# UNIVERSITY OF PORT HARCOURT

# LIFE AS A CHEMICAL REACTION: THE CLINICAL LABORATORY AND THE BATTLES FOR LIFE

## AN INAUGURAL LECTURE

By

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## DEDICATION

This inaugural lecture is dedicated to God almighty, for His unfailing love and favours.

## ACKNOWLEDGEMENTS

Firstly and most profoundly, to God almighty, the alpha and the omega, who in his infinite mercies, has made all things possible and lifted me up from nothingness to where I am today. I remain eternally grateful.

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Special gratitude to Dr. U. S. Etawo, who said he identified a leadership potential in me and appointed me a Deputy Chairman, Medical Advisory Committee in 2003. I acquired a lot of knowledge and skills in management and administration under his tutelage, which enabled me to emerge as the 6th Chief Medical Director of the University of Port Harcourt Teaching Hospital in 2009.

Immense gratitude to all my teachers and trainers at the Departments of Chemical Pathology, University College Hospital, Ibadan and the College of Medicine, University of Ibadan, especially my main trainer, mentor and role model, late Professor Babatunde Osotimehin, a distinguished Physician and Chemical Pathologist, former Director General, National Agency for Control of Aids (NACA) and former Honourable Minister of Health of the Federal Republic of Nigeria. As Head of Department, he offered the counsel and opportunity for me to do the residency training in Chemical Pathology. He offered me immense support and a free hand in the use of his research facilities at the Metabolic Research Unit of the department. I cut my tooth in research under his tutelage.

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(immediate past Vice-Chancellor, Nnamdi Azikiwe University, Awka) and Prof. C. Ezenwaka, for their friendship and support during my period of training.

Special gratitude to all the Medical Laboratory Scientists in the Department of Chemical Pathology, University College Hospital, Ibadan, during my period of training, especially late Mr. Lukanmbi (then Chief Medical Laboratory Scientist) and Mr. Fajimi (Chief Medical Laboratory Scientist), who were very well- trained laboratory scientists of the old school and were of immeasurable technical assistance during the period my training.

I would also like to place on record immense gratitude to my colleagues (senior and junior) in the Department of Chemical Pathology, College of Health Sciences, University of Port Harcourt and the University of Port Harcourt Teaching Hospital, especially Professor Nsirim Nduka, the founding/pioneer staff of the department, whose encouragement and advice turned me from a potential Obstetrician and Gynaecologist to a Chemical Pathologist; Professor Victor Wakwe (a distinguished Chemical Pathologist and Past President of the National Postgraduate Medical College of Nigeria), Dr(Mrs). A. A. Ejilemele, Professor C. Orluwene, Dr(Mrs) E. P Odum (the current Head of Department), Dr. Nkoyo Ntuen, Dr. Otokunefor, Dr. Allison and Dr. Hamilton Opurum (current Head of the Department of Medical Biochemistry).

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To all my very close office staff, colleagues and friends, too numerous to name, especially Joseph, Philemon, Silas, Martins, Ngozi, Jama, Major and Goddy. Thank you for your friendship. You all made life easy and worthwhile. God bless you all.
To my spiritual family at the Faith Baptist Church, Port Harcourt, especially the Pastor-in-Charge, Rev. (Dr) Nkem Osuigwe, all the Associate Pastors, the Diaconate, the Baptist Men's Fellowship and indeed, all members of the church, for their encouragement, support and prayers, especially during the challenging period of my service as the Chief Medical Director of the University of Port Harcourt Teaching Hospital.

I owe all of you immense gratitude.
To all my numerous friends, colleagues, associates and relations, I remain eternally grateful for your support and continued friendship. God bless you all.

## ORDER OF PROCEEDINGS

2.45P.M. GUESTS ARE SEATED

3.00P.M. ACADEMIC PROCESSION BEGINS

The procession shall enter the Ebitimi Banigo Auditorium, University Park, and the Congregation shall stand as the procession enters the hall in the following order:

ACADEMIC OFFICER
PROFESSORS
DEANS OF FACULTIES/SCHOOLS
DEAN, SCHOOL OF GRADUATE STUDIES
PROVOST, COLLEGE OF HEALTH SCIENCES
LECTURER
REGISTRAR
DEPUTY VICE-CHANCELLOR [ACADEMIC]
DEPUTY VICE-CHANCELLOR [ADMINISTRATION]
VICE CHANCELLOR

After the Vice-Chancellor has ascended the dais, the congregation shall remain standing for the University of Port Harcourt Anthem. The congregation shall thereafter resume their seats.

THE VICE-CHANCELLOR'S OPENING REMARKS.

The Registrar shall rise, cap and invite the Vice-Chancellor to make the opening Remarks.

THE VICE-CHANCELLOR SHALL THEN RISE, CAP AND MAKE HIS OPENING REMARKS AND RESUME HIS SEAT.

## THE INAUGURAL LECTURE

The Registrar shall rise, cap, invite the Vice-Chancellor to make his opening remarks and introduce the Lecturer.
The Lecturer shall remain standing during the Introduction. The Lecturer shall step on the rostrum, cap and deliver his Inaugural Lecture. After the lectures, he shall step towards the Vice-Chancellor, cap and deliver a copy of the Inaugural Lecture to the Vice-Chancellor and resume his seat. The Vice-Chancellor shall present the document to the Registrar.

**CLOSING**
The Registrar shall rise, cap and invite the Vice-Chancellor to make his Closing Remarks.

THE VICE-CHANCELLOR'S CLOSING REMARKS.
The Vice-Chancellor shall then rise, cap and make his Closing Remarks. The Congregation shall rise for the University of Port Harcourt Anthem and remain standing as the Academic [Honour] Procession retreats in the following order:

VICE CHANCELLOR
DEPUTY VICE-CHANCELLOR [ADMINISTRATION]
DEPUTY VICE-CHANCELLOR [ACADEMIC]
REGISTRAR
LECTURER
PROVOST, COLLEGE OF HEALTH SCIENCES
DEAN, SCHOOL OF GRADUATE STUDIES
DEANS OF FACULTIES/SCHOOLS
PROFESSORS
ACADEMIC OFFICER

## PROTOCOLS

- The Vice-Chancellor
- Previous Vice-Chancellors
- Deputy Vice-Chancellors (Admin and Academic)
- Previous Deputy Vice-Chancellors
- Members of the Governing Council
- Principal Officers of the University
- Provost, College of Health Sciences
- Dean, Graduate School
- Deans of Faculties
- Heads of Departments
- Distinguished Professors
- Directors of Institutes and Units
- Visiting Academics and Colleagues
- Esteemed Administrative Staff
- Captains of Industries
- Cherished Friends and Guests
- Unique Students of UNIPORT
- Members of the Press
- Distinguished Ladies and Gentlemen.

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## PREAMBLE

Vice Chancellor, Sir, I consider it a great privilege and honour to stand here today to deliver this inaugural lecture, which has been rather late in coming (about ten (10) years), due to circumstances relating to an additional area of service to our fatherland and humanity as the Chief Medical Director of the University of Port Harcourt Teaching Hospital (2009 – 2017). For this period, I was on leave of absence from the university.

An Inaugural Lecture provides an opportunity for newly promoted or appointed Professors to inform colleagues in the university and the general public about what they are professing and their career achievements so far in teaching, research and service. This is thus a big privilege for me to let you know about the work I have been doing, especially in a relatively little known area like Chemical Pathology.

This is the 2nd inaugural lecture from the Department of Chemical Pathology of the College of Health Sciences of this unique university, after about 40 years of existence of the College. The 3rd inaugural lecture from the Department should be around the corner as my younger colleague, Prof. G. C. Orluwene, has already been elevated to this exalted position.

The 1st inaugural lecture was delivered by my senior colleague and pioneer medically qualified academic staff of the department, an erudite Chemical Pathologist and Past President of the National Postgraduate Medical College of Nigeria, Professor Victor C. Wakwe, in 2005. Co-incidentally, he meritoriously bowed out of formal service about two months ago, with a valedictory lecture that was given on April 23, 2019.

The topic of Professor Wakwe's inaugural lecture was "Do You Need A Check-up? Meet the Clinical Pathologist". I believe this topic was chosen deliberately in an attempt to introduce and explain the role of the specialty of Chemical

Pathology in medical practice, which members of the public still do not understand as readily as they understand more popular specialties like Surgery, Internal Medicine, Paediatrics, Obstetrics and Gynaecology and other more fascinating and more financially rewarding traditional specialties of medicine.The topic for today's inaugural lecture is:

**"Life as a Chemical Reaction: The Clinical Laboratory and the Battles for Life"**.

This topic has also been deliberately chosen in a further attempt to assist the non-medical public to have a better understanding of the great specialty of Chemical Pathology (which is what I profess) and the role played by Pathology, particularly Chemical Pathology and the clinical laboratory, in modern medicine and healthcare delivery.

## INTRODUCTION

The specialty of Chemical Pathology does not have a universal name, as it is called different names in different countries. While some call it Chemical Pathology, others call it Clinical Chemistry or Clinical Biochemistry or Medical Biochemistry, reflecting its dual nature as a basic and an applied science that cuts across the disciplines of biology, chemistry and medicine.

Due to its cross-cutting role and importance, even within the medical and health professions, it is usually challenging for many health professionals to understand and explain the exact role of Chemical Pathology and the Chemical Pathologist in the healthcare setting, as almost all groups of professionals in the health sector study and assume sufficient knowledge and expertise of the specialty and are usually hesitant and reluctant to make consultations and referrals to Chemical Pathologists and the Chemical Pathology department. The scenario is

usually that of a specialist field with everybody being the specialist!

## THE ROLE OF PATHOLOGY IN MODERN MEDICINE AND HEALTHCARE DELIVERY

**Medicine** is the science and practice of the diagnosis, treatment and prevention of disease. Disease is an enemy of health and an enemy of life. Disease, if untreated, usually leads to poor health and later to the cessation of life or death.
**Disease** broadly refers to any condition that impairs the normal functioning of the body and is associated with dysfunction of the body's normal **physiologic and homeostatic** processes.

**Medicine, as a foremost ancient profession, evolved naturally in an effort to fight disease and maintain and restore health,** hence the concept of a battle.

The Webster dictionary defines a ***battle as a combat between hostile armies or any fighting, conflict or struggle for a cause.*** In this context, we should please note that as valuable and as precious as life is, it is also very precarious and fragile and under constant threat by disease.

Vice Chancellor, Sir, this was the sole purpose for the establishment of our **College of Health Sciences**, which has become a foremost component and show piece of this university. The College exists principally to train professionals to battle **disease** and maintain and sustain **life** and **health**!

## WHAT IS PATHOLOGY

The word "**Pathology**" comes from the Greek root words '**pathos**', meaning 'suffering' or 'disease' and '**logia**', meaning 'study of' or 'a treatise of ', i.e. **a treatise of disease**. **Pathology** is thus the study of disease, which is the sole objective of medicine.

**Pathology** is a major medical specialty that investigates the **cause and nature of diseases** by examining and testing body tissues and body fluids. The results from these pathology tests help doctors to diagnose and treat patients correctly.
As a **diagnostic** specialty, **Pathology** can be considered the basis of modern scientific medicine. ***It is the science behind the cure!***

## DIVISIONS OF PATHOLOGY

There are four (4) major divisions of Pathology, namely:-

### (a) Anatomical Pathology

This is the branch of pathology that deals with the **tissue diagnosis** of disease. The Anatomical Pathologists examine not only samples of solid tissue, but also small specimens of separated cells (**cytology**). The specimens include fluids and tissue smears mainly for diagnosis and prevention of cancer. The Anatomical Pathologists also perform **post-mortem** examinations to establish the cause of death.

### (b) Haematology

This is the division of pathology that investigates and treats **diseases of the blood** (e.g. anaemia, leukaemia, lymphoma, clotting or bleeding disorders, etc) and management of blood transfusion services.

### (C) Medical Microbiology

This subspecialty of pathology deals with diseases caused by **infectious agents** such as bacteria, viruses, fungi and parasites. Microbiologists have roles both in the laboratory and directly in patient care.

### (d) Chemical Pathology

This is the subspecialty of pathology which deals with **biochemical changes** in the entire range of diseases,

encompassing the detection of changes in a wide range of biochemical substances in blood and body fluids (electrolytes, enzymes and proteins, etc) in association with many diseases. For example, Chemical Pathologists are involved in detecting and measuring tumor (cancer) markers, hormones, enzymes, antigens, antibodies, poisons, toxins, therapeutic and illicit drugs, etc, in body fluids that occur in various illnesses.

**IS PATHOLOGY A BASIC OR A CLINICAL SCIENCE?**

Globally, it is agreed that **Pathology is the scientific basis of modern medicine**. However, even the medical establishment is still not quite certain of the place and exact role of Pathology in the healthcare setting, as there is usually some confusion as to whether to classify it as a **Basic Science** or a **Clinical Science**.

In some universities, it is domiciled in the Faculty of Basic Medical Sciences, while in others, it is in the Faculty of Clinical Sciences. We, therefore, must appreciate the intervention of the Medical and Dental Council of Nigeria which has now insisted that all medical schools in Nigeria should establish faculties of **Basic Clinical Sciences** to warehouse Pathology and Pharmacology for purposes of accreditation. This is because **Pathology is both a basic science and applied clinical science.**

You can now appreciate that Pathology is **amphibious**, like the crocodile, not quite sure whether we belong to the land or the sea! **Pathology is thus a little bit to the left, and a little bit to the right,** apologies to the politicians.

**PUBLIC PERCEPTION OF PATHOLOGY**

Many members of the public have some limited understanding of the specialty of Pathology, which is generally but erroneously associated with **death** and **dead bodies** and **post-**

**mortem** examinations! In a survey in the United States of America, over two thirds of people interviewed thought that pathologists worked only with the **dead**, as depicted in some popular television programs like CSI (Crime Scene Investigation)!

Once you introduce yourself as a Pathologist, many members of the public develop a negative mental profile of who you are: a fellow that is not very friendly, not very sociable, queer, weird, etc. Even in developed countries, most people see Pathologists as people who chose the career because they did not like to see patients or indeed, did not like to see people at all, preferring to spend their time mostly in the company of corpses.

In 2009, the Royal College of Pathologists in the United Kingdom conducted a survey in which they asked people in schools and communities a range of questions about the field of Pathology. To them, Pathologists were considered 'creepy' and 'scary' and in 45% of responses, were related specifically to corpses, dead bodies or autopsies. Fortunately for us in Nigeria, the situation may not be as bad, though the negative stereo-type is still there.

Because of this negative profiling, Pathology has become a relatively unpopular residency choice for medical students, attracting only 1 – 3 percent of medical graduates in the United Kingdom, a situation resulting in a severe and longstanding shortage of personnel, to the point where it has even been referred to as a worldwide crises.

This is even worse in the developing world, including Nigeria, where relatively few medical graduates choose to specialize in Pathology. For example, since the formal inception of the Residency Training Program in Chemical Pathology at the University of Port Harcourt Teaching Hospital since 1990, only about twelve (12) candidates have successfully completed the program. Consequently,

Pathologists are still relatively few and scarce in the health sector.

As at 2014, Nigeria had only 182 Pathologists registered with the Medical and Dental Council of Nigeria, giving a ratio of one (1) Pathologist to about 990,000 citizens. Only one (1) state (Lagos) had up to 20 Pathologists; most states had less than 5, with six (6) states having none. Nigeria is much better than many sub-saharan African countries, where you can count the number of Pathologists on your finger tips.

## SPECIALISTS AND STATE OF PRACTICE (AS AT AUGUST, 2014)

| STATE OF RESIDENCE | PHYSICIANS | PEADIATRICS | SURGEONS | PATHOLOGISTS | OBSTETRICS/G | PUBLIC HEALTH | DENTISTS | TOTAL |
|---|---|---|---|---|---|---|---|---|
| ABIA | 3 | 9 | 12 | 4 | 8 | 4 | | 40 |
| ADAMAWA | | 5 | 2 | | 1 | | | 8 |
| AKWA IBOM | 5 | 19 | 6 | 3 | 5 | 10 | | 48 |
| ANAMBRA | 6 | 18 | 36 | 7 | 15 | 6 | | 88 |
| BAUCHI | 1 | 4 | 6 | 1 | 5 | 1 | | 18 |
| BAYELSA | 1 | 12 | 13 | 4 | 7 | 4 | 1 | 42 |
| BENUE | | 8 | 21 | 8 | 7 | | 2 | 46 |
| BORNO | 6 | 14 | 14 | 4 | 10 | 5 | 2 | 55 |
| CROSS RIVER | 11 | 13 | 18 | 2 | 7 | | 1 | 52 |
| DELTA | 8 | 21 | 33 | 6 | 16 | 3 | 4 | 91 |
| EBONYI | 6 | 13 | 17 | | 9 | 2 | | 47 |
| EDO | 9 | 33 | 58 | 8 | 25 | 8 | 9 | 150 |
| EKITI | 2 | 20 | 12 | 4 | 10 | 1 | 1 | 50 |
| ENUGU | 16 | 53 | 55 | 9 | 27 | 7 | 7 | 174 |
| GOMBE | 1 | 4 | 6 | 3 | 1 | | | 15 |
| IMO | 5 | 21 | 30 | 2 | 12 | 1 | | 71 |
| JIGAWA | | 2 | 2 | | 2 | | | 6 |
| KADUNA | 9 | 34 | 36 | 10 | 16 | 4 | 1 | 110 |
| KANO | 8 | 28 | 16 | 6 | 9 | 1 | 1 | 69 |
| KATSINA | 1 | 7 | 9 | | 3 | | 1 | 21 |
| KEBBI | | 3 | 9 | 1 | 2 | | 1 | 16 |
| KOGI | 2 | 8 | 12 | 2 | 6 | | | 30 |
| KWARA | 3 | 29 | 31 | 10 | 11 | 5 | 1 | 90 |
| LAGOS | 35 | 102 | 214 | 22 | 62 | 49 | 51 | 535 |
| NASARAWA | 7 | 13 | 8 | 1 | 2 | 3 | | 34 |
| NIGER | 5 | 7 | 9 | 2 | 3 | | 1 | 27 |
| OGUN | 4 | 18 | 21 | 2 | 16 | | 4 | 65 |
| ONDO | 1 | 11 | 26 | 1 | 8 | 3 | 1 | 51 |
| OSUN | 12 | 41 | 64 | 9 | 19 | 4 | 13 | 162 |
| OYO | 16 | 36 | 75 | 13 | 20 | 11 | 11 | 182 |
| PLATEAU | 15 | 19 | 39 | 7 | 13 | 4 | 1 | 98 |
| RIVERS | 23 | 40 | 69 | 11 | 29 | 7 | 7 | 186 |
| SOKOTO | 3 | 10 | 14 | 2 | 12 | 1 | | 42 |
| TARABA | | 1 | 2 | | 3 | 2 | | 8 |
| YOBE | | 1 | 4 | | | | | 5 |
| ZAMFARA | 1 | 5 | 8 | 2 | 2 | | | 18 |
| FCT | 21 | 76 | 82 | 5 | 41 | 14 | 9 | 248 |
| OTHERS | 2 | 11 | 20 | 1 | 4 | | 3 | 41 |
| NO STATE INDICATED | 3 | | 3 | 10 | 1 | | | 17 |
| TOTAL | 251 | 769 | 1112 | 182 | 449 | 160 | 133 | 3056 |

* Source- Medical and Dental Council of Nigeria

## WHO IS A PATHOLOGIST

A **Pathologist,** who is also called a **Laboratory Physician,** is a medical doctor that specializes in any branch of Pathology, after initial qualification as a medical doctor. This training usually requires a minimum of five (5) years and much longer for further sub-specialty training.

