

## SCHOOL OF BIOLOGICAL SCIENCES

### DEPARTMENT OF ANIMAL BIOLOGY AND CONSERVATION SCIENCE (DABCS)

#### 1. GENERAL INTRODUCTION

The Department of Animal Biology and Conservation Science (DABCS) of the University of Ghana offers three postgraduate programmes which provide a mix of courses geared towards training students in theoretical and applied zoology: Parasitology, Biodiversity Studies and Insect Science (Entomology). The Insect Science Programme, run under the African Regional Postgraduate Programme in Insect Science (ARPPIS), offers basic courses like *Insect Ecology*, *Systematics*, *Functional Morphology*, *Physiology* and *Biochemistry*, and more applied courses like *Insecticide Science*, *Agricultural Pests*, *Applied Insect Taxonomy* and *Insect Pests* and *Disease Vector Management*. The course content of the Parasitology Programme includes basic courses like *Parasite Biology*, *Epidemiology* and *Physiology*, alongside applied ones like *Immunology*, *Field Techniques*, *Histopathology* and *Zoonotic Diseases*. The Biodiversity Studies Programme offers *Biology and Ecology of Tetrapods*, *Animal Ecology* and *Population Ecology* as basic courses, as well as applied courses like *Conservation Biology*, *Wildlife Biology*, *Field Techniques*, *Environmental Impact Assessment* and *Remote Sensing*. The Department has plans to introduce a new programme in Aquatic Biology (Hydrobiology and Fishery Biology) in the near future. This will be an interdisciplinary programme focusing on understanding the functioning of freshwater and brackish water ecosystems under different environmental pressures and disturbances (e.g. oil pollution, small and large scale mining) and changes in the life processes and threats to biodiversity.

The Department is proposing to introduce corresponding PhD programmes to the existing MPhil programmes in line with the recent introduction of a four-year PhD programmes by the University. Like the masters programmes, the new PhD programmes are intended to provide a mix of courses in pure and applied zoology and to constitute the terminal phase of three levels of postgraduate programmes in the Department, notably MSc, MPhil and PhD. The one-year MSc programme will target first degree holders who are interested in obtaining a short-term higher degree that would enhance entry or advancement into careers in industry and the public sector. The two-year MPhil programme will be the starting point for entry into the PhD programme based on academic/research ability and could be the terminal point for students unable to proceed to the PhD programme for academic or other reasons.

The PhD Parasitology programme will offer pure science courses like *Cell Biology and Infection*, *Control of Parasitic Diseases* and *Parasite Evolution and Ecology*, as well as applied courses like *Special Topics in Parasitology* and *Host-Parasite-Environment Interactions*. Students may also offer two elective courses in the Department of Biochemistry and Molecular Biology: *Advances in Molecular Biology* and *Advances in Biomedical and Infectious Disease Research*. The new PhD programme in Biodiversity and Conservation Science has pure science courses like *Advanced Behavioural Ecology*, *Restoration Ecology*, *Advances in Biodiversity*

*Conservation Research, Advances in Wetland Ecology and Management, and Conservation Genetics* as well as applied courses like *Economic Tools for Biodiversity Conservation, Global Perspectives of Biodiversity Conservation, Human Dimensions of Conservation Science, and Topics in Conservation Science, Policy and Practice.*

The Insect Science PhD programme is administered by the College of Basic and Applied Sciences, with DABCS and the Crop Science Department as collaborators. The programme offers the pure science courses *Behavioural and Chemical Ecology of Insects, Chemical Control of Plant Pests, Forest Entomology, Aquatic Insect Ecology and Conservation, Biology of Haematophagous Insects, and Insect Molecular Biology and Immunology.* There are also applied courses like *Commercial Insects, Urban Ecology and Insect Disease Vector Management.*

In addition to the above courses offered at departmental level, all PhD candidates entering the three programmes shall be required to take School-required courses that are intended to acquaint students with historical and contemporary issues in science, current trends in scientific research, as well as improving their knowledge in quantitative research techniques and analysis. There is also a course designed to equip students with the requisite skills for managing students in academia, as it is anticipated that many PhD students may have ambitions for a future career in academia and research. These courses are *Special Topics in Science, Advanced Quantitative Research Methods, and Teaching Science at the Tertiary Level.*

Details of the two programmes (Biodiversity and Conservation Science; and Parasitology) are provided in the ensuing sections of this document. The details of the PhD programme in Insect Science have been submitted under a separate cover.

## **2. ADMISSION REQUIREMENTS**

*A relevant degree in Biology, Zoology, Botany or related biological science course. Admission into any of the programmes shall be limited to candidates whose academic and scholastic records show potential for successful completion of doctoral degree programme. Like other PhD programmes in the University, all the PhD programmes offered by DABCS shall be fee-paying.*

### **2.1 Candidates with a first degree:**

Candidates with a good first degree may apply for admission into PhD programme. A first degree holder will first be issued with a conditional admission, and will take prescribed courses (Level 600 courses) in the first year after which they will be assessed, and may progress into the PhD depending on performance.

### **2.2 Candidates applying with a Masters degree:**

Candidates with a Masters degree may apply for admission into PhD programme. Such candidates will first be issued a conditional admission, and will take prescribed courses (Level 700 courses) in Year 1 as well as “make-up” course if necessary in Years 1 and 2. On

successful completion of the prescribed courses, they will be assessed, and may progress into the PhD depending on performance.

### 3. **DURATION OF THE PROGRAMME**

*The duration of the PhD programme shall be four (4) years for full-time students, and six (6) years for part-time students.*

#### 3.1 **Graduation Requirements**

COMPONENT	CREDITS
Course work	18-24
Seminars	12
PhD Thesis	45
Total	75-81

## 4. PHD BIODIVERSITY AND CONSERVATION SCIENCE

### 4.1 PROGRAMME STRUCTURE

#### 4.1.1 *Year 1 Course Work*

##### *Semester I*

Course Code	Course Title	Credits
<b>CORE</b>		
FACS 701	Science and Society	3
BIOS 701	Advances in Biodiversity and Conservation Research	3
<b>TOTAL</b>		<b>6</b>

##### **\*ELECTIVES**

BIOS 703	Economic Tools for Ecosystem Conservation	3
BIOS 705	Advanced Wetland Ecology and Management	3
BIOS 707	Global Perspectives of Biodiversity Conservation	3
BIOS 709	Advanced Behavioural Ecology	3
FACS 710	Teaching Science at the Tertiary Level	3

*\*Select minimum of 3 credits and a maximum of 6 credits. Courses may be selected from level 600*

##### *Semester II*

Course Code	Course Title	Credits
<b>CORE</b>		
FACS 702	Advanced Quantitative Research Methods	3
BIOS 702	Human Dimensions of Conservation Science	3
<b>TOTAL</b>		<b>6</b>

**\*ELECTIVES**

BIOS 704	Topics in Conservation Science, Policy and Practice	3
BIOS 706	Restoration Ecology	3
BIOS 708	Conservation Genetics	3
FACS 710	Teaching Science at the Tertiary Level	3

*\*Select a minimum of 3 credits and a maximum of 6 credits. Courses may be selected from level 600.*

**4.1.2 Year 2**

**Experiential learning /Internship plus two (2) Seminars**

Course Code	Course Title	Credits
<b>CORE</b>		
BIOS 700	PhD Thesis	45
BIOS 710	Seminar I (Research Proposal – 1 <sup>st</sup> semester of Year 2)	3
BIOS 720	Seminar II (2 <sup>nd</sup> Semester of Year 2)	3

**4.1.3 YEARS 3 AND 4**

Thesis research, and submission and two (2) seminars

BIOS 730	Seminar III (Progress report -Year 3)	3
BIOS 740	Seminar IV (Final Results - Year 4)	3

**4.2 COURSE DESCRIPTIONS**

**FASC 701: SCIENCE AND SOCIETY**

This course will enable students gain insights in the practice of science as a discipline including major scientific concepts like inductivism are examined as well as the history of science and science itself, an overview of current approaches to research and an understanding of research partnerships, networks and appropriate methods of communicating science depending on audience. The aim of the course is to help students to fit their research to relevant trends and

directions for national development. Course content will cover topics such as the basis for the scientific method; conceptual frameworks; the philosophy of science; ethics in research; pure versus applied science debates; approaches to research; science for development and the merit of broader impact criteria; north south/south south collaboration and partnerships; research networks; communicating science to the policy make, lay audience and to media.

### **FASC 702: ADVANCED QUANTITATIVE RESEARCH METHODS**

The course will serve as a step up for students who need to add up to their knowledge in quantitative methods of research techniques and analyses. Topics to be covered include: Sampling distributions and hypothesis testing. Sample size determination. Categorical data and chi-square, Non parametric tests. Principles of Design of Experiments. Analysis of variance and its assumptions. Experiments with single and multiple factors. Orthogonal and multiple Comparisons. Completely Randomized, Randomized Complete Block, repeated measures, cross over and Latin square designs. Nested designs. Fixed, random and mixed effects models. Factorial designs. Confounding. Fractional factorial designs. Split plot designs. Incomplete block designs. Analysis of covariance. Regression models: basic concepts; Regression Model Diagnostics. Categorical data analysis. Logistic regression, univariate and multivariate. Confounding and collinearity in logistic regression. Model selection in logistic regression.

### **FASC 710: TEACHING SCIENCE AT THE TERTIARY LEVEL**

It is anticipated that many of the students who go through the PhD programme in the Sciences may nurse special interest in teaching and academia. Focusing on group discussions, this course is expected to equip students with the requisite knowledge in overall management of students at the tertiary level. The course will focus on teaching the methodologies and techniques in handling Science-teaching at the undergraduate level. Topics such as laboratory supervision and safety, grading issues, special needs students, lecturing and tutoring techniques, examination preparation, teacher/student relationship, tertiary education management, will be discussed through reading, class/group discussions as well as presentations.

### **BIOS 701 ADVANCES IN BIODIVERSITY AND CONSERVATION RESEARCH**

This course examines historical and emerging issues in biodiversity studies in light of recent increasing pressures on the global environment largely as a result of climate change and anthropogenic influences. Topics to be considered include: Species interactions; Physiological ecology and population dynamics; Invasive and endangered species; Biodiversity and climate adaptations; Role of social science in biodiversity research: methods for studying social impacts of biodiversity conservation, trans-disciplinary research approaches in conservation science; Management of wildlife diseases; Wildlife research techniques including methods of trapping, immobilization and marking of herpetofauna, birds and mammals. Conservation genetics; Agrobiodiversity; Ecological informatics and modelling techniques.

## **BIOS 702 HUMAN DIMENSIONS OF CONSERVATION SCIENCE**

Most of the threats and pressures impacting on biodiversity are driven by anthropogenic factors. In this course, students will explore and examine the interactions between people and the natural environment, how they affect and are affected by conservation interventions, and how human culture and economic activities shape their interaction with the environment. The course will critique popular solutions for returning conservation benefits to people such as community-based natural resources management, ecotourism and the concept of sustainability. Students on this course will use specific case studies and practical field examples to query existing theories and principles.

The topics to be covered will include: value of wildlife and other forms of biodiversity, African cultures and wildlife, human wildlife conflicts, dynamics of zoonotic diseases, wild animals as pests, anthropogenic threats to biodiversity, including habitat destruction (e.g. deforestation, fragmentation, impact of extractive industries), over-exploitation of wildlife resources (hunting, wildlife trade); population growth, pollution and encroachment on protected landscapes, impact of conservation interventions on communities (e.g. displacement of communities and livelihoods sources), costs and benefits of biodiversity conservation and payment for ecosystem services.

## **BIOS 703 ECONOMIC TOOLS FOR ECOSYSTEM CONSERVATION**

This course focuses on the discipline of ecological economics, which looks at how humans can manage ecosystems for instrumental purposes of optimizing human economic growth. The course will discuss market theory, supply, demand, market equilibrium, and competition, market failures and public goods: Why markets are inefficient when it comes to environmental protection; Capital theory: The time value of money, interest rates and how they influence the use of natural resources; optimal harvesting and policy options. Environmental Valuation: Environmental values, the methods used to calculate them, and how these methods are best used in various countries, valuation of ecosystem services.

## **BIOS 704 TOPICS IN CONSERVATION SCIENCE, POLICY AND PRACTICE**

The course examines historical and contemporary issues in biodiversity conservation and policy. Topics to be dealt with include: Renewable resource policy and governance; history, laws, policies and administrative structure of agencies dealing with renewable natural resources; conservation in the socio-cultural and political context; renewable resources; notably biodiversity at intraspecific (gene), species and ecosystem levels, species survival, evaluation of *in-situ* and *ex-situ* conservation approaches using SWOT analysis, relevance of biodiversity-related conventions of which Ghana is signatory, national and global biodiversity conservation strategies. Policy formulation and implementation; National Biodiversity Strategy, National Policy on Forest and Wildlife Resources, National Wetlands Strategy.

## **BIOS 705 ADVANCED WETLAND ECOLOGY AND MANAGEMENT**

The course focuses on advanced studies in wetland science and management and human practices in managing wetlands. . Topics include: ecological structure, function, and diversity of wetlands and applications in management and laws; basin morphology, hydrology, chemistry, human impacts; biological adaptation and energy pathways. Wetland values and valuation of

wetland resources and services. Physical and biological characteristics of wetlands and their functions, urbanisation and aquaculture as threats to wetlands, disaster risk management, wetlands and climate change.

### **BIOS 706 RESTORATION ECOLOGY**

The course involves a survey of the general ecological principles that guide restoration ecology and its applications in reclamation schemes; the process of assisting the recovery of degraded, damaged or destroyed ecosystems: Topics include: Approaches to restoration ecology. Conceptual framework for restoration ecology; major principles of ecology related to practical problems confronting humankind, such as environmental pollution and degradation, exotic species invasions, land use and management trade-offs and consequences; importance of biological diversity. Effect of climate change on restoration actions; restoration planning; monitoring ecological recovery. Animal recolonization; revegetation and species re-introductions.

### **BIOS 707 GLOBAL PERSPECTIVES OF BIODIVERSITY CONSERVATION**

This course examines the relationship between humans and the global biotic environment that supports them. It is intended to help students understand how humans affect global life support systems. Topics include: Evolutionary history of the earth. Species distribution patterns; origin, structure, measurement and mapping of biodiversity; climate change, global warming and impacts on biodiversity; agriculture and biodiversity. Global phylogenetic and geographical patterns in biodiversity. Origin, structure and measurement of biodiversity. Local and international agencies that manage wildlife worldwide.

### **BIOS 708 CONSERVATION GENETICS**

The course explores the modern methods used in the study of conservation genetics. Main topics include: advances in conservation genetics. Genetics and extinction; characterizing and conserving genetic diversity. Population genetics concepts and the mechanisms that underlie genetic and phenotypic variation. Application of these concepts to conservation of endangered species of animals. Use of current genomic technologies to study genetic variability. Inbreeding and inbreeding depression. Fragmentation of populations and gene flow. Genetic management of wild and captive populations. Genetic management considerations for reintroduction. Population Viability Analysis (PVA). Molecular genetics of forensic science. Genetic markers.

### **BIOS 709 ADVANCED BEHAVIOURAL ECOLOGY**

This course focuses on cutting-edge methods used within the study of animal behavioral ecology and innovative approaches to the study of animals in the interest of their conservation. Theoretical and practical arguments for considering behaviour patterns in conservation of biodiversity; ecological aspects of animal behaviour adaptations; animal foraging strategies; animal mating and social systems; predator-prey interactions and life-history strategies. Sexual selection and sexual conflict, evolutionary conflict, mechanisms of behaviour and life-history evolution.

### **4.3 PROGRAMME YEAR 2 EXPERIENTIAL LEARNING**

The Department has been collaborating with a number of institutions to undertake joint research projects as well as hosting of students for practical attachments. This arrangement will continue under the new PhD programme. Some of the collaborating institutions are listed below:

- Environmental Protection Agency
- Ministry of Food and Agriculture
- Ministry of Lands and Natural Resources
- Wildlife Division (Forestry Commission)
- Forestry Services Division (Forestry Commission)
- Animal Research Institute (CSIR)
- Forestry Research Institute
- Water Resources Commission

In addition to the attachment to institutions, students on the PhD Biodiversity and Conservation Science Programme will be encouraged to compete for funding to participate in the Annual Student Conservation Science Conferences organised by the University of Cambridge as well as the international conferences of the Society for Conservation Biology. The students will undertake various types of internships and participate in ongoing research projects such as the projects outlined below that are implemented by various organizations. In addition students will have the opportunity to participate in field trips to conservation areas and undertake practical attachments to learn protected area management techniques.

#### ***PROJECT 1***

#### **DEVELOPMENT OF MANAGEMENT SYSTEM FOR BIRDS AND OTHER WILDLIFE SPECIES AT THE KOTOKA INTERNATIONAL AIRPORT**

**Prof. Daniel K. Attuquayefio, Dr. Erasmus H. Owusu, Dr. Lars H. Holbech & Dr Francis Gbogbo**

**Collaborating institution:** Ghana Airport Company Ltd.

**Project Description:** This is collaborative project between the Department of Animal Biology and Conservation Science and the Ghana Wildlife Society. The project seeks to establish a robust baseline to assist the Ghana Airports Company to develop a strategy for the Ghanaian aviation industry that will mitigate the negative impacts of increasing numbers of birds and other wildlife. Specifically, the project will establish baseline data on the distribution and abundance of wildlife species to enable the development of cost-effective protocols to reduce wildlife populations and birdstrike hazards at airports. Students will be attached to the Ghana Airport Company to undertake monitoring of wildlife species based on earlier baseline information collected in 2009.



## **PROJECT 2**

### **UTILIZATION OF BUSHMEAT AND THE RELEVANCE OF THE “CLOSE SEASON” IN THE FACE OF CHANGING CLIMATIC CONDITIONS**

Prof. Yaa Ntiamoah-Baidu & Dr. Erasmus H. Owusu

**Collaborating institution:** Wildlife Division of the Forestry Commission

**Project Description:** The project involves an examination of reproductive patterns of various animal species sold as bushmeat on two major markets in Ghana (Atwemonom in Kumasi and Kantamanto in Accra) during the close and the open seasons to determine whether there are significant overlaps in reproductive periods and therefore the need to review government policies guiding wildlife management with reference to threatened species. Within the period of their experiential learning, students will be attached to the Wildlife Division of the Forestry Commission for guidance.

