

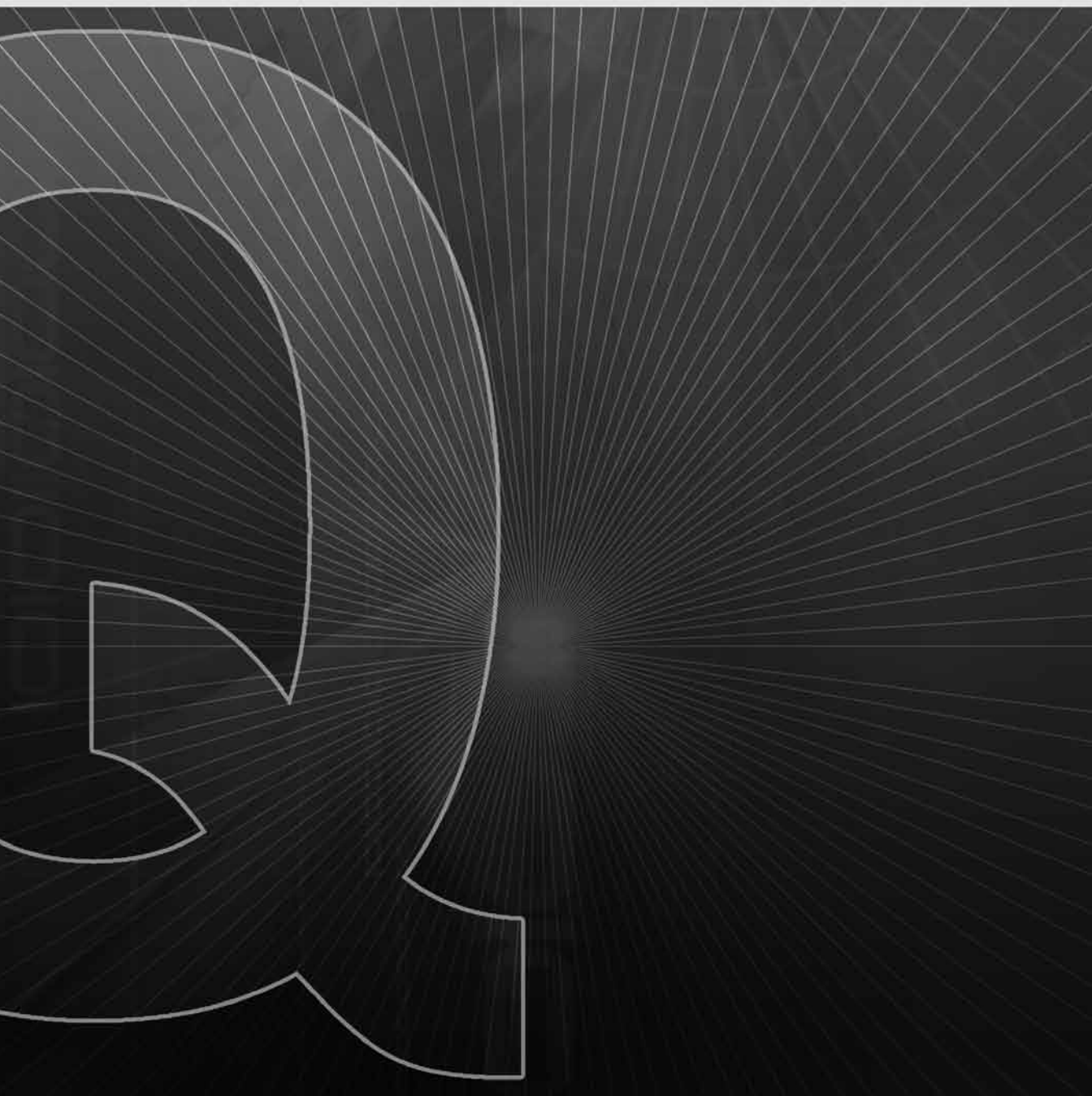
STANDARD PROGRAM : **BIOTEKNOLOGI**

PROGRAMME STANDARDS : **BIOTECHNOLOGY**

Bioteknologi merupakan penggunaan organisma atau bahagian-bahagian organisma untuk menghasilkan atau menambahbaik produk atau perkhidmatan demi kesejahteraan dan kualiti hidup.

Biotechnology is the utilisation of living organisms or parts of organisms to produce or enhance products or services for the well-being and quality of life.

STANDARD PROGRAM :
BIOTEKNOLOGI



Diterbitkan oleh
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Unit Hal Ehwal Awam & Antarabangsa
Agensi Kelayakan Malaysia

PRAKATA

Agensi Kelayakan Malaysia merupakan satu-satunya Organisasi Jaminan Kualiti Pendidikan Tinggi Negara yang memudah cara pengawalan kualiti melalui penghasilan dokumen jaminan kualiti. Dokumen yang dimaksudkan ialah Kerangka Kelayakan Malaysia, Kod Amalan, Garis Panduan Amalan Bijak dan Standard Program yang harus digunakan sebagai rujukan dalam mengendalikan program pendidikan tinggi di Malaysia.

Standard Program dibangunkan bagi memperuntukkan panduan spesifik kepada pemberi pendidikan dalam bidang tertentu bagi memenuhi keperluan dan kehendak Kerangka Kelayakan Malaysia. Dengan pematuhan dan pelaksanaan yang betul dan bijak, standard program ini mampu menjana pembangunan dan mengekalkan kualiti program pendidikan di Malaysia seterusnya meningkatkan kualiti graduan dalam aspek pekerjaan dan mobiliti.

Standard Program: Bioteknologi ini diformulasi bagi membantu pembangunan dan penjaan program akademik dalam bidang Bioteknologi pada tahap Diploma hingga Ijazah Kedoktoran Falsafah. Ia merangkumi panduan spesifik bagi Matlamat dan objektif program, hasil pembelajaran program, reka bentuk program (termasuk cadangan struktur program), penilaian pelajar, staf akademik, sumber pendidikan dan penambahbaikan berterusan.

Panel pakar yang terlibat dalam pembangunan Standard Program ini mewakili pelbagai pihak berkepentingan termasuklah agensi kerajaan dan swasta serta pemberi pendidikan tinggi. Bagi memastikan penerimaan sepenuhnya, dokumen Standard Program ini telah dibentangkan dalam bengkel pihak berkepentingan yang telah diadakan pada 15 November 2007. Pandangan umum telah diteliti dan digabungkan dalam penghasilan Dokumen akhir Standard Program tersebut.

Setinggi-tinggi penghargaan ditujukan kepada mereka yang terlibat, juga pegawai Agensi Kelayakan Malaysia yang telah menyumbang sepenuh tenaga dan masa dalam merealisasikan Standard Program: Bioteknologi ini.

Tahniah.

Tan Sri Dato' Dr. Mohamed Salleh Mohamed Yasin

Pengerusi

Agensi Kelayakan Malaysia

2010

PENGHARGAAN

Dokumen Standard Program Bioteknologi disempurnakan berbekalkan sokongan padu individu dari pelbagai institusi pengajian tinggi, industri dan agensi kerajaan. Berlatarbelakangkan kepakaran yang pelbagai, kumpulan panel pakar ini telah mencurahkan sepenuh usaha dan tumpuan mereka selama lebih kurang sembilan (9) bulan untuk menghasilkan dokumen ini.

Agensi Kelayakan Malaysia mengucapkan terima kasih kepada kumpulan panel pakar yang terlibat atas sokongan dan bantuan mereka terhadap pembangunan Standard Program ini.