## WHAT DOES A PATHOLOGIST DO?

A **Pathologist** is a physician who studies body fluids and tissues in order to help your primary care doctor make a diagnosis about your health or any medical problems you have, and uses laboratory tests to monitor the health of patients with chronic conditions.

Typically, Pathologists are busy, behind the scenes, studying body fluids and tissues of patients and providing the information your doctor needs to make accurate diagnoses, monitor the progression of existing medical conditions and provide the best patient care possible.

Pathology plays a vital role across all facets and specialties of medicine throughout our lives, from the stage of conception to the post-mortem period. In fact, it has been said that **"pathology is medicine".**

*Unfortunately, many people still erroneously associate Pathologists with only dead bodies and post-mortem examinations! The truth is that Pathologists deal more and are busy in hospital laboratories helping to improve the health of living people!*

All the doctors that see patients in the clinics/hospitals depend on the knowledge, diagnostic skills and advice of pathologists. Whether it is a general practitioner requesting for a blood or urine test or a surgeon wanting to know the nature of a lump

removed at operation, the definitive answer is usually provided by a Pathologist.

By providing the correct diagnosis, the Pathologist also indirectly suggests the best line of treatment to the clinician for most illnesses. Hence, he also indirectly participates in the treatment of patients. Some Pathologists also see patients and are involved in day-to-day delivery of patient care, especially, **Clinical Pathologists**(Chemical Pathologists, Haematologists and Medical Microbiologists).

**It has been estimated that seventy per cent (70%) of all medical decisions rely on pathology**[1]**.**
***The Pathologist is thus said to be the doctor's doctor!***

## THE SPECIALTY OF CHEMICAL PATHOLOGY

When it comes to **Chemical Pathology**, many people are completely at sea as to what it is all about! If I should put the question to the audience as to what Chemical Pathology is, we may get as many different answers as there are faces here!

**Chemical Pathology** has been variously described as difficult, vague, volatile, evasive, abstract, theoretical, too academic, uninteresting, etc, by various groups of medical students and resident doctors. This is due to the very complex and broad nature of the subject. It is the broadest subspecialty in Pathology.

**Chemical Pathology deals with the changes in the biochemical entities associated with life and disease at the cellular and sub-cellular levels**.

These biochemical molecules cannot be visualized physically or even seen with the microscope. There are usually no specific physical signs and symptoms or palpable or visible abnormalities as seen in diseases of other specialties of

medicine like surgery, where you can see and palpate a tumor or enlarged organ.

The parameters we deal with in Chemical Pathology are usually sub-microscopic. I have personally never seen the sodium or potassium atom, neither have I visualized a glucose or urea molecule, though we measure them everyday! Everything is supposedly imaginary and abstract and exist in the 'minds' eye', but we have to measure them and report the results, thanks to science and technology! *Do you believe?*

Recently, the President of a major developed country was quoted to have said that the science behind **global warming was fake news!** Therefore, he declined to endorse some major international protocols to control global warming, despite the over-whelming evidence and devastating effects of global warming experienced all over the world! I hope some of us would not be similarly tempted or persuaded to write off Chemical Pathology as **fake news!**

Luckily, examples like the case of **Caster Semenya,** the female South African long-distance runner with testosterone levels higher than what is acceptable as normal for females, are practical proof of the importance and usefulness of Chemical Pathology!

The Chemical Pathologist usually works in liaison with clinicians, advising them about the appropriate tests for the investigation of particular clinical problems and the interpretation of the results of these tests.

The Chemical Pathologist is also involved in the evaluation of new technologies and the development of new tests. This applies particularly in new scientific areas such as the use of **genetic** and **molecular biology** techniques in diagnostic tests.

**Specialized areas of practice include inherited metabolic disorders/inborn errors of metabolism, trace metal disorders, environmental monitoring and toxicology, drugs of abuse, nutritional disorders, endocrine disorders and metabolic diseases.**

## WHY CHEMICAL PATHOLOGY AS A CAREER?

Mr. Vice Chancellor, Sir, let me confess at this point that Chemical Pathology was not my career option of first choice after graduation from medical school, as divine providence had dictated another career path for me, following the 'doctrine of natural selection'.

I was drawn into this specialty by 'some strange circumstances of disappointment' and divine intervention through a timely **revelation and appeal** by the foundation/pioneer academic staff of the Department of Chemical Pathology of this university, **Professor Nsirim Nduka**, as to the dearth of medically qualified manpower in the department, for purposes of accreditation in 1987. I owe a lot of gratitude to this distinguished but now retired Professor of Chemical Pathology.

This was despite the fact that I had already chosen to specialize in Obstetrics and Gynaecology and had taken and passed the Primary level examination of the National Postgraduate Medical College of Nigeria in Obstetrics and Gynaecology at the first attempt in 1985, having been honoured and awarded a prize as the best graduating student in Obstetrics and Gynaecology at the College of Medicine, University of Lagos, in 1983. Obstetrics and Gynaecology thus automatically became my career option of first choice!

As a young man who was focused on early commencement and completion of specialist training, though disappointed by the turn of events, I took up that challenge in 1988 in the spirit of patriotism. This was due to the fact that

the authorities of the of the University of Port Harcourt Teaching Hospital at that time considered me "**not qualified enough**" to be admitted into the Residency Training program of the hospital in the Department of Obstetrics and Gynaecology, despite the fact that I was the only candidate that had taken and passed the Primary level examination in Obstetrics and Gynaecology among those that were interviewed for recruitment into the program in 1986.

However, as our elders would say, **"every disappointment is a blessing in disguise"**. This change in career choice was a practical illustration of this 'wisdom' of the elders. **That was really our great God at work, using Professor Nsirim Nduka as the messenger!** To God alone be all the glory, as I have not had any reason to regret that decision till date.

**This is, however, a very sad commentary on our national value system, which sacrifices merit for other less noble considerations, even in professional and academic settings, where we should be setting good examples**. Unfortunately, this practice is still prevalent in all spheres of our national life till date and has inadvertently compromised our march to national development. **Our country, and our race, the negro race, is at the bottom of all global human developmental indices, due, in part, in my view, to such "genetically" perverted value systems.**

Vice Chancellor, Sir, there is an urgent need to change this narrative. The age-old Chinese saying states that "the best time to have planted a tree was yesterday; the next best time is now". It is my considered opinion that the University should function as the **'brain' or 'thinking faculty' of the society** and proffer solutions to various societal problems.

Our problems as a nation are many, encompassing all facets of the economy, including our divisive, rancorous, dangerous and combative politics, poor governance, poor power and water supply, poor and non-functional educational and health systems, poor quality roads, poor environmental sanitation, corruption, etc.

In my considered opinion, it is the University and the academia that should be at the forefront of efforts to provide solutions to these various problems.

I am of the considered opinion that our primordial **'genetic'** predisposition to favouritism, tribalism/ethnicity, nepotism, greed and corruption, etc, instead of meritocracy, transparency, patriotism, altruism and selfless service, is a significant contributory factor to the under-development of all black societies in all continents of the world, including our own dear country, Nigeria.

Why are we unable to do anything properly, except for the negative vices, where we excel internationally? The last general elections are a good example! **Blacks are usually at the bottom of all human developmental indices in all countries, in all continents of the world!** Why? Why? Why? **Is it genetic?** Are we really okay?

We may be failing in our responsibilities as universities and as academics and intellectuals if we feign ignorance and refuse to conduct appropriate research aimed at proffering appropriate workable solutions to these fundamental problems of the black race!

Mr. Vice Chancellor, Sir, my sincere apologies for this digression, which I consider as one of the fundamental problems of the black race, which has contributed in no small measure to our under-development in all spheres of life.

Let us now get back to the topic of this lecture – **"Life as a Chemical Reaction: The Clinical Laboratory and the Battles for Life".**

## WHAT IS A CHEMICAL REACTION?

A chemical reaction is simply defined as a process that leads to the chemical transformation of one set of chemical substances to another.

In this lecture, we would try to illustrate and demonstrate that "life" and "health" are nothing but a mere set of complex chemical reactions and that Pathology, especially Chemical Pathology, the Chemical Pathologist and the Clinical Laboratory play critical roles in the battles for, and in the sustenance of life and health.

## THE CONCEPTS OF LIFE AND HEALTH

**The medical profession** is one of the original three professions recognized by medieval and early modern tradition and civilization: divinity, medicine and law[2]. It is one of the original **"learned"** professions, although the lawyers have erroneously laid claim to being the only 'learned' profession.

We have been constantly reminded by **philosophers** and **sociologists** that **life and health are the most important possessions of man** and that without good health, man cannot enjoy any other earthly possessions. **Life is therefore highly valued and regarded as sacred by all human societies!**

**In fact, it has been further suggested that all human civilization and developmental efforts are finally geared towards the improvement and preservation of the life and health of the human race.**

Furthermore, the major fundamental objective and directive principles of state policy of the constitution of all countries all over the world include the *preservation, promotion and protection of the life and health(welfare) and property of their citizens.*

**In order to realize these noble considerations, the medical and health professions therefore evolved naturally for the promotion, preservation and protection of life and health.**
Healthcare was considered so important that in 2017, the United States of America was said to have spent an estimated $3.5 trillion on healthcare costs, giving a per capita expenditure of about $10,739 (or about 3,866,040 Naira). This accounted for about 17.9% of the Gross Domestic Product (GDP). From the foregoing, it is thus indisputable that issues of life and health are of paramount importance to man.

However, we are also evidently aware that life and health are constantly under threat by various diseases, right from the moment of conception, till disease and death finally win. This necessitates the huge expenditure on health.

**In order to protect life and health, the medical and health professions evolved, and are said to be in a constant state of fight against all factors that are inimical to life and good health, hence the concept of a battle and the usual classification of healthcare as an essential service.**
With this perceived level of importance, it is therefore pertinent to ask ourselves these two important questions: **What is life? What is health?**

For us to be promoting, preserving and protecting life and health, it is rational to assume that we know what they are. **We cannot be protecting and promoting what we do not know!**
However, I may not be too far from the truth to imagine that we would get as many different answers as there are faces in this auspicious audience, if I should ask these two questions.
*Even those of us in the health professions would find it difficult to define life or health. We have a situation where all of us know about life and health but would find it difficult to say exactly what they are!*

**WHAT IS LIFE?**

**Life** is a mystery and the **definition of life has remained controversial**. Throughout history, there have been many attempts to define "life" and many theories on the **properties** and **emergence** of life have been propounded. Some of these theories include:

***Materialism***, the belief that everything is made out of `matter and that life is merely a complex form of it;

***Hylomorphism***, the belief that all things are a combination of matter and form, and the form of a living thing is its soul;

***Spontaneous generation***, the belief that life repeatedly emerges from non-life;

***Vitalism***, a now largely discredited hypothesis that living organisms possess a 'life-force' or vital spark; and ***Spiritual/Supernatural Creation***, as recorded by the holy scriptures. The **Bible** records the creation of the earth and life in Genesis Chapter 1 through the **commandments of God**, starting with light (day) and darkness(night) on day 1, the firmament (heaven) and the waters on day 2, dry land and seas, grasses, herbs and plants on day 3, the sun, the moon and stars on day 4; the fishes and birds on day 5 and man on the 6$^{th}$ day.

This account of the **emergence of man and life** is without scientific foundation and proof and beyond human comprehension and scientific evaluation! It however appears to be the most probable and most plausible explanation for the origin of life as science has confirmed, and is still unraveling the **very complex and amazing organization of the many biochemical processes associated life.** No wonder the Psalmist says *"man was fearfully and wonderfully made"* (Psalm 139:14).

I am of the considered opinion that the very complex and integrated **metabolic** processes associated with life could only have been put in place by a **supernatural intelligence, the almighty GOD**, and not by accident, happenstance or chance occurrence.

**It has been a big challenge for scientists and philosophers to define life**. This is partly because life is a process, and not a substance[3]. Any acceptable definition must therefore be general enough to both encompass all known life and any unknown life that may be different from life on earth[4].

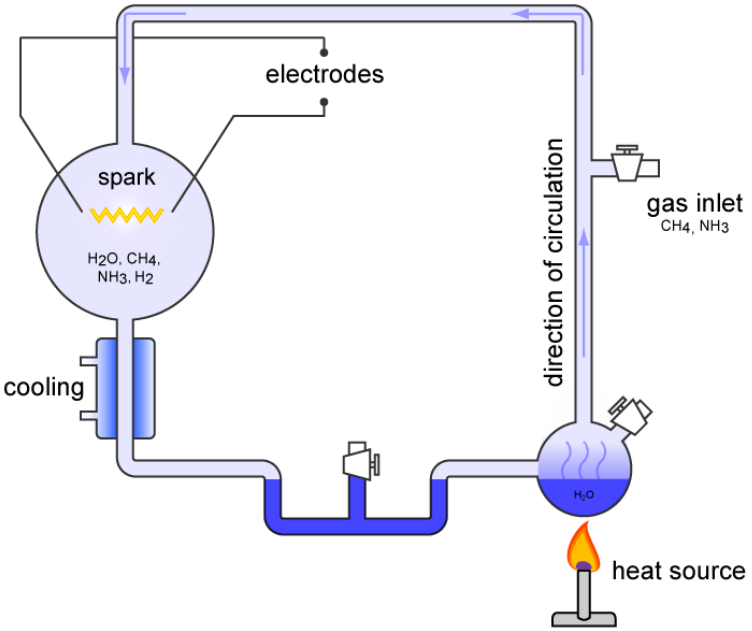
We may wish to note that the super powers and the developed world have been searching for evidence of extra-terrestrial life in outer space, using the science and technology of their space programs. Many unconfirmed reports of the sighting of **unidentified flying objects (UFOs), mystery aliens and space ships** in different parts of the world abound. Though this may sound like science fiction, but could these be examples of other kinds of intelligent life?

**The Origins of Life**

Life on earth is estimated to have first appeared as early as 4.28 billion years ago, soon after formation of the ocean about 4.41 billion years ago, and not long after the formation of the earth about 4.54 billion years ago[5]. Does this correspond to the sequence of the creation story in the Bible? It is postulated that the current life on the earth may have descended from an RNA world, although RNA-based life may not have been the first.

Scientifically, the origin and mechanism by which life began on earth is unknown, though many hypotheses have been formulated and are often based on the Miller-Urey experiment (1952)[6], which was based on the hypothesis that putative conditions on the primitive earth favoured chemical reactions that synthesized more complex organic compounds,

such as amino acids, from simpler inorganic precursors such as water ($H_2O$), methane ($CH_4$), Ammonia ($NH_3$) and Hydrogen ($H_2$).




## THE MILLER-UREY EXPERIMENT

The earliest known life forms are microfossils of bacteria. Some Australian rocks that are about 3.45 billion years old are reported to have contained micro-organisms[7]. In 2016, scientists reported identifying a set of 355 genes thought to be present in the last universal common ancestor (LUCA) of all living organisms (the most recent common ancestor of all current life on earth), already a complex organism and not the first living thing[8].

**Various forms of life exist**, such as plants, animals, fungi, bacteria, etc. The criteria for definition of life can at times be ambiguous and may or may not define viruses or viriods as

living things, as they mandatorily require other living cells for replication.

**Biology** is the primary science concerned with the study of life, although many other sciences have become involved. Since there is no unequivocal definition of life, most current definitions in biology are descriptive.

## DEFINITION OF LIFE

The Webster's dictionary defines life as "that state in which animals and plants exist which distinguishes them from inorganic substances and from dead organisms: characterized by metabolism and growth and reproduction". It further defines life as "that vital existence, the loss of which means death".

**Wikipedia defines life** as a characteristic that distinguishes physical entities that have **biological processes**, such as signaling and self-sustaining processes, from those that do not, either because such functions have ceased, or because they never had such functions and are classified as inanimate. **Life** is considered to be a characteristic of something that preserves, furthers or reinforces its existence in the given environment.
This definition refers to **living organisms** as those that have the **capacity to maintain homeostasis**, are composed of cells, undergo metabolism, can grow, adapt to their environment, respond to stimuli and reproduce.
This characteristic exhibits all or most of the following traits[9,10]:

(a) **Homeostasis** – regulation of the internal environment to maintain a constant biochemical state; e.g. sweating to reduce temperature;

(b) **Organization** – being structurally composed of one or more cells (the basic unit of life) that are further organized into tissues and organs;

(c) **Metabolism** – transformation of energy by converting chemicals and energy (chemical reactions) into cellular components (**anabolism**) and decomposing organic matter (**catabolism**);

(d) **Growth** – maintenance of a higher rate of anabolism than catabolism. A growing organism increases in size proportionately in all its parts, rather than simply accumulating matter haphazardly.

(e) **Adaptation** – the ability to change structure and function over time in response to the environment. This ability is fundamental to the process of **evolution** and is determined by the organism's heredity, diet and other external factors.

(f) **Response to External Stimuli** – a response can take many forms, from the contraction of a unicellular organism to external chemicals, to complex reactions involving all the senses of multi-cellular organisms. A response is often expressed by motion, for example, the leaves of a plant turning towards the sun (phototropism) and chemotaxis.

(g) **Reproduction** – the ability to produce new individual organisms, either asexually from a single parent organism or sexually from two parent organisms.

**ENERGY FOR LIFE**

We may wish to note that all the basic characteristics and attributes that describe and define life are **energy dependent**. This energy is generated in a suitable form solely as **high**

**energy phosphate bonds (e.g. ATP**) that are produced by **biochemical reactions** that are coupled to the reactions that drive the fundamental processes of life. **ATP is the energy currency of life!**

All living things can therefore be considered as **biochemical energy systems or power plants** (compare with a Generator)**.** The process is self-sustaining, as long as there is a constant supply of **fuel**, in the form of food, and the homeostatic mechanisms are maintained (compare this to a nuclear reactor!). Therefore, *life has also been defined as a self-sustaining chemical system*[11].

**May I, therefore, ask at this point: *Is life is a chemical reaction or a series of complex chemical reactions?***

**WHAT IS METABOLISM?**

A property common to all forms of life include the need for certain core biochemical entities to sustain some fundamental biochemical functions and reactions (**metabolic processes)**. These complex processes, also called **physiological functions**, have underlying physical and biochemical basis, as well as signaling and control mechanisms (**intermediary metabolism**) that are essential to maintaining life.

**Metabolism refers to the sum of all chemical reactions that occur in living organisms**. It is the set of life-sustaining chemical transformations within the cells of organisms.

