

## BQA NCQF QUALIFICATION TEMPLATE

| SECTION A: QUALIFICATION DETAILS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |  |                                         |   |                                                             |     |                |   |                       |          |                                     |  |                  |  |                                     |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|-----------------------------------------|---|-------------------------------------------------------------|-----|----------------|---|-----------------------|----------|-------------------------------------|--|------------------|--|-------------------------------------|
| <b>QUALIFICATION DEVELOPER (S)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |  |                                         |   | Botswana International University of Science and Technology |     |                |   |                       |          |                                     |  |                  |  |                                     |
| <b>TITLE</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |  | Bachelor of Science in Biotechnology    |   |                                                             |     |                |   | <b>NCQF LEVEL</b>     |          | 7                                   |  |                  |  |                                     |
| <b>STRANDS (where applicable)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |  | 1. N/A<br>2.<br>3.<br>4.                |   |                                                             |     |                |   |                       |          |                                     |  |                  |  |                                     |
| <b>FIELD</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |  | Natural, Mathematical and Life sciences |   |                                                             |     |                |   | <b>CREDIT VALUE</b>   |          | 522                                 |  |                  |  |                                     |
| <b>SUB FIELD</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |  | Biological Sciences                     |   |                                                             |     |                |   |                       |          |                                     |  |                  |  |                                     |
| New Qualification                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |  | <input checked="" type="checkbox"/>     |   | Legacy Qualification                                        |     |                |   |                       |          | Renewal Qualification               |  |                  |  |                                     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |                                         |   |                                                             |     |                |   |                       |          | Registration Code                   |  |                  |  |                                     |
| <b>SUB-FRAMEWORK</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |  | General Education                       |   |                                                             |     |                |   | TVET                  |          |                                     |  | Higher Education |  | <input checked="" type="checkbox"/> |
| <b>QUALIFICATION TYPE</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |  | Certificate                             | I | II                                                          | III | IV             | V | Diploma               | Bachelor | <input checked="" type="checkbox"/> |  |                  |  |                                     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  | Bachelor Honours                        |   | Post Graduate Certificate                                   |     |                |   | Post Graduate Diploma |          |                                     |  |                  |  |                                     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  | Masters                                 |   |                                                             |     | Doctorate/ PhD |   |                       |          |                                     |  |                  |  |                                     |
| <h3>RATIONALE AND PURPOSE OF THE QUALIFICATION</h3> <p><b>1.1. Rationale of the Qualification</b></p> <p>Biotechnology can generally be defined as the use of living organisms for the benefit of humankind. In modern times, biotechnology has advanced to also mean the genetic modification of living organisms. Both of these definitions are important and relevant in the Botswana content in many ways. Botswana indigenous people have always harbored knowledge of using organisms such as plants, micro-organisms and animals for their benefit. Recently, Botswana has been dependent on natural resources, mainly diamonds. These minerals have contributed immensely to economic growth in the</p> |  |                                         |   |                                                             |     |                |   |                       |          |                                     |  |                  |  |                                     |

country, however, they will eventually get depleted. In that case, Botswana will need an alternative source of economic sustenance and growth. The country is shifting from a resource-based to a knowledge-based economy. To achieve this, Botswana will have to tap into the indigenous knowledge generated over generations or generate new knowledge through scientific studies or entrepreneurship. One of the highly rich and opportune areas recently to develop knowledge is Biotechnology.

Apart from minerals, Botswana is known for its success in conservation of its biodiversity. This has been another significant source of income for the country, in the form of tourism. Biodiversity can also be a source of knowledge through different studies, including Biotechnology. In recent times, there is great economic potential in genetic diversity, in addition to the diversity in morphology of the biodiversity. Exploring genetic diversity could be one of the areas in which biotechnology may be important for Botswana, if capacity is built in this discipline. It can help us diversify how we benefit from our biodiversity. Documents like the National Development Plan (NDP11), National Biodiversity Strategy and Action Plan (NBSAP) and the Fifth National Report to the Convention of Biological Diversity have already indicated the need for capacity building in the management of national biodiversity. There is also need for capacity building in Botswana for the fulfilment of national obligations to the globe such as the Nagoya Protocol on Access and Benefit Sharing, United Nations Convention of Combating Desertification, RAMSAR convention on Wetlands of International Importance; United Nations Sustainable Development Framework (UNSDF); World Bank Programme, Wealth Accounting and Valuation of Ecosystem Services (WAVES), Convention of Biological Diversity (CBD) and the Cartagena Protocol on Biosafety.

Botswana could benefit from capacity building in many different areas of Biotechnology. Three obvious gaps that need to be urgently addressed are in the areas of industrial, plant and animal biotechnology. Biotechnology graduates that could benefit Botswana should have knowledge and skills in these three main areas of Biotechnology.

- A. *Plant Biotechnology*: this is a broad field that allows for the use of plants for the benefit of humans and the modification, improvement and mass production of crops and other plants for human use. It is beneficial for improvements in agriculture and other plant-based industries such as biofuel production. These are important for attaining national food security, economic growth and meeting national energy needs. Through plant biotechnology, plants can be used

to mass produce pharmaceuticals, industrial enzymes and vaccines. Therefore, biotechnology also has potential to improve public health and industrial production.