## **PROJECT 3**

### **ECOLOGICAL RESTORATION OF QUARRY SITES IN GHANA**

**Dr. Erasmus H. Owusu, Dr. Rosina Kyerematen & Mr. Yahaya Musah**

**Collaborating institution:** Ghana Cement (GHACEM).

**Project Description:** This project forms part of a larger project for the restoration of the quarry sites of Ghana Cement (GHACEM). Specifically, the project involves ecological and biodiversity assessment of the operational area of GHACEM quarry sites at Yongwa and Beposo in the Eastern and Western Regions respectively. The assessment will involve the gathering of information on the general habitat and landscape features, flora, avifauna, large mammals and herpetofauna (amphibians and reptiles). Results of the assessment will be used for the ecological restoration of the site as part of the decommissioning exercise of the quarry. Specific activities will include:

- A review of all existing ecological and biological data on the site
- Ecological and biodiversity assessments focusing on the flora, birds, large mammals and herpetofauna, as well as characterization of ecosystems types in the area
- Definition of the ecological and biodiversity values of the site by assessing the conservation status of the faunal and floral communities
- Assessment of the High Conservation Value (HCV) of the site and proposing of recommendations based on the results of the assessment to mitigate the ecological impact of quarrying operations to enhance the maintenance of biodiversity and ecology of the area.

## **PROJECT 4**

### **LEVELS OF HEAVY METALS IN WETLAND FOOD WEBS**

**Dr. Francis Gbogbo & Dr. Michael Osae**

**Collaborating institution:** Atomic Energy Commission

**Project Description:** Metals are non-biodegradable and can accumulate in living tissues and become concentrated in the food chain. With wetlands serving as sinks for metals, wetland

organisms may take up heavy metals from the environment, resulting in serious consequences to humans. This project uses Instrumental Neutron Activation Analysis (INAA) to evaluate the level of heavy metals in wetland organisms, particularly in wetlands receiving sewage from parts of Accra. The project is collaboration between the Department of Animal Biology and Conservation Science (DABCS) and the Ghana Atomic Energy Commission (GAEC). Specifically, DABCS will be involved in collection and processing of biological samples for analysis, while GAEC will focus on the analysis of samples using INAA.

## **PROJECT 5**

### **CLIMATE CHANGE, ECOSYSTEMS AND BIODIVERSITY**

**Prof. Yaa Ntiamoah-Baidu, Dr Erasmus H. Owusu, Dr. Rosina Kyerematen, Dr Lars H. Holbech**

**Collaborating institutions:** Centre for African Wetlands and Ghana Wildlife Society

**Project Description:** The project involves Climate Change and Ecosystems component of the UG project on Building Capacity to meet the Climate Challenge (B4C). Specifically, students will take part in case studies of two protected areas in Ghana. The studies focus on the changes in species composition of terrestrial birds and mammals as well as the dependence of local people on natural resource in the face of the changing climate in the Muni-Pomadze Ramsar site (Winneba) and the Kogyae Strict Nature Reserve (Ejura).

## **PROJECT 7**

### **BIOS 710 SEMINAR I**

Each student will present a formal research proposal seminar by the end of the first semester of the second year of the programme. This will include justification or relevance of the study including objectives and methodology. Invitation is open to all.

### **BIOS 720 SEMINAR II**

This will be a seminar and a report submitted to the department in the first semester of the second year. It would be based on experiential research learning by attachment of the student to a departmental or external project. Invitation is to the general University community.

## **4.4 PROGRAMME YEARS 3 AND 4**

### **BIOS 730 SEMINAR III**

In the third year, each student will present a progress report on his/her research to the department. The University community will be invited.

### **BIOS 740 SEMINAR IV**

This will be a presentation of the final results of the research in the fourth year before the thesis is finally presented to the University. Invitation is open to all.

#### 4.5 RECOMMENDED SCIENTIFIC JOURNALS

<b>Journal</b>	<b>Publishers</b>
<i>African Journal of Ecology</i>	East African Wildlife Society/Wiley
<i>Animal Conservation</i>	Zoological Society of London/John Wiley & Sons
<i>Biodiversity and Conservation</i>	Springer Netherlands
<i>Biological Conservation</i>	Elsevier, Amsterdam
<i>British Herpetological Society Bulletin</i>	British Herpetological Society
<i>British Journal of Herpetology</i>	British Herpetological Society
<i>Bulletin of the American Museum of Natural History</i>	American Museum of Natural History
<i>Conservation Biology</i>	Society for Conservation Biology/Wiley
<i>Conservation Genetics</i>	Springer Netherlands
<i>Conservation Letters</i>	Society for Conservation Biology/Wiley
<i>Diversity and Distributions</i>	Wiley
<i>Ecological Applications</i>	Ecological Society of America
<i>Ecology</i>	Ecological Society of America
<i>Ecology Letters</i>	Wiley
<i>Environmental Conservation</i>	Microsoft Academic
<i>Environmental Research</i>	Elsevier, Amsterdam
<i>Ghana Journal of Science</i>	Council for Scientific & Industrial Research/GSA
<i>Herpetological Monographs</i>	The Herpetology League/Allen Press
<i>Journal of Animal Ecology</i>	British Ecological Society/Wiley
<i>Journal of Applied Ecology</i>	British Ecological Society
<i>Journal of Ecology</i>	British Ecological Society
<i>Journal of Herpetology</i>	Society for the Study of Amphibians and Reptiles
<i>Journal of Mammalogy</i>	American Society of Mammalogists
<i>Journal of Natural History</i>	Taylor and Francis
<i>Journal of Wildlife Management</i>	The Wildlife Society, USA/Wiley-Blackwell
<i>Journal of Zoology (London)</i>	Zoological Society of London/Wiley-Blackwell
<i>Nature</i>	Macmillan Publishing
<i>Oecologia</i>	Springer
<i>Oikos</i>	Nordic Foundation Oikos/Wiley-Blackwell
<i>Ostrich: Journal of African Ornithology</i>	BirdLife South Africa
<i>Science</i>	American Association for the Advancement of Science
<i>Trends in Ecology and Evolution</i>	Elsevier
<i>Unasylva</i>	Food and Agriculture Organization (FAO)

<i>West African Journal of Applied Ecology</i>	Ecological Laboratory, University of Ghana
<i>Wildlife Biology</i>	Nordic Council for Wildlife Research
<i>Wildlife Monographs</i>	The Wildlife Society, USA

#### 4.6 INTERNATIONAL PARTNERSHIPS/COLLABORATIONS/VISITING SCHOLARS

In delivering the Biodiversity and Conservation Science programme, DABCS will draw on existing collaborative links that the Department and /or its faculty have with external universities as well as establish new collaborative arrangements. The external institutions that the Department currently has ongoing collaborative research and post-graduate supervision include;

- The Cambridge University: Contact person, Prof. James Wood, Epidemiologist, Department of Veterinary Medicine, University of Cambridge, Madingley Road, UK CB3 0ES. Fax;+44 1223764667, E-mail: jlnw2@cam.ac.uk
- The Zoological Society of London: Contact person, Prof. Andrew A. Cunningham, Epidemiologist, Institute of Zoology, Zoological Society of London, Regents Park London NW1 4RY, Fax 020 7586 5743, Tel. 02074496674
- Wildlife Research Centre, Kyoto University: Contact person, Prof. Miho Murayama, 606-8203, Tanakaa Sekiden-cho, Sakyo, Kyoto
- Laboratory of Veterinary Microbiology: Contact person, Prof Kenji Ohya, Department of Veterinary Medicine, Faculty of Applied Biological Sciences, Gifu University, Yanagido, Gifu 501-1193, Japan.
- Professor Li Maosong (Graduate School of Chinese Academy of Agricultural Sciences - CAAS, the Institute of Agricultural Resources and Regional Planning - IARRP, Beijing)

## 5 PHD APPLIED PARASITOLOGY PROGRAMME

### 5.1 PROGRAMME STRUCTURE

#### 5.1.1 Year 1 Course Work

##### *Semester 1*

##### **CORE COURSES**

Course Code	Course Title	Credits
FACS 701	Science and Society	3
PARA 701	Special Topics in Parasitology	3
<b>TOTAL</b>		<b>6</b>

##### **\*ELECTIVE COURSES**

FACS 710	Teaching Science at the Tertiary Level	3
PARA 703	Cell Biology and Infection	3
PARA 705	Control of Parasitic Diseases	3

**\*Select a minimum of 1 elective and a maximum of 2 electives. Courses may be selected from level 600**

##### *Semester 2*

##### **CORE COURSES**

Course Code	Course Title	Credits
<b>CORE</b>		
FACS 702	Advanced Quantitative Research Methods	3
PARA 702	Host-Parasite-Environment Interactions	3
<b>TOTAL</b>		<b>6</b>

##### **\*ELECTIVE COURSES**

FACS 710	Teaching Science at the Tertiary Level	3
BCMB 704	Advances in Molecular Biology and Applications	3
BCMB 708	Advances in Biomedical and Infectious Diseases Research	3
PARA 704	Parasite Evolution and Ecology	3
PARA 706	Wildlife Parasites and Conservation	3

**\*Select a minimum of 1 elective and a maximum of 2 electives. Courses may be selected from level 600**

#### 5.1.2 YEAR 2

## Experiential learning /Internship plus two (2) Seminars

Course Code	Course Title	Credits
PARA 700	PhD Thesis Research	45
PARA 710	Seminar I (Research Proposal – 1 <sup>st</sup> semester of Year 2)	3
PARA 720	Seminar II (Experiential Learning)	3

### 5.1.3 YEARS 3 AND 4

Thesis research, and submission and two (2) seminars

Course Code	Course Title	Credits
PARA 700	PhD Thesis Research	45
PARA 730	Seminar III (Progress report)	3
PARA 740	Seminar IV (Final Results)	3

## 5.2 COURSE DESCRIPTIONS

### FASC 701: SCIENCE AND SOCIETY

This course will enable students gain insights in the practice of science as a discipline including major scientific concepts like inductivism are examined as well as the history of science and science itself, an overview of current approaches to research and an understanding of research partnerships, networks and appropriate methods of communicating science depending on audience. The aim of the course is to help students to fit their research to relevant trends and directions for national development. Course content will cover topics such as the basis for the scientific method; conceptual frameworks; the philosophy of science; ethics in research; pure versus applied science debates; approaches to research; science for development and the merit of broader impact criteria; north south/south south collaboration and partnerships; research networks; communicating science to the policy make, lay audience and to media.

### FASC 702: ADVANCED QUANTITATIVE RESEARCH METHODS

The course will serve as a step up for students who need to add up to their knowledge in quantitative methods of research techniques and analyses. Topics to be covered include: Sampling distributions and hypothesis testing. Sample size determination. Categorical data and chi-square, Non parametric tests. Principles of Design of Experiments. Analysis of variance and its assumptions. Experiments with single and multiple factors. Orthogonal and multiple Comparisons. Completely Randomized, Randomized Complete Block, repeated measures, cross over and Latin square designs. Nested designs. Fixed, random and mixed effects models. Factorial designs. Confounding. Fractional factorial designs. Split plot designs. Incomplete block designs. Analysis of covariance. Regression models: basic concepts; Regression Model

Diagnostics. Categorical data analysis. Logistic regression, univariate and multivariate. Confounding and collinearity in logistic regression. Model selection in logistic regression.

### **FASC 710: TEACHING SCIENCE AT THE TERTIARY LEVEL**

It is anticipated that many of the students who go through the PhD programme in the Sciences may nurse special interest in teaching and academia. Focusing on group discussions, this course is expected to equip students with the requisite knowledge in overall management of students at the tertiary level. The course will focus on teaching the methodologies and techniques in handling Science-teaching at the undergraduate level. Topics such as laboratory supervision and safety, grading issues, special needs students, lecturing and tutoring techniques, examination preparation, teacher/student relationship, tertiary education management, will be discussed through reading, class/group discussions as well as presentations.

### **PARA 701: SPECIAL TOPICS IN PARASITOLOGY**

The course examines historical and contemporary issues in parasitology, relating to the student's area of specialization and relevance. Such topics are expected to challenge the students into exploring current and relevant research trends/discoveries in scientific approaches. The course will enable students explore scientific knowledge in modern parasitology, and add on to their depth of information in their chosen areas of specialty. It is expected that, the course will compliment other courses on the PhD flagship of the various departments in the Parasitology and elsewhere. Additionally, it will expose students to current trends of presentations, and foster stronger confidence-building attitude that will enable enhanced international academic competitive spirit.

### **PARA 702: HOST-PARASITE-ENVIRONMENT INTERACTIONS**

This course aims to give the students a solid foundation in the knowledge of disease transmission. The course will consist of lectures and tutorials and laboratory demonstrations of the principal factors which interact to affect levels of parasite infection and treatment of infections in humans and animals. The integration and management of host-parasite-environment relationships, in terms of transmission, population dynamics, environmental management, environmental modulation of host-parasite relationships, host and parasite behaviour, immune responses, pathology and pharmacology, to decrease parasitic disease.

### **PARA 703: CELL BIOLOGY AND INFECTION**

This course will cover new principles in cell biology that would provide a better understanding of the molecular and cellular mechanisms that regulate host-pathogen interactions. In particular, the mechanisms by which gene expression is regulated through signal transduction pathways initiated at the cell surface will be presented. Such understanding may lead to better strategies for preventing and combating infectious processes.

## **PARA 704: PARASITE EVOLUTION AND ECOLOGY**

The course seeks to provide students with an overview of evolutionary ecology approach to the dynamics of the interactions between parasites and hosts towards developing research ideas that seeks to shed light on evolutionary forces that influence the outcome of these interactions. With particular emphasis on the ecological and evolutionary impact of parasites on their host, themes to be studied will include the following: Origins of parasitism and complex life cycles; Evolution of parasite life-history strategies; Host specificity and exploitation strategies; Causes and consequences of parasite aggregation; Parasite population dynamics and genetics, Inter-species and parasite niche interactions, Infracommunity structure of parasites, Component communities and parasite faunas

## **PARA 705: CONTROL OF PARASITIC DISEASES**

In this course, the different approaches to the control of parasitic diseases (from diagnosis, to treatment and cure of selected parasitic diseases), to control the transmission within the community by preventative chemotherapy and vector control will be outlined. The course will enable students gain insight into some of the key concepts and methods of disease control as it pertains to parasitic infections. The course will also enable students to understand and appreciate research developments in parasitology and vector biology that may lead to the development of novel control strategies as well as disease elimination and eradication. Topics to be covered should include: Emerging infectious diseases, Food borne and Zoonotic Diseases and the epidemiology of some Parasitic Diseases of public health importance. The course will be covered in the form of lectures, tutorials and assignments.

## **PARA 706: WILDLIFE PARASITES AND CONSERVATION**

This course will explore how human natural resource exploitation impact on landscape changes, which in turn influences the emergence of diseases, especially those of zoonotic/ anthroponotic importance. The course also emphasizes the need for wildlife parasites as conservation targets to shed light on the influence of parasites on ecosystem organization and function as well as unravelling parasite biodiversity. An understanding into the role of emerging diseases in the decline of vulnerable wildlife species will also be sought to gain insight into the properties of pathogens capable of driving extinction of wildlife species. Such an understanding will help mitigate the negative impact of wildlife parasites on human and animal health, food production, economic trade, and biodiversity conservation. Topics to be treated will include the following: Non-specific wildlife infections and zoonotic diseases; Wildlife parasites and environmental resilience; Host types and the transmission dynamics of wildlife parasites in human-dominated landscapes; Translocation of hosts and the spread of infections; Transmission of wildlife parasites by domestic animals and exotic pets; The role of wildlife parasites in extinction; Numerical and functional importance of parasites to wildlife management and conservation; Current conservation status of wildlife parasites; Challenges to the incorporation of parasite biodiversity into conservation strategies.



## **BCMB 704: ADVANCES IN MOLECULAR BIOLOGY AND APPLICATIONS**

The goal of this course is to provide graduate-level instruction on molecular biology with detailed analysis of the biochemical mechanisms that control the maintenance, expression, and evolution of prokaryotic and eukaryotic genomes. The topics will cover current advances in methodological approaches for analyzing the function of cellular macromolecules and macromolecular complexes in DNA replication, recombination, transposition and repair, gene expression and its regulation, mRNA splicing, genome organization, non-coding RNAs, signal transduction, protein synthesis, folding and degradation, growth control, and other life processes. A focus on critical thinking and problem solving will be used to show how fundamental, highly significant biological problems are solved. We will also explore the logic of experimental design and data analysis.

## **BCMB 708 ADVANCES IN BIOMEDICAL AND INFECTIOUS DISEASES RESEARCH**

The course is aimed at equipping students with knowledge on current methods for studying the transmission, diagnosis, and pathogenesis of diseases that are of public health concern in sub-Saharan Africa. Diseases to be covered include infectious diseases such as Malaria, HIV, and TB, neglected tropical diseases (NTDs) such as Leishmania, Buruli ulcer, and Schistosomiasis. Current knowledge of the biology of the causative agents, as well as progress towards improved therapeutic mechanisms and vaccine development will be discussed. The relevance of genomics and proteomics for research into the various diseases will also be emphasized.

### **5.3 PROGRAMME YEAR 2**

#### **EXPERIENTIAL LEARNING**

Students will engage in activities that guarantee experiential learning through attachments and internships. These activities will mainly involve obligatory participation in a year-long internship programme with partner institutions and collaborative projects within the department, where skills will be acquired in modern techniques of diagnoses of parasitic infections and pathological analyses (particularly, those plaguing the tropical world) and well as new trends in parasitological research. Additionally, students will engage in field trips to endemic communities to acquire skills in identifying disease vectors, intermediate hosts, tropical disease reservoirs and, study disease patterns and their interaction with environmental factors. The partner institutions shall include (but not limited to) the following:

The Department has over the years continually had good collaborations with all nine, notably the parasitology, immunology and bacteriology, departments of the NMIMR. Presently, the NMIMR, which has over 60 on-going projects, takes on some of the department's postgraduate students (parasitology programme) on on-going research projects at the institute for their theses.

On-going projects at the NMIMR that will for host students are as follows:

**1. PROJECT TITLE: Investigations into Endothelial Biomarkers and Pathogenesis of Cerebral Malaria**

**PRINCIPAL INVESTIGATOR(S): Professor Ben Gyan**

This project is hosted by the Immunology Department and seeks to elucidate endothelial biomarkers of cerebral malaria and to better understand the pathogenesis of childhood malaria to facilitate early detection for effective treatment so as to minimise the scourge of the disease particularly amongst children under 5 years old.

**2. PROJECT TITLE: Effects of local Antimalarial drugs on *Plasmodium falciparum* gametocytes**

**PRINCIPAL INVESTIGATOR(S): Professor Ben Gyan/ Dr. Regina Appiah-Oppong/ Dr. Niels Quarshie**

The study is a multi-departmental collaborative project between the Immunology, Parasitology and Clinical Pathology Departments of NMIMR and DABCS. This project investigates the efficacy and toxicity of phytomedicines or herbal preparations claimed to treat and manage. Ultimately the study will contribute towards the development of cost-effective treatment for malaria.

