HUMAN PATHALOGY

Chapter One

Introduction to Pathalogy

Unit Introduction

The Greek words pathos, which means anguish, and logos, which means study, are combined to form the English word "pathology". Thus, pathology is the scientific study of the physiology and anatomies of diseased organisms; or, to put it another way, pathology is the anomalies that take place due to disease in anatomical structures (including histopathology) and physiology (Wright, 1954). One other term that is frequently used in connection with the study of illnesses is "pathophysiology," which combines the two terms patho (anguish) and physiology (the study of normal functioning).

Fun Fact:

Pathology is the study and diagnosis of disease through examination of organs, tissues, bodily fluids, and whole bodies (autopsies).

Thus, the study of abnormal function or the malfunction of homeostasis in illness is called pathophysiology (Cheville, 1999). The illness is diagnosed by pathologists. Since they cannot implement adequate treatment or recommend precautionary measures to the patient without comprehending the processes, causes, nature, and kind of disease, knowledge, and comprehension of pathology are crucial for all aspiring physicians, including medical doctors, specialist doctors, and general healthcare professionals (Crowley, 2013). The field of pathology serves as a crucial link between the first learning period of pre-clinical fields of science and the last learning stage of clinical subjects for students of any medical system. Keep in mind Sir William Osler's ominous prognostication from the late 19th and early 20th centuries: "Your

practice of medicine will be as good as your understanding of pathology" (Crystal & Varley, 2013).

1.1. HEALTH AND DISEASE

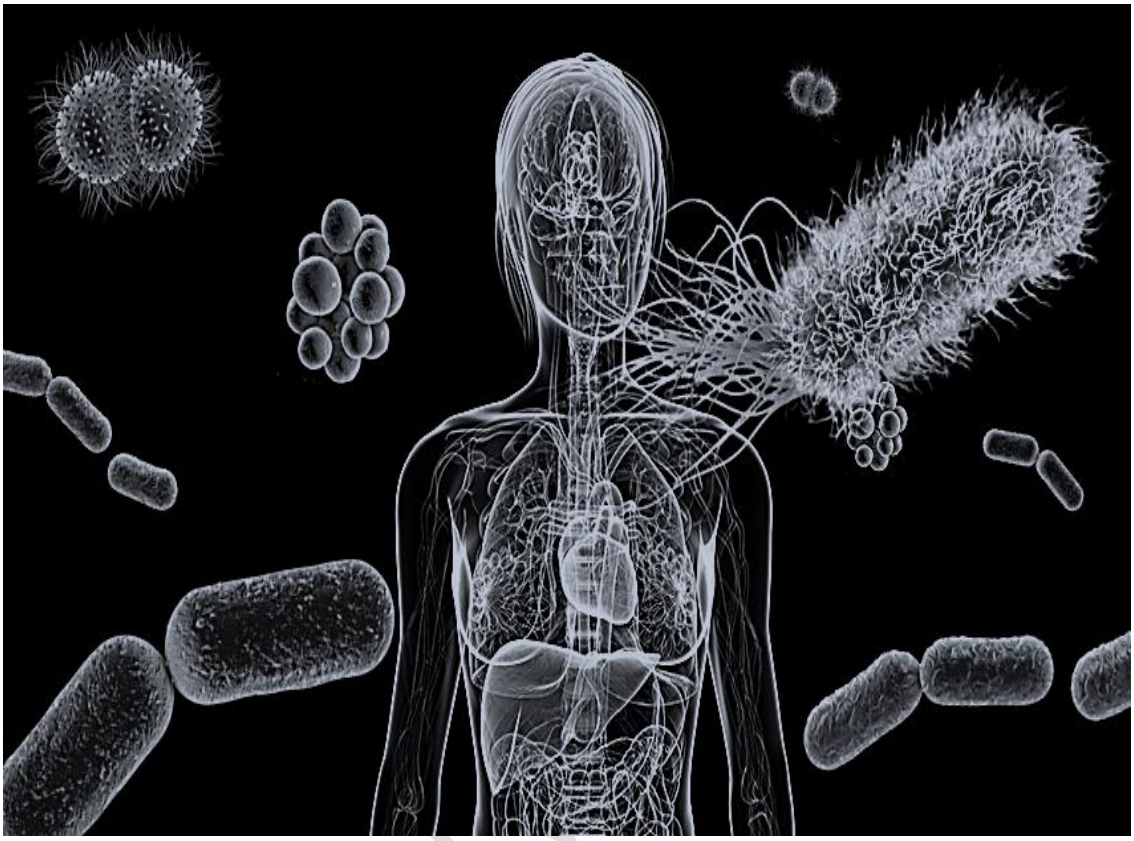

Figure 1.1. A relationship between health and disease

Even in earlier and earlier animals where there were no humans on the planet, illness existed. What is a disease, then, if pathology is the investigation of disease? Simply put, the disease is something that is not fit and active; it is contrary of health (Strowig et al., 2012). When a person is in perfect harmony with their environment, he is said to be in good health. Conversely, the disease is characterized by the loss of easiness (or contentment) in our body (i.e. dis-ease). The fact that there is a broad array of "normality" in terms of, for example, tallness, mass, plasma, tissue chemical makeup, etc., must be kept in mind (Engel, 1960). It is also important to recognize that, at the cellular level, healthy cells exhibit a broad variety of activities that are similar to those of diseased cells. As a result, states such as well-being and illness are viewed as relative rather than ultimate (Smyth et al., 2009).

Illness is a word that is frequently confused with the disease. While illness denotes a person's response to a disease in the form of symptoms (the patient's grievances) and visible symptoms, disease implies an entity with a reason (elicited by the clinician) (Kersten et al., 2000). Despite

the fact that illness and disease are inseparable, pathology is the field that studies diseases, while wards and clinics are the places where illnesses are studied and treated. Aside from illness and disease, there also exist syndromes, which are characterized by a collection of symptoms brought on by alterations in physiological processes (Bircher, 2005).