In a local context, Plant biotechnology will help the country address problems in many areas, including the ones discussed below. ,

- (i) **Agriculture:** Botswana is mainly covered by a desert. However, citizens have historically depended on agriculture, especially arable and pastoral farming. Due to challenges related to the desert conditions and climate change, agricultural yield continues to be a concern in Botswana. The World Food Programme in 2018 categorized Botswana as having about 25-35 % malnutrition levels. This demonstrates the need for improved food production in Botswana. The former Permanent Secretary in the ministry of Agriculture expressed to Sunday Standard publication in 2014 that Botswana needs genetically modified food. He said he believes that they will increase food production and result in Botswana being an exporter of food. This demonstrates that, for many years, the Botswana government has recognized the need for Biotechnology. Capacity, in the form of graduates, needs to be built for Botswana to be able to produce, sell and regulate GMOs. These GMOs will tackle other problems that the country is facing, such as increases in average temperatures and low unpredictable rains, which have been decreasing yields in both arable and pastoral production. Traditional methods for producing adaptable varieties of crop plants like drought tolerant sorghum are slow and cannot keep up with the rapid need for improved crops. Crop improvement through biotechnology is currently the most effective option. It is fast, efficient and direct. Crop traits such as drought tolerance, disease resistance and pest resistance can be targeted and improved in a relatively short period of time. Seeds that possess improved traits suitable for our local conditions can also be produced through seed biotechnology and distributed to farmers. The Botswana Daily News (2019) reported that State Counsel at the Ministry of Agricultural Development and Food Security Mr Thamsanqa Silitshena expressed that Botswana needs laws that regulate GMOs. GMOs need to be highly regulated to safeguard against potential shortcomings. Currently, Botswana is a signatory to the Cartagena Protocol, however the country lacks laws that regulate GMOs. Capacity is needed in the form of professionals who will identify, test and regulate GMOs once the draft laws that exist are effected. Experts in the field of biotechnology are also required as within the Biosafety Clearing House of the Cartagena

protocol Botswana needs to upload experts who farmers (or anyone who needs information in the area of Biosafety) can contact.

- (ii) **Medicinal plants:** Botswana has an invaluable amount of medicinal plants that are underutilized, especially at a national economic level. Most of these plants are used only for subsistence. However, there is a massive potential to make commercial products out of these highly diverse plants to contribute to the national economy. The indigenous knowledge technologies involved in the use of these plants are also of immense value. Through plant biotechnology, production of specific compounds within the plants that are known to have medicinal value can be enhanced to be able to produce these compounds at industrial scales. The compounds (or plants) could then be packaged and used in mainstream medical applications. In 2010, in Mmegi publication, Professor Daniel Motlhanka expressed the need for a screening center for medicinal and nutritional plants. This facility could generate and record a lot of information on the use of indigenous plants for medicine and food. This information could be part of the knowledge that the country could use to boost its economy. Knowledge of plant biotechnology will also help in conservation of medicinal (and other) plants through development of tissue culture and propagation techniques, especially for species which are endangered or extensively used.
- (iii) **Molecular pharming:** Through molecular pharming, plants can be used to produce industrial enzymes, antibodies, pharmaceuticals and vaccines. Plant biotechnologists can help address both human and animal health issues in Botswana through this approach. Diseases like foot and mouth, which cost the local economy a lot of money, can be addressed the use of plant biotechnology. According to the Botswana Veterinary Association, some of these diseases (Foot and Mouth Disease, Contagious Bovine Pleuropneumonia, Trypanosomiasis and rabies) pose a threat to the national herd. Institutions like Botswana Vaccine Institute could benefit from graduates who know how to design and make vaccines at a much lower cost using plants. Production of industrial enzymes can also boost the local economy as we won't have to import these enzymes. Most of these enzymes are costly to import. We can produce them at a lower cost and sell them locally and internationally.

- (iv) **Bioremediation:** Phytoremediation is the process of decontaminating the environment through the use of plants, microorganisms and their associations. Botswana as a mining country, has accumulated a lot of pollutants which destroy the environment. This often means that the land near mines is rendered useless for agricultural production or contains contaminants such as heavy metals that are harmful to animals and humans. The contamination mostly affects our soils and water, therefore it can easily spread if not controlled. Graduates with knowledge in phytoremediation can help to design plant-microbe based systems that will remove the contaminants from our environment and allow it to be used for other purposes.
- (v) **Indigenous knowledge-based technologies:** These are our traditional methods of using plants for purposes such as food, feed and medicine. This knowledge was developed over time and generations and is invaluable. It needs to be tested, validated and protected. Plant biotechnology will help in testing, documenting and developing ownership of this knowledge. Currently, most of this knowledge is lost either through generational disconnect or to other countries (which recognize its value). Useful products can be made from these indigenous technologies and we communities could own intellectual property rights to the indigenous technologies. The local community members such as traditional doctors could collaborate with plant biotechnology graduates to validate and establish rights. Botswana is already losing this valuable knowledge to other countries. This is demonstrated by a Mmegi publication in 2005 that reported that the former Deputy Secretary in the Ministry of Environment, Wildlife and Tourism, Tutu Tsiang was discussing that Botswana is trying to protect its rights to Sengaparile (Kalahari Devils Claw) over a German company.
- (vi) **Safety and regulation:** Botswana imports most of its food from neighboring countries such as South Africa. A lot of this food is genetically modified crops themselves or their products. There may be potential short-term and long-term risks associated with consuming genetically modified products, therefore their use needs to be regulated. In Botswana there is no framework that regulates utilization of genetically modified crops (or their products). Graduates in plant biotechnology are required to influence design of the framework and implementation, to make sure that we practice responsible use of genetically modified plants. In addition, the graduates will be important to assist in generating public awareness and in testing of imported crops or their products.

