



Anatomy: A Chronological Review of the Evolution of Context and Content

J. O. Owolabi^{1*}, P. O. Ogunnaike¹ and A. A. Tijani²

¹*Department of Anatomy, Ben Carson School of Medicine, Babcock University, Nigeria.*

²*Department of Anatomy, Ekiti State University, Ado-Ekiti, Nigeria.*

Authors' contributions

This work was carried out in collaboration between all authors. Author JOO conceptualised and designed the study and wrote the first draft of the manuscript. Authors POO and AAT did the review with author JOO. Author POO did advanced review on the article content while author AAT managed external consultations. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJMAH/2017/33742

Editor(s):

(1) Janvier Gasana, Department of Environmental & Occupational Health, EO Epidemiology, and EO Medicine, Robert Stempel College of Public Health & Social Work, Florida International University, USA.

Reviewers:

(1) Abdelmonem Awad Hegazy, Zagazig University, Egypt.

(2) Alicia Noemi Kohli Bordino, Italian University Institute of Rosario, Argentina.

(3) Elvira Bormusov, Technion- Israel Institute of Technology, Israel.

Complete Peer review History: <http://www.sciedomain.org/review-history/19487>

Review Article

Received 27th April 2017

Accepted 28th May 2017

Published 12th June 2017

ABSTRACT

Anatomy as a subject is an ancient medical science. The early practitioners of Anatomy were morphological explorers and observers. Anatomy was one of the earliest sciences that marked the transition of logical reasoning from philosophy to science. This is why it is appropriate to describe the early scientists as both philosophers and scientists. Anatomy was considered and purposefully practised by the early scientists as a subject that was indispensable to understanding the form and functions of the body and the causes of pathologies. The subject of Anatomy evolved greatly; yet, has remained the bedrock of modern health sciences. Consequently, Anatomy has increased in sophistication and content volume. Advancements in technology and increased demand for better solutions have given several perspectives to the subject; thus anatomy in its current form has several fields - primary and applied. While Anatomy started as what is currently called Gross Anatomy which is the study of tangible morphology, other primary fields including Embryology, Histology, Genetics and Histochemistry have evolved particularly due to the advancements and sophistications in methods of studying the body towards better understanding of form, functions

*Corresponding author: E-mail: olaowolabi001@yahoo.com, owolabijo@babcock.edu.ng;

and disorders. Obviously, the radical, yet positive and purposeful evolution of Anatomy has an interesting chronicle and impact on content dynamics and the contexts at each point in time. To this end, it is necessary to have a clear understanding of Anatomy in the context of its modern form, yet with a clear understanding of its evolution and how it has affected the content of its modern form. This review article considered the chronicles of Anatomy in term of its content and context at each stage.

Keywords: Anatomy; review; modern; content; context; history.

1. INTRODUCTION

Anatomy: A means to ends and an end to itself

Anatomy is originally the study of the structure of the body. It is an ancient basic medical science. It is logical to understand that intelligent humans would have developed the curiosity, will and quest to explore nature, forms and functions from antiquity. Though the prehistorical accounts were not adequately documented, there are evidences of anatomical studies and practices before the formal accounts began, in India for instance [1]; and by implication in every established early human populations. The early instance of formal anatomical studies was recorded in Egypt about 500 years B.C. [2]; who sought to know the form and functions of structures and bodily products [3,4]. This is also true of their unique interest in ancient medical practices. It was also recorded that Anatomy was practiced in Persia - an ancient Asian Empire built around the modern day Iran - as early as the 6th century BC [5]. These reports suggested that the practice of Anatomy was part or a feature of the development in ancient education in different empires and established human populations across the world. The mode of study was originally observational and exploratory, arguably with much philosophy and complimentary little logic. Thus, Anatomy started as a transition of philosophy to science or logical reasoning [6,7]. The transformations that the world has witnessed have no doubt affected education or could be said to have been caused by advancements in education. Anatomy therefore has no doubt evolved and advanced over the years as a subject or field of science. Anatomy as a subject also has an ancient antecedent and the earlier practitioners of Anatomy were morphological observers and explorers.

Anatomy was one of the earliest sciences that marked the transition of logical reasoning from philosophy to science- this is why it is appropriate to describe the early scientists as both philosophers and scientists. Anatomy was purposefully pursued by the early scientists as a

subject that was indispensable to understanding the form and functions of the body and the causes of pathologies [2]. Over the years, the subject of Anatomy evolved greatly; yet, has remained the bedrock of modern Health Sciences. Consequently, Anatomy has increased in sophistication and content volume. Advancements in technology and increased demand for better solutions have given several perspectives to the subject.

Thus, Anatomy in its current form has several fields- primary, advanced and applied. Anatomy as a subject has witnessed radical evolution in context and content. While Anatomy started as what is currently called Gross or Basic Anatomy- the study of tangible morphology, other primary fields including Embryology, Histology, Genetics and Histochemistry among others have evolved particularly due to the advancements and sophistications in methods of studying the body towards better understanding of form, functions and disorders.

The aim of this narrative review is to appreciate and put into the proper perspective, the chronicle of Anatomy as a subject as well as the dynamics involved in its evolution, particularly in terms of content and context. While most articles have emphasised historical accounts basically; this article attempts to emphasise the dynamics of content and contexts along the timelines. Expectedly, this article would provide answers to the questions usually raised about the definition for Anatomy in the modern context, the extent of its content as well as its primary relevance and importance to other subjects and walks of life. It should also help to appreciate the fact that the subject has greatly evolved and its modern form has much greater contributions to make to various walks of life even beyond biomedical sciences.

