
11 Capacity Building in Contemporary Biotechnology in Nigeria *History, Impact and Way Forward*

Sylvia Uzochukwu
Federal University

Christie Onyia
Godfrey Okoye University

Nwadiuto Esiobu
Florida Atlantic University
Applied Biotech International Nigeria Ltd

Joan Campbell
Frederksberg Hospital

Paul Keese
Office of Gene Technology Regulator

Ivan Ingelbrecht
FAO/IAEA Laboratory on Plant Breeding and Genetics

Alex Ochem
Cape Peninsula University of Technology

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11.1 INTRODUCTION

The 21st century has been referred to as the age of biology, driven by monumental discoveries and innovations in the field of molecular biology, with gene cloning and DNA manipulations at its core (Glover, 2012). In the 1990s, recombinant insulin, first approved for use in 1982 (Sandow et al., 2015) had already taken over diabetes control in the world. Also, in the Americas and Canada, genetically modified (GM) crops had already enjoyed many years of use, starting with the approval of the GM tomato Flavr Savr in 1992 (Aldemita et al., 2015), but most of Africa was yet to get involved. African scientists, who are otherwise talented in their various fields in the life sciences, lagged in the new biology. The lack of competence in basic molecular biology principles and techniques impacted teaching and learning at all levels. As a result, their graduates were poorly equipped for contemporary scientific research at the cutting-edge of modern biotechnology. The scientists however recognized that the situation put the continent at risk of losing the opportunity to join the rest of the world in achieving food security, affordable health care, sustainable environment and other benefits of the life science revolution.

It, therefore, became imperative to seek strategies for building up a critical mass of home-based scientists competent in the new techniques, who could lead the continent's growth in DNA and gene technology. In Nigeria, human capacity building and training became the top priority of all stakeholders, requiring the need for collaborative efforts of home-based scientists, government, the private sector, diaspora and international bodies/institutions, donor agencies and the Biotechnology Society of Nigeria (BSN).

Short, intensive train-the trainers workshops were visualized as the fastest means of raising the urgently needed critical mass of scientists competent in the new molecular biology techniques in Nigeria, and universities, research institutes and the private sector took up the challenge.

11.2 HISTORY OF BIOTECHNOLOGY CAPACITY BUILDING IN NIGERIA

The federal government of Nigeria, in realization of the role biotechnology could play in solving these problems, set up a new outfit, known as the National Agency for Science and Engineering Infrastructure (NASENI), established in 1992 (NASENI, 1992) of which biotechnology programme was part of until 2001, when National Biotechnology Development Agency (NABDA) was created (NABDA, 2001). NABDA's mandate is promotion, coordination, and deployment of cutting-edge research and development, processes and products for the socio-economic well-being of the nation; while her vision is to promote biotechnology activities that positively respond to national aspirations of food security, job/wealth creation, affordable healthcare delivery and sustainable environment.

To accelerate the development and application of biotechnology to national development, the Executive Chairman of NASENI, late Prof. Godian Ezekwe, set up a seven-man committee to advise the government and develop the road map and time line for achieving the set goals, with the coordinating Director of Science Infrastructure, Hon. Prof. R. A. Borofice as chairman and Dr. Christie Oby Onyia, the first Desk Officer for Biotechnology in Nigeria, as Secretary. Based on their recommendations, the first National Conference on Biotechnology was organized and held in Durbar Hotel, Lagos, in 1993, followed by development of vision 2010 for capacity building in biotechnology and development in Nigeria, with the assistance of UNESCO. The main thrust was to train 1,000 first-generation Nigerian biotechnologists in the focussed areas of fermentation technology, tissue and cell culture techniques and marker-assisted/DNA techniques.