**3. PROJECT TITLE: The Role of Environmental Factors on Seasonal Variations in Infectivity of Schistosome snail hosts and Schistosomiasis transmission dynamics.**

**PRINCIPAL INVESTIGATOR(S): Dr. William Anyan/ Dr. Fred Aboagye-Antwi**

The research project mentioned above is part of a larger collaborative project between the NMIMR and the Ministry of Health of Ghana; “Schistosomiasis Control Initiative Ghana (SCIG)”. The development and implementation of an integrated national plan for sustainable control of schistosomiasis in Ghana, utilizing a comprehensive stakeholder approach, constitutes the main aim of the project.

#### **PROJECT 4**

**TITLE: Trends in the transmission of helminth and other parasitic infections amongst student visitors to the University of Ghana Hospital.**

**PRINCIPAL INVESTIGATOR(S): Professor Dominic E. Edoh/ Dr. Langbong E. Bimi**

**Collaborating institution: The University Hospital, University of Ghana, Legon, Accra.**

**Project description:** The hospital is the major health facility that serves students and staff of the University of Ghana community as well as neighbouring communities including Madina, Oponglo, Adenta, East and West Legon, Oyibi and other suburbs. As such the laboratory of the hospital processes large numbers of human tissues, faecal and bodily fluid samples for diagnosis and prognosis of diseases, particularly parasitic infections. Internships at the hospital’s laboratory will thus provide students a first-hand experience of identifying common parasitic infections prevalent amongst persons on the University campus and its environs.

## **PROJECT 5**

**TITLE: Disease transmission dynamics of soil transmitted helminths in school-going children in Accra-North (Maamobi and Achimota).**

**PRINCIPAL INVESTIGATOR(S): Professor Dominic E. Edoh/ Dr. Langbong E. Bimi**

**Collaborating institution: The Maamobi Polyclinic, Maamobi, Accra and the Achimota Hospital, Achimota, Accra.**

**Project Description:** These health facilities also serve other densely populated communities such as Maamobi and Achimota, which are in close proximity to the University of Ghana campus. Similarly large human tissue, faecal and fluid samples are examined in the laboratories of the health facilities and hence offer students the experiential learning opportunities that will equip them with the requisite skills for detecting protozoan and metazoan parasites amongst inhabitants of these communities.

## **PROJECT 6**

**TITLE: Molecular characterization of Trypanosomes and determination of infection prevalence in *Glossina palpalis* in the Jomoro District of Ghana”.**

**PRINCIPAL INVESTIGATOR(S): Dr. Alex Egyir Yawson**

**Collaborating institution: Ghana Atomic Energy Commission (GAEC)**

**Project description:** The DABCS collaborates with the GAEC on the “Molecular characterization of Trypanosomes in *Glossina palpalis* and the determination of infection prevalence in the Jomoro District of Ghana”. Participation in this project, by students, by way of their attachment to this research work will deepen students’ insight into the field molecular parasitology and the exploitation of such tools to control Neglected Tropical Diseases (NTDs) of which trypanosomiasis (African SleepingSickness) is one.

## **PROJECT 7**

**TITLE: Development and optimization of molecular tools for characterization of *Onchocerca volvulus* for effective control of Onchocerciasis Project.**

**PRINCIPAL INVESTIGATOR(S): Dr. Michael Atweneboanah**

**Collaborating institution : Centre for Scientific and Industrial Research-Science and Technology Policy Research Institute (CSIR-STEPRI)**

**Project description:** Development and optimization of molecular tools for characterization of *Onchocerca volvulus* for effective control of Onchocerciasis Project. The project aims at characterizing the responses of the parasite to ivermectin treatment and by so doing tailor appropriate and effective treatments to control the infection.

The project has two main components:

1. Identification of single nucleotide polymorphisms of *Onchocerca volvulus* associated with Onchocerciasis infection.
2. **Parasitological responses of *Onchocerca volvulus* to ivermectin treatment and genetic analysis of beta tubulin gene showing sub-optimal responses.**

Students on internship on these projects will particularly sharpen their skills in molecular biology to equip them the hands-on experience to enhance the conduct of their own projects.

## **PROJECT 8**

**TITLE: Bats and Zoonotic disease transmission**

**PRINCIPAL INVESTIGATOR(S): Professor Yaa Ntiamoa-Baidu**

**Collaborating institutions:** University of Ghana, Veterinary Services Department, Wildlife Division of the Forestry Commission, University of Cambridge, Zoological Society of London, Institute of Development Studies.

### **Project description: Bats and Zoonotic Disease Transmission Project**

The research project on Bats and Zoonotic disease transmission is part of a bigger project implemented by a consortium of several local (University of Ghana, Veterinary Services Department, Wildlife Division of the Forestry Commission) and external institutions including (University of Cambridge, Zoological Society of London, Institute of Development Studies). The study focuses on disease spillover from wild animal reservoirs to humans, using henipaviruses and bats as a case study. The components of this multidisciplinary study include: i) Disease dynamics involving surveillance of bats, domestic animals and human populations for evidence of henipavirus prevalence, and ii) Ecological studies to understand the distribution and population dynamics of bats as well as their role in the ecosystem and interrelationships with environmental changes and iii) Sociological studies that seek to examine the historical, social and cultural dimensions of bats and disease transmission. The wide range of local and international expertise ranging from epidemiologists to animal ecologists and social scientists involved in this study offers extensive opportunities for PhD student attachment for experiential learning. The project is funded by the Ecosystems Services for Poverty Alleviation (ESPA) (UK) Programme through the Dynamic Drivers of Disease in Africa Consortium.

### **Field Trips to Study Sites (Mole National Park, Northern Region, Shai Hills National Park and Kpong, Greater Accra Region)**

The practical components of wildlife parasites, zoonoses and epidemiological aspects of courses shall involve students undertaking visits to national parks and disease endemic communities where they shall be required to design and conduct investigative research in order to better understand parasites and disease transmission dynamics. The field trips will normally involve the students undertaking a comprehensive exploration of:

1. The ecological conditions that exists at disease transmission sites.
2. The type of disease parasites and vectors present at these sites.
3. Human and animal behaviour that aid in diseases transmission.

### **PARA 710: SEMINAR I**

Each student will present a formal research proposal seminar by the end of the first semester of the second year of the programme. This will include justification or relevance of the study including objectives and methodology. Invitation is open to all.

### **PARA 720: SEMINAR II**

Based on the expertise gained through experiential research learning via attachment/internship of students to departmental or external projects, an oral presentation will be given at a seminar and a report submitted to the department in the second semester of the second year.

## **5.4 PROGRAMME YEARS 3 AND 4**

### **PARA 730: SEMINAR III**

In the third year, each student will present a progress report on his/her research to the department. The University community will be invited.

### **PARA 740: SEMINAR IV**

This will be a presentation of the final results of the research in the fourth year before the thesis is finally presented to the University. Invitation is open to all.

## **5.5 RECOMMENDED SCIENTIFIC JOURNALS**

<b>Journal</b>	<b>Publisher</b>
<i>Acta Parasitologica</i>	Springer Professional Publishing
<i>Acta Tropica</i>	Elsevier Foundation
<i>Advances In Parasitology</i>	Academic Press Inc..
<i>Annals of Tropical Medicine And Parasitology</i>	Liverpool School of Tropical Medicine, Maney Publishing
<i>Plos Neglected Tropical Diseases</i>	Public Library of Science.

<i>Comparative Parasitology</i>	Helminthological Society of Washington
<i>Experimental Parasitology</i>	Academic Press Inc.
<i>Emerging Infectious Diseases</i>	Centers for Disease Control and Prevention (CDC), USA
<i>International Journal for Parasitology</i>	Bioinfo Publications.
<i>Journal of Helminthology</i>	Cambridge University Press
<i>Malaria Journal</i>	National Institutes of Health (U.S.), PubMed Central.
<i>Journal of Parasitology</i>	Allen Press <i>Publishing Services</i>
<i>Journal of Vector Borne Diseases</i>	National Institute of Malaria Research, India
<i>Vector-Borne and Zoonotic Diseases</i>	Mary Ann Liebert Inc.
<i>Molecular and Biochemical Parasitology</i>	Elsevier
<i>Parasite Immunology</i>	Blackwell Publishing
<i>Parasites &amp; Vectors</i>	BioMed Central.
<i>Parasitology International</i>	Elsevier
<i>Parasitology Research</i>	Springer Verlag.
<i>International Journal for Parasitology Research</i>	Bioinfo Publications.

## 5.6 INTERNATIONAL PARTNERSHIP(S) AND COLLABORATION(S)

### **Collaborating institutions: Centre for Disease Control and Prevention (CDC), USA**

The DABCS currently working at strengthening its existing links with the Centres for Disease Control and Prevention (USA), to enable students visit their facilities to acquaint themselves with novel protocols in parasitology research. In line with this, researchers at the CDC's Department of Parasitic Diseases will also assist the Department to set-up and modernize our parasitology laboratory.

## DEPARTMENT OF BIOCHEMISTRY, CELL AND MOLECULAR BIOLOGY

### PHD IN BIOCHEMISTRY

#### Introduction

Capacity development in biochemistry is critical for the future competitiveness of Ghana in the bioscience industries. Established in 1962, the Department of Biochemistry, Cell and Molecular Biology has undergone several transformations in its course content and offerings, the recent being the extensive review of its undergraduate and master's degree programmes.

The Department is poised to play an important role in the University's strategic plan for achieving pre-eminence in teaching and research in the life sciences. Biochemistry has been termed central to all life sciences because the learning of Biochemistry provides an essential foundation for research in the emerging Bioscience and Biotechnology-based disciplines.

**Admission requirements:** Applicants with a relevant Master's degree in Biochemistry or related discipline whose academic record show a potential for a successful completion of a PhD.

**Duration:** The programme would normally take a minimum of four years for full-time and six years for part-time to complete.

**Graduation Requirement:** To be awarded a Doctor of Philosophy in Biochemistry, a candidate must have taken and passed the following:

Course work	18 – 24 credits
Thesis	45 credits
Seminars	12 credits
<b>Total</b>	<b>75 – 81 credits</b>

### PROGRAMME STRUCTURE

#### YEAR 1

##### SEMESTER 1

##### CORE

##### CREDITS

FASC 701	Science and Society	3
BCMB 630	Research Methodology & Scientific Communication	3
BCMB 701	Advance Topics in Bioinformatics	3
FASC 700	Special Topics in Science	3
<b>Total</b>		<b>12</b>

##### SEMESTER 2

##### CORE

##### CREDITS

FASC 702	Advanced Quantitative Research Methods	3
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**Candidates should select at least 3 credits base on your proposed thesis area**

BCMB 702	Advances in Biochemical Pharmacology and Toxicology	3
BCMB 704	Advances in Molecular Biology and Applications	3
BCMB 706	Advances in Natural Product Research	3
BCMB 708	Advances in Biomedical and Infectious Diseases Research	3

**Electives**

FASC 710	Teaching Science at Tertiary Level	3
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<b>Total</b>		<b>18</b>
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**YEAR 2**

BCMB 710	Seminar 1	3
BCMB 720	Seminar II	3
BCMB 700	Thesis	

**YEAR 3 & 4**

BCMB 730	Seminar III	3
BCMB 740	Seminar IV	3
BCMB700	Thesis	45

**Course Description  
Credits**

**FASC 700: Special Topics in Science** **3**

The course examines historical and contemporary issues in science, relating to the student's area of specialization and relevance. Such topics are expected to challenge the students into exploring current and relevant research trends/discoveries in scientific approaches. The course will enable students explore scientific knowledge in modern science, and add on to their depth of information in their chosen areas of specialty. It is expected that, the course will complement other courses on the PhD flagship of the various departments in the Sciences and elsewhere. Additionally, it will expose students to current trends of presentations, and foster stronger confidence-building attitude that will enable enhanced international academic competitive spirit.

**FASC 701: Science and Society** **3**

This course will enable students gain insights on the practice of science as a discipline including major scientific concepts like inductivism are examined as well as the history of science and science itself, an overview of current approaches to research and an understanding of research partnerships, networks and appropriate methods of communicating science depending on the audience. The aim of the course is to help students to fit their research to relevant trends and directions for national development. Course content will cover topics such as the basis for the scientific method; conceptual frameworks; the philosophy of science; ethics in research; pure versus applied science debates; approaches to research; science for development and the merit of broader impact criteria; north south/south south collaboration and partnerships; research networks; communicating science to the policy make, lay audience and to the media.



**FASC 702: Advanced Quantitative Research Methods****3**

The course will serve as a step up for students who need to add up to their knowledge in quantitative methods of research techniques and analyses. Topics to be covered include: Sampling distributions and hypothesis testing. Sample size determination. Categorical data and chi-square, Non parametric tests. Principles of Design of Experiments. Analysis of variance and its assumptions. Experiments with single and multiple factors. Orthogonal and multiple Comparisons. Completely Randomized, Randomized Complete Block, repeated measures, cross over and Latin square designs. Nested designs. Fixed, random and mixed effects models. Factorial designs. Confounding. Fractional factorial designs. Split plot designs. Incomplete block designs. Analysis of covariance. Regression models: basic concepts; Regression Model Diagnostics. Categorical data analysis. Logistic regression, univariate and multivariate. Confounding and collinearity in logistic regression. Model selection in logistic regression.

**FASC 720: Teaching Science at the Tertiary Level****3**

It is anticipated that many of the students who go through the PhD programme in the Sciences may nurse special interest in teaching and academia. Focusing on group discussions, this course is expected to equip students with the requisite knowledge in overall management of students at the tertiary level. The course will focus on teaching the methodologies and techniques in handling Science-teaching at the undergraduate level. Topics such as laboratory supervision and safety, grading issues, special needs students, lecturing and tutoring techniques, examination preparation, teacher/student relationship, tertiary education management, will be discussed through reading, class/group discussions as well as presentations.

**BCMB 701 Advanced Topics in Bioinformatics****3**

This course will expose students to all the bioinformatic tools that are being used to acquire and analyse biological data across all the major types of experiments. Software programmes used for genomics, transcriptomics and proteomics/protein networks are considerably different, and hence it is important for students to learn the main softwares used in these fields of molecular biology as well as the new and updated versions that will be introduced from time-to-time. In addition to reviews of bioinformatic tools covering these main areas of molecular biology, softwares used in high-content image analysis, lipidomics as well as chemoinformatics will also be included to give students a holistic view of the bioinformatics. The course will be mainly conducted through the use of review articles selected by the lecturer during the period of the course for students to study in groups and present at lectures for discussions. At the beginning of the course, there will be a few lectures to be given by the course instructor to provide general overview of the bioinformatic landscape.

**BCMB 702 Advances in Biochemical Pharmacology and Toxicology****3**

This course will equip students with the necessary theoretical knowledge in taking up research on medicinal plants. Major topics in biochemical pharmacology and toxicology would be discussed in this course with particular emphasis on medicinal plant research. This will include advanced topics in toxicity testing and safety evaluation, herb-drug interactions, and mitochondrial as pharmacological targets.

**BCMB 704 Advances in Molecular Biology and Applications****3**

The goal of this course is to provide graduate-level instruction on molecular biology with detailed analysis of the biochemical mechanisms that control the maintenance, expression, and evolution of prokaryotic and eukaryotic genomes. The topics will cover current advances in methodological approaches for analyzing the function of cellular macromolecules and macromolecular complexes in DNA replication, recombination, transposition and repair, gene

expression and its regulation, mRNA splicing, genome organization, non-coding RNAs, signal transduction, protein synthesis, folding and degradation, growth control, and other life processes. A focus on critical thinking and problem solving will be used to show how fundamental, highly-significant biological problems are solved. We will also explore the logic of experimental design and data analysis.

**BCMB 706 Advances in Natural Product Research 3**

Compounds and biomolecules derived from nature will continue to represent an important source of new chemical entities for use as medicines, food supplements and other applications. The main source for the search and study of natural products has been plant; this course will cover the use of plants as well as other promising but traditionally unused sources. Efforts will be made to study fungi, actinomycetes, myxobacteria, macroalgae and microalgae as potential sources of new natural products being both primary and secondary metabolites. The main classes of natural products such as alkaloids, polyketides, glycopeptides, aminoglycosides, cyclic peptides, etc will be discussed including their predominant uses. Product discovery platforms use for the isolation of new compounds will also be discussed, namely the traditional bioassay assisted screening and the modern genome-guide approaches.

**BCMB 708 Advances in Biomedical and Infectious Diseases Research 3**

The course is aimed equipping students with knowledge on current methods for studying the transmission, diagnosis, and pathogenesis of diseases that are of public health concern in sub-Saharan Africa. Diseases to be covered include infectious diseases such as Malaria, HIV, and TB, neglected tropical diseases (NTDs) such as Leishmania, Buruli ulcer, and Schistosomiasis. Current knowledge of the biology of the causative agents, as well as progress towards improved therapeutic mechanisms and vaccine development will be discussed. The relevance of genomics and proteomics for research into the various diseases will also be emphasized.

***Selected Journals***

Nature, Science, Journal of Immunology, Journal of Infectious Diseases, Infection and Immunity, PLoS Pathogens

**BCMB 710 Seminar I 3**

Each student will make a presentation, on his/her thesis research proposal. In addition each student will be required to attend all departmental seminars.

**BCMB 720 Seminar II 3**

This is experiential research, which would be carried out either inside or outside of the laboratory. The student will be attached to research groups and will use the period to optimise his/her methods and also develop protocols. Students will be required to present (oral and written) progress report.

**BCMB 730 Seminar III 3**

Each student will make a presentation, on his/her thesis progress report. In addition each student will be required to attend all departmental seminars.

**BCMB 740 Seminar IV 3**

Each student will present a final seminar on his/her research findings prior to the submission of thesis.

## **YEAR 2**

Each PhD candidate would be required to sit and pass the comprehensive examination and present a research proposal at the beginning of the first semester of Year 2. Candidates who have successfully passed the comprehensive examination and had their research proposal approved would be attached to research laboratories for their experiential. Each candidate would be required to use the experiential period to develop protocols, optimise methods, collect preliminary data and present experiential report seminar and write up at the end of the semester. Thesis research would begin at the beginning of the second semester of Year 2.

## **Experiential Learning**

After their PhD research proposal is approved, each student would be attached to a research laboratory for their experiential learning. The experiential learning period could be used to develop protocols, optimise methods, or collect preliminary data. Students will submit a written report of their laboratory attachment or field work, and also present a seminar.

Students will have the option to work on some of the ongoing research projects being led by faculty members and their international collaborators. The departmental graduate committee will ensure that each student is assigned to the projects that will provide the appropriate training. A summary of the research projects currently available is provided below. This list will be updated annually to reflect addition of new projects or termination of existing ones.