Bil. Nama	Organisasi
1. Alan Ong Han Kiat (Dr.)	Fakulti Sains dan Kejuruteraan Universiti Tunku Abdul Rahman
2. Hirzun B. Mohd Yusoff (Dr.)	Sime Darby Technology Centre Sdn. Bhd.
3. Hon Wei Min (Dr.)	Fakulti Sains Gunaan University College Sedaya International
4. Lokman Shamsudin (Prof. Dr.)	Pusat Pengajian Bioteknologi dan Sains Hidupan Universiti Industri Selangor
5. Mazlan Mohamad (Dr.)	Malaysian Vaccines and Pharmaceuticals Sdn. Bhd.
6. Mohd Razip Samian (Prof. Madya)	Pusat Pengajian Sains Kajihayat Universiti Sains Malaysia
7. Quah Soon Cheang (Dr.)	Pusat Pengajian Seni dan Sains (Tumbuhan Genetik dan Pembiakan Tumbuhan) Monash University Malaysia
8. Rozilini Mary Fernandez-Chung (Dr.)	Agensi Kelayakan Malaysia
9. S. Vikineswary Sabaratnam (Prof. Dr.)	Fakulti Sains Universiti Malaya

Bil. Nama	Organisasi
10. Tan Chon Seng (Dr.)	Pusat Penyelidikan Bioteknologi Institut Penyelidikan dan Kemajuan Pertanian Malaysia (MARDI)
11. Wan Mokhtar Wan Yusoff (Prof.)	Fakulti Sains dan Teknologi Universiti Kebangsaan Malaysia

Proses kreatif penghasilan dokumen ini turut dibantu oleh warga kerja Agensi Kelayakan Malaysia, Cik Mahfiza Mohd. Nasir. Beliau boleh dihubungi melalui mahfiza@mqa.gov.my untuk sebarang pertanyaan atau penjelasan lanjut.

Terima kasih.

Dato' Dr. Syed Ahmad Hussein
Ketua Pegawai Eksekutif
Agensi Kelayakan Malaysia (MQA)
2010

kandungan

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Standard Program: Bioteknologi

PENGENALAN

Bioteknologi merupakan penggunaan organisma atau bahagian-bahagian organisma untuk menghasilkan atau menambahbaik produk atau perkhidmatan demi kesejahteraan dan kualiti hidup. Bioteknologi dilihat sebagai bidang yang meliputi pelbagai sektor dan disiplin yang melibatkan integrasi antara pengetahuan dan kemahiran yang diserap daripada disiplin merangkumi Mikrobiologi, Biokimia, Genetik, Biologi Molekular dan Kimia.

Dengan menggabungkan Sains, Kejuruteraan dan Bioinformatik, Bioteknologi menawarkan peluang yang luas dan pelbagai. Bioteknologi juga membawa faedah ekonomi dalam pelbagai bidang dan industri termasuk pertanian, perubatan, penjagaan kesihatan, kejuruteraan, sains persekitaran, pembuatan dan perkhidmatan.

Perkembangan pesat Industri Bioteknologi di seluruh dunia telah mewujudkan peluang kerjaya bagi graduan Bioteknologi. Bahagian teras yang tertera dalam Dasar Bioteknologi Kebangsaan menunjukkan komitmen kerajaan bagi memastikan perkembangan sihat Industri Bioteknologi di Malaysia.

Bagi melahirkan graduan yang berke Layakan dalam bidang Bioteknologi pada tahap kelayakan yang berbeza, tanda aras penganugerahan setiap kelayakan adalah seperti di bawah.

Contoh kelayakan dalam bidang bioteknologi ialah:

- Diploma Bioteknologi
- Ijazah Sarjana Muda Sains (Bioteknologi)
- Ijazah Sarjana Muda Bioteknologi

- Ijazah Sarjana Sains
- Ijazah Kedoktoran

Standard Program dibahagikan seperti berikut:

1. Matlamat dan Objektif
2. Hasil Pembelajaran
3. Reka Bentuk Program
4. Kemasukan Pelajar
5. Penilaian Pelajar
6. Staf Akademik
7. Sumber Pendidikan
8. Penambahbaikan Berterusan
9. Lampiran*

*Lampiran merangkumi Laluan Pendidikan dan Panduan kandungan Program Bioteknologi pada pelbagai tahap. Dokumen ini mestilah dibaca bersama penerbitan berikut dan mana-mana penerbitan lain yang berkaitan:

1. Kerangka Kelayakan Malaysia, Agensi Kelayakan Malaysia, 2007.
2. Kod Amalan Akreditasi Program, Agensi Kelayakan Malaysia, 2008.
3. Kod Amalan Audit Institusi, Agensi Kelayakan Malaysia, Jun 2008.

MATLAMAT DAN OBJEKTIF

Objektif Umum

Objektif utama Program Bioteknologi adalah untuk melahirkan graduan yang berpengetahuan, berkemahiran dan mampu mengintegrasikan pengetahuan sains biologi dan teknologi yang berkaitan dengan mengambil kira aspek etika dan tanggungjawab sosial.

Diploma

Objektif Program Diploma adalah untuk melahirkan graduan yang:

1. mempunyai pemahaman asas konsep Bioteknologi;
2. kompeten dalam kemahiran pratikal yang tertentu;
3. mempunyai kesedaran tentang isu bio bahaya dan keselamatan pekerjaan;

4. mampu menyokong dan membantu dalam pengurusan makmal dan industri yang berkaitan; dan
5. mempunyai kemahiran komunikasi asas dan interpersonal.

Ijazah Sarjana Muda

Objektif Program Ijazah Sarjana Muda adalah untuk melahirkan graduan yang:

1. mempunyai pemahaman yang komprehensif dalam bidang Bioteknologi dan aplikasinya;
2. kompeten dalam kemahiran praktikal yang luas;
3. mempunyai kesedaran tentang isu bio bahaya dan keselamatan pekerjaan;
4. kompeten dalam kemahiran komunikasi dan interpersonal;
5. memiliki pemikiran inovatif, keupayaan analitikal dan penyelesaian masalah; dan
6. mempunyai kesedaran tentang isu semasa dan kemajuan teknologi dalam bidang Bioteknologi dengan mengambil kira isu komersial, etika, sosial dan perundangan.

Ijazah Sarjana

Objektif Program Ijazah Sarjana adalah untuk melahirkan graduan yang:

1. mempunyai pengetahuan mendalam mengenai bidang Bioteknologi yang relevan;
2. kompeten dalam membangunkan protokol dan prosedur;
3. mempunyai kesedaran tentang isu bio bahaya dan keselamatan pekerjaan;
4. kompeten dalam kemahiran komunikasi dan interpersonal;
5. mampu menjalankan penyelidikan berpandu;
6. mempunyai pengetahuan terkini tentang isu semasa dan kemajuan teknologi dalam bidang Bioteknologi dengan mengambil kira isu komersial, etika, sosial dan perundangan yang relevan; dan
7. inovatif, kreatif dan memiliki keupayaan analitikal dan penyelesaian masalah.

Ijazah Kedokteran

Objektif Program Ijazah Kedokteran adalah untuk melahirkan graduan yang:

1. mempunyai pengetahuan khusus dalam bidang Bioteknologi yang relevan;
2. kompeten dalam membangunkan protokol dan prosedur;
3. kompeten dalam isu bio bahaya dan keselamatan pekerjaan;
4. kompeten dalam kemahiran komunikasi dan interpersonal;
5. mampu menjalankan penyelidikan sendiri;
6. boleh menyumbang kepada pemahaman tentang isu semasa dan kemajuan teknologi Bioteknologi dengan mengambil kira isu komersial, etika, sosial dan perundangan yang relevan; dan
7. inovatif, kreatif dan memiliki keupayaan analitikal dan penyelesaian masalah.