2. MATERIALS AND METHODS

Three major conventional search engines were employed to search for literatures-keywords on

the subject of the article. Selection criteria required that only articles that addressed the subject of the article with emphasis on the keywords were selected. Information on the subject was extracted and analysed objectively. Common accounts were considered and contradictory reports were critically analysed. Whenever deemed necessary, a number of contradictory opinions were rather reported than merely taking a position- this is to enable for objectivity in comparison of facts. Informed positions were however taken whenever factually documented information outweighed opinions and unsubstantiated reports. Literatures were considered based on the quality and standard of the sources: they included standardised academic and scholarly publications that specifically included and in the order of preference: scholarly articles, standard published texts, standard published web pages and publications with emphasis on *referenceability* in science. An average of 16,000,000 literatures appeared in connection with the key words. Altogether, over 1000 literatures met the selection criteria and about 72 literatures were specifically considered citable in the reviews leading to this report.

2.1 Introducing and Defining Anatomy in Content and Context

Anatomy in its most popular context is meant to mean the study of the body and bodily structures. The word Anatomy originated from the Latin word that means 'dissection' which can further be described to mean the exploration of body structures by cutting-up or cutting through the body. However, in general terms, anatomy simply means the study of forms or structures; hence there could be anatomy of any animate thing and by extension, there could be anatomy of tangible or physical inanimate things as well. Albeit, the term Anatomy in its very original use in the context of a subject or field of knowledge is meant to be the exploration and appreciation of body and bodily structures with particular emphasis on the body of animals, especially humans and its constituent structures. This is why the earliest scientists acknowledged as Anatomists studied the body of humans, either by observing physical structures and their uses cum functions in the living or by dissection of cadaveric bodies of humans or other animals. Early Anatomists made great drawing of gross structures of humans and animals including other relevant animate things. This original and ancient Anatomy in its evolved and advanced form is

now a part of modern Anatomy content known as Gross Anatomy [8].

Early Anatomists also sought to appreciate the process of development - the aspect of Anatomy that is currently known as Embryology. It was easy to observe the embryological development on the eggs of the avian species. The development of the chick provided great insight into embryology at the beginning because the eggs were big enough for macro-examination and they develop largely outside the body environment. There was more to the practice of Anatomy along the line of history, as several anatomists were also artist and the historical landscape is quite interesting [9,10].

While scientists successfully established the other fields of knowledge; development and its process especially *in vivo* was demystified through Embryology- the field of study that considers the process leading to fertilisation and the development of the formed zygote till parturition, not excluding the implications of developmental process on life and life functions afterwards. Furthermore, the need to understand and address the numerous problems associated with abnormal developmental processes led to creating a defined field of knowledge - Teratology. Genetics- as it relates to heredity and establishment of forms and functions, was also incorporated into anatomical content due to its fundamental roles in explaining the establishment of forms and functions and their anomalies including their consequences.

The invention of the microscope from the idea of the telescope made scientists see the need for a deeper or more comprehensive understanding of the body structures especially by using tools that could enable humans to explore and appreciate microscopic units that constitutes the gross structures. With the aid of the microscope, scientists could observe tissue organisations in organs as well as the forms of various cells. This gave birth to microscopic Anatomy that would further divide into two elaborate fields of knowledge Histology- the study of tissues and their constituent cells and Cytology- the study of cells' ultra structures. At first, it was the light microscope that allowed for just cellular organisation into tissues with limited understanding of the cell ultra structure. The electron microscope and other modifications to the original optical microscope to give rise to more effective methods of microscopy gave rise to very advanced understanding of the ultra

structures of tissues and cells in particular. It also facilitated the understanding of the mechanisms underlying cellular and tissue functions. Debatably, this ushered scientists into molecular biology. Histochemistry is another field that evolved as an offshoot of Histology to localise and appreciate chemical reactions in tissues *in situ*. Employment of antibodies in the process of localising and appreciating chemical reactions and tissue components led to an advanced form of histochemistry called immunohistochemistry [11,12].

Despite the radical evolution of Anatomy in context and content; it has continually provided the foundational knowledge to most fields of Biomedical Sciences including Medicine, Nursing, Dentistry, Physiotherapy and Allied Health Sciences. In several instances, only the relevant aspects of the contents of Anatomy are made available to students of the courses or school of knowledge. Several allied health science students undertake only Gross Anatomy, being the study of the body or bodily structures. To them, Gross Anatomy would appear majorly to be Anatomy. What is deducible from this scenario therefore, is that the subject Anatomy though wide and comprehensive could always be tailored towards meeting the knowledge-content requirements of the various fields of health sciences. This scenario is therefore typical of the modern context of Anatomy. Notwithstanding, Anatomy as a course of study for the modern Anatomist is all encompassing. Hence Anatomy has been described to have an end to itself while serving as a means to several ends.

2.2 Defining the Evolution of Anatomy in the context of Historical Landscape

It will be very helpful to define and describe how Anatomy as a subject has evolved in context over time.

2.3 Anatomy: Historical Perspective and Evolution of Philosophies

Anatomy, through its rich history has evolved over the years- both in content and context. The Philosophy has also changed as follows:

- (1) **Ancient Observational Anatomy [From about 500 BC – 600AD]:** This describes the first stage of formal anatomical practices that witnessed the transformation of systemised philosophy into logical

reasoning termed science. The practice of Anatomy at the stage was largely observational.

(2) Early Civilization Exploratory Anatomy [From about 600AD -1800AD]:

This describes the second stage of the development of Anatomical sciences in which the practice was largely exploratory; based on the scientific curiosity to appreciate forms and functions, with relatively little emphasis on application and advanced applications. This period include the latter part of the Middle Ages; the High Medieval Era; Renaissance and the Age of Exploration.

