ABSTRACT

Paradigms of Medical History

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There have been two prominent beliefs in western medicine through history: humoralism and modern scientific medicine. Despite humoralism often being looked at as a quite aged medical practice, there are still influences from the times of antiquity, such as the well-known Hippocratic Oath. This influence has often led people to view the progression of medicine as a constant evolution, but this thesis looks into how the history of medicine is made up of several paradigms. I analyze the development of humoralism in Ancient Greece and Rome and how it overtook the prior belief based on superstitions and religion. Then, I look into the major scientific and medical discoveries from the Renaissance, Enlightenment, and up to the current times, showing the development of the scientific medicine that we now know. This allowed me to suggest that, rather than developing from each other, these paradigms of medicine developed independently, causing an incommensurable paradigm shift.

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TABLE OF CONTENTS

Table of Figures……..iii

Acknowledgements…….iv

Introduction……..1

Chapter One: Hippocrates and the Foundation of Humoralism……...2

Chapter Two: Roman Medicine, Galen, and Advances in Public Health……..12

Chapter Three: Middle Age, Renaissance, and Enlightenment Medicine…….……23

Chapter Four: Modern Scientific Medicine……...35

Conclusion…….43

Resources……...45

TABLE OF FIGURES

Figure 1: Illustrating the Four Humors and the Attributes……..4

Figure 2: Illustrating Galen's Physiological System…….17

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INTRODUCTION

In this thesis, I explore the paradigm shifts in Western Medicine from humoralism to science-based medicine and to address what led to the change in traditional humoralism after millennia. The real question in this matter is whether there was an incommensurable paradigm shift between humoralism and scientific medicine or if it was a gradual change that led to our current view of medicine.

First, I look at ancient Greek and Roman medicine and specifically some of the major figures within this period, including figures such as Hippocrates and Galen. This allows me to analyze the beginnings and the lasting impact caused by some of the first well-documented practices of Western medicine. Next, I examine the Middle Ages, Renaissance, and Enlightenment, as it shows both an adherence to medical practices of antiquity and tremendous scientific development.

I then look at how the numerous advances in the sciences have led to a completely different medical approach contra to humoralism. The analysis of the shift in paradigms from humoralism to science-based medicine and from holistic to reductionist views allows for one to understand how medical practices and beliefs are ever-changing. The study of medical history also allows one to understand the many influences seen in medicine today.

CHAPTER ONE

Hippocrates and the Foundation of Humoralism

The name Hippocrates is often associated with the "Father of Western Medicine." Very little is known about the life of Hippocrates, most of which is known through the some sixty or so works that represent the Hippocratic Corpus. In fact, the only contemporary mention of Hippocrates is made by Plato in, his work, "Protagoras" during which "the young Hippocrates, son of Apollodorus has come to Protagoras, ‘that mighty wise man,' to learn the science and knowledge of human life." The most quoted life of Hippocrates was written by Soranus, who was a physician of the time. It says that Hippocrates was born in 460 B.C. on the island of Cos and that he had traveled throughout Greece, before returning to Cos and becoming the most renowned physician of the time until his death around 375 B.C.[1] It is during this that the Hippocratic Corpus was transcribed. It is unsure as to whether or not the entire collection of the Hippocratic Corpus can be attributed to the man Hippocrates, despite it bearing his name. The wide opinion is that the Hippocratic Corpus represents the work of many authors and that it embodies the library of the Hippocratic School of Cos. This conclusion came about through the fact that the many books within the Corpus are consistent with the ethical and ideal standpoint of the Hippocratic origin.[2] Out of all of the ideals seen within the

[1] William Osler, *The Evolution of Modern Medicine*, 1 edition (Yale University Press, 1921).Osler, *The Evolution of Modern Medicine*.

[2] Charles Singer and E. Ashworth Underwood, *A Short History of Medicine*, 2Rev Ed edition (OXFORD UNIV + PRESS, 1962).

Hippocratic Corpus, the most apparent and impactful are those of empirical medicine and humoralism.

Hippocrates is often attributed as the founder of the humoristic view of medicine. Humoralism stands on the cardinal principle of equilibrium and balance. This idea is most prevalent within the books *On Regimen* and *On the Nature of Man*. In *On Regimen*, the body is described as being permanently fluid and On the Nature of Man describes illness as an imbalance of this fluidity. The specific features that determined this balance were the four major bodily fluids or humors. The four humors consist of blood, phlegm, black bile, and yellow bile. The aspects of each of the humors were attributed through the observations made from each. These attributes were then used to treat the imbalance of the humors. Blood was associated with life and the natural loss of blood through nose bleeds and menstruation suggested the practice of bloodletting to release an excess of blood. Next, phlegm was associated with winter sickness and yellow bile associated with summer diarrhea and vomiting. This was decided through observations made about the "pasty, phlegmatic peoples of the North [in contrast to] the swarthy, hot, dry, bilious Africans," which were both found to be inferior to the perfect balance within the Greek climate. Then, black bile was also associated with sickness, as it was said to be seen in vomit and excreta, as well as contributing to the dark tint of dried blood. The four humors were able to complete a "symmetrical grid of binary oppositions," which are seen in the figure below.[3] These oppositions of blood, yellow bile, black bile, and phlegm were able to be applied to several qualities, respectively: the fundamental qualities (hot, dry, cold, and wet), the four seasons (Spring, Summer, Winter, and Autumn), the four ages

[3] Roy Porter, *The Greatest Benefit to Mankind: A Medical History of Humanity*, 1 edition (New York: W W Norton & Co Inc, 1998).

(infancy, youth, adulthood, and old age), the four elements (air, fire, earth, and water). One of the major contributors to this idea of the humors applying to these fundamental qualities was Empedocles of Agrigentum, who also found the organs that the humors originated in, which are the heart, liver, spleen, and brain. Empedocles, a "physician, physiologist, religious teacher, politician, and poet", was highly regarded at the time and often thought to have all kinds of magical powers attributed to him.[4] Despite this, he is most renowned for this idea of equilibrium of primeval substances within all human beings. These assumptions allowed for the formulation of the schema below.

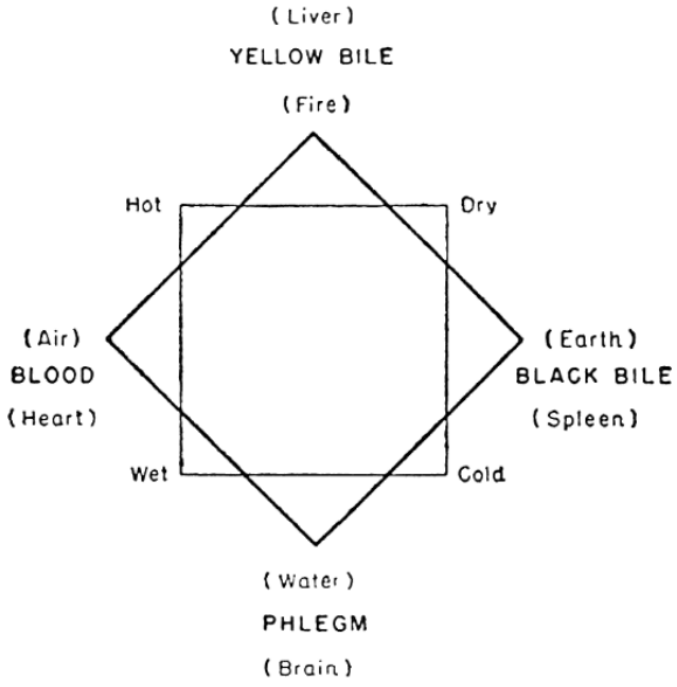

Figure 1: Illustrating the Four Humors and the Attributes[5]

[4] Osler, *The Evolution of Modern Medicine*.

[5] Erwin H. Ackerknecht and Charles E. Rosenberg, *A Short History of Medicine*, revised and expanded edition (Baltimore: Johns Hopkins University Press, 2016).

