d. religious uprising

7. Dr. James Harris' 1965 studies in Egypt were done to shed light on what malady?

   a. Malocclusions
   b. IAC malformations
   c. Spinal Arthritis
   d. lower leg malformations

8. The British expedition to the Northwest Passage was sent to:

   a. test ships readiness
   b. study polar bears
   c. chart area
   d. study ice formations

9. Who controlled the Northwest Territories when the researchers arrived in 1986?

   a. United States
   b. Canada
   c. Russia
   d. Britain

10. Lead poisoning can cause many physical and mental problems including:

    a. muscle spasm
    b. alopecia
    c. convulsions
    d. anorexia

11. The Medical team to the Arctic took which of these radiographic items with them:

    1. portable x-ray unit
    2. processing chemicals
    3. automatic processor
    4. radiographic film

    a. 1, 2, and 3
    b. 1, 3, and 4
    c. 2, 3, and 4
    d. 1, 2, and 4

12. The film speed system used in the Arctic project was:

a. 100 speed b. 200 speed c. 400 speed d. 800 speed

13. What was the nationality of the mummy examined at the Medical College of Ohio in 1987?

a. British b. Egyptian c. American Indian d. French

14. The length of the Toledo study was:

a. three days c. two weeks

b. seven days d. three weeks

15. Fine carbon particles in undigested muscle fibers suggested:

a. the food had been cooked c. the food had been dried

b. the food was eaten raw d. the food was rancid when eaten

16. The name "Soap Man Mummy" comes from:

a. soap found with him c. body turned into an ammonia soap

b. he manufactured soap d. someone covered body with soap

17. Descriptions of the bodies stated that the "soap" mummies died of:

a. yellow fever c. the plague

b. diphtheria d. salmonella

18. The film system used to image the soap mummies was:

a. 200 speed c. 800 speed

b. 400 speed d. 1000 speed

18. What was determined to be the occupation of the soap man mummy?

a. physician c. accountant

b. manual laborer d. teacher

19. The mean age of the soap man mummy was determined to be:

a. 30 years c. 40 years

b. 50 years d. 60 years

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Unit Number 18
Title: The Practice of Medicine: From Wizardry to the Magic of MRI

______ 1. Observations of what group of people at the time of Columbus helped us to understand Primitive man?
- A. Sherpa guides
- B. North American Indians
- C. Tibetan monks
- D. A gypsy tribe in Romania

______ 2. A primitive surgery performed by cutting an opening into the cranium was called
- A. Craniectomy
- B. Sinusotomy
- C. Myringotomy
- D. Trephining

______ 3. Evidence of what disease that still afflicts man today has been found in the fossil record of both man and animal?
- A. Aids
- B. Rheumatoid Arthritis
- C. Tuberculosis
- D. Pleurisy

______ 4. The Babylonian king responsible for an elaborate code of laws was
- A. Hammurabi
- B. King Saul
- C. Imhotep
- D. Asklepios

______ 5. In this code of laws if a physician failed in his treatment of a gentleman and the patient died, what was the penalty?
- A. Death
- B. He is made a slave
- C. Cut off his fingers
- D. Banishment from the country

______ 6. It was the custom of the Babylonians to seek advice on their illnesses at
- A. A festival
- B. The marketplace
- C. Their mother-in-laws
- D. The Garden of Eden

______ 7. The basis of our knowledge of Egyptian Medicine comes from
- A. Medical Papyri
- B. Word of Mouth
- C. The Bible
- D. The Mummies

______ 8. The Egyptians belief in immortality probably led to the practice of
- A. Sacrifice of virgins
- B. Worship of the Nile
- C. Mummification
- D. Keeping cats as pets

______ 9. The "Birthplace of Medical Science" was with the
- A. Anglo-Saxons
- B. Romans
- C. Greeks
- D. Egyptians

______10. What group of people left us a wealth of laws concerning sanitation and hygiene?
- A. Hebrews
- B. Egyptians
- C. Romans
- D. Anglo-Saxons