The main purposes of metabolism are:-

(a) Conversion of food/fuel to energy to run cellular processes.
(b) Conversion of food/fuel to building blocks for proteins, lipids, nucleic acids and some carbohydrates.
(c) Elimination of nitrogenous wastes.
(d) Maintenance of homeostasis.

**Metabolic reactions** are **enzyme-catalyzed** reactions that allow organisms to grow and reproduce, maintain their structures and respond to their environment. They are divided into two (2) main categories:-

(i) **Catabolism** – the breaking down of organic matter, e.g. glucose to pyruvate by cellular respiration, to produce energy, usually in the form of ATP, to drive other metabolic processes.

(ii) **Anabolism** – the building up of components of cells such as proteins and nucleic acids.

## METABOLIC PATHWAYS

The complex chemical reactions of metabolism are organized into **metabolic pathways** in which one chemical is transformed through a series of steps into another chemical, by a sequence of enzymes.

**Enzymes** are crucial to metabolism because they allow organisms to drive desirable reactions that require energy and that will not occur spontaneously by themselves, by coupling them to spontaneous reactions that generate and release energy.

The enzymes act as **catalysts** that allow the reactions to proceed more rapidly. Enzymes also allow the **regulation** of metabolic pathways in response to changes in the cell's environment or to signals from other cells through secondary regulatory mechanisms that influence the availability and concentration of the enzymes at the reaction sites.

## UNIVERSALITY OF METABOLISM

**A striking feature of all life is the similarity of the basic metabolic pathways and components between even vastly different species of living organisms**[12].

For example, the set of carboxylic acids that are best known as intermediates in the **citric acid cycle** are present in all known living organisms, being found in species as diverse as the unicellular bacterium, E. Coli and large multi-cellular organisms like man and elephants[13].

## THE CITRIC ACID CYCLE

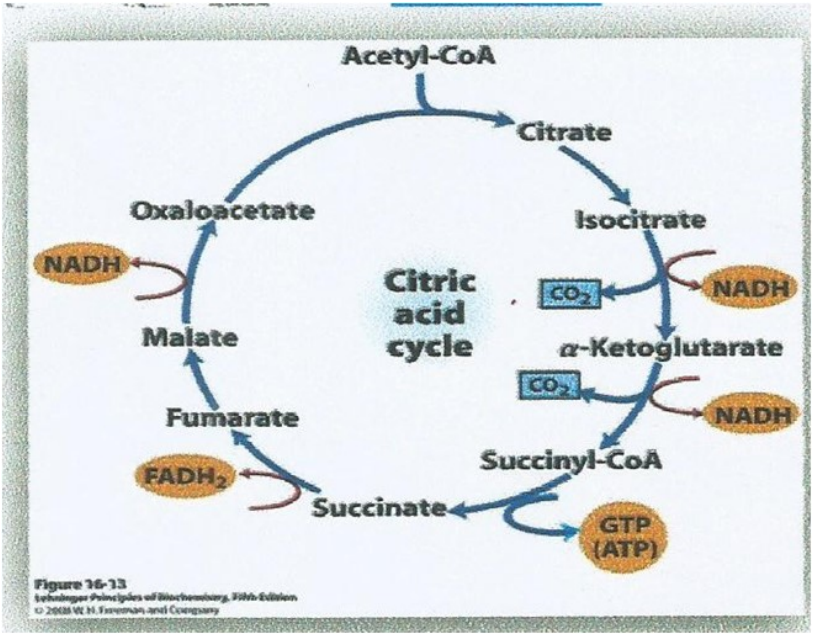



Figure 16-13

These striking similarities in metabolic pathways are likely due to their early appearance in evolutionary history, and their retention because of their efficacy or due to supernatural design[14,15].

It may therefore be pertinent at this point in time to ask the question: **Is the presence of these metabolic intermediates and pathway in living cells and organisms a *sine qua non* for life?**
***Is life, therefore, really a series of chemical reactions?***

## THE CONCEPT OF HOMEOSTASIS

The concept of the regulation of the internal environment was described by the French physiologist, Claude Bernard, in 1865, and the word, homeostasis, was coined by Walter Bradford Cannon in 1926[16, 17.] Homeostasis is an almost exclusively biological term referring to the concepts described by Bernard and Cannon, concerning the **constancy of the internal environment in which the cells of the body live and survive**. Homeostasis is one of the fundamental attributes of life.

**Homeostasis can be defined as the stable state of an organism and of its internal environment**. It refers to the maintenance or regulation of the stable condition or its equilibrium. The stable condition is the **condition of optimal functioning** for the organism, and is dependent on many variables, such as **body temperature**, and **fluid balance**, being kept within certain pre-set limits.

Other variables include the **pH** (concentration of Hydrogen ions) of extracellular fluid, the concentrations of sodium, potassium and calcium ions (salt), as well as that of blood sugar, etc, and these constituents need to be regulated, despite changes in the external environment, diet or level of activity. Each of these variables is controlled by one or more

regulators or homeostatic mechanisms, which together maintain life.

**Homeostasis is brought about by a natural resistance to change in optimal conditions and equilibrium is maintained by many regulatory mechanisms[18,19].**
All homeostatic control mechanisms function as **thermostats** and have at least three (3) interdependent components for the variable being regulated:-
(a) A receptor (or detector)
(b) A control centre (or integrator/processor)
(c) An effector

**The receptor** is the sensing component that monitors and responds to changes in the environment, either external or internal, e.g. thermo-receptors and mechanoreceptors.

**Control centres** are like processors (CPUs) or brain-boxes and include the respiratory centre, the renin-angiotensin system, etc.

**An effector** is the target acted on, to bring about the change back to the normal state.

When the receptor senses its stimulus, it reacts by sending an action potential to a control centre. The control centre sets the maintenance range, the acceptable upper and lower limits for the particular variable, such as temperature.

The control centre responds to the signal by determining an appropriate response and sending signals to an effector, which can be one or more muscles, an organ or gland. When the signal is received and acted on, negative feedback to the receptor stops the need for further signaling.

Homeostasis thus refers to the maintenance of a stable internal environment in a state of equilibrium. *When homeostasis and equilibrium are maintained, the result is optimal function or good health of the organism.*

**In fact, good health has been defined as a measure of the efficiency of metabolism and homeostasis.**

**In many life-threatening illnesses, the disease causes derangement of homeostasis and treatment is ultimately aimed at restoring homeostasis, either through medications or by surgical intervention. If these efforts fail, the vital metabolic processes would fail and lead ultimately to death.** The concept of homeostasis is of cardinal importance in clinical laboratory practice. It is only when homeostasis and equilibrium are maintained, with the body in optimal health, can reference values for various laboratory tests be established. These reference intervals or 'normal' values depict the concentrations of the various biochemical parameters in optimal health.

Laboratory tests can only be interpreted by comparison with these 'normal' values. During illness, homeostasis is usually deranged and the values of different biochemical parameters become equally deranged. With successful treatment, homeostasis is re-established and the values return to 'normal'. Failure to return to normal signifies that treatment is yet to be successful.

## WHAT IS HEALTH?

The definition of health has evolved over time and remains **controversial**, as there is no generally accepted universal definition of health.

In keeping with the early **biomedical perspective** of health in relation to the **absence of disease**, early definitions

focused on the theme of **the body's ability to function**. Health was seen as a **state of normal function** that could be disrupted from time to time by disease.

**Accordingly, health had been defined as a state characterized by anatomic, physiologic and psychological integrity; ability to perform personally valued family, work and community roles; ability to deal with physical, biological, psychological and social stress**[20]**.**

In consonance with this perspective, **health has also been defined as the level of functional and metabolic efficiency of living organisms**.

However, in 1948, the World Health Organization (WHO) defined health in a broader sense in its constitution, linking health to well-being**. It defined health as a state of complete physical, mental and social well-being, and not merely the absence of disease or infirmity**[21]**.**

Although this definition was welcomed as being innovative, it has also been subject to controversy, and criticized as being vague, excessively broad and not measurable and because of the problem created by use of the word "complete", which makes it practically impossible to achieve.

For a long time, this definition was set aside as an impractical ideal, and most discussions on health returned to the practicality of the biomedical model.

However, in 1984, WHO further revised the definition of health as **"the extent to which an individual or group is able to realize aspirations and satisfy needs and to change or cope with the environment".**

**It further defined health as a resource for everyday life, not the objective of living**; **it is a positive concept,**

**emphasizing social and personal resources, as well as physical capacities[22].**

Therefore, **physical health** referred to the ability to maintain homeostasis and recover from insults of disease and infirmities. In addition to physical health, we also have **mental health, intellectual health, emotional health and social health** to contend with.

*These refer to a person's ability to handle stress, to acquire skills and maintain relationships, all of which form resources for resiliency and independent living*.

This is in keeping with the change in the concept of health as a process rather than a state. Without good physical health, all other forms of health would be embarrassed.

**METABOLISM AS LIFE**

Vice Chancellor, Sir, permit me to remind us once more of the title of this inaugural lecture: **"Life as a Chemical Reaction: The Clinical Laboratory and the Battles for Life"**. In the course of this discussion so far, we have examined the concepts of Life and Health.

A close scrutiny would reveal that the fundamental characteristic or property of life is **metabolism**. It is metabolism is that provides the energy to drive all other processes that characterize life. It is present in living things and absent in non-living things. Hence **metabolism is a sine-qua-non for life.**

It is the energy produced by metabolism that is used to maintain the internal biochemical environment or **homeostasis** of the cell, which is a basic requirement for the **enzymes** of all the vital biochemical metabolic pathways to function optimally.

When there is loss of equilibrium and homeostasis, the resultant effect is inefficient metabolism and ill-health. If this persists and gets to some critical levels, all metabolic processes become embarrassed and eventually cease, leading to cessation of life, otherwise called **death.**

Vice Chancellor, Sir, **could we then at this stage reasonably conclude that life and good health are synonymous with efficient metabolism and good homeostatic control?** Are these chemical reactions?

**WHAT IS DEATH?-**

Vice Chancellor, Sir, we cannot talk about life without talking about the twin brother or the other side of the coin, **death.**

Death, dying and the after-life are all shrouded in deep mystery, cloaked in darkness and generally surrounded by fear and apprehension. The very idea of death strikes fear into many people's hearts. Who wants to die? Who wants to go to heaven?

**Death is defined as the permanent end of the life of a biological organism. It is the cessation of all biological functions that sustain a living organism**[23]**.**

Death threatens all living organisms right from conception. The medical and health professions thus evolved and are engaged in a constant battle to confront this threat and preserve life.

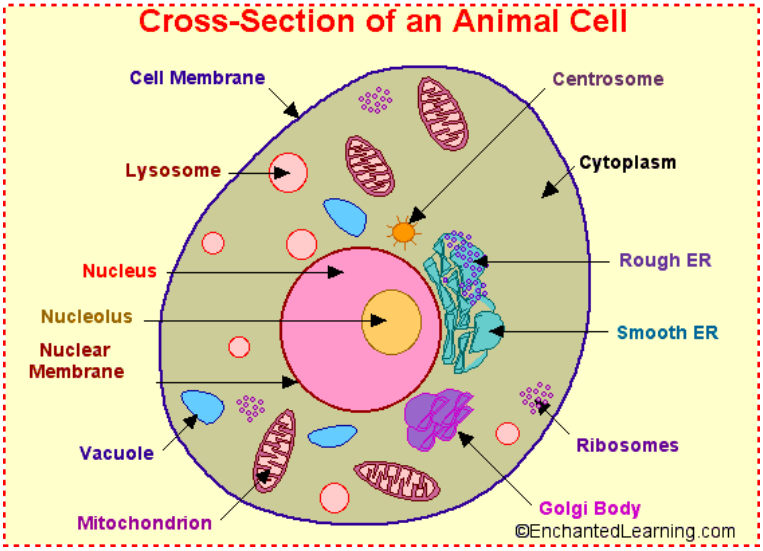
**HOW DOES DEATH OCCUR?**

The cell is the basic unit of life. Death occurs due to **irreversible injury to the cells** of the body from various causes. Death is caused by any activity or agent that **disrupts metabolism** in the cells. These conditions eventually cause loss of homeostasis, leading to cardiac arrest, causing loss of oxygen and nutrient supply and irreversible deterioration of the

metabolism of the brain and other organs and tissues due to unavailability of biochemical energy (ATP).

## MECHANISM OF CELL INJURY

Regardless of the type of insult, injury to a cell occurs through a limited set of basic biochemical processes. Many of these biochemical processes are inter-connected and the precipitation of one pathway can lead to the initiation of others. These processes include;-




(a) Plasma membrane damage
(b) Mitochondrial damage
(c) Cytosolic calcium derangement
(d) ATP depletion
(e) Nucleic acid damage

## CAUSES OF CELL INJURY

Although disease processes are multifarious, the basic categories of insult which precipitate cell injury and death include the following;-

(i) Metabolic cell injury
- insults due to hypoxia and ischaemia

(ii) Chemical cell injury
- insults due to endogenous and exogenous chemical toxicity

(iii) Free radical injury
- insults due to free radicals (oxygen atoms with unpaired electrons) generated by reactive oxygen species

(iv) Immune cell injury
- insults due to immune system dysfunction

(v Infectious cell injury
- microbial insult can occur via direct release of cellular toxins or intracellular infection/damage.

(vi) Genetic cell injury
- insults due to gene defects (hereditary or acquired) in the production of key cellular proteins and enzymes

(vii) Physical cell injury
- insults due to trauma

## CONSEQUENCES OF CELL INJURY

Cells can survive and recover from mild disturbances in their biochemical processes and when this occurs, the cell injury is considered **reversible.**

However, intense derangements in any of these biochemical processes often precipitates an **irreversible** sequence of events which ultimately ends in cell death. Given the inter-connectedness of cellular biochemical processes **(intermediary metabolism)**, severe dysfunction in any one

basic process will inevitably cause dysfunction and derangement of the others, leading to cell death.
All medical treatments are thus aimed at eliminating the causes of cell injury before they become irreversible!

## BIOCHEMICAL CHANGES IN CELLULAR INJURY

**Energy (ATP) depletion** is a common biological alteration that occurs with cellular injury. This change can occur whatever the initiating agent of the cell damage. A reduction in intracellular ATP can have a number of functional and morphologic consequences during cell injury. These effects include:-
(a) failure of the ATP dependent pumps (Na+/K+ pump and Ca++ pump), resulting in the net influx of Na+ and Ca++ ions and osmotic swelling.

(b) ATP depleted cells begin to undertake anaerobic metabolism to derive energy from glycogen (glycogenolysis).

(c) a consequent decrease in intracellular pH of the cell arises, which mediates harmful biochemical processes, including disruption of the activity of many enzymes of several metabolic pathways.

(d) early clumping of nuclear chromatin then occurs, known as **pyknosis**, and leads to eventual death.

Vice Chancellor, Sir, please permit me to summarize this lengthy and rather 'boring technical monologue' by saying that whatever the mechanism of cellular injury, the end result is a disturbance of metabolism and substantial alteration of the internal environment of the cell (**loss of homeostasis**), which eventually leads to cellular **death, multiple organ failure and loss of life**.

**This is how simple and how complex and how precarious life can be!**

May I, therefore, state categorically again at this point that "**Life is nothing but a series of self-sustaining Chemical Reactions**". No more, no less! Whenever these reactions stop, life is gone!

## THE MOMENT OF DEATH

One of the challenges of defining death is in distinguishing it from life. As a point in time, death would seem to refer to the moment at which life ends. Determining when death has occurred is difficult, as cessation of life functions is often not simultaneous across all organ systems[24].

Such determination therefore requires drawing precise conceptual boundaries between life and death. This is difficult due to there being little consensus on how to define life. This general problem applies to the particular challenge of defining death in the context of medicine.

Historically, attempts to define the exact moment of a person's death have been subjective or imprecise. Death was once defined as the cessation of heart beat (cardiac arrest) and of breathing, but the development of cardio-pulmonary resuscitation (CPR) and prompt defribrillation have rendered that definition inadequate because breathing and heart beat can sometimes be re-started artificially.

Events which were causally linked to death in the past no longer kill in all circumstances: without a functioning heart or lungs, life can sometimes be sustained with a combination of life support devices, organ transplants and artificial pacemakers.

Today, where a definition of the moment of death is required, doctors and coroners usually turn to the concepts of "**brain death**" or "**biological death**" to define a person as being dead.

By definition, a person is considered dead when the **electrical activity** in his or her brain ceases. It is presumed, but not that an end of electrical activity indicates the end of consciousness. This is **brain death**.

However, the suspension of consciousness must be permanent and not transient, as occurs during certain sleep stages, and especially in coma. In the case of sleep, electro-encephalography (EEG) can easily tell the difference.

The use of **brain death** as a definition of death has also become problematic. The equation of brain death with death has been challenged by scholars, based on evidence regarding the array of biological functioning displayed by patients correctly diagnosed as brain dead, who were maintained on mechanical ventilation for substantial periods of time (e.g. a former Israeli Prime Minister, Ariel Sharon, who had a massive stroke with unconsciousness on 4/1/2006 but was only declared dead on 11/1/2014).

These patients maintained the ability to sustain circulation and respiration, control temperature, excrete wastes, heal wounds, fight infections, and most dramatically, to gestate fetuses (in case of pregnant "brain dead" women)[25]. The case of a comatose lady on prolonged life support who was raped and impregnated by a nurse in Phoenix, Arizona, United States in 2018, is a good example.

However, at present in most developed countries, the more conservative definition of death as "**the irreversible cessation of electrical activity in the whole brain**" has been adopted as a working legal definition, e.g. the Uniform determination of Death Act in the United State of America. This is **legal death**!

Even by this criterion, the determination of brain death can be complicated, as EEGs can still detect spurious electrical impulses in some of these patients, while certain drugs,

hypoglycaemia, hypoxia or hypothermia can suppress or even stop brain activity on a temporary basis.

Because of these circumstances, hospitals have developed different protocols for determination of brain death, involving the use of EEGs at widely separated intervals under defined conditions.

For our environment, considering our stage of scientific and technological development and lack of EEG machines in most clinics and hospitals, **death is usually diagnosed clinically when a physician confirms that there is no pulse, no heart beat, and no respiration, with fixed, dilated and non-reactive pupils.**

These rather simple clinical criteria may lead to occasional **misdiagnosis of death**. In the past, there have been unconfirmed reports of people being declared dead and later "coming back to life", sometimes several days later, in their own coffins or in the mortuary. Such stories have often been laced with **superstitious spiritualism**, which I may not be professionally competent to comment on.

**There is therefore the need for caution before certification of death by physicians in our environment.**

## WHO ARE THE ENEMIES IN THE BATTLES FOR LIFE?

The common causes of death (the enemies) are generally classified as **communicable** (disease from infectious agents such as bacteria, viruses, fungi, parasites, etc) or **non-communicable** (metabolic diseases, cardiovascular diseases, cancers, trauma, accidents, malnutrition, aging, homicide, etc).