1.2. TERMINOLOGY IN PATHOLOGY

A pathology novice should be acquainted with the terms used in the field:

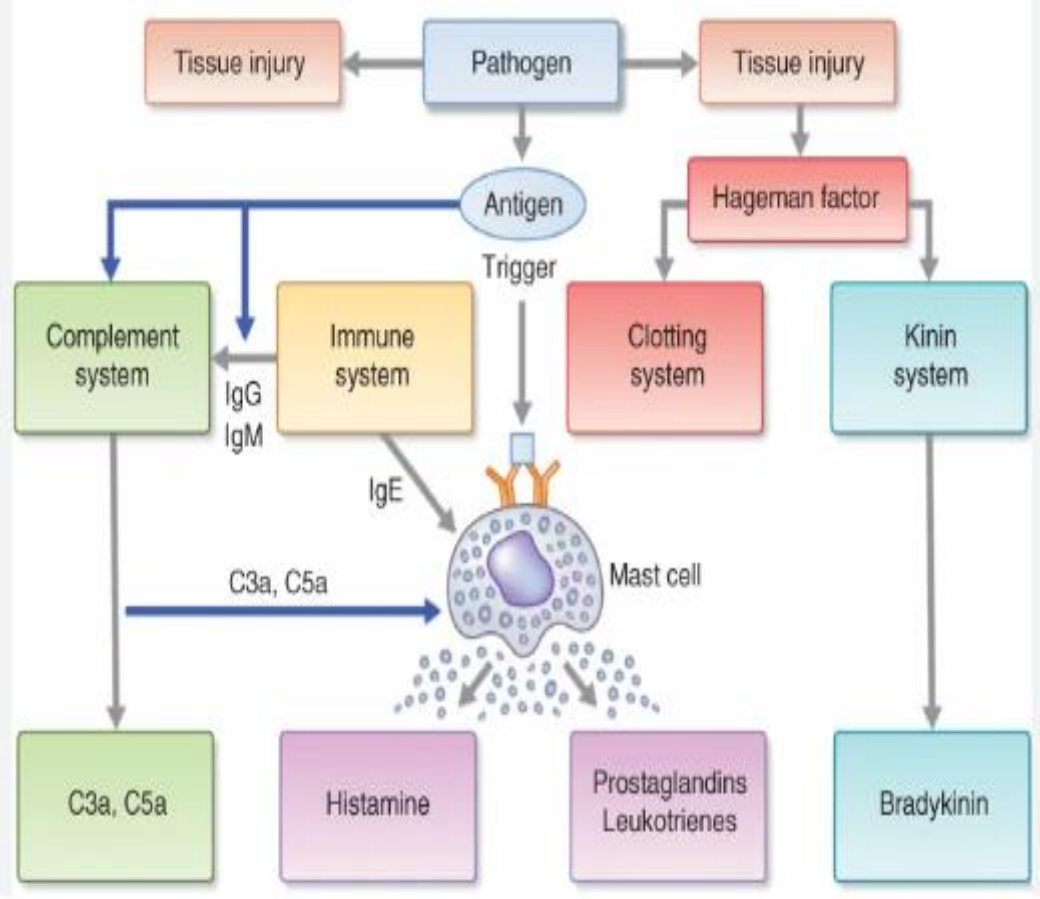

Figure 1.2. Terminolgy in Pathology (Source: Veterian key, Creative Commons License).

- A *patient* is a person who has a disease.
- *Lesions* are the distinctive alterations in cells and tissues brought on by disease in a human or laboratory animal (Ferlito, 1993).
- *Examining* malignant cells/tissues is a part of studying *pathologic* changes or *morphological* characteristics.
- *Pathologic variations* can be seen with the naked eye (gross or macroscale changes) or investigated by light microscope tissue analysis (Davies, 1984).

- *The etiology of the disease*, or the "why" of the disease, includes the causative factors in charge of the lesions.
- *Pathogenesis*, or the "how" of a disease, refers to the process through which lesions are generated.
- The *physical signs* of the lesion are those that the physician finds and the patient experiences as symptoms (Chow et al., 2021).
- The *clinical utility* of the morphological and functional changes, along with the findings from other investigations, aid in determining the "what" of the disease, such as what is untoward (diagnosis), what will occur (prognosis), and what is possible performed to correct it (treatment), and what ought to be carried out to avoid health problems and spread (prevention) (Bos & Parlevliet, 1995).

1.3. EVOLUTION OF PATHOLOGY

The scientific (systematic) study of the disease process which is known as pathology has a long history in medicine. There has always been a requirement and a desire to learn more about the origins, pathophysiology, and origin of diseases (Richter, 2000). The explanations to these queries have changed over time, from superstitious notions to the current level of our understanding of contemporary pathology (Rothstein, 1979). However, pathology cannot be separated from the other numerous medical specialties and owes its advancement to the interplay and interdependence of discoveries in numerous neighboring scientific fields, in addition to the advancements in medical advanced technologies. As we'll see in the following chapters, pathology has developed over time into a separate field of study from anatomy, medicine, and surgery (Dallos et al., 1997).

The introductory pages of the book include a brief overview of the rich history of pathogenesis and the many magnificent individuals who have made significant contributions to the field of pathology (Kertesz et al., 2005). This is done to show our respect for the outstanding people who have built the illustrious foundations of our field. The following individuals' lives and works are connected to a particular illness or process with the intention of stimulating the curious newcomer to pathology about how this vibrant field of study has developed (Teixeira et al., 2006).

FROM RELIGIOUS BELIEFS AND MAGIC TO RATIONALAPPROACH (PREHISTORIC TIME TO AD 1500)

Religious doctrine, wizardry, and basic healthcare were all closely related in ancient times, according to the scientific understanding of the primitive culture that predominated in the world

at the time. The patient versus the healer's earliest understanding of the disease was either a religious notion that it was the result of a "wrath from God" or a magical notion that the illness had a paranormal source from an "evil eye of the spirit world." Clerics used to behave as faith healers, arouse mystical abilities, and appease the gods to shield them with prayers, selfless sacrifice, and wizardry (Kelly, 2009).

Some regions of the world still practice old superstitious beliefs. As the relationship between healthcare and religion spread across the globe, various societies developed their own goddesses and gods of healing. For instance, the mythological Greeks revered *Asclepios* as well as *Apollo* as the two main healers, while Indians revered Dhanvantri as the god of medicine and orthodox Indians *Mata Sheetala Devi* also as the disease goddess (Godwin, 2010). The metaphysical and logical technique to disease by the observational methods followed the era of ancient religion as well as magical beliefs. This took place at a time when all natural phenomena were conceptualized philosophically by great Greek philosophers like *Socrates*, *Plato*, and *Aristotle*. But *Hippocrates* (460 to 370 BC), the greatest Greek clinical genius ever and often referred to as "the father of medicine," is credited with founding the true medical practice (Fig. 1.1) (Faguet, 2015). According to the writings from that time period, Hippocrates practiced and taught medicine in accordance with logical and moral attitudes. He discussed diagnostic methods and was adamant that patients' symptoms should be studied. Hippocrates also promoted the current theory of disease, which is based on the disequilibrium of the four essentially basic humors (air, water, fire, and earth) (Sneader, 2005).

