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The laboratories of anatomy and the standard practices therein

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Abstract:

A laboratory is a facility that is equipped for carrying out scientific experiments or procedures for the purposes of research, teaching, or analysis for service provision under controlled and optimal working conditions. Anatomy is the basic essential science of medicine, laboratories of anatomy are those facilities equipped for carrying out such scientific experiments to understand the structures and functions of human and animal bodies. The laboratories of anatomy, as generally required, for any conventional laboratory, do serve three known basic functions. Each could be a teaching, research, or service laboratory or perform two or three of the functions. Common laboratory units in the department of anatomy include anatomy museum and workshop, animal cell and tissue culture laboratory, biological anthropology and forensic anatomy laboratory, clinical embryology and andrology laboratory, cytogenetic laboratory, histology and histochemistry laboratory, mortuary and gross anatomy laboratory, and radiological anatomy laboratory.

Keywords:

Common laboratory units, laboratories of anatomy, standard practices

The Laboratories of Anatomy

Anatomy is a basic medical science. A laboratory is a facility that is equipped for the purpose of carrying out scientific experiments or procedures for research, teaching, or analysis (Oxford English Dictionary, 2005). Laboratories are, therefore, indispensable to the training of anatomists, conducting research in anatomical sciences or providing anatomical services. Anatomy laboratories are indispensable to the success of the work of the anatomist (Arráez-Aybar *et al*., 2010). These laboratories also require standard practices and proper understanding for the purpose of safety and effectiveness (CDC, 2011; CDC, 2012; CDC and NIH, 2017).

Anatomy museum and workshop

Anatomy museum has remained a key facility to medical science training, especially as from the 16th century and these facilities have emphasized anatomy and pathological features (Turk, 1994). These facilities have played crucial roles in medical educational training (Marreez *et al*., 2010). Anatomy museum permits the study of comparative anatomy and human evolution, while popularization of the knowledge of anatomy is ensured through display of anatomical specimens for institutional and external visits. It serves teaching and research purposes in archaeology, anatomy museum techniques, comparative mammalian anatomy, and human evolution. It is directed by a qualified and experienced technologist with a basic degree or qualification in anatomy or anatomical science and adequate knowledge and expertise in morphological and comparative anatomy and human evolution. Working in anatomy museum requires the knowledge of gross anatomy and the skills of specimen dissection as well as the knowledge of animal handling, together with skills in handling tools needed in anatomy museum workshop.

While the importance of anatomical museum cannot be undermined or overlooked, it is

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important to note that special trainings are often not available for the laboratory workers to match their skills with the level of technical dissections that will be required for them. This is the current situation in Nigeria for instance, but it is also a global challenge in medical science education. Again, graduates of the anatomy program are basically qualified to serve as museum technologist and workers because they take during and have trainings during the bachelors' degree program that make them qualify as managers or directors, curators, registrars, museum educators, graphic designer, exhibit designer and preparator and technologists in anatomy museum and workshop (Rodrigues *et al*., 2015). While this has helped to address the want of museum technologist in many instances, there is a need to set up formal training programs that specifically lead to certification in anatomy museum practices so as to provide high-skilled service to meet the need of the training institutions.

Concerning its setup, anatomy museum commonly features displays of human and animal skeletal material and anatomy museum mounts of organs, systems, and organisms in pots, jars, and aquaria. Anatomy museum workshop is an appendage of anatomy museum where museum materials are prepared. Some of the procedures employed in anatomy museum and workshop include specimen dissection, embalming, bone maceration, and organ/system potting. While these are still very relent to anatomical and medical science education, they need to be considered in light of the current revolutions of the information age and the information technology-driven educational system of the current time. The inability to align the rational use and practice of anatomical museum facilities with the advances in information technology and web-based learning has caused the roles of anatomy museum in medical and allied health education to be misunderstood or not adequately appreciated. This current prevalent situation is however not good and should be addressed.

Animal cell and tissue culture laboratory

Key areas of anatomy which animal cells and tissue culture procedures and services are required include embryology, cytology, stem cell biology, cancer research, basic molecular studies, *in vitro* cell studies, drug selection and toxicology studies, gene research, monoclonal antibody production, *in vitro* fertilization technology, and cryopreservation (Oyeleye *et al*., 2016; Nema and Khare, 2012).

