

マレーシア国
プトラ大学バイオテクノロジー学科拡充計画
アフターケア調査団報告書

平成11年4月

国際協力事業団

序 文

マレーシア国政府は今般、国際協力事業団が先に行ったプロジェクト方式技術協力、「マレーシア農科大学バイオテクノロジー学科拡充計画」について、我が国にアフターケア協力を要請してきました。先の協力は1990年6月から1995年5月までの5年間、マレーシア プトラ大学(当時：マレーシア農科大学)において大学研究者の研究能力向上を図るため実施され、成功を収めたもので、協力終了から3年半余を経ています。

日本国政府がこの要請を受け入れたので、国際協力事業団は平成11年3月11日から3月19日まで、岡山大学農学部教授 田中英彦氏を団長とするアフターケア調査団をマレーシア国に派遣しました。

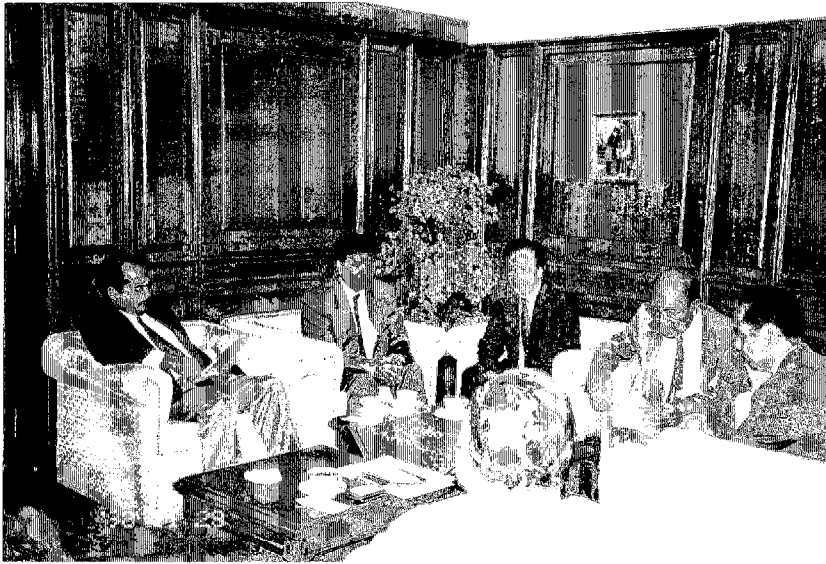
同調査団は、当初協力終了後のプトラ大学の研究活動の現状を調査するとともに、アフターケア協力の必要性について、同大学関係者と協議を行いました。その結果、「マレーシア国プトラ大学バイオテクノロジー学科拡充計画アフターケア」の技術協力が、平成11年4月から2年間にわたり、実施されることになりました。