Hippocrates used the attributes of the four humors to approach his methodology for curing and preventing illness. Dietary regulation was his preferred method of healing while being cautious towards drug therapy, and that a good diet was crucial to health and the maintenance of the body's balance. For example, the blood prevailed in the Spring and amongst the youth, therefore precaution could be used by avoiding blood-rich foods, like red meat, or bloodletting to avoid an excess This is an example of how Hippocratic healing was revolutionary in how it was patient-centered focused on disease, rather than focusing on disease as an ontological entity.[6] Before Hippocrates' teaching, Greek medicine had a focus on priest healers and deities, namely Asclepius, the son of Apollo. Asclepius was said to be able to raise the dead as well as charitably used herbal remedies to humans. He was often pictured with his winged staff, around which two snakes were intertwined and stands as the origin of the symbol of the modern physician. He also eventually became a cult figure and the patron of physicians. It is unsure of when the introduction of the cult of Asclepius into Greece occurred, but his worship in places, such as Epidaurus, Cos, Pergamos, and Tricca, thrived. The cult especially flourished in places of hygienic advantages, with features that included fresh and hot mineral springs and mountains. Temples were erected throughout these "natural health resorts" and lead to sanctuaries of healing by temple priests. These priests utilized numerous superstitious practices and rites that often incorporated the sacred snakes and drugs that "visited patients during the night" within the temples.[7] The formation of the cult of Asclepius,

[6] Porter, *The Greatest Benefit to Mankind*.

[7] Osler, *The Evolution of Modern Medicine*; E. Ashworth Underwood, *A Short History of Medicine*.

which eventually found its way into Roman culture amidst the rage of the plague, shows the religious basis of pre-Hippocratic medicine. The vast shift in the approach to medicine between the cult of Asclepius and Hippocratic teaching shows an example of an incommensurable paradigm shift within medicine. Despite his immense contribution, Hippocrates was not the sole forerunner in the movement towards a patient-centered, humoristic view of medicine.

In addition to Hippocrates, several other major figures played a major part in the development of the Greek practice of medicine. Although Aristotle is often thought of as strictly a philosopher, he had great influences upon medicine. His attempts of influence are seen through his encyclopedic attempts to describe the entirety of nature and man.[8] This includes his foundation of comparative anatomy, which gave good descriptions of several organs, such as the uterus. In addition to this, one of his most notable anatomical feats was his illustration of the development of a dogfish, which proved to be illustrated very similarly to the attachment of a mammal embryo in the womb. These anatomical discoveries were the result of Aristotle's many animal dissections, rather than the dissections of humans, which were taboo of the time. In addition to his anatomical discoveries, Aristotle had a vast influence on the direction of medical thought after him. An embryological investigation was his major method of research and his research on the chick allowed him to examine the development of the organs. This led to one of Aristotle's most significant views, which was that the seat of intelligence was the heart due to its early appearance in the embryo. Although we now know that this theory is incorrect, it set a precedent of an important conception of nature, which is that of

[8] Ackerknecht and Rosenberg, *A Short History of Medicine*.

vitalism. Vitalism is the belief that the distinction between living and non-living substance is the presence of what he calls the psyche, which is equivalent to the modern-day idea of a soul. Aristotle distinguished three types of souls, which are vegetative (nutritive and reproductive), animal (sensitive), and the rational soul (intellectual).[9] The importance of this concept is that it began the practice of investigating the definition of life, which has been the key motivation for nearly all biological studies since. Aristotle held these discoveries and theories in concurrence with the abovementioned theory of the four humors and their qualities.

Two more Greek influences of medicine were Herophilus and Erasistratus. Herophilus was likely the first to preform public human dissections and thus is often attributed as the father of anatomy. He wrote at least eleven treatises with three on anatomy where he discovered and named organs such as the duodenum and prostate. He also wrote a treatise on the diagnostic use of the pulse, based upon the different strengths, rates, and rhythms.[10] Herophilus was also the first to make a clear distinction between arteries and veins. In addition to Herophilus, Erasistratus also contributed to major scientific advancements. He was much more controversial due to his practice of studying and experimenting with living animals and perhaps humans. This practice was nearly unheard of the time due to the taboo against experimenting on the human body. This also likely lead to the inaccuracies of previous anatomical discoveries, as they were performed on degrading cadavers. Erasistratus had been described "as an early mechanist, because of his model of bodily processes" and therefore referred to as the father of physiology.[11]

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[9] E. Ashworth Underwood, *A Short History of Medicine*.

[10] Porter, *The Greatest Benefit to Mankind*.

[11] Porter.

Per the teachings of Hippocrates, he had considered the excess of blood to be a primary cause of disease, which leads to the lasting practice of blood-letting for nearly every condition.[12] These variances in approach to studying medicine between Hippocrates and his method of experiential investigation, Herophilus, and anatomy, as well as Erasistratus and physiology, lead to the creation of sects in philosophy and medicine, despite the fact of them all being rational approaches.

In addition to Aristotle, Herophilus, and Erasistratus, Eryximachus was also a physician that was a strong advocate for the moderation of both the mind and body. He was deeply influenced by the aforementioned views of Empedocles, as said by:

> "…so too in the body the good and healthy elements are to be indulged, and the bad elements and the elements of disease are not to be indulged but discouraged. And this is what the physician has to do, and in this the art of medicine consists: for medicine may be regarded generally as the knowledge of the loves and desires of the body, and how to satisfy them or not; and the best physician is he who is able to separate fair love from foul, or to convert one into the other; and he who knows how to eradicate and how to implant love, whichever is required, and can reconcile the most hostile elements in the constitution and make them loving friends, is skillful practitioner."[13]

This quote shows how Eryximachus has expanded the views of balance and equilibrium within the body and through lifestyle. This conveys how the holistic/humoristic medical philosophy had been integrated within Greek lifestyle and philosophy by the way that scientific discovery has shifted from religion-based to experiential. Further integration is seen by the social impact made by the Hippocratic writing of *Airs, Water, and Places*, which focuses on the balance between man and his environment. This book held the practical purpose for physicians to be able to predict the future course of illnesses in the

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[12] E. Ashworth Underwood, *A Short History of Medicine*.

[13] Osler, *The Evolution of Modern Medicine*.

various environments within the expanding Greek communities. For example, it characterized lowlands and swamp regions as prone to disease and said that it is best to construct houses on elevated areas that are warmed by the sun. Although the epidemiological factors behind diseases and endemics were not fully understood for another 200 years, experiential and empirical investigation was utilized to find general causations for diseases that were commonly found within populations. The importance of health within the Greek communities was further expanded through the growing prominence of a community-wide tax that would stand as a means for the community to have a physician settle down there since physicians of the time would often wander from city to city.[14] The development of a public health administration within Greek cities exposed a further movement from away from the time of religious healing and temples into a much more secular, experience-based medical practice, as Hippocrates advocated. This new approach to medicine had been developing for centuries through the influential civilizations and philosophers preceding Hippocrates.

One of the major influencers to the Hippocratic and Greek approach to medicine was Pythagoras. Pythagoras of Samos was a multifaceted talent that transcended his mathematical laws onto philosophy and science. His ideas of "critical days" for the progression of disease, during which a disease will enter a decisive stage on either the fourth, seventh, eleventh, fourteenth, or seventeenth day. Hippocrates applies this doctrine of critical days to mark the crucial turning points during which a patient's health will change for better or worse.[15] Pythagoras is also known for being to the first

[14]George Rosen, Elizabeth Fee, and Pascal James Imperato, *A History of Public Health*, revised expanded edition (Baltimore: Johns Hopkins University Press, 2015).

[15] Ackerknecht and Rosenberg, *A Short History of Medicine*.

philosopher to discuss the existence of the principle of harmony and balance within the "cosmos."[16] This principle is a key feature of Hippocrates' teaching, as described before, and it highlights the importance of Hippocrates' philosophical predecessors, in the development of his school of medical thought. Another major influence on Greek medicine were the ancient Egyptians. Egyptian thinking played a major factor in both the religious and rational aspects of Greek medicine. Just as the Greeks had deified Asclepius, the Egyptians had Imhotep, who was "the first figure of a physician to stand out clearly from the mists of antiquity" and later deified as the god of medicine, as well as identified with the previous mentioned god Asclepius of the Greeks.[17] The Egyptians also contributed to Greek medicine through their discovery of several drugs and the discussion of several diseases and symptoms that were recorded on papyri. It is also believed that Pythagoras had traveled during his studies and had been influenced by the Egyptian studies in mathematics and sciences.[18] These influences upon the Greek medicine depict the lasting impact of medical discoveries and philosophy, which is later seen in the lasting impact of Hippocrates's humoralism.