1. **Alternative molecular mechanisms for erythrocyte invasion by *Plasmodium falciparum* in Ghana (PIs, Gordon Awandare & David Conway):** This study is investigating the relationship between sequence variation in malaria parasites genomes which may result from immunological pressure, and the invasion mechanisms deployed by the parasites to infect red blood cells. Malaria parasite isolates are being collected from children in Navrongo and Kintampo. Students would benefit from experience in sample collection and processing at the various sites, and the subsequent molecular and immunological analysis (red cell invasion assays, ELISA, real time PCR, genome sequencing), and bioinformatics in our laboratories and with our collaborators at the London School of Hygiene and Tropical Medicine and the Sanger Institute. This study is funded by a Royal Society-Leverhulme Africa Award.
2. **Role of complement receptor 1 in erythrocyte invasion by *Plasmodium falciparum* in semi-immune Ghanaians (PI, Gordon Awandare):** These studies focus on the role of complement receptor 1 (CR1) in malarial pathogenesis in children exposed to varying intensities of transmission. Samples are being collected in Navrongo, Kintampo, and Accra, and we are determining the relationship between expression of CR1 protein on the RBCs of children with malaria, peripheral parasitemia, and ligand-specific antibody titers. In addition, molecular and immunological techniques are being used to confirm the role of *P. falciparum* Rh4 as a ligand for CR1 and also to look for novel CR1 ligands. These studies will help identify new targets for vaccine development, and students will benefit from the field work as well as the molecular and immunological analysis in our laboratories at Legon and the laboratories of our collaborators at Penn State University, PA, USA. The study is funded by a grant from the National Institutes of Health (NIH), USA.
3. **Zoonotic risks of non-tuberculous mycobacteria between humans and small mammals (potential transmission of Buruli ulcer) in Cote d'Ivoire and Ghana (PIs, Lydia Mosi and Bassirou Bonfoh):** This collaborative project aims to discover the underlying zoonotic

potential of non-tuberculous mycobacterial transmission between the environment, small mammals and humans. The aims and objectives of this study employs a ONE HEALTH approach to deciphering the mode of transmission of Buruli ulcer and other non-tuberculous mycobacterial diseases. These studies provide studies with opportunities to experience field work, the use of animal models of disease, and to learn techniques in microbiological handling and molecular diagnosis. This project is funded by the Wellcome trust/ Afrique One consortium.

4. **Microbiology of secondary infections in Buruli ulcer lesions: implications for therapeutic interventions (PI, Lydia Mosi):** This Project is designed to determine the occurrence of secondary infections in Buruli ulcer lesions and the rate of antibiotic resistance emergence associated with treatment. Students participating in this project will learn techniques for molecular diagnosis and handling of microorganisms. The project is funded by a grant from the University of Ghana Research Fund.
5. **Characterisation of trypanosome infections over the lifetime of cattle in Ghana (PIs, Theresa Manful and Mark Carrington):** The aim is to determine the molecular diversity of trypanosomes infection in cattle in two different geographical locations in Ghana and to identify whether there is a correlation between age and predominant infecting trypanosome species. Students will learn the use of molecular fingerprinting to identify individual trypanosome genotypes and characterise the epidemiology of the trypanosome populations present in individual cows over their lifetimes. This study is funded by a Royal Society-Leverhulme Africa Award and a CAPREx fellowship.
6. **Proteomic analysis of the molecular mechanisms of latency and drug-resistance in *Mycobacterium africanum I* and screen for novel antimycobacterials from fungal sources (PI, Patrick Arthur).** This project seeks to discover new and more effective drugs for tuberculosis from fungal sources using an integrated proteomics platform, which determines both the mechanism of drug action and resistance. This project makes use of our assembled library of wood decaying fungi and marine endophytic fungi, which have demonstrated the production of metabolites with anti-microbial activities. Students will gain experience in proteomics, drug susceptibility testing for microorganisms and purification and characterization of novel compounds. This study is funded by a grant from Grand Challenges Canada.

## INTERNATIONAL COLLABORATION

The PhD in Biochemistry programme will benefit from the department's collaborations with regional partners and international institutions including the American Society for Cell Biology (ASCB). Through these collaborations, the programme will benefit from short teaching visits from research scientists, as well as opportunities for laboratory attachments at partner institutions. Some of the ongoing collaborations include:

1. American Society for Cell Biology (ASCB): This collaboration is for the purpose of organizing annual training workshops on the Cell Biology of Infectious Diseases. The ASCB has a vast network of renowned scientists, including Prof Keith Gull of Oxford University, Prof. Kirk Deitsch of Cornell University, NY, and Prof Dick McIntosh of the University of Colorado, who have committed to supporting our programmes.
2. London School of Hygiene and Tropical Medicine (LSHTM), UK: This is based on two collaborative research grants between Dr. Gordon Awandare and Prof. David Conway of LSHTM. It includes training and joint supervision of students and is funded by grants from the Royal Society, UK, and the European Research Council. These collaborations

also include regional partners including Dr Ambroise Ahouidi (International Center of Excellence in Malaria Research (ICEMR), Universite Cheikh Anta Diop in Senegal), Dr Mahmadou Diakite (University of Bamako in Mali), and Dr Alfred Amambua-Ngwa (MRC Laboratories in The Gambia).

3. Penn State University School of Medicine, Hershey, PA: This is based on a collaborative research grant between Dr. Gordon Awandare and Prof. Jose Stoute of Penn State. It includes training and joint supervision of students. It is funded by a National Institutes of Health, USA grant award.
4. Cambridge University, UK: This is based on a collaborative research grant between Dr. Theresa Manful and Prof. Mark Carrington of Cambridge. It includes training and joint supervision of students. It is funded by a Royal Society-Leverhulme Africa award.
5. Malaria Vaccine Research and Capacity Building in Ghana (MAVARECA): This is a DANIDA-funded collaboration with NMIMR and the University of Copenhagen, for the training of PhD students in malaria vaccine research. It is being led by Prof Kwadwo Koram and Dr. Michael Ofori.
6. Centre Suisse de Recherche Scientifique (CSRS), Cote d'Ivoire: This is based on a collaboration between Prof. Bassirou Bonfoh of CSRS and Dr. Lydia Mosi on a Wellcome Trust/Afrique-One funded research and training project in molecular epidemiology of Buruli Ulcer in Ghana and La Cote d'Ivoire. It includes training and joint supervision of students.

## **PHD IN MOLECULAR CELL BIOLOGY OF INFECTIOUS DISEASES (PHD MCBI)**

**Admission requirements:** Candidates with a Master's degree in the biological sciences, physical sciences, or other fields relevant to Infectious Diseases may apply for direct admission into the PhD MCBI program. Candidates with a good first degree (at least 2<sup>nd</sup> class lower) in a relevant discipline, including Biological or Physical Sciences may also apply into the PhD MCBI program.

**Duration:** Four years full time, six years part time.

### **Graduation requirements:**

- Course work: 18 – 24 credits
- Seminar (4): 12 credits
- Thesis: 45 credits
- Total: 75-81 credits**

### **Program structure**

#### **Year 1**

#### **Semester 1**

#### **CORE**

#### **CREDITS**

MCBI 701:	Advanced Qualitative Research Methods and Information Literacy	3
*FASC 700:	Special Topics in Science	3
*FASC 701:	Science and Society	3
	<b>TOTAL</b>	<b>9</b>

**ELECTIVES (select one elective)**

MCBI 710:	Laboratory Rotation	3
*BCMB 701:	Advanced Topics in Bioinformatics	3
MCBI 601:	Bacterial and Viral Infections	3
*BCMB 609:	Immune Response Mechanisms	3

**Semester 2****CORE****CREDITS**

*FASC 702:	Advanced Quantitative Research Methods	3
MCBI 702:	Current Vaccine Approaches	3
*BCMB 708	Advances in Biomedical and Infectious Diseases Research	3

**ELECTIVES (select one elective)**

MCBI 704:	Advances in Drug Discovery and Development	3
*FASC 710:	Teaching Science at Tertiary Level	3
MCBI 602:	Eukaryotic Infections: Protozoan, Helminthic and Fungal	3
MCBI 604:	Host and Pathogen Genomics	3

**Year 2**

MCBI 700:	Thesis	
MCBI 720:	Seminar I	3
MCBI 730:	Seminar II	3

**Years 3 & 4**

MCBI 700:	Thesis	45
MCBI 740:	Seminar III	3
MCBI 750:	Seminar IV	3

**\*Existing courses****COURSE DESCRIPTIONS****\*FASC 700: Special Topics in Science**

The course examines historical and contemporary issues in science, relating to the student's area of specialization and relevance. Such topics are expected to challenge the students into exploring current and relevant research trends/discoveries in scientific approaches. The course will enable students explore scientific knowledge in modern science, and add on to their depth of information in their chosen areas of specialty. It is expected that, the course will complement other courses on the PhD flagship of the various departments in the Sciences and elsewhere. Additionally, it will expose students to current trends of presentations, and foster stronger confidence-building attitude that will enable enhanced international academic competitive spirit.

**\*FASC 701: Science and Society**

This course will enable students gain insights on the practice of science as a discipline including major scientific concepts like inductivism are examined as well as the history of science and science itself, an overview of current approaches to research and an understanding of research

partnerships, networks and appropriate methods of communicating science depending on the audience. The aim of the course is to help students to fit their research to relevant trends and directions for national development. Course content will cover topics such as the basis for the scientific method; conceptual frameworks; the philosophy of science; ethics in research; pure versus applied science debates; approaches to research; science for development and the merit of broader impact criteria; north south/south south collaboration and partnerships; research networks; communicating science to the policy make, lay audience and to the media.

### **\*FASC 702: Advanced Quantitative Research Methods**

The course will serve as a step up for students who need to add up to their knowledge in quantitative methods of research techniques and analyses. Topics to be covered include: Sampling distributions and hypothesis testing. Sample size determination. Categorical data and chi-square, Non parametric tests. Principles of Design of Experiments. Analysis of variance and its assumptions. Experiments with single and multiple factors. Orthogonal and multiple Comparisons. Completely Randomized, Randomized Complete Block, repeated measures, cross over and Latin square designs. Nested designs. Fixed, random and mixed effects models. Factorial designs. Confounding. Fractional factorial designs. Split plot designs. Incomplete block designs. Analysis of covariance. Regression models: basic concepts; Regression Model Diagnostics. Categorical data analysis. Logistic regression, univariate and multivariate. Confounding and collinearity in logistic regression. Model selection in logistic regression.

### **\*FASC 710: Teaching Science at the Tertiary Level**

It is anticipated that many of the students who go through the PhD programme in the Sciences may nurse special interest in teaching and academia. Focusing on group discussions, this course is expected to equip students with the requisite knowledge in overall management of students at the tertiary level. The course will focus on teaching the methodologies and techniques in handling Science-teaching at the undergraduate level. Topics such as laboratory supervision and safety, grading issues, special needs students, lecturing and tutoring techniques, examination preparation, teacher/student relationship, tertiary education management, will be discussed through reading, class/group discussions as well as presentations.

### **\*BCMB 701 Advanced Topics in Bioinformatics**

This course will expose students to all the bioinformatic tools necessary for acquisition and comparative analysis of host and pathogen genomic data. Software programmes used for genomics, transcriptomics and proteomics/protein networks are considerably different, and hence it is important for students to learn the main softwares used in these fields of molecular biology as well as the new and updated versions that will be introduced from time-to-time. In addition to reviews of bioinformatic tools covering these main areas of molecular biology, softwares used in high-content image analysis, lipidomics as well as chemoinformatics will also be included to give students a holistic view of the bioinformatics. The course will be mainly conducted through the use of review articles selected by the lecturer during the period of the course for students to study in groups and present at lectures for discussions. At the beginning of the course, there will be a few lectures to be given by the course instructor to provide general overview of the bioinformatic lanscape.

### **\*BCMB 708 Advances in Biomedical and Infectious Diseases Research**

**3**

The course is aimed equipping students with knowledge on current methods for studying the transmission, diagnosis, and pathogenesis of diseases that are of public health concern in sub-Saharan Africa. Diseases to be covered include infectious diseases such as Malaria, HIV, and

TB, neglected tropical diseases (NTDs) such as Leishmania, Buruli ulcer, and Schistosomiasis. Current knowledge of the biology of the causative agents, as well as progress towards improved therapeutic mechanisms and vaccine development will be discussed. The relevance of genomics and proteomics for research into the various diseases will also be emphasized.

**\*BCMB 609: Immune Response Mechanisms**

This course is an advanced study of Immunology and takes a detailed look at the molecular mechanisms through which the immune system responds to pathogens. A major goal of the course is to prepare students for research in the fields of Immunology, disease pathogenesis and vaccine development. The content includes discussions of the mechanisms of antigen processing and presentation, T-cell and B-cell receptor gene rearrangements, recombination of VDJ gene segments, affinity maturation and somatic hypermutation. Current advances in immunological methods such as flow cytometry, and new developments in the search for vaccines for malaria and HIV will also be discussed.

**MCBI 700: Thesis**

Each student will undertake a major research project and present a written dissertation. In addition, students will present an oral defence of their thesis.

**MCBI 701: Advanced Qualitative Research Methods and Information Literacy**

This course will provide students with an advanced knowledge of qualitative research strategies including discussion of study design and methods for data collection and discuss their strengths and limitations. Approaches for collection, analysis and reporting of qualitative data will also be covered. Topics will include case studies, comparative analysis, predictive deduction, triangulation, and validity/reliability/generalizability. In addition, the course will cover information literacy to help students develop the ability to identify their information needs, effectively locate, critically evaluate and creatively use such information for their research. The course will also cover proposal writing, ethics of research and intellectual property issues.

**MCBI 702: Current Vaccine Approaches**

This course aims to review recent developments in the design, development and delivery of vaccines against infectious diseases. An overview of the principles of vaccination and discussion of the successes and failures of historical vaccines including the small pox and yellow fever vaccines will be discussed. The strengths and limitations of current approaches to vaccine design will also be reviewed, including live attenuated, peptide and subunit vaccines and the applications of recombinant DNA vectors and idiotypic antibodies will be discussed. In addition, the factors hampering the development of vaccines to major infectious diseases such as malaria and HIV, as well as the promising new strategies for overcoming these challenges will be reviewed.

**MCBI 704: Advances in Drug Discovery and Development**

This course aims to provide students with a deep understanding of the most modern approaches to discovery and development of drugs. Topics to be discussed will include mechanistic disease target discovery and validation, basic disease models, genes to medicines. In addition, advances in the development process will also be covered, including stage-gates from exploratory research targets (ERTs) to drug candidates, late discovery to early development, pre-clinical and candidate validation, clinical phases, post launch and drug surveillances.



### **MCBI 710: Laboratory Rotation**

This course is designed for students who are interested in exploring the research projects available in the various laboratories of the faculty members. Students will be placed on attachment to each laboratory for at least two months to experience research and then submit a written report for assessment.

### **MCBI 720: Seminar I**

Each student will make a presentation on his/her thesis research proposal. In addition each student will be required to attend all departmental seminars. Students will also be assigned into small groups of five for journal clubs led by a faculty member, where they will review and critique recent seminal articles in a relevant field.

### **MCBI 730: Seminar II**

For their experiential learning, students will be attached to local, regional, or international research partners, and they may use the period to collect and analyze pilot data, optimise methods or develop protocols. Students will be required to present (oral and written) reports of their attachments, which will be graded. In addition students will be required to attend all departmental seminars when they are not traveling.

### **MCBI 740: Seminar III**

Students will be required to provide updates on their research projects at least once each semester through a progress report seminar presentation. In addition students will be required to attend all departmental seminars.

### **MCBI 750: Seminar IV**

Students will be required to provide updates on their research projects at least once each semester through a progress report seminar presentation. In addition students will be required to attend all departmental seminars.

### **MCBI 601: Bacterial and Viral Infections**

This course aims to provide insight on bacterial and viral infections that are major public health concerns in sub-Saharan Africa. Aspects to be discussed will include the biology of the pathogen, the pathogenesis of its infection, the pathophysiology of the human host, and current strategies for therapeutics and vaccinology. The molecular mechanism of each pathogen will be discussed, thereby elucidating the pathways for disease progression and pathogen success. Treatment of each pathogen will be organized in two complementary formats; the first based on the major classes of pathogens, and the second grouped according to the primary site of pathogenesis within the human host.

### **MCBI 602: Eukaryotic Infections: Protozoan, Helminthic and Fungal**

This course will aim to teach the biology of eukaryotic pathogens with an emphasis on the molecular mechanisms underlying pathogen success. Treatments will elucidate diseases caused by both protozoan parasites (e.g., *Plasmodia*, Trypanosomes, *Leishmania*, and *Toxoplasma*) and selected pathogenic fungi and helminths. The uniqueness of each host-pathogen interaction will be developed, including pathways for infection and host cell invasion, host pathophysiology, and the survival strategies by each pathogen (e.g., immune evasion by antigenic variation). Modern

efforts at vaccine development and the identification of new drug targets will be discussed, as well as the resistance mechanisms by these pathogens.

### **MCBI 604: Host and Pathogen Genomics**

This course aims to introduce students to the principles and tools for genomic and proteomic study of host-pathogen interactions. To that end it will discuss the content of multiple genomes elucidating their functions and organization. The course will also develop the modern, computer-based subjects of transcriptomics/metabolomics and the functional genomics of bacterial, viral and eukaryotic pathogens. Classical and complex disease genetics and quantitative trait locus (QTL) analysis, natural selection of pathogens, comparative genomics, genome wide association studies, genetic manipulations, computational learning (genome databases, modern methods for DNA sequencing, assembling pathogen genome sequences, genome-wide sequence read mapping and variant calling) will be discussed.

### **Details of Experiential Learning**

After their PhD research proposal is approved, each student would be attached to a research laboratory for their experiential learning. The experiential learning period will give students the opportunity to learn research techniques in a practical setting. This period could also be used to develop protocols, optimise methods, or collect preliminary data. Students will submit a written report of their laboratory attachment or field work, and also present a seminar.

Students will have the option to work on some of the ongoing research projects being led by faculty members and their international collaborators. The departmental graduate committee will ensure that each student is assigned to the projects that will provide the appropriate training. A summary of the research projects currently available is provided below. This list will be updated annually to reflect addition of new projects or termination of existing ones.

- 7. Alternative molecular mechanisms for erythrocyte invasion by *Plasmodium falciparum* in Ghana (PIs, Gordon Awandare & David Conway):** This study is investigating the relationship between sequence variation in malaria parasites genomes which may result from immunological pressure, and the invasion mechanisms deployed by the parasites to infect red blood cells. Malaria parasite isolates are being collected from children in Navrongo and Kintampo. Students would benefit from experience in sample collection and processing at the various sites, and the subsequent molecular and immunological analysis (red cell invasion assays, ELISA, real time PCR, genome sequencing), and bioinformatics in our laboratories and with our collaborators at the London School of Hygiene and Tropical Medicine and the Sanger Institute. This study is funded by a Royal Society-Leverhulme Africa Award.
- 8. Role of complement receptor 1 in erythrocyte invasion by *Plasmodium falciparum* in semi-immune Ghanaians (PI, Gordon Awandare):** These studies focus on the role of complement receptor 1 (CR1) in malarial pathogenesis in children exposed to varying intensities of transmission. Samples are being collected in Navrongo, Kintampo, and Accra, and we are determining the relationship between expression of CR1 protein on the RBCs of children with malaria, peripheral parasitemia, and ligand-specific antibody titers. In addition, molecular and immunological techniques are being used to confirm the role of *P. falciparum* Rh4 as a ligand for CR1 and also to look for novel CR1 ligands. These studies will help identify new targets for vaccine development, and students will benefit from the field work as well as the molecular and immunological analysis in our laboratories at Legon and the laboratories of our collaborators at Penn State University, PA, USA. The study is funded by a grant from the National Institutes of Health (NIH), USA.