**B. *Animal Biotechnology:*** Generally, animal biotechnology encompasses employing molecular techniques to modify genomes of animals for pharmaceutical, agricultural and industrial purposes. It also involves techniques like embryo transfer, whole genome enabled selection, cloning and genetic engineering. These techniques will improve the quality of our national herds and help us address other national issues such as human healthcare.

- (i) **Embryo transfer:** This technique is a method of artificial breeding, which allows for genetic improvement of animals such as cattle. It allows for cross breeding for improved traits to be attained more quickly. Animals with desired traits can be used to bear more offspring than they naturally would. This would be useful for animal production in Botswana and will assist processes like artificial insemination, which the government has introduced, and improve the quality of the national herd faster. Graduates in Biotechnology from the animal stream will have knowledge of this technique and will be useful for the country.
- (ii) **Whole genome enabled selection:** This is whereby you use specific genes within animal genomes to select for a particular trait such as tender meat. Selected individuals can then be used to serve as parents. In this technique, instead of using morphological traits, which may not always be obvious, specific genes are used for selection. It requires knowledge of animal genes and traits, which graduates in Biotechnology degree will be trained in. They will help in using modern technologies to improve qualities of our animals.
- (iii) **Cloning:** This is where a genetically identical animal is produced from a parent animal using non-reproductive means. This way traits are maintained in the cloned animal as they are. Animals with desired traits may be cloned to produce many of that same genetic make-up. Graduates from the animal biotechnology stream will be taught this technique and they will be useful in the animal production industry.
- (iv) **Genetic engineering for therapeutic purposes:** Genetically engineered animal cells can be used to produce therapeutic drugs for treatment of diseases. For example, genetically modified hens can be used to make eggs containing a specific therapeutic protein. This can also be done using transgenic cell culture lines, which is more expensive. Human antibodies may also be produced in the same way. Through a process called hemotech.
- (v) **Transgenic animals in Agriculture:** Transgenic livestock are those that have introduced genes without the use of crossbreeding or hybridization. They are produced through genetic engineering and can be made to be more productive in agriculture, more disease



resistant and can produce meat or milk more efficiently. Transgenic animals may have enhanced growth rates and better meat. This has been done in animals like pigs, fish. Botswana can benefit from the same in cattle, goats and sheep. Transgenic animals may also be used to address food production issues such as producing milk that lasts longer on the shelf. Universities in other countries, like University of California Davis, USA, have researched and adopted this technology. This technology may also be used to assist animals with their welfare and improve their disease resistance. This may be important to Botswana in dealing with diseases like Foot and Mouth Disease, Contagious Bovine Pleuropneumonia, Trypanosomiasis and rabies. Due to the economic implications of these diseases, Botswana Vaccine Institute continues to make vaccines against these diseases, which are expensive to make. Other things that may be improved include the quality of attributes such as hair and fiber. These can be made longer, tougher and of better quality through transgenic means. This will have obvious economic benefits in the animal industry. These technologies are practiced elsewhere, therefore Botswana could use graduates with knowledge in these technologies either to perform them locally or to assist in regulation of the safe use of products from these technologies. There are obviously potential pitfalls and risks that may be associated with any new technology, therefore capacity needs to be built to deal with them. Engineering of livestock is complex, and one needs to be knowledgeable and careful when carrying it out. Therefore, the learners will be taught how to deal with issues like animal welfare, ethics, risks and benefits of the procedures.

- C. *Industrial Biotechnology*: It involves the use of microorganisms and enzymes in the production of goods such as food, chemicals, energy carriers, plastics and pharmaceuticals. It is important for pollution prevention, conservation of resources and reduction of industrial production costs. Some of the common products produced through industrial microbiology include cheese, yoghurt, bread and vinegar. These are common everyday household commodities that Botswana imports from other countries, especially South Africa. Botswana could benefit from graduates with knowledge in producing these locally and in the other different industrial biotechnology techniques, which will lead to a boosted economy. Botswana is in desperate need of economic diversification, especially in terms of industries. The economy is mainly based solely on the mining industry. However, through Industrial Biotechnology other industries can be established or boosted, in less costly and environmentally friendly ways.

Industrial Biotechnology basically uses the advances in knowledge of genomics, proteomics and bioinformatics to improve production or to make new products.