Prior to this, assessment of the existing facilities and human resources capacity needs of the country was carried out by NASENI and the Israeli embassy in Nigeria. The exercise was successfully conducted by two Israeli consultants assisted by Nigerian scientists, with the financial support of both governments. With the adoption of their report, Obafemi Awolowo University, Ile-Ife, and Federal Institute for Industrial Research, Oshodi, were designated centres of excellence for fermentation technology; University of Nigeria, Nsukka, Nnamdi Azikiwe University, Awka, and Bioresources Development and Conservation Programme were mandated to develop capacity in tissue and cell culture techniques, while NASENI (Biotechnology Programme) and International Institute for Tropical Agriculture (IITA), Ibadan, were to conduct training workshops and training in deployment of marker-assisted and DNA technologies for crop improvement and food security, in order to achieve the goals set out in Nigeria's vision 2010 for manpower development. However, before the turn of the century, Nigeria had created enough interest in the adoption of advances in new technologies, including space science and biotechnology, resulting in the creation of two agencies known today as: (1) National Space Research and Development

AU: Please expand "UNESCO".

Agency (NASRDA), founded in 1999, and (2) establishment of advanced laboratory for biotechnology research and development in Sheda Science and Technology Complex (SHESTCO), in 1994, and NABDA in Abuja 2001.

In the realization of the importance of public-private partnership (PPP) in this sector, the Nigerian government, under the leadership of President Olusegun Obasanjo, launched the Diaspora Science Day, thereby throwing the door open for collaborations between scientists and entrepreneurs at home and abroad – fostering capacity building and training in different areas of endeavour, including biotechnology.

11.3 EARLY CAPACITY BUILDING EFFORTS IN DNA TECHNOLOGY TECHNIQUES IN NIGERIA

11.3.1 FOUNDATION FOR AFRICAN DEVELOPMENT THROUGH INTERNATIONAL BIOTECHNOLOGY (FADIB)

FADIB was founded in 1992 by Professor Nduka Okafor, a Professor of Microbiology then at the University of Nigeria Nsukka. He was perhaps the first to make spirited efforts towards developing a critical mass of African scientists to drive the DNA revolution in Nigeria and sub-Saharan Africa. FADIB's annual hands-on training workshops were basically on gene cloning and recombinant DNA technology through sourced grants from the United Nations Development Programme (UNDP), United Nations Environment Programme (UNEP), etc. Resource persons, with relevant expertise, were drawn from across the globe, until 2006, when he stepped aside as the convener. FADIB has however continued with its annual activities, now limited to national conferences and workshops under the leadership of Prof. James C. Ogonna of the University of Nigeria, Nsukka.

11.3.2 DANIFOL BIOTECHNOLOGY CONSULT LIMITED

DANIFOL Biotechnology Consult Limited was founded and registered in 1998 by Dr. Daniel Olukoya, a molecular biologist and then a researcher at National Institute for Medical Research (NIMR), Yaba, Lagos. The outfit, after inception, trained and issued certificates in Molecular Biology Techniques: Genome Analysis for a few years. Dr. Daniel Olukoya was a member of the seven-man committee set up by NASENI to draft the blueprint for development of Nigeria's biotechnology, of which Dr. Christie Onyia was the Secretary.

11.3.3 CONTRIBUTIONS OF THE UNIVERSITY OF AGRICULTURE ABEOKUTA (UNAAB, NOW FEDERAL UNIVERSITY OF AGRICULTURE, FUNAAB)

The next major sustained impetus for capacity building in modern biotechnology and DNA techniques came from UNAAB, now FUNAAB (Uzochukwu 2008, Uzochukwu, et al., 2012).