9. **Zoonotic risks of non-tuberculous mycobacteria between humans and small mammals (potential transmission of Buruli ulcer) in Cote d'Ivoire and Ghana (PIs, Lydia Mosi and Bassirou Bonfoh):** This collaborative project aims to discover the underlying zoonotic potential of non-tuberculous mycobacterial transmission between the environment, small mammals and humans. The aims and objectives of this study employs a ONE HEALTH approach to deciphering the mode of transmission of Buruli ulcer and other non-tuberculous mycobacterial diseases. These studies provide studies with opportunities to experience field work, the use of animal models of disease, and to learn techniques in microbiological handling and molecular diagnosis. This project is funded by the Wellcome trust/ Afrique One consortium.
10. **Microbiology of secondary infections in Buruli ulcer lesions: implications for therapeutic interventions (PI, Lydia Mosi):** This Project is designed to determine the occurrence of secondary infections in Buruli ulcer lesions and the rate of antibiotic resistance emergence associated with treatment. Students participating in this project will learn techniques for molecular diagnosis and handling of microorganisms. The project is funded by a grant from the University of Ghana Research Fund.
11. **Characterisation of trypanosome infections over the lifetime of cattle in Ghana (PIs, Theresa Manful and Mark Carrington):** The aim is to determine the molecular diversity of trypanosomes infection in cattle in two different geographical locations in Ghana and to identify whether there is a correlation between age and predominant infecting trypanosome species. Students will learn the use of molecular fingerprinting to identify individual trypanosome genotypes and characterise the epidemiology of the trypanosome populations present in individual cows over their lifetimes. This study is funded by a Royal Society-Leverhulme Africa Award and a CAPREX fellowship.
12. **Proteomic analysis of the molecular mechanisms of latency and drug-resistance in *Mycobacterium africanum I* and screen for novel antimycobacterials from fungal sources (PI, Patrick Arthur).** This project seeks to discover new and more effective drugs for tuberculosis from fungal sources using an integrated proteomics platform, which determines both the mechanism of drug action and resistance. This project makes use of our assembled library of wood decaying fungi and marine endophytic fungi, which have demonstrated the production of metabolites with anti-microbial activities. Students will gain experience in proteomics, drug susceptibility testing for microorganisms and purification and characterization of novel compounds. This study is funded by a grant from Grand Challenges Canada.
13. **Towards effective control of Buruli ulcer (PI, Dorothy Yeboah-Manu):** This project aims to improve understanding of the ecology and transmission of *Mycobacteria ulcerans*, analyse for evolution of Buruli ulcer wounds to determine underlying mechanism(s) of wound healing delay and improve diagnosis by development, improvement and evaluation of point-of-care diagnostic laboratory test systems. Students involved with this project will learn techniques including conventional and real-time PCR, western blotting, ELISA, DNA sequence analysis, and conventional microbiological methods. The project is funded by the UBS Optimus foundation and VW Foundation.
14. **Understanding the genomic diversity between *Mycobacterium africanum (MAF)* and *Mycobacterium tuberculosis (MTB)* (PI, Dorothy Yeboah-Manu):** This is a prospective molecular epidemiological study of tuberculosis in one urban district and one rural district of Ghana. The study aims to define the genetic diversity (including drug resistance) of MTB and MAF circulating in these areas and compare the transmission of MTB and MAF and associated risk factors, such as HIV, drug resistance, and diabetes in these areas. Gene expression profiles of MTB and MAF will also be examined. This study will use several techniques which students would learn from, including, Spoligotyping, MIRU-VNTR, SNP

analysis, genomics-bioinformatics, gene expression by RNAseq, conventional microbiological methods. The project is funded by the Wellcome Trust, UK.

15. **Measuring changes in reservoir of malaria infection in northern Ghana using molecular diagnostic methods (PI, Kwadwo Koram):** This project aims to characterize the reservoir of malaria infection by microscopy and PCR-based methods, to calculate multiplicity of infection by MSP2 genotyping, and assess the frequency of drug resistance alleles. Students involved with this project will be trained to measure linkage disequilibrium in *P. falciparum* using microsatellite repeat loci and genome-wide single nucleotide polymorphisms (SNPs) and to characterize the reservoir of infection in terms of the number of *var* gene types in the population. The project is funded by Howard Hughes Medical Institute/NIH.
16. **Impact of Distinct Eco-epidemiology on Malaria Drug Resistance in Ghana (PI, Anita Ghansah).** This project seeks to compare the clinical and parasitological efficacy of anti-malarial drugs in two ecological zones of Ghana over time. This is being done by determining the multiplicity of infections (MOI) in the two ecological zones and their association with drug resistance over time. The study will also characterize and compare the frequency of known drug resistance markers in the two zones and their correlations with *ex vivo* drug response over time. This project gives students exposure to cohort study design and statistical analysis, SNP genotyping, PCR, high resolution melting curve technique, genome-wide sequencing and analysis. The studies are funded by a grant from the National Institute of Allergy and Infectious Diseases (NIAID), NIH, USA.
17. **Exploring *Plasmodium falciparum* genome to understand the genetic diversity, emergence of drug resistance and vaccine efficacy (PI, Anita Ghansah).** This study is investigating *P. falciparum* population diversity in parasites circulating in forest and coastal Savanna zones of Ghana, by examining the genetic structure of *P. falciparum* over space and time in the study area, and mapping the Linkage Disequilibrium architecture of parasite isolates to detect signatures of natural selection in the Ghanaian parasite pool. The study will also determine the frequency distribution of polymorphisms in candidate vaccine antigens and known drug resistance genes. This project will teach students in field study design, DNA extraction techniques, whole genome sequencing and analysis of whole genome data. The project is funded by the MRC Centre for Genomics and Global Health.
18. **Association of strong T cell responses to HLA class I-restricted CSP and AMA1 epitopes with the risk of *P. falciparum* infection (PI, Kwadwo Asamoah Kusi):** The aim of this study is to determine the relationship between T cell responses to HLA class I-restricted epitopes within the Plasmodium antigens CSP and AMA1, and the risk of infection with Plasmodium and/or the incidence of clinical malaria in a longitudinal cohort from a malaria endemic area. Methods that students could learn through this project include IFN- $\gamma$  ELISPOTS, Flow cytometry, HLA typing, and bioinformatics. The study is funded by a grant from the University of Ghana Research fund.
19. **Immortalization of B cells from *P. falciparum*-exposed individuals for the production of parasite-specific monoclonal antibodies (PI, Kwadwo Asamoah Kusi):** The aim of this project is to develop a protocol for the continuous production of immortalized human B cells and subsequently purify/characterize secreted antibodies that have specificity for selected *P. falciparum* antigens. Students involved with this project will be trained on Cell culture, cell cloning by limiting dilution, ELISA, SDS PAGE, Western blotting, and fluorescence microscopy. This project is funded by a grant from the World Academy of Sciences (TWAS).

## **Funding and International Collaborations**

The proposed new MCBI graduate programs will be funded by a grant (approximately \$8M) from the World Bank's African Centers of Excellence Initiative. In addition, the programs will benefit from collaborations with regional partners and international institutions including the American Society for Cell Biology (ASCB). Through these collaborations, the MCBI programs will benefit from short teaching visits from some of the leading Infectious Disease research scientists in the world, as well as opportunities for laboratory attachments at partner institutions. Some of the ongoing collaborations include:

7. American Society for Cell Biology (ASCB): This collaboration is for the purpose of organizing annual training workshops on the Cell Biology of Infectious Diseases. The ASCB has a vast network of renowned scientists, including Prof Keith Gull of Oxford University, Prof. Kirk Deitsch of Cornell University, NY, and Prof Dick McIntosh of the University of Colorado, who have committed to supporting the MCBI program.
8. London School of Hygiene and Tropical Medicine (LSHTM), UK: This is based on two collaborative research grants between Dr. Gordon Awandare and Prof. David Conway of LSHTM. It includes training and joint supervision of students and is funded by grants from the Royal Society, UK, and the European Research Council. These collaborations also include regional partners including Dr Ambroise Ahouidi (International Center of Excellence in Malaria Research (ICEMR), Universite Cheikh Anta Diop in Senegal), Dr Mahmadou Diakite (University of Bamako in Mali), and Dr Alfred Amambua-Ngwa (MRC Laboratories in The Gambia).
9. Penn State University School of Medicine, Hershey, PA: This is based on a collaborative research grant between Dr. Gordon Awandare and Prof. Jose Stoute of Penn State. It includes training and joint supervision of students. It is funded by a National Institutes of Health, USA grant award.
10. Cambridge University, UK: This is based on a collaborative research grant between Dr. Theresa Manful and Prof. Mark Carrington of Cambridge. It includes training and joint supervision of students. It is funded by a Royal Society-Leverhulme Africa award.
11. Malaria Vaccine Research and Capacity Building in Ghana (MAVARECA): This is a DANIDA-funded collaboration with NMIMR and the University of Copenhagen, for the training of PhD students in malaria vaccine research. It is being led by Prof Kwadwo Koram and Dr. Michael Ofori.
12. Centre Suisse de Recherche Scientifique (CSRS), Cote d'Ivoire: This is based on a collaboration between Prof. Bassirou Bonfoh of CSRS and Dr. Lydia Mosi on a Wellcome Trust/Afrique-One funded research and training project in molecular epidemiology of Buruli Ulcer in Ghana and La Cote d'Ivoire. It includes training and joint supervision of students.
13. Centre National de Recherche et de Formation sur le Paludisme (CNRFP), Burkina Faso: This is based on previous collaborations between Dr. Sodiomon Sirima of CNRFP and NMIMR for malaria research and training. CNRP is a partner for the proposed center of excellence (WACCBIP) and will continue to collaborate on research and training on malaria.



## **DEPARTMENT OF MARINE AND FISHERIES SCIENCES**

### **Introduction**

The Department of Marine and Fisheries Sciences (MAFS) is Ghana's foremost centre directly concerned with oceanographic research and training of fisheries scientists among her institutions of higher learning. The mission of MAFS is to understand the physical, biological, geological and chemical functioning of the oceans and other aquatic ecosystems; and of the fisheries through research and training of professionals in marine and freshwater science for effective and sustainable exploitation of Ghana's marine and other aquatic resources.

Following local and international requests, post graduate programmes in Coastal Management, Fisheries Stock Assessment and Management, and aquaculture are being run in addition to existing courses. These programmes have received collaborations from both local and international institutions.

To ensure the sustainability of fisheries and other marine life requires the development and implementation of verifiable, science-based practices. In line with the current trend and challenges in research and training in the fields of marine and fisheries sciences, the department has recently reviewed and overhauled its existing undergraduate and postgraduate degree programmes to meet national and international demands. This is in consonance with the University of Ghana's directive to review the PhD programme.

In the review, the intrinsic interdisciplinary nature of modern marine and fisheries sciences and the necessity for cross-disciplinary graduate level training is recognized. Areas such as biological, chemical and physical oceanography, marine geology and geophysics are covered with the view to understanding the ocean as an integrated system. The research focus will allow all aspects of the multidisciplinary fields in marine and fisheries sciences to be addressed towards the award of the PhD degree.

### **PH.D MARINE SCIENCE**

The Ph.D programme in Marine Science is multidisciplinary and focuses on the application of advanced technology to ocean research and observation. The programme emphasises on the resolution of key scientific issues through novel scientific research and technological developments. Researchers study changes in ocean phenomena on seasonal to interannual time scales with emphasis on: paleoclimatic changes over geological time scale; chemical processes operating within the marine environment; application of general principles of mathematics and experimental physics to fundamental problems of the oceans, complex physical ocean-atmosphere interactions e.g. waves, tides and currents, and their impacts on the coastal environment; and application of general principles of geology and geochemistry to problems in marine and terrestrial environments.

#### **Admission Requirements**

To qualify for admission to the PhD programme in Marine Science, the applicant must have a relevant master's degree, in addition to other requirements detailed in the University of Ghana Handbook.

#### **Duration of Programme**

The minimum duration for the PhD programme will be normally four (4) years for full time candidates and six (6) years for part-time candidates.

## Graduation Requirements

Course work	18-24 credits
Seminars (4)	12 credits
Thesis	45 credits
<b>Total</b>	<b>75-81 credits</b>

### Course codes

**MAFS: Core courses for Marine and Fisheries Sciences programmes**

**MASC: Marine Science courses**

**FISH: Fisheries Science courses**

## PROGRAMME STRUCTURE

### YEAR 1

#### FIRST SEMESTER

##### CORE COURSES

Course Code	Course Title	Credits
MAFS 701	Marine Resources and Fisheries Governance	3
FASC 701	Science and Society	3

##### ELECTIVE COURSES (maximum of 6 credits)

Course Code	Course Title	Credits
FASC 710	Teaching Science at the Tertiary Level	3
MASC 701	Advances in Biological Oceanography	3
MASC 703	Advances in Chemical Oceanography	3
MASC 705	Advances in Physical Oceanography	3
MASC 709	Advances in Marine Geoscience	3

#### SECOND SEMESTER

##### CORE COURSES

Course Code	Course Title	Credits
FASC 702	Advanced Quantitative Research Methods	3
MAFS 702	Project Management in Science	3

##### \*ELECTIVE COURSES (maximum of 6 credits)

Course Code	Course Title	Credits
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FASC 700	Special Topics in Science	<b>3</b>
MASC 702	Current Trends in Remote Sensing and GIS Applications	<b>3</b>

**\*Students are free to choose other level 700 courses from other departments.**

### **YEAR 2**

<b>Course Code</b>	<b>Course Title</b>	<b>Credits</b>
MAFS 710	Seminar I	<b>3</b>
MAFS 720	Seminar II	<b>3</b>

### **YEAR 3 and 4**

MAFS 700	Thesis	<b>45</b>
MAFS 730	Seminar III (Year 3)	<b>3</b>
MAFS 740	Seminar IV (Year 4)	<b>3</b>

### **COURSE DESCRIPTIONS**

#### **FASC 700 SPECIAL TOPICS IN SCIENCE (3 Credits)**

The course examines historical and contemporary issues in science, relating to the student's area of specialization and relevance. Such topics are expected to challenge the students into exploring current and relevant research trends/discoveries in scientific approaches. The course will enable students explore scientific knowledge in modern science, and add on to their depth of information in their chosen areas of specialty. It is expected that, the course will complement other courses on the PhD flagship of the various departments in the Sciences and elsewhere. Additionally, it will expose students to current trends of presentations, and foster stronger confidence-building attitude that will enable enhanced international academic competitive spirit.

#### **FASC 701 SCIENCE AND SOCIETY (3 Credits)**

This course will enable students gain insights in the practice of science as a discipline including major scientific concepts like inductivism are examined as well as the history of science and science itself, an overview of current approaches to research and an understanding of research partnerships, networks and appropriate methods of communicating science depending on audience. The aim of the course is to help students to fit their research to relevant trends and directions for national development. Course content will cover topics such as the basis for the scientific method; conceptual frameworks; the philosophy of science; ethics in research; pure versus applied science debates; approaches to research; science for development and the merit of broader impact criteria; north south/south south collaboration and partnerships; research networks; communicating science to the policy make, lay audience and to media.

#### **FASC 702 ADVANCED QUANTITATIVE RESEARCH METHODS (3 Credits)**

The course will serve as a step up for students who need to add up to their knowledge in quantitative methods of research techniques and analyses. Topics to be covered include: Sampling distributions and hypothesis testing. Sample size determination; Categorical data and chi-square; Non parametric tests; Principles of Design of Experiments; Analysis of variance and its assumptions; Experiments with single and multiple factors. Orthogonal and multiple Comparisons; Completely Randomized, Randomized Complete Block, repeated measures, cross over and Latin square designs. Nested designs; Fixed, random and mixed effects models. Factorial designs. Confounding; Fractional factorial designs. Split plot designs. Incomplete block

designs. Analysis of covariance; Regression models: basic concepts; Regression Model Diagnostics. Categorical data analysis; Logistic regression; univariate and multivariate analyses; Confounding and collinearity in logistic regression; Model selection in logistic regression.

**FASC 710: TEACHING SCIENCE AT THE TERTIARY LEVEL (3 credits)**

It is anticipated that many of the students who go through the PhD programme in the Sciences may nurse special interest in teaching and academia. Focusing on group discussions, this course is expected to equip students with the requisite knowledge in overall management of students at the tertiary level. The course will focus on teaching the methodologies and techniques in handling science-teaching at the undergraduate level. Topics such as laboratory supervision and safety, grading issues, special needs students, lecturing and tutoring techniques, examination preparation, teacher/student relationship, tertiary education management, will be discussed through reading, class/group discussions as well as presentations.

**MAFS 701: MARINE RESOURCES AND FISHERIES GOVERNANCE (3 Credits)**

This course seeks to identify the broad range of marine resources as well as policy and governance issues affecting fisheries in particular. It highlights on how anthropogenic activities impact on marine resources and conservation measures that are in place to preserve these resources for the future generations.

The areas to be covered include:

Marine systems; which would entail the principles of marine ecology, governance and conservation of marine systems. Life history of aquatic organisms which involves the biology and ecology of aquatic organisms, with emphasis on species which are important for fisheries and nature conservation. Environmental quality and governance, which will cover environmental toxicology, water quality, public administration, and environmental governance. Governing institutions (Regional Fishery organizations, FAO Committees in fisheries, national governance). International Instruments relevant to marine fisheries governance (UNCLOS, UN Fish Stocks Agreement, FAO Compliance Agreement, UNCED Agenda 21 and responsible fisheries, the code of Conduct for Responsible Fisheries, Kyoto conference on sustainable contribution of fisheries to food security): governance of EEZs. Rights-based fisheries (common property and Territorial Use rights in Fisheries (TURFs); ecosystem management, the precautionary approach; monitoring, control and surveillance.

**MAFS 702 PROJECT MANAGEMENT IN SCIENCE (3 Credits)**

There are a number of approaches for managing project activities including lean, iterative, incremental and phased approaches. Regardless of the methodology employed, careful consideration must be given to the overall project objectives, timeline and cost as well as the roles and responsibilities of all participants and stakeholders. Students will be equipped with advanced skills in managing research projects individually. Specific areas include practical guidance on how research projects and facilities are managed from commencement to end. Topics include: Project management processes including project initiation, project planning, execution, control, and close-up; project risk analysis; Project control including project break-downs and scheduling; Research cost estimation techniques and procurement; Research views and quality assurance; Research project integration and documentation; Use of modern tools and techniques for project planning, evaluation, analysis, management, and control. Students will be assessed based on term papers.