- (i) Bioremediation; Due to the history of mining in Botswana, some of the areas close to the mines are contaminated with heavy metals and other compounds. These compounds can be toxic to the environment and affect ecosystems around the mines. They pollute soils, water, plants and eventually get transferred to animals and humans. They end up affecting agriculture, animal production and being a threat to human health. Micro-organisms (sometimes with associations with plants) can be used to clean these compounds off the soils and make the contaminated environment safer and re-useable for other activities.
- (ii) Isolation of novel microorganisms and enzymes: Industrial biotechnology is based on the use of microorganisms or special enzymes they produce for industry. Botswana has not explored much the novel microorganisms that may be present in the country and the enzymes that they may produce. Extreme environments (such as drought and contaminated soils) usually result in microorganisms in that environment adapting by producing special enzymes and metabolites. These are the same enzymes that can be identified, purified and used in industry. We could find novel microorganisms or enzymes that can be of value to the country through Industrial Biotechnology. Graduates in this programme will be able to explore this possibility and determine how this natural resource can be exploited. This may include through probiotics, antibiotics, insecticides, enzymes and solvents. They will also be able to elucidate and document the genetic diversity of our local microbial populations.
- (iii) Improvement of existing enzymes: With the knowledge of biotechnology, one can improve existing enzymes to be more efficient. The natural enzymes may be modified through transgenic technologies to improve their function in industries. An example of this is the use of genetically modified fungi that is more efficient in bioremediation. Graduates in the Biotechnology degree will use their knowledge to explore this opportunity within our local context.
- (iv) Improvement of existing processes: Industrial biotechnology used in making useful products such as biofuel has been experiencing challenges such as slow rates of microbial growth, high sterilization costs, low conversion rates of substrates into products and costly production facilities. These technologies are important for economic growth and are



environmentally friendly, however they need to be improved. Graduates will have the skills to find ways to improve these processes and contribute to industrial development.

Entrepreneurship: Knowledge in Biotechnology enables one to come up with innovative ways to use knowledge of organisms to solve societal challenges. Therefore, it encourages entrepreneurship as graduates can make innovative products and establish new industries. They may also use biotechnology as a basis for business ideas and create successful companies. To support this, our Biotechnology programme contains many modules that teach the learners about designing and running a business.

Protection of genetic resources: Botswana is well known for its natural beauty, great biodiversity and conservation practices. It has unique natural environments (the Okavango Delta, expansive pan systems, vast Kalahari system to name a few) which attract global attention from scientists, learners and tourists alike. This provides a unique opportunity to expand Botswana's image of wildlife protection to Botswana also being a harbor for genetic diversity (in microorganisms, plants and animals) which can be used for Biotechnological purposes. This genetic diversity, just like organismal diversity, has to be studied, documented and protected. Graduates from this programme will have the capacity to achieve these outcomes.

Opportunity for internationalization: The degree in Biotechnology offers unlimited opportunities for internationalization. The knowledge is easily transferable across international borders and Biotechnological solutions designed locally may be exported. Graduates may also find employment internationally, since Biotechnology is a flourishing discipline across the world. It also offers an opportunity for international learners to study in Botswana, which will generate income and exposure for the country. The degree structure is also strategically designed to foster internationalization, international-local collaboration, and local hands-on training skills that are exportable.

### **PURPOSE: (itemise exit level outcomes)**

#### **1.2. Purpose of the Qualification**

The purpose of this qualification is to produce graduates with specialized knowledge, skills and competences to:

1. Promote sustainable useability of biodiversity and combat effects of climate change by providing biotechnological methods and techniques that can address these challenges in Botswana and globally.
2. Develop biotechnological products used in industry, agriculture (such as GMOs) and medicine.
3. Implement regulatory measures associated with biological and biotechnological products and services to achieve one of Botswana's sustainable development goal of 'responsible consumption and production' of biological and biotechnological products.
4. Conduct applied research to address various biotechnology-related problems facing the country and the world at large.
5. Develop strategies for implementation of sustainable development goals in addressing poverty, hunger, achieving food security, improving nutrition, promoting sustainable agriculture, promoting manufacturing of products and ensuring healthy lives.

### MINIMUM ENTRY REQUIREMENTS (including access and inclusion)

- Certificate IV, NCQF Level 4 – General Education/technical and vocational education and training (TVET) with passes in Biology, Mathematics, English plus one other science subject or equivalent.
- Applicants who do not meet the above criteria but possess relevant industry experience may be considered through Recognition of Prior Learning (RPL) and Credit Accumulation and Transfer (CAT) policies for access. This consideration will be done following guidelines of the ETP which are aligned with BQA/National policies.