本報告書は、同調査団による調査及び協議結果を取りまとめたものであり、今後アフターケアの実施にあたって、関係方面に広く活用されることを願うものです。

最後に、本調査の実施にご協力、ご支援を頂いた内外の関係各位に対し、心から感謝の意を表します。

平成11年4月

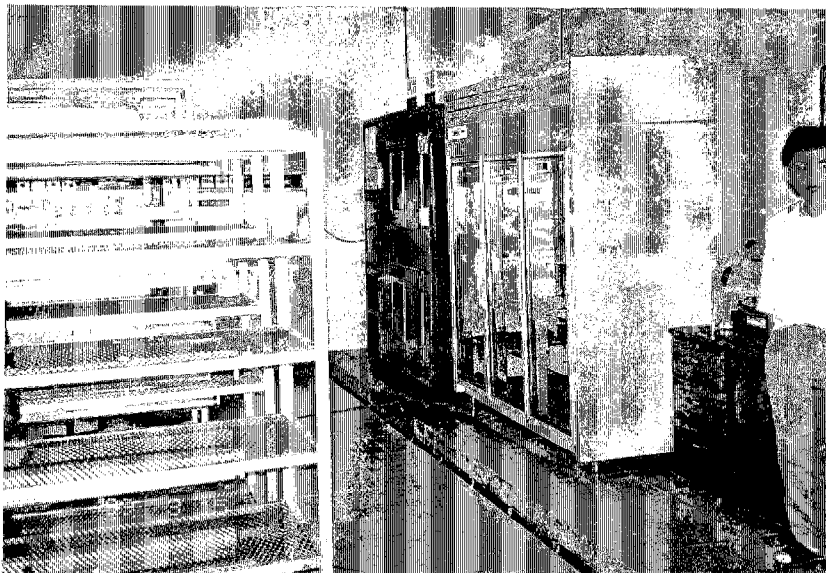
国際協力事業団
理事 亀若 誠



マレーシア プトラ大学 (UPM)
副学長 (Dr.Kamel Ariffin、向かって
左) 表敬



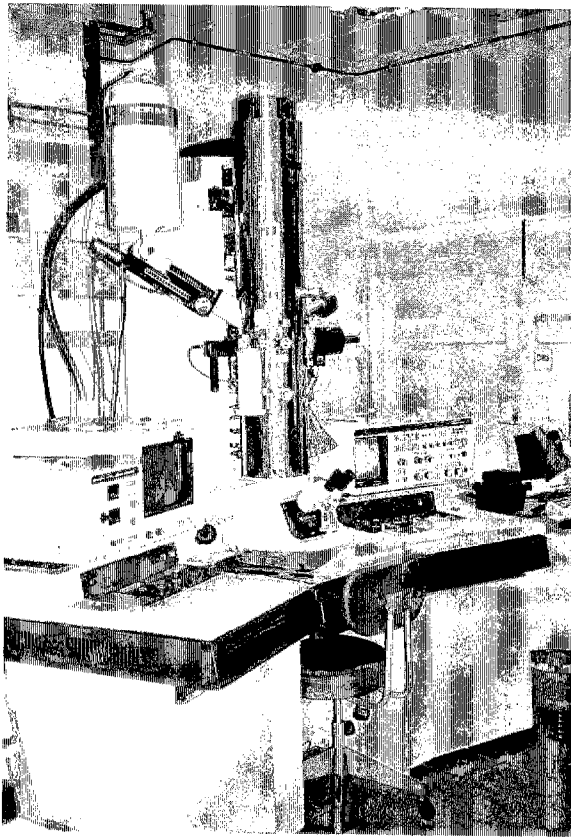
生化学／プロセス分野の分野別協議



当初協力で建設した人工気象室内



生化学研究所（Institute of Bioscience : IBS）の一部研究室が設置されている建物



UPMにて購入した透過型電子顕微鏡



ミニッツ署名・交換
(左からDr.Ismailバイオテクノロジー学科長、田中団長、Dr.Zohadie副学長、Dr.Gulam Rusul食品科学・バイオテクノロジー学部長)

プロジェクトサイト図



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1. アフターケア調査団の派遣

1-1 調査団派遣の経緯と目的

マレーシア国では、化学産業における高等教育を受けたエンジニアが不足しているが、これら技術者の養成は海外の大学に頼っているのが現状であり、国内の高等教育機関の充実・整備が緊急の課題となっていた。一方、農業分野では従来、ゴム、オイルパーム、ココアなど一次農産物の高収量化、高品質化に多大の努力を払っており、輸出振興、輸出製品の多様化とあいまって食品加工産業育成に力を入れている。

かかる状況下、マレーシア国政府はバイオテクノロジー技術の開発・応用に高い関心をよせ、本分野唯一の大学レベルの教育機関として、1986年1月、マレーシア農科大学にバイオテクノロジー学科を設立し、本学科の充実・整備及び人材育成のためのプロジェクト方式技術協力を我が国に要請した。これを受けて国際協力事業団は1990年6月1日から1995年5月31日まで5年間にわたり、マレーシア農科大学を実施機関とした「マレーシア農科大学バイオテクノロジー学科拡充計画」を実施し、酵素・発酵工学、組織培養、分子生物・遺伝子工学、生物反応プロセス分野を研究課題に、大学研究者の研究能力向上をめざした技術協力をを行い、大きな成果を上げた。