**MASC 701: ADVANCES IN BIOLOGICAL OCEANOGRAPHY (3 Credits)**

This course will deal with recent advances and trends in building a foundation for research in biological oceanography. Students will be required to conduct independent readings and case studies on various topics in relevant scientific journals. Aspects to be treated include the following: microbiological oceanography, bacterio-plankton, plankton biomass and production; ocean ecosystem dynamics and elemental cycling in surface ocean; fisheries oceanography; climate change effects on marine ecosystem; marine conservation; effects of environmental disturbances on deep-sea and coastal community dynamics; chemical cycling; global change issues in the Atlantic including open ocean and coastal upwelling; biological modeling of marine individuals and populations; sediment biogeochemistry.

**MASC 702 CURRENT TRENDS IN REMOTE SENSING AND GIS APPLICATIONS (3 Credits)**

This course is aimed at understanding current trends in remote sensing and geographic information systems. Topics will cover; ocean remote sensing; image processing and archiving; Data collection systems; data processing techniques and software; Global Earth Observation systems (GEOS) and Global Ocean Observing Systems (GOOS); Integrating remote sensing data and other ocean observing system (PIRATA, Argo floats, Current drifters, Waveriders); Aerial Photography; Feature mapping/DEM using LIDAR; Applications (e.g. ocean colour, upwelling, currents, habitat mapping); Introduction to Geographic Information Systems (GIS); Spatial analysis applications-e.g. coastal mapping, coastal erosion, vulnerability and hazard analysis. Students would be allowed the opportunity of self-directed study and be required to undertake and submit term papers on individual projects.

**MASC 703: ADVANCES IN CHEMICAL OCEANOGRAPHY (3 Credits)**

Chemical oceanography is concerned with understanding chemical processes in the ocean and how they are influenced by physical, biological, geological, atmospheric and terrestrial processes. Much of chemical oceanography describes the cycling of elements. Another important area of the subject area is the behavior of isotopes and how they can be used as tracers of the past and present oceanographic processes. Thus, the course will deal with aspects of chemical equilibria (acid-base and solution equilibria, buffer solutions and solubility, complexation equilibria), redox reactions and chemical speciation, chemical kinetics, physico-chemical processes at the sediment-water interface, elemental cycling, isotope geochemistry, radio- and nuclear chemistry, ocean-atmosphere interactions, land-ocean interactions, and photochemistry. Oceanic anoxic events (OAE) – mechanism, occurrence and consequences of anoxic events in Earth's history. Advances and trends in chemical oceanographic research will also be considered.

**MASC 705: ADVANCES IN PHYSICAL OCEANOGRAPHY (3 Credits)**

The course is designed to allow students explore in-depth recent advances and trends in physical oceanography. The broad areas to be covered will be in areas Circulation (Coriolis effect, Ekman transport, Langmuir circulation, ocean-atmosphere interface, planetary waves Ekman layers and Ekman spirals; equatorial upwelling; turbulence and internal waves); Climatic Variability: La Nina- El Nino, ocean currents; Heat flux- (heat storage, sea level change): Equations of motion (dominant forces, types of flow, and momentum equation, conservation of mass and salt, continuity equation) and stability in the ocean. Meteorological instrumentation and experimentation; Sverdrup balance and gyre circulation; ocean observing systems; modeling; upper ocean mixing; bio-optical oceanography and remote sensing;

**MASC 709: ADVANCES IN MARINE GEOSCIENCE (3 Credits)**

The course is designed to allow students explore in-depth recent advances and trends in marine geoscience. The broad areas to be covered will be in areas such as the formation, structure and morphology of ocean crust; ocean circulation; carbonate systems; impacts of geohazards in the marine environment such as tsunamis, earthquakes, crustal uplift, hurricanes, volcanic eruptions and landslides; tectonic processes; deep marine sedimentary processes; surface and hydrographic processes; palaeoceanography; deltas and coastal dynamics; seismic stratigraphics.

**MAFS 700 THESIS (45 Credits)**

Students will undertake a supervised research study from the student's preferred field of specialization, leading to a written thesis. Thesis will be evaluated based on the academic contribution to the relevant field of study. The research will include a study of its possible implications, its potential application, and its relationship to previous related work reported in the literature. The contributions and results obtained will be synthesized and compiled into a publication-quality research papers presenting the new idea. The thesis must be successfully defended in an oral examination before an examination committee.

**MAFS 710 SEMINAR I (3 Credits)**

Each student will do a presentation on experiences gained during the experiential learning and also present another seminar on a chosen topic of interest related to his/her area of interest. Students are required to undertake a comprehensive examination (both oral and written) at the end of the semester.

**MAFS 720 SEMINAR II (3 Credits)**

In the second year students are also required to present and defend their research proposals. Each candidate in the second semester is expected to present orally a research proposal that he/she intends to work on for the thesis. The candidate will be required to give a progress report on the research project during the middle part of the second semester. The student is also required to participate in all departmental seminars.

**MAFS 730 SEMINAR III (3 Credits)**

The candidate will make an oral presentation on the provisional findings of the research and the progress of work made on the research and present a full write-up of the presentation. In addition each student will be required to attend and participate in all departmental seminars, internal and external workshops and conferences. These will earn a total of 3 credits.

**MAFS 740 SEMINAR IV (3 Credits)**

This will form the final part of the research where the candidate presents his research findings in a seminar to the general public and to the supervisory committee at the end of his final thesis year. It shall cover results obtained throughout the research project and the candidate's work will then be subjected to questioning and discussions with the view to ensuring the submission of a thesis that is of the standard of a PhD.

**At the end of year 1, students will be required to undertake a comprehensive examination (both oral and written).**

## **YEAR 2 EXPERIENTIAL LEARNING EXPERIENTIAL LEARNING COMPONENT**

Students will be attached to relevant faculty research, a research vessel or a relevant organization to gain experience in data gathering and interpretation as well as industrial experience in their areas of research during the second year on the program. At the end of the second year, each student is expected to present a seminar on the experiences gained during the experiential learning.

### **PARTICIPATION IN RESEARCH PROJECTS**

In addition to the general activities outlined above, students will be engaged in on-going projects in the Department. This includes the following:

#### **A: MONITORING FOR ENVIRONMENT AND SECURITY IN AFRICA (MESA) PROJECT**

Monitoring for Environment and Security in Africa (MESA) is a pan-African project that extends the use of Earth Observation (EO) technologies and data to environment and climate monitoring applications, using space-based and *in situ* EO data and GIS applications. The goal of the project is to improve management of the environment and security at continental, regional, and national levels in Africa. The Project is being implemented according to Thematic Actions at all the Regional Economic communities of Africa. For the ECOWAS Region, the Thematic Action will focus on EO monitoring for coastal and marine resources management. The services for managing fishery resources and the marine environment in 14 countries of West Africa (i.e. Benin, Cape Verde, Cote d'Ivoire, Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Nigeria, Senegal, Sierra Leone, Togo; Mauritania, Sao Tome and Principe). The implementation strategy will consider: (i) improved access to EO data and services related to managing the coastal and marine environment and its resources; (ii) operational services in support of fisheries management and monitoring of ocean state communicated to mariners via internet and mobile phones; (iii) strengthened co-operation between national institutions in the use of EO products; (iv) development of a regional network of policy makers and technocrats for coastal and marine resources management; (v) EO training programmes at national levels. The Project is funded by the 10<sup>th</sup> European Development Fund.

#### **Expected outcomes**

- Acquisition of skills on EO data collection and analysis
- Acquisition of skills in remote sensing for environmental monitoring
- Acquisition of skills in marine resources management.

#### **B: DEITAS, VULNERABILITY AND CLIMATE CHANGE: MIGRATION AND ADAPTATION (DECCMA) PROJECT (PIs: Prof. Samuel Codjoe and Dr. Kwasi Appeaning Addo)**

This project focuses on the inter-relationships between climate change impacts, migration, land use change, agricultural production systems, vulnerability and poverty, and seeks to identify sustainable gender-sensitive adaptations in deltaic regions. DECCMA adopts an interdisciplinary, mixed methods, systems-based perspective bringing together natural, social and physical scientists with community level, district, regional and national stakeholders to co-produce knowledge that addresses gender-differentiated stakeholder needs to enable sustainable

gender-sensitive adaptation to climate change. The approach involves (i) governance and legal analyses; (ii) climate model evaluation and climate scenario development; (iii) vulnerability hotspot mapping; (iv) migration tracer studies; (v) input-output analysis of climate stresses on deltaic economies; (vi) economic assessments of exogenous climate-driven stresses on deltas (vii) household adaptation mapping and evaluation; and (ix) policy support through grant writing for Adaptation Funds for the deltaic regions. The research is focusing on the **Ganges-Brahmaputra-Meghna (GBA) delta** IN Bangladesh/India, the **Nile delta** in Egypt, the **Mahanadi delta** in India and the **Volta delta** in Ghana. The project is co-funded by IDRC and DFID, and it is part of the CARIAA wide project.

### **Expected outcomes**

- Acquisition of skills in biophysical data collection and analysis
- Acquisition of skills in hydrological modelling
- Acquisition of skills in vulnerability assessment
- Analysis of climate variability data
- Developing integrated system dynamic models.
- Acquisition of skills in using GIS tool for coastal resource management

### **C: GEOCHEMICAL STUDIES AND RECONSTRUCTION OF POLLUTION HISTORIES IN GHANA'S COASTAL ENVIRONMENT (PI: Prof. E. Nyarko)**

This study is part of an IAEA Regional Africa project (RAF 7009) involving twelve (12) African countries namely; Ghana, Cote d'Ivoire, Nigeria, Senegal, Benin, Cameroon, Egypt, Tunisia, Morocco, Kenya, Tanzania and Namibia. In Ghana, we are investigating geochemical processes affecting trace metal and organic contaminants in Ghana's near shore and deep-sea environments, and the use of natural and artificial radionuclides to reconstruct metal and organic pollution histories in sediment cores. Our approach involves: (i) acquisition of sediment samples from the field using different grabbing and coring techniques; (ii) preparation of samples for trace metals, organics and radionuclide analyses; and (iii) dating sediments using different dating models. We have so far estimated sedimentation rates and radionuclide ages of sediment cores from the Ankobra, Amisa, Pra, Densu, Sakumo II and Volta estuaries for the last 200 years using the  $^{210}\text{Pb}$  dating method. The rates and ages will help us understand the geochemical and historical flux of trace metals into the near shore environment and how these are linked to geochemical processes occurring in the off-shore environment.

### **Expected outcomes**

- Acquisition of skills in trace metals in sediment, biota and water
- Acquisition of skills in organic in sediment, biota and water
- Acquisition of skills in radionuclide analysis in sediment, biota and water
- Field techniques techniques on sediment coring and preparation.
- To gain indepth knowledge in radiometric dating techniques such as the  $^{210}\text{Pb}$ ,  $^{239,240}\text{Pu}$ ,  $^{26}\text{Al}$ ,  $^{10}\text{Be}$ , and  $^{241}\text{Am}$ .

## **COLLABORATORS**

The Department of Marine and Fisheries Sciences has been able to successfully and efficiently run its postgraduate programmes (MPhil and PhD) with the assistance of its national and international collaborators. These are indicated below:

- i. International Atomic Energy Agency (IAEA)
- ii. National Oceanic and Atmospheric Administration (NOAA)
- iii. Office of Naval Research of the United States Navy
- iv. University of British Columbia, Vancouver, Canada
- v. Department of Marine Science and Technology, University of Newcastle Upon-Tyne, UK
- vi. Interim Guinea Current Commission (IGCC)
- vii. Ghana Ports and Harbour Authority (GPHA)
- viii. Ghana Maritime Authority (GMA)
- ix. Ghana Atomic Energy Commission (GAEC)
- x. EU Funded ECOWAS Coastal Marine Thema – MESA Project
- xi. Australian National Centre for Ocean Resources and Security, University of Wollongong, Australia
- xii. MERAKA Institute, CSIR, South Africa  
University of Calabar, Cross River State, Nigeria

## PH.D FISHERIES SCIENCE

The Ph.D programme in Fisheries Science focuses on the understanding of fish as a biological and economic resource; and all the interactions with fishers and the aquatic environment, during and after fish extraction. The programme emphasises on the state of the art research using modern technology to address all issues prior, during and after capture. Fisheries science as an applied subject generates knowledge to provide management advice to policy.

### Admission Requirements

To qualify for admission to pursue a Doctor of Philosophy (PhD) in Fisheries Science, the applicante must have a relevant master's degree, in addition to other requirements detailed in the University of Ghana Handbook.

### Duration of Programme

The minimum duration for the PhD programme will be normally four (4) years for full time candidates and six (6) years for part-time candidates.

### Graduation Requirements

Course work	18-24 credits
Seminars (4)	12 credits
Thesis	45 credits
<b>Total</b>	<b>75-81 credits</b>

## PROGRAMME STRUCTURE

### YEAR I

#### FIRST SEMESTER

Course Code	Course Title	Credits
MAFS 701	Marine Resources and Fisheries Governance	3
FASC 701	Science and Society	3

#### ELECTIVE COURSES (maximum of 6 credits)

Course Code	Course Title	Credits
FASC 710	Teaching Science at the Tertiary level	3
FISH 701	Current Trends in Aquaculture	3
FISH 703	Current Trends in Fisheries Management	3
FISH 705	Current Trends in Ecology of Fishes	3
FISH 707	Current Trends in Fisheries Resource Dynamics and Assessment	3
FISH 709	Current Trends in Conservation and Preservation of Fisheries Genetic Resources	3



## SECOND SEMESTER

### CORE COURSES

Course Code	Course Title	Credits
FASC 702	Advanced Quantitative Research Methods	3
MAFS 702	Project Management in Science	3

### ELECTIVE COURSES (maximum of 6 credits)

Course Code	Course Title	Credits
FASC 700	Special Topics in Science	
FISH 702	Advances in Fisheries Economics	3
FISH 704	Advances Fish Nutrition and Energetics	3

### YEAR 2

Course Code	Course Title	Credits
MAFS 710	Seminar I	3
MAFS 720	Seminar II	3

### YEAR 3 and 4

MAFS 700	Thesis	45
MAFS 730	Seminar III (Year 3)	3
MAFS 740	Seminar IV (Year 4)	3

### COURSE DESCRIPTIONS

#### **FASC 700 SPECIAL TOPICS IN SCIENCE (3 Credits)**

The course examines historical and contemporary issues in science, relating to the student's area of specialization and relevance. Such topics are expected to challenge the students into exploring current and relevant research trends/discoveries in scientific approaches. The course will enable students explore scientific knowledge in modern science, and add on to their depth of information in their chosen areas of specialty. It is expected that, the course will compliment other courses on the PhD flagship of the various departments in the Sciences and elsewhere. Additionally, it will expose students to current trends of presentations, and foster stronger confidence-building attitude that will enable enhanced international academic competitive spirit.

#### **FASC 701 SCIENCE AND SOCIETY (3 Credits)**

This course will enable students gain insights in the practice of science as a discipline including major scientific concepts like inductivism are examined as well as the history of science and science itself, an overview of current approaches to research and an understanding of research partnerships, networks and appropriate methods of communicating science depending on audience. The aim of the course is to help students to fit their research to relevant trends and directions for national development. Course content will cover topics such as the basis for the scientific method; conceptual frameworks; the philosophy of science; ethics in research; pure versus applied science debates; approaches to research; science for development and the merit of

broader impact criteria; north south/south south collaboration and partnerships; research networks; communicating science to the policy make, lay audience and to media.

### **FASC 702    ADVANCED QUANTITATIVE RESEARCH METHODS    (3 Credits)**

The course will serve as a step up for students who need to add up to their knowledge in quantitative methods of research techniques and analyses. Topics to be covered include: Sampling distributions and hypothesis testing. Sample size determination. Categorical data and chi-square, Non parametric tests. Principles of Design of Experiments. Analysis of variance and its assumptions. Experiments with single and multiple factors. Orthogonal and multiple Comparisons. Completely Randomized, Randomized Complete Block, repeated measures, cross over and Latin square designs. Nested designs. Fixed, random and mixed effects models. Factorial designs. Confounding. Fractional factorial designs. Split plot designs. Incomplete block designs. Analysis of covariance. Regression models: basic concepts; Regression Model Diagnostics. Categorical data analysis. Logistic regression, univariate and multivariate. Confounding and collinearity in logistic regression. Model selection in logistic regression.

### **FASC 710: TEACHING SCIENCE AT THE TERTIARY LEVEL    (3 credits)**

It is anticipated that many of the students who go through the PhD programme in the Sciences may nurse special interest in teaching and academia. Focusing on group discussions, this course is expected to equip students with the requisite knowledge in overall management of students at the tertiary level. The course will focus on teaching the methodologies and techniques in handling science-teaching at the undergraduate level. Topics such as laboratory supervision and safety, grading issues, special needs students, lecturing and tutoring techniques, examination preparation, teacher/student relationship, tertiary education management, will be discussed through reading, class/group discussions as well as presentations.

### **MAFS 701: MARINE RESOURCES AND FISHERIES GOVERNANCE (3 Credits)**

This course seeks to identify the broad range of marine resources as well as policy and governance issues affecting fisheries in particular. It highlights on how anthropogenic activities impact on marine resources and conservation measures that are in place to preserve these resources for the future generations.

The areas to be covered include:

Marine systems; which would entail the principles of marine ecology, governance and conservation of marine systems. Life history of aquatic organisms which involves the biology and ecology of aquatic organisms, with emphasis on species which are important for fisheries and nature conservation. Environmental quality and governance, which will cover environmental toxicology, water quality, public administration, and environmental governance. Governing institutions (Regional Fishery organizations, FAO Committees in fisheries, national governance). International Instruments relevant to marine fisheries governance (UNCLOS, UN Fish Stocks Agreement, FAO Compliance Agreement, UNCED Agenda 21 and responsible fisheries, the code of Conduct for Responsible Fisheries, Kyoto conference on sustainable contribution of fisheries to food security): governance of EEZs. Rights-based fisheries (common property and Territorial Use rights in Fisheries (TURFs); ecosystem management, the precautionary approach; monitoring, control and surveillance.

**FISH 701: CURRENT ADVANCES IN AQUACULTURE (3 Credits)**

The course is designed to expose students to current advances and trends in aquaculture in details. Students will be required to present term papers on selected topics. The topics to be covered include: aquaculture technology, systems and equipment; commercial aquaculture; keys to successful investments in aquaculture (management, siting, risk assessment, economic sustainability and maximization of returns); aquaculture nutrition; aquaponics (design, subsistence and commercial); feasibility analysis of commercial culture facilities for selected fishes in Ghana such as the Nile tilapia.