HASIL PEMBELAJARAN

Diploma

Pada akhir Program Diploma, graduan seharusnya berkebolehan untuk:

1. menunjukkan pemahaman konsep asas Bioteknologi;
2. mengaplikasikan pengetahuan teori dan kemahiran praktikal dalam bidang Bioteknologi yang relevan;
3. berkomunikasi secara efektif dengan rakan sebaya dan yang lain;
4. mengumpul data eksperimental dengan seliaan dan menghasilkan laporan ringkas;
5. menjalankan aktiviti teknikal asas;
6. melaksanakan prosedur asas bio bahaya dan keselamatan pekerjaan;
7. menggunakan aplikasi asas komputer; dan
8. mengenal pasti dan mengamalkan konsep pembelajaran sepanjang hayat.

Ijazah Sarjana Muda

Pada akhir Program Ijazah Sarjana Muda, graduan seharusnya berkebolehan untuk:

1. menunjukkan pemahaman komprehensif Bioteknologi;
2. mengguna dan menyelenggara peralatan asas Bioteknologi;

3. menganalisis, mensintesis, dan mengintegrasikan pengetahuan dan maklumat;
4. mengaplikasikan pengetahuan teori dan kemahiran praktikal;
5. mengendalikan penyelidikan berpandu asas;
6. menunjukkan kebolehan mencari, mengadaptasi dan memberi penyelesaian bagi menangani cabaran dan permasalahan Bioteknologi;
7. mengenal pasti dan mengamalkan konsep pembelajaran sepanjang hayat;
8. menunjukkan kesedaran dan pemahaman terhadap isu asas komersial, etika, perundangan dan sosial yang berkaitan dengan Bioteknologi; dan
9. berkomunikasi dan menunjukkan kemahiran interpersonal.

Ijazah Sarjana

Pada akhir Program Ijazah Sarjana, graduan seharusnya berkebolehan untuk:

1. menunjukkan pengetahuan mendalam dalam bidang Bioteknologi yang relevan;
2. mengakses, menilai dan menganalisis informasi Bioteknologi daripada pelbagai sumber dan menerangkan prinsip-prinsipnya secara lisan dan bertulis;
3. menilai dan menganalisis informasi terkini dari sumber yang relevan bagi menggabungkannya dalam penyelidikan Bioteknologi dengan panduan minimum;
4. menunjukkan kebolehan mencari, mengadaptasi dan memberi penyelesaian bagi menangani cabaran dan permasalahan Bioteknologi;
5. mengenal pasti dan mengamalkan konsep pembelajaran sepanjang hayat;
6. menunjukkan kesedaran dan pemahaman isu asas komersial, etika, perundangan dan sosial yang berkaitan dengan Bioteknologi;
7. melaksanakan tugas pengurusan atau penyeliaan dalam makmal dan industri berkaitan; dan
8. berkomunikasi dan menunjukkan kemahiran interpersonal.

Ijazah Kedoktoran

Pada akhir Program Ijazah Kedoktoran, graduan seharusnya berkebolehan untuk:

1. menghasilkan pengetahuan dan pemahaman melalui penyelidikan sendiri;
2. menyumbang kepada bidang spesifik Bioteknologi;
3. menghasilkan dan menginterpretasikan pengetahuan ke arah kemajuan Bioteknologi;
4. mengaplikasikan teknik dan pengetahuan khusus bagi meningkatkan kemajuan Bioteknologi;
5. menunjukkan kebolehan mencari, mengadaptasi dan memberi penyelesaian bagi menangani cabaran dan permasalahan Bioteknologi;
6. menyumbang kepada pemahaman tentang isu semasa dan kemajuan teknologi Bioteknologi dengan mengambil kira isu komersial, etika, sosial dan perundangan yang relevan;
7. memimpin dan menyumbang kepada penyelidikan dan penerbitan berwasit; dan
8. melibatkan diri dalam perbincangan akademik dengan rakan sebaya dan pakar dalam disiplin yang berkaitan.

REKA BENTUK PROGRAM

Keperluan spesifik bagi setiap tahap adalah seperti dinyatakan di bawah. Sebagai panduan umum, ketetapan berikut perlu dipertimbangkan:

- kredit minimum bagi Program Diploma ialah 90 dan Ijazah Sarjana Muda ialah 120; dan
- tempoh pengajian minimum bagi Program Diploma ialah dua tahun setengah (2.5) dan Ijazah Sarjana Muda ialah tiga (3) tahun.

Diploma

Kaedah penyampaian:

- Kuliah dan tutorial bagi konsep dan teori;
- Pembangunan kemahiran melalui kerja makmal dan penempatan pelajar; dan

- Jadual (1a) mengandungi komponen reka bentuk program dan pecahan peratusan yang disyorkan bagi tahap ini.

Ijazah Sarjana Muda

Kaedah penyampaian:

- Kuliah, amali, tutorial, projek penyelidikan, seminar, pembentangan, e-pembelajaran, pembelajaran berasaskan masalah, lawatan industri dan penempatan pelajar;
- Program Bioteknologi harus memfokuskan kepada pembentangan, perbincangan dan kerja amali yang membolehkan pelajar menunjukkan pemahaman terhadap teori dan mempunyai kemahiran analitikal, kebolehan berkomunikasi, merancang dan mengurus;
- Program ini perlu menggalakkan pembangunan kerja berpasukan dan kemahiran kepimpinan;
- Penempatan pelajar adalah wajib; dan
- Jadual (1b) mengandungi komponen reka bentuk program dan pecahan peratusan yang disyorkan bagi Tahap ini.

Ijazah Sarjana

Struktur:

- Struktur A – Penyelidikan sahaja;
- Struktur B – Kerja Kursus (18 – 24 kredit) dan Penyelidikan; dan
- Struktur C – Kerja Kursus sahaja (40 kredit termasuk projek).

Nota:

1. Tempoh minimum adalah satu (1) tahun sepenuh masa atau dua (2) tahun separuh masa bagi semua Struktur.
2. Metodologi Penyelidikan dicadangkan sebagai subjek wajib.

Ijazah Kedoktoran

Struktur:

- Struktur A – Penyelidikan sahaja; dan
- Struktur B – Penyelidikan dan Kerja Kursus

Nota:

1. Tempoh minimum adalah dua (2) tahun sepenuh masa atau empat (4) tahun separuh masa bagi semua Struktur.
2. Metodologi Penyelidikan dicadangkan sebagai subjek wajib.

KEMASUKAN PELAJAR

Keperluan spesifik bagi setiap Tahap adalah seperti di bawah. Sebagai panduan umum, ketetapan berikut perlu dipertimbangkan dalam proses pemilihan:

- keperluan di bawah adalah syarat kelayakan masuk minimum; dan
- sebarang pengecualian yang diberi untuk kemasukan ke satu Tahap yang lebih tinggi adalah berasaskan polisi sedia ada.

Diploma

- Lulus Sijil Pelajaran Malaysia (SPM) dengan tiga (3) kredit dalam bidang yang berkaitan atau yang setaraf; **ATAU**
- Sijil dalam Bidang yang berkaitan.

Ijazah Sarjana Muda

Lulus Sijil Pelajaran Malaysia (SPM) atau yang setaraf; **DAN**

- Sijil Tinggi Persekolahan Malaysia (STPM) dengan dua (2) prinsipal atau setara; **ATAU**
- Diploma dalam Bidang yang berkaitan; **ATAU**
- Program Asas, Matrikulasi, Program Pra-universiti dalam Aliran yang berkaitan atau yang setaraf.

Ijazah Sarjana

- Ijazah Sarjana Muda atau yang setaraf dalam Disiplin yang berkaitan.