Cell and tissue culture is an important aspect of anatomy, albeit, not limited to anatomy. There are specific aspects of anatomy that are basically anatomical. Animal cell and tissue culture laboratory is more of a service and a research laboratory in the department of anatomy. Useful cell lines are propagated and maintained in culture media to further study the structure and behavior of such cells. Teaching involving animal cell and tissue culture techniques in the areas of stem cell, embryology, cell and molecular biology is carried out in the laboratory. It is normally directed by a qualified and experienced scientist who has a basic degree in anatomy with knowledge and expertise in culture techniques. The knowledge of microscopic anatomy, cellular reproduction, and molecular biology with skills in the techniques of animal cell and tissue culture is required to be able to work in this laboratory. Animal cell and tissue culture laboratory serves as a support laboratory to some other laboratories of anatomy, apart from being in existence in similar other departments where tissue culture techniques are most often employed. Some of the procedures employed in animal cell and tissue culture laboratory include culture media preparation, sterilization, and culturing.

Biological anthropology and forensic anatomy laboratory

Biological anthropology and forensic anatomy laboratory is a teaching laboratory in the department of anatomy. It is dedicated for the teaching of courses in biological anthropology and techniques, biometry, human growth and aging, forensic anatomy, anthropometry, and somatotyping. It exists with anatomy museum in most old departments of anatomy where no distinction is made between the two laboratories and is named anatomy museum. It serves the purpose of a service laboratory when forensic anatomy (involving determination of species, sex, age, ethnicity, stature, lifestyle, injury, and cause of death from bony remains) is predominantly carried out there. Forensic anatomy is the utilization of the science of physical anthropology for medicolegal implications.

The identification of decomposed skeletal or unidentified human remains is crucial for both legal and humanitarian reasons. Forensic anatomy requires standard scientific procedures or techniques developed in physical anthropology to identify human remains and to assist in the detection of crime. Forensic anatomists often work in conjunction with forensic odontologists, pathologists, and homicide investigators to identify a dead person, discover evidence of violent and foul play, and/or the postmortem interval. "In addition to assisting in locating and recovering suspicious remains, forensic anatomists work to suggest the age, sex, ancestry, stature, and unique features of a decedent from the skeleton." Broad training in the field of biological anthropology and forensic anatomy requires a broad range of cultural practices and detailed principles of archaeology. Students should undertake courses in the field of archaeology, bio-statistics, histology, osteology and skeletal biology,

and histochemistry. The laboratory is directed by a qualified and experienced scientist with vast knowledge in human and vertebrate animal anatomy and expertise in the techniques of anthropometry. Working in this laboratory also requires the knowledge of gross anatomy of human and vertebrate biology, the knowledge of animal handling, and skills of anthropometry and somatotyping.

Commonly displayed in this laboratory are human and animal skeletal materials. Some of the procedures carried out and services provided in biological anthropology and forensic anatomy laboratory include assignment of sex to skeleton, age estimation, decrypting ancestral and cultural background, stature estimation, skeletal markers of activity and life history, serology and forensic DNA analysis, legal considerations, and Mendelian genetics (Klepinger, 2006). Other techniques employed are facial reconstruction, reconstruction of broken or fragmented bones, antemortem, perimortem, postmortem, and radiographic evaluation, human remains preservation, remains identification, scientific prosections and demonstrations, bone maceration, anthropometry, and somatotyping.

Clinical embryology and andrology laboratory

Traditionally, clinical embryology and andrology laboratory serves the three functions of a medical laboratory with teaching and research in departments of anatomy and services in hospitals and other health facilities. It is today, in Nigeria, there is an appendage of assisted reproductive technology unit of hospitals and the health facilities. The main goal of this laboratory is to provide a safe and secure environment with optimal conditions for gametes, embryos, and embryonic development. It is directed by qualified and experienced scientists with expertise in the field of embryology. Laboratory staff are vast with the knowledge of embryology and well skilled in the techniques of assisted reproduction. Appropriate qualification is a basic degree in anatomy or its specialties, though many so-called embryologists in Nigeria today have a basic degree in life science and short-term training in assisted reproductive techniques. Procedures in the laboratory require the knowledge of developmental biology and hands-on experience of embryologists. Embryology and andrology laboratory finds its importance in

i. Overcoming male and female infertility problems
ii. Preimplantation genetic diagnosis to rule out the presence of genetic disorders
iii. Gametes' (egg and sperm) donation and preservation.