Figure 1.3. Hippocrates (460-370 BC). The great Greek clinical genius and regarded as 'the father of medicine. He introduced ethical aspects to medicine.

He wrote down his observational data on cases, which became the standard practice of medicine for almost two millennia (Hippocratic aphorism). The following list of key Hippocratic techniques can be summarized:

1. . Always maintain objectivity.
2. Focus on the patient as opposed to the illness.
3. Adopt a reasonable assessment.

4. Make use of disposition (Szelągowska, 2013).

By taking the *"Hippocratic oath"* when beginning medical practice, Hippocrates, who is held in high regard by the medical field, tried to introduce ethics into the practice of medicine. Greek medicine experienced great success in the advancement of medicine throughout medieval Greece ever since Hippocrates reached Rome (current-day Italy), which controlled the Greek world after 146 BC. In fact, since the old period, numerous tongue-twisting medical phrases have their roots in Latin, the main language of the nations that made up the old Roman civilization (Spanish, Italian, Portuguese, Greek, and French languages originated from Latin) (Jeffers, 1996).

Roman medical professionals, particularly *Cornelius Celsus* (53 BC to 7 AD) as well as *Cladius Galen*, spread the Hippocratic teaching in Rome (130–200 AD). The four central symptoms of inflammation that Celsus first identified are rubor (happening redness), tumor (the swelling), calor (temperature), and dolor (the pain). Galen proposed the humoral theory, which became known as the *Galenic theory* (McNamara, 2010). According to this theory, a mismatch between the body's four humors—blood, lymph, black bile, which was thought to come from the spleen, and bile duct secretion from the liver—was the cause of the illness. In the *Charaka Samhita*, one of Charaka's finest works on medicine, which lists 500 remedies, and the Sushruta Samhita, a related manuscript of surgery sciences by Sushruta, which contains about 700 plant-derived medications, the supposition of disequilibrium of the four components comprising the body (Dhatus), similar to the Hippocratic doctrine, is mentioned (Ostrowski, 1983).

Regressions in medical technology were evident at the end of the Middle Ages. Pervasive and catastrophic epidemics caused people to think differently and return to believing in supernatural beings as well as spiritual punitive for "sins." The prevalent view at the time was that the control of the soul over vital substances was what gave rise to life (theory of vitalism). As a result, it was strictly prohibited to dissect human bodies because doing so would harm the "*soul* " (Winslow, 1980).

FROM HUMAN ANATOMY TO ERA OF GROSS PATHOLOGY (AD 1500 to 1800)

The Renaissance, which saw a reemergence of learning, followed the Medieval period's ignorance. Italy was the starting point for the Renaissance, which eventually spread throughout all of Europe. There was a quest for scientific and artistic advancements during this time. Since there were mental freedom, philosophic and logical attitudes were once more emphasized. Famous Italian painter *Leonardo da Vinci's* drawings and paintings of muscle tissues and fetuses throughout this time marked the start of the development of the human anatomy (1452–1519). Vesalius (1514–1564) began dissecting the bodies of executed offenders. His students *Fabricius*

(1523–1562) and *Gabriel Fallopius* (1523–1562), who unearthed lymphatic vessels around the bird's intestines (bursa of Fabricius) and characterized human oviducts (Fallopian tubes), helped spread the concept of human anatomic dissection, in which specialized post - mortem amphitheaters were built throughout ancient Europe (Fig. 1.2) (Jay, 2000).

In his free time, Dutch fabric trader *Antony van Leeuwenhoek* (1632–1723) created the very first microscope by hand-grinding the lenses, which allowed him to see men's sperm cells as small formulated men (or "homunculi") and blood capillaries. In order to investigate muscle fibers, he also developed histological discoloration in 1714 utilizing saffron. *Marcello Malpighi*, referred to as the "father of histology," is credited with discovering capillaries, describing the Malpighian layers of the skin, and identifying lymphatic vessels inside the spleen (the Malpighian corpuscles) using a microscope (Żytkowski et al., 2021).