今般、マレーシア国政府は、上記プロジェクトの当初研究課題・研究技術の完了、実験機材の整備、保守管理・修理を目的とするアフターケア協力を要請してきたため、下記目的のもとに、アフターケア調査団の派遣となった。

- ① アフターケア実施の妥当性を判断するうえで必要な情報を、現地調査及びマレーシア国側関係者との協議を通じて収集する。
- ② アフターケアが妥当と判断された場合、現地調査結果に基づき、アフターケア協力内容の概要を検討する。
- ③ 日本側協力案をもとにマレーシア国側と協議を行い、アフターケア協力の詳細計画を検討するとともに、協議結果をミニッツに取りまとめる。

1-2 調査団の構成

氏名	担当	所属
田中 英彦	団長	岡山大学農学部教授
多田 幹郎	酵素・発酵	〃
中西 一弘	生化学・プロセス	岡山大学工学部教授
高木 茂明	研究計画	川崎医療福祉大学医療技術学部教授
森口 加奈子	技術協力	国際協力事業団農業開発協力部農業技術協力課

1-3 調査日程

1999年（平成11年）3月11日～3月19日

日順	月日（曜）	移動及び業務	宿 泊
1	3/11（木）	移動 成田10:30→クアラルンプール17:05（MH089）	クアラルンプール
2	3/12（金）	日本国大使館表敬、JICA事務所打合せ 「水産資源・環境研究計画」にて打合せ プトラ大学副学長表敬、学部長・学科長と打合せ	〃
3	3/13（土）	資料整理	〃
4	3/14（日）	資料整理 中西団員：成田13:00→クアラルンプール19:35（JL723）	〃
5	3/15（月）	プトラ大学調査（研究成果報告、機材・施設調査）	〃
6	3/16（火）	プトラ大学調査（分野別協議）	〃
7	3/17（水）	ミニッツ作成、Institute of Bioscience（IBS）視察	〃
8	3/18（木）	ミニッツ署名・交換、団長主催昼食会、JICA事務所報告 移動 クアラルンプール 21:10、23:00→	機中
9	3/19（金）	移動 →関空6:25（JL722）、→成田6:20（JL724）	

1-4 主要面談者

〔マレーシア国側〕

Dr.Kamel Ariffin Mohd. Atan	Deputy Vice-Chancellor(Academic Affairs),UPM(副学長)
Dr.Mohd.Zohadie bin Bardaie	Deputy Vice-Chancellor(Development), UPM(副学長)
Dr.Gulam Rusul Bin Rahmat Ali	Dean, Faculty of Food Science & Biotech.,UPM(学部長)
Dr.Hasanah Mohd. Ghazali	Deputy Dean, Assoc.Prof., Dept. of Biotechnology, UPM (副学部長)
Dr.Mohamed Ismail Bin Abdul Karim	Head, Dept. of Biotechnology, UPM(学科長)
Dr.Mohd. Ali Hassan	Assoc.Prof., Dept. of Biotechnology, UPM
Dr.Arbakariya Ariff	Assoc.Prof., Dept. of Biotechnology, UPM
Dr.Abdul Manaf Ali	Assoc.Prof., Dept. of Biotechnology, UPM
Dr.Raha A. Rahim	Lecturer, Dept. of Biotechnology, UPM
Dr.Norihan Mohd. Salleh	Lecturer, Dept. of Biotechnology, UPM
Dr.Son Radu	Lecturer, Dept. of Biotechnology, UPM
Dr.Hirzun Mohd. Yusof	Lecturer, Dept. of Biotechnology, UPM
Mr.Badlishah Sham Baharin	Lecturer, Dept. of Biotechnology, UPM
Mr.Lai Oi Ming	Lecturer, Dept. of Biotechnology, UPM
Mr.Foo Hooi Ling	Lecturer, Dept. of Biotechnology, UPM