Cytogenetic laboratory

Cytogenetic laboratory in the department of anatomy is a teaching laboratory where the structure and functions of cells, especially chromosomes, are studied. Chromosome structure, number, markings, and classification with chromosome identification and karyotyping and determination of cytogenetic abnormalities are carried out in these teaching cytogenetic laboratories using banding techniques. When attached to a health facility, cytogenetic laboratory is predominantly a service laboratory where an extent of research is carried out and advanced molecular cytogenetic procedures are employed for diagnosis. Service and research cytogenetic laboratories investigate the whole genome for loss or gain of chromosomal material and structural rearrangements of the chromosomes. The range of investigations in these laboratories is karyotyping (chromosome analysis), array comparative genome hybridization (CGH), fluorescence *in situ* hybridization (FISH), and quantitative fluorescence-polymerase chain reaction. Living cells from blood and tissue samples are required for cell culture to produce the chromosome preparations for karyotyping and array CGH while FISH is undertaken on preparations from cultured or uncultured cells or from paraffin-embedded fixed material.

Histology and histochemistry laboratory

Histology laboratory is indispensable to anatomy and medical science training, practice, and research; hence to national development (Mohammedsaleh, 2014; Buesa, 2007). This has basically been a teaching and research laboratory for students and staff of the department of anatomy. Scientists in the laboratory are anatomists (histologists) who are vast with the techniques of tissue fixation, processing, microtomy, staining, and microscopy. Required knowledge, skills, and certification to work in histology and histochemistry laboratory are acquired with a basic degree in anatomy.

Histology laboratory in the context of anatomy is basically teaching and research oriented. Anatomists in various fields including basic histology and other applied fields of histology such as toxicology, cancer studies, reproductive sciences, and neurosciences among others apply the skills and methods of histology to study tissues *in situ*. In addition, histochemistry, either in its basic traditional form or its more advance forms including immunohistochemistry, is being used to study the chemistry of histological and cytological materials or specimens obtained from biological sources *in situ*. The use of the laboratories for the purpose of teaching bothers on the need to train scientists and help them acquire scientific skills and knowledge.

Scientists certified to work in the histology and histochemistry laboratory could study specimens of cells and tissue samples removed from the patients, processed using special histological techniques (histological slides and sections prepared and stained to make the sample ready for observation with a microscope). Either a light

microscope or an electron microscope may be used to examine histology slides (Musumeci, 2014).

Hematoxylin and eosin, otherwise known as H and E, is the routine staining used to evaluate histological changes in tissues and organs from animals in toxicity researches. H and E is a basic dye that has affinity for acid structures of the cell (mostly nucleic acids of the cell nucleus), and eosin is an acidic dye that binds to cytoplasmic structures of the cell. As a result, H and E stains nuclei in blue and cytoplasm in orange-red (Slaoui and Fiette, 2011). Unstained paraffin sections have very low contrast and hence the histology of the tissue cannot be visualized microscopically. It is, therefore, necessary to apply coloring (dye) reagents (mostly chemicals) to stain tissue structures. There are many histochemistry staining techniques that can be applied to examine specific tissue or cell structures. Basic knowledge of microscopy is principally required. Some of the basic tools required in the laboratory histology and histochemistry laboratory are cryostats, fume hood, dissecting board, gloves, rubber, eyeglasses, mask, microtome, tissue water bath with a thermometer, disposable microtome blades, fine paint brushes, forceps, microscope glass slides, laboratory oven, enclosed tissue processors, plastic cassettes, and disposable knives (Slaoui and Fiette, 2011).

Mortuary and gross anatomy laboratory

This is an ancient teaching and research laboratory in the department of anatomy which was started as gross anatomy laboratory unit. It has dissection room, body store room, body preparatory room, and store as its components, with mortuary being established nowadays to render services to the university community and the general populace in most departments of anatomy. It is directed by qualified and experienced anatomists with at least a basic degree in anatomy or its specialty. Working in the mortuary and gross anatomy laboratory requires an in-depth knowledge of gross anatomy of human body and experience in dissection of human and animal bodies, with expertise in the techniques of embalming and restoration. Assisting the anatomists (laboratory scientists) are the mortuary and laboratory attendants who are employed with no relevant qualification but learn on the job. It is being suggested that these attendants should be formally trained and officially certified to improve the standard of practice in the mortuary and gross anatomy laboratories of the departments of anatomy in the country.

Radiological anatomy laboratory

This is a new laboratory in most departments of anatomy. It is established for the purpose of teaching and research in anatomy using radiological approach. It is directed by qualified and well-experienced anatomists who work with staff having adequate knowledge of anatomy.

Standard Practices in the Laboratories of Anatomy

Anatomists and other laboratory staff with students working in the different laboratories of anatomy work on human and animal cells, tissues, organs, systems, or even the complete organisms in either of living or dead state. While working on these, they work with physical, chemical, and radiological substances. The biological, physical, chemical, and radiological substances in these laboratories of anatomy pose one or the other health and safety risk to those laboratory staff and students. Standard laboratory practices focus on decisions of safety from these hazardous substances. Safety in the laboratories is ensured from the standard practices on the side of the laboratory management and on the side of the laboratory staff and students.