Ijazah Kedoktoran

- Ijazah Sarjana Muda dalam Bioteknologi atau Disiplin yang berkaitan dan Ijazah Sarjana; **ATAU**
- Ijazah Sarjana Muda dengan kepujian dalam Disiplin yang berkaitan dan Sijil atau Diploma Pascasiswazah dalam Bidang yang berkaitan.

Nota:

Calon yang mendaftar untuk Ijazah Sarjana, boleh menukar pendaftaran kepada Ijazah Kedoktoran selepas setahun tertakluk kepada kriteria tertentu yang dipenuhi.

PENILAIAN PELAJAR

Keperluan khusus bagi setiap Tahap adalah seperti yang tertera di bawah. Walaubagaimanapun, sebagai panduan umum, perkara-perkara berikut perlu diberi perhatian:

- Setiap Tahap perlu mengandungi penilaian formatif dan sumatif bergantung kepada keperluan subjek/modul; dan
- Pemberi Pendidikan Tinggi (PPT) digalakkan menggunakan pelbagai kaedah dan instrumen yang bersesuaian dengan hasil pembelajaran dan kompetensi. Di bawah adalah senarai contoh jenis-jenis penilaian.

Diploma

Penilaian adalah seperti berikut:

- Peperiksaan *Open/Closed Book*
 - ▶ Soalan aneka pilihan
 - ▶ Soalan jawapan pendek
 - ▶ Soalan esei campuran
 - ▶ Soalan esei berasaskan masalah
- Penilaian berterusan
 - ▶ Pembentangan
 - ▶ Penyertaan dalam kelas
 - ▶ Penulisan laporan
 - ▶ Kemahiran makmal
 - ▶ Tugas/Projek mini

Ijazah Sarjana Muda

Penilaian adalah seperti berikut:

- Peperiksaan *Open/Closed Book*
 - ▶ Soalan aneka pilihan
 - ▶ Soalan jawapan pendek
 - ▶ Soalan esei campuran
 - ▶ Soalan esei berasaskan masalah
- Penilaian berterusan
 - ▶ Ulasan kritikal terhadap artikel
 - ▶ Pembentangan

- ▶ Penglibatan dalam kelas
- ▶ Penulisan laporan
- ▶ Kemahiran makmal
- ▶ Tugas/Projek mini
- Projek Penyelidikan dengan Laporan Projek/Disertasi/*Viva Voce*

Ijazah Sarjana

Contoh penilaian adalah seperti berikut:

- Peperiksaan *Open/Closed Book*
 - ▶ Soalan jawapan pendek
 - ▶ Soalan esei campuran
 - ▶ Soalan esei berasaskan masalah
- Penilaian berterusan
 - ▶ Ulasan kritikal terhadap artikel
 - ▶ Pembentangan
 - ▶ Penglibatan dalam kelas
 - ▶ Penulisan laporan
 - ▶ Kemahiran makmal
 - ▶ Tugas
- Projek Penyelidikan dengan Laporan Projek/Disertasi/*Tesis/Viva Voce*

Ijazah Kedoktoran

Penilaian adalah seperti berikut:

- Projek Penyelidikan/*Tesis/Viva Voce*.

Nota:

Penerbitan dalam jurnal *peer-reviewed* atau pembentangan dalam persidangan digalakkan.

STAF AKADEMIK

Keperluan khusus bagi setiap Tahap adalah seperti yang tertera di bawah. Sebagai panduan umum, perkara berikut perlu diberi perhatian:

- ketua akademik sekolah/fakulti/jabatan mestilah berkelayakan Ijazah Kedoktoran atau mempunyai Ijazah Sarjana dengan sekurang-kurangnya sepuluh (10) tahun pengalaman berkerja dalam Bidang yang berkaitan;

- staf sokongan seperti staf teknikal makmal dan pentadbiran yang mencukupi; dan
- Pemberi Pendidikan Tinggi (PPT) seharusnya berusaha mengimbangi antara staf akademik senior dan staf akademik junior.

Nota: Walaubagaimanapun, sekiranya pensyarah tidak memiliki kelayakan pascasiswazah, pengalaman industri boleh diambil kira dalam pengambilan staf.

Diploma

- Kelayakan minimum staf akademik: Ijazah Sarjana Muda dalam Bidang berkaitan
- Nisbah staf akademik-pelajar: 1:25
- Peratusan antara staf akademik sepenuh masa dan separuh masa adalah 60% dan 40%.

Ijazah Sarjana Muda

- Kelayakan minimum staf akademik: Ijazah Sarjana
- Nisbah staf akademik-pelajar: 1:20
- Peratusan antara staf akademik sepenuh masa dan separuh masa adalah 60% dan 40%.

Ijazah Sarjana

- Kelayakan minimum staf akademik: Ijazah Kedoktoran atau Ijazah Sarjana dengan minimum lima (5) tahun pengalaman bekerja dalam Bidang yang berkaitan.
- Nisbah staf akademik-pelajar: 1:10
- Peratusan antara staf akademik sepenuh masa dan separuh masa adalah 60% dan 40%.

Ijazah Kedoktoran

- Kelayakan minimum staf akademik: Ijazah Kedoktoran dengan minimum tiga (3) tahun pengalaman bekerja.
- Nisbah staf akademik-pelajar: 1:5
- Peratusan antara staf akademik sepenuh masa dan separuh masa adalah 60% dan 40%.

SUMBER PENDIDIKAN

Bagi Semua Tahap Kelayakan

Bagi Bidang Bioteknologi, Pemberi Pendidikan Tinggi (PPT) juga perlu mematuhi keperluan keselamatan dan kesihatan seperti yang diperuntukkan di bawah Akta Keselamatan dan Kesihatan Pekerjaan 1994.

- **Kemudahan Asas**

Sebuah makmal Boteknologi perlu dilengkapi dengan peralatan seperti mikroskop, inkubator, meter pH, water baths, pengempar, radas elektroforesis, spektrofotometer (*ultraviolet-visible*), *inkubator shakers*, autoklaf, neraca, penyejuk beku, kebuk wasap serta komputer dengan sambungan Internet dan perisian yang relevan untuk menjalankan eksperimen asas Bioteknologi.

- **Kemudahan Khusus**

- o **Kemudahan Biologi Molekul:** mesin Rantai Tindak-Balas Polimerase (PCR), radas elektroforesis dan sistem dokumentasi gel;
- o **Kemudahan Teknologi Protein/Enzim:** radas pengekstrakan protein dan kromatografi;
- o Kemudahan Kultur: inkubator, kabinet aliran lamina dan kebuk pertumbuhan; dan
- o **Peralatan Biopemprosesan yang sesuai untuk proses *upstream* dan *downstream*.**

Nota:

Pemberi Pendidikan Tinggi (PPT) yang tidak mempunyai kemudahan yang sesuai perlulah membuat perjanjian akses dengan PPT yang lain yang mempunyainya.

- **Perpustakaan**

- o Pemberi Pendidikan Tinggi (PPT) mesti menyediakan kemudahan perpustakaan yang mencukupi termasuk e-perpustakaan; dan
- o Perpustakaan mesti mempunyai koleksi bahan rujukan terkini untuk memenuhi keperluan setiap Program dan Penyelidikan di kalangan staf dan pelajar.

- **Sumber Bukan Akademik**
 - o Sumber bukan akademik tergolong dalam kemudahan dan sumber akademik secara tidak langsung, tetapi adalah perlu untuk menyokong aktiviti pengajaran-pembelajaran oleh Pemberi Pendidikan Tinggi (PPT);
 - o Pemberi Pendidikan Tinggi (PPT) juga perlu menyediakan sumber untuk menyokong aktiviti kokurikulum pelajar seperti aktiviti rekreasi dan khidmat masyarakat;
 - o Bilik rehat dengan kemudahan Internet adalah perlu untuk pelajar beristirahat dan mesti disediakan dengan secukupnya;
 - o Pemberi Pendidikan Tinggi (PPT) juga perlu menyediakan bilik sakit dan bilik kaunseling supaya keperluan khusus pelajar boleh dipenuhi; dan
 - o Sumber bukan akademik juga merujuk kepada kemudahan fizikal yang mencukupi dan sesuai bagi pelajar kurang upaya.