The Hellenistic period in Greece was a time of vast medical development from a history of religion and superstition-based healing to a much more rational approach to the study and practice of medicine. The two approaches were described above from the influences of the ancient Egyptians and the several generations of philosophers. We are

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[16] "Microcosm and Macrocosm - New World Encyclopedia." "Microcosm and Macrocosm - New World Encyclopedia," accessed October 26, 2019, https://www.newworldencyclopedia.org/entry/Microcosm_and_Macrocosm.

[17] Osler, *The Evolution of Modern Medicine*; E. Ashworth Underwood, *A Short History of Medicine*.

[18] Hakim Mohammad Said, *Traditional Greco-Arabic Medicine and Modern Western Medicine: Conflict and Symbiosis.* (Karachi: Hamdard, 1982).

then able to analyze the rise in prevalence of rationality and humoralism through the hands of Hippocrates and his contemporaries. Although much of the discoveries and advancements from the time were later found to be inaccurate, the new approach to medicine and experiential learning lead to a new passion for discovery and social integration that had an incommensurable impact on future healthcare. The impact of Greek medical philosophy can still be witnessed in society today through the Hippocratic Oath, as well as rational and experiential thinking. The social integration seen within the Greek culture is an important indicator of the future upsurge of growth of rational humoralism and social medicine that is seen within Roman medicine and beyond. The sect of religious and superstitious healing, as seen by the cult of Asclepios, showed a separate paradigm of medicine, which began to see its fall among the growing cultural assimilation to the humoristic approach of the Greek physicians. This example of a paradigm shift within medicine is vital to the understanding of the later shift from humoralism to modern scientific medicine.

CHAPTER TWO

Roman Medicine, Galen, and Advances in Public Health

Early ancient Roman medicine thought that healing should remain in the family, under the care of paterfamilias, who would dispense and dose various herbs and charms. Romans enjoyed criticizing Greek physicians and writers, such as Cato, who said how Romans should "Beware of doctors" and that they would bring death by their medicine.[19] There were three major sects of medicine during this early period that, despite the warnings, exhibited Greek influence. These were the Empiricist, Methodist, and Pneumatist sects.

The three early schools of medicine all originated from Alexandria, where many of the ideas brought about in Greek medicine were adopted by Roman physicians. The Empiricists reduced relevant medical knowledge to their observations that are complemented by the observations of older authors. Practical experience and observable facts took precedence over theories in the eyes of Empiricists. Despite not playing a major part in the future development of medicine, this sect specifically enriched fields like symptomology, pharmacology, and surgery, which are all largely experience-based.[20] The Methodist sect is known to have reduced their theory of medicine and therapeutics to a few very simple methods. They limited the causation of disease down to either *status strictus* (narrowing of the internal pores) or *status laxus* (an excessive relaxation of the

[19] Porter, *The Greatest Benefit to Mankind*.

[20] Ackerknecht and Rosenberg, *A Short History of Medicine*.

pores). Therefore, treatment was simplified and concerned with overcoming the excessive contraction or relaxation. The origin of Methodism has been attributed to the necessity for treating a large number of patients at a time on large slave plantations.[21] And finally, Pneumatism, which was largely influenced by Stoic philosophy, based its disease theory on changes of the *pneuma*, which is the vital source of life and permeates organisms. This school of thought brought about many highly developed traditions of drugs and an attempt to differentiate between the primary and secondary phenomena of disease. Unlike the previous Roman and Greek medical thoughts with the four humor, the Pneumatists believed that *pneuma* was a fifth element that flowed through the arteries to sustain vitality and life.[22] Many extraordinary clinical descriptions of some diseases, such as diabetes, diphtheria, and leprosy, by the Pneumatics were very comparable to the modern clinical descriptions.[23] In addition to these three major sects of early Roman medicine, there were important writings by Celsus that were compiled to form an encyclopedia of medicine.

Aulus Cornelius Celsus was a Roman encyclopedist who was widely known for his contribution to medicine through his elegant and articulate writings of both theory and treatment. These were included in a twenty-one book compilation called *Artes* [The Sciences], which brought about his title of "Cicero of physicians".[24] Eight of these books are focused on medical practice and are introduced by the story of medicine from the time of the Trojan War, including the rise of the several sects that were discussed

[21] Ackerknecht and Rosenberg.

[22] Porter, *The Greatest Benefit to Mankind*.

[23] Ackerknecht and Rosenberg, *A Short History of Medicine*.

[24] Porter, *The Greatest Benefit to Mankind*.

previously. The first book focuses on the preservation of health and diet. The second on the signs that a doctor should look for and the remedies. Thirdly, Celsus wrote on diseases of the whole body, such as fevers and jaundice. He wrote on diseases of individual body parts in the customary order of top-to-toe in book four, then he addressed various drugs and treatments for things, such as bites and ulcers. The sixth book dealt with treatments of diseases of the different parts of the body. The final several books then focused on surgery, including a brief history of the art, a list of surgical conditions, as well as the many surgical techniques. These descriptions included the cardinal signs of inflammation- *calor, rubor, dolor,* and *tumor* (heat, redness, pain, and swelling)- that are all still used today.[25] Since this is the first major medical writing in Latin, along with the fact that it was a complete summary of medicine of the time, Celsus was able to be a major influence on the future of not only Roman medicine but Western medicine as a whole. This is until the rise of Galen, who was the medical giant of the Roman era.

Galen of Pergamon was the medical titan of the Roman era. His impact surpassed the work of his many Roman contemporaries. One of them was Aretaeus of Cappadocia, who made disease the center of his study and even wrote in Greek, which showed his loyalty to Greek medicine along with his many allusions to Hippocrates. He was inclined to the pneumatic school, as discussed earlier. Aretaeus gave descriptions of things such as epilepsy, diabetes, and mental disorders. Another, Soranus of Ephesus, was largely known from his work in gynecology, on which he wrote a three-part book, discussing conception, pregnancy, labor, and associated maladies. The work of Galen overshadows these contemporaries largely because their works have only survived in fragments (unlike

[25] Porter.

Galen), as well as the fact that Galen was known to often belittle them.[26] It is thought that Galen's work was able to survive through history due to his work being based on a sort of determinism, in which the body was a reflection of perfection. This idea appeals to the Christian point of view, which would be a reason as to why Galen's work has been preserved more than other pagan writers. Galen's studies also played a major part in the basic medical knowledge of Muslim writers, further preserving his impactful work.

Galen was as prominent within Roman medicine as Hippocrates was in Greece. In fact, Galen was largely influenced by the work done by Hippocrates. Galen praised his work and adopted the idea of the four bodily humors. The importance of balance and harmony of the humors carried into Galen's work. Both Galen and Hippocrates emphasized the important relationship between the environment, especially the food consumed, and the body's health. Despite their similarities, they had several aspects at which they differed. The first is that Galen emphasized teleology, in which he looked to assign causes and purposes to various parts of the body unlike Hippocrates, who did not often consider causes. They also differed in their views of philosophy in medicine. Hippocrates believed that philosophy freed medicine from superstition, but it should not be substituted for errors of hypotheses that go against observations. Galen, on the other hand, believed that the best physician was a philosopher and well versed in logic, physics, and ethics, but Hippocrates said a physician was confined to medicine.[27] The

[26] Porter.

[27] Philip R. Liebon, "Philosophy of Science and Medicine Series — II: Galen vs. Hippocrates," *Hektoen International*, 2016, https://hekint.org/2017/01/22/philosophy-of-science-and-medicine-series-ii-galen-vs-hippocrates/.

idea of the best physician also being a philosopher is one of Galen's central ideals and it guides his rational approach to studying medicine.

Galen approached medicine and anatomy through rational and logical thinking and often presented his work as "perfecting" Hippocrates' legacy with a fusion of clinical and theoretical study. Concerning Galen's emphasis on teleology, he held the belief that "nature does nothing in vain" and that every part of the organ has been endowed with a special purpose with functions that can be determined.[28] Although he was both an anatomist and a physiologist, Galen's most important work was done in physiology, as he was the first to carry out experiments on a large scale. One of the most impactful were those regarding the circulatory system. Before Galen, it was commonly thought that arteries contained air but, through his experimentation of tying off the femoral arteries, Galen found that they carried the blood that transmitted nutrition through the body. Galen placed the liver as the central organ of nutrition and that the heart was a sort of fireplace from which the innate heat of the body derived.[29] This system is illustrated in the figure below. He also demonstrated how urine was formed within the kidneys rather than the often falsely assumed bladder, by tying off the ureters of his experimental specimens, which were often monkeys, pigs, and dogs.[30] Although parts of his ideas are now found to be largely inaccurate, they show major progress in better understanding the human body.