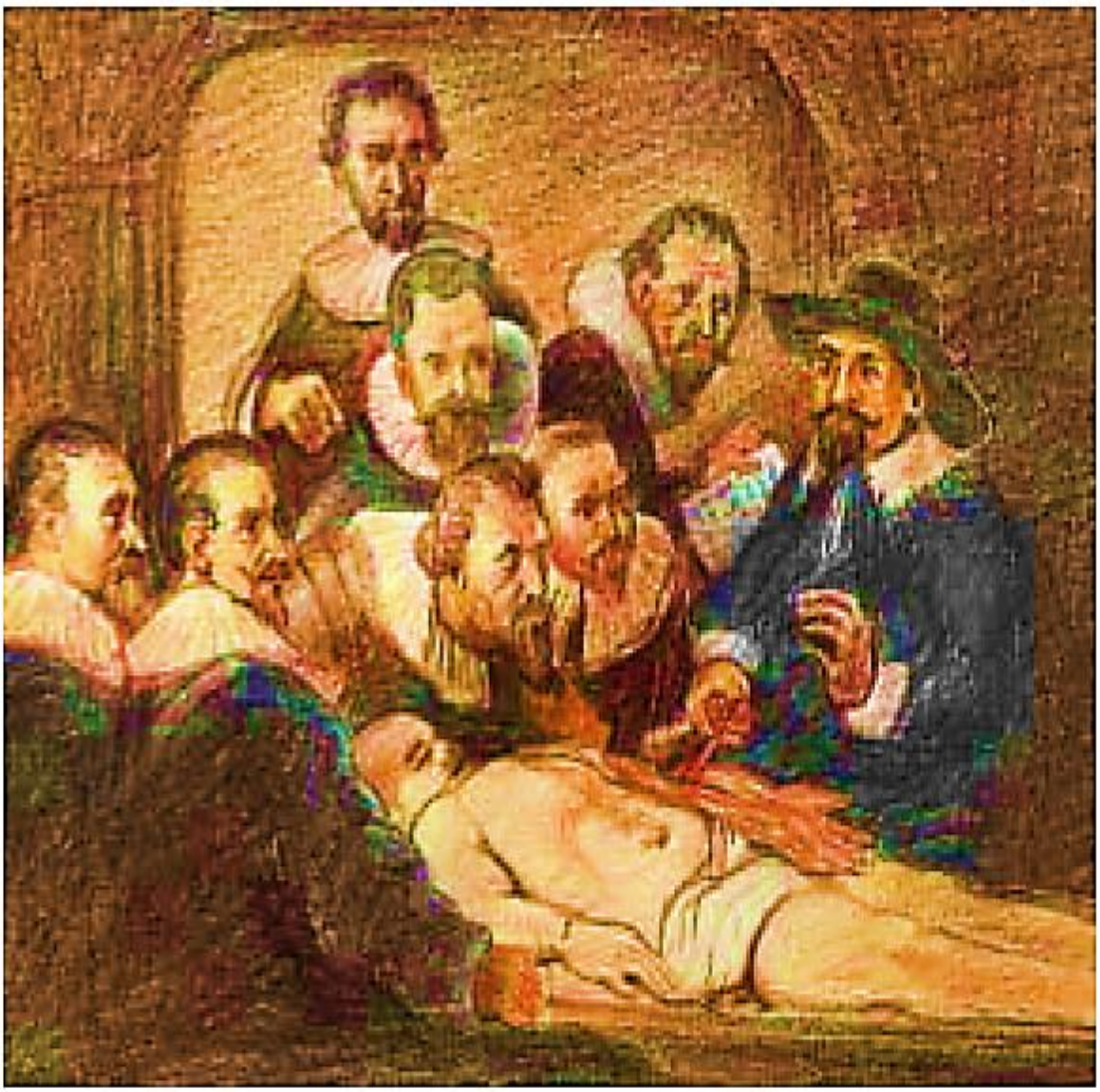

Figure 1.4. In the 16th Century, postmortem amphitheater in Europe was a place of learning human anatomic dissection conducted and demonstrated by professors to eager learners and spectators.

However, Italian anatomist and pathologist *Giovanni B. Morgagni* deserves credit for initiating the research of macabre anatomy (pathologic anatomy) (1682–1771). *Morgagni* was a brilliant writer, a practicing physician, and a superb anatomy instructor. The primitive humoral concept of disease was disproved by Morgagni's work, which also included the publication of his past experience premised on 700 post-mortems and the correlating clinical findings (Chaffin, 1969). He established a cohesive series of the disease's reason, lesions, symptoms, and consequences as a result, laying the groundwork for clinical and pathological research methods in the research of disease and developing the idea of clinical and pathological linkage (CPC) (Fig. 1.3) (Van den Tweel & Taylor, 2010).

Figure 1.5. Giovanni B. Morgagni (1682–1771) FATHER OF CPCs.

Figure 1.6. John Hunter (1728-1793) Father Of the Museum In Pathology.

The very first workplace cancer was found in chimney sweeps in 1775 by renowned English surgeon *Mister Percival Pott* (1714–1788), who also recognized chimney coal dust as the first human carcinogen. However, the 2 different *Hunter* brothers monopolized the research of anatomy in Britain during the second half of the 18th century: The finest surgeon and anatomist of all time, *Sir Percival Pott's* student *John Hunter* (1728–1793) founded the first pathologic

anatomy museum along with his eldest brother William Hunter (1718–1788), a renowned anatomist-obstetrician (or guy) (Oveisgharan et al., 2018). John Hunter created the very first gallery of physiology and ancient pathology in the world, the Hunterian Gallery, now located at the *Royal College of Surgery of London*, by collecting well over 13,000 surgery samples from his thriving practice, organizing them into distinct major organs, comparing samples from plants and animals with those from humans, and including numerous histopathology samples as well (Gross, 1999).

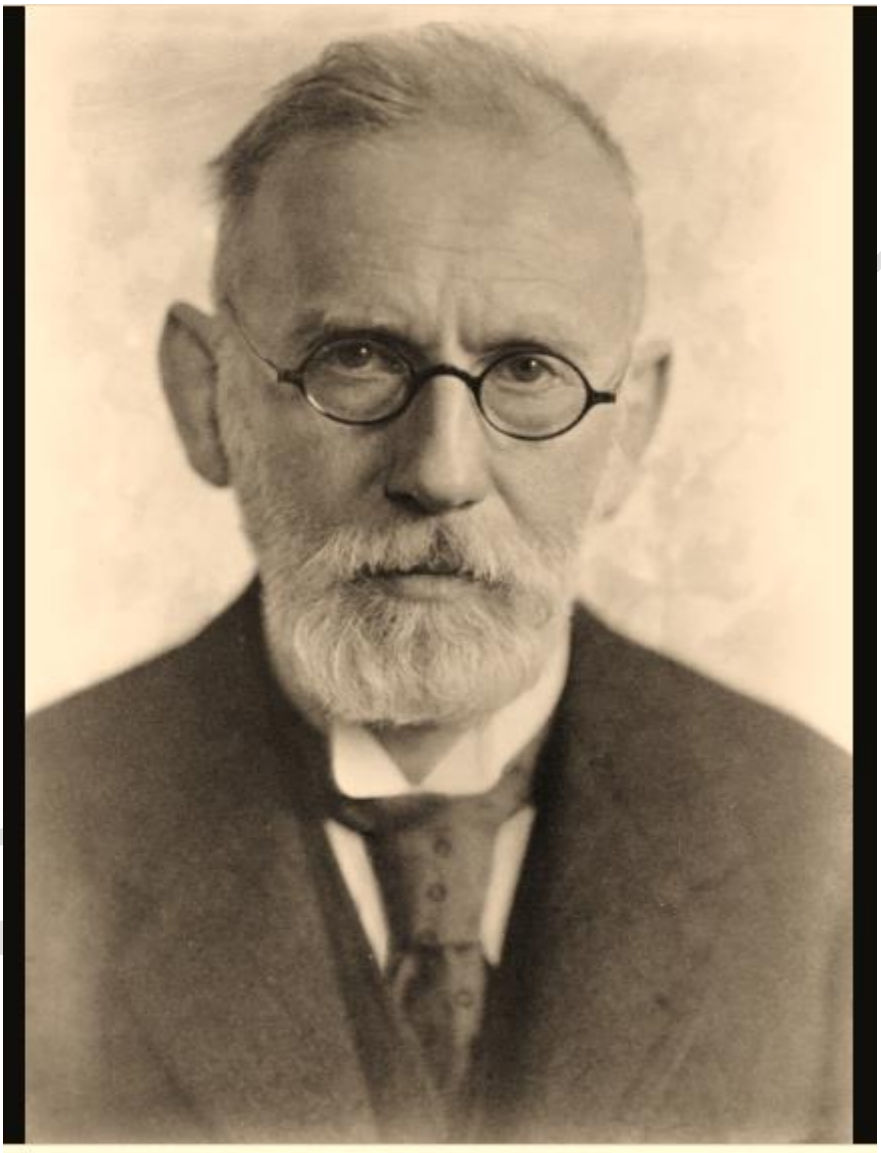

Figure 1.7. Paul Ehrlich (1854-1915) Father Of Clinical Pathology.