Mr. Tan Siang Hee

Lecturer, Dept. of Biotechnology, UPM

〔日本国側〕

香月 英伸

在マレーシア日本国大使館二等書記官

野呂 忠秀

水産資源・環境研究計画リーダー

杉山 俊士

〃 業務調整

西牧 隆壮

JICAマレーシア事務所 所長

寺西 義英

〃 次長

田中 資記

〃 所員

2. 要約

マレーシア国におけるバイオテクノロジー技術の開発・発展を目的として、「マレーシア農科大学バイオテクノロジー学科拡充計画（1990～1995年）」が実施され、大きな成果を上げた。今般はまた、上記プロジェクトが取り上げた研究課題・研究技術の完了及び実験機材・器具の整備を主とするアフターケア協力の要請が行われた。

本大学は1971年にマラヤ大学農学部とマラヤ農業専門学校が合併されたことに始まり、当時はマレーシア農科大学（Universiti Pertanian Malaysia）と称されていたが、1997年に科学分野に重点を置いた総合大学として規模を拡充し、マレーシア プトラ大学（Universiti Putra Malaysia）と改称している。

本調査団は、このアフターケア協力要請の妥当性の確認と協力内容の設定を目的として派遣されたものであり、プトラ大学（UPM）当局、食品・バイオテクノロジー学部及び当該学科からアフターケア協力要請の具体的説明を受けるとともに、対象となる研究者との数回にわたる協議と、施設や実験機材・器具の使用状況及び管理体制の実施調査を行った。

実質5日間にわたる綿密な調査と協議の結果、後述の調査結果の項に概説するように、アフターケア協力要請の妥当性を確認するとともに、1999年（平成11年）4月から2年間にわたってアフターケア協力を実施することに合意し、その詳細な内容を定め、それらをミニッツ（資料1）に取りまとめて署名を取り交わした。

(1) アフターケア協力要請の背景

マレーシア国では、化学産業を支えるエンジニアが不足しており、高等教育機関の充実が重要課題となっている。また、農業関連分野においては、従来の一次生産物の高収量化や高品質化に止まらず、それらへの付加価値の付与あるいは加工産業への展開をめざすと同時に、産業発展に伴う環境汚染防衛あるいは副産物のバイオマス利用なども重要課題となっている。本アフターケア協力は、これら農業関連産業の発展にかかわる教育・研究に対する当初協力（1990～1995年）に引き続いての協力要請であると受け止められた。

(2) 当初協力の成果及び協力終了後の自助努力の成果

当初協力終了時の評価は、終了時評価調査報告書で既報のとおり、成功であったことを確認した。事実、バイオテクノロジー学科の研究教育スタッフの能力は著しく向上し、今日では、マレーシア国におけるバイオテクノロジーにかかわる研究・教育の中核としてのみならず、近隣諸国の人材育成を目的としたワークショップを開催するなどの活動も行っている。また、協力終了後の3年間においても、予想以上に活発な教育・研究活動を続け、有為の人材を社会に

送り出すとともに、100編を越える研究成果を学術論文あるいは学会発表として公表し、国内のバイオテクノロジーあるいは食品科学分野に強い影響を与えている。

このような成果は、カウンターパートの能力向上と自助努力だけではなく、マレーシア国、UPMあるいは当該学部・学科の強力なサポートによるものと考えられた。

(3) 当初協力内容とアフターケア要請内容の関連性

マレーシア国のアフターケア要請内容は、当初協力内容と同じ4課題であり、それらは、一次生産物の高収量化や高品質化を目的とした2課題（組織培養／自然産物化学、分子生物学）と農業関連産業に直結する2課題（生物反応／生化学・発酵、生化学／生物化学プロセス）に区分され、いずれも、当初協力内容の完了と実用化への発展を目的とするものであった。特に、パームオイル産業にかかわる研究テーマ（育種から利用、廃物処理に至る範囲）に重点を置いていることがうかがえ、当初協力内容との関連性と妥当性が認められた。

(4) アフターケア協力の基本計画策定と終了後の見通し

マレーシア国から要請されたアフターケア協力内容は、上記のように4課題であったが、予算枠と期間の制限を考慮して協議した結果、パームオイル産業と直結する課題（生化学／プロセス）を中心として、これにバイオテクノロジーの化学産業への応用の観点に立脚した課題（酵素／発酵）を研究対象に加えることで合意に至った。