From all causes, nearly 150,000 people die each day around the world or about 55 - 60 million people each year[26]. Of these, two thirds (2/3) or about 70% are estimated to die directly or indirectly due to old age (senescence) and diseases associated

with old age. Globally, however, **atherosclerosis** (ischaemic heart disease and stroke) and **cancer** are the two leading direct causes of death.

The leading causes of death in the **developed industrialized countries** are **non-communicable diseases**, such as **atherosclerosis** (heart disease/heart attack and stroke), **cancer** and other diseases related to **obesity** and **aging**. The developed world has virtually conquered the communicable diseases, which now constitute a rare cause of death in their population.

By an extremely wide margin, the largest unifying cause of death in the developed world is **biological aging**[26], leading to various complications known as aging-associated diseases, and accounting for about 90% of all the deaths.

In contrast, in **developing nations**, such as Nigeria, the leading cause of human death is **communicable (infectious) disease**. This is due to the presence of inferior sanitary conditions and poor housing, with lack of access to modern medical technology and healthcare facilities and generally very low human development index (HDI) scores.

**Tuberculosis** is one of such diseases, which is estimated to have killed 1.8 million people in 2015[27]. **Malaria** causes about 400 – 900 million cases of fever and 1 – 3 million deaths annually[28]. **AIDS** death toll in Africa is estimated to reach 90 – 100 million by 2025[29]. Others include **respiratory tract infections** (e.g. pneumonia) and **diarrhoeal diseases**, especially in children.

According the United Nations, mortality due to **malnutrition** accounted for 58% of the total mortality rate globally in 2006[30]. The same report stated that worldwide, approximately 62 million people died from all causes and of those deaths, more than 36 million died of hunger or diseases due to deficiencies in micronutrients, the vast majority occurring in developing countries.

**Tobacco smoking** is another indirect major cause of death globally. It has been estimated that tobacco smoking killed about 100 million people worldwide in the 20th century and could kill 1 billion people around the world in the 21st century, according to the World Health Organization[31].

It is to be noted, however, that an increasing proportion of deaths in developing countries due to non-communicable diseases is beginning to emerge due to increased acculturation and westernization. These include diseases such as **diabetes mellitus, cancers, hypertension, heart attack and stroke.**

In the high and middle income (developed) countries, life expectancy is high, and about two thirds (67%) of all citizens live beyond the age of 70 years and predominantly die of chronic, non-communicable diseases, while in low income (developing) countries, life expectancy is relatively lower and less than one (1) in five (5) or 20% of citizens reach the age of 70. More than a third (1/3rd) (33%) of all deaths occur among children under 15 years of age, predominantly due to infectious diseases, in contrast to what obtains in developed countries[32].

Many of the leading non-communicable causes of death in the developed world can be postponed by diet and physical activity, but the accelerating incidence of disease with age still imposes limits on human longevity.

**The evolutionary cause of aging** is, at best, just beginning to be understood. Some organisms have been noted to experience negligible aging or senescence, even exhibiting biological immortality. These include the jellyfish (*Turritopsis dohrnii*), the hydra, and the planarian[33]. It has been suggested that direct intervention in the aging process may now be the most effective intervention against major non-communicable causes of death in the developed world.

Currently, research on the control of the length of the **telomeres** in our **genes** is showing promises of a break-through on aging, with the prospects of conquering the aging process and prolonging life much longer and may be indefinitely! Is this science fiction?!

Many scholars, including Selye[34], have proposed a unified, non-specific approach to many causes of death. He demonstrated that **stress** decreases **adaptability** of an organism and proposed to describe adaptability as a special resource, **adaptation energy**. The animal dies when this resource is exhausted. Selye assumed that the adaptability is in a finite supply, presented at birth.

Later on, Goldstone[35] proposed the concept of a production or **income of adaptation energy**, which may be stored (up to a limit) as a **capital reserve of adaptation**. It has been demonstrated that oscillations of well-being or ill-health appear when the reserve of adaptability is almost exhausted[36].

## THE ROLE OF THE CHEMICAL PATHOLOGIST IN THE BATTLES FOR LIFE

All organs of the body work in concert to maintain metabolism and the internal environment (homeostasis). There is a natural division of labour among all the organs, with each organ specializing in an essential area of competence! As long as the organs are able to perform their normal functions, life is sustained in good health.

Diseases cause ill-health by disrupting the metabolism and normal function of one or more organs of the body. When this occurs, the constancy of the internal environment (**homeostasis**) is disrupted.

Fundamentally, treatment of all life-threatening illnesses by doctors in all specialties of medicine is mostly finally targeted at restoring metabolism and the internal

environment (homeostasis) through the restoration of function in one or more of these organs.

**The Chemical Pathologist is the specialist Physician principally responsible for monitoring the state of metabolism and the internal environment (homeostatic status) of the patient.**

He does this through the measurement of several parameters of metabolism in the body fluids and tissues of the patient in the clinical laboratory, according to the specific organs affected by the disease. Through these tests, he guides the clinician as to whether his treatment is being effective or not.

In this central capacity, the Chemical Pathologist works with all medical practitioners (in all specialties) and all health professionals to manage almost all patients, irrespective of the disease they present with.

Consequently, therefore, the Chemical Pathologist is **indispensable** to medical practice, as all patients with serious illnesses that present in hospitals will ultimately need biochemical information from the Chemical Pathology laboratory in order to obtain standard holistic and evidence-based care from his healthcare provider.

**Without a Chemical Pathologist and his chemical pathology report, it would be akin to sailing in the ocean without a navigator or flying an aircraft without a compass!** The destination would definitely be missed! Therefore, Chemical Pathologists, like all other Pathologists, have been described as the **'doctor of doctors'**.

All patients in a hospital are usually registered under a Consultant who takes responsibility for the care of that patient. While the Chemical Pathologist invariably attends to most of these patients indirectly, only very few are usually registered directly under him. He is like a **"general service"** specialist,

attending to most patients, but does not own many**.** Apologies to the politicians again, **"we are for every patient but not for any patient".** This is one of the reasons the specialty may not be very appealing or popular!

Vice Chancellor, Sir. Let me use the analogy of the human body as a very complex machine, with its own self-sustaining energy system, such as a modern car, to further illustrate the role of the Chemical Pathologist in the battles for life. In fact, the human being is reputed to be the most complex, most advanced and most efficient machine ever designed and built.

**Till date, despite various attempts, no Engineer has been able to design any machine or robot that is as efficient and functional as the human being.** He was *"fearfully and wonderfully made"*. All glory, adoration and majesty be ascribed to the greatest **Design Engineer** and the author and manufacturer of man, our **God Almighty**, for the wonders of man! **Anyone who thinks that this ingenuous design was an accident of nature has several questions to answer!**

For this **human machine**, it takes several "specialist engineers and technicians", as health professionals, to maintain and keep it functional. The hospital is the workshop for the repair of the human machine.

You may liken the Physicians and Paediatricians as the mechanics; the General and Orthopaedic surgeons as the panel beaters (apologies to my esteemed colleagues); the Neurologists and Neuro-surgeons as auto-electricians and brain-box specialists; the Dermatologists as the body-shop and spray painters; the Ophthalmologists as the head lamp specialists; and the Cardiologists as the engine/fuel pump specialists!

The Chemical Pathologist can be likened to the **Diagnostic or Quality Control Engineer** who does the initial diagnostic test to detect the problems of the car and the final inspection after repairs to confirm that all the problems that brought the car to the workshop have been resolved before the car leaves the workshop. He gives the final **discharge certificate and the certificate of road worthiness** through his biochemical laboratory tests! *(Is he the VIO as well?)*

As in a car, once the engine that produces the energy that propels the car is defective, the car is dead! Same applies to the human machine. Once the mechanism that produces energy in the cells through intermediary metabolism is deranged, the human being would be dead if urgent intervention is not undertaken!

All life-threatening diseases interfere with **intermediary metabolism** and threaten life. All treatments are therefore geared towards terminating this interference in order to restore **homeostasis**.

**Monitoring the status of intermediary metabolism and homeostasis through laboratory tests is the only objective evidence to prove the effectiveness of any treatment. This is the cardinal duty of the Chemical Pathologist.**

## WHAT IS A CLINICAL LABORATORY

A laboratory, by definition, is a special room or building used for scientific investigation.

A Clinical or Medical Laboratory is thus a laboratory where tests are carried out on clinical specimens to obtain information about the health of a patient to aid the diagnosis, treatment and prevention of disease.

The clinical laboratory is an example of an **applied science laboratory**, as opposed to research laboratories that focus on basic science, such as found in academic institutions.

The clinical laboratory is the **workshop** of Pathologists and other categories of laboratory professionals.

Clinical laboratories provide information and services that contribute to optimizing the effective delivery of care in today's complex healthcare system by assuring that the correct test is performed on the right person, at the right time, producing accurate test results that enable healthcare providers to make the right diagnostic and therapeutic decisions, using the right level of healthcare resources.

The clinical laboratory is the vehicle for most of the applied science used in modern healthcare delivery. Without clinical laboratories, treatment of diseases by medical doctors would become **guess work**, as practiced by **native doctors!**

Medical laboratories vary in size and complexity and so offer a variety of services, depending on the need of the institutions they serve. More comprehensive services can be found in tertiary and specialist hospitals, as compared to general hospitals and health centres, where the laboratories offer fewer basic services.

## STAFFING OF CLINICAL LABORATORIES

The staff of clinical laboratories may include some or all of the following, depending on the size and nature of the laboratory:-

- Pathologists
- Clinical Biochemists
- Pathologist Assistants
- Biomedical Scientists (UK) / Medical Laboratory Scientists (USA) /Medical Laboratory Technologists(Canada)
- Medical Laboratory Technicians
- Medical Laboratory Assistants
- Phlebotomists

**JOB SPECIFICATION OF LABORATORY PROFESSIONALS**

The clinical laboratory deals with serious life and death issues involving delicate and precise measurements. Therefore, according to various national and international regulations such as the ISO 15189, all clinical laboratory tests must be carried out by competent **licensed** laboratory professionals and **all pathology laboratory results must be verified by a competent professional**.

In some countries, staff composed of clinical scientists (medical laboratory scientists) do the majority of this work inside the laboratory, with the abnormal results referred to the relevant Pathologist. Laboratory scientists have the responsibility for limited interpretation of test results in their discipline in some countries, depending on their level of training. In some other countries, only professional medical staff **(Pathologists)** are involved with **interpretation** and **consultation**.

Medical Laboratory Departments in some countries are exclusively directed by a specialist Pathologist. In others, a Consultant, medical or non-medical, may be the head of department. In Europe and some other countries, Clinical Scientists with a Master's level education may be qualified to head the department in the absence of a Pathologist. Others may have a PhD and can have an exit qualification equivalent to medical staff (e.g. FRCPath in the UK). In France, only medical staff with specialist qualification in Pathology can discuss pathology results.

**It is inconceivable to find a clinical laboratory staffed with qualified pathologists being headed by a non-pathologist laboratory professional, except he/she has an equivalent exit qualification, e.g. FRCPath, with relevant experience.**

In Nigeria, Pathologists head the department. Where a Pathologist is not available, a Laboratory Scientist may head

the department. Sadly, as in most other sectors of the Nigerian economy, the "**Nigerian factor**" has crept into the clinical medical laboratory, with the laboratory scientists now claiming sole ownership of clinical laboratories, to the exclusion of Pathologists.

Recently, the Association of Medical Laboratory Scientists of Nigeria (AMLSN) instituted court cases against the management of several Teaching and Specialist Hospitals, the Minister of Health and the Minister of Justice and Attorney General of the Federation at the National Industrial Court, asking for, among other reliefs, that separate Medical Laboratory Services Departments headed by Medical Laboratory Scientists be created for them and that Pathologists should not be part of the medical laboratory in Nigeria and should practice only in the clinics and wards. The adverse effects of these developments on clinical laboratory practice in Nigeria will be discussed later in this lecture.

## THE LABORATORY INDUSTRY

The laboratory industry is a part of the broader healthcare and health technology industry. It is huge and companies exist at various levels, including those offering clinical laboratory services, suppliers of instrumentation equipment and consumable materials, and suppliers and developers of diagnostic tests themselves (often by biotechnology companies).

In developed countries such as the United States of America, clinical laboratory services are rendered by some large private commercial laboratories, including multinational corporations, but a significant proportion of revenue, estimated at about 60% in the United States, is still generated by hospital laboratories.

In 2018, the total global revenue for these companies was estimated to reach $146 billion by 2024[37]. Another estimate

places the market size at about $205 billion, reaching $333 billion by 2023[38]. In most developing countries, such large private laboratories are not available, and the market share of private laboratories is much smaller.

Clinical laboratories are supplied by other multinational companies which focus on materials and equipment, which can be used for scientific research and medical testing. In 2016, global life sciences instrumentation sales were around $47 billion, not including consumables, software and services[39].

In general, laboratory equipment includes centrifuges, spectrophotometers, colorimeters, auto-analyzers, water purification systems, extraction techniques, concentrators, evaporators, fume hoods, incubators, biological safety cabinets, lab washers, shakers stirrers, etc.

As of 2016, the in vitro diagnostics (IVD) reagent market was estimated at a global value of around $45-50 billion, with six key multi-national companies (Roche Diagnostics, Abbott Diagnostics, Siemens, Johnson and Johnson Medical Devices and Diagnostics, Beckman Coulter and BioMerieux) being the major players. Newer international big players are beginning to emerge out of China. Many of these companies sell capital equipment and supply consumables, and the devices are also used for industrial purposes such as food testing.

Molecular diagnostics is estimated at about 10% of total revenue, and half of that is focused on infectious disease testing, such as malaria, typhoid fever, tuberculosis, lassa fever, ebola, etc[40], which are largely diseases of more public health importance in sub-saharan Africa and other under-developed areas of the world.

The sad story here is that in the whole laboratory industry value chain, as in the entire healthcare value chain, **there is hardly any local content**, including such minor everyday

items as cotton wool, swab sticks, specimen bottles, syringes and needles, etc, as virtually all the hardware and consumables are imported. This is not just a big risk for our health system, but also a significant economic and security risk for this country.

**The need to encourage and promote a local healthcare and laboratory industry value chain cannot be over-emphasized, especially if we realize that unemployment is a huge time bomb in Nigeria.**

## THE ROLE OF THE CLINICAL LABORATORY IN THE BATTLES FOR LIFE

The clinical laboratory is the workshop of the Pathologist and other laboratory professionals. The work of these professionals in clinical laboratories provides information and services that contribute to maximizing the effective delivery of care in today's complex healthcare system.

Laboratory information enables physicians and other healthcare professionals to make appropriate evidence-based diagnostic or therapeutic decisions for their patients. Clinical laboratory services are the most cost effective and least invasive source of the objective information used in clinical decision-making. **As already noted, about seventy percent (70%) of clinical decisions depend on laboratory test results**[1].

Clinical laboratory services have a direct impact on many aspects of patient care including, but not limited to, length of hospital stay, patient safety, resource utilization, and customer satisfaction, as correct laboratory results lead to fast and accurate diagnosis, early commencement of correct treatment, early healing and early discharge from the hospital.

While technology continues to improve the productivity of today's laboratories, new technologies, new diseases, and

disease strains continue to drive the need for more tests and testing. Changes in the world political and socio-economic environment, such as bio-terrorism and the speed with which diseases spread globally due to ease of international travels and mobility of labour, drive the need for more rapid diagnosis.

Let me remind us about the **ebola epidemic** of 2014 in Nigeria, particularly the situation in Port Harcourt. Without the local support of the molecular laboratories in Lagos, Irrua and the University of Port Harcourt Teaching Hospital, the outcome would have been completely different!

Thus, the clinical laboratory is an indispensable partner in providing patient care, and making direct improvements in the lives of patients, in the maintenance of the health of the general public and in the effectiveness of the battles for life.

## THE QUALITY OF LABORATORY SERVICES IN NIGERIA

Mr. Vice Chancellor Sir, in the course of this lecture, we have vigorously asserted that the clinical laboratory should function as the compass and navigator, i.e, the eye, the ear and the nose of the clinician in healthcare delivery. In order to fulfill this role effectively, using our local parlance, the eye must see well, the ear must hear well and the nose must smell well!

### How well is the clinical laboratory in Nigeria fulfilling this role in the battles for life in Nigeria?

Clinicians rely on the information given by clinical laboratories in order to give effective treatment to patients. The clinicians have the fundamental trust on the correctness of the results given by the clinical laboratories. If the quality of information provided by the clinical laboratories is faulty, then the clinician would be misguided and hence give wrong treatment.

***A wrong laboratory result is dangerous and misleading and may be worse than a situation with no laboratory result.***
We should therefore be asking ourselves this fundamental question: "**what is the quality of the information given by medical laboratories to clinicians in Nigeria?" Rephrased, how reliable is the information from our clinical laboratories in Nigeria?** I might not have all the answers, but in this lecture, I would attempt to give us an insight.

**Laboratory quality can be defined as the accuracy, reliability and timeliness of the reported test results.** For the laboratory results to be as accurate as possible, all aspects of the laboratory operations must be standardized and reliable and reporting must be **timely** in order to be useful in a clinical or public health setting. In order to be accurate and reliable, we must **reduce errors** to the barest minimum in all processes involved in laboratory analyses.

**Errors in Measurement:**
Clinical laboratory analysis is largely about making measurements. When making measurements, there is always a problem of **accuracy** and we end up mostly with some degree of **error**.

***The challenge is usually how to reduce the level of error or inaccuracy as much as possible, given the limitations of our testing systems and the operating environment.***
Laboratories produce test results that are widely used in clinical and public health settings, and health outcomes depend on the accuracy of the testing and reporting.
**If inaccurate results are provided, the consequences can be very significant and dangerous:**
- making wrong diagnosis
- failure to provide correct treatment
- unnecessary treatment

- delay in making correct diagnosis
- additional and unnecessary diagnostic testing

***These consequences result in increased cost in time, personnel effort, resources and often in poor patient outcomes. In fact, the patient could die, especially in critical emergencies.***

In order to achieve the lowest level of error and the highest level of accuracy and reliability, it is essential to perform all processes and procedures in the laboratory in the best possible way according to accepted international standardized protocols. There is need for the testing process to have '**near-zero error tolerance'!**

The laboratory testing process is a complex operation, involving many steps of activity and many people, from the pre-analytical, to the analytical and post-analytical stages. The complexity of the system requires that all processes and procedures be performed properly, using **standard operating procedures (SOPs),** in order to minimize errors and produce accurate results. How do we achieve this?

## THE TOTAL QUALITY MANAGEMENT CONCEPT IN CLINICAL LABORATORIES

In order to perform optimally, the total quality management system model, which looks at the entire system, is very important for achieving good laboratory performance. To get accurate and reliable results that meet international standards, all processes and procedures must be undertaken properly, during the pre-analytical, analytical and post-analytical phases of the testing process.

To start with, the laboratory request form must be properly completed with all the necessary information required, the patient must be prepared properly for the test, the

sample or the specimen must be obtained using proper equipment and technique from the correct patient at the correct time, the sample bottle must be the correct one, the storage and transportation of the specimen to the laboratory must be done in accordance to standard operating procedures, the sample must be processed correctly in the laboratory and the testing done using the correct equipment that has been properly and regularly serviced and calibrated.