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11.3.4 THE ROLE OF THE NIGERIANS IN THE DIASPORA

Many of the home-based Nigerian scientists who felt ill-prepared for the DNA revolution in their various fields sought to address this deficiency by seeking short training courses abroad, but this approach was both expensive and limited in impact. In 1999, a Nigerian scientist in the Diaspora, Dr. Joan Campbell-Tofte, herself a former undergraduate and Master's student of Prof. Nduka Okafor, and an Edinburgh-trained molecular biologist, rationalized that intensive short training courses organized in Nigeria by a Nigerian expert domiciled in a western country will be the fastest way to address this need and build human and infrastructural capacity in the new DNA technology. She envisaged that lectures and laboratory work spanning from fundamental to applied topics presented to Faculty would allow for maximal learning outcomes. She collaborated with Dr. Sylvia Uzochukwu, then of UNAAB, who assembled a team in UNAAB, and in 2000, they commenced a series of annual 2-week intensive hands-on training courses in DNA manipulating techniques, Bioinformatics and Biosafety of GM organisms. The courses were known as the UNAAB Summer Courses in Biotechnology and were designed to re-train scientists in the life sciences in Nigeria, on techniques for manipulating nucleic acids. Dr. Campbell-Tofte sourced the grants for the first two years, from Denmark, to support her participation and to purchase vital equipment and reagents. She bought the first molecular biology equipment in FUNAAB from these grants and single-handedly taught the practical classes and mentored participants, those first years. The university showed its appreciation, by creating a Biotechnology Centre, in 2001, after the second course. It was probably the first in the country under the Pioneer Directorship of Professor Isola Adamson.

Other Nigerian scientists in the Diaspora worked with the group at different times including Dr. Alex Ochem, a molecular biologist, who supported the work of the group every summer for the training workshops from 2005 to 2009, by his employers, the International Centre for Genetic Engineering and Biotechnology (ICGEB), Trieste, Italy. He helped source grants and reagents, taught the courses and mentored scientists.

Professor Diuto Esiobu, another Nigerian biotechnology expert at Florida Atlantic University, USA, in the Diaspora, member of the Board of the Education Committee of the American Society for Microbiology in Washington DC, was invited by the Obasanjo administration to give the keynote address at the first annual Nigeria Science Diaspora summit 2005 in Abuja. Following a highly insightful talk on the applications of biotechnology in nation building and development, she was introduced to the UNAAB team by NABDA in 2006, to help with their re-training programme. She joined the UNAAB team's summer workshop efforts from 2007 to 2009. Applying the proven active learning, intensive short course approach, already in use by the American Society for Microbiology (ASM), Prof Esiobu introduced transformative pedagogy (Esiobu et al., 1999) helped source grants for her participation, equipment and reagents and mentored scientists on ground. Altogether, a series of 14 training workshops responsible for the paradigm shift in biotechnology manpower development in Nigeria between 2000 and 2009 were designed and presented by the UNAAB group.

11.3.4.1 The Role of the International Scientists in Nigeria

The secret of the success and sustainability of these initial courses was collaboration with Nigerians in the Diaspora, but the secret of the survival of the courses at all lay with the international scientists within the country. The Biotechnology Laboratory of IITA played a major role in nurturing the courses within the first five years, with its scientists serving as resource persons and bringing their equipment. This collaborative effort between the organizing Nigerian scientists, the Nigerian scientists in the diaspora and international scientists in Nigeria was the key to the success of these re-training courses.

11.3.4.2 Target Participants

Target participants included scientists from national research institutes, university lecturers and post-graduate students, and on one occasion, a special one was held just for final year undergraduates in the life sciences.

11.3.4.3 Course Curriculum

Scheme of work included active learning and hands-on exercises, lectures and laboratory practical work covering fundamentals of molecular biology, gene structure, gene cloning, gene expression and analysis, DNA manipulation, as well as extraction and purification of proteins. All participants presented personal projects, and team projects were built into the work schedule. Assessment of learning outcome was based on responses to questionnaires after each course as well as written tests and peer evaluations of team projects and presentations.

The original course curriculum and manual was developed by Dr. Joan Campbell-Tofte, now of the Department of Clinical Biochemistry, Frederiksberg Hospital, Denmark, and was later improved with input from the other scientists in the Diaspora – Prof Diuto Esiobu of Florida Atlantic University, USA, and Dr. Alex Ochem of ICGEB, Trieste, Italy.