______11. Who was the god of healing for the Greeks?
- A. Pluto
- B. Asklepios
- C. Zeus
- D. Imhotep

______12. **Who is known as the "Father of Medicine"?**

A. Pythagoras **C. Galen**
B. Paracelsus **D. Hippocrates**

______13. **What group of people built the aqueducts and the Cloaca Maxima?**

A. Romans **C. Greeks**
B. Arabs **D. Babylonians**

______14. **During the Middle Ages what institution was considered to be omnipotent?**

A. The Roman Emperor **C. The Church**
B. The DeMedici Family **D. The Unitarians**

______15. **Nestor and his band of followers became the first**

A. Methodists **C. Episcopalians**
B. Unitarians **D. Lutherans**

______16. **During the Middle Ages a hospital and school were established at a great health resort in Italy. What was the name of the site?**

A. Genoa **C. Salerno**
B. Florence **D. Naples**

______17. **Who gave the first demonstration of the circulation of the blood?**

A. William Turner **C. Marco Aurelio Severino**
B. William Harvey **D. Renee Descartes**

______18. **Who made many of the first microscopes and is known as the "Father of protozoology bacteriology"?**

A. John Morgan **C. Edward Jenner**
B. Alexander Fleming **D. Anton van Leeuwenhoek**

______19. **November 8, 1895, X-rays were discovered by**

A. Marie Curie **C. Henri Becqueral**
B. Wilhelm Roentgen **D. Louis Pasteur**

______20. **What foundation contributed large sums of money to fight disease and develop medical education?**

A. The Guggenheim Foundation **C. The Rockefeller Foundation**
B. The Kellog Foundation **D. The Ford Foundation**

Unit Number 18
Title: The Practice of Medicine: From Wizardry to the Magic of MRI

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Specialized Topics in Areas of Radiologic Sciences
P.O. Box 2931 Toledo, Ohio 43606
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Unit Number 19
Title: The Original X-Files Wilhelm Konrad Roentgen

_____ 1. Wilhelm Roentgen did **not** receive a diploma from the technical school in Utrecht because
- A. he was ill and never finished
- B. he was expelled
- C. he left to marry Bertha
- D. it was closed during the war

_____ 2. One of the most important systems developed in the last 25 years combines x-ray
- A. with water
- B. with iron ore
- C. with computers
- D. with ultrasound

_____ 3. Bertha's father was
- A. a professor of Wilhelm's
- B. the owner of a bakery
- C. the father of a close friend
- D. the owner of a tavern

_____ 4. When Wilhelm graduated from the Polytechnic Institute his degree was in
- A. mechanical engineering
- B. analytical mechanics
- C. physics
- D. partying and sightseeing

_____ 5. The young physics professor that encouraged Wilhelm to follow the path of physics was
- A. Professor Gustav Zuener
- B. Professor Carl Thormann
- C. Professor August Kundt
- D. Professor Gottfried Ludwig

_____ 6. Wilhelm received his Ph.D. from
- A. The University of Utrecht
- B. The University of Strassburg
- C. the University of Wurzburg
- D. the University of Zurich

_____ 7. Wilhelm's first work with Kundt involved
- A. the behavior of gasses
- B. the effect of beans on the body
- C. the development of x-rays
- D. the uses of the Hittorf tube

_____ 8. While waiting to marry Wilhelm, Bertha stayed
- A. in a villa on the lake
- B. at his mother's house
- C. in the dormitory at school
- D. in a convent

_____ 9. Roentgen co-authored several articles with a colleague named
- A. Ernest Hohenheim
- B. John Wittenburg
- C. Franz Exner
- D. Gottfried Ludwig

_____10. Roentgen finally married Bertha in

A. 1910
B. 1872
C. 1890
D. 1868

_____11. Roentgen's discovery

A. was ignored for many years
B. was only used by scientists
C. made him a millionaire
D. was used by charlatans & quacks

_____12. Coolidge portable x-ray machines were

A. were developed in 1933
B. were used during WWI
C. are the newest development in X-ray
D. were named after Calvin Coolidge