PENAMBAHBAIKAN KUALITI BERTERUSAN

Pemberi Pendidikan Tinggi (PPT) adalah diharapkan dapat membuktikan kemampuan mereka dalam mengikut perkembangan dan perubahan dalam Bidang serta keperluan pihak berkepentingan. Antara lain, ini boleh ditunjukkan melalui:

1. kajian semula kurikulum sekurang-kurangnya sekali setiap tiga (3) tahun;
2. pelantikan Pemeriksa luar untuk proses penilaian kualiti;
3. hubungan dengan industri;
4. kajian semula secara berterusan terhadap amalan dan rekod latihan industri;
5. sesi dialog dengan pihak berkepentingan sekurang-kurangnya sekali setiap dua (2) tahun;
6. penyertaan staf akademik secara aktif dalam persidangan, seminar, bengkel dan kursus pendek yang relevan;
7. pembentangan daripada penceramah jemputan tempatan atau antarabangsa; dan
8. penganjuran persidangan, seminar dan bengkel.

Jadual (1a): Komponen Reka Bentuk Diploma Bidang Bioteknologi

Kandungan

Teras Sains Asas dan Sains Biologi Asas (35-40%)

- **Sains Asas** (Matematik, Fizik, Kimia, Biologi),
- **Sains Biologi Asas** (Biokimia, Mikrobiologi, Biologi Sel dan Molekul, Genetik)

Teras Major (30-40%)

Mata Pelajaran Gunaan dalam Disiplin Bioteknologi seperti Prinsip Teknologi DNA, Kultur Sel dan Tisu, Pem-biakan Tumbuhan dan Haiwan, Teknologi Enzim & Fermentasi, Kejuruteraan Bioproses, Instrumentasi dalam Bioteknologi.

Elektif Major (0-5%)

Kursus elektif boleh diambil daripada bidang pengkhususan terpilih seperti Bioteknologi Marin & Akuakultur, Bioteknologi Tumbuhan, Bioteknologi Haiwan, Bioteknologi Pertanian, Bioteknologi *Pharmaceutical*, Bioteknologi Persekitaran, Bioteknologi Makanan, *Nutraceutical* dan makanan berfungsi, Fermentasi/Bioproses, Bioteknologi Industri dan Kejuruteraan Protein.

Latihan Industri (5-10%)

Kemahiran Generik, Kemanusiaan dan Sastera Liberal (15-20%)*

Boleh terdiri daripada Disiplin terpilih dalam Kemahiran Komunikasi, ICT, Pengurusan, Keusahawanan, Hak Harta Intelek, Etika & Keselamatan Biologi, Isu Sosial & Perundangan, Bahasa Malaysia, Pengajian Malaysia dan Pengajian Islam/ Moral.

(5-10%)*

* Nota: Boleh diintegrasikan dengan komponen teras

Jadual (1b): Komponen Reka Bentuk Ijazah Sarjana Muda bidang Bioteknologi**Kandungan****Komponen Sains Asas (10-20%)**

(Biologi, Kimia, Fizik dan Matematik terutama Statistik)

Nota: Kursus komponen teras Sains Asas boleh diintegrasikan atau dimasukkan dalam kursus komponen teras Sains atau kursus Sains Gunaan.

Komponen Teras: Sains Teras dan Mata Pelajaran Gunaan (40-48%)

- Sains Teras (Biokimia, Mikrobiologi, Genetik, Sel dan Biologi Molekul)
- Mata Pelajaran Gunaan seperti Kejuruteraan Genetik / Teknologi DNA Rekombinan, Diagnostik Molekul, Kultur Sel dan Tisu, Baik Baka Tumbuhan dan Haiwan, Fermentasi, Bioproses, *Biopharming*, Bioinformatik, Genomik, Proteomik.

Elektif Pengkhususan (15-20%)

Kursus elektif boleh diambil daripada bidang pengkhususan terpilih seperti Bioteknologi Marin & Akuakultur, Bioteknologi Tumbuhan, Bioteknologi Haiwan, Bioteknologi Pertanian, Farmaseutikal, Bioteknologi Persekitaran, Bioteknologi Makanan, Nutrasedutikal, Bioteknologi Perubatan, Fermentasi/ Bioproses, Bioteknologi Industri dan Kejuruteraan Protein.

Projek Penyelidikan Tahun Akhir (5 - 10 %)**Latihan Industri (2-5%)**

**Kemahiran Generik, Kemanusiaan dan Sastera Liberal
(10-15%)***

Terdiri daripada Kemahiran Komunikasi, ICT, Pengurusan, Keusahawanan, Hak Harta Intelek, Etika & Keselamatan Biologi, Isu Sosial & Perundangan, Bahasa Malaysia, Pengajian Malaysia dan Pengajian Islam/Moral.

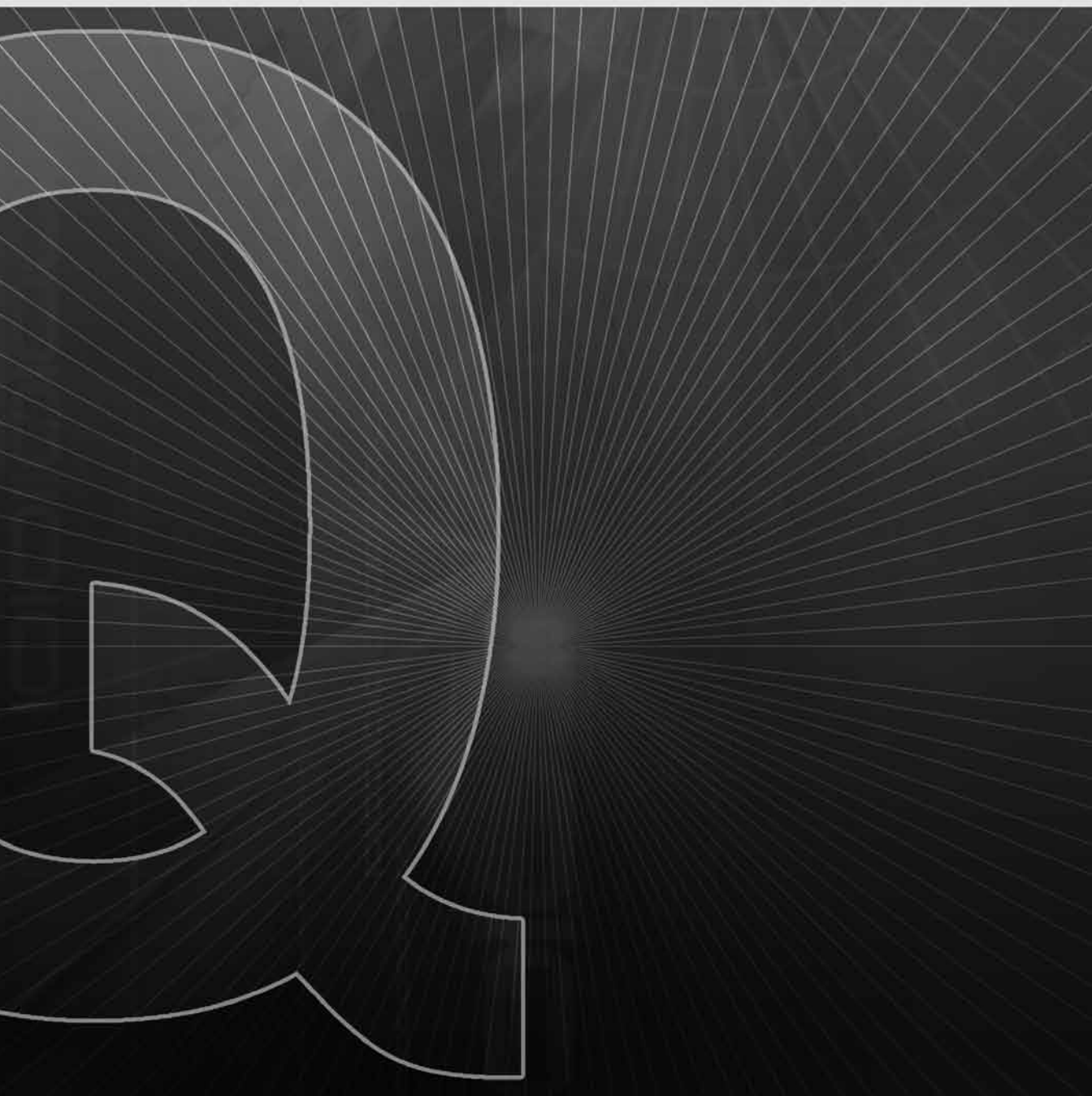
Nota*: Komponen kursus kemahiran generik boleh diintegrasikan atau dimasukkan ke dalam komponen teras atau elektif.