11.3.4.4 Faculty

Participating Faculty consisted of the organizing group of Scientists at the University of Agriculture, Abeokuta, the Nigerian Diaspora (scientists) practising in developed countries and International Scientists in Nigeria. The scheme benefited from a Federal government initiative which brought home notable Nigerian scientists in the Diaspora, during the summer, and invited universities to send local scientists to interact with them. It was at such Diaspora meetings that Drs. Ochem and Esiobu were introduced to the UNAAB team.

Guest lecturers were invited to lecture on important related topics, especially Biosafety, Bioinformatics and Intellectual Property Rights (IPRs). Such Guest Lecturers were usually drawn from the Biosafety Desk of the Ministry of the Environment, which was the Focal Point for Biosafety in Nigeria, as well as from NABDA, and SHESTCO.

As already mentioned, international scientists at the nearby IITA were an important reason the FUNAAB re-training workshops survived the first five years. Collaboration with locally available expertise was vital for the success of this enterprise. The authors of this chapter are the international and national resource persons during the period

2000–2009, and the leader of the local team at FUNAAB, Prof. Sylvia Uzochukwu. The names of the other members of the local team are given later in this chapter.

11.3.4.5 Funding

Support came in cash and kind from international donor grants, first at the instance of the Nigerian scientists in the Diaspora and later at the instance of the FUNAAB team. The success of the first two courses created donor-confidence, and the grants grew from very modest few thousand dollars to hundreds of thousands of USD. Counterpart funding from the university consisted of provision of laboratory space, board for visiting experts, salaries of the local personnel and other facilities such as electricity and water. The university responded to the activity of the group not just by creating a biotechnology centre in 2001 but also by following up thereafter, with the erection of a beautiful befitting biotechnology centre building in 2008. The solid support of the university was the most important factor responsible for the take-off and sustenance of the courses (Table 11.1).

TABLE 11.1
Summary of Donor Support for UNAAB Summer Courses in Biotechnology, 2000–2009

S/N	Donor	Grant to	Year	Purpose of Grant
1	World Bank STEP-B Project	Prof. Sylvia Uzochukwu and team	2009	Equipment for the new biotech centre, air fare and full support for two experts, and for one short course
2	International Centre for Genetic Engineering and Biotechnology (ICGEB)	Dr. Alex Ochem and Prof. Sylvia Uzochukwu	2009	Full support for one short course
3	Academy of Science for Developing Countries (TWAS)	Prof. Diuto Esiobu and Prof. Uzochukwu	2008	International expert grant for air fare and support for expert
4	American Society for Microbiology (ASM) USA	Prof. Diuto Esiobu and Prof. Sylvia Uzochukwu	2007	International professorship grant for air fare, equipment and support for expert
5	International Centre for Genetic Engineering and Biotechnology (ICGEB)	Dr. Alex Ochem	2005–2009	Air fare and support for expert, and reagents
6	USAID NARP Project in Nigeria: sub-grant	Prof. Sylvia Uzochukwu	2004	Equipment and tuition support for one short course
7	International Institute for Tropical Agriculture (IITA)	Dr. Paul Keese and Dr. Ivan Ingelbrecht	2000–2005	Loan of equipment, consumables and faculty
8	Society for General Microbiology (UK)	Dr. Campbell-Tofte	2001	Air fare, equipment and reagents, and support for expert
9	Plasmid Foundation, Denmark	Dr. Joan Campbell-Tofte	2000	Air fare, equipment and reagents, and support for expert

11.3.4.6 Course Fees

Whenever there was a moderate grant, the courses were tuition-free so that the younger scientists, who really needed the training, could attend. When there was no grant or the grant was small, the participants had to pay a minimal tuition fee, to cover cost of reagents and logistics. It was not the intention of the organizers to use the course as a source of internally generated revenue for the university. It was not for profit but entirely for service to the country. For all courses, participant selection was based on perceived need, as judged from applicants' curriculum vitae.