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### 2. QUALIFICATION SPECIFICATION

#### SECTION B

#### GRADUATE PROFILE (LEARNING OUTCOMES)

#### ASSESSMENT CRITERIA

1. Use specialized knowledge of biotechnology competently for capacity building

- 1.1 Correctly explain biotechnological concepts in the workplace, during workshops, training related settings etc.
- 1.2 Correctly explain biotechnological concepts in settings that inform decision making
- 1.3 Competently explain biotechnological concepts in consultation services and when providing advice related to Biotechnology

2. Demonstrate specialized knowledge of biotechnological concepts in plant, animal, industrial, medical and environmental biotechnology

- 2.1 Explain biotechnological concepts in the research involved in product development, management and modification of biological systems
- 2.2 Correctly explain and use specialized knowledge of biotechnological concepts to suggest solutions in the different areas of Biotechnology.
- 2.3 Suggest methodologies and techniques to carry out different processes and tasks of Biotechnology

3. Carry out specialized methodologies and processes in research of different areas of biotechnology

- 3.1 Apply specialized techniques and methodologies to make biotechnological products that fulfil specific given needs
- 3.2 Suggest biotechnological processes that may be used to solve scientific problems
- 3.3 Use specialized biotechnological methods and techniques and suggest improvements to the existing processes

4. Solve problems using specialized biotechnological knowledge and methodologies in areas such as agriculture, industry,

- 4.1 Use specialized knowledge to solve social, medical and economic problems through Biotechnology
- 4.2 Solve social, medical and economic problems through biotechnology
- 4.3 Create improvements to existing processes using biotechnological knowledge, methods and techniques

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| environmental management, medicine etc.                                                                                            | 4.4 Apply research strategies to find solutions to Biotechnological problems                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>5.</b> Demonstrate responsibility and accountability for own work output and of others within biotechnology project or task     | <p>5.1 Develop efficient and achievable Biotechnology projects and programs for undertaking in ways that are ethical and are within the regulatory framework</p> <p>5.2 Use biological and biotechnological resources in a responsible manner</p> <p>5.3 Demonstrate effective time management skills when undertaking science projects in ecology and evolutionary biology</p>                                                                                                                                                                |
| <b>6.</b> Work effectively as a member of a team in specialized Biotechnology projects                                             | <p>6.1 Contribute effectively as a member of a team or group in scientific project or investigations.</p> <p>6.2 Communicate and contribute Biotechnological knowledge as part of a team handling societal and economic issues collectively</p> <p>6.3 Demonstrate organizational skills in managing projects and show competent teamwork</p>                                                                                                                                                                                                  |
| <b>7.</b> Apply high level awareness of bioethics and safety diligence when working with biological and biotechnological specimens | <p>7.1 Handle biological and biotechnological specimens in a safe, ethical and culturally sensitive manner and within the legislative framework while undertaking experiments in Biotechnology</p> <p>7.2 Apply ethical practices and safety measures when handling, using, and modifying biological systems</p> <p>7.3 Demonstrate ethical and cultural sensitivity when disseminating scientific findings in Biotechnology</p> <p>7.4 Make ethically and culturally sensitive decisions on the effects of biotechnology based activities</p> |

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|                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|-------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>8.</b> Communicate effectively with appropriate audiences of a wide variety regarding Biotechnology</p>                             | <p>8.1 Use appropriate scientific language to produce clear and coherent written (and oral) statements about biotechnology in scientific documents, reports and presentations</p> <p>8.2 Communicate research findings, orally and in written form, through diverse platforms including online platforms</p> <p>8.3 Use appropriate referencing conventions in written communications, avoiding plagiarism and respecting intellectual property.</p> |
| <p><b>9.</b> Apply entrepreneurial and business skills in developing and managing business projects within the field of biotechnology</p> | <p>9.1 Valuate biological resources for their use in sustainable business</p> <p>9.2 Design and manufacture tangible products that are of economic value</p> <p>9.3 Produce valuable services that address to fill a market gap or reduce costs of production in businesses</p> <p>9.4 Use biotechnological knowledge to set up and effectively manage a biotechnology-based business</p>                                                            |

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**BOTSWANA**  
Qualifications Authority

| SECTION C | QUALIFICATION STRUCTURE |                                 |             |             |               |
|-----------|-------------------------|---------------------------------|-------------|-------------|---------------|
| COMPONENT | TITLE                   | Credits Per Relevant NCQF Level |             |             | Total Credits |
|           |                         | Level [ 5 ]                     | Level [ 6 ] | Level [ 7 ] |               |
|           | Principles of Biology I | 12                              |             |             | 12            |

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|                                                                     |                                                                     |    |    |  |    |
|---------------------------------------------------------------------|---------------------------------------------------------------------|----|----|--|----|
| <b>FUNDAMENTAL COMPONENT</b><br>Subjects/ Courses/<br>Modules/Units | Principles of Biology II                                            | 12 |    |  | 12 |
|                                                                     | General Chemistry I                                                 | 12 |    |  | 12 |
|                                                                     | General Chemistry II                                                | 12 |    |  | 12 |
|                                                                     | Introduction to Mechanics                                           | 12 |    |  | 12 |
|                                                                     | Introduction to Electricity and Magnetism                           | 12 |    |  | 12 |
|                                                                     | Pre-Calculus I                                                      | 12 |    |  | 12 |
|                                                                     | Pre-Calculus II                                                     | 12 |    |  | 12 |
|                                                                     | Introduction to Calculus                                            | 12 |    |  | 12 |
|                                                                     | Introduction to Computing                                           | 6  |    |  | 6  |
|                                                                     | Introduction to Academic and Professional Communication for Science | 6  |    |  | 6  |
|                                                                     | Scientific Writing Process                                          | 6  |    |  | 6  |
|                                                                     | Introduction to Report Writing and Research Skills                  | 6  |    |  | 6  |
| <b>CORE COMPONENT</b><br>Subjects/Courses/<br>Modules/Units         |                                                                     |    |    |  |    |
|                                                                     | Biochemistry                                                        |    | 12 |  | 12 |
|                                                                     | Microbiology                                                        |    | 12 |  | 12 |
|                                                                     | Developmental Biology                                               |    | 12 |  | 12 |
|                                                                     | Introductory Physical Chemistry                                     |    | 12 |  | 12 |