(3) Modern Basic, Educational and Advanced Anatomy [Late 1800sAD-1980AD]:

Anatomy at this stage of evolution centred on *study and analysis* in context and, *basic and applied* in content. This describes the stage of Anatomical practices in which the results of observations and scientific exploration were applied to medical practices, research and improvement of other human working systems in various walks of life. Thus Anatomy was practiced basically as a science; the knowledge was used for education in medical sciences and research. For better understanding, advanced forms of Anatomical sciences were introduced and these brought Anatomy into synergy with several developing modern era sciences. To this end, fields of studies such as histochemistry, molecular biology, anthropological sciences, comparative Anatomy, Radiological Anatomy, Clinical Anatomy, and so on were either developed as advanced forms of basic Anatomy or incorporated from the developing world of sciences to complement the original contents. This included the era of the Start of Enlightenment; the Industrial Revolution and the High Modern Era.

(4) Post-Modern Basic, Advanced and Applied Anatomy [1980AD – Till Date]:

The post modern era witnessed the most radical development in education and application of knowledge and this is equally applicable to the science and the practice of Anatomy. Thus, in addition to the advance fields, Anatomical sciences and practices were designed to address

problems in almost all fields of endeavour and walks of life where the human body would interact with other systems. This ushered in *Applied Anatomy*. To this effect Anatomical sciences and practices include applied fields such as ergonomics, forensic sciences, genetic engineering, Neurosciences, toxicology *et cetera*. This includes the era of the Information Age and Cutting Edge Technology in many spheres of human endeavours.

Each of these stages of evolution is discussed in historical context in the next part.

2.4 Ancient Observational Anatomy [From about 500 BC – 600AD]

Anatomy was basically concerned with the observation of Animals and human structures; in a bid to appreciate nature and appreciate the form and functions of the human body. Though the first documented account were in Egypt by about 500BC [2]; it is understood that observational Anatomy was practiced in other places- for instance, India where Rishi Sushruta [about 600BC], stood out [9] as one of the worlds earliest surgeons recorded in history [13-16]. There are also reports of the practice of structural or anatomical studies in the ancient Persia [17-19]; even ancient Egypt [20] and such

studies were probably preceded by anatomical and surgical practices during the Babylonian Empire [5].

Objectivity was introduced and Anatomy was purposefully studied to help the science of medicine. The Grecian Anatomists and morphologists laid the foundation for the development of Anatomy at this stage and the Greek Anatomists stood out in history [21]. Because the methods were not largely empirical; information collected were largely partly scientific and partly philosophical. This is why the knowledge of this era had series of misconceptions about life, breath, mind, soul heart, blood and organ functions. Players included the nations of early civilisation with the Greeks being major players in their later stage because of their philosophy of 'Reason and Justice'.

On a more precise note, methodical and nomenclature-based Anatomical studies would be attributed to the Greeks. Methodical dissections of animals and humans- dead and living, gave great insight into the form and functions of the human body. A number of Greek philosophers and ancient scientists played significant roles. Alcmaeon through dissections identified and named the optic nerve and Eustachius [24].

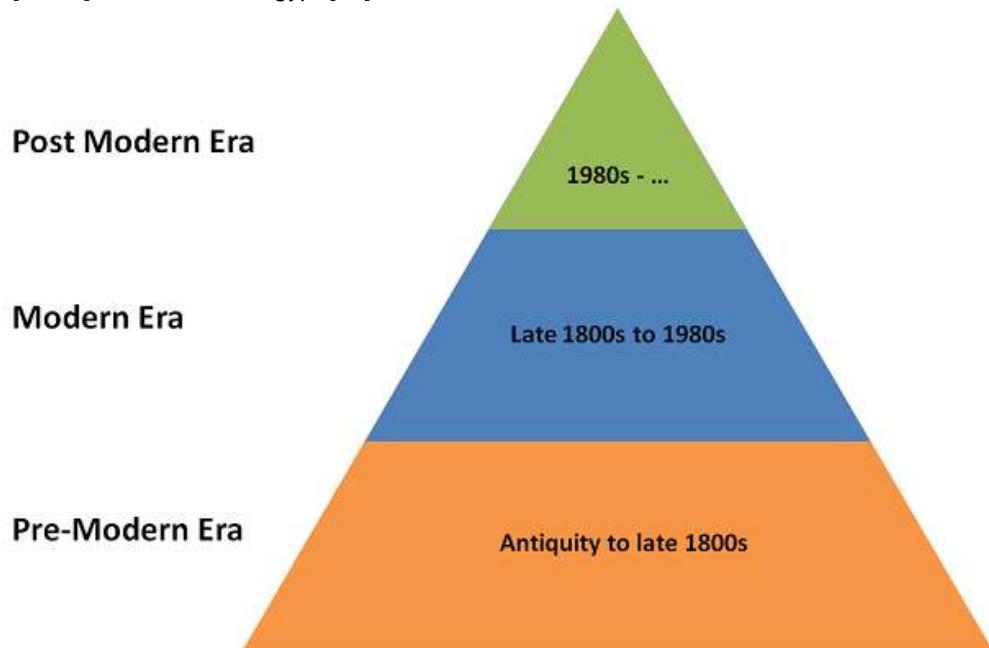


Fig. 1. Pyramid of histological timeline [journalpsyche.org [1994-2016] [22]