It is important that efforts towards similar re-training initiatives be directed towards making them tuition-free, and never seeing them as a source of revenue for hosting institutes and organizations. When tuition is paid in Nigeria for such training courses, most of the participants will be those who don't need the course, such as friends and cronies of chief executives.

11.3.4.7 Impact of Training Courses

Over 500 scientists from 46 tertiary institutions were trained in 14 1- to 2-week intensive courses. Courses were at first for two weeks, but experience showed that 1 week was optimal duration for the course. Longer courses wore out the resource persons due to the high intensity of the courses. While the vast majority of course graduates were Nigerians, a small percentage came from Togo, Argentina, Benin, Ghana, Iran, Cameroon and Rwanda. Post course assessment and research proposals presented by participants at the end of courses showed 40%–80% improvement in grasp of key molecular biology techniques and applications presented. Nearly 100% of participants acknowledged the courses as relevant and eye-opening.

Project impact

- A world-class Biotechnology Centre Building at the Federal University of Agriculture, Abeokuta, built by the university authorities in response to the course activities, and equipped with a World Bank STEP-B grant, also in response to the course activities.
- A much-increased national awareness for modern biotechnology and biosafety was achieved – 500 scientists from 46 tertiary and research institutions.
- Up to 40 tertiary institutions and research institutes in Nigeria established biotechnology centres and departments, often initiated and headed by alumni of the courses, who then began to organize their own training courses.
- Revision of biotechnology curricula in Nigerian universities, and establishment of policy to guide it by the National Universities Commission, in response to the increased biotechnology awareness.
- The condensed intensive courses were relatively inexpensive platforms compared to observed transformational impact created.

The FUNAAB Home Team 2000–2009 (Titles are as at 2009)

- Prof. Sylvia Uzochukwu
- Prof. Mobolaji Bankole
- Dr. Yinka Edema

- Dr. Akin Popoola
- Dr. Emily Ayo-John
- Emmanuel Idehen
- Dr. Toyin Opeolu
- Dr. Andrew Agbon
- Johnson Oyewunmi
- Dr. Tumi Adebambo
- Dr. Martha Bemji
- Dr. Olusegun Atanda
- Dr. Peter Akintokun
- Mr. Ibiwunmi Oloye

11.3.5 CREATION AND ROLE OF APPLIED BIOTECH INTERNATIONAL NIG. LTD (ABINL) IN BUILDING BIOTECH EXPERTISE

As the myth of the new DNA science was being decoded and many researchers, academic staff and technologists were being trained, two major gaps and unresolved needs became apparent. First, the urgency of the need to scale the train-the-trainer effort; and second, the lack of any well-established functional laboratories in most of the universities and government research institutions meant that the workshop participants could not grow the new skills learned. Even when funds or donations were available, the paucity of basic understanding and skills made it near impossible for the economy of scale to apply. Many of the participants at the workshops lamented that they produced graduates who were outdated in the fundamentals and applications of contemporary life sciences! To meet the urgency to widen the training of trainers and take the emerging science to home institutions where more persons will have access, Prof. Diuto Esiobu launched the first major Nigerian private biotechnology company – Applied Biotech International Nigeria Ltd (ABINL) in 2006. ABINL rapidly developed mobile training labs with the founders' personal funds, partnered with the National Biotechnology Development Agency, under Professor Bamidele Solomon and other home-based scientists to take the innovative learning techniques to universities and government research institutes, reaching participants from nearly all the six geopolitical regions of the country. Between 2006 and 2016, more than 600 participants from all geopolitical regions of the country had been trained, creating the paradigm shift that created a whole generation of current biotechnology leaders in Nigeria. By taking the training to the universities and research institutes, capacity building workshops became more cost-efficient and allowed local post-graduate students and technologists, who would not have been able to afford the travel and lodging expenses to distant locations, to attend and participate. At the same time, applied biotech staff was able to provide free consultancy for many universities and helped to procure equipment, design laboratories and establish functional world-class biotech centres around the country. **ABI Nigeria** is run as a social enterprise where the funds realized from setting up labs are ploughed back into developing a world-class laboratory at Wuye, Abuja, for researchers and graduate students to come and receive personalized training and mentoring in advanced biotech research protocols. Sample drop-off services are also available for molecular analysis of all types of samples