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|--|-----------------------------------------------------------|--|----|--|----|
|  | Molecular Biology                                         |  | 12 |  | 12 |
|  | Professional Communication for Science                    |  | 6  |  | 6  |
|  | Management and Entrepreneurship - Concepts and Principles |  | 6  |  | 6  |
|  | Cell & Tissue Culture Technology                          |  | 12 |  | 12 |
|  | Recombinant DNA Technology                                |  | 12 |  | 12 |
|  | Starting and Sustaining a Business                        |  | 6  |  | 6  |
|  | Bioethics                                                 |  | 6  |  | 6  |
|  | Genomics and Bioinformatics                               |  | 12 |  | 12 |
|  | Environmental Biotechnology                               |  | 12 |  | 12 |
|  | Work Integrated Learning in Biotechnology                 |  | 18 |  | 18 |
|  | Research Methods                                          |  | 6  |  | 6  |
|  | Biostatistics                                             |  | 6  |  | 6  |
|  | Bioprocess Technology                                     |  | 12 |  | 12 |
|  | Project in Biotechnology                                  |  | 18 |  | 18 |
|  | Entrepreneurship in a Specific Context                    |  | 6  |  | 6  |
|  | Omics Technology                                          |  | 12 |  | 12 |

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| STRANDS/<br>SPECIALIZATION | Subjects/ Courses/<br>Modules/Units  | Credits Per Relevant NCQF Level |             |            | Total Credits |
|----------------------------|--------------------------------------|---------------------------------|-------------|------------|---------------|
|                            |                                      | Level [ 5 ]                     | Level [ 6 ] | Level [7 ] |               |
| 1.                         |                                      |                                 |             |            |               |
|                            |                                      |                                 |             |            |               |
|                            |                                      |                                 |             |            |               |
| 2.                         |                                      |                                 |             |            |               |
|                            |                                      |                                 |             |            |               |
|                            |                                      |                                 |             |            |               |
| Electives                  | Plant Physiology                     |                                 |             | 12         | 12            |
|                            | Animal Physiology                    |                                 |             | 12         | 12            |
|                            | Microbial Physiology                 |                                 |             | 12         | 12            |
|                            | Bioanalytical Chemistry              |                                 |             | 12         | 12            |
|                            | Organic Spectroscopy                 |                                 |             | 12         | 12            |
|                            | Toxicology                           |                                 |             | 12         | 12            |
|                            | Plant Biotechnology                  |                                 |             | 12         | 12            |
|                            | Animal Biotechnology                 |                                 |             | 12         | 12            |
|                            | Microbial Biotechnology              |                                 |             | 12         | 12            |
|                            | Protein Chemistry                    |                                 |             | 12         | 12            |
|                            | Stem Cell Biology                    |                                 |             | 12         | 12            |
|                            | Developing a Strategic Business Plan |                                 |             | 6          | 6             |

## BQA NCQF QUALIFICATION TEMPLATE

|  |                                                                |  |  |    |    |
|--|----------------------------------------------------------------|--|--|----|----|
|  | Innovation, Commercialization and Intellectual Property Rights |  |  | 6  | 6  |
|  | Metabolic Engineering                                          |  |  | 12 | 12 |
|  | Plant Pathology                                                |  |  | 12 | 12 |
|  | Transgenic Technology                                          |  |  | 12 | 12 |
|  | Forensic Biology                                               |  |  | 12 | 12 |
|  | Immunology                                                     |  |  | 12 | 12 |
|  | Stem Cell Technology                                           |  |  | 12 | 12 |
|  | Bioprospecting and Biomaterials                                |  |  | 12 | 12 |
|  | Enzyme Technology                                              |  |  | 12 | 12 |
|  | Food Science and Technology                                    |  |  | 12 | 12 |
|  | Immunotechnology                                               |  |  | 12 | 12 |

## BQA NCQF QUALIFICATION TEMPLATE

### SUMMARY OF CREDIT DISTRIBUTION FOR EACH COMPONENT PER NCQF LEVEL

#### TOTAL CREDITS PER NCQF LEVEL

| NCQF Level           | Credit Value |
|----------------------|--------------|
| 5                    | 90           |
| 6                    | 168          |
| 7                    | 264          |
| <b>TOTAL CREDITS</b> | <b>522</b>   |

#### Rules of Combination:

(Please Indicate combinations for the different constituent components of the qualification)

A minimum of 114 credits should come from the listed Electives and they should all be at Level 7. These should come from 5 Elective modules at year 3 (for a total of 60 credits) and 5 Elective modules at year 4 (for a total of 54 credits).