Jadual 2: Pengagihan Peratus Reka Bentuk Program Berdasarkan Komponen Konsep/Teori dan Komponen Kemahiran dalam Program Pengajian.

Komponen	% Mengikut Tahap Kelayakan	
	Diploma	Ijazah Sarjana Muda
Konsep dan Teori	30-35	40-45
Kemahiran	45-55	40-50
Kemahiran Generik, Kemanusiaan dan Sastera Liberal	15-20	10-15

Catatan: Konsep dan teori pada kebiasaannya diperolehi melalui Kuliah, Tutorial dan Pembacaan. Kemahiran pada kebiasaannya diperolehi melalui kerja tangan/pendedahan (Kerja Makmal, Projek, Latihan Industri) dan dipertingkatkan melalui penilaian yang berkesan.

PROGRAMME STANDARDS : **BIOTECHNOLOGY**



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FOREWORD

The Malaysian Qualifications Agency (MQA), as the Sole National Higher Education Quality Assurance Organisation, facilitates quality through the development of quality assurance documents. These documents are Malaysian Qualifications Framework (MQF), Codes of Practice, The Guidelines to Good Practices and Programme Standards, all of which must be used as a Reference point in the conduct of a programme of study in Malaysia.

Programme Standards are developed to provide specific guidelines to providers in a particular field or course of study so as to fulfil the MQF requirements. These guidelines, if followed closely and wisely, enable the development and sustenance of quality Programmes in Malaysia, consequently improving the quality of graduates and their employability and mobility.

The Programme Standards: Biotechnology is formulated to promote the development of academic programmes in the field of Biotechnology from Diploma to the Doctoral levels. It includes specific guidelines on programme aims and objectives, programme-learning outcomes, programme design (including a proposed programme structure), admission criteria, student assessment, academic staff, educational resources and continuous quality improvement.

The panel of experts involved in the development of this Programme Standards represents various stakeholders including the Government and private agencies, and Higher Education providers. To ensure greater acceptance of the Document, a larger stakeholder workshop was held on 15 November, 2007 where the draft was presented and views consolidated into this final Document.

My deepest gratitude goes to them and the MQA officers who have put forth tremendous effort and generously gave their time in realising the Programme Standards: Biotechnology.

Congratulations.

Tan Sri Dato' Dr. Mohamed Salleh Mohamed Yasin

Chairman

Malaysian Qualifications Agency

2010

ACKNOWLEDGEMENT

The completion of this Document, The Programme Standards: Biotechnology has been largely due to the support of outstanding individuals from the institutions of higher education, industries and government agencies. Coming from different backgrounds, these panel of experts worked meticulously over a period of nine (9) months to produce this final document.

Malaysian Qualifications Agency would like to thank the following experts for their support and contribution towards the production of this Programme Standards.

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Within this Agency, the creative process was assisted by Ms. Mahfiza Mohd. Nasir who may be contacted at mahfiza@mqa.gov.my for further clarification or query.

With our sincere appreciation and gratitude,

Dato' Dr. Syed Ahmad Hussein
 Chief Executive Officer
 Malaysian Qualifications Agency
 2010

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Programme Standards: Biotechnology

INTRODUCTION

Biotechnology is the utilisation of living organisms or parts of organisms to produce or enhance products or services for the well-being and quality of life. Biotechnology can be viewed as a multi-sectoral and multi-disciplinary field involving the integration of knowledge and skills drawn from various disciplines, inclusive of Microbiology, Biochemistry, Genetics, Molecular Biology and Chemistry.

There are great and diversified opportunities in Biotechnology as it combines Science, Engineering and Bioinformatics. Biotechnology can generate economic benefits in several areas and industries including agriculture, medicine, health care, engineering, environmental sciences, manufacturing and services.

The rapid development of the Biotechnology Industry worldwide has created career opportunities for graduates in Biotechnology. The thrust areas as envisioned in the National Biotechnology Policy are indicative of the government's commitment to ensure the healthy development of Biotechnology Industries in Malaysia.

In order to produce graduates qualified in the field of Biotechnology at different levels, the benchmarks leading to the award of individual qualifications are given below.

The qualifications in the field of Biotechnology may be demonstrated by, but not limited to:

- Diploma in Biotechnology
- Bachelor of Science (Biotechnology)
- Bachelor of Biotechnology
- Master of Science
- Doctor of Philosophy

The Programme Standards are subdivided as follows:

1. Aims and Objectives
2. Learning Outcomes
3. Programme Design
4. Student Admission
5. Student Assessment
6. Academic Staff
7. Educational Resources
8. Continuous Improvement
9. Appendices*

*The Appendices include an Educational Pathway and a Guide to Biotechnology programme contents at the various levels. This document should be read in conjunction with the following publications and any other related future publications:

1. The Malaysian Qualifications Framework, Malaysian Qualifications Agency, 2007.
2. Code of Practice for Programme Accreditation, Malaysian Qualifications Agency, 2008.
3. Code of Practice for Institutional Audit, Malaysian Qualifications Agency, June 2008.

AIMS AND OBJECTIVES

General Objectives

The main objective of a Biotechnology Programme is to produce graduates who are knowledgeable, skilful and able to integrate knowledge drawn from biological sciences and related technologies, taking into account aspects of ethics and social responsibility.

Diploma

The objectives of the Diploma Programme are to produce graduates who:

1. possess basic understanding of concepts in Biotechnology;
2. are competent in designated practical skills;
3. are aware of biohazard and occupational safety issues;
4. can support and assist in the management of laboratories and related industries; and
5. possess basic communication and interpersonal skills.

Bachelor's Degree

The objectives of the Bachelor's Degree Programme are to produce graduates who:

1. have a comprehensive understanding of Biotechnology and their applications;
2. are competent in wide ranging practical skills;
3. are aware of biohazard and occupational safety issues;
4. are competent in communication and interpersonal skills;
5. possess innovative thinking, analytical skills and problem solving abilities; and
6. are aware of current issues and technological advancement in Biotechnology taking into account of commercial, ethical, social and legal issues.

Master's Degree

The objectives of the Master's Degree Programme are to produce graduates who:

1. have enhanced knowledge of relevant areas in Biotechnology;

2. are competent in developing protocols and procedures;
3. are aware of biohazard and occupational safety issues;
4. are competent in communication and interpersonal skills;
5. have the ability to carry out guided research;
6. keep abreast of current issues and technological advancement in Biotechnology taking into account relevant commercial, ethical, social and legal issues; and
7. are innovative, creative, and possess analytical and problem-solving abilities.