UPMとの協議では、日本側の投入として、短期専門家を4名/年、研修員受入を3名/年、機材供与については、2年間で約2,500万円程度とする方針で望んだ。協議の結果、短期専門家及び研修員受入計画については、ミニッツANNEX 2（Plan of Operation）に、派遣及び受け入れの時期を表した。また、UPM側からは、それら以外に、廃液処理分野で2年目に1名、バイオプラスチック分野で1年目に1名の研修員の受け入れがそれぞれ追加要請として調査団に出された。

1) 生化学／プロセスの課題では、パームオイル産業と直結する次の2つの研究テーマを定めた。

① パームオイル廃液中の有機成分を原料とするバイオプラスチックの生産

パームオイル廃液中には多種の有機成分が多量に含まれており、環境への負荷の観点からその処理が問題となっている。本研究では、まず有機成分を基質として微生物による発酵を行い（後記する酵素／発酵の一部を含む）、次いでその生産物である有機酸からプラスチックを生産することを目的としている。

② パーム食油精製工程に適用が可能なカロテノイド分離技術の確立

マレーシア国の主要産業の一つであるパーム食油生産において、パームオイル中に含まれているカロテノイドは、食品加工の分野で利用が可能であるにもかかわらず、その精製

過程で除去廃棄されている。本研究は、このカロテノイドの分離技術を確認させ、そのプロセスをパーム食油生産現場に導入し、カロテノイドを食品加工に利用しようとするものである。

ここに掲げた2研究テーマはともに、当初協力において実験室レベルでの成果を得ており、早い時期に実用化されることが期待される。

2) 酵素/発酵の課題では、バイオテクノロジー産業への応用の観点から次の二つの研究テーマを定めた。

① 有用酵素 (L-methionine γ -lyase) の検索

機能性成分や医薬品など、各種生理活性が期待される含硫あるいは含セレンアミノ酸の生産に利用される酵素を、好熱性微生物を中心として検索するとともに、その耐熱性酵素の応用を検討する。本研究を通して、微生物に由来する合成酵素の化学産業への適用についての認識が向上するものと期待される。

② パームオイル廃液からの生理活性物質の生産

パームオイル廃液中には多種の有機成分が多量に含まれており、生理活性を有する化合物も存在すると考えられる。また、微生物による変換反応によって有用な生理活性物質が生成されることも予想される。本研究では、人由来の培養細胞を検定に用い、機能性成分や医薬品への利用が可能な生活性物質を検索あるいは生成することを目的としている。

ここに掲げた2研究テーマは、バイオテクノロジーを化学産業に応用することを意図しており、このような研究方向の設定はバイオテクノロジー研究の更なる発展を促すものと期待される。

(5) 供与機材等の活用状況と要請機材の妥当性

当初協力で供与された100種を越える研究機材は、いずれも十分に利活用されており、その管理状況も良好であった。多くの研究機材には経年劣化による破損が認められたが、更新を要する機材は少なく、部品交換・修理によって十分に作動するものと判断された。それゆえ、要請機材の大部分は、ミニッツに取りまとめたように、部品交換・修理による対応とすることとした。

(6) 予算措置

マレーシア国では大学の独立法人化が進み、大学運営は財政的独立性が強まる傾向にある。また、各研究者の研究費は、2種の研究費補助制度〔Short-term Research Project Funds及びIntensification of Research in Priority Areas scheme (IRPA grant)〕に申請・採択されることによって得られる。このような状況下で、当初協力終了後の3年間(1996~1998年)にバイオテクノロジー学科のスタッフが獲得した研究費は約300万RM(約1億円)であった。

このことは、スタッフ及び学部・学科の自助努力の成果であり、このような自助努力が続けられれば、アフターケア協力に基づく2年間の研究費は不足しないものと判断した。これに関して、大学当局及び学部も努力する意向を述べていた。