Historical Eras - An Idiosyncratic Partial Timeline			
125000 BCE 65000 BCE 35000 BCE 9000 BCE 7500 BCE 5300 BCE 4500 BCE 3500 BCE	Emergence of homo sapiens sapiens Bone tools created in Africa Fish commonly used for food Cultivation of grains; proto-city of Jericho Proto-city of Catal Hoyuk Cities of Sumeria Invention of the plow Domestication of horse	PRE M O D E R N	Prehistoric Era Emergence of Civilization
3110 BCE 530 BCE 395 CE 440 CE	Earliest written records According to legend, Pythagoras, Mahavira, Confucius and Buddha are all alive at this time Last united rulership of Roman Empire ends Drowning of the city of Ys	A N C I E NT	Ancient Era Late Antiquity in Transition
632 CE 1085 CE 1244 CE 1453 CE	Death of Mohammed Reconquista, fall of Toledo Fall of the Cathar citadel at Montsegur Fall of Constantinople	M I D D L E A G E S	Start of the Middle Ages High Medieval Era Renaissance and Age of Exploration
1620 CE 1623 CE 1626 CE 1632 CE 1727 CE 1776 CE 1799 CE 1811 CE 1838 CE 1856 CE 1865 CE 1905 CE 1945 CE	Battle of White Mountain Modern patent systems introduced Death of Francis Bacon Galileo's relative motion theory Death of Isaac Newton American independence; Adam Smith's <i>Wealth of Nations</i> Napoleon assumes dictatorship Luddites smash industrial machines in England Darwin's first notes on his theory of evolution World's first large oil refinery built in Romania Mendel's laws of heredity Einstein's Special Theory of Relativity Second worldwide war in 30 years ended by atomic bomb	M O D E R N	Beginning of the Modern Era Puritan Era Start of the Enlightenment Beginnings of Industrial Revolution Maturity of Enlightenment and Early Romantic Era Maturity of Industrial Revolution and Later Romantic Era Beginning of the Petroleum Age High Modern Era
1948 CE 1962 CE 1964 CE 1975 CE	Shannon's information theory; Wiener's <i>Cybernetics</i> ; invention of the transistor; television becomes a mass market phenomenon; Orwell completing 1984 Kuhn's <i>Structure of Scientific Revolutions</i> ; Cuban missile crisis brings world to the brink of nuclear war McLuhan's <i>Understanding Media</i> ; Berkeley Free Speech Movement; Philip K. Dick's middle two "political" novels Feyerabend's <i>Against Method</i> ; first personal computers introduced for the mass market	P O S T M O D E R N	Beginning of the Postmodern Era

Fig. 2. Chart of histological timeline: Historical Eras- An idiosyncratic partial timeline [23]

Empedocles identified the organ as the central organ of blood circulation [Singer, 1957]; but erroneously named the blood *innate heat* [24]. Others including Acron, Pausanias and Philistion contributed to ancient Anatomy about 480 BC [24].

The great Greek philosopher, Aristotle, contributed to ancient Anatomy and is credited to be the father of comparative Anatomy around 4th century BCE; though he erroneously posited that the heart was the seat of intelligence. The report of Siddiquey [25] stated that Alexandria had the first school of Anatomy about 3rd to 2nd century BC. The King Ptolemy I permitted cadaveric dissections. Anatomical dissections and studies progressed and by the 4th century BCE, Herophilus and Erasistratus conducted extensive dissections and vivisections that helped not just

to appreciate structures, but also functions by examining how structures functions while dissecting criminals live [24,26]. Herophilus corrected Aristotle's position on the seat of intelligence and stated that the brain is the seat of intelligence [Singer, 1957] [24]. Galen is the last major and most informed anatomist of the ancient era. He was a gladiators' chief physician. He built his findings for human bodies and animals- apes and pigs especially- dissection on the numerous findings of the previous Anatomists and corrected a number of erroneous assertions. He was active in the 2nd Century BCE. He documented several of his findings including the major two: *On anatomical procedure* and *On the uses of the parts of the body of man* [24]. His major misconception however was that blood would circulate in a back-and-forth pattern. This was later debunked

and corrected by Vesalius and Harvey in the 16th Century BCE [27].

Obviously, Anatomy at this age was observational; with discretely and sparsely documented observations and little understanding about the systemic functions of the body and how structures are related. Also the term Anatomy was never used for such studies. Hence the basic characteristics of the ancient Anatomy could be highlighted as follows:

1. Anatomy was basically concerned with the observation of Animals and human structures; in a bid to appreciate nature.
2. Because the methods were not empirical; information collected were largely philosophical
3. Players included the nations of early civilisation with the Greeks being major players in their later stage because of their philosophy 'Reason and Justice' [2].

2.5 Early Civilization Exploratory Anatomy [From about 600AD - 1800AD]

This period include the latter part of the Middle Ages; the High Medieval Era; Renaissance and the Age of Exploration. At first, Anatomical studies depended on the ancient era information, especially the work of Harvey up till the 12th century BCE. Animal dissections were also carried out to complement the records [28,29]. Political influences affected anatomical practices: for instance Boniface VIII laws restricted dissection [30]; whereas Emperor Frederick II later compel medical trainees to dissect in medical colleges in Italy [31]. Mondino de Luzzi, 1276 – 1326 was the first Anatomist of this era to conduct extensive dissection and he documented his findings in a book titled *Anathomia* in 1316. His efforts were complemented by Alessandro Achillini and Antonio Benivieni [32,33] of the fifteenth century.

Leonardo Da Vinci [1452–1519] was a great Artist cum Anatomist of his time. He worked with established models of human Anatomy but more importantly, conducted several dissections and made masterful anatomical representations that reportedly totalled about seven hundred and fifty; many of which were used as teaching aids after him. He established nomenclatures for Anatomical drawings and models. He also made some earliest pathological representation including liver cirrhosis and arteriosclerosis [34]

[24,35]. Also in the 16th century BCE Vesalius, a renowned Belgian anatomist challenged a number of Galen's erroneous presumptions and made Anatomy a discipline. He published a great treatise *De humani corporis fabrica* [36].