Edward Jenner (1749–1823), a student of John Hunter who is very well recognized for his work on smallpox vaccination, was one of several. *Matthew Baillie* (1760–1823), a notable English pathologist and the godson of the Hunter brothers, authored the very first methodical textbook on morbid anatomy in 1793. Three more eminent and excellent physician-pathologists who

worked together at *Guy's Hospital* in London during the period of gross pathology included Richard Bright (1789–1858), Thomas Addison (1793–1860), and *Thomas Hodgkin* (1798–1866). *Bright* characterized nonsuppurative nephritis, which was later known as glomerulonephritis or Bright's disease, Addison explained severe adrenocortical insufficiency (Larsen & Grant, 1997).

In France, *Xavier Bichat* (1771–1802) defined that body parts were made of tissue and separated the research of morbid anatomy to General Pathology & Systemic Pathology at the end of the eighteenth century. Another French doctor, R.T.H. Laennec (1781-1826), monopolized the first decade of the nineteenth century with his specialist knowledge. He also invented the sphygmomanometer and explained a number of lung diseases, including tuberculosis, miliary lesions, caseous lesions, bronchiectasis, and pleural effusion. With the appearance of German pathologist *Carl von Rokitansky* (1804 to 1878), a self-taught individual who conducted close to 30,000 autopsies, morbid anatomy reached its pinnacle. He wrote a superb monograph on artery illnesses and heart defects, explained the severe yellow loss of function of the hepatic system, and explained congenital heart defects. Rokitansky introduced the idea that pathologists should limit themselves to making diagnoses, that subsequently became the acknowledged role of a pathologist, in contrast to the majority of other doctors at that period (Gụhl et al., 1999).

ERA OF TECHNOLOGY DEVELOPMENT AND CELLULAR PATHOLOGY (AD 1800 TO 1950s)

The primary method of disease research up until the middle of the nineteenth century was the connection of clinical diseases' symptoms to gross pathological conditions at autopsies. Pathology advanced as surgery became more sophisticated. In the nineteenth century, surgeon-pathologists increasingly supplanted the anatomist-surgeons of past periods. The progress of cellular pathology, that was intimately correlated to technological developments in machines and equipment fabrication for slashing thin slices of tissue, improved performance in a magnifying glass, innovation of the chemical sector, and progression of chemical process industries and colorants for discoloration, pathology started building as a diagnosing discipline in the second half of the nineteenth century. A French chemist named *Louis Pasteur* (1822 to 1895) disproved the prevalent theory of the spontaneous generation of all diseases by discovering the presence of disease-causing microbes (Hunter, 2018). This solidified the germ theory of disease. *Hansen's bacillus* was later discovered to be the cause of leprosy (also known as Hansen's disease) by German scientist G H A Hansen (1841to1912) throughout 1873. The notion of immune regulation and allergy surfaced during the research of communicable diseases and served as the foundation for *Edward Jenner's* immunization program. Russian zoologist *Ilya Metchnikoff*

(1845–1916) first described the occurrence of human defensive system cells phagocytosing foreign microbes (Byers, 1989).

Aniline violet, the first of these synthetic dyes created by Perkin in 1856, was the transition from prior colorings of plant origin to textile dyes. This was made possible by advancements in the chemical sector. As a result, a profitable dye market for microbiological and histological uses emerged. The works of many founders, including the following, served as a catalyst for the thriving and prosperous dye industry (Alpaugh & Cicchetti, 2019):

1. *Paul Ehrlich (1854–1915),* a German physician who won a Nobel Prize in the year 1908 for his career in immunology, characterized the Ehrlich's exam for urobilinogen using the Ehrlich's aldehyde reagent, developed staining methods for microbes and cells, and established the principles of histopathology (Fig. 1.5) (Chatterjee, 2014).
2. *Christian Gram (1853 to 1938),* a Danish doctor who invented crystal-violet bacteriologic-staining.
3. Eosin as well as methylene blue derivative products were used to create a smudge for peripheral blood smear by Russian physician *D.L. Romanowsky (1861–1921).*
4. German bacteriologist *Robert Koch (1843–1910)* unearthed bacilli in the year 1882 and cholera vibrio life form in 1883 in addition to Koch's postulate and Koch's occurrences. He also developed methods for fixing and discoloring microbes for characterization.
5. *May-Grunwald and Giemsa* advanced blood stains and used them to classify cells and sometimes even bone marrow cells in 1902 and 1914, respectively.
6. *Leishman Donovan Bodies* (LD bodies) were discovered in leishmaniasis by *Sir William Leishman (1865–1926),* who also explained Leishman's stain for blood smears in 1914.
7. *Robert Feulgen (1884–1955),* established the principles of cyto-chemistry and histo-chemistry and characterized the Feulgen response for DNA staining (Coghlan et al., 1985).

The development and enhancement of microtomes for acquiring thin slices of tissues and organs for staining by colorings to enhance the thorough analysis of sections resulted from concurrent technological advancements in machines and equipment fabrication. Even though Robert Hooke had earlier, in 1667, shown that there were cells in thin layers of non-living object cork, F.T. Schwann (1810 to 1882), the very first neurohistologist, as well as *Claude Bernarde* (1813–1878), a pathophysiology founder, revitalized the idea that cells were an entity of life forms in the late nineteenth century (Boyd, 1963). The research of morbid anatomy was primarily autopsy-based and thus a retrospective scientific knowledge till the end of the nineteenth century.

Histopathology as a field of study was developed by *Rudolf Virchow* (1821 to 1905) in Germany through the use of microscopic analysis of infected tissue at the cell level. *Virchow* presented two main theories:

1. All cells are descended from other cells.
2. Disease is a variation of such cells' typical functioning and structure.

In pathology circles in Europe, Virchow became recognized as ***Pope***, and he is rightly made reference to as the ***"father of cellular pathology"*** (Fig. 1.6). As a result, a solid foundation for diagnoses of pathology had been established, and many talented subsequent employees continued to build on it. Consequently, the discipline of surgery and pathology emerged as a result of the application of the experience and expertise gained by making a precise diagnosis based on post - mortem research results to surgical biopsy (Virchow, 1999). In addition, Virchow discussed the causes of blood clots (Virchow's triad—slowing of the blood, variations in the vascular wall, and modifications in the plasma itself), the vessels and nodes node described by Virchow in terms of the metastatic spread of cancer, and blood products and diseases (fibrinogen, leukocytosis, leukemia) (Kumar et al., 2010).