AU: Please clarify if "ABI Nigeria" and "ABINL" are the same or different.

(microbes, animals, plants and biodiversity). In addition, ABI Nigeria facilitates regular workshops beyond the basics at its headquarters in Abuja, thus complementing the basic molecular biology workshops of UNAAB and other universities. In collaboration with the BSN and international partners, ABINL is working to introduce accreditation and certification exams covering theoretical and laboratory skills to ensure a quality and skilled workforce in Nigeria.

To provide real-life, practical experience in biotechnology for the growing population of young learners, Applied Biotech Nigeria established internship programmes and hopes to expand its reach as resources grow. In addition to providing paid internships to undergraduates in biotech, the privately run company provides research scholarships for graduate researchers at the annual BSN international meetings and helps to organize and run the pre-conference workshops at the widely acclaimed annual international conferences of the BSN. Further to providing quality research materials to laboratories, ABI also assists Nigerian scientists by bringing international partners for networking and expanded services. The full suite molecular biology laboratory is equipped with world-class functional equipment for microbial culture, food, water and soil quality tests, metagenomics, plant and animal barcoding, protein analysis and functional genomics research. With its partners and collaborators, applied biotech guarantees minimal sequencing costs – Sanger and next generation, as well as metagenomics research and analysis.

For more than one decade, Applied Biotech Nigeria has operated with the vision of powering Nigeria's bioeconomy through development of skilled workforce, leadership in research direction and design and equipping of research infrastructure to address all aspects of the sustainable development goals. The company is honoured to be among the leading experts involved in designing and creating the bioeconomy strategic blueprint for Nigeria. Beyond the shores of Nigeria, Applied Biotech Nigeria is helping to shape the Global Bioeconomy through international advocacies and hosting a workshop at the Global Bioeconomy Summit 2020 (www.GBS2020.net). As the needs of Nigeria as a country grows, applied biotech diversifies its modalities, investing into virtual training equipment and expanding its programmes into a department of accredited tertiary molecular diagnostics laboratory for detection and precise identification of human, animal and plant pathogens, including all viruses, bacteria and fungi. The lack of adequate capital, limited policy support (tax rates, power & infrastructure resources) and complicated business ecosystem remain the major handicaps in growing and scaling private biotech companies in Nigeria. Yet, the private sector is pivotal to shaping the economy and job ecosystem through translation of research into products and services. A deliberate path to support a healthy growth and participation of private companies will provide wealth and jobs for the burgeoning brilliant Nigerian youth.

11.3.6 THE ROLE OF NABDA IN CAPACITY BUILDING

The initial focus of NABDA was developing capacity in Bioinformatics, as follow-up on the achievements of NASENI and other stakeholder in training in biotechnology. The first NABDA's national workshop on Bioinformatics was held in 2003 under the supervision of Prof C. P. E. Omaliko as the Director General of NABDA, who