**FISH 702: ADVANCES IN FISHERIES ECONOMICS (3 Credits)**

The course is designed to allow students to make critical analysis of the economic performance of fisheries industry. Students will be required to present term papers on selected topics. The topics to be covered include: models and indicators used in supporting fisheries management (bioeconomic and ecosystem models); economics of fisheries management (regulation and allocation systems; rights-based fisheries management); fisheries economics and environmental effects of fishing; gender issues in fisheries and aquaculture; globalization, markets and their impacts on small-scale fishers; markets and marketing of fish products including value chain analysis; investment analysis of fisheries; roles of traditional small-scale fisheries in food security and livelihoods.

**FISH 703: CURRENT TRENDS IN FISHERIES MANAGEMENT (3 Credits)**

The course will provide in-depth studies on current advances and trends in the application of fishery management. Students will be required to present term papers on selected topics utilizing selected journals on fisheries management. Topics to be covered include: Primary considerations in fisheries management (biological, ecological, social, technical and economic considerations); management plans, measures and strategies; fisheries and climate change; ecosystem based fisheries; the precautionary approach to capture fisheries; national and international legislation and instruments.

**FISH 704: ADVANCES IN FISH NUTRITION AND ENERGETICS (3 Credits)**

The course will provide in-depth studies on current advances and trends in the application of fish bioenergetics. Students will be required to present term papers on selected topics utilizing selected journals on fish nutrition and energetics. Topics to be covered include: nutrition facts and analysis for farmed fish species such as tilapia; fish diet formulation and manufacture; nutrition and fish health; nutritional pathology (mycotoxins, metabolic products of fungal contaminants of feed components); effects of toxicants on fish; bioconcentration of toxicants in fish tissue.

**FISH 705: CURRENT TRENDS IN ECOLOGY OF FISHES (3 Credits)**

Students will be provided with opportunity to undertake independent research on pertinent issues related to current affairs in the ecology of fishes. Students will be required to present term papers on selected topics utilizing selected journals on the ecology of fishes. Topics to be covered include: biotic and abiotic factors and the structure of fish communities; migration, territoriality and shoaling in fishes; deep-sea fish ecology; feeding and reproductive strategies of fish; impacts of climate change on fisheries; fish toxicology; effects of endocrine disruptions in fish.

**FISH 707: CURRENT TRENDS IN FISHERIES RESOURCE DYNAMICS AND ASSESSMENT (3 Credits)**

Students will be provided with opportunity to undertake independent research on pertinent issues related to current affairs in fish stock assessment. Students will be required to present term papers on selected topics utilizing selected journals on fish stock assessment and management. Topics to be covered include the following: Review of conventional stock assessment models; population models as applied to fishery resources and fish population dynamics; fish growth and mortality parameter estimations; fish data collection needs for different assessment methods; design and analysis of statistically sound catch data; trawl survey design and evaluation.

**FISH 709: CURRENT TRENDS IN CONSERVATION AND PRESERVATION OF FISHERIES GENETIC RESOURCES (3 Credits)**

This course is to expose students to current issues in the applicability of genetics and conservation to fisheries. Students will be required to write term papers on independently and in-depth studied topics. The areas to be covered include the following: Fisheries FA and marine conservation (e.g. bilateral issues, illegal, unreported and unregulated (IUU) fisheries, ecosystem issues, by-catch and associated species such as sea turtles, sharks, marine mammals and sea birds); population genetics and fishery management; application of marine reserves to fisheries; the world's aquatic genetic resources: status and needs.

**YEAR 2 EXPERIENTIAL LEARNING**

**EXPERIENTIAL LEARNING COMPONENT**

Students will be attached to relevant faculty research, a research vessel or a relevant organization to gain experience in data gathering and interpretation as well as industrial experience in their areas of research during the second year on the program. At the end of the second year, each student is expected to present a seminar on the experiences gained during the experiential learning.

**PARTICIPATION IN RESEARCH PROJECTS**

In addition to the general activities outlined above, students would be engaged in on-going projects in the Department. These include the following:

**A: FISHING FOR SECURITY IN THE GULF OF GUINEA (PIs: Prof. P. K. Ofori-Danson, Dr. F.K.E. Nunoo and Prof. E. Nyarko)**

This two year study aims to answer the following research questions: What are the drivers of piracy and other unlawful maritime activities in the Gulf of Guinea? Can criminality arise within communities because of conflict between fisheries sectors, or because of conflicts between fisheries and other sectors? In what ways can communities and governments ensure that fisheries remain economically viable and attractive by comparison with alternative, criminal livelihoods? How can governments act to minimise threats, including threats to community cohesion and livelihoods, from conflict, piracy and other unlawful maritime activities? Can international cooperation minimise conflict in maritime sectors and communities? Data collected along the entire coast of Ghana on fish catch, fishers and the aquatic environment will be analysed to help provide answers to above research questions.

Expected training needs will include project design, data collection, entry, analysis, and interpretation, and in the communication of information for decision makers. A workshop will be held specifically to decide how information may be incorporated into policy briefs, management strategies and implementation plans. The project will focus its capacity building on the national fisheries and maritime agencies in Ghana and hopefully other countries in the region. The project will build strong research partnerships among national and regional collaborators that should last beyond the timeframe of the project itself. Staff and students will be mentored and trained so that they themselves have sufficient skills and expertise to continue this work in future.

### **Expected outcomes**

- Acquisition of knowledge on security issues in fishing. (e.g. loss of gears due to entanglement, loss of boats due to theft, loss of lives at sea due to storms, lack of wearing life jackets, etc.)
- Acquisition of knowledge on daily income of fishers
- Acquisition of knowledge on management issues associated with fishers through interaction with community-based fisheries management committees
- Acquisition of knowledge of types of litter associated with our beaches and our coasts and their devastating effects on beach seine fisheries

### **B: IMPACT OF OCEAN ACIDIFICATION ON ABUNDANCE AND DIVERSITY OF FISH SPECIES LANDED BY ARTISANAL, SEMI-INDUSTRIAL AND CULTURE FISHERIES IN WEST AFRICA, AND LIVELIHOODS. (PI: Prof. F.K.E. Nunoo)**

This study is designed to fit into the global Framework for Ocean Observation (FOO) for ocean acidification. The study combines science and societal needs by monitoring some of the key essential ocean variables including biodiversity and social issues. It aims to determine possible impacts of ocean acidification in Ghanaian waters on abundance of key fish species (including crustaceans and molluscs) and the reliance of humans on these affected species. The project will monitor; i) the abundance and species composition of landings of a semi-industrial and an artisanal vessel to evaluate the biological impacts of ocean acidification; ii) Potential socio-economic impacts due to ocean acidification would be assessed by surveying coastal communities to determine degree of human reliance on key fish species as sources of their livelihoods; iii) The review of current aquaculture practices and species to analyse the vulnerability and expansion potential of Ghana/regional aquaculture based on primary species used and available alternatives would address aquaculture production and development as an alternative source of livelihood. The project would span duration of four years, in four West African countries namely Ghana, Benin, Togo and The Gambia. First year data collection would solely be in Ghana while from the second year, data collection will be extended to the other countries, subject to funding availability. Data collection is on-going, and physico-chemical parameters such as pH, Alkalinity, Salinity, Sea Surface Temperature, Total Dissolved solids, Fe, Ca, Mg, Nutrients (Nitrates, Phosphates, Sulphates, Silicates) have been analysed for two coastal sites. Also, fish catch and abundance data has also been collected and analysed as well as ichthyofauna data. Data collection for the three other West African countries – Togo, Benin and Gambia will begin in January 2014.

### **Expected outcome**

- Acquisition of skills in the collection and analysis of physico-chemical data
- Acquisition of field experience ichthyoplankton sampling

### **C: A BIOTOPE'S RESPONSE TO IRRIGATION: CASE STUDY OF THE KETA LAGOON COMPLEX AND MUNI LAGOON, GHANA. (PI: Prof. P.K. Ofori-Danson)**

This study was part of the environmental section of the “Sustainable food production through irrigated intensive farming systems in West Africa” (SIFA) Project which was a joint project between University of Ghana, Universities of Copenhagen and Århus in Denmark. In this study, the biotopes of the Keta Lagoon Complex were reviewed from fisheries, benthos and avifauna points of view. Impacts of intensive farming activities on water and sediments quality were also investigated. Sampling was conducted in wells on various farmlands along the banks of the Keta Lagoon, as well as in three fish landing sites at Anloga, Woe and Anyanui near the Keta Lagoon. Data collected included the physico-chemical parameters of; i) well water, rainwater and lagoon water; ii) sediments as well as iii) diversity and relative abundance of fish; iv) benthic macrofauna and v) avifauna. A Water Quality Index (WQI) was developed for both the wells and the Keta Lagoon and floodplains. Also, in order to evaluate the healthy conditions of benthic macrofauna community in the three sampling stations, the Benthic Pollution Index (BPI) was estimated. The Catch per unit effort (CPUE) of the Keta Lagoon fishery was also estimated. In addition, the diversity indices of benthic macrofauna, avifauna and fish were estimated. Students would benefit from this project by analysing the Muni data and other unused data from Keta Lagoon Complex. Students would also benefit from field work on how to collect hydrological, meteorological and physico-chemical data. The first phase of the project ended in December 2013. The second phase of the project titled; “Green cohesive Agricultural Resource Management” (WEBSOC) started in January 2014 and hopefully end by December 2018.

- Acquisition of knowledge of various biotopes (fish, benthos, plankton, algae, seabirds, mangroves etc.)
- Acquisition of knowledge on the effects of anthropogenic activities such as farming, fishing etc on biotopes
- Acquisition of knowledge of the effects of anthropogenic activities on water and sediment quality
- Experience in biotope restoration and management (e.g. mangroves)

### **D: HYDRO-BIOLOGY AND FISH PRODUCTION OF THE BLACK VOLTA NEAR THE BUI DAM DURING THE PRE- AND POST- IMPOUNDMENT PERIODS (PIs: Prof. P.K. Ofori-Danson and Dr. F.K.E. Nunoo)**

The hydro-biology of the Black Volta near the Bui dam was studied in relation to fish production as measured by catch per unit effort (CPUE) during the pre- and post-impoundment periods between February 2011 and December 2012. The approach was to assess the ecological impacts of the dam on the; i) hydro-biological factors and ii) fish production and iii) provide data for monitoring the hydro-biology and fisheries of the Bui reservoir. Two sampling stations at Bui and Bamboi were selected to represent the upstream and downstream stations respectively. Physico-chemical parameters such as electrical conductivity, total dissolved solids, colour,

dissolved oxygen and sulphates were monitored to determine the impact of the impoundment on these parameters. The Canonical Correspondence Analysis was used to trace temporal phytoplankton and zooplankton community changes, and to examine the relationships between species composition and physico-chemical variables. The change from riverine to lacustrine conditions during the formation of the reservoir, led to the immediate reduction in the numbers of a variety of fish families. The mean estimated CPUE in the post-wet season and in the dry season were also estimated. A model to predict fish production as measured by CPUE was derived as:

**CPUE = - (0.456 x water level) + (0.062 x chlorophyll *a*) + 3.363.** Students put on this project would get to know and collect further data on the checklist of organisms present in the water for subsequent exploitation, conservation and sustainable management of the resources of the Bui reservoir. Student would also collect further data to ascertain the fact that the impoundment altered the hydro-biology and fisheries characteristics of the downstream (Bamboi and other areas) station.

**E: EFFECTS OF PRE- AND PROBIOTICS ON POND PRODUCTION, GROWTH AND DISEASE SUSCEPTIBILITY OF CHANNEL CATFISH (*Ictalurus punctatus*) AND NILE TILAPIA (*Oreochromis niloticus*) (PI: Dr. Sam Addo)**

This study evaluated the effects of a pre-biotic and pro-biotics under i) pond production conditions as well as ii) the effects on growth and disease susceptibility under laboratory conditions. Four investigations were conducted. The first two examined the effects of two commercially-available probiotic products Lymnozyme® and PondToss™ as water additives in reducing mortality due to columnaris and improving pond water quality and pond production of channel catfish *Ictalurus punctatus*. Results from these two investigations led to the evaluation of a prebiotic Previda® and some probiotic strains of *Bacillus subtilis* as feed additives in diets of Nile tilapia, *Oreochromis niloticus*. Hence, the third and fourth studies evaluated the effects of the prebiotic and probiotics and their combinations as feed additives on growth, immunity parameters and survival from *Aeromonas hydrophila* and *Streptococcus iniae* challenges in Nile tilapia *Oreochromis niloticus*. The effectiveness of the commercially-available aquatic probiotic product Lymnozyme® as a water additive to reduce mortality due to *Flavobacterium columnare* in juvenile channel catfish was assessed. The efficacy of using PondToss™ in ponds to improve water quality and pond production of channel catfish was evaluated. Students would benefit from this project by receiving training in the use of prebiotic and probiotic strains as; i) water or feed additives; and ii) effectively reducing disease mortality in channel catfish and Nile tilapia under laboratory conditions.

## **COLLABORATIONS**

The Department of Marine and Fisheries Sciences has been able to successfully and efficiently run its postgraduate programmes (MPhil and PhD) with the assistance of its national and international collaborators. These are indicated below:

- i. International Atomic Energy Agency (IAEA)
- ii. National Oceanic and Atmospheric Administration (NOAA)
- iii. Office of Naval Research of the United States Navy
- iv. University of British Columbia, Vancouver, Canada

- v. Department of Marine Science and Technology, University of Newcastle Upon-Tyne, UK
- vi. Interim Guinea Current Commission (IGCC)
- vii. Ghana Ports and Harbour Authority (GPHA)
- viii. Ghana Maritime Authority (GMA)
- ix. Ghana Atomic Energy Commission (GAEC)
- x. EU Funded ECOWAS Coastal Marine Thema – MESA Project
- xi. Australian National Centre for Ocean Resources and Security, University of Wollongong, Australia.
- xii. MERAHA Institute, CSIR, South Africa  
University of Calabar, Cross River State, Nigeria



## **DEPARTMENT OF NUTRITION AND FOOD SCIENCE**

### **PhD (NUTRITIONAL SCIENCE)**

#### **INTRODUCTION**

This is a restructured PhD programme in Nutritional Science in the Department of Nutrition and Food Science

#### **ADMISSION REQUIREMENT**

To qualify for admission to the Doctor of Philosophy in Nutritional Science, the candidate must have a relevant Master's degree in related field from a recognized University. Applicants with working experience in relevant fields will be preferred.

#### **DURATION OF THE PROGRAMME**

The duration of the PhD programme in Nutritional Science will normally be for **FOUR(4)** years for **full-time** candidates and **SIX (6)** years for **part-time** students.

#### **REQUIREMENTS FOR GRADUATION**

Course work	18-24 credits
Seminars 4	12 credits
Thesis	45 credits
<b>Total</b>	<b>75-81 credits</b>

#### **AWARD OF DEGREE**

Successful completion of the programme, course work and research, will lead to the award of Doctor of Philosophy in Nutritional Science

## PROGRAMME STRUCTURE

### YEAR 1

#### SEMESTER 1: CORE COURSES

COURSE CODE	COURSE TITLE	CREDITS
FASC 701	Science and Society	3
NUTN 701	Advanced Nutritional Epidemiology	3
NUTN 703	Scientific Writing and Communication	3
	<b>TOTAL</b>	<b>9</b>

**SEMESTER 1: ELECTIVES** (*Students are to required to take maximum 3 credits of courses*)

COURSE CODE	COURSE TITLE	CREDITS
FASC 700	Special Topics in Science	3
NUTN 613	Assessment of Nutritional Status	2
NUTN 705	Technology in Nutrition Research	3

#### SEMESTER 2: CORE COURSES

COURSE CODE	COURSE TITLE	CREDITS
FASC 702	Advanced Quantitative Research Methods	3
NUTN 702	Global Nutrition Issues and Programme Planning	3
NUTN 704	Nutrition Education and Health Promotion	3
	<b>TOTAL</b>	<b>9</b>

**SEMESTER 2: ELECTIVES** (*Students are required to take 3 credits of courses*)

COURSE CODE	COURSE TITLE	CREDITS
FASC 720	Teaching Science at the Tertiary Level	3
NUTN 604	Advances in Macro and Micro-Nutrients	3
NUTN 650	Community Nutrition Assessment	3

#### YEAR 2, 3 and 4

COURSE CODE	COURSE TITLE	CREDITS
NUTN 700	Thesis	45
NUTN 710	Seminar I: Proposal seminar (Year 2)	3
NUTN 720	Seminar II: Experiential research learning (Year 2)	3
NUTN 730	Seminar III: Progress of work seminar) (Year 3)	3
NUTN 740	Seminar IV: Results seminar (Year 4)	3

**STUDENTS CAN TAKE MAXIMUM OF 6 CREDITS FROM LEVEL600**

## **COURSE DESCRIPTION**

### **FASC 700: Special Topics in Science (3 credits)**

The course examines historical and contemporary issues in science, relating to the student's area of specialization and relevance. Such topics are expected to challenge the students into exploring current and relevant research trends/discoveries in scientific approaches. The course will enable students explore scientific knowledge in modern science, and add on to their depth of information in their chosen areas of specialty. It is expected that, the course will complement other courses on the PhD flagship of the various departments in the Sciences and elsewhere. Additionally, it will expose students to current trends of presentations, and foster stronger confidence-building attitude that will enable enhanced international academic competitive spirit.

### **FASC 701: Science and Society (3 credits)**

This course will enable students gain insights on the practice of science as a discipline including major scientific concepts like inductivism, current approaches to research and an understanding of partnerships, networks and appropriate methods of targeted communication. The aim of the course is to help students link research to relevant trends and directions for national development. Course will cover topics such as: scientific method; conceptual frameworks; ethics; pure/applied science debates; approaches to research; science for development and the merit of broader impact criteria; north south/south south collaboration and partnerships; research networks; communicating science to policy makers, and the media.

### **FASC 702: Advanced Quantitative Research Methods (3 credits)**

The course will serve as a step up for students who need to add up to their knowledge in quantitative methods of research techniques and analyses. Topics to be covered include: Sampling distributions and hypothesis testing. Sample size determination. Categorical data and chi-square, Non parametric tests. Principles of Design of Experiments. Analysis of variance and its assumptions. Experiments with single and multiple factors. Orthogonal and multiple Comparisons. Completely Randomized, Randomized Complete Block, repeated measures, cross over and Latin square designs. Nested designs. Fixed, random and mixed effects models. Factorial designs. Confounding. Fractional factorial designs. Split plot designs. Incomplete block designs. Analysis of covariance. Regression models: basic concepts; Regression Model Diagnostics. Categorical data analysis. Logistic regression, univariate and multivariate. Confounding and collinearity in logistic regression. Model selection in logistic regression.