Julius Cohnheim, Virchow's student, developed the idea of an iced segment investigation while the client was still lying on the operating table (1839–1884). In fact, the frozen section was regarded as more appropriate by physicians during the early stages of the advancement of surgical pathology at the turn of the nineteenth century. Then there was the time when tactile imprint smear morphologic investigation of cells was preferred for diagnostic purposes over real tissue sections. Further developments in surgical pathology then were facilitated by upgraded equipment and the creation of colorings and stains (Smiddy et al., 1990). In most clinics, the idea of a surgeon and a doctor sharing the responsibility of a pathologist dates back to the 19th century and persisted through the twentieth century's middle decades. *A.P. Stout* (1885-1967), *Lauren Ackerman* (1905-1993), *James Ewing* (1866-1943), *Pierre Masson* (1880-1958), and *RA Willis* throughout Australia were a few of the remarkable pathologists during the first half of the twentieth century who had backgrounds in medical experience. This was because it was common practice to assign biopsy pathologist research to some academic staff in the clinical department (Tybjerg, 2022). Other significant developments in this era's development of modern pathology include the following:

1. *Karl Landsteiner (1863–1943),* who is known as the father of blood transfusion, explained the presence of the key human blood types in 1900 and won the Nobel Prize in 1930.

2. In 1933, *Ruska and Lorries* created the scanning electron, enabling pathologists to see the ultrastructure of cells and their organelles.
3. The **'father of exfoliative cytology,'** *George Papanicolaou* (1883 to 1962), an American pathologist of Greek descent, pioneered the use of exfoliative cytology for the early diagnosis of cervical cancer (Sabatelli et al., 1998).

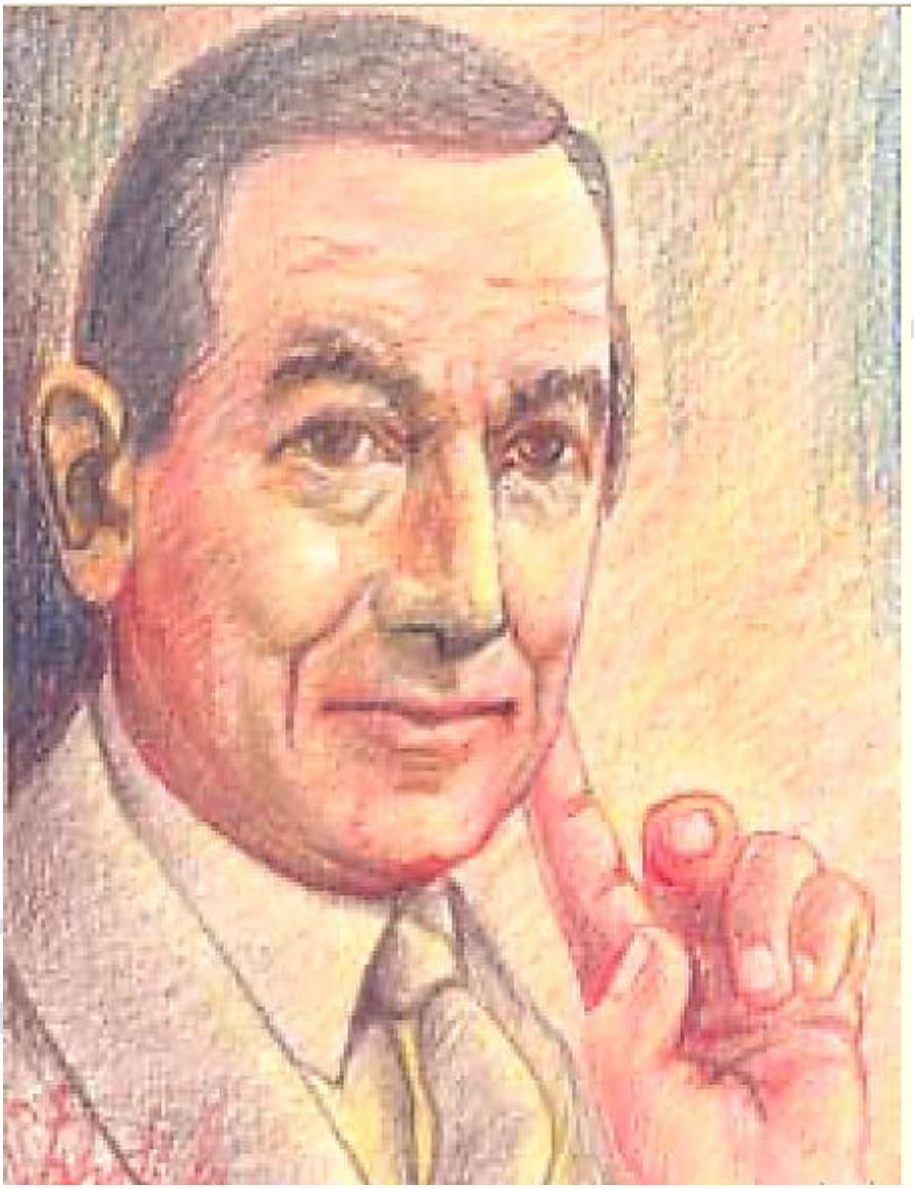

Figure 1.8. William Boyd (1885-1979). Canadian pathologist and eminent teacher of pathology who was a pioneering author of textbooks of pathology which have been read all over the world by students of pathology and surgery for over 50 years.

A renowned instructor, *William Boyd* (1885-1979), a psychiatrist turned into a pathologist, made another groundbreaking participation in pathology in the twentieth century. His textbooks, ***"Pathology for Surgeons"*** (1st edition 1925) and ***"Textbook of Pathology"*** (1st edition 1932),

monopolized and influenced pathology students from around the world for around 50 years until the 1970s owing to his flowery prose and lucid tone. Boyd was regarded by MM Wintrobe (1901 to 1986), a student of his who made the hematocrit discovery, as a highly arousing instructor with a strong interest in the advancement of museums (Vidya et al., 2019).