Anatomy practices and studies continued in the 17th and 18th centuries as organised dissection classes under teachers and professors. This period had anatomical dissections tailored towards developing medical and surgical skills. The supply and use of cadavers was the major challenge of this period; hence body snatching, grave robbery and dissections of relatives and criminals were witnessed.

Deductions from the above accounts can be heighted as follows:

1. Anatomy of the Early civilisation age was exploratory.
2. Philosophy was giving way to logic
3. Anatomists explored bodies through active dissections of plant and animals; even the structures of plants were carefully and curiously studied
4. Key players included Harvey, Vesalius, Da Vinci and others

2.6 Modern Basic, Educational and Advanced Anatomy [Late 1800sAD- 1980AD]

This stage was actually important in the historical landmark of Anatomical practices in terms of standardisation and modernisation. This stage, based on Paul Connelly's Chart of Idiosyncratic Partial Timeline- included the beginning of the Modern Era; Puritan Era; Start of the Enlightenment; Romantic Era; Industrial Revolution; the Petroleum Age and the High Modern Era.

Standard Medical Schools were being established, in Europe in particular. Anatomical dissections thus became a fundamental and indispensable requirement for training. Due to the challenges of obtaining cadavers for dissections, legally, the British Anatomy Act was passed in 1832. Anatomical theatres were also established [2,26,27,36]. Other developments of the 19th century included the regulation of medical schools by the Royal College of Surgeons; establishment of anatomical museum and very importantly, the expansion of Anatomy into developmental and microscopic domains of Embryology and Histology respectively. Thus,

this period witnessed for the first time the advancement of the study of Anatomy from the mono-perspective of Gross Anatomy into multi-perspective of Gross, Embryology and Histology [37,38].

2.7 Anatomy as Gross, Embryology and Histology and Advanced Forms

The continuous evolution and advancement of Anatomy as a medical science and the advancements in technology resulted in the conventional inclusion of Embryology or Developmental Anatomy as well as Histology or microscopic Anatomy in the 19th Century; there were medical schools regulated by the Royal College of Surgeons and Anatomical museums for the purpose of teaching [37,38]. Though advancements in tools and learning methods provided the opportunity to study developmental and microscopic anatomy; the drive could be adduced to quest for more knowledge and explanations for phenomena that lead to *in vivo* development as well as the explanations for the body architecture at microscopic levels. Marcello Malpighi, the Italian scientist has been reported to have been the first scientist to practice Histology; he studied basically Anatomy and Medicine and he was a revered professor [Encyclopaedia Britannica] [39]. This therefore implies that Histology was systemised between 17th and 19th Century, and was conventionally integrated into Anatomy or Anatomical studies by the 19th Century. It should be noted that Histology and Microscopic Anatomy started with what is now termed Optical or Light Microscopy; its major limitation was resolution and quest to overcome this ushered in the electron microscopy [40] which became a major feature of scientific advancement in the 20th century. Cytology or Cell Anatomy was also defined as an aspect of Anatomy in the 19th and 20th Centuries.

In the latter part of the modern era of anatomical science advancement which extended a bit beyond the first half of the; advancement was explosive as industrialisation transformed the world greatly through technology. The electron microscopy techniques in the various forms contributed greatly. So also the development of computer based analytical methods. Histochemistry and its advanced forms made microscopic and tissue studies interesting and invaluable to research and diagnosis. It became a modern advancement of Anatomy. In addition, industrialisation changed the philosophy of

education and Anatomical science was not left out: rather than advancing basically the quest of knowing; the philosophy shifted to what to do with knowledge. Hence, gross Anatomy was applied to fields such as forensics and anthropology, ergonomics and systems design, prosthetics and modelling; advanced preservation techniques including *plastination* among others. Embryology was also applied to the science and practise of Assisted Reproduction Technology such as In Vitro Fertilisation. Yet the end of this era only marked the beginning of the Applied Anatomy as it witnessed largely the practice of the basic Anatomy in the early part; and the Advanced Anatomy in its latter part.

It is obvious that Anatomy at this stage was studied in the context of medical education and research of natural phenomena. Hence, this stage of Anatomical history witnessed the study of anatomy for two major reasons:

1. The multi-perspective- and dimensional study of the human body for science and research- as the advancement and continuation of the *ancient observational and early civilisation era exploratory* anatomical studies of structures
2. The study of Anatomy as a fundamental requirement and component of medical education

There was however a mixture of these reasons and philosophies, such that departments of Anatomical Sciences were set up either to satisfy both or either needs.

Deductions from the above accounts can be heighted as follows:

1. Anatomy, when the world civilisation attained the modern age; at first the Study of Anatomy emphasised the Study and Analysis of the Human Structures for Holistic understanding;
2. Hence, the multi-perspective approach to the study of Anatomy to include: Gross Anatomy, Histology, Embryology.
3. Secondly, the Basic and Applied Approach was employed, whereby research perspective was emphasised more than ever before, with the goal of solving the problems of diseases and anomalies, while attempting to improve the conditions of life and living

2.8 Post-modern Basic, Educational, Advanced and Applied Anatomy [1980AD – Till Date]

This is the most advanced stage of human life and activities which is typically designated the information age. It has within its content and more importantly, context, the older forms of Anatomy as the more stable part of its form. The applied content lays emphasis on the wide range of application of Anatomical knowledge to solving problems in the various walks of life. This arguably informs why many modern schools and departments of Anatomy are set up as Departments and Schools of Anatomical Sciences. Some other offer the *Basic, Educational, Advanced; and add an Applied Anatomical field such as molecular biology, forensic anthropology, reproductive biology or assisted reproduction technology, cell biology, neuroscience among others.* This trend clearly indicates that though Anatomy remains connected to its basic modern era forms, well as an advancement of the ancient anatomical practices; the transformation in the philosophy of education in the postmodern era has also influenced Anatomy. Hence, Anatomical science is studied with emphasis on areas of useful application. This is being termed cutting-edge anatomical education.