[28] Ackerknecht and Rosenberg, *A Short History of Medicine*.

[29] Osler, *The Evolution of Modern Medicine*.

[30] Ackerknecht and Rosenberg, *A Short History of Medicine*.

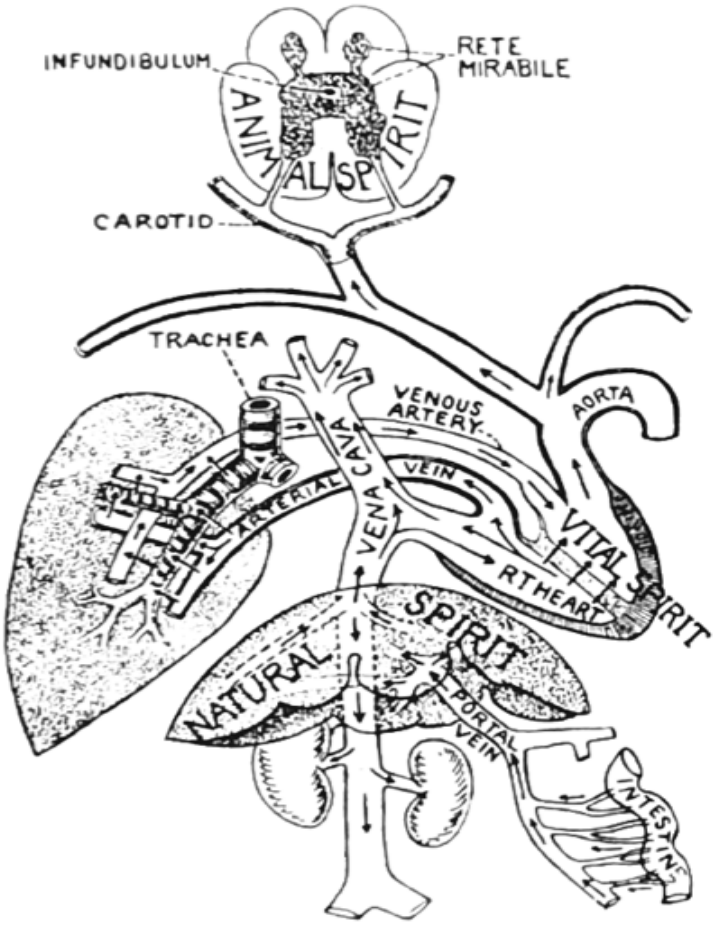

Figure 2: Illustrating Galen's Physiological System.[31]

Galen was known as a great descriptive anatomist at his time and was able to express many key important details that were common misconceptions of his time. One of which was that the heart was the central organ for nerves and the brain was for the vessels. He was able to provide accurate descriptions of the human skeletal and muscular systems, largely because he was able to study and actual human skeleton when he was in Alexandria. Specifically, he distinguished the long bones as those with a "central canal," which we now know is for marrow and vessels. Galen divided the joints of bones into

[31] E. Ashworth Underwood, *A Short History of Medicine*.

two main divisions, which were those with movement and those without. His descriptions of muscles have largely been seen as pioneer work due to his accuracy. He was able to accurately describe many of the muscular systems, such as the muscles of the orbit, larynx, tongue, and hand, and indicate/acknowledge the differences between humans and his animal specimens.[32] It is impressive that Galen was able to describe what he did considering that it is widely thought that he may have never dissected a human body, due to the social taboo towards human dissection.

Galen's approach to pathology was very similar to that of Hippocrates, but he refined and introduced many subdivisions in line with the four humors. Galen also did not confine himself to the simplicity of Hippocrates' approach to curing disease. He had great faith in drugs and various plants from the known world, although he aligned with the idea of "hot" remedies being used to treat "cold" diseases and vice versa. Galen had even described 473 drugs from vegetable, animal, and mineral origin in his writings.[33] One of the most significant beliefs of Galen was that of the "critical days" of a disease, which is supported by the major diseases of his time, being pneumonia, typhoid fever, and malaria. This idea was also discussed before with the works of Pythagoras. Galen did not confine his pathological thinking to one specific school of thought, but rather he was eclectic and incorporated differing ideas from many of the schools. Such ideas were the notion of *pneuma* of the Stoics and *status strictus* or *status laxus* of the Methodists. Despite this, Galen was largely against these theoretical practitioners of the time who were more concerned with the disease itself and not the conditions that they caused. One

[32] E. Ashworth Underwood.

[33] Porter, *The Greatest Benefit to Mankind*.

of the most important steps that Galen made is that he concluded that "a function could not be impaired without part of the governing function being affected" when analyzing local pathology.[34] This allowed for Galen to distinguish the importance of specific symptoms when diagnosing. In spite of this contribution to localized pathology and medicine, his approach essentially remained focused on humoralism and a holistic view of health.[35] Although his beliefs did not follow the localized and systematic view of medicine, these ideas seem to form a conduit by which more modern medicine follows.

Outside of the impact of Galen's work, Roman medicine had a major impact on the advancement of public health and social medicine. One of Rome's largest contributions to organized medical care is the creation of the hospital. The development of the hospital came as a result times of increasing military life, during which hospitals provided first aid treatment of those wounded in the field. Public hospitals paralleled the development of military hospitals. The public hospitals were largely used to treat poorer civilians, slaves, and soldiers, as the affluent would receive treatment in a doctor's household or even their own. This was only possible through the incorporation of a public medical service with which physicians were appointed to various towns, cities, and institutions throughout Rome.[36] This appears to be a continuance and extension to the public health administration that began in Greek communities. The standard hospital plan was typically a long hall that had many individual cells for patients, along with

[34] Ackerknecht and Rosenberg, *A Short History of Medicine*.

[35] Osler, *The Evolution of Modern Medicine*.

[36] Rosen, Fee, and Imperato, *A History of Public Health*; E. Ashworth Underwood, *A Short History of Medicine*.

bathrooms and baths.[37] The Romans also placed a foremost emphasis on the importance of public cleanliness and health. Much like the baths seen in the hospital plans, public baths were an important part of Roman life and were made available to almost all citizens, as personal hygiene was placed on the daily itinerary for all within the Roman society.

The importance of hygiene is apparent through other parts of Roman society as well. One of which is seen in the attention paid to the purity of the water pumped into the cities. At the peak of Rome, it has been estimated that the major aqueducts probably delivered nearly 40 million gallons of water a day and, due to this large influx, there was a major responsibility to maintain the cleanliness of the water supply. This was typically done by flowing water from large reservoirs into smaller ones, so that sediment would be deposited from the water. Then based on the purity of the water, it would be either reserved for drinking water or, if the source was polluted, it would have other uses, such as gardens and fountains.[38] Although hygienic facilities such as freshwater, baths, and hospitals were available for much of the Roman society, there was a dark side to some of the overcrowded slums where some of the masses did not have access to them.

Despite the apparent cleanliness and hygiene seen throughout Roman society, there are several historical instances of endemic and epidemic disease outbreaks that plagued the Roman Empire. There are mentions of many diseases that certainly occurred in epidemic form, such as diphtheria, malaria, typhoid, dysentery, strep, tuberculosis, and possibly influenza, but there are a few epidemics that reached the level of a plague. One

[37] Porter, *The Greatest Benefit to Mankind*.