Doctoral Degree

The objectives of the Doctoral Degree Programme are to produce graduates who:

1. have specialised knowledge in relevant areas of Biotechnology;
2. are competent in developing protocols and procedures;
3. are competent in biohazards and occupational safety;
4. are competent in communication and interpersonal skills;
5. have the ability to carry out independent research;
6. can contribute to the understanding of current issues and technological advancement in Biotechnology taking into account relevant commercial, ethical, social and legal issues; and
7. are innovative, creative, and possess analytical and problem-solving abilities.

LEARNING OUTCOMES

Diploma

At the end of the Diploma Programme, graduates should be able to:

1. demonstrate an understanding of basic concepts in Biotechnology;
2. apply theoretical knowledge and practical skills in relevant areas of Biotechnology;
3. communicate effectively with peers and others;
4. collect experimental data under supervision and generate a simple report;
5. perform basic technical activities;
6. execute basic biohazard and occupational safety procedures;

7. use basic computer applications; and
8. recognise and practise the concept of lifelong learning.

Bachelor's Degree

At the end of the Bachelor's Degree Programme, graduates should be able to:

1. demonstrate a comprehensive understanding of Biotechnology;
2. operate and maintain basic Biotechnology equipment;
3. analyse, synthesise, and integrate knowledge and information;
4. apply theoretical knowledge and practical skills;
5. conduct basic-guided research;
6. demonstrate the ability to seek, adapt, and provide solutions to address challenges and concerns in Biotechnology;
7. recognise and practise the concept of lifelong learning;
8. demonstrate an understanding and awareness of basic commercial, ethical, legal and social issues related to Biotechnology; and
9. communicate and demonstrate interpersonal skills.

Master's Degree

At the end of the Master's Degree Programme, graduates should be able to:

1. demonstrate enhanced knowledge of relevant areas in Biotechnology;
2. access, evaluate and analyse Biotechnology information from a variety of sources and to communicate the principles both orally and in writing;
3. evaluate and analyse current information from relevant sources for incorporation into Biotechnology research with minimal guidance;
4. demonstrate the ability to seek, adapt and provide solutions to address challenges and concerns in Biotechnology;
5. recognise and practise the concept of lifelong learning;
6. demonstrate an understanding and awareness of basic commercial, ethical, legal and social issues related to biotechnology;
7. perform managerial or supervisory roles in laboratories and related industries; and
8. communicate and demonstrate interpersonal skills.

Doctoral Degree

At the end of the Doctoral Degree Programme, graduates should be able to:

1. generate knowledge and understanding through independent research;
2. contribute to a specific area in Biotechnology;
3. create and interpret knowledge towards the advancement of Biotechnology;
4. apply specialised techniques and knowledge at the frontiers of Biotechnology development;
5. demonstrate the ability to seek, adapt and provide solutions to address challenges and concerns in Biotechnology;
6. contribute towards the understanding of current issues and technological advancement in Biotechnology, taking into account relevant commercial, ethical, social and legal issues;
7. provide leadership and contribute to research and refereed publication, and
8. be involved in academic discourse with peers and experts in related Disciplines.

PROGRAMME DESIGN

The specific requirements for each level are as indicated below. As a general guide, the following should be considered:

- the minimum credits for Diploma and Bachelor's Degree Programmes are 90 and 120, respectively; and
- the minimum duration of study for Diploma and Bachelor's Degree Programmes are two and a half (2.5) years and three (3) years respectively.

Diploma

Modes of delivery:

- Concept and theory by lecture and tutorial;
- Skill development through laboratory hands-on and student placement; and
- Table (1a) provides programme design components and percentage breakdown recommended for this Level.

Bachelor's Degree

Modes of Delivery:

- Lectures, practicals, tutorials, research projects, seminars, presentations, e-learning, problem-based learning, industrial visits and student placements;
- Biotechnology Programmes must focus on presentation, discussion and practical work that enable students to demonstrate an understanding of theories and possess analytical skills, ability to communicate, plan and manage;
- Programmes should encourage the development of teamwork and leadership skills;
- Student placement is compulsory; and
- Table (1b) provides programme design components and percentage breakdown recommended for this Level.

Master's Degree

Structure:

- Structure A – Research only;
- Structure B – Coursework (18 - 24 credits) and Research; and
- Structure C – Coursework only (40 credits inclusive of a Project-paper).

Note:

1. Minimum duration is of one (1) year full-time or two (2) years part-time for all Structures.
2. Research Methodology as a compulsory subject is recommended.

Doctoral Degree

Structures:

- Structure A – Research only; and
- Structure B – Research and Coursework.

Note:

1. Minimum duration is of two (2) years full-time or four (4) years part-time for all Structures.
2. Research Methodology as a compulsory subject is recommended.

STUDENT ADMISSION

The specific requirements for each Level are as indicated below. As a general guide, the following should be considered in the selection process:

- the requirements given below are the minimum entry qualifications; and
- any exemptions provided for entry into a higher Level are subjected to existing policies.

Diploma

- Pass Sijil Pelajaran Malaysia (SPM) with three Credits in related Field or equivalent; OR
- Certificate in a related Field.

Bachelor's Degree

Pass Sijil Pelajaran Malaysia (SPM) or equivalent, AND

- Sijil Tinggi Persekolahan Malaysia (STPM) with two Principals or equivalent; OR
- Diploma in a related Field; OR
- Foundation, Matriculation, Pre-university programme in a related Stream or equivalent.

Master's Degree

A Bachelor's Degree or equivalent from related Disciplines.

Doctoral Degree

- A Bachelor's Degree in Biotechnology or related Disciplines and a Master's Degree; OR
- A Bachelor's Degree with distinction from a related Discipline and a Postgraduate Certificate or a Diploma in a related Field.

Note: A Candidate registered for a Master's Degree may opt to convert his Registration after a year to a Doctoral Degree subject to fulfilment of the specified criteria.

STUDENT ASSESSMENT

The specific requirements for each Level are as indicated below. However, as a general guide, the following items should be considered:

- Each Level, depending on the requirements of individual subjects/modules, should incorporate both summative and formative assessments; and
- Higher Education Providers (HEPs) are encouraged to use a variety of methods and tools appropriate to the learning outcomes and competencies. The types of assessments shown below are examples.

Diploma

Assessments are as follows:

- Open/Closed Book Examinations
 - ▶ Multiple choice questions
 - ▶ Short answer questions
 - ▶ Mixed essay questions
 - ▶ Problem-based essay questions
- Continuous Assessments
 - ▶ Presentations
 - ▶ Class participation
 - ▶ Report-writing
 - ▶ Laboratory skills
 - ▶ Assignment/Mini project

Bachelor's Degree

Assessments are as follows:

- Open/Closed Book Examinations
 - ▶ Multiple choice questions
 - ▶ Short answer questions
 - ▶ Mixed essay questions
 - ▶ Problem-based essay questions
- Continuous Assessments
 - ▶ Critical review of published articles
 - ▶ Presentation

- ▶ Class Participation
- ▶ Report-writing
- ▶ Laboratory skills
- ▶ Assignment/Mini project
- Research Project with Project Report/Dissertation/Viva Voce

Master's Degree

Assessments may be as follows:

- Open/Closed Book Examinations
 - ▶ Short answer questions
 - ▶ Mixed essay questions
 - ▶ Problem-based essay questions
- Continuous Assessments
 - ▶ Critical review of published articles
 - ▶ Presentation
 - ▶ Class participation
 - ▶ Report-writing
 - ▶ Laboratory skill
 - ▶ Assignment
- Research project with Project Report/Dissertation/Thesis/Viva Voce

Doctoral Degree

Assessments are as follows:

- Research Project, Thesis and Viva Voce.