(7) 人材育成の状況

当初協力において、カウンターパートとなった若手のスタッフは、順調に能力を向上させ、各グループにおける研究活動の中心的役割を果たし、研究の活性化に貢献している。本アフターケア協力においても、計12名のカウンターパートを定め、若手スタッフを中心に、うち6名を日本での研修に受け入れる予定である。

(8) アフターケア協力期間中（2年間）の実行計画

アフターケア協力にかかわるバイオテクノロジー学科のスタッフと詳細な打合せを行い、ミニッツに取りまとめたように、延べ8名の短期専門家派遣、6名の研修員受け入れ、及び28機種の供与（補修を主とする）の実行計画を定めた。なお、研修員受け入れに関しては、更なる増員（2名）について強い要望を受けた。

(9) Institute of Bioscience (IBS) について

当初計画の終了時評価調査の際、UPMにおいては、学内における遺伝子及びバイオテクノロジー関連の研究を、学部を越えて総合的に促進することを目的とした「遺伝子及びバイオテクノロジー研究センター（Centre for Genetics and Biotechnology）」設立構想があり、当時、マレーシア国政府の承認も得られていた経緯がある。

今般、センター設立計画のその後の経緯について調査を行ったところ、当初の計画から研究所の名称が「生化学研究所（Institute of Bioscience：IBS）」（資料4参照）に変更され、さらに、この名称変更にともない研究室の構成・内容についても見直しが行われたことが確認された。

IBSは、5つの研究室（リモートセンシング／地理情報システム：GIS、天然物化学、水産資源技術、家畜微生物学、家畜病理学）と植物遺伝資源センター、電子顕微鏡室から構成されており、当初計画のセンターに比べて、より広範囲の生化学に関連する研究活動を推進する研究機関として位置づけられている。

ただし、IBS独自の建物は、折りからのマレーシア国政府の財政難から、まだ建設されていない。したがって、現在のところ、これらの研究室は同一の建物内に設置されているわけではなく、各関連学部内に間借りの状態で設置されているにすぎない。そのため、一つの独立した研究所としての運営や活動がなされているとはいえない状況にある。

3. 農業分野におけるバイオテクノロジー技術の現状

マレーシア国の代表的農産物であるパームオイルの、①食用油脂以外の利用と、②パームオイル搾油工程から排出される廃液（Palm Oil Mill Effluent：POME）の処理、及び③主にサラワク地方におけるサゴヤシ澱粉廃液の生物的処理において、バイオテクノロジー技術の導入が試みられている。

パームオイルそのものの利用としては、パームオイル中に含まれる α -カロチン及び β -カロチンの抽出に力が注がれようとしている。特に、 α -カロチン及び β -カロチンはビタミンAの前駆体であり、食品添加物としての利用が期待されている。②に関しては、現在行われているラグーンを用いた処理（嫌気処理）では生物学的酸素要求量（BOD）を十分に低下させることは困難である。また、③に関しては現在のところ何の対策も取られていない。このため、環境保全の観点から両廃液処理法の改善のための有効な対策を立てることが急務とされている。POME中には高濃度の脂肪酸が、またサゴヤシ澱粉中には高濃度の糖分が含まれている。すなわち、いずれの廃液も炭素源濃度が高い点の特徴である。このような高濃度の炭素源を含む廃液のBODを十分に低下させるためには、広大な廃水処理装置が必要となるが、発想を変えて廃液から有用物質を生産することが考えられている。

高濃度の炭素源を含む廃液は、原理的には生分解性プラスチックであるポリヒドロキシアルカノイド（Polyhydroxyalkanooids：PHA）の生産に適している。マレーシア国では現在、プトラ大学（UPM）を中心として、廃液からPHAを効率的に生産するバイオプロセス構築の可能性が検討されつつある。本プロセスはマレーシア国における最重要農産物であるパームオイルやサゴヤシを利用する、農業を基盤とした産業の発展につながるものと期待される。さらに、POMEを培地としたアセトン／ブタノール発酵の工業化についても検討されている。