Thus, the modern Anatomist can still be a teacher of the subject of Anatomy, as practiced right from the early civilisation or premodern era, or a researcher and educator as practiced largely in the modern era. Very importantly, is the fact that the modern Anatomists is also trained to apply the knowledge of Anatomical science to all relevant fields and walks of life in the post modern world. Thus the post modern Anatomist could be an educator, researcher, anatomical services provider, and most advanced, a professional in a field that requires Anatomical practices. This could include forensic experts in the security and defence services; researchers in the health and biomedical industries; service providers in health sectors and entrepreneurs of the anatomical sciences and skills [11,12]. This is being reflected in the trend of curricular structures [41,42] as well as policy nomenclatures [43].

To this end, it should be noted that modern Anatomy is a greatly advanced form of the ancient science which has greatly evolved [11,

12]. Interestingly, several Anatomist of the last era- the modern era- have failed to catch up with the evolution as their definitions of Anatomy, which unfortunately dominate the existing literatures has fast become archaic relative to the realities of the current era. The mere study of body structures has paved way to the use of the knowledge to improve health which in turn has advanced to the multidimensional application of anatomical sciences and skills.

For instance Glasgow [44] defines Anatomy as '**scientific study of the human body in relation to its function**' and states that the career prospect for its graduate as follows: Our graduates are employed in biomedical laboratories (in both industry and hospitals) and in forensic science. Others have entered the paramedical services, publishing and teaching, while many have continued in postgraduate training, or have become graduate entrants into Medicine or Dentistry. Witwatersrand [2016] [45] on other hand stated: The School of Anatomical Sciences was established as the Department of Anatomy in 1919. The School currently comprises of three academic divisions, namely morphological anatomy, structural biology (histology), and biological anthropology. These two instances illustrate the roles of philosophical evolutions in relations to context and content of training in Departments and Schools of Anatomy.

Anatomy- in addition to the developed basic, basic, educational and advanced forms- acquired the *applied* form in its full fledge at this stage of development.

1. Anatomy in the postmodern world has an addition dimension to the second phase of the modern era Anatomy:
2. This encompasses the Basic, Applied and Advanced Approach to the Study and Practices of Anatomy
3. This created a cutting-edge approach to Anatomy
4. Thus, Anatomy is studied, in addition to the purpose of Education and Services provision- to provide applied and advanced services to any walk of life where the knowledge of human morphological systems is required
5. Thus fields such as forensic anthropology, ergonomics, IVF/Assisted Reproductive Technology, Neuroscience, Histochemistry

2.9 The Microevolution of the Postmodern Time [1980AD – Till Date]

The fact that Anatomy is indispensable to Medical Education remains undisputable; as suggested by Papa and Vaccarezza [46] in their article introduction: Anatomy has historically been a cornerstone in medical education regardless of nation, racial background, or medical school system. Many literatures have supported this assertions and established their correctness and realties [47-55]. The emphasis of the article however sheds light on the context of Anatomy in the medical context as a fundamental requirement and foundation for medical training and practice [56]. This is one perspective to Anatomy- Anatomy as a means to an end. For emphasis, this is not only applicable to medicine, but to almost all medical and allied health courses and professions. The other is Anatomy as an end to itself- the science, education and application of Anatomical sciences. This perspective emphasises the training of professionals by equipping them with Anatomical education and skills.

Therefore, Anatomical Sciences in itself involves all the basic, developed and advanced forms and branches of Anatomy as stated. It is interesting to note that there of micro-evolution in each of these fields based on research and skill demands as manifested in cutting-edge orientation to research, for example. For instance, radiological Anatomy as applicable to neuroscience has advanced to include high-tech methods that are superior to the equivalent methods that are used in clinical and laboratory medicine. The same is applicable to molecular methods and histochemical procedures among others. The most advanced developments in these fields and several others are ever first of all available to researchers. This is because research is the first line of response to challenge as well as the scientific-proactive means of addressing potential challenges. It is expected that this series and dynamics of microevolution will continue following closely the trends in scientific and technological developments. This fact thus, explains why Anatomical Sciences cannot be tied to the orthodox definitions, context and scope. It also accounts for the new nomenclatures that are being used in training regimen and issuance of degrees- for instance, B Sc., Anatomy and Forensic Anthropology.

Deductions from the above accounts can be heighted as follows:

1. Anatomy has been an indispensable basic medical science and remains the inlet for all medical sciences.
2. It is important to appreciate the very dynamic changes and trends that have accompanied the changes in the study of Anatomy across the world
3. Anatomy as a subject has greatly evolved and expanded and its branches have become quite vast; such that certain schools now have schools of Anatomical Sciences
4. On the other hand, some other institutions have carved their niches with emphases on certain areas such as molecular Biology, Neuroscience, Tissue Toxicology, Applied Anthropology etc. [7,12,57-63]

3. SUBMISSIONS

1. Anatomy is an evolving Science
2. Its Postmodern form is dynamic and advancing
3. Anatomical Education has changed in context and content over the centuries
4. Four key stages have been identified
5. Postmodern Anatomy is Basic, Applied and Advanced
6. Modern Anatomical Education MUST be dynamically structured to meet the need of the 21st Century
7. The anatomist should have substantial applied or clinical anatomical knowledge and skills to put the basic knowledge into an applicable form.
8. Anatomy 'has an end to itself as much as it is a means to many ends'