MODERN PATHOLOGY (the 1950s TO PRESENT TIMES)

The advancements made from the second half of the twentieth century to the beginning of the new millennium had already made it feasible to research diseases at the cellular scale, include an objective, proof diagnosis, and allow the doctor to implement the proper therapy (Young, 2005). The main effects of the development of molecular are in the areas of cancer, immunology, and the diagnosis and later the treatment of hereditary diseases. Following are a few of the ground-breaking discoveries made at this time (Fig. 1.10) (Chenevert, et al., 2012):

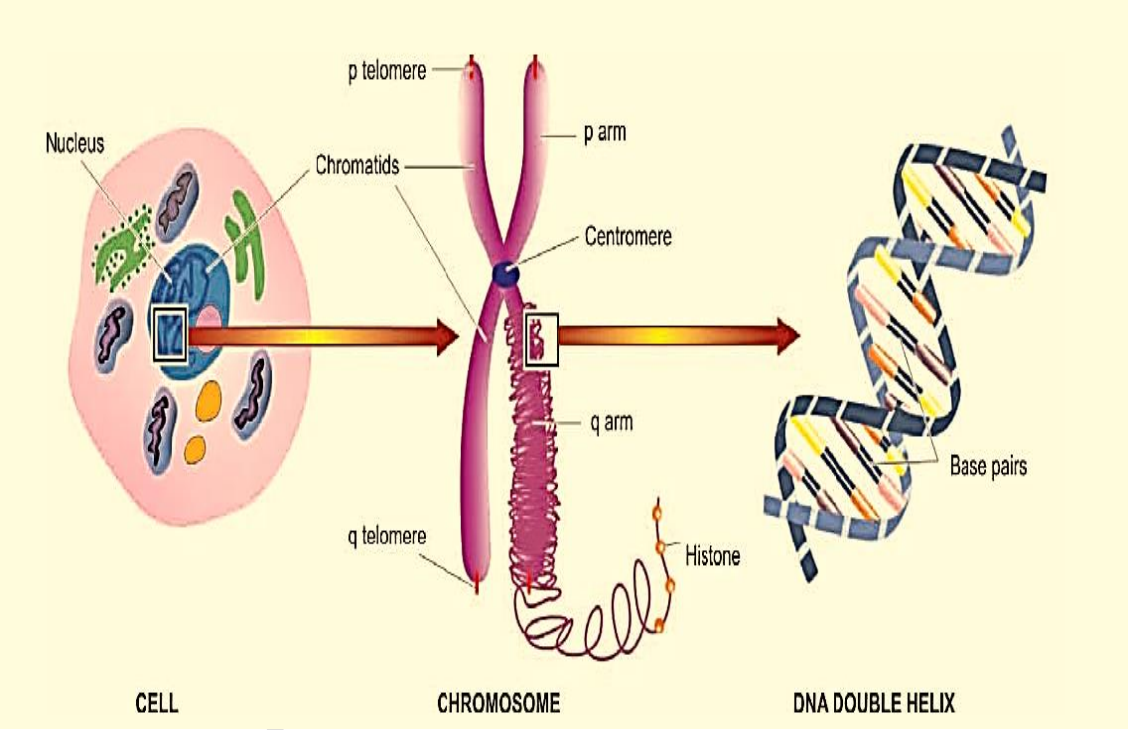

Figure 1.9. Molecular structure of the human chromosome.

- *Watson & Crick's* (1953) explanation of the cell's DNA configuration.
- In 1956, *Tijo and Levan* correctly identified human beings' 46 chromosomes as well as recorded their count.
- The very first chromosome number anomaly to be discovered in any cancer was Philadelphia chromosome t(9;22) in myeloid leukemia chronic by *Nowell & Hagerford* in the year 1960.

- In *Situ Hybridization*, which was first used in 1969 and uses a marked probe to locate and identify particular RNA as well as DNA sequences "in situ" (inside the original place) (Mitrovic et al., 2012).
- The 1972 invention of the recombinant DNA methodology. DNA fragments were cut and pasted using restriction enzymes.
- *Kary Mullis* fundamentally changed diagnosing molecular genetics in 1983 by introducing the polymerase chain reactions (PCR), which "xeroxes" DNA fragments.
- Barbara McClintock's discovery of the DNA's versatility and fluidity, for which she received the 1983 Nobel Prize (Louis et al., 2016).
- A sheep decided to name ***Dolly*** was cloned and expressed in 1997 by *Ian Wilmut* as well as his coworkers at the Roslin Institute in Edinburgh using the somatic cell nuclear division technique. This takes place during the cloning of mammals. However, human cloning for humans carries a great deal of risk and is wholly ethically wrong (Haust, 2004).
- The period of stem-cell research began in 1998 when US scientists found a method for extracting stem cells, a subset of primitive cells, from fetuses and sustaining even their own development inside the lab. Many scientists believe that stem cells can be used to cure a broad range of human diseases, including Alzheimer's, diabetes, cancer, cerebrovascular disease, and more. Adult stem cells and embryonic stem cells are the two distinct types of cell sources (Buchner, 1957). Cloning of embryos as just a source of stem cells for trying to treat a few debilitating diseases has been made legal in some regions of the world due to the greater availability of embryonic stem cells. There may be a day when insulin-producing cells can be transplanted into the pancreatic system of a patient with insulin-dependent diabetes utilizing embryonic cells, or even when stem cells can be cultured in the lab in place of the entire organ transplantation. In order to avoid a full organ transplant, it won't be long before organs can be "harvested" from the embryos (Voltaggio & Montgomery, 2015).
- A group of nations' **Human Genome Project (HGP),** which was finished in April 2003, came 50 years after *Watson and Crick* first described the DNA double helix in that month of 1953. The 23 chromosome pairs found in the nucleus of every human cell, which characterize human genetic code, contain about three billion base pairs, according to the sequence analysis of the human genome (Gibbs, 2020). The genetic code, which carries the instructions for producing proteins, is thought to contain 30,000 genes, as compared to an earlier assumption at around 100,000 genes, on every chromosome. We now have

access to nature's entire genetic template for creating each individual human thanks to the HGP. All of this has created new opportunities for the study and treatment of a seemingly endless number of illnesses which are currently not curable. In the future, medical researchers will be capable of developing new and extremely effective therapies for illness as well as making recommendations for preventing disease (Tauber & Sarkar, 1993). They will also be able to create extremely effective diagnostic equipment, fully comprehend people's healthcare needs to be based on their unique genetic make-ups, as well as better comprehend how to diagnose people. These discoveries have ushered in a brand-new period of human molecular genetics, one that can now be used as a cutting-edge therapeutic and diagnostic instrument and is no longer restricted to research labs. The finest notable example of how human molecular physiology and information systems are intertwined is the accessibility of molecular stereotyping by **cDNA** microarrays, which allows for the simultaneous measurement of multitudes of genes' expression on a tiny silicon chip (Yager et al., 1991).