subsequently created the Department of Bioinformatics and Molecular Biology. Several workshops and trainings were conducted in partnership with National Information Technology Development Agency (NITDA), IITA, etc. NABDA acknowledges the contributions of biotech registered companies, especially Applied Biotech Institute (ABI), Nigeria, headed by Prof N. Esiobu for her concerted efforts in holding several trainings/workshops in collaboration with NABDA. These collaborative efforts with ABI and other individuals both at home and in diaspora led to the development of an award-winning grant proposal – the STEP-B projects. The over \$54 million grant, secured under the dynamic leadership of Prof. B. O. Solomon, enabled NABDA to equip her zonal centres located in North-East Zonal Biotech Centre in the University of Maiduguri; South-East Zonal Biotech Centre in the University of Nigeria, Nsukka; South-West Zonal Biotech Centre in the University of Port-Harcourt; and NABDA headquarters in Abuja. The availability of these state-of-the-art equipment has accelerated capacity building and training in Nigeria, thereby enabling the country to leap-frog into the new era of application of biotechnology in national development.

11.3.7 DNA LEARNING CENTER NIGERIA (DNALC) – NIGERIA

- The DNALC-Nigeria was established to pioneer a shift from theoretical instruction of modern biology to hands-on and inquiry-based learning. The centre was conceived through a collaboration between CSHL, Bowie State University and GOU. It is the first hands-on teaching institution of its kind in Africa. The objective of DNALC-Nigeria is to offer the same hands-on lab experience in Nigeria as is offered at the DNALC in Cold Spring Harbor, providing teachers, professors and students with lab and analytical skills needed for scientific discoveries for the benefit of mankind. We prepare students to pursue successful graduate and post-graduate research in American universities.

AU: Please expand "CSHL" and "GOU".

DNALC, an operating unit of Cold Spring Harbor Laboratory is the world's first science centre, devoted to public genetics education and research. The DNALC is the world's largest provider of student lab instruction in molecular genetics, operating teaching laboratories throughout Long Island and Manhattan and more recently opened in China and Mexico.

11.3.8 DNA LEARNING CENTER (DNALC) – NIGERIA

DNALC-Nigeria was established in the permanent site of Godfrey Okoye University, located at Ugwuomu, Nike, Enugu, in 2019, after receiving licence, worth \$300,000.00 from DNALC NYC, in support of the centre. The objective of the centre, which was conceived through collaboration between CSHL, Bowie State University and GOU, is to pioneer a shift from theoretical instruction of modern biology to hands-on and inquiry-based learning.

AU: Please check if the paragraph can be combined with the previous section as the section headings are the same.

The vision of the centre is to make it a reference point of excellence in scientific training and research, while the mission is to support molecular biology training and research by facilitating adequate hands-on laboratory experience in Nigeria and

AU: The sentence starting "The objective of DNALC Nigeria..." seems to be a repetition of the sentence in previous section. Please check if it can be deleted.

Africa at large. The objective of DNALC-Nigeria is to offer the same hands-on lab experience in Nigeria as is offered at the DNALC in Cold Spring Harbor, providing teachers, professors and students with lab and analytical skills needed for scientific discoveries for the benefit of mankind. Total number of teachers and faculties trained at the lab till date is 117. The total number of Alumni of Godfrey Okoye University that have benefited from the study abroad programme is nine as at 2019 and two more have been admitted to benefit.

11.3.8.1 Board of Trustees – DNALC-Nigeria

The board of trustees of DNALC-Nigeria was inaugurated at Godfrey Okoye University on Thursday, 7 January 2021, by the Executive Director, Dolan DNA Learning Center (DNALC), Dr. Dave Micklos, D.Sc.

Memberships include:

- i. Prof. Bartho Okolo – Chairman, Board of Trustees, Godfrey Okoye University, Enugu
- ii. Rev. Fr. Prof. Christian Anieke – Vice Chancellor, Godfrey Okoye University
- iii. Prof. George Ude – Chair, Faculty Senate, Bowie State University, Maryland, USA
- iv. Dr. Dave Micklos – Executive Director, DNALC New York, Cold Spring Harbor Lab, USA
- v. Prof. A. M. A. Imevbore, Pro Chancellor and Chairman of Governing Council of Joseph Ayo Babalola University, Osun
- vi. Barr (Mrs) Joy Ogbonnaya – Legal Practitioner & President, Pleasant Gathering International
- vii. Dr. Christie Onyia – Head of Department, Biological Sciences, Godfrey Okoye University, Enugu
- viii. Mr Michael Okolo – Assistant Lecturer, Godfrey Okoye University, Enugu, Secretary to the Board.