(Note: Please use Arial 11 font for completing the template)

### ASSESSMENT ARRANGEMENTS

#### Formative Assessment

All formative assessments shall be aligned to learning outcomes. The formative assessment will contribute 50% towards the final grade.

#### Summative Assessment

Summative assessment will contribute 50% of the final grade. Assessors must be BQA registered and accredited.

### MODERATION ARRANGEMENTS

There will be internal and external moderation for the qualification. Moderation will be performed by suitably qualified and preferably registered assessors and moderators. Both internal and external moderation will be performed in-line with institutional and national policies.

### RECOGNITION OF PRIOR LEARNING

Candidates may submit evidence of prior learning and current competence and/or undergo appropriate forms of RPL assessment for the award of credits towards the qualification in accordance with applicable RPL policies and relevant national-level policy and legislative framework.

### CREDIT ACCUMULATION AND TRANSFER

Credit transfer will be awarded in accordance with the University Credit Accumulation and Transfer Policy and Guidelines on Credit Accumulation and Transfer.

### PROGRESSION PATHWAYS (LEARNING AND EMPLOYMENT)

#### Horizontal Progression

- Bachelor of Science in Biology
- Bachelor of Science in Plant Biology and Plant Biotechnology
- Bachelor of Science in Zoology and Animal Biotechnology
- Bachelor of Science Industrial Biotechnology
- Bachelor of Science Environmental Biotechnology

#### Vertical Progression

- Bachelor of Science and Honours in Biotechnology
- Bachelor of Science and Honours in Biology
- Master of Science in Biotechnology

- Master of Science in Biology

### Employment Pathways

- Animal Biotechnologists
- Plant Biotechnologists
- Industrial Biotechnologists
- Biochemists
- Cell Biologists
- Environmental Biotechnologist
- Research Technicians
- Science and Technology Researchers
- Biotechnology Laboratory Technician
- Biotechnology / Pharmaceutical Sales
- Conservationist
- Food and Beverage Technicians
- Clinical Research Associate
- Quality Control Analyst

### QUALIFICATION AWARD AND CERTIFICATION

A candidate will be awarded a qualification in Bachelor of Science Biotechnology upon meeting the minimum of 522 credits as prescribed in the rules of combination.

#### Certification

A certificate and transcript will be issued to graduates upon successful completion of the qualification.

### SUMMARY OF REGIONAL AND INTERNATIONAL COMPARABILITY

#### REGIONAL COMPARABILITY

This qualification was compared regionally and internationally as follows:

**Bachelor of Science in Biotechnology, University of Pretoria, , South Africa, South African Qualifications Authority (NQF level 7)**

The University of Pretoria provides Bachelor of Science in Biotechnology as a three year (minimum) qualification with minimum total credits of 428. The entry requirements to this qualification include a Grade 12 certificate with university endorsement (certificate that is equivalent), a graduate from

another tertiary institution or graduate from another faculty at the University of Pretoria. The candidate should have a minimum of As level C (or NSC/IEB 5) in English, Mathematics and a Physical Science. The candidates that do not meet the minimum requirements may be admitted into the BSc- Extended qualification which has a duration of four years. For award of this qualification, a student must fulfil at least 144 credits at 300-/400-level. A maximum of 150 credits will be recognized at 100-level.

The aim of the degree qualification is to produce graduates who are empowered to pursue their interest in biotechnology, especially molecular biology. The graduates are exposed to aspects of Biochemistry, Genetics, Cell Biology, Molecular Biology, Organismal Biology, Organismal Diversity, Organismal Physiology, Organismal Biotechnology, Metabolism, Food Science and Technology, Food Microbiology, Plant Production, Plant Protection, Plant Pathology, Plant medicine, Genomics, Bioinformatics, Organismal interactions, Disease Biology and Soil Science. The total minimum credits required include Fundamental units worth 12 credits, Core worth 290 credits and Electives worth 126 credits. Assessment strategies for this qualification emphasize Integrated approaches and include: oral/written questions and answers, assignments, simulations, on the job assessment, case studies, role plays and provision of RPL.

In relation to our proposed qualification, the entry requirements are similar to those of the qualification compared with, especially also considering the BSc-Extended which also has a minimum duration of four years. In our program, Level 100 is to bring candidates to the required level for admission into the BSc three year program in University of Pretoria. The core modules offered in our program are also similar and the assessment strategies are consistent. Contrastingly, the proposed qualification incorporates communication and writing, business and entrepreneurship skills to better equip learners with communication, business development and management skills with relation to Biotechnology.