For equipments to function properly, they should ordinarily be housed in a clean and conducive environment with constant air-conditioning. There should be constant and good quality water and power supply to guarantee optimal performance of the equipment. Most laboratory equipment in Nigeria get frequently damaged by poor quality power supply. Most importantly, all the critical staff need to be professionally trained and licensed, with regular re-training and re-certification.

The results obtained from the investigation must be accurately transcribed to the patient's laboratory form and finally forwarded to a Pathologist for final quality checks before dispatch to the requesting physician through an appropriate professional channel.

These are rigorous processes which ensure that the correct laboratory tests are done on the correct patients by properly trained and licensed staff, using adequately maintained and calibrated equipment, in a conducive operating environment, in a professionally **accredited** laboratory using standard operating procedures.

Considering that a busy laboratory analyzes several hundreds of samples everyday, with all the samples looking alike, this could be a challenging and difficult task that requires optimal professionalism at every stage. Any shortcuts in any of these

processes could lead to errors and inaccurate and unreliable laboratory results.

**Applying these principles systematically is the total quality management concept which can only be guaranteed and verified through a process of laboratory accreditation.**
**Unfortunately in Nigeria, there is presently no local licensing or accreditation requirement or accreditation process for clinical laboratories**. If, per chance, there is any regulatory requirement, these policies only exist on paper, with little or no methodological implementation process.
Presently, I am not aware of any clinical laboratory in a public health institution in Nigeria that has local or international accreditation. The implication of this is that there are no set standards and no process for verification of the application of the total quality management process in clinical laboratories in Nigeria.

Furthermore, there is therefore no guarantee that all stages of the testing process (pre-analytical, analytical and post-analytical) are being carried out properly according to standard international protocols. Therefore, no clinical laboratory in any public health institution in Nigeria can confidently claim to be producing verifiable, accurate and reliable laboratory results. **This, to say the least, is unfortunate and a very sad commentary on the state of affairs in our national health system.**

Mr. Vice Chancellor, Sir, permit me to emphasize once more that any health system can only be as good as its clinical laboratories and other diagnostic services, because over 70% of clinical decisions are dependent on laboratory results. In this circumstance, can we therefore really beat our chest and claim that we have proper clinical laboratories in Nigeria? ***Are we really practicing modern medicine in Nigeria?***

For us as a nation to build a robust, reliable and dependable health system with standard clinical laboratories, there is a need for a reliable **national or, better still, an international accreditation system for clinical laboratories** and the up-grading and re-equipping of clinical laboratories in our public and private health institutions to meet international standards in order to prepare and qualify them for accreditation.

In realization of this deficiency in the health systems and clinical laboratories across many developing countries in Africa, Asia, Latin America, the Caribbean, and the Pacific, the United States Centers for Disease Control and Prevention(CDC) , in collaboration with the World Health Organization (WHO), the Clinton Health Access Initiative, and the American Society for Clinical Pathology (ASCP) established a program for Strengthening Laboratory Management Towards Accreditation (SLMTA) in 2009 in order to assist these countries improve on the standard of their clinical laboratories.

**SLMTA is a structured quality improvement program** which teaches laboratory managers how to implement quality management systems in resource-limited settings, using available resources. To date, over 1,100 laboratories in about 52 countries in the designated regions of the world have implemented the program.

Unfortunately, while some African countries have seized the opportunity of this CDC/WHO-sponsored program, Nigeria is yet to embrace the program in any impactful or significant way. The need for all public and private laboratories to key into this program cannot be over-emphasized at this point in time.

For any clinical laboratory to assure the public it serves of accurate and reliable results, that laboratory needs to meet

some minimal operational requirements which are assessed through the process of **accreditation** by a national or internationally recognized accreditation agency. An essential component of the accreditation process requires that such laboratories must establish and follow written policies and procedures for a **comprehensive quality assurance program** that is designed to monitor and evaluate the ongoing and overall **quality of the total testing process**.

Accreditation ensures that such laboratories have put in place **total quality management/quality assurance/quality improvement practices** that guarantee that the laboratory performs all processes and procedures in accordance with set international best practices that would minimize errors and guarantee good quality results.

In a **total quality management system**, all aspects of the laboratory operation, including the organizational structure, processes and procedures, need to be addressed to assure quality, including all pre-analytical, analytical and post-analytical operations.

**Quality Assurance** is an ongoing, comprehensive program which analyzes every aspect of the entire operation. It involves pre-determining a **quality goal**, deciding whether or not the goal has been achieved after **evaluation**, and implementing corrective action if the goal has not been reached, in order to achieve the set goal.

In developed countries such as the United States of America and Europe, **it is mandatory for all clinical laboratories to be accredited before they can be permitted to offer service to the public,** because of the critical importance of clinical laboratories to the health system. This is the only objective way to guarantee that the quality of results from such clinical laboratories would be **accurate and reliable**. The current international quality standard in use for

clinical laboratories is the ISO 15189 (International Standard Organization).

## REGULATION AND CONTROL OF CLINICAL LABORATORY PRACTICE IN NIGERIA

In Nigeria, unfortunately, there is presently no regulation for the compulsory accreditation of clinical laboratories. There is even confusion and controversy as to the proper government agency to regulate and provide oversight on clinical laboratory practice in Nigeria.

The Medical and Dental Practitioners Council (MDCN) (Amendment) Decree No. 78 of 1992 vests the control and supervision of **clinical laboratories** on the Medical and Dental Council of Nigeria. It has not been repealed.

In 2003, the Medical Laboratory Science Council (MLSCN) Act No. 11 was passed and signed into law. This Act also vests the control and supervision of **medical laboratories** on the Medical laboratory Science Council of Nigeria. **Is there any difference between a clinical laboratory and a medical laboratory?** *The "Nigerian factor" at play again?*

Another interesting aspect of this drama was that the three (3) readings of the MLSCN bill were carried out on May 21, 2003, after suspending several Orders of the Rules and Regulations of the National Assembly on the day of the last substantive seating of that Senate before it was dissolved.

There was no public hearing and the major stakeholders were not involved and the supervising Ministry (the Federal Ministry of Health) was said to be ignorant until the Bill was signed into Law by the President in June, 2003. *"Nigeria we hail thee!"*

This singular legislation is at the root of the catastrophic inter-professional rivalry in clinical laboratories in Nigeria today, because, while the MDCN decree vests the

headship of clinical laboratories on Pathologists, the MLSCN Act vests the headship of medical laboratories on Laboratory Scientists! Who is the Captain in the boat? **Who is responsible for this confusion?**

The confusion has even become more absurd as the Association of Medical Laboratory Scientists of Nigeria (AMLSN) had approached the National Industrial Court of Nigeria (NICN) and the NICN has given an order to the Management of various Teaching Hospitals in Nigeria to establish Departments of Medical Laboratory Service to be headed by Medical Laboratory Scientists, since Medical Laboratory Science is by fiat of that law, a separate profession, *sui generis*. This department will be to the exclusion of all Pathologists, in accordance with provisions of the MLSCN Act. The MLSCN Act does not recognize the role of Pathologists in clinical laboratories! *Nigeria, we hail thee!*

***With this ruling of the NICN, the Medical Laboratory Scientists have requested all Pathologists to move out of the clinical laboratories and go to practice in the clinics and wards, where they belong!***

Meanwhile, the National Postgraduate Medical College of Nigeria (NPMCN), established by Decree No. 67 of 1979, and the West African Postgraduate Medical College (WAPMC), among others, have Faculties of Pathology and Laboratory Medicine, respectively, charged with the responsibility of postgraduate training of Pathologists for the country and the West African sub-region. The resident doctors in Pathology can only be trained in a clinical laboratory.

For a Teaching Hospital to be accredited to train Resident doctors in Pathology and other medical and surgical specialties for production of Specialist Consultants for the Nigerian health sector, it is required to have standard clinical

laboratories headed by Pathologists. Without such clinical laboratories and Consultant Pathologists, it would not to be accredited for undergraduate or postgraduate training.

The question that is begging for answer now is: Which department should such clinical or medical laboratories belong to – the various departments of Pathology or the Departments of Medical Laboratory Services? Should we have different medical and clinical laboratories in the same hospital, one for Pathologists and another for Laboratory Scientists? *Nigeria, we hail thee!*

In addition, and most unfortunately, the Laboratory Scientists also do not want to see Resident doctors in our clinical laboratories, as they claim that doctors do not belong to the laboratories, but to the wards and clinics! The Resident doctors are prevented from taking call duties in the clinical laboratories. Where will the Resident doctors do their training? *Confusion! Confusion!! Confusion!!!*

In view of the current order by the NICN, what is the Management of the various Teaching and Specialist Hospitals in Nigeria expected to do? How do they obey this court order? Should they disobey or should they duplicate the laboratories? Where are the financial resources and how would they function? Is the order implementable or was it just a mere academic legal exercise? ***Should our legal authorities not be more circumspect before issuing such orders or rulings?***

Who will send the requests to clinical laboratories manned solely by laboratory scientists? Would it be other doctors? What would be the reaction of the Nigerian Medical Association (NMA), the College of Nigerian Pathologists and the National and West African Postgraduate Medical Colleges?

With the current atmosphere of acrimony, suspicion and confusion, can we in true conscience rule out inter-professional sabotage with regards to the quality of results produced by the feuding professional groups? Can we really

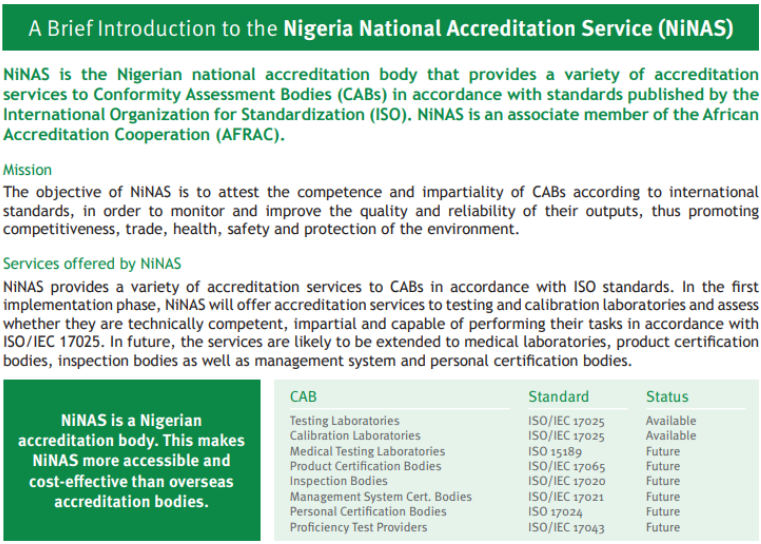
produce good quality results with the current rivalry between the two major professional groups in the clinical laboratory? When two elephants fight, who suffers? Are we being fair to our patients and fellow countrymen? *Is Nigeria really a country of the absurd?*

Medical practice, including laboratory medicine, and the allied health professions are international professions with established international best practices and benchmarks. They cannot be practiced in any other way in Nigeria! *Is this another example of the Nigerian factor?*

***The end result is that there is largely very poor control or oversight, with no established standards or quality assurance programs to ensure strict adherence of clinical laboratories to such standards.***

## THE NIGERIAN NATIONAL ACCREDITATION SERVICE

The only ray of hope in the horizon pertains to the incorporation of the Nigeria National Accreditation Service (NiNAS). NiNAS was established in 2015, within the framework of the EU-funded National Quality Infrastructure Project for Nigeria (NQIP), implemented by UNIDO. The project aims to support the improvement of missing standards and quality control bodies in Nigeria, with the objective of improving the competitiveness of Nigerian goods and services domestically and abroad.



A Brief Introduction to the **Nigeria National Accreditation Service (NiNAS)**

**NiNAS is the Nigerian national accreditation body that provides a variety of accreditation services to Conformity Assessment Bodies (CABs) in accordance with standards published by the International Organization for Standardization (ISO). NiNAS is an associate member of the African Accreditation Cooperation (AFRAC).**

Mission

The objective of NiNAS is to attest the competence and impartiality of CABs according to international standards, in order to monitor and improve the quality and reliability of their outputs, thus promoting competitiveness, trade, health, safety and protection of the environment.

Services offered by NiNAS

NiNAS provides a variety of accreditation services to CABs in accordance with ISO standards. In the first implementation phase, NiNAS will offer accreditation services to testing and calibration laboratories and assess whether they are technically competent, impartial and capable of performing their tasks in accordance with ISO/IEC 17025. In future, the services are likely to be extended to medical laboratories, product certification bodies, inspection bodies as well as management system and personal certification bodies.

**NiNAS is a Nigerian accreditation body. This makes NiNAS more accessible and cost-effective than overseas accreditation bodies.**

| CAB | Standard | Status |
|---|---|---|
| Testing Laboratories | ISO/IEC 17025 | Available |
| Calibration Laboratories | ISO/IEC 17025 | Available |
| Medical Testing Laboratories | ISO 15189 | Future |
| Product Certification Bodies | ISO/IEC 17065 | Future |
| Inspection Bodies | ISO/IEC 17020 | Future |
| Management System Cert. Bodies | ISO/IEC 17021 | Future |
| Personal Certification Bodies | ISO 17024 | Future |
| Proficiency Test Providers | ISO/IEC 17043 | Future |

Unfortunately, NiNAS appears to have more focus on the certification of the quality of goods and services for export, rather than clinical laboratory services. This is reflected in the composition of their Board of Trustees, Board of Directors and the Accreditation Advisory Committee, where there is no singular representation from the health sector.

However, a management staff of the agency has confirmed that they have capacity for clinical laboratory accreditation, though they are yet to establish any functional official relationship with the Federal Ministry of Health or any of the regulatory agencies under the ministry. In addition, there is, for now, no legislation for the mandatory accreditation of clinical laboratories before they can be permitted to render service to the public.

## EXTERNAL QUALITY ASSURANCE

To make matters worse, most of our clinical laboratories (both public and private) do not also participate in **External Quality Assurance (EQA)** programs. EQA is a system for objectively

checking a laboratory's performance in comparison to other clinical laboratories, using a recognized external agency or facility. This is an additional quality assurance tool.

It involves the evaluation of the technical performance of participating laboratories in comparison to the performance of a peer group of laboratories or to the performance of a reference laboratory. This is a critical aspect of the assessment of the quality management system of the laboratory.

**The end result, therefore, is that there is no guarantee for the accuracy and reliability of laboratory test reports from any Nigerian clinical laboratory**, except for the few private laboratories with international accreditation.

**What is the implication of this?** It implies that if a Nigerian clinical laboratory gives you a result that says, for example, your blood sugar (e.g. in diabetes) is normal, we cannot say with any certainty that it is truly normal! You should accept the result with a 'pinch of salt'!

We might therefore erroneously be saying that you do not have diabetes mellitus (wrong diagnosis) or that you are in good control (wrong assessment) when, in actual fact, you truly have the disease or you are in poor control. **It further implies that we cannot vouch that the laboratory result given to you is the truth and nothing but the truth!**

The facts revealed above should however not be seen as scary or alarming, but rather cautionary. It should not be misconstrued to mean that our clinical laboratories are not adding any value to the battles for life in our hospitals and clinics. However, the quality of our laboratory services should have been better. Let us be comforted by the wisdom of our elders in the saying that ***"half bread is better than none"!***
***Even if it amounts to an alarm, I believe that in good conscience, we owe it as a duty to our fatherland to sound such alarms. If, as learned professionals, we do not raise***

***these alarms in our various areas of expertise, then, who will?***

The essence of these observations is to serve as a call to action by our governments to put in place a credible health system that would guarantee that the results from our clinical laboratories compare with the best international standards by providing adequate resources and enabling legislations and regulations that would **institute compulsory periodic accreditation and participation in external quality assessment programs for our clinical laboratories in order to guarantee accurate and reliable laboratory results.**

To serve as a practical illustration of the state of affairs of our clinical laboratories, a laboratory in one of our top teaching hospitals recently participated in a World Health Organization (WHO)-sponsored international external quality assessment (EQA) program. Interpretation of the results of such exercises is usually complex and technical, but has also been simplified for the lay man by illustrating the result with the traffic light colors as follows:

- Green – the laboratory is performing as well as the state-of-the-art allows.
- Yellow – borderline.
- Red – the laboratory result is outside the acceptable limits of performance for that substance.

| International EQAS for Clinical Chemistry | Laboratory : 95002 |
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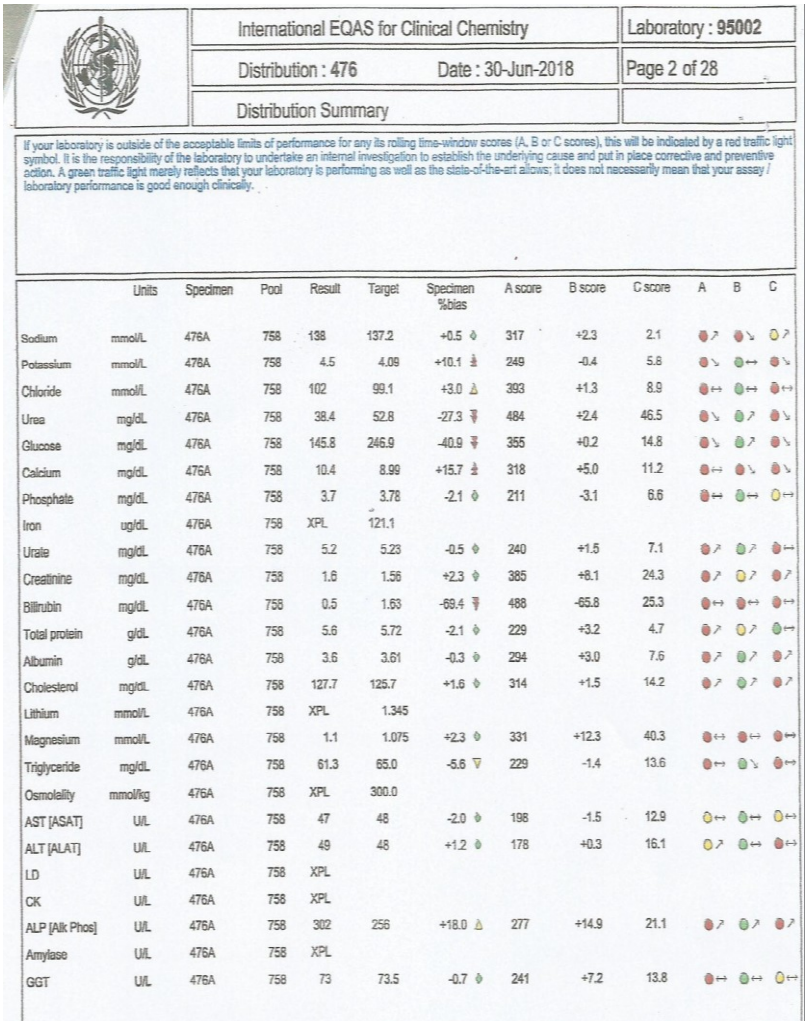
| Distribution : 471 Date : 31-Jan-2018 | Page 2 of 28 |
| Distribution Summary | |

If your laboratory is outside of the acceptable limits of performance for any its rolling time-window scores (A, B or C scores), this will be indicated by a red traffic light symbol. It is the responsibility of the laboratory to undertake an internal investigation to establish the underlying cause and put in place corrective and preventive action. A green traffic light merely reflects that your laboratory is performing as well as the state-of-the-art allows; it does not necessarily mean that your assay / laboratory performance is good enough clinically.