11.3.9 OVERALL EXPONENTIAL EFFECT

Alumni of these training courses were encouraged to mount their own courses and train their colleagues and students. This resulted in a proliferation of basic biotech training short courses, biotechnology centres and biotechnology programmes, all over Nigeria, like a chain reaction. The synergistic collaborations and the subsequent cascade of activities were primarily responsible for creating the biotechnology workforce that exists in Nigeria today. This helped to generate a formidable network of biotechnology stakeholders and more private biotech enterprises in the country, with the BSN playing a pivotal professional role.

11.4 CONCLUSIONS AND RECOMMENDATIONS

Competent manpower can be generated in new areas of science in a short time, in a cost-effective manner, using the collaborative approach described herein. African scientists in the Diaspora have an important role to play in initiating and supporting

such interventions. Committed and dedicated collaborators at home are a vital requirement for the survival of such schemes. Sincere Institutional support for home-based collaborators is a sine qua non for success.

Some critics view the proliferation of contemporary molecular biology short training courses in Nigeria negatively, pointing out that many of the organizers were themselves mediocre in the field. The earlier narrative in this chapter shows clearly that these organizers do not claim to be experts themselves but only facilitated the meeting of the experts and the novices. They have played the very important role of pointing the country's young scientists in the right direction. One of the objectives the training courses hoped to achieve was to demystify DNA technology and create awareness and a hunger for more, in fertile minds. It is hoped that the yearning will drive young scientists in search of more, and they will come back to Nigeria fully empowered as experts to launch Nigeria into the Age of the New Biology. It is gratifying to note that this is beginning to happen.

REFERENCES

- Aldemita, R. R., E Reaño, I. M., Solis, R. O., and Hautea, R. A. (2015) Trends in global approvals of biotech crops (1992–2014). *GM Crops & Food*, 6(3):150–166; DOI: 10.1080/21645698.2015.1056972.
- Esiobu, N., Fisher, L., Fulks, J., Kandel, J., and Sherwood, L. (1999) *Laboratory Investigations of Topical Issues in Microbiology*. American Society for Microbiology Education Publications 18pp. <https://www.asmscience.org/content/education/curriculum/curriculum.81>.
- Glover, A. (2012) The 21st century: the age of biology. OECD Forum on Global Biotechnology, Paris 12 November 2012. oecd.org/sti/emerging-tech/A%20Glover.pdf.
- Juergen, S., Wolfgang, L., Reinhard, B., and Gerhard, S. (2015) Equivalent recombinant human insulin preparations and their place in therapy. *European Endocrinology*, 11(1):10–16 DOI: 10.17925/EE.2015.11.01.10.
- NABDA (2001) *NABDA Policy Document*. <https://nabda.gov.ng/about-us/> Accessed: 20/01/2021.
- NASENI (1994) *NASENI Policy Document*. https://en.wikipedia.org/wiki/National_Agency_for_Science_and_Engineering_Infrastructure. Accessed: 20/01/2021.
- Uzochukwu, S. (2008) Capacity building in biotechnology in Nigeria: the UNAAB experience. *Journal of Biotechnology*, 136:S769.
- Uzochukwu, S. V. A., Campbell-Tofte, J., Esiobu, N., Keese P., Inglebrecht, I., and Ochem, A. (2012) Proven strategies for building capacity in biotechnology and biosafety in developing countries: an integrated short course approach. Presented at the 12th International Symposium on the Biosafety of Genetically Modified Organisms, St Louis, Missouri, USA, 16–20 September 2012.

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