[38] Rosen, Fee, and Imperato, *A History of Public Health*.

of which was the plague of Cyprian which lasted from 251 to 266 A.D. and is through writings is now thought to have been smallpox, especially since there was another outbreak of smallpox again in 312 A.D. From 164 to 180 A.D., there was another epidemic known as the Antonine pestilence that ravaged the entire Roman Empire. It is unknown as to what disease caused the pestilence, but it is thought to have possibly been either typhus, bubonic plague, or smallpox. The Antonine pestilence was the most lethal of the epidemics that were seen across the ancient Greek and Roman world.[39] One of the last recorded plagues of the Roman period was sometime during the 6th century and known as the Plague of Justinian, during which it is thought that up to 25-50 million people died. This plague has been recognized as an epidemic of the bubonic plague and is only later resembled in severity by the Black Death.[40] Despite the many advancements in medical care by figures like Galen, many of the public authorities blamed these epidemics on acts from the gods and sacrifices were made to the city protecting gods and even the therapeutics changed little from the Greeks.[41]

Throughout the time of the Romans, the influence of Greek medicine, especially Hippocrates, is more than apparent. The three early sects of medicine, Empiricist, Methodist, and Pneumatist, all acquired a substantial amount of influence from Greece, like the idea of *pneuma* from the Stoic philosophers or the importance of rationality and observation in discovery. The prevalence of the Hippocratic idea of humoralism throughout all Roman medicine also shows the lasting impact of Greek medical thought,

[39] Porter, *The Greatest Benefit to Mankind*.

[40] Rosen, Fee, and Imperato, *A History of Public Health*.

[41] Porter, *The Greatest Benefit to Mankind*.

expressly seen through Galen's idea that he was sort of perfecting the work of Hippocrates. This situation begins to illustrate how a scientific or medical philosophy can introduce itself into multiple societies and continue to develop, improve, and evolve. In addition to this, the increasing importance of public health in Roman society conveys how the ever-advancing knowledge in the fields of pathology, anatomy, and physiology can bring about changes in an entire civilization. It also shows the movement towards a more secular society as they begin to understand the things they can manipulate, such as the significance of physical hygiene and clean drinking water. This movement further illustrates the ongoing social paradigm shift from religious and superstitious healing to more scientific medicine. The religious response that occurred in response to the plagues, despite the significant advances in medicine, illustrates how two approaches to medicine can coexist in society although one may dominate public belief. With the increasing scientific knowledge in the centuries to come, society seemed to further shift in favor of a rational, scientific approach to medicine over other superstitious beliefs.

CHAPTER THREE

Middle Age, Renaissance, and Enlightenment Medicine

The Middle Ages often referred to as the Dark Ages, are often thought of as a stagnant time, in regards to academics, due to the disintegration of the Roman Empire and the frequent warfare from the migration of barbarian and pagan groups.[42] Superficially, medical studies seem to have digressed as well, because of the major impact the Church had on medical study. On the contrary, several advances in public health, medical education, and medical practice came out of this time. The advancement of medicine in the Middle Ages can be largely classified into two parts: a period of monastic medicine and a period of scholastic medicine.

The Catholic Church held very close ties with scientific and medical achievements throughout the Middle Ages. For much of the Middle Ages, the body of people who studied medicine were clerics and monks of the Catholic Church. A result of this was that the Church often interleaved its beliefs into medical care. In the early Middle Ages, these seemed to be especially drastic. For example, the common belief was that there was a fundamental connection between sin and disease, which followed along with therapeutic methods of prayer, penitence, and the assistance of saints. This led to a belief that it was more important for the sick to be blessed by a priest than be bled by a doctor. Under these beliefs, every cure was regarded as a miracle.[43] This approach to

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[42] "Migration Period | European History," Encyclopedia Britannica, accessed April 7, 2020, https://www.britannica.com/event/Dark-Ages.

[43] Ackerknecht and Rosenberg, *A Short History of Medicine*.

medicine and health seemed to be similar to the times of antiquity. The period of this religion-based medicine is part of the period of monastic medicine. Despite it appearing like medicine was in a regression, the Church did help lead to many advances to modern medicine, such as monasteries becoming key medical centers and the use of herbal remedies from the translated Greek works.

The establishment of hospitals in the Middle Ages originated from the Church. The original monastic medical centers had their doors open to not only fellow monks but also travelers and pilgrims. Between the 8th and 12th centuries, the monastic hospitals were the only institutions in Europe that had the main task of caring for the sick.[44] The Benedictine rule that states "the care of the sick is to be placed above and before every other duty, as if indeed Christ were being directly served by waiting on them," leaves no surprise as to why monasteries became the key medical centers of the West.[45] The medical centers developed through the Middle Ages and were later funded to provide medical care and social assistance to entire cities. The medical centers often had a garden of medicinal plants to provide treatment based upon the ancient Greek, Roman, and Arabic texts that were being translated in these monasteries.

A major contribution of the Church in the early Middle Ages was the translation of ancient Greek and Roman writings. This movement was originally led by Benedictine monks, especially Alphanus of Salerno, and Constantine. They became acquainted with Greek medicine from the Arabic translations of Greek works that were funneled into Europe through Salerno, where the Latinized versions were then channeled into the West.

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[44] Rosen, Fee, and Imperato, *A History of Public Health*.

[45] Porter, *The Greatest Benefit to Mankind*.

Salerno was even the sight of the first university of medicine, which was founded in the 10th century.[46] The works of Galen and Hippocrates dominated the Latinized works, which lead to Medieval medicine to be largely based on medicine from the time of antiquity. Of these translations, a new canon of medical authority, known as *Articella* [Little Art of Medicine], came about, which mostly focused on the works Galen.[47] Although it included works from the Methodist and Hippocratic teachings of Greek medicine, it had a distinctly Galenic character.

In 1130, the Council of Clermont forbade the practice of medicine to monks, as it was seen as disruptive of the monastic life. Therefore, medical practice and study fell to the secular clergy, which led to the period of scholastic medicine.[48] Along with the expansion of hospital building during this time, the period of scholastic medicine saw a flourishing of universities. The first of these universities included the following: Paris in 1110, Bologna in 1158, Oxford in 1167, Montpellier in 1181, Cambridge in 1209, Padua in 1222, and Naples in 1224.[49] These universities expanded upon the work done in Salerno, including the idea that surgery was a separate specialty from other medical studies as well as an emphasis on the medical canon within *Articella.* The idea that surgery was a specialty was an indication of the specialization of medicine to come in more modern times. Also, the importance of the Galenic *Articella* meant that there was a prominence of bloodletting as the first resort for treatment for all diseases and the medicines recommended by Galen. One of the most important figures of this period was

[46] Porter.

[47] Porter.

[48] Ackerknecht and Rosenberg, *A Short History of Medicine*.

[49] Porter, *The Greatest Benefit to Mankind*.

Mondino de Luzzi. He performed the first recorded human dissection in 1315, leading him to write *Anathomia* the following year, which remained a classical anatomical textbook in Europe for at least two centuries.[50] This was a very important event for medical advancement as it helped shift away from animal dissection, which had been the standard for hundreds of years due to it being seen as taboo. Although Mondino had several inaccuracies within his work, such as the three-chambered heart or the five-lobed liver, he set a new precedent of detaching from the teachings of Galen that so much of Europe had been blindly following.[51] This would become an important precedent for the future of anatomical and medical advancement towards a scientific medicine over humoralism.

Another factor that led to important advances in the Middle Ages was due to the spread of several plagues and diseases. Two of the most significant diseases during this time were leprosy and the bubonic plague. Leprosy is thought to have reached epidemic proportions in the 13th and 14th centuries, which was likely due to the widespread movement of the population due to the Crusades. This disease caused a fright throughout medieval society and therefore lead to a need for action. Largely through the leadership of the Church, as physicians were unable to do anything, people who suffered from leprosy were isolated from communities and considered dead socially. This led to the vital public health action of isolating people with communicable diseases. Next, the Black Death led to many changes within society, which are seen with disease outbreaks

[50] Alexandra Mavrodi and George Paraskevas, "Mondino de Luzzi: A Luminous Figure in the Darkness of the Middle Ages," *Croatian Medical Journal* 55, no. 1 (February 2014): 50–53, https://doi.org/10.3325/cmj.2014.55.50.

[51] Mavrodi and Paraskevas.

today. One of the most important realizations was the idea of quarantine to be able to minimize the spread of disease. The severity of the Black Death caused this principle to have to undergo rapid development. This included principles such as patients being reported to authorities and held in isolation, a ban placed on houses with a plague victim, special messengers provided necessities, and people from communities inflicted by the plague were not allowed to enter other communities.[52] The social responses to leprosy and the bubonic plague show that Western society began to further understand the spread pathogens and disease. This can be interpreted as the initial stimulation for the rise of microscopic science and medicine seen several centuries later.