±2

| | Units | Specimen | Pool | Result | Target | Specimen %bias | A score | B score | C score | A | B | C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sodium | mmol/L | 471A | 759 | 147.0 | 142.5 | +3.1 | 238 | +1.3 | 1.9 | ↘ | ↘ | ↔ |
| Potassium | mmol/L | 471A | 759 | 4.5 | 4.41 | +2.0 | 168 | -0.7 | 4.6 | ↔ | ↔ | ↔ |
| Chloride | mmol/L | 471A | 759 | 97.0 | 105.2 | -7.8 | 436 | +4.3 | 9.0 | ↘ | ↗ | ↘ |
| Urea | mg/dL | 471A | 759 | 27.0 | 30.9 | -12.6 | 461 | -2.1 | 34.6 | ↔ | ↘ | ↗ |
| Glucose | mg/dL | 471A | 759 | 68.4 | 64.5 | +6.0 | 316 | +6.4 | 4.5 | ↗ | ↔ | ↔ |
| Calcium | mg/dL | 471A | 759 | 9.6 | 10.14 | -5.4 | 372 | +5.2 | 9.1 | ↔ | ↗ | ↘ |
| Phosphate | mg/dL | 471A | 759 | 1.9 | 4.29 | -55.8 | 249 | -4.2 | 6.1 | ↘ | ↘ | ↔ |
| Iron | ug/dL | 471A | 759 | XPL | 145.2 | | | | | | | |
| Urate | mg/dL | 471A | 759 | 9.3 | 9.44 | -1.5 | 311 | +3.3 | 8.6 | ↗ | ↗ | ↔ |
| Creatinine | mg/dL | 471A | 759 | 1.8 | 1.83 | -1.7 | 461 | +10.2 | 28.1 | ↗ | ↗ | ↗ |
| Bilirubin | mg/dL | 471A | 759 | 0.5 | 2.14 | -76.7 | 449 | -33.8 | 57.2 | ↔ | ↘ | ↔ |
| Total protein | g/dL | 471A | 759 | 6.4 | 6.16 | +3.9 | 218 | +4.2 | 3.3 | ↔ | ↔ | ↔ |
| Albumin | g/dL | 471A | 759 | 4.1 | 3.92 | +4.5 | 316 | +3.1 | 9.3 | ↗ | ↔ | ↗ |
| Cholesterol | mg/dL | 471A | 759 | 104.5 | 159.4 | -34.4 | 440 | +13.2 | 13.0 | ↔ | ↗ | ↘ |
| Lithium | mmol/L | 471A | 759 | XPL | 1.910 | | | | | | | |
| Magnesium | mmol/L | 471A | 759 | 2.3 | 1.222 | +88.2 | 231 | +5.1 | 14.4 | ↘ | ↘ | ↘ |
| Triglyceride | mg/dL | 471A | 759 | 70.0 | 83.3 | -16.0 | 173 | +1.0 | 8.6 | ↘ | ↗ | ↘ |
| Osmolality | mmol/kg | 471A | 759 | XPL | 299.5 | | | | | | | |
| AST [ASAT] | U/L | 471A | 759 | 72.0 | 70 | +2.3 | 176 | -4.4 | 13.6 | ↗ | ↗ | ↗ |
| ALT [ALAT] | U/L | 471A | 759 | 48.0 | 72 | -33.5 | 237 | +0.1 | 20.5 | ↘ | ↗ | ↘ |
| LD | U/L | 471A | 759 | XPL | | | | | | | | |
| CK | U/L | 471A | 759 | XPL | | | | | | | | |
| ALP [Alk Phos] | U/L | 471A | 759 | 406.0 | 383 | +5.9 | 384 | +21.6 | 31.7 | ↗ | ↗ | ↔ |
| Amylase | U/L | 471A | 759 | XPL | | | | | | | | |
| GGT | U/L | 471A | 759 | 151.0 | 112.5 | +34.2 | 183 | +3.6 | 3.9 | ↘ | ↔ | ↔ |



International EQAS for Clinical Chemistry | Laboratory : 95002

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Distribution Summary

If your laboratory is outside of the acceptable limits of performance for any its rolling time-window scores (A, B or C scores), this will be indicated by a red traffic light symbol. It is the responsibility of the laboratory to undertake an internal investigation to establish the underlying cause and put in place corrective and preventive action. A green traffic light merely reflects that your laboratory is performing as well as the state-of-the-art allows; it does not necessarily mean that your assay / laboratory performance is good enough clinically.

| | Units | Specimen | Pool | Result | Target | Specimen %bias | A score | B score | C score | A | B | C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sodium | mmol/L | 476A | 758 | 138 | 137.2 | +0.5 | 317 | +2.3 | 2.1 | ↗ | ↘ | ↗ |
| Potassium | mmol/L | 476A | 758 | 4.5 | 4.09 | +10.1 | 249 | -0.4 | 5.8 | ↘ | ↔ | ↘ |
| Chloride | mmol/L | 476A | 758 | 102 | 99.1 | +3.0 | 393 | +1.3 | 8.9 | ↔ | ↔ | ↔ |
| Urea | mg/dL | 476A | 758 | 38.4 | 52.8 | -27.3 | 484 | +2.4 | 46.5 | ↘ | ↗ | ↘ |
| Glucose | mg/dL | 476A | 758 | 145.8 | 246.9 | -40.9 | 355 | +0.2 | 14.8 | ↘ | ↗ | ↘ |
| Calcium | mg/dL | 476A | 758 | 10.4 | 8.99 | +15.7 | 318 | +5.0 | 11.2 | ↔ | ↘ | ↘ |
| Phosphate | mg/dL | 476A | 758 | 3.7 | 3.78 | -2.1 | 211 | -3.1 | 6.6 | ↔ | ↔ | ↔ |
| Iron | ug/dL | 476A | 758 | XPL | 121.1 | | | | | | | |
| Urate | mg/dL | 476A | 758 | 5.2 | 5.23 | -0.5 | 240 | +1.5 | 7.1 | ↗ | ↗ | ↔ |
| Creatinine | mg/dL | 476A | 758 | 1.6 | 1.56 | +2.3 | 385 | +8.1 | 24.3 | ↗ | ↗ | ↗ |
| Billirubin | mg/dL | 476A | 758 | 0.5 | 1.63 | -69.4 | 488 | -65.8 | 25.3 | ↔ | ↔ | ↔ |
| Total protein | g/dL | 476A | 758 | 5.6 | 5.72 | -2.1 | 229 | +3.2 | 4.7 | ↗ | ↗ | ↔ |
| Albumin | g/dL | 476A | 758 | 3.6 | 3.61 | -0.3 | 294 | +3.0 | 7.6 | ↗ | ↗ | ↗ |
| Cholesterol | mg/dL | 476A | 758 | 127.7 | 125.7 | +1.6 | 314 | +1.5 | 14.2 | ↗ | ↗ | ↗ |
| Lithium | mmol/L | 476A | 758 | XPL | 1.345 | | | | | | | |
| Magnesium | mmol/L | 476A | 758 | 1.1 | 1.075 | +2.3 | 331 | +12.3 | 40.3 | ↔ | ↔ | ↔ |
| Triglyceride | mg/dL | 476A | 758 | 61.3 | 65.0 | -5.6 | 229 | -1.4 | 13.6 | ↔ | ↘ | ↔ |
| Osmolality | mmol/kg | 476A | 758 | XPL | 300.0 | | | | | | | |
| AST [ASAT] | U/L | 476A | 758 | 47 | 48 | -2.0 | 196 | -1.5 | 12.9 | ↔ | ↔ | ↔ |
| ALT [ALAT] | U/L | 476A | 758 | 49 | 48 | +1.2 | 178 | +0.3 | 16.1 | ↗ | ↔ | ↔ |
| LD | U/L | 476A | 758 | XPL | | | | | | | | |
| CK | U/L | 476A | 758 | XPL | | | | | | | | |
| ALP [Alk Phos] | U/L | 476A | 758 | 302 | 256 | +18.0 | 277 | +14.9 | 21.1 | ↗ | ↗ | ↗ |
| Amylase | U/L | 476A | 758 | XPL | | | | | | | | |
| GGT | U/L | 476A | 758 | 73 | 73.5 | -0.7 | 241 | +7.2 | 13.8 | ↔ | ↔ | ↔ |

You are to please judge for yourself how this top laboratory in one of our best teaching hospitals has performed in this external quality assessment (EQA) program. **If this is one of our best laboratories, then we are in real trouble!**

## CONTRIBUTIONS TO KNOWLEDGE, TEACHING, TRAINING AND HEALTH SERVICE DELIVERY

Vice Chancellor, Sir, before I finally go into the concluding aspects of this lecture, I wish to remind us that one important aspect of an inaugural lecture is an opportunity to highlight the contributions of a Professor to knowledge, teaching, training and professional service delivery in the university and the community. While I feel it may sound immodest for one to "blow his own trumpet", I am equally constrained by duty to state some of these contributions. I believe I have paid some modest dues in all these areas of endeavor, though the research component could have been better.

## CONTRIBUTIONS TO TEACHING AND TRAINING

As a member of staff of the Department of Chemical Pathology of this University and the Department of Chemical Pathology of the University of Port Harcourt Teaching Hospital since 1993 (26 years), I have been directly and indirectly involved in the training of about **2940 medical and dental graduates** (MBBS/BDS), **12 Specialist Consultants in Chemical Pathology and about 250 other Consultants** in Pathology and other specialties of Medicine. Many of them are currently serving as doctors, lecturers and Consultants in various Universities and Teaching and Specialist Hospitals in this country and abroad. Two (2) of them are already Professors in this university. I have had the privilege of supervising the dissertations of some of them and a few medical laboratory scientists.

It may be necessary to emphasize here that no conventional university offers postgraduate programs in **clinical medicine**. The clinical departments and the lecturers in the Colleges of Medicine, therefore, do not run conventional professional postgraduate programs where they would have the opportunity to supervise Masters or Doctoral students.

Patronage of the academic Doctor of Medicine (MD) program is sparse. The only professional postgraduate programs available in clinical medicine are as obtainable in the Residency Training Programs of the various tertiary/teaching hospitals in the country under the supervision of Consultants and Clinical Lecturers from the Colleges of Medicine, under the auspices of the various Postgraduate Medical Colleges.

In view of their major mandates of health manpower training, tertiary health service delivery and health research, Teaching Hospitals are therefore institutions involved in tertiary education. **One therefore wonders why Teaching Hospitals are excluded from benefitting from support by the Tertiary Education Trust Fund**.

How long would it take to correct this mistake, if we assume that it was an initial error during the crafting of the enabling law? Could this be taken as a deliberate act of discrimination against the health sector or a mere reflection of the low prioritization of health service delivery in Nigeria? Whose responsibility is it to rectify this anomaly? How can we be delivered from **medical tourism** without these kinds of intervention? This may be a part of the solution to the healthcare crises in Nigeria. Is this delay in correction of the enabling law another example of the Nigerian factor? ***Nigeria, we hail thee!***

## CONTRIBUTIONS TO HEALTH SERVICE DELIVERY

With regards to contributions to health service delivery in Rivers State and the nation, I have been specially privileged to serve in various administrative and professional positions that had impacted significantly on health service delivery in our sister Teaching Hospital, which is the apex health institution in Rivers and Bayelsa states, where for some period of time(1995-1997), **I even had to head two (2) clinical**

**departments (Haematology and Chemical Pathology) at the same time due to lack of qualified manpower.**

Subsequently, I was appointed as the first medically qualified staff to be in-charge of service delivery at the permanent site of the hospital in 2003, as a **Deputy Chairman, Medical Advisory Committee**, before the final movement of the entire hospital to the permanent site in 2006. While acting in this capacity, I also directly **supervised the completion of physical infrastructure and the installation of new medical equipment (VAMED) in the hospital**, preparatory to the final movement of the hospital to the permanent site.

Later in 2007, I was similarly privileged to be the **Director of Clinical Services and Training** at the University of Port Harcourt Teaching Hospital as the **Chairman, Medical Advisory Committee**. In this position, **I supervised the day to day clinical service delivery in the hospital**. I was in that position until 2009, when I was appointed the **Chief Medical Director** and Chief Executive of the hospital. In all these positions, I made some humble and modest contributions to health service delivery in Rivers State and by extension, the entire nation.

I wish to use this opportunity to express my immense gratitude to the Vice Chancellor and the Management of this University for permitting me to proceed on leave of absence to the University of Port Harcourt Teaching Hospital for eight (8) years (2009 – 2017) to serve as the **Chief Medical Director** of the hospital.

Needless to remind us that the Teaching Hospital is the workshop and laboratory of our College of Health Sciences, without which we would not be given accreditation for the training of medical and dental students in this university. Furthermore, the medical and dental schools can only be as

good as their laboratory or workshop! Service to the hospital is thus, also, service to the university.

May I use this opportunity to inform the Vice Chancellor, the university community and the public that the leave of absence was very well utilized for the improvement of service delivery and undergraduate and postgraduate medical and dental training in this university and the Teaching hospital. Due to our culture of poor record keeping in Nigeria, I decided to put on record in a pamphlet, a brief **account of stewardship** as Chief Medical Director, highlighting our modest achievements during this period of service. A limited number of copies are available to guests at this inaugural lecture.

Let me also use this opportunity to appreciate the management team and all the staff of the hospital, clinical and non-clinical, who worked with me during this period, including the immediate past Provost of the College of Health Sciences, Professor C. N. Mato and Dr. Charles Tobin-West, who both served as Chairmen, Medical Advisory Committee (Deputy Chief Medical Directors/Directors of Clinical Services and Training) at different times during this period. They all contributed immensely in realizing these modest achievements.

Without sounding immodest, the report speaks for itself. Some of the more significant achievements include:

(a) **Increase in bed capacity** of the hospital from 510 in 2009 to 840 in 2017 (65% increase);

(b) **Establishment of four (4) new training schools** in the hospital (where there had been none since the establishment of the hospital in 1980, except the traditional Residency training program for medical doctors);

- **Community Health Officers Training School (2010)**
- **Post-basic Nursing Training School (Paediatrics) (2010)**

- **Post-basic Nursing Training School (Accident & Emergency) (2014)**
- **School of Health Information Management (2015)**

(c) **Commencement of Internship (House Officers) and Residency training in Dentistry;**

(d) Establishment of a 30-bedded **Specialist Multi-Drug Resistant Tuberculosis Treatment Centre**, at our Primary Health Centre premises in Aluu (in collaboration with IHVN (Institute of Human Virology, Nigeria).

(e) Establishment of a **Specialist Geriatrics/Care of Elderly Persons Centre (CEPU)** (one of the few in the country).

(f) Establishment of **Assisted Reproduction Unit** (delivery of the first baby was achieved last year).

(g) Establishment of **Regional Tuberculosis Reference Laboratory** (in collaboration with USAID & FHI).

(h) Establishment of a functional **Molecular Laboratory** with capacity to make diagnosis of viral haemorahagic fevers such as Ebola, Yellow fever and Lassa fever (the 2nd in the South-South) in collaboration with IHVN and the Nigerian Centres for Disease Control (NCDC). This laboratory was used effectively in the Ebola epidemic in Port Harcourt in 2014.

i) Establishment of a **Drug Rehabilitation Centre** (in collaboration with the United Nations Office on Drugs and Crimes (UNODC and the Federal Ministry of Health).

(j) Establishment of a 3-star **KOKOON/UPTH Guest House** in the hospital (through PPP with Kokoon Hotels Ltd).

(k) Secured a commitment by Total (E&P) to build and equip a standard **Oncology/Cancer Centre** in UPTH (implementation still in the pipe line).

(l) Provision of accommodation in the hospital for the **McArthur Clinical Skills Laboratory** (one of the first to be established in Nigeria).

(m) Provision of accommodation for the **Institute Of Maternal and Child Health** in the hospital.
(n) Provision of accommodation for the **Master of Public Health (MPH)** program in the hospital.

(o) Allocation of land for the construction of the permanent site of the **College of Health Sciences** in the hospital (construction still in progress).

**CONTRIBUTIONS TO KNOWLEDGE**

Mr. Vice Chancellor, Sir, we have to tell ourselves the naked truth that cutting edge research has not been our major area of strength in the Nigerian university system.

As I had canvassed earlier in this lecture, the university should play the role of the 'brain' of the society, to search for solutions to the common problems plaguing the society through research. It should do this in partnership and synergy with industry and government. Our research must be focused at solving and providing solutions to peculiar problems of the society and industry, which are many, in all spheres of our national life.

Research requires substantial funding, which the universities lack. We do not have many organizations that can fund research in Nigeria, as obtains in more developed countries. While the industry should provide the funding for research, it should also benefit from the results of research,

which it applies to solve the problems of the society, with consequent financial benefits.

**This is translational research and the necessary handshake between the town and the gown, for the mutual benefit of all stakeholders.**

This synergy is still lacking in our country and the findings from the few purposeful research endeavors end up accumulating dust on the shelves in our universities and government offices. As a result of this lack of collaboration, the motivation for research in the Nigerian university system has been rather misplaced, as most of the research done is largely carried out for purposes of career advancement and promotion *(the publish or perish phenomenon)*. The few that are targeted at contemporary societal problems are hardly patronized by industry or government because of this inherent lack of synergy.

Consequently, most of our current research efforts are usually of relatively poor quality and mostly epidemiologic and descriptive, with little uptake and application by industry. Consequently, the number of patents registered within the Nigerian university system are relatively few. This is in contrast to what obtains in more developed societies where many academic departments and units are run substantially with research funds/grants and record relatively higher numbers of patents from their research efforts.

**There is thus an urgent need for a paradigm shift so that all stakeholders – the university, the industry and society – will benefit from purposeful research.**

Despite these obvious shortcomings, I would like to suggest that in addition to direct proposals from potential funding agencies, different faculties, departments and academic units in the university should periodically identify important research

themes bordering on contemporary problems of our nation, relating to their area of expertise and proffer the needed solutions through research.

This should enhance the academic culture of our universities and our productivity and relevance to the society, especially with regards to our postgraduate programs and further justify the considerable resources spent on tertiary education in our country.