4. CONCLUSION

It is important to note that Anatomy or Anatomical Science[s] has evolved in context and content over the years and these evolutions have influenced the philosophy at each stage of the evolutions. Four key stages have been identified: The Ancient *Observational Anatomy* [From about 500 BC – 600AD]; the Early Civilization *Exploratory Anatomy* [From about 600AD -1800AD]; the Modern *Basic, Educational and Advanced Anatomy* [Late 1800sAD-1980AD]; Post-Modern *Basic, Educational, Advanced and Applied Anatomy* [1980AD – Till Date]. The current postmodern Anatomy or rather Anatomical sciences considers in addition

to the modern era emphasis on research and education, the applied forms of Anatomical Sciences. Worthy of note is also the fact that while Anatomy remains fundamental to the curriculum content and training of medical and allied health professionals; Anatomical Sciences as a field of science emphasises the training of professionals in the field of Anatomy for a number of reasons including education, research, professional services, applications to several walks of life and not excluding the development of ideas into entrepreneurial systems. Thus, the post modern anatomy as a field is an end to itself as much as it is a means to several ends. The modern Anatomist is trained for job opportunities in all the identified fields and walks of life. This philosophy should influence curricular structures and training designs in Schools of Anatomy and Anatomical sciences that either educate potential anatomists, doctors or other professionals. It may therefore be suggested that Schools of Anatomical Sciences may be applicable to some settings rather than the School or Departments of Anatomy.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Jacob TG. History of teaching anatomy in India: From ancient to modern times. American Association of Anatomists. 2013; 6:351–358.
2. Moore KL, Dalley AF. Clinically oriented anatomy. 5th Edition, Philadelphia: Lippincott Williams & Wilkins; 2006.
3. Porter R. The greatest benefit to mankind: a medical history of humanity (The Norton History of Science). W. W. Norton. 1999;49–50.
4. Nunn JF. Ancient Egyptian medicine. University of Oklahoma Press; 2002.
5. Shoja MM, Tubbs RS. The history of anatomy in Persia. J. Anat. 2007; 210:359–378.
6. Persaud TVN. Early history of human anatomy from antiquity to the beginning of the Modern Era. Springfield, IL, Thomas; 1984.
7. Persaud TVN. A history of anatomy. The Post-Vesalian Era. Springfield, IL, Thomas; 1997.
8. Hakim SZR, Tarikh IT. An extensive Book in Urdu on History of anatomy (1967), Tibbi Academy, Delhi. Second Revised Edition; 2009.
9. Ogeng'o J. The changing face of human anatomy practice: Learning from history and benefiting from technology. Anatomy Journal of Africa. 2014;3(2):308-312.
10. Malomo AO, Idowu OE, Osuagwu FC. Lessons from history: Humana anatomy, from the origin to the renaissance. Int. J. Morphol. 2006;24(1):99-104.
11. Adeniyi PA, Omomeji KO, Ishola AO, Owolabi JO, Tijani AA, Shallie PD. Advancing anatomical science and education: The Need to Develop its Branches in Nigeria. The Journal of Anatomical Sciences. 2016;7(1):11-12.
12. Owolabi JO. Introducing anatomy. Published by Ace-World Publishers, Ilorin, Nigeria; 2011.
13. Saraf S, Parihar R. Sushruta: The first plastic surgeon in 600 BC. The Internet. J Plastic Surg. 2006;4(2).
14. Bhattacharya S. Sushruta – our proud heritage. Indian J Plast Surgery. 2009; 42(2):223 – 225.
15. Deeper B, Pushpalatha K. A glimpse of our past: Contributions of Sushruta to Anatomy. Anat J Afr. 2014;3(2):362–365.
16. Loukas M, Lanteri A, Ferrauiol J, Tubbs RS, Maharaja G, Shoja MM, Yadav A, RAo VC. Anatomy in Ancient India: A focus on Sushruta Samhita. J Anat. 2010;217:646-650.
17. Price M. History of ancient medicine in Mesopotamia and Iran; 2001. Available:http://www.iranchamber.com/history/articles/ancient_medicine_mesopotamia_iran.php
18. Rust JH. Animal models for human diseases. Perspect Biol Med. 1982;25: 662–672.
19. Elgood C. A Medical history of Persia and the Eastern Caliphate. London: Cambridge University Press; 1952.
20. Porter R. The greatest benefit to mankind: A medical history of humanity (The Norton History of Science). W. W. Norton. Neurosurg Focus 16, E2. 1999;49–50.