The Renaissance and Enlightenment, between the 14th and 18th centuries, were very important periods for not only medical and scientific history but for humanity. It saw a spike in cultural and intellectual movements, including arts and sciences. Two movements that especially effected the development of medicine were the encouragement of experimentation and observation, as well as the emphasis on the beauty of the human body. The leading figures of these movements were Frances Bacon and Leonardo da Vinci, respectively.

Leonardo da Vinci took interest in more than just an artistic interest in the structure and working of the human body, which set him apart from many of the other artists of his time. His achievements in the sciences were on par with that of his works of art. He carried out anatomical dissections for many years and was able to create about 750 anatomical drawings in the early 1500s that largely paid attention to embryonic development, muscles, and the nervous, respiratory, vascular, and urogenital systems.

[52] Rosen, Fee, and Imperato, *A History of Public Health*.

Leonardo was one of the first anatomists to question the views of Galen and perform careful first-hand investigations of the body. This idea was later continued and expanded upon by a man named Andreas Vesalius.

Andreas Vesalius was a true Galenic anatomist in that he followed the mantra to see for oneself. He proceeded to perform dissections through his career in Paris and Padua and it is through his eventual familiarity with human anatomy that he concluded that Galen had only ever dissected animals. This led Vesalius to create his masterpiece named *De humani corporis fabrica,* published in 1543. Although other anatomists had criticized parts of Galenic anatomy, the *Fabrica* was the first to do so systematically.[53] Many think of this work as the foundation of medicine as a science as it led to anatomists throughout the West to begin to approach anatomy through observation and experimentation, rather than follow suit with the medicine of antiquity.[54]

In addition to the developments seen with the study of anatomy, advancements were seen throughout the sciences. One of the most influential people to advances to a "new science" was Frances Bacon. He emphasized the importance of experimentation and observation to provide a basis for reasoning. Bacon also held a strong view against the old forms of reasoning that proceeded from insufficient data and hypotheses the lacked any foundation of fact.[55] This ideal was the basis for the future advances of science throughout the rest of history and soon developed into the scientific method that

[53] Porter, *The Greatest Benefit to Mankind*.

[54]E. Ashworth Underwood, *A Short History of Medicine*.

[55] G. W. Steeves, "Medical Allusions in the Writings of Francis Bacon.," *Proceedings of the Royal Society of Medicine* 6, no. Sect_Hist_Med (May 1, 1913): 76–96, https://doi.org/10.1177/003591571300601509.

we know today. There was a new skepticism introduced into the sciences and medical field, which lead to what is now known as the "Scientific Revolution."

The new wave of thought led to even further expansion of the previous anatomical work of Vesalius. Anatomists were impatiently prioritizing the discovery of new structures to expand upon and correct past discoveries. This led to a sort of specialization of anatomy, in which anatomists would focus on specific parts of the body. One such person was Hieronymus Fabricius, who published several treatises on topics such as venous valves and embryology. Fabricius not only described the anatomical structures as Vesalius but also focused on describing the functions and uses of the structures, showing the advancement of physiology along with anatomy.[56] This demonstrates one of the first instances of science approaching a reductionist view as studies become more and more specialized just as we see today.

Another figure to depart from the Galenic view of medicine was Theophrastus von Hohenheim. Known as Paracelsus, he had a significant impact on the natural philosophy. Paracelsus ridiculed the work of Galen and those who adhered to it. His significance lies upon his natural philosophy that was based upon chemical principles. His philosophy was based on ideas from alchemy and astrology and therefore received much controversy. Despite this, Paracelsus upheld Bacon's philosophy as he used his observations to come to his view of medicine. He came to look at disease through chemical principles, rather than humoralism. One such example of this comes from his interpretation of gout. Through Hippocratic medicine, gout is seen as a classic humoral imbalance within the foot, but Paracelsus proposed that gout may be caused by external

[56] Porter, *The Greatest Benefit to Mankind*.

factors of water and food supply to lead to the chemical deposits in joints.[57] His basis in alchemy was primarily a way for him to search for new remedies based on his chemical knowledge and elements of his creation. Through this influence, elements, such as lead, sulfur, iron, arsenic, copper and potassium sulfate, were introduced into the pharmacopeia of the time.[58] The basic chemical principles of Paracelsus allude to the new scientific paradigm of medicine that is further advanced within the Scientific Revolution.

In orientation with the reductionist view of anatomy, the microscope was one of the most significant inventions of this period. The microscope was invented around 1590 by one of three Dutch spectacle makers, Hans Janssen, his son Zacharias, or Hans Lippershey.[59] From this, Robert Hooke reported the first treatise on microscopic studies that was named *Micrographia* published in 1665. It is in this work that he came up with the cell theory from describing the pores he viewed in wood. This work was expanded upon by Anton van Leeuwenhoek, who examined and discovered bacteria, spermatozoa, and protozoa, which he described as "animalcules." He excelled above the many other microscopists because of his skill in making high-quality lenses. His discoveries led to an increase in the use of microscopy in medicine. The work of Marcello Malpighi stood out as he used a microscope to advance the mechanical structure of living beings. He revealed structures such as the alveoli of the lungs, taste buds and papillae of the tongue, nerve fibers, and many others in the 1660s.[60] Despite the obvious potential and advances made within microscopy, it was not for a couple centuries later that it became appreciated

[57] Porter.

[58] Ackerknecht and Rosenberg, *A Short History of Medicine*.

[59] David Bardell, "The Invention of the Microscope," *Bios* 75, no. 2 (2004): 78–84.

[60] Porter, *The Greatest Benefit to Mankind*.

by clinical and laboratory scientists.[61] An outcome of the discovery of the new microscopic world was that it helped contribute to the novel epidemiology that had been developed throughout the Renaissance and Enlightenment ages.

Due to the epidemics of the Middle Ages and the appearance of syphilis, a novel, early theory of epidemiology was developed. The continued prevalence of the black plague along with the appearance of syphilis from the discovery of the Americas caused the study into the constitution of these epidemics. The origins of epidemiology can be seen within the previously discussed work of Hippocrates, *Airs, Water, and Places,* in which he talks about the course of illness in various environments. The 16th century saw an expansion upon this idea in which Girolamo Fracastoro presented the rise and spread of epidemic disease in a systematic form. His treatise was composed of three books in 1546 that covered his theory of contagion, various contagious diseases, and their cures, respectively. Fracastoro was the first to clearly present a theory of infection in which he found infection as a cause and epidemics as a consequence. He concluded that disease was caused by minuscule infective agents that are transmissible and self-propagating, which he came to refer to as *seminaria*. It is unlikely that his conception of *seminaria* is comparable to the microbes we now know but more likely that he saw them as "seeds of disease" regarded as chemical substances or fermenting agents. Fracastoro recognized three modes of contagion: by direct contact between people, through intermediate objects/agents, or at a distance, for example, through the air or water.[62] This greater understanding of the spread of disease coming from microscopic means follows the

[61] Steven I. Hajdu, "The First Use of the Microscope in Medicine," *Annals of Clinical & Laboratory Science* 32, no. 3 (July 1, 2002): 309–10.

[62] Rosen, Fee, and Imperato, *A History of Public Health*.

reductionist and scientific path seen within the studies of anatomy and microscopy discussed earlier, which later becomes the central focus of medicine.

Another advancement in the treatment of disease during this time was the introduction to the idea of inoculation. This came as a result of smallpox becoming virulent throughout Europe. In the early 18th century, the use of variolation was introduced to the West from Asia. Variolation involved taking material from a smallpox patient and often blown into an at-risk individual in the hopes of mild infection and eventual immunity.[63] This procedure showed great potential and was later used as inspiration for modern vaccines.

Despite the many advancements in science and medicine, the practice of medicine was found to still have a strong affinity to the ancient teachings. Largely due to the immense Greek admiration that occurred as a result of the Renaissance movement. This initiated the movement to directly translate the original Greek texts of Galen and Hippocrates to have a more accurate representation of his teachings. These newly translated texts were used throughout the medical universities of the West. This led to physicians to adhere to the paradigm of humoralism and the herbal remedies taught by Galen.[64] This led to a deep division between the scientific advances discussed earlier and the practice of clinical medicine.