Note: Publication in peer-reviewed journal or presentation of a conference paper is encouraged.

ACADEMIC STAFF

The specific requirements for each Level are as indicated below. As a general guide, it is important to note that:

- the academic leadership of the school/faculty/department must be a person with a Doctoral Degree or a Master's Degree with at least ten (10) years work experience in related Field;

- sufficient support staff such as lab technicians and administrators should be provided; and
- the Higher Education Providers (HEPs) should strive towards maintaining a balance between senior and junior academic staff.

Note: However, where the lecturer lacks post-graduate qualifications, industrial experience may be taken into account in the recruitment of staff.

Diploma

- Minimum qualification of academic staff: Bachelor's Degree in a related Field.
- Academic staff-student ratio: 1:25.
- Percentage of full-time and part-time academic staff is 60% and 40% respectively.

Bachelor's Degree

- Minimum qualification of academic staff: Masters degree.
- Academic staff-student ratio: 1:20.
- Percentage of full-time and part time academic staff is 60% and 40% respectively.

Master's Degree

- Minimum qualification of academic staff: Doctoral Degree or Master's Degree with minimum five (5) years working experience in a related Field.
- Academic staff-student ratio: 1:10.
- Percentage of full-time and part-time academic staff is 60% and 40% respectively.

Doctoral Degree

- Minimum qualification of academic staff: Doctoral Degree with three (3) years working experience.
- Academic staff-student ratio: 1:5.
- Percentage of full-time and part time academic staff is 60% and 40% respectively.

EDUCATIONAL RESOURCES

For All Levels

For the Field of Biotechnology, Higher Education Providers (HEPs) must also comply with the provisions of safety and health as prescribed under the Occupational Safety and Health Act, 1994.

- **Basic Facilities**

A typical laboratory should be equipped to carry out basic Biotechnology experiments and should have equipment such as microscopes, incubators, pH meters, water baths, centrifuges, electrophoresis apparatus, spectrophotometers (ultraviolet-visible), incubator shakers, autoclaves, balances, freezers/chillers, fumehoods as well as computers with Internet connection and relevant software.

- **Specialised Facilities**

- **Molecular Biology facilities:** Polymerase Chain Reaction (PCR) machines, electrophoresis apparatus and gel documentation system;
- **Protein/enzyme technology facilities:** protein-extraction and chromatographic apparatus;
- **Culture facilities:** incubators, laminar flow cabinets and growth chambers; and
- **Bioprocessing equipment suitable for upstream and downstream processing.**

Note:

Where high-end facilities are not available in-house, the Higher Education Providers (HEPs) should make arrangement with other Institutions for access.

- **Library**

- Higher Education Providers (HEPs) must provide adequate library facilities including e-library; and
- The library must have adequate collection of up-to-date reference material required to support the needs of each Programme and Research amongst staff and students.

- **Non-Academic Resources**
 - o These fall under a wide umbrella of facilities and resources not directly academic but necessary for supporting the teaching-learning activities of the Higher Education Providers (HEPs);
 - o Higher Education Providers (HEPs) are required to provide among others resources to support students' extra curricular activities, such as recreational and community-based activities;
 - o Student lounges with Internet facilities are necessary for student relaxation and must be adequately provided;
 - o Higher Education Providers (HEPs) must also provide sick-bay and counselling room where specific needs of their students can be met; and
 - o Non-academic resources also refer to sufficient and appropriate physical facilities for the physically-challenged.

CONTINUOUS QUALITY IMPROVEMENT

The Higher Education Providers (HEPs) are expected to provide evidence of ability to keep pace with changes in the Field and requirements of stakeholders. These may be demonstrated by, but not limited to:

1. curriculum review, conducted at least once every three (3) years;
2. appointment of external Reviewer for quality assessment processes;
3. linkages with industry;
4. continuous review of industrial attachment practices and records;
5. dialogue sessions with stakeholders at least once every 2 years;
6. active participation of academic staff at relevant conferences, seminars, workshops and short courses;
7. presentations by invited speakers, local or international; and
8. organisation of conferences, seminars and workshops.

Table (1a): The Design Components for Diploma in the Field of Biotechnology

Content
Core Fundamental Sciences and Biological Sciences (35-40%) Fundamental Sciences (Mathematics, Physics, Chemistry and Biology) Basic Biological Sciences (Biochemistry, Microbiology, Cell and Molecular Biology and Genetics)
Core Major (30-40%) Applied Subjects in Biotechnology Disciplines such as Principles of DNA Technology, Cell and Tissue Culture, Plant and Animal Breeding, Fermentation and Enzymes Technology, Bioprocess Engineering and Instrumentation in Biotechnology.
Electives in Major (0-5%) Elective courses may be taken from selected areas such as Marine & Aquaculture Biotechnology, Plant Biotechnology, Animal Biotechnology, Agribiotechnology, Pharmaceutical Biotechnology, Environmental Biotechnology, Food Biotechnology, Nutraceutical and Functional Food, Fermentation/Bioprocessing, Industrial Biotechnology and Protein Engineering.
Industrial Training (5-10%)
Generic Skills, Humanities & Liberal Arts (15-20%)* May consist of selected Disciplines in Communication Skills, ICT, Management, Entrepreneurship, Intellectual Property Rights, Bioethics & Biosafety, Legal, Social Issues, Bahasa Malaysia, Malaysian Studies and Islamic/Moral Studies

* Note: May be integrated in core components

Table (1b): The Design Components for Bachelor's Degree in the Field of Biotechnology

Content
Fundamental Sciences (10-20%)
(Biology, Chemistry, Physics and Mathematics in particular Statistics) Note: Courses for Fundamental Science components may be integrated or embedded within the core Sciences and Applied Science courses.
Core Component (Core Sciences and Applied Courses) (40-48%)
<ul style="list-style-type: none">• Core Sciences (Biochemistry, Microbiology, Genetics, Cell and Molecular Biology)• Applied Courses such as Genetics Engineering/Recombinant DNA Technology, Molecular Diagnostics, Cell and Tissue Culture, Plant & Animal Breeding, Fermentation, Bioprocessing, Biopharming, Bioinformatics, Genomics and Proteomics,
Specialisation Electives (15-20%)
Elective Courses may be taken from selected areas such as Marine & Aquaculture Biotechnology, Plant Biotechnology, Animal Biotechnology, Agribiotechnology, Pharmaceutical, Environmental Biotechnology, Food Biotechnology, Nutraceuticals, Medical Biotechnology, Fermentation/Bioprocessing, Industrial Biotechnology and Protein Engineering.
Final Year Project (5-10%)
Industrial Training or Internships (2-5%)

Generic Skills, Humanities & Liberal Arts: (10-15%)*

Consisting of Communication Skills, ICT, Management, Entrepreneurship, Intellectual Property Rights, Bioethics & Biosafety, Legal, Social Issues Bahasa Malaysia, Malaysian Studies and Islamic/Moral Studies

*Note: The Subject-components for Generic-skills may be integrated or embedded into the core or elective components.

Table 2: Distribution Percentage (%) Programme Design According to Theoretical / Concepts and Skills in Programme of Studies

Components	% by Qualification Level	
	Diploma	Bachelor's Degree
Concept and Theory	30-35	40-45
Skills	45-55	40-50
Generic Skills, Humanities and Liberal Arts	15-20	10-15

Note: Concepts and Theories are normally acquired through Lectures, Tutorials and Readings. Skills are normally acquired through hands-on work/exposure (Laboratory-work, Projects, Industrial-training) and enhanced through supervised and effective assessment.

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