_____13. Roentgen received the 1st Nobel prize ever given for

A. Physics
B. Engineering
C. Peace
D. Mathematics

_____14. As a young man, Roentgen was

A. very shy
B. very fashionable and social
C. only interested in his studies
D. dyslexic and could not read

_____15. Roentgen died

A. within 5 years of his discovery
B. impoverished and alone
C. of a heart attack while climbing the Alps
D. of cancer

Matching

_____16. Heinrich Geissler
_____17. Phillip Lenard
_____18. Johann Hittorf
_____19. Frances E. Willard
_____20. Gustav Zeuner

A. Named flow of electricity "cathode rays"
B. Was the leader of the temperance movement
C. Was quite bitter that Roentgen did not acknowledge his work
D. Was a physicist, glass blower & instrument maker
E. A professor at the Polytechnic Institute

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Unit Number 20
Title: Madame Curie: A Woman Before Her Time

1. Manya Salome Sklodowski was born in
   a. Paris
   b. London
   c. Warsaw
   d. Berlin

2. Marie Curie attended the following university to receive her graduate degrees:
   a. Sorbonne
   b. Oxford
   c. Cambridge University
   d. University of Wurtzberg

3. Marie and Pierre Curie shared their Nobel prize with
   a. Wilhelm Konrad Roentgen
   b. Antoine Henri Becquerel
   c. Albert Einstein
   d. Louis Pasteur

4. The 2 elements discovered by the Curies are
   a. polonium and tungsten
   b. silver and pitchblende
   c. iodine & thorium
   d. radium and uranium

5. Both Curies suffered from the biological effects of radiation, but attributed their poor health to
   a. poor nutrition
   b. genetic disorders
   c. poor air quality in Paris
   d. overwork and lack of fresh air and exercise

6. Pierre Curie's scientific contributions included the
   a. invention of the spectrometer
   b. invention of x ray tube
   c. scale for weighing research animals
   d. piezoelectricity

7. After Pierre's death, Marie was unanimously elected to succeed Pierre as the first woman to
   a. become a professor at the Sorbonne
   b. become the chairwoman of Physics
   c. study with Roentgen
   d. receive 3 Master's degrees

8. In 1911, Marie Curie accepted her second Nobel Prize and was
   a. wealthy and retired
   b. ready to return back to Poland
   c. the only woman in history to accomplish it
   d. influential with Albert Einstein's research

9. Marie supported education and the advancement of scientific research by developing
   a. theories on relativity
   b. drafts for the atomic bomb
   c. nuclear reactors
   d. 2 radium institutes in Paris & Warsaw

10. The utilization of "Curie wagons" occurred during
    a. World War II
    b. World War I
    c. Korean War
    d. Spanish-American War

11. One of Marie's daughters received the Nobel Prize in Chemistry. She was
    a. Irene
    b. Eve
    c. Bronya
    d. Charlotte

12. Marie received 2 grams of radium from 2 U.S. Presidents as gifts. They were
   a. Roosevelt & Harding
   b. Lincoln & Roosevelt
   c. Harding & Hoover
   d. Roosevelt & Wilson

13. "Curietherapy" was the precursor to
   a. radiation brachytherapy
   b. radioactivity
   c. nuclear medicine
   d. nuclear reactors

14. The centennial for the discovery of radium was or is
   a. 1996
   b. 1998
   c. 1988
   d. 2000

15. Marie received Master's Degrees in both
   a. mathematics & physics
   b. mathematics & chemistry
   c. chemistry & physics
   d. physics & biology

16. One of Marie's daughters publishes her mother's biography after her death. She was
   a. Irene
   b. Eve
   c. Bronya
   d. Charlotte

17. Mobile x-ray services in wartime was implemented by
   a. Wilhelm K. Roentgen
   b. Antoine Henri Becquerel
   c. Marie Curie
   d. Pierre Curie

18. Marie died at age 66 from
   a. cataract surgery
   b. "radiation sickness"
   c. cancer of the bowel
   d. leukemia or aplastic anemia

19. Pierre died at age 48 from
   a. a tragic accident
   b. "radiation sickness"
   c. cancer of the bowel
   d. leukemia or aplastic anemia

20. The term "radioactivity" and its discovery was given to the world by
   a. Wilhem Konrad Roentgen
   b. Antoine Henri Becquerel
   c. Irene & Eve Curie
   d. Marie Curie

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