Clinical medicine often adhered to observing a patient's symptoms for diagnosis and the following therapy. Conventional therapies often focused on purging the body of disease-causing humors, which were most commonly the procedure of bloodletting and

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[63] Arthur Boylston, "The Origins of Inoculation," *Journal of the Royal Society of Medicine* 105, no. 7 (July 2012): 309–13, https://doi.org/10.1258/jrsm.2012.12k044.

[64] E. Ashworth Underwood, *A Short History of Medicine*.

the learned concoctions from Galen. In addition to this, there was also the appearance of new drugs from the Americans and Asia, including tobacco, opium, rhubarb, and several others. Another common treatment that came along with the syphilis was the use of mercury, which often caused side effects that rivaled the symptoms of the disease itself.[65] Although it was not a full proof treatment, the use of mercury as a treatment showed potential motivation from the growing medical chemistry field. Surgery saw little changes through this time, despite the great advances in anatomy and physiology. Surgeons knew their limitations and often confined themselves to simple procedures, like bloodletting, lancing boils, pulling teeth, etc. This was due to the well-known risks of internal surgery, which included shock, sepsis, and blood loss. Therefore, internal malfunctions and illnesses were treated by the previously mentioned medicines and management. In addition to the humoralism based clinical medicine, religious and superstitious healing was still quite prevalent within Western society.[66] As a result, this period of history showcases all three of the major medical paradigms from history, which are religion, humoralism, and science-based.

In closing, the period between the 5th and 18th centuries showed a wide array of medical philosophies and changes. Throughout this period, all of the major medical paradigms seem to exist. This is especially apparent between the 15th and 17th centuries with the influence of the Church, Bacon's philosophy on scientific and medical research, as well as the humoralism-based practices of physicians. Through the earlier discussions, we see that the Scientific Revolution was almost completely independent of the medical

[65] Rosen, Fee, and Imperato, *A History of Public Health*.

[66] Porter, *The Greatest Benefit to Mankind*.

practice of the time, despite the medical sciences of anatomy, biology, and chemistry following a path of reductionism and specialization with the many advances within each respective field. Due to this, it is fair to conclude that humoralism and scientific medicine represent two separate paradigms of medicine. As scientific advancement continue, medicine soon follows suit and moves away from humoralism and follows the specialization and reductionist path seen from the Scientific Revolution.

CHAPTER FOUR

Modern Scientific Medicine

Before the 19th century, hospital medicine had purely focused on the use of clinical observation and autopsy for progress. After the great advancement of the sciences during the Renaissance and Enlightenment, along with the faltering clinical medicine, it became apparent that future progress must depend on the ability to apply scientific discoveries to their field. This led to a greater medical understanding of disease and stimulated the specialization of medicine, which is much like the reductionist trend seen in the earlier period. It is during this time that we see scientific medicine take its hold over the humoristic medicine that had dominated for centuries.

One of the earliest and most important of these scientific advances to effect medicine was the development of the modern cell theory in the early 1800s. The development of the modern cell theory began with one of the co-founders, Matthias Schleiden. He was studying the microscopic structure of plants when he found that the plant tissues were made up of cells, which were constantly being reproduced. From this, he concluded that plants were "aggregates of cells, existing as self-producing units."[67] Theodor Schwann took up this idea and explored possible analogies between animal structures and Schleiden's findings in plants. He expanded upon the findings of Schleiden and found that complex animal tissues composed of cells and that living cells were basic

[67] Porter; E. Ashworth Underwood, *A Short History of Medicine*.

to living things.[68] These basic findings of these men started a surge in research regarding the major parts of the cells, namely being the cell wall and nucleus. One of the most important scientists to expand on this work was Rudolf Virchow. Unlike Schleiden and Schwann, who thought that cells arose through a kind of spontaneous generation, Virchow concluded that cells always arose from pre-existing cells through division. In regard to medicine, Virchow attracted the attention of medical professionals through his discovery of leukemia and his studies on embolism and thrombosis. He approached his studies through his new "solid pathology" that stated that diseases were the result of disturbances of the body's cellular structures. Virchow published his work, *Cellular Pathology*, in 1858 and, despite his basic principles being attacked, it became the supreme work for the field of pathological anatomy. Not long after, he became one of the best known and most respected medical men of his time, which is a true indication of the paradigm shift within medicine, as medical leadership began to be assumed by laboratory scientists.[69]

In continuation of Virchow's claim that disease has a cellular basis, Louis Pasteur and Robert Koch both studied microorganisms and developed the germ theory of disease. Pasteur spent many years studying various processes of fermentation. He expanded his study to what he called ferments, which were the organisms that he found to cause fermentation. He found that these ferments demonstrated the power of reproduction and that without them no fermentation occurred. Pasteur concluded that the ferments, found to be different types of bacteria, could be transferred through the air although not in a

[68] Porter, *The Greatest Benefit to Mankind*; E. Ashworth Underwood, *A Short History of Medicine*.

[69] Ackerknecht and Rosenberg, *A Short History of Medicine*; Porter, *The Greatest Benefit to Mankind*.

uniform fashion. From this, Pasteur used his findings by looking at anthrax and rabies. He found that anthrax was a bacterium that could readily reproduce, and it could be preserved in spores that spread infection. Then in 1880, Pasteur found that he could attenuate the virulence of bacteria. This allowed him to do this to the anthrax bacteria, along with preventing it from developing spores, and, after injecting it into sheep, he was able to protect the sheep against virulent anthrax. He was also able to follow these findings and methods to develop a method to prevent rabies infection.[70]

Just as Pasteur had laid the foundations for the nature of infection, Robert Koch is known to have laid the foundations for the study of how diseases are studied. Koch was able to develop methods of growing pure cultures of microbes, which were largely due to his development of nutrient-rich gelatin that would be poured onto glass slides that we now know as Petri dishes. This became a key development in the successful study of microorganisms and their diseases.[71] Koch also developed his four postulates that are required to find a causative relationship between a microbe and a disease. Koch's postulates are as follows: the bacteria must be present in every case of the disease, the bacteria must be isolated from the host with the disease and grown in pure culture, the specific disease must be reproduced when a pure culture of the bacteria is inoculated into a healthy susceptible host, and the bacteria must be recoverable from the experimentally infected host and shown to be the same as the original.[72] The greater understanding of the

[70] E. Ashworth Underwood, *A Short History of Medicine*.

[71] E. Ashworth Underwood.

[72] William C. Shiel Jr., "Definition of Koch's Postulates," MedicineNet, accessed April 16, 2020, https://www.medicinenet.com/script/main/art.asp?articlekey=7105.

spread of infection and microbes allowed for medicine to further develop ways to avoid and prevent its spread.

With an even more advanced understanding of the spread of disease, medicine was able to find ways to hinder the spread of infection. Three major figures to bring these newfound ideas of disease and infection were Ignaz Semmelweis, Joseph Lister, and John Snow. Semmelweis analyzed the mortality rates of two obstetric clinics and found that one had a three times higher rate of mortality than the other. He found that this came as a result of contamination of the hands of doctors and medical students coming from the autopsy room. In order to confirm his conclusion, Semmelweis required the routine of handwashing with a chlorine solution before manual examination and as a result, there was a drastic reduction in mortality due to infection.[73] With the discoveries of Pasteur and Semmelweis, Dr. Joseph Lister brought a greater understanding of infection to surgery. Lister brought the idea of antiseptics into surgery due to tremendous losses seen within the surgical practice due to infection and gangrene. After learning from the work of Pasteur, he concluded that the issues seen in surgery were likely due to airborne bacteria entering a wound. This led him to turn to his use of antiseptics, typically carbolic acid, to cleanse wounds and keep out infection. Lister saw tremendous results from his new antiseptic procedure and published his results in 1867, which lead to other surgeons to expand and further develop his procedure.[74] The introduction of these procedures into surgery completely transformed surgical methods and allowed for further advancements within the field, as patients had a much higher rate of survival.

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[73] Ackerknecht and Rosenberg, *A Short History of Medicine*.

[74] Ackerknecht and Rosenberg; Porter, *The Greatest Benefit to Mankind*.