While appreciating these limitations, I believe we have also made our modest contributions in research, though it should have been better. My research focus, in collaboration with other colleagues, has been in five (5) major areas:

(i) DIABETES MELLITUS AND BLOOD GLUCOSE REGULATION[41-48]

(ii) IODINE DEFICIENCY DISORDERS[49-51]

(iii) HEALTH AND SAFETY IN CLINICAL LABORATORIES[52-55]

(iv) BLOOD-BORNE VIRAL DISEASES[56-60]

(v) BIOCHEMICAL CHANGES IN PREGNANCY[61-63]

## THE NIGERIAN HEALTH SYSTEM, THE CLINICAL LABORATORY AND THE BATTLES FOR LIFE

Vice Chancellor, Sir, kindly permit me, in conclusion, to go back once more to the topic of this lecture, which is "The Clinical Laboratory and The Battles For Life".

Let me once more to re-iterate that life is nothing other than the complex chemical reactions of intermediary metabolism that sustain homeostasis, as demonstrated earlier in this lecture.

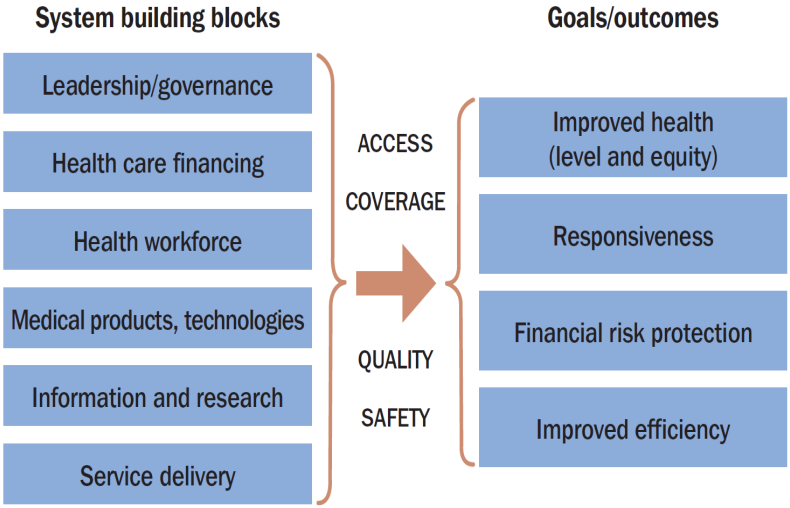
The clinical laboratory and Chemical Pathologists participate in the battles for life by monitoring changes in various biochemical parameters in body fluids and tissues that occur with disease, including electrolytes, urea and creatinine,

proteins and enzymes, hormones, tumor markers, infectious agents, etc.

The medical and allied health professions are organized into **health systems** in different countries of the world to prosecute this battle. As defined by the World Health Organization (WHO), *a health system consists of all organizations, people and actions whose primary interest is to promote, restore or maintain health.* The clinical laboratory is an essential component of all health systems.

The WHO further states that a well-functioning health system, working in harmony, is built on having trained and motivated health workers, a well-maintained infrastructure, and reliable supply of medicines and technologies, backed by adequate funding, strong health plans and evidence-based policies

*Figure 1. The WHO Health Systems Framework*[1]




1 World Health Organization (2013). Universal eye health: a global action plan 2014-2019

I believe we have highlighted sufficiently the critical role the clinical laboratory should play in the normal course of this battle. What remains finally is to evaluate the role and capacity of our clinical laboratories in supporting our national health system and our health institutions in the battles for life in Nigeria.

Our clinical laboratories operate within the context of the Nigerian health system. Therefore, all the challenges identified in the health sector in Nigeria will definitely impact directly or indirectly on the clinical laboratory, as the clinical laboratory provides 70% of the critical information needed by clinicians for optimal care of patients.

**CHALLENGES OF THE NIGERIAN HEALTH SECTOR**

The challenges of the health sector in Nigeria are monumental, with Nigeria having one of the worst developmental and health indices, occasioned by persistent neglect and consistently very low prioritization and very poor budgetary allocations to the health sector.

*A recent global survey (2018) ranked the Nigerian health system 187 out of 190, being better than that of only four (4) countries in the world (Democratic Republic of Congo, Central African Republic, Myanmar and Sierra Leone*[64] .

World Health Organization

# Key Country Indicators

Key Country Indicators > Country summaries

## Nigeria key indicators

| Key indicators: Nigeria | |
|---|---|
| WHO region | Africa |
| **Child health** | |
| Infants exclusively breastfed for the first six months of life (%) (2016-2017) | 23.3 |
| Diphtheria tetanus toxoid and pertussis (DTP3) immunization coverage among 1-year-olds (%) (2017) | 42 |
| **Demographic and socioeconomic statistics** | |
| Poverty headcount ratio at $1.25 a day (PPP) (% of population) (2011) | 54.4 |
| Gender inequality index rank (2014) | ... |
| Human development index rank (2014) | 152 |
| **Health financing** | |
| Total expenditure on health as a percentage of gross domestic product (2014) | 3.67 (Nigeria note) |

## NIGERIA KEY INDICATORS

| | |
|---|---|
| Private expenditure on health as a percentage of total expenditure on health (2014) | 74.85 (Nigeria note) |
| General government expenditure on health as a percentage of total government expenditure (2014) | 8.17 (Nigeria note) |
| **Health systems** | |
| Physicians density (per 1000 population) (2009) | 0.376 |
| Nursing and midwifery personnel density (per 1000 population) (2008) | 1.489 |
| **Mortality and global health estimates** | |
| Neonatal mortality rate (per 1000 live births) (2017) | 32.9 (Both sexes) |
| Under-five mortality rate (probability of dying by age 5 per 1000 live births) (2017) | 106.1 (Male) |
| | 93.8 (Female) |
| | 100.2 (Both sexes) |
| Maternal mortality ratio (per 100 000 live births) (2015) | 814 [ 596 - 1 180] |
| **Sustainable development goals** | |
| Life expectancy at birth (years) (2016) | 54.7 (Male) |
| | 55.7 (Female) |
| | 55.2 (Both sexes) |
| Births attended by skilled health personnel (%) (2013-2017) | 43.0 |
| **World Health Statistics** | |
| Population (in thousands) total (2016) | 185 990 |
| Population proportion under 15 (%) (2016) | 44.1 |
| Population proportion over 60 (%) (2016) | 24.0 |
| Literacy rate among adults aged >= 15 years (%) (2007-2012) | 61 |

**Poor Budgetary Allocations To Health:**

Nigeria has allocated less than 5% of its total budget to health in the last three years, as against South Africa's 13% to 15% over the same period, according to recent reports by BusinessDay newspaper.

In 2018, South Africa had a health budget of R205,446 billion ($17.1 billion), representing an expenditure of $299 per head (population 57 million). Nigeria, on the other hand, with a population of about 198 million, had a total health budget of

N340 billion ($946 million) (3.9% of total budget), amounting to about $5 per person.

Recent data compiled by Africa Check[65] shows that the South African government, for nine consecutive years (2010-2018) spent about six (6) times more on health than the Nigerian government. However, total expenditure on health (public and private) was about sixteen (16) times more in South Africa as compared to Nigeria.

The WHO data shows that about 70.3% of health expenses in Nigeria is made out of pocket, whereas for South Africa, it is about 7.7%, with the difference paid through health insurance schemes. Contemporary evidence indicates that, globally, all countries with strong health systems rely on health insurance schemes, public or private or both. In Nigeria, total health expenditure through health insurance schemes (public and private) still stands at an abysmal 29.7%. Yet, we still pride ourselves as being the giant of Africa (may be in size and population only!).

Statistical data obtained from several other African countries show that in 2016, Rwanda allocated 18% of its national budget to health, while Botswana and Malawi devoted 17.8% and 17.1%, respectively. Zambia was 16.4%, while Burkina Faso was 15%.

Nigeria, which hosted the "2001 Abuja Declaration", where it pledged among other member states of the African Union to commit at least 15% of their national budgets to health, is still at about 4.3%, with no trajectory towards achieving the 15% target.

This abysmal level of budgetary allocation clearly shows the neglect and low priority we attach to health as a nation, bearing in mind that the life and health of citizens should be the greatest assets of any nation.

**Dysfunctional Health System:**
Nigeria operates a **dysfunctional three-tier health system** (primary, secondary and tertiary) characterized by gross underfunding, largely donor-driven health programs, poor infrastructure, inadequate manpower, lack of modern diagnostic equipment, poor equipment maintenance policy and capacity, lack of drugs and medical supplies, high prevalence of fake drugs and poor quality medical consumables, lack of health insurance with consequent largely out-of-pocket payment system, poor/manual paper medical records system, poor national health records/statistics, very weak referral system, poor capacity for quick response to emergencies (solitary or mass casualties), high level of inter-professional rivalry and attendant frequent industrial disputes/strike actions and consequently, poor quality of healthcare delivery.

**Poor Access To Healthcare:**
Considering the high level of poverty in the country *(Nigeria is currently said to be the poverty capital of the world!)*, it means that many Nigerians do not have access to quality health care.
This general healthcare scenario impacts adversely on the clinical laboratory because the clinical laboratory is a critical and indispensable component of the national health system. It is a known fact that any healthcare system can only be as good as its diagnostic services.

## CHALLENGES OF CLINICAL LABORATORY PRACTICE IN NIGERIA

All the general challenges associated with the Nigerian health system are replicated in our clinical laboratories, including:

* neglect and inadequate recognition and prioritization of clinical laboratories

* inadequate resource allocation
* inadequate infrastructure
* lack of constant and good quality power and water supply
* non-availability of modern equipment
* lack of policy/capacity for equipment maintenance
* lack of constant supply of good quality diagnostic kits and reagents.
* lack of regulation and control of sale of diagnostic kits and reagents.
* easy availability/marketing of fake/expired kits and reagents
* poor/manual (paper) laboratory records system/data storage
* lack of modern electronic medical records/laboratory information system (LIS)
* poor regulation and control for the establishment and and supervision of clinical laboratories
  - lack of accreditation policy for clinical laboratories
  - lack of Total Quality Management/Quality Assurance/ Quality Improvement practices in clinical laboratories
  - lack of External Quality Assessment (EQA) programmes
* inadequate professional manpower
* inadequate training/retraining of laboratory personnel.
* severe/harsh/intractable inter-professional rivalry, etc.

## CHALLENGES OF THE LABORATORY TESTING PROCESS IN NIGERIA

The clinical laboratory testing process is a complex system, involving many steps of activity and many people. The process starts with test requisition, filling the laboratory forms correctly and completely and ensuring that the right and

relevant tests are requested, patient preparation, specimen collection, labeling of the specimen, preservation and transportation, laboratory processing and testing, timely reporting of results, proper recording and storage of results and timely delivery of reports to the clinicians.

The complexity of the system requires that these processes and procedures be performed properly to ensure accurate results. These processes are categorized into pre-analytical, analytical and post-analytical phases of the testing process, as enumerated above. Any mistake in any of the steps introduces an error and the total or cumulative error is the sum of the errors in all the steps!

Mr. Vice Chancellor, Sir, there is one other aspect of the clinical laboratory testing process that has not been adequately emphasized in Nigeria. The clinical laboratory operates like a computer. It is whatever you send to the laboratory that it will process and give you an answer - "**garbage in, garbage out**".

This is to emphasize the fact that in addition to the deployment of adequate technical quality control tools, the quality of the results produced by clinical laboratories is also dependent on the quality of samples submitted to the laboratory – **good specimen, good result; bad specimen, bad result!**

Therefore, the quality of a laboratory result does not depend only on the technical quality and capacity of the laboratory and its staff, but also on the competence of other non-laboratory staff involved in the pre-analytical phase of the testing process. If the quality of the specimen submitted to the laboratory is not good, the laboratory result will definitely be of poor quality.

Unfortunately in Nigeria, most of the laboratory specimens collected outside the laboratory, especially those from in-patients (in the wards) and some out-patient clinics,

are obtained by non-laboratory staff, who may not have been sufficiently trained on proper laboratory techniques and methods. ***Available evidence suggests that 70% of the errors that occur with laboratory tests occur during the pre-analytical phase.***

These errors are largely outside the direct control of the laboratory and is affected by the quality and training of the other non-laboratory professionals operating in our hospitals and clinics, who are charged with the responsibility of specimen collection.

In better resourced environments, this problem has been largely solved by the hiring and training of professional **Phlebotomists** and **Laboratory Attendants/Assistants**, who are attached to the wards and out-patient clinics, in a bid to reduce these pre-analytical errors.

There are many peculiar challenges associated with each phase of the laboratory testing process in Nigeria, including the following:-

**(a) Pre-analytic Challenges:**

This phase starts from the stage of test requisition till the specimen is delivered to the laboratory. Most of the activities undertaken at this stage are carried out by non-laboratory staff who are not under the direct control of the laboratory and any errors committed at this stage affect the quality of the final result. To minimize errors at this stage, it is advocated that trained laboratory staff be used to perform some essential aspects of these operations.

The common challenges encountered during this phase include:

(1) Incomplete filling of the request form by clinicians

(a) Patient Identification

- Hospital Number, Name (Surname, First Name, Middle name), Age/Date of Birth, Tribe, Nationality.

(b) Location of Patient - (Hospital/Ward/Clinic)
(c) Provisional Diagnosis/Clinical details
(d) Date and Time of Request/Sampling
(e) Type of Sample – venous/arterial blood, urine, saliva, etc.
(f) Doctor Identification
- Name of Doctor/Consultant, Signature, Telephone No.

(g) Selection of Appropriate Tests by ticking.
- unavailability of many tests

(2) Delays in Payment
- Lack of health insurance, out-of-pocket payment, lack of funds, difficult/cash payment processes, fraud/diversion of funds, diversion of samples to private laboratories.

(3) Delays in Sample Collection
(4) Lack of sample collection consumables/materials
(5) Improper Sample Collection/technique
(6) Improper Sample Storage.
(7) Delay in Sample Transportation/Delivery

In a recent study we conducted in a tertiary hospital in Nigeria (not yet published), we made the following findings in order of frequency:

* Forms/samples that were marked urgent but not truly urgent – 98.5%
* Forms with no clinical details – 83.7%
* Samples improperly labeled – 81.9%
* Forms with patient identification errors – 80.2%
* Request forms without Physician's phone no. – 70.3%
* Samples with inadequate volume – 37.7%
* Forms with inappropriate test request (with respect to clinical question) – 35.0%

* Forms with Physician identification errors – 34.4%
* Requests/samples without time of collection – 25.0%
* Samples with blood stain on the containers/leakages – 23.9%
* Samples not transported in time – 22.8%
* Samples with inappropriate request forms – 13.8%
* Unintelligible request forms – 8.2%
* Forms without provisional diagnosis – 4.7%
* Samples damaged in transport – 3.5%
* Samples collected into inappropriate containers – 1.2%
* Clotted samples – 0.8%
* Haemolyzed samples – 0.3%

**(b) Analytic Challenges:**

The challenges encountered at this stage relate to the professional and technical competence of the laboratory, including the following:-

(i) Availability of trained manpower (frequent reliance on Laboratory Assistants/Attendants)
(ii) State of infrastructure, equipment, power and water supply
(iii) Availability and quality of reagents and kits
(iv) Availability of quality control specimens.
(v) Method of analysis (manual/automation)
(vi) Limitations of test menu.

**(c) Post –Analytic Challenges:**

These challenges relate to the proper recording, transcription, timely dispatch of results to patients and clinicians and proper storage and archiving of results, including:-

(i) Method of record keeping/Transcription (manual/electronic (LIS))
(ii) Delay in Delivery/Transmission of results to end users/prolonged turn-around-time, especially for emergencies.

(iii) Poor communication with clinicians.

The numerous challenges enumerated above in relation to the laboratory testing process in Nigeria define the roles and contributions of the clinical laboratory in the battles for life in Nigerian hospitals and clinics.

***In summary, the testing process in clinical laboratories in Nigeria is associated with many challenges and can be very frustrating for all stakeholders – the patient, the clinician and the Pathologist. The frustration arises from several factors, including:-***

(a) Lack of funds for necessary laboratory tests.

(b) in carrying out requested laboratory tests by the patient.

(c) Long turn-around-time in obtaining laboratory reports/results.

(d) Delay in clinical decision-making/diagnosis/delayed treatment.

(e) Prolonged hospital stay.

(f) Wrong diagnosis/wrong treatment due to inaccurate results.

## TOUTING IN CLINICAL LABORATORIES

Touting is another peculiar problem associated with the laboratory testing process in Nigeria. This has arisen due to the several difficulties experienced by patients during the pre-analytical phase of the laboratory testing process. Due to these frustrations, touts take advantage of these poor patients by offering unsolicited assistance. Many patients fall prey to these advances and part with substantial sums of money (may be slightly cheaper than the official price).

At the best, these touts arrange to process the tests illegally in the hospital laboratories, without paying the proper

fees and without following due process or they take the samples to their substandard private laboratories and produce poor quality results.

In the worst case scenario, they collect the money and the samples and **manufacture fake results** which they hand over to the patient for onward transmission to his doctor.

**This, to say the least, is extreme wickedness and is particularly dangerous.** A vivid case in point was that of a wrongly cross-matched pint of blood sourced from a 'private blood bank', which resulted in the death of a prominent patient in one of our hospitals several years ago.

## SOLUTIONS AND RECOMMENDATIONS

The clinical laboratory professions are practiced universally. We are not expected to re-invent the wheel. All we need to do is to copy and adapt international best practices to our environment.

A few basic measures, as recommended below, would solve most of the challenges associated with the clinical laboratory and laboratory testing in Nigeria, including:-

(i) **Improved Funding for the Health Sector**

- this should start with the implementation of the Basic Health Services Provision Fund as provided for in the National Health Act of 2014 to aid in achieving the minimum 15% of national budget as recommended by the 2001 Abuja Declaration of the African Union.

This should improve funding for the health sector and the clinical laboratory and solve most of the personnel, infrastructure, equipment and consumable needs of the laboratory. **Why has the National Health Act of 2014 not been implemented till date?**

ii) The National Assembly should amend the necessary laws that would pave the way for recognition and support of

Teaching and Specialist Hospitals as **tertiary health educational institutions** by the **Tertiary Education Trust Fund (TETFUND).** This should further improve funding for acquisition of equipment and infrastructure for specialist health manpower training and service delivery and eventually lead to **reduction in medical tourism** in Nigeria. The Federal Ministry of Health should provide the necessary leadership by drafting and driving the process through an executive bill.

(iii) **Compulsory National/Social Health Insurance Schemes** - this would ensure **Universal Health Coverage** and eliminate out-of-pocket payment for healthcare and all the bottle-necks associated with it. This would further improve funding for health services and guarantee improved access and better quality healthcare for all citizens.

(iv) **Streamline and improve legislation for oversight and regulation of clinical laboratory practice** in Nigeria, clearly delineating the job descriptions, roles and responsibilities of the various cadres of staff in clinical laboratories to minimize inter-professional rivalry.

(v) **Mutual respect, co-operation and collaboration between all professional groups** in the clinical laboratory. This will reduce friction and inter-professional rivalry in the clinical laboratory and give rise to better quality results from our clinical laboratories. The various professional associations and groups in the clinical laboratory could champion this initiative.