### **FASC 720: Teaching Science at the Tertiary Level (3 credits)**

It is anticipated that many of the students who go through the PhD programme in the Sciences may nurse special interest in teaching and academia. Focusing on group discussions, this course is expected to equip students with the requisite knowledge in overall management of students at the tertiary level. The course will focus on teaching the methodologies and techniques in handling Science-teaching at the undergraduate level. Topics such as laboratory supervision and safety, grading issues, special needs students, lecturing and tutoring techniques, examination preparation, teacher/student relationship, tertiary education management, will be discussed through reading, class/group discussions as well as presentations.

### **NUTN 700: Thesis**

This is the final write up of the thesis to be submitted to the Graduate School for examination. The write up should follow the set standard for graduate thesis (consult graduate handbook). PhD thesis will be based on students own proposal and research work. It should be an original work. Student must develop their research question, come up with conceptual frame work, do data collection, analysis and write up. Thesis involving human subjects must be submitted to the Institutional Review Board for ethical clearance **before** the study can start. Secondary data analysis is not normally permitted for doctoral research.

### **NUTN 701: Advanced Nutritional Epidemiology**

This course will provide an understanding between the relation between diet and long-term health and disease; Topics to be covered will include: epidemiologic study designs; Causation in epidemiologic investigation and research; issues on analysis and presentation of dietary data; Nutrition monitoring and surveillance; Vitamin A and lung cancer; Dietary fat and breast cancer, diet and coronary heart disease, folic acid and neural tube defect.

### **NUTN 702: Global Nutrition Issues and Programme Planning**

Global nutrition Issues, Current initiative for addressing malnutrition (Under-nutrition and over-nutrition), Scaling up nutrition, foundations for grant writing and identification of funding source, proposal writing, budgeting, ethics and nutrition. Assessment of community capacity and needs, factors that trigger programme planning, programme goals and objectives, development of plan of action and management systems, evaluation elements and effectiveness; entrepreneurship in programme planning, case analysis and reports of intervention programmes.

### **NUTN 703: Scientific Writing and Communication**

This course is designed to enable students learn, understand and appreciate the art and the science in writing and communicating to both the scientific audience and the general population. Areas to cover include: Scientific presentation, writing an abstract, writing a scientific paper, critique of scientific papers, oral presentation, power-point, poster preparation, computer graphics and other applications. Audio-visual techniques and applications in scientific presentations; as well as other nutrition and health education fora are integral component of this course. Writing specifically for the media and interviewing with the media are stressed. Design of succinct nutrition information flyers with key messages segmented towards the general population are critical component of the course.

### **NUTN 704: Nutrition Education and Health Promotion**

This course is to help candidates develop the skills for effective nutrition education and communication strategies that will ensure behaviour change to promote health. Thematic areas to be covered will include: Behaviour change and health promotion theories, Nutrition Educators as change agents in the environment, principles of education and communication; communicating in group settings and other channels for nutrition education; Design and development of nutrition educational materials; Food and nutrition advocacy; Overview of Food and Agriculture, Nutrition, and Health policies, and their implications for health promotion in Ghana.

### **NUTN 750: Technology in Nutrition Research**

This hands-on course has two components; a theoretical sections and a practical section. The different softwares used in analyzing nutrition survey data, such as dietary, anthropometry and

clinical will be reviewed. Softwares, such as; Access, Epi-info, The Food Processor<sup>®</sup>, WHO Anthro 2006. Instrumentation, principles and calibration of equipment will be covered.. Students will be given secondary dataset to analyze using software for nutrition data analyses. Also basic knowledge and skills regarding the design, implementation, analysis, and interpretation of research in the field of nutrition as well as policy with respect to nutrition research technology.

#### **NUTN 720: Seminar I**

Candidates are to give a seminar on their proposal for thesis research. This seminar is to detail the relevance, meaningfulness, viability, feasibility and the capability of completing the work within the timeframe, as well as the resource constraints.

#### **NUTN 730: Seminar II**

This is experiential research learning where students are attached to industry, government and non-governmental institutions and projects involved in nutritional science and health promotion activities and research to have practical life situation and state of the art experience. Students may come out with preference agencies which will need approval by the department

#### **NUTN 740: Seminar III**

During the third year candidates will be required to present a seminar detailing the progress of the research work.

#### **NUTN 750: Seminar IV**

This is the results presentation seminar of the candidates work. The findings are disseminated and discussed in relation to the literature, and any implications for nutrition, health, policies and development.

### **PHD FOOD SCIENCE PROGRAMME**

#### **OBJECTIVE OF THE PHD PROGRAMME IN FOOD SCIENCE**

The objective is to produce graduates who demonstrate theoretical knowledge and research capabilities in the discipline of Food Science. The PhD Food Science graduates are also expected to acquire effective communication skills and will be encouraged to gain some teaching skills as part of their training.

#### **ADMISSION REQUIREMENTS**

Candidates to be admitted into the Doctor of Philosophy in the Food Science programme, must have a relevant Master's degree in Food Science, or a related field (e.g. Nutrition, biochemistry, Food Process Engineering, Chemical Engineering, Chemistry Postharvest technology, etc) from a recognized University.

## **DURATION OF THE PROGRAMME**

The duration of the PhD programme in Food Science will normally be for **FOUR(4)** for **full-time** candidates and **SIX (6)**years for **part-time** students.

## **REQUIREMENTS FOR GRADUATION**

Course work	18-24 credits
Seminars 4	12 credits
Thesis	45 credits
<b>Total</b>	<b>75-81 credits</b>

## **AWARD OF DEGREE**

Successful completion of the programme, course work and research, will lead to the award of Doctor of Philosophy in Food Science

## **AREAS OF SPECIALISATION**

There are four areas of specialization for the PhD Food Science programme namely:

- i. Food Chemistry,
- ii. Food Processing and Engineering,
- iii. Food Quality Systems,
- iv. Food Microbiology and Biotechnology.

## COURSE STRUCTURE

### YEAR 1

Course Code	COURSE TITLE	CREDITS
<b>SEMESTER 1</b>		
<b><u>Core courses</u></b>		
FASC 701	Science and Society	3
FOSC 701	Advanced Food Analysis and Instrumentation	3
	Total credits	<b>6</b>
<b><u>Electives</u></b>		
	<i>Students are to take 3-6 credits of courses based on their area of specialization. Choice of electives is done in consultation with the Graduate committee.</i>	
<b><u>General Electives</u></b>		
**FASC 700	Special Topics in Science	3
FASC 720:	Teaching Science at the Tertiary Level	3
<b><u>Food Chemistry</u></b>		
FOSC 707	Food Toxicology and Toxins	3
FOSC 711	Advanced Food Safety	3
<b><u>Food Processing and Engineering</u></b>		
FOSC 703	Advanced Physical Principles of Food Processing	3
FOSC 709	Food Structure and Rheology	3
<b><u>Food Quality Systems</u></b>		
FOSC 703	Advanced Physical Principles of Food Processing	3
FOSC 711	Advanced Food Safety	3
<b><u>Food Microbiology and Biotechnology</u></b>		
FOSC 705	Advances in Food Microbiology	3
FOSC 711	Advanced Food Safety	3
<b>SEMESTER 2</b>		
<b><u>Core Courses</u></b>		
FASC 702	Advanced Quantitative Research Methods	3
FOSC 702	Advances in Food Science and Technology	3
	Total credits	<b>6</b>
<b><u>Electives</u></b>		
	<i>Students are to take 3-6 credits of courses based on their area of specialization. Choice of electives is done in consultation with the Graduate committee.</i>	
<b><u>General Electives</u></b>		
**FASC 700	Special Topics in Science	3

### Food Chemistry

FOSC 704	Advances in Lipid Chemistry	3
FOSC 708	Advances in Protein Chemistry	3
FOSC 712	Advances in Carbohydrate Chemistry	3
FOSC 716	Flavour Chemistry	3

### Food Processing and Engineering

FOSC 706	Food Quality Assurance and Management	3
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### Food Quality

#### Systems

FOSC 706	Food Quality Assurance and Management	3
FOSC 716	Flavour Chemistry	3

### Food Microbiology and Biotechnology

FOSC 714	Food Biotechnology	3
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*\*\* Can be taken in either semester*

### **YEAR 2, 3 and 4**

<b>Course Code</b>	<b>COURSE TITLE</b>	<b>CREDITS</b>
FOSC 700	Thesis	45
FOSC 710	Seminar I: Proposal seminar (Year 2)	3
FOSC 720	Seminar II: Experiential research learning (Year 2)	3
FOSC 730	Seminar III: Progress of work seminar (Year 3)	3
FOSC 740	Seminar III: Results seminar (Year 4)	3

### **COURSE DESCRIPTIONS**

#### **FASC 700: Special Topics in Science (3 credits)**

The course examines historical and contemporary issues in science, relating to the student's area of specialization and relevance. Such topics are expected to challenge the students into exploring current and relevant research trends/discoveries in scientific approaches. The course will enable students explore scientific knowledge in modern science, and add on to their depth of information in their chosen areas of specialty. It is expected that, the course will complement other courses on the PhD flagship of the various departments in the Sciences and elsewhere. Additionally, it will expose students to current trends of presentations, and foster stronger confidence-building attitude that will enable enhanced international academic competitive spirit.

#### **FASC 701: Science and Society (3 credits)**

This course will enable students gain insights on the practice of science as a discipline including major scientific concepts like inductivism, current approaches to research and an understanding of partnerships, networks and appropriate methods of targeted communication. The aim of the course is to help students link research to relevant trends and directions for national



development. Course will cover topics such as: scientific method; conceptual frameworks; ethics; pure/applied science debates; approaches to research; science for development and the merit of broader impact criteria; north south/south south collaboration and partnerships; research networks; communicating science to policy makers, and the media.

### **FASC 702: Advanced Quantitative Research Methods (3 credits)**

The course will serve as a step up for students who need to add up to their knowledge in quantitative methods of research techniques and analyses. Topics to be covered include: Sampling distributions and hypothesis testing. Sample size determination. Categorical data and chi-square, Non parametric tests. Principles of Design of Experiments. Analysis of variance and its assumptions. Experiments with single and multiple factors. Orthogonal and multiple Comparisons. Completely Randomized, Randomized Complete Block, repeated measures, cross over and Latin square designs. Nested designs. Fixed, random and mixed effects models. Factorial designs. Confounding. Fractional factorial designs. Split plot designs. Incomplete block designs. Analysis of covariance. Regression models: basic concepts; Regression Model Diagnostics. Categorical data analysis. Logistic regression, univariate and multivariate. Confounding and collinearity in logistic regression. Model selection in logistic regression.

### **FASC 720: Teaching Science at the Tertiary Level (3 credits)**

It is anticipated that many of the students who go through the PhD programme in the Sciences may nurse special interest in teaching and academia. Focusing on group discussions, this course is expected to equip students with the requisite knowledge in overall management of students at the tertiary level. The course will focus on teaching the methodologies and techniques in handling Science-teaching at the undergraduate level. Topics such as laboratory supervision and safety, grading issues, special needs students, lecturing and tutoring techniques, examination preparation, teacher/student relationship, tertiary education management, will be discussed through reading, class/group discussions as well as presentations.

### **FOSC 701 Advanced Food Analysis and Instrumentation [3 credits]**

This course focuses on analytical techniques in food research: –chromatographic techniques, electrophoresis nuclear magnetic resonance spectroscopy, differential scanning calorimetry, light microscopy, mass spectrometry, transmission and scanning electron microscopy etc. Use of radioisotopes. Laboratory exercises involving the use of selected analytical techniques in the evaluation of the chemistry and quality of food products.

### **FOSC 702 Advances in Food Science and Technology [3 credits]**

This course is designed to give an overview of current advances in the field of food science and technology. It will be taught by all graduate faculty in the department. The course will focus on critical reviews and discussion of current trends in food processing, food plant operations, product development and quality evaluation of foods. Advances in research into the chemistry of and functionality of various commodities will also be reviewed.

### **FOSC 703 Advanced physical principles of food processing [3 credits]**

The course covers the theory, principles and applications of unit operations of food processing technologies. Fluid flow; Heat transfer theory and their applications. Theory and application of size reduction of solid and liquid foods. Emulsification and homogenization of liquid foods; Mechanical separations Mixing; Dehydration Chilling and freezing - theory and applications,

Equipment; Evaporation - theory and applications, equipment, industrial applications; Extrusion - theory, equipment and operation, Irradiation - theory, equipment and, applications in food processing. A mini project involving at least one of these unit operations will be carried out.

#### **FOSC 704 Advances in Lipid Chemistry**

This course provides an in-depth study of chemical and physical properties of edible fats and oils their functional properties in food systems and the effects of processing on the nutrient function of lipids. Chemistry of triglycerides and antioxidants. Principles and application of polymorphism, interesterification and hydrogenation. Chemical reactions in deep-fat frying, Functions and chemistry of emulsions and emulsifiers, Lipid-Derived Flavors & Odors. Non-triglyceride lipids and Lipid substitutes in food systems. Biotechnology of fats and oils. Instrumental analyses of lipids. A review of current literature on the applications of chemical and biochemical principles of lipids to food composition, preservation and processing.

#### **FOSC 705 Advances in Food Microbiology [3 credits]**

In this course involves an in-depth review of current research and advances in the theory and practice of food microbiology. The format will include discussion and critical reviews of literature on food microbiology issues of current interest. Specifics include: Rapid methods of identification and typing of food pathogens and spoilage organisms; Microbiology in environmental management in food industries (microbiology of effluents from food industries and waste management.).

#### **FOSC 706 Food Quality assurance and management [3 credits]**

This course reviews the advances and current trends in the concepts of quality and techniques involved in delivering quality products in the food industry. Discussion and reviews of Quality management systems and functions within the food industry. Statistical quality control and analyses of quality control data. Food standards and legislation and procedures involved in establishing standards. Principles and application of HACCP. Physical, chemical and sensory methodologies for assessing the quality of foods. A term paper will be written based on a mini-project on an aspect of quality management in a specific food industry.

#### **FOSC 707 Food Toxicology and Toxins [3 credits]**

The essentials of toxicology as pertains to foods and food systems will be covered in the course. Specific areas of interest include naturally occurring toxicants and pesticide residues in foods. The chemistry and functionality of animal and plant toxins. Biological toxins, bacterial toxins, mycotoxins (aflatoxins, etc). Polycyclic Aromatic Hydrocarbons and other Processing Products. General principles of Toxicology. Factors that influence Toxicity. Mechanisms of toxicity. Acute and chronic toxicity. carcinogens. Analytical protocols for the estimation of toxicity of substances in food. Risk analyses in toxicology. Regulatory aspects of toxicology. Agrochemical residues in foods-pesticides, hormones (and other growing aids) and fertilizers. Contaminants and irradiation effects in foods. Aspects of nutritional toxicology such as alcohol in nutrition, nutrition and metabolism of drugs.

#### **FOSC 708 Advances in Protein Chemistry [3 credits]**

In this course the current knowledge of animal and plant protein chemistry and its application in food systems will be studied. Specific areas include conformational stability and adaptability of proteins. Protein denaturation, functional properties of proteins. processing-induced physical,

chemical, and nutritional changes in proteins. chemical and enzymatic modification of proteins. Enzymes: kinetics of enzyme-catalyzed reactions. enzyme utilization in the food industry. Analytical methods and techniques used in protein research. (amounts, types, nutritional quality, amino acid profile).

### **FOSC 709 Food Structure and Rheology [2 credits]**

The course will cover various topics on the mechanical properties of foods. Areas to be reviewed include instrumental measurement of food texture, interpretation of force curves. Newtonian and non-newtonian flow. Texture of different food commodities. Sensory measurements of texture. Psychophysical relations in food texture. Texture-structure relations in food systems. Fluid dynamics in food processing engineering.

### **FOSC711 Advanced Food Safety [3 credits]**

The advances in the microbial, chemical and physical aspects of food safety will be highlighted in this course. Areas to be covered include the principles and practice of risk analysis. Food intolerance and allergy. Recent understanding of microbial Infections, bacterial toxins and mycotoxins their modes of action and clinical symptoms. Chemical residues in Foods. Industrial and environmental contaminants, processing by-products of safety concern. Regulatory framework for food safety issues (HACCP, GMOs, Food labelling etc). Laboratory work. Food safety assessment methods; acute toxicity, dose range finding and dose response curve for lethality; Genetic toxicity testing methods (Ames test, etc), Food safety assessment

### **FOSC 712 Advances in Carbohydrate Chemistry [3 credits]**

The advances in carbohydrate research especially in the area of staple starchy crops Ghana will be reviewed. Specific topics include chemistry and functions of structured and non-structured carbohydrates. Chemistry and functionality of starches from different commodities e.g. cereal starches, root crop starches. Starch hydrolysis, polyols. Modified starches and their derivatives, Processes for modifying starches. Non-nutrient carbohydrates: Cellulose. Cellulose Modifications and Derivatives. Hydrocolloids (gums, etc). Pectins. Fiber and Carbohydrate Digestibility. Enzymology of carbohydrates. Non-enzymatic browning and caramelization in foods.. Analytical techniques in carbohydrate research –chromatographic techniques, spectroscopy, polarimetry, refractometry.

### **FOSC 714 Food Biotechnology [3 credits]**

This course assumes that the student is familiar with the general principles in Food biotechnology. Discussion and critical reviews of current knowledge in topics including the following: Genetic engineering and the Food industry, the role of microorganisms in biotechnology. Yeast biotechnology, Enzymes in biotechnology. Application of biotechnology to improve food quality and yield, environmental, ethical, legal and other issues in biotechnological applications.

### **FOSC 716 Flavour Chemistry [3 credits]**

The course provides an overview of food flavor chemistry as well as in-depth study of the theories of Taste and olfaction. Other topics include the effects of processing on flavor modifications and profile. Chemistry and creation of food flavours. Methods of flavor analysis including sensory and instrumental methods in flavor analysis.

**FOSC 700: Thesis**

Students will undertake supervised research study on a selected topic in their area of specialization leading to a written thesis. A research proposal should be submitted before the beginning of the research academic year. Areas of research specialization may be in any of the following: Food Processing and Engineering, Food analysis and Quality assurance, Food Microbiology and Biotechnology, Food Safety and Toxicology, Food Chemistry, Postharvest Management and Handling. The thesis will be original work.

**FOSC 710: Seminar I**

Candidates are to give a seminar on their proposal for thesis research. This seminar is to detail the relevance, meaningfulness, viability, feasibility and the capability of completing the work within the timeframe as well as the resource constraints. This seminar will be graded.

**FOSC 720: Seminar II**

This is experiential research learning where students are attached to industry, government and non-governmental institutions involved in food science and technology activities and research to have practical and state of the art experience. Students may choose areas of preference with approval by the department.

**FOSC 730: Seminar III**

During the third year candidates will be required to present a minimum of one seminar on aspects of their thesis research and detailing the progress made. This will be graded.

**FOSC 740: Seminar IV**

In the final year candidates will present the results of their research. The presentation will discuss the findings in relation to the literature and any other relevant material that relates to the candidate's work.