21. Siddiquey AKS, Husain SMS, Laila SZH. History of anatomy. *Bang J Anat.* 2008; 7(1):1-3.
22. Anonymous. Pyramid of histological timeline. *Authors & Journal Psyche;* 1994-2015.
Available:<http://journalpsyche.org/psychology-timeline>
(Accessed, 28th September, 2016)
23. Connelly P. Chart of histological timeline: Historical eras- an idiosyncratic partial timeline; 2008.
Available:www.darc.org
24. Singer C. A short history of anatomy & Physiology from Greeks to Harvey. New York: Dover Publications Inc. 1957;5-10: 59.
25. Siddiquey AK, Shamsuddin H. History of Anatomy. *Bangladesh Journal of Anatomy.* 2009;7(1).
26. Roach M. Stiff: The curious lives of human cadavers. New York: W.W. Norton. 2003;37-57.
27. Boas M. The Scientific Renaissance 450-1630. Fontana. 1970;120-143:248, 262.
28. Nutton V. Ancient medicine. London and New York: Routledge Taylor & Francis Group. 2004;138.
29. Siraisi NG. Medieval and early renaissance medicine. Chicago and London: University of Chicago Press. 1990;84.
30. Glick L, Wallis T, Steven JF. Medieval Science, Technology and Medicine. New York and London: Rutledge Taylor & Francis Group. 2005;32.
31. Crombie AC. Medieval and Early Modern Science (volume 1 ed.). Cambridge, Massachusetts: Harvard University Press. 1967;180 and 181.
32. Zimmerman LM, Veith I. Great Ideas in theHistory of Surgery. Norman Publishing; 1993.
33. Thorndike L. A history of magic and experimental science: Fourteenth and fifteenth centuries. Columbia University Press; 1958.
34. O'Malley, Charles D. Leonardo on the Human Body. New York: Dover; 1983.
35. Mason Stephen F. A history of the sciences. New York: Collier. 1962;550.
36. Klestinec C. A history of anatomy theatres in sixteenth-century padua. *Journal of the History of Medicine and Allied Sciences.* 2004;59(3):375-412.
37. McLachlan J, Patten D. Anatomy teaching: Ghosts of the past, present and future. *Medical Education.* 2006;40(3):243-253.
38. Reinarz J. The age of museum medicine: The rise and fall of the medical museum at Birmingham's School of Medicine. *Social History of Medicine.* 2005;18(3):419-437.
39. Encyclopaedia Britannica.
Available:<http://www.britannica.com/biography/Marcello-Malpighi#ref81339>
(Accessed 30th July, 2015)
40. Minard JG. Contributions of the electron microscope. *Bios.* 1956;27(4) 235-237.
41. Babcock University. Babcock University: Anatomy Programme Curriculum. Published by the Directorate of Academic Planning, back university, Nigeria; 2015.
42. University of the Witwatersrand, Johannesburg. School of Anatomical Sciences.
Available:www.wits.ac.za/anatomicalsciences
(Retrieved 4th October, 2016)
43. Tijani AA, Owolabi JO, Adeniyi PA, Adekomai DA. Amending the Nigerian anatomy act in line with global trends and towards meeting Nigeria's need for sustainable development: The Proposition. *British Journal of Education, Society & Behavioural Science.* 2016;16(4):1-13.
44. University of Glasgow.
Available:<http://www.gla.ac.uk/undergraduate/degrees/anatomy/#/programmestucture,careerprospects>
(Retrieved 3rd October, 2016)
45. University of Witwatersrand- 2016. University of Witwatersrand: School of Anatomical Sciences.
Available:<https://www.wits.ac.za/science/biology/planning-a-degree/school-of-anatomical-sciences>
(Accessed 11th January, 2016)
46. Papa V, Vaccarezza M. Teaching anatomy in the XXI century: New aspects and pitfalls. *The Scientific World Journal.* 2013; 2013:310348:1-5.
47. Bolender DL, Ettarh R, Jerrett DP, and Laherty RF. Curriculum integration = course disintegration: what does this mean for anatomy? *Anatomical Sciences Education.* 2013;6(3):205-208.
48. Older J. Anatomy: A must for teaching the next generation. *Surgeon.* 2004;2(2):79-90.

49. O'Neill PA. The role of basic sciences in a problem-based learning clinical curriculum. *Medical Education.* 2000;34(8):608–613.
50. Prince KJAH, Scherpelbier AJAA, van Mameren H, Drukker J, van der Vleuten CPM. Do students have sufficient knowledge of clinical anatomy? *Medical Education.* 2005;39(3):326–332.
51. Ellis H. Medico-legal litigation and its links with surgical anatomy. *Surgery.* 2002; 20(8):1–2.
52. Parker LM. What's wrong with the dead body? Use of the human cadaver in medical education. *Medical Journal of Australia.* 2002;176(2):74–76.
53. Cahill DR, Leonard RJ, Marks Jr. SC. Standards in health care and medical education, *Clinical Anatomy.* 2000;13(2): 150.
54. Heylings DJA. Anatomy 1999-2000: The curriculum, who teaches it and how?" *Medical Education.* 2002;36(8):702– 710.
55. Schmidt HG, Dauphinee WD, Patel VL. Comparing the effects of problem-based and conventional curricula in an international sample. *Journal of Medical Education.* 1987;62(4):305–315.
56. Moxham B. Symposium on anatomical education. *Journal of Anatomy.* 2014; 224(3):255.
57. Tijani AA, Owolabi JO, Shallie PD. Nigerian students' perception of anatomy as an undergraduate degree programme. *Journal of Anatomical Sciences.* 2015;6(1): 7-11.
58. Park K. *Secrets of Women: Gender, Generation, and the Origins of Human Dissection.* Zone Books, New York; 2006.
59. Owolabi JO, Tijani AA, Shallie PD. An assessment of the level of motivation towards the study of anatomy among students in south-western Nigerian Universities. *Journal of Health Science Research.* 2013;1(1):7989
60. Hildebrandt S. Lessons to be learned from the history of anatomical teaching in the United States: The example of the University of Michigan. *Anatomical Sciences Education. Anat Sci Educ.* 2010; 3:202–212.
61. Halperin EC, Perman JA, Wilson EA. Abraham flexner of Kentucky, his report, medical education in the United States and Canada, and the historical questions raised by the report. *Acad Med.* 2010; 85:203–210.
62. Peter AI, Azu OO, Ekandem G, Etuknwa BT, Bassey RB. A survey of attitude of lecturers and students of anatomy towards making anatomy career friendly in Nigeria. *Ibom Med. J.* 2012;5:39-44.
63. Tait CN, Boers D, McAndrew D. Review of anatomy education in Australian and New Zealand medical schools, *ANZ Journal of Surgery.* 2010;80(4):212–216.

© 2017 Owolabi et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:
The peer review history for this paper can be accessed here:
<http://sciedomain.org/review-history/19487>