A deeper understanding of the spread of disease was also shown by the English epidemiologist John Snow. Amidst large epidemics of cholera throughout Europe and America, Snow spent several decades studying it. It was often thought that cholera was spread through human-to-human contact or the air, but Snow found that it was actually transmitted via the oral-fecal route. He did this through studying the London water supply, in which he found that the majority of the cases during the cholera epidemic of 1848 and 1849 were found within on specific water company that had been contaminated. With these findings, Snow published them in his paper entitled "*On the Mode of Communication of Cholera*" in 1849. All of these studies that increased the knowledge of the spread of disease indicated the rise of preventive medicine.[75] With this knowledge, it was not only the people of science that benefitted in their studies but people throughout society could better alleviate the spread of the diseases that plagued places across the world.

Surgery experienced immense progress during the 19th century and beyond due to the ability to decrease the threat of sepsis and infection, as well as several other critical inventions to increase success. Following the work done by Semmelweis and Lister, surgery was able to become much more advanced. Another major discovery, along with antiseptics, was general anesthesia. Prior to the 19th century, opium and alcohol had been used as analgesics. In 1795, Humphry Davy discovered the nitrous oxide, or "laughing gas," to cause reversible unconsciousness. Other discoveries included ether and then, in 1831, chloroform was discovered and became widely accepted. Until the discovery and adoption of anesthesia, the speed of surgical operations had been the primary focus,

[75] Osler, *The Evolution of Modern Medicine*.

whereas after its discovery surgeons were able to focus on the neatness and thoroughness of an operation.[76] The higher rates of success and ability to be more thorough allowed for surgeons to be able to specialize in specific fields of surgery, such as thoracic, abdominal, orthopedic, or neurological surgery. This sort of specialization was seen throughout medicine of the time, just as we had seen in the laboratory sciences.

Along with the many advancements seen within the practice of medicine, medical education saw many changes as it became more centralized and specialized. There were many different specialties of medicine that arose in though the 19th century and even more today. Generally, the specialties were split into two different sections: surgery and medicine specialties. Some of the earliest specialties to come about were obstetrics, pediatrics, and orthopedics.[77] As scientific understanding continued to advance, specialties continued to crystalize, such as the eye and ophthalmology. As expected, there was much hostility towards the movement towards medical specialization. In 1900, the General Practitioner said that specialists had their minds narrowed and their judgment was unbalanced and biased due to their disproportionate knowledge, which would cause patients to suffer.[78] These counter-movements against the specialization of medicine would become known as alternative medicine, discussed later.

Another important factor seen within the scientific medicine of the current time it the search for "magic bullets" in order to cure specific diseases at their simplest view. The concept of a "magic bullet" was introduced by Paul Ehrlich, who had the notion that

[76] E. Ashworth Underwood, *A Short History of Medicine*; Porter, *The Greatest Benefit to Mankind*.

[77] Porter, *The Greatest Benefit to Mankind*; E. Ashworth Underwood, *A Short History of Medicine*.

[78] Porter, *The Greatest Benefit to Mankind*.

the chemical constitution of drugs must have their action and affinity studied for cells of the organisms they are directed for.[79] This idea further developed from the discovery of penicillin and insulin. In 1928, Alexander Fleming accidentally discovered a rare strain of *Penicillium nottum* that appeared to secrete something that inhibited bacterial growth. Therefore, he purified the "mold juice" and, in 1929, he published his findings that found penicillin to have potential therapeutic benefits. Future studies confirmed the incredible therapeutic and antibiotic effects, which lead to the large scale production of the drug.[80] Penicillin was especially important to the treatment of syphilis, as it was introduced as a cure for the disease that afflicted many people in 1946, as well as many other common infections of the time.[81] The success of the discovery of penicillin, although accidental, is an example of how scientific medicine continued to look for "magic bullets" to cure diseases.

Insulin is another example of a "magic bullet" that was discovered and isolated in 1921 by Fredrick Banting and Charles Best. Insulin allowed for the management of diabetes, especially type-1, or juvenile, diabetes, which was often seen as a death sentence as it had a mortality rate of about 50% for children under the age of 10. As we know, insulin is still widely used to help manage the disease today. This was one of the

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[79] Porter.

[80] "Alexander Fleming Discovery and Development of Penicillin - Landmark," American Chemical Society, accessed April 16, 2020, http://www.acs.org/content/acs/en/education/whatischemistry/landmarks/flemingpenicillin.html.

[81] George Rosen, Elizabeth Fee, and Pascal James Imperato, *A History of Public Health*, revised expanded edition (Baltimore: Johns Hopkins University Press, 2015).Rosen, Fee, and Imperato, *A History of Public Health*.

first hormones to be isolated and used as a treatment.[82] The discovery of insulin proved to scientists that there were indeed "magic bullets" that could be used to treat disease and that by understanding the basic process of a disease these cures could be found for many more common diseases. This same idea is seen within the modern advances in chemotherapy, which looks to find specific chemical treatments for cancer. Also applicable is the development of genomic medicine as it truly follows the reductionist view of modern medicine. This is because of the general goal of genomic medicine is to understand and potentially treat disease from the fundamental level of life, which is DNA. Overall, it is apparent that modern medicine has fully accepted the scientific paradigm of medicine, as they have embraced laboratory sciences and the advancements resulting from the expanding studies.

[82] Ignazio Vecchio et al., "The Discovery of Insulin: An Important Milestone in the History of Medicine," *Frontiers in Endocrinology* 9 (October 23, 2018), https://doi.org/10.3389/fendo.2018.00613; Porter, *The Greatest Benefit to Mankind*.

CONCLUSION

Today, we see the result of the paradigm shift to scientific medicine from the humoristic medicine of antiquity. We see the result of the exponential growth of science and medicine throughout medicine today, especially with the countless new studies that are all looking for a new "magic bullet" cure. This confirms the authority of scientific medicine. Despite this, the archaic paradigms that were discussed still show their influence within society. One of the most obvious is the still relevant Hippocratic Oath. Despite its foundation in the humoristic and superstitious medicine of the ancient Greeks, the basis of ethics in Hippocratic medicine is still used as an influence. In addition, the holistic view of humor-based medicine, as discussed in Chapter One, is still apparent in modern alternative medical movements. One such movement is systems medicine and biology. The foundation of systems medicine is based upon looking at the systems of the body as a whole and integrating the various biochemical, physiological, and physical interactions it has.[83] This continued idea of holism is also seen within the growing movement of osteopathic medicine. Founded in 1874 by A.T. Still, osteopathic medicine embraced the holistic, person-oriented medicine. It held the belief that the body has intrinsic healing abilities, which lead to Still's development of osteopathic manipulative medicine.[84] In addition, the idea of holism in regards to health is seen throughout society,

[83] Marc Kirschner, "Systems Medicine: Sketching the Landscape," *Methods in Molecular Biology (Clifton, N.J.)* 1386 (2016): 3–15, https://doi.org/10.1007/978-1-4939-3283-2_1.

[84] Bob E. Jones, *The Difference a D.O. Makes*, The Millennium Edition (Oklahoma Educational Foundation for Osteopathic Medicine, 2001).

with the various dietary movements and supplements, such as veganism, the keto, and paleo diets, juice cleansing, and many others, that are said to foster better health.[85] The appearance of these various influences throughout society shows how a better understanding of the separate paradigms of medical history can be applicable for people of all academic backgrounds. As medical progress continues to advance and viewpoints are consistently proven and disproven, it may be possible that new medical paradigms may see a shift in the future.

Despite these advances in scientific medicine, there are still several challenges faced by modern medicine. With a greater understanding of diseases at a cellular and genetic level, researchers are faced with the issue of producing new ways to prevent and treat diseases as we now know that people carry a higher risk within their genetics and lifestyle. One such example is obesity, which cannot be purely explained by lifestyle and diet, but also genetics. A growing field related to this is epigenetics, which looks at heritable changes that are not based on the DNA sequence. It is with this growing research that we see a trend towards personalized medicine based on an individual's biomarkers and genetics.[86] This shows that there may be a new holistic paradigm that medicine may shift towards in the near future.

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[85] Melissa Wdowik, "The Long, Strange History of Dieting Fads," The Conversation, accessed April 17, 2020, http://theconversation.com/the-long-strange-history-of-dieting-fads-82294.

[86] Anne Ringgaard, "What are the major challenges to modern medicine?," July 20, 2014, https://sciencenordic.com/antibiotics-denmark-illness/what-are-the-major-challenges-to-modern-medicine/1404651.

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