1.4. SUBDIVISIONS OF PATHOLOGY

Prior to actually delving further into the study of illnesses inside the chapters that will come next, we will first start introducing ourselves to the divisions of human pathology after looking back on the historical perspectives of pathology (Rappaport et al., 1954). There are numerous fields of pathology, including such *humans pathology, animal pathology, plants' pathology, veterinary's pathology, poultry's pathology*, etc., based on the species being researched. *Relative pathology* examines illnesses in animals and compares them to those that affect humans. The largest subfield of pathology in human pathology (Fujii et al., 2021). It is typically divided into two categories: systemic pathology, which encompasses the study of diseases relating to particular body systems and organ systems, and general pathology, which deals with the basic principles of disease. The field of pathology has expanded to encompass the following subspecialties thanks to the development of diagnostic equipment, the basic rules of which are described in the next chapter (Batsakis & Regezi, 1978):

HISTOPATHOLOGY

Histopathology, also known as anatomical pathology, pathological anatomy, or sometimes morbid anatomy, is the oldest and remains the most effective method of research that has withstood the test of time (Paparella, 1980). In order to make the most actual diagnosis, the study takes into account structural changes seen by unaided eye exam, also known as gross or macroscopic variations, as well as variations observed by electron and light microscopic examination aided by various specialty staining methods, which include histochemical and

immunological techniques (Khan et al., 1999). Super-specialties like cardiac pathology, breast pathology, pulmonary pathology, neuro-pathology, renal pathology, gynecologic pathology, gastrointestinal pathology, oral pathology, dermatopathology, and others are included in modern anatomic pathology. Anatomic pathology is divided into the following 3 categories (Schmitz et al., 2010):

i. ***Pathology in surgery:*** It focuses on the examination of body tissue taken from a physical human. The medical examiner uses it as the majority of the tissue material and studies the tissue using frozen sections and *paraffin* plugging methods for quick diagnosis (Streubel et al., 2014).

ii. ***Autopsy & forensic pathology:*** It includes the examination of tissues and organs that were separated at the time of the post-mortem in order to conduct medicolegal research and establish the reason for death (Li et al., 2020). By doing this, the pathologist tries to piece together the sequence of events that may have taken place in the patient all through his life and led to his dying (Campobasso & Introna, 2001). Whereas forensic autopsy is useful for medical or legal purposes, post - mortem anatomy-specific diagnostic aids the clinician's understanding of the disease and judgment. The adage *"the dead instruct the living"* can be used to sum up the importance of a thorough post - mortem examination (Thali et al., 2003).

iii. ***Cytopathology***: Despite being a part of anatomic-pathology, it has recently emerged as a separate subspecialty. Exfoliative cytology, the research of cells barn from lesions, and *fine-needle-aspiration-cytology* (FNAC), the diagnosis of both superficial and deep-seated lesions, are included (Layfield et al., 2004).

HAEMATOLOGY

Blood diseases are the focus of haematology. It consists of clinical and laboratory haematology, of which the latter also deals with patient assessment (Shaskey & Green, 2000).

CHEMICAL PATHOLOGY

This division of pathology includes the analysis of the biochemical components of plasma, semen, urine, CSF, and other bodily fluids (McCully, 1993).

IMMUNOLOGY

Immunology and immunopathology are two fields that study the identification of anomalies in the innate immune system (Mateu & Díaz, 2008).

EXPERIMENTAL PATHOLOGY

This is characterized as the induction of illness in the experimental model and its analysis of it. However, due to organism distinctions, not all results of animal research may be present in humans (Gutiérrez et al., 2009).

GEOGRAPHIC PATHOLOGY

Geographic pathology is the study of variations in the regularity and category of diseases among populations all over the world (Yatani et al., 1982).

MEDICAL GENETICS

The connection among genetic inheritance and disease is covered by this area of human genetics (Roberts & Pembrey, 1963). Significant advancements have been made in the world of clinical genetics, including those relating to blood types, inborn metabolic errors, chromosome abnormalities in congenital anomalies and tumors, etc (Christianson & Modell, 2004).

MOLECULAR PATHOLOGY

In molecular pathology, irregularities at the DNA level of the cell are found and diagnosed (Selkoe, 1991). Recent developments in single-molecule biologic methodologies have made these techniques available not just for scientific purposes but also as a diagnosing pathology tool (Harris & McCormick, 2010). Finally, it is claimed that specialization isolates human minds from one another. However, since pathology encompasses all medical specialties, it is likely that some of the aforementioned groupings of pathology into different specializations will overlap (Peters et al., 2015). Although every effort has been made to introduce the entire topic trying to cover diseases of the body as a whole in the sections that follow, knowledge is expanding rapidly on a regular basis and the pursuit of learning more is an ongoing process. As a result, we are all perpetual students of the science of disease pathology (Cree et al., 2014).

1.5. SUMMARY

In order to comprehend the origin and spread of diseases, pathology investigates the composition and operation of the human body's organ systems as well as the tissues. Disease diagnosis and treatment are the focus of this area of medicine. There are many trillions of cells in the human body, and each one serves a particular purpose. The research of pathology examines how well these tissues and cells work in both health and disease. To identify the disease's underlying cause, pathologists investigate organs and tissues using a variety of techniques. To provide patients with comprehensive care, pathologists frequently collaborate with other medical specialists on teams, including doctors, surgeons, and nurses. They could also work with researchers to create new early diagnoses and therapeutic options.

REVIEW QUESTIONS

1. What is the main purpose of pathology?
2. What are the different types of pathology?
3. What are the different methods of pathology?
4. How does pathology help in diagnosis and treatment?
5. What are the most common diseases studied in pathology?
6. What are the major branches of pathology?
7. What is the role of a pathologist in medical practice?
8. How have advances in technology changed the field of pathology?
9. What are the core concepts in pathology?
10. How do pathologists interpret and analyze tissue samples?

MULTIPLE CHOICE QUESTIONS

1. Pathology is the study of:

   A. Diseases

   B. Cells

   C. Infectious organisms

   D. All of the above

2. What type of pathology is the study of abnormal cells?

   A. Cytopathology

   B. Molecular pathology

   C. Clinical pathology

   D. Histopathology

3. What type of pathology examines changes in cells caused by disease?

   A. Molecular pathology

   B. Clinical pathology

   C. Cytopathology

   D. Histopathology

4. What type of pathology focuses on the diagnosis and treatment of diseases?

   A. Molecular pathology

   B. Clinical pathology

   C. Cytopathology

   D. Histopathology

5. What type of pathology examines the effects of disease on organs and tissues?

   A. Clinical pathology

   B. Molecular pathology

   C. Cytopathology

   D. Histopathology

6. What type of pathology is the study of changes in the structure and function of cells caused by disease?

   A. Molecular pathology

   B. Clinical pathology

   C. Cytopathology

   D. Histopathology

Answers

1. (D) **2. (A)** **3. (C)** **4. (B)** **5. (A)** **6. (D)**

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