### INTERNATIONAL COMPARABILITY

#### **Bachelor of Science (Biotechnology), Imperial College London, United Kingdom, Regulated Qualifications Framework (RQF), Level 6**

This is another three year (minimum) qualification with minimum total of 330 (CATS). The entry requirements into the BSc Biotechnology from Imperial College London include A levels with



minimum Chemistry, Biology, Mathematics (or Physics) and any other subject. The credits are made of modules such as Cell Biology, Genetics, Biochemistry, Molecular Biology, Developmental Biology, Bioanalytical Chemistry, Genomics & Bioinformatics, Plant Biotechnology, Protein Chemistry, Stem Cell Biology or Technology, Metabolic Engineering, Plant Pathology, Immunology Enzyme Technology and Cancer Biology. The qualification also includes a Research project that may be laboratory or field based. Assessment modes include coursework, essays, individual research, laboratory write-ups, presentations, reports and written examinations.

Similar to the proposed qualification, graduates of this qualification will have the knowledge and skills in the various areas of Biotechnology (such as medical, plant and animal biotechnology) and an in-depth knowledge of the methodologies and principles required to apply Biotechnological knowledge. They both allow learners to use many of the latest equipment and instruments in the field. Some of that can be pursued by graduates of this qualification include higher degree in the field such as Honors, Master's degree, followed by a PhD. Some of the possible careers available for both qualifications include academic research, industry, government and industrial research, public health, and careers in business.

**Bachelor of Science in Biotechnology, BRAC University, Bangladesh, Bangladesh National Qualification Framework (BNQF), Level 7**

BRAC University offers the 4-year (12 semesters) biotechnology undergraduate qualification which consists of a minimum of 136 credits. Out of these 136 credits, general education takes up 21 credits, 76 credits are from departmental core modules. These include a Biotechnology Internship and (3 credits) and a thesis/project (4 credits). A minimum of 12 credits are from electives and 27 credits are from modules outside the student's area of specialization. The qualification has been designed to include topics of recent trends in this new and emerging field with emphasis on applications of biotechnology in different areas of socio-economic activities. Some of the modules offered in this qualification are Introductory Biology, Physiology, Biochemistry, Plants and People, Biochemistry, Molecular Biology, Introduction to Biotechnology and Genetic Engineering, Immunology, Microbial Biotechnology, Industrial Biotechnology, Environmental Biotechnology, Plant Biotechnology and Genetic Engineering, Livestock and Fishery Biotechnology, GMOs and Biosafety, Bioprocess Technology, Food Biotechnology, IPR and Biotechnology and Bioethics. The program also includes modules for improving communication skills, strengthening mathematical background and acquainting the student with socio-economic background of Bangladesh. Once a student has

completed this qualification he/she should be well equipped to fulfill the requirement for jobs in public sectors and private enterprises involved in different biotechnology efforts and to face the challenges of new developments in the Biotechnology field. With this basic background the student should face no problem to find a suitable job in different universities, research and development organization and private enterprises.

This qualification is similar to our proposed qualification in many ways including the duration, the modules offered and the requirement for an internship and research project/thesis. The scope of coverage applications within Biotechnology is also similar, from agricultural, plant, microbial, industrial, environmental, food, biomedical and regulation. Based on these similarities, the graduate produced will be similar and will have similar skills. The main difference is the presence of a higher proportion of business and entrepreneurial modules in our proposed qualification.

### **Bachelor of Science in Biotechnology (BS Biotechnology), University of Houston, United States of America**

The Bachelor of Science qualification in Biotechnology at the University of Houston is another 4-year qualification. It is intended to provide learners with strong core science concepts and an application-oriented undergraduate education. Strongly interdisciplinary, this innovative program strives to help learners develop critical-thinking skills and increased interest and /or persistence in STEM related courses. The program's objective is to prepare learners for employment opportunities in the critically important and dynamic biotechnology industry. In addition, the curriculum provides learners with knowledge and core set of skills that span across basic sciences, technology, engineering, and mathematics (STEM) education. It has an emphasis on environmental biotechnology and integrates bioprocessing, nanobiotechnology, bioinformatics and environmental biotechnology into the undergraduate curriculum. The qualification recognizes the need for cross-disciplinary training and fosters collaborative interactions that will strengthen undergraduate education.

Similar to our proposed qualification, the University of Houston Bs Biotechnology program is specifically designed to develop adaptable learners with a strong foundation in skills that are relevant to the changing world of biotechnology and provide learners with practical training in the skills and techniques of biotechnology. Some of the learning outcomes of the two qualifications are similar.

## BQA NCQF QUALIFICATION TEMPLATE

These include graduates who will be able to demonstrate their knowledge of technical background knowledge needed to support biotechnology research biotechnology concepts, able to work effectively in teams and apply research strategies to solve biotechnology problems.

### REVIEW PERIOD

5 Years in line with the NCQF

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| CODE (ID)               |                  |                           |                       |
|-------------------------|------------------|---------------------------|-----------------------|
| REGISTRATION STATUS     | BQA DECISION NO. | REGISTRATION START DATE   | REGISTRATION END DATE |
|                         |                  |                           |                       |
| LAST DATE FOR ENROLMENT |                  | LAST DATE FOR ACHIEVEMENT |                       |
|                         |                  |                           |                       |