(vi) **There is an urgent need for a new legislation for compulsory accreditation and licensing** and periodic re-accreditation of clinical laboratories to qualify for clinical service delivery in Nigeria. Legislation for compulsory periodic participation in External Quality Assessment programs should also be instituted. The Federal Ministry of

Health should drive this process with an Executive Bill through the Federal Executive Council.

(vii) **Public and private clinical laboratories in Nigeria should be encouraged to embrace the CDC-sponsored SLAMTA programme** to prepare them for accreditation through improved advocacy and ownership of the program by the Federal and State Ministries of Health.

In conclusion, Mr. Vice Chancellor, distinguished ladies and gentlemen, let me affirm once more that life is our most valuable possession, though it is precarious and under constant threat by disease and death. Life is 'sweet' and however 'tough and rough' life might be, nobody is willing to go to the paradise of heaven in a hurry.

The medical and health professions are engaged in the constant battles for life. The clinical laboratory and the Chemical Pathologist are indispensable members of this formidable medical army because they provide the **intelligence for the battle**, as **LIFE IS NOTHING BUT A CHEMICAL REACTION!**

Mr. Vice Chancellor, Sir, distinguished ladies and gentlemen, let me end this lecture by borrowing from one interesting but soberly intriguing 'poem' on Nigeria obtained from the social media. The author is unknown.

**It describes Nigeria as the land of:**

* History without glory
* Unity without love
* Wars without enemies
* Generals without wars
* Wealth without prosperity
* Billionaires without businesses
* Hunger without famine
* Democracy without citizens
* The oppressed without worries

* Youths without dreams
* Elders without wisdom
* Politicians without ideology
* Leaders without vision
* Heroes without sacrifice
* Policies without plans
* Criminals without fears
* Crimes without culprits
* Terrorists without identity
* Courts without justice
* Religion without piety
* Saints without humility
* Schools without learning
* Intellectuals without thought
* Professors without discoveries;

*I have excluded lines with political connotations to avoid any political labels. However, I have added:*
* Hospitals without healing and
* Clinical laboratories without quality.

**I therefore ask:**
*Is this really who we are?*

**And I plead:**
*Let us reflect and act right!*
***Let us all collectively make Nigeria better from our little corners of influence!***

**THANK YOU FOR YOUR PATIENCE AND ATTENTION!**

## REFERENCES


1. https://health-usnews.com/health-news/patient-advice/articles/2015/01/30/hospital-labs-behind-the-scenes.
2. Perks RW. Accounting and Society;1993:Chapman& Hall (London); ISBN 0-412-47330-5, P.2.
3. Mautner, MN. Seeding the universe with Life: Securing our cosmological future. 2000: Legacy Books, Washington DC.
4. McKay CP. What is life – and how do we search for it in other worlds? PLoS Biology 2004; 2(2(9): 302.
5. Dodd MS et al. Evidence for early life in earth's oldest hydrothermal vent precipitates. Nature 2017; 543(7643): 60-64
6. Hill HG, Nuth JA (2003). The catalytic potential of cosmic dust: implications for prebiotic chemistry in solar nebular and other protoplanetary systems. Astrobiology 3(2): 291-304.
7. Schopf JW, Kitajima K, et al. (2017). SIMS analysis of the oldest known assemblage of microfossils document their taxon-correlated carbon isotope compositions. PNAS 2017; 115: 53.
8. Wade N. (2016). Meet LUCA, the ancestor of all living things. New York Times.
9. Koshland J, Daniel E (2002). The seven pillars of life. Science 295(5563): 2215-16.
10. Trifonov EN (2012). Definition of life: Navigation through uncertainties. J. Biomolecular Struct & Dynamics. Adenine Press 29(4): 647-50.
11. Joyce GF 1995). The RNA World: Life before DNA and protein. Cambridge University Press. pp. 139-51.

12. Pace NR (2001). The universal nature of biochemistry. Proc. Natl. Acad. Sci. USA 98(3): 805-8.
13. Smith E, Morowitz H (2004). Universality in intermediary metabolism. Proc. Natl. Acad. Sci. USA. 101(36): 13168-73.
14. Ebenhoh O, Heinrich R. (2001). Evolutionary optimization of metabolic pathways. Theoretical reconstruction of the stoichiometry of ATP and NADH producing systems. Bull Math Biol 63(1): 21-55.
15. Melendez-Hevia E, Waddell T, Cascante M (1996). The puzzle of the Krebs citric acid cycle: assembling the pieces of chemically feasible reactions and opportunism in the design of metabolic pathways during evolution. J. Mol. Evol. 43(3): 293-303.
16. Cannon WB (1932). The wisdom of the body. New York: W. W. Norton. pp. 177-201.
17. Cannon WB (1926). Physiological regulation of normal states: some tentative postulates concerning biological homeostasis. In: Pettit A, Riches AC. *anis, ses collegnes ses eleves (in French).* Paris: Les Editions Medicales. P. 91.
18. Martin E (2008) A dictionary of biology (6th edition). Oxford. Oxford University Press. pp.315-316. ISBN 978-0-19-920462-5.
19. Kalaany NY, Mangelsdorf DJ (2006). LXRS and FXR: the yin and yang of cholesterol and fat metabolism. Annual Review of Physiology 68: 159-191.
20. Stokes J, Noren J, Shindell S (1982). Definition of terms and concepts applicable to clinical preventive medicine. J. Comm. Health 8(1): 33-41.
21. World Health Organization (2006). Constitution of the World Health Organization – Basic Documents, 45th edition, Supplement, October 2006.

22. World Health Organization. Regional Office for Europe (1984). Health promotion: a discussion document on the concept and principles: summary report of the working group on concept and principles of health promotion; Copenhagen, 9 – 13 July, 1984. Copenhagen: WHO Regional Office for Europe.
23. Definition of death. Encyclopedia of Death and Dying. Advameg Inc. 2007.
24. Henig RM. Crossing over: How science is redefining life and death. National Geographic 2016.
25. Miller FG (2009). Death and organ donation: back to the future. J. Med. Ethics 35(10): 616 – 620.
26. Aubery DNJ (2007). Life span extension research: Societal considerations. Studies in Ethics, Law and Technology 1 (1 Article 5).
27. Tuberculosis Fact Sheet $N^0$104 – Global and regional incidence (http://www.who.int/mediacentre/factsheets/fs104/en/index.html. WHO 2006.
28. Chris T. Global Health/Health, Infections Diseases and Nutrition (2009). USAID's Malaria Programs. (http://www.usaid.gov/our_work/global_health/mch/ch/techareas/malaria_brief.html).
29. Terry L (2006). Aids toll may reach 100 million in Africa. (https://www.washington post.com/wp-dyn/content/article/2006/06/03/AR 2006060300229.html). Washington Post.
30. Ziegler J (2007). *L 'Empire de la honte,* Fayard. ISBN 978-2-253-12115-2. P. 130.
31. WHO (2008). Report on the Global Tobacco Epidemic. (http://www.who.int/tobacco/m/power/mpower_report_full_2008). WHO.

32. The top 10 causes of death. (http://www.who.int.mediacentre/factsheets/fs310/en/index2.html). WHO 2012.
33. Turritopsis nutricula (Immortal jellyfish). (http://www.jellyfishfacts.net/turritopsis_nutricula_immortal_jellyfish.html) 2016.
34. Selye H (1938). Experimental evidence supporting the conception of "adaptation energy". Am. J. Physiol. 123(1938): 758 – 765.
35. Goldstone B (1952). The general practitioner and the general adaptation syndrome. South Afr. Med, J. 26(6): 106 – 109.
36. Gorban AN, Tyukina TA, Smirnova EV, Pokidysheva LI (2016). Evolution of adaptation mechanisms: adaptation energy, stress and oscillating death. (http://www.researchgate.net/publication/287251014_Evolution_of_adaptation_mechanisms - Adaptation energy, stress and oscillating death. J. Theor. Biol.
37. MarketWatch (2018). Clinical laboratory services market size is projected to be around US$146 Billion by 2024.
38. Medgadget 2018. Global clinical laboratory services market growing with 7.1% CAGR by 2023 – Leading players are Spectra Laboratories, Sonic Healthcare Ltd, Siemens, Quest Diagnostics, Qiagen and More.
39. Thayer AM. Top instrument firms in 2016. Chemical Engineering News Vol. 96, Issue 10, March 6, 2017.
40. Morel C, McClure L, Edwards S, Goodfellow V, Sandberg D, Thomas J, Thomas J, Mossialos E. Overview of the diagnostic market. European Observatory on Health Systems and Policies 2016.
41. Nyenwe EA, Odia OJ, Ihekwaba AE, **Ojule AC**, Babatunde S. Type 2 diabetes in adult Nigerians: a study of its prevalence and risk factors in Port

Harcourt, Nigeria. Diab. Res. Clin. Pract. 2003; 62: 177 – 185.
42. Frank-Briggs AI, **Ojule AC**, Nkanginieme KE. Neonatal hypoglycaemia: Prevalence and clinical manifestations in Port Harcourt, Nigeria. Port Harcourt Med. J. 2008; 2: 166 – 170.
43. **Ojule AC**, Obayemi IO. Plasma glucose level in children with diarrhea. Nig. Postgrad. Med. J. 1999; 6(4): 186 – 188.
44. Akanji AO, **Ojule AC**, Kadiri S, Osotimehin BO. Plasma glucose and insulin responses to oral glucose loading in non-obese Nigerian subjects with essential hypertension. J. Nat. Med. Assoc. 1993; 85: 267 – 272.
45. Ihekwaba AE, **Ojule AC**. Morbidity pattern of diabetic admissions at the University of Port Harcourt Teaching Hospital. J. Med. Invest. Pract. (JOMIP) 2001; 3: 23 - 25.
46. Orluwene CG, **Ojule AC**. Plasma cholinesterase activity in obeses type 2 diabetics. Port Harcourt Med. J. 2006; 1: 39 – 43.
47. Orluwene CG, **Ojule AC**. Microalbuminuria and the metabolic syndrome in obese type 2 diabetics. Port Harcourt Med. J. 2007; 2: 61 – 66.
48. Ejilemele AA, **Ojule AC**, Orluwene CG. Plasma glucose in a reference population in Port Harcourt Nigeria. Port Harcourt Med. J. 2008; 2: 228 – 232.
49. **Ojule AC**, Abbiyesuku FM, Osotimehin BO. Endemic goiter prevalence in Ifedapo Local Government Area of Oyo State, Nigeria. Afr. J. Med. Med. Sci. 1998; 27: 77 – 81.
50. **Ojule AC**, Osotimehin BO. Maternal and neonatal thyroid status in Saki, Nigeria. AFr. J. Med. Med. Sci. 1998; 27: 57 – 61.

51. **Ojule AC**, Osotimehin BO. The influence of iodine deficiency on the cognitive performance of school children in Saki, South-West Nigeria. Afr. J. Med. Med. Sci. 1998; 27: 95 – 99.
52. **Ojule AC**, Ejele AO, Opurum HA. HIV Infection: Risk of occupational exposure in a Chemical Pathology laboratory in Nigeria. Nig. Postgrad. Med. J. 2001; 8(2): 78 – 80.
53. Ejele AO, **Ojule AC**. HBsAg: Risk of occupational exposure in a Chemical Pathology laboratory. Nig. J. Clin. Pract. 2003; 6(2): 99 – 101.
54. Ejilemele AA, **Ojule AC**. Health and safety in clinical laboratories in developing countries: safety considerations. Nig. J. Med. 2004; 13(2): 182 – 188.
55. Ejilemele AA, **Ojule AC**. Knowledge, attitudes and practices of laboratory safety at the University of Port Harcourt Teaching Hospital, Nigeria. Nig. J. Clin. Pract. 2005; 8: 102 – 106.
56. Ejele AO, **Ojule AC**. Human Immuno-Deficiency Virus (HIV 1 & 2) screening at the University of Port Harcourt Teaching Hospital: A ten year review (1989 – 1998). J. Clin. Pract. 2001; 4(2): 64 – 68.
57. Ejele OA, **Ojule AC**. The prevalence of Hepatitis B surface antigen (HBsAg) among prospective blood donors and patients in Port Harcourt, Nigeria. Nig. J. Med. 2004; 13(4): 336 – 338.
58. **Ojule AC**, Akani CA, John CT, Opurum HA. Sero-prevalence of HIV in pregnant women in Port Harcourt, Nigeria. Nig. J. Med. 2004; 15(1): 44 – 48.
59. **Ojule AC**, Akani CA, Opurum HA, Ejilemele AA. Sero-prevalence of HBsAg in pregnant women in Port Harcourt. Nig. Postgrad. Med. J. 2005; 12(4): 266 – 270.

60. **Ojule AC**, Akani CI, Opurum HC. Sero-prevalence of in Hepatitis C antibodies in pregnant women in Port Harcourt, Nigeria. Port Harcourt Med. J. 2008; 3: 66 – 61.
61. **Ojule AC**, Ezeodili PA, Akani CA. Plasma sodium and potassium during pregnancy in Nigerian subjects. Nig. Postgrad. Med. J. 2000; 7(4): 159 -162.
62. **Ojule AC**, Akani CA, Opurum HC. Plasma lipids in pregnant subjects in Port Harcourt, Nigeria. Nig. J. Med. 2005; 14 (2): 55 –
63. **Ojule AC**, Ikpeazu O, Okpani OAU. Effect of hormonal contraceptives on plasma protein concentrations of Nigerian females. Trop. J. Med. Research 2002; 6(2): 28 – 32.
64. Ajay T, Christopher JLM, Jeremy AL, David BE. Measuring overall health system performance for 191 countries. GPE Discussion Paper Series: No. 30. EIP/GPE/EQC. World Health Organization. (https://www.who.healthinfo/paper 30.pdf).
65. Africa Check (2018). Nigeria spends 5 times less per person on healthcare than South Africa, not 7. (https;//www.africacheck.org/reports). 5th April 2016.

**PROFESSOR AARON CHINONYE OJULE**
(MBBS; MSC; FMCPath)
PROFESSOR OF CHEMICAL PATHOLOGY

Aaron Chinonye Ojule was born to the family of Chief and Mrs. Appolos Ojule of Elele-Alimini in Emohua Local Government Area of Rivers State, Nigeria on the 8th day of April, 1957.

He started his educational journey from State School, Elele-Alimini, where he obtained his First School Leaving Certificate (FSLC) after attending the institution from 1964-1970. He proceeded in 1971 to the prestigious Government Comprehensive Secondary School, Borikiri, Port Harcourt, Rivers State for his secondary school education and obtained the West Africa School Certificate in 1975 with Grade 1 (Distinction). He thereafter attended the then College of Science and Technology (now Rivers State University), Port Harcourt, where he obtained his G.C.E A'/L (in Physics,

Chemistry and Biology) in 1977. Between 1977 and 1978, he was a Science Teacher at St. Aquinas' Secondary School, Elele, in Ikwerre Local Government Area of Rivers State. In 1978, Aaron Ojule gained admission into the College of Medicine of the University of Lagos and obtained the MBBS degree of the University in 1983 and won that year the BISOLA OGUNWO-OSHINOWO prize for the best over-all student in Obstetrics and Gynaecology.

Aaron Chinonye Ojule had a passion for Obstetrics and Gynaecology and passed the Primary examination of the National Postgraduate Medical College of Nigeria in Obstetrics and Gynaecology in 1985 after his internship period at the University of Lagos in 1984. Destiny and providence, coupled with the strong advice from Professor Nsirim Nduka, drove Aaron Ojule into Chemical Pathology. He obtained M.Sc. (Chemical Pathology) from the University of Ibadan in 1990 while in his residency training at the University College Hospital, Ibadan. Being a very brilliant scholar, he completed his residency training within the record time, obtaining a Fellowship of the National Postgraduate Medical College of Nigeria in Chemical Pathology (FMCPath) in 1992.

Professor Aaron Ojule enjoyed several scholarship awards as a brilliant student, for example:

Elele-Alimini Community Scholarship-1969-1970
Rivers State Government Scholarship – 1971-1975
Rivers State Government Scholarship – 1978-1983
Superanumerary Residency Training at UCH, Ibadan by UPTH management – 1988-1992, just to mention a few.

In the course of his educational pursuit, Professor Aaron Ojule received more than 55 awards, honours and distinctions.

He started work at the Lagos University Teaching Hospital (LUTH), Lagos, as an intern in 1983. He also worked with the Nigerian Air force Medical Centre, Benin City, Edo

State from 1984-1985 during his National Youth Service Corps Programme. Between 1985 and 1986 he worked as a Medical Officer with the International Medical Centre, Port Harcourt. Prof. Aaron Ojule joined the services of the University of Port Harcourt Teaching Hospital (UPTH) in 1986 as the very first Casualty Officer of the hospital – a position he left in 1988 to start his residency training at the University College Hospital (UCH), Ibadan under the sponsorship of the University of Port Harcourt Teaching Hospital (UPTH).

Professor Ojule joined the services of the University of Port Harcourt in 1993, after his residency training, as Lecturer 1/Consultant Chemical Pathologist. He rose steadily through the ranks to become Professor of Chemical Pathology in 2009. He served in various capacities in the University e.g. Acting HOD, Co-ordinator of Pathology, Associate Dean and Acting Dean of the Faculty of Basic Medical Sciences. He served in various capacities in the UPTH – Consultant Chemical Pathologist, Head of Department, Project Manager, Deputy Chairman, Medical Advisory Committee (DCMAC), Chairman, Medical Advisory Committee (CMAC) and Chief Medical Director (CMD).

He has successfully handled various positions of trust in his community, University of Port Harcourt, University of Port Harcourt Teaching Hospital, Professional associations, etc. He had served as a member of the Council of the Nigerian Institute of Management (NIM) and the Governing Board of the Bowen University Teaching Hospital (of the Nigerian Baptist Convention), Ogbomosho, Oyo State. He is presently a member of the Governing Council of the Rivers State University.

He is a member of the following professional organizations:

Nigerian Medical Association, College of Nigerian Pathologists, Nigerian Cancer Society, Nigerian Diabetes Association, Medical and Dental Consultants Association of Nigeria (MDCAN), Academic Staff Union of Universities (ASUU), American Diabetes Association, Nigerian Society of Endocrinology and Metabolism, Nigerian Institute of Management, Fellow of the Institute of Hospital Administrators of Nigeria, Fellow of the Health Insurance and Managed Care of Nigeria, Society of Electronic and Telemedicine in Nigeria, etc.

He is an Examiner to the National Postgraduate Medical College of Nigeria and External Examiner to many Medical Schools in Nigeria. He has to his credit more than forty (40) scholarly articles in many National and International Journals. He had edited many learned journals.

He is a devoted Christian of the Baptist denomination and a former President of the Baptist Men's Fellowship, Faith Baptist Church, Port Harcourt. He is married to his heart-throb, Dr. (Mrs.) Inumanye N. Ojule (Nee Dennar), a Consultant Public Health Physician and Lecturer, Department of Community Medicine, College of Health Sciences, University of Port Harcourt. The marriage is blessed with four lovely children.

**Professor Ndowa E. S. Lale**
Vice-Chancellor