Standard laboratory practices from management

Management ensures standard practices in the following aspects of the laboratories:

a. Health and safety
- Provision of personal protective equipment (PPE – hand gloves, laboratory coat, aprons, face mask, enclosed footwear, and goggle) in the laboratories
- Provision of running water sources and disinfectants/antiseptics
- Provision for vaccination of all laboratory staff and students against hepatitis and tetanus
- Provision of record book for reported cases of medical conditions, incidents, and laboratory accidents involving staff and students
- Regular organization/sponsorship of safety training and retraining for staff and students
- Making copies of laboratory procedures and associated health and safety risk available in the laboratories
- Strategically placing written instructions in the laboratories
- Making surfaces or walls, floors, and roofs to be resistant to chemicals, disinfectants, and water and easy to clean

b. Security and access to the laboratories.

Written instructions/regulations on security of and access to the laboratories are put strategically in the vicinity of the laboratories. Regulations usually circulated among students and members of staff always include the following:
- Visitors, staff, and students who do not have any business with the laboratories are not permitted to come into the laboratories
- Visitors and contractors, if they must come in, must be escorted in by a member of laboratory staff
- Students must always be supervised while in the laboratories

- Unrelated audio/video recordings and photography while in the laboratories are prohibited for students and staff.

c. Laboratory attire
- Making it mandatory for students and staff to wear PPE when in the laboratories
- Making it prohibited for students and staff to wear hat, sunglass, contact lenses, local dresses that may not be smart enough on them, long hair, hand/leg chains, and bangles when in the laboratories.

d. General housekeeping
- Provision for thorough and constant cleaning of work areas, equipment, and spills
- Provision for tidiness of the floors, fire exits, and aisles
- Adequate handling of body fluids and wet preparations
- Provision for segregation of anatomy laboratory wastes into biological, physical, chemical, and mixed wastes, and storage of different waste types in different waste bins/containers
- Employment of acceptable method of disposal of wastes from the laboratories. Common methods usually employed are burning/incineration, burying/biological decomposition, disposal in biohazard bags, and disposal in rivers/streams.

Standard laboratory practices from laboratory staff and students

i. Considering what you work with and what hazards are therewith; working with biological, chemical, physical, and radiological agents with attendant health and safety risks in the different laboratories of anatomy. The standard practices include:
- Seeking immediate assistance
- Using running water for at least 15 min to wash blood, body fluid, or chemical splash
- Reporting any accident, injury, or uncontrolled release of potentially hazardous materials to laboratory supervisors.

ii. Always getting prepared for laboratory work; standard laboratory practices that shall ensure this include:
- Attending necessary laboratory safety training and retraining
- Always reading laboratory procedures and associated safety information before the start of laboratory work
- Following all instructions, written or verbal. Ask for clarification if confused and for assistance if you need guidance
- Understanding the laboratory setup and getting acquainted with the locations and operating procedures for all safety equipment (eyewash stations, fire alarm, extinguishers, and sand buckets), and at least two ways out of the laboratory building
- Learning the proper emergency response procedure for laboratory accidents or injuries
- Always being alert and prepared to proceed with caution at all times in the laboratories.

iii. Preventing potential exposure by
- Being responsible and professional in the laboratory; no pranks or jokes
- Putting clothing and shoes that cover exposed parts of the body and protect them from potential splash or sharp objects. Dressing should be smart enough and should be impossible to catch in the laboratory equipment
- Using biosafety cabinet where applicable
- Reporting damaged electrical equipment to laboratory supervisors
- Keeping laboratories clean always.

iv. Protecting oneself and ones environment by
- Practicing good personal hygiene; hand washing after removal of gloves, after each time of handling potentially hazardous material and before leaving the laboratory at the end of laboratory work
- Wearing PPE
- Properly segregating and disposing all laboratory wastes.

Recommendations

Having been able to identify the various laboratories of anatomy and the standard practices therein, and with the roles anatomy and its laboratories play in medical and allied health education and practices, we wish to recommend that heads of anatomy departments in the various medical schools across Nigeria should work in hands with the leadership of their colleges and management and council of these universities to ensure the establishment and optimal functionality of these laboratories. We also wish to recommend that concerned bodies of anatomists work on curriculum to develop the workforce for these laboratories while anatomists develop the many fields of research, teaching, and services these laboratories serve.

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Conflicts of interest

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