4. マレーシア プトラ大学 (UPM) におけるバイオテクノロジー研究の現状と将来展望

現在UPMにおけるバイオテクノロジー研究は、食品科学・バイオテクノロジー学部のバイオテクノロジー学科のみでなく、環境科学部の微生物・生化学科、生物学科、環境学科等においても行われているが、なかでもバイオテクノロジー学科における活動は、教官1人当たりの論文発表件数が最も多いことから、際立っていると見える。さらに、バイオテクノロジー学科はマレーシア国政府等から研究費助成金を取得する件数も多い。そのため、バイオテクノロジー学科は今後も引き続きUPMにおけるバイオテクノロジー研究の中心として発展することが期待される。

以下、バイオテクノロジー学科における、アフターケア協力に関連する分野の研究の現状及び将来展望について、記載する。

(1) 酵素／発酵分野

当初協力においては、有用微生物の検索・単離を基礎技術として、有用物質の微生物生産並びに微生物由来酵素の精製とその利用に関する研究への展開をめざした。それらの供与技術と知識は、マレーシア国側に着実に根付き、種々の研究成果を得るに至っている。

発酵（微生物利用）の分野では、実験室レベルでのコウジ酸発酵の成功に端を発し、サゴヤシ澱粉を原料としたアルコール発酵や、各種の有機酸生産などの研究が実用化をめざして続けられている。また、微生物を利用した環境浄化に関しても、微生物によるモリブデン除去の可能性を示す研究成果に続いて、各種の有害重金属除去への微生物の利用に関する基礎研究が行われている。酵素（微生物由来酵素の利用）の分野では、主にアミラーゼとリパーゼを対象とした基礎的・応用的研究が続けられている。アミラーゼあるいはリパーゼ活性の強い多数の微生物の単離・保存から始まった研究は、アミラーゼとイソメラーゼを組み合わせたサゴヤシ澱粉からの異性化糖の生産、リパーゼを利用したパームオイルの物性、栄養価の改善や脂肪酸の糖エステル生産など、実験室レベルでの研究から実用化をめざした研究へと展開しつつある。また、分子生物学／遺伝子工学グループとの共同研究として、上記の研究に使用される微生物の機能向上をめざして遺伝子操作にも取り組み始めた。

上記の研究活動はマレーシア国において高く評価され、実用化に期待がよせられている。しかし、先進諸国においては、これらの技術は既に完成されており、それを越えるためには飛躍的な発展が必要であり、微生物の遺伝子操作による機能アップに関する研究の進展が望まれるところである。

また、酵素／発酵分野の研究における世界の流れは、食品・食品素材の改質や開発利用に止まらず、高い価値を有する物質の生産の方向に向かっている。マレーシア国側においても、こ

れまでに培った技術と知識をもとに、酵素／発酵の成果を先端化学産業につなぐという発想の転換さえあれば、この分野への進出は十分に可能であり、リパーゼによる脂肪酸の糖エステル生産などは兆しでもあると考えられる。

(2) 生化学プロセス分野

1) 農作物加工産業からの廃液処理と有用物質生産

Waste Utilizationの考えのもとに、パームオイル及びサゴヤシ澱粉製造工程から排出される廃液・廃棄物（固体）の微生物処理によるバイオプラスチック製造原料と、ある有機酸の生成・単離及び光合成微生物を用いたプラスチック生成の基礎的研究が行われている。また、同じ廃液を対象とした各種有用物質生産の研究の取り組みも行われている。

この研究の最終目標は、廃棄物ゼロ（zero-emission）にすることであるが、道は遠く、当面は産業廃棄物の微生物を利用した処理と、そこからの資源回収のための各種研究を進めている。

2) パームカロチン回収

粗パームオイルから、カロチンを油脂を残したまま分離・回収し、油脂は食用パームオイル精製工程に戻して、従来どおりの食用油とするパームカロチン回収法を確立し、実用化に向けての研究を始めるところである。回収されたカロチンは、種々の荷姿となって人間の健康に貢献する商品となる。これは、マレーシア経済に貢献すると同時に、これまで廃棄物となっていたカロチンを回収することにより、環境改善に寄与することとなる。

5. 当初協力終了後の活動状況

当初協力終了時の評価報告に記載されているように、バイオテクノロジー学科の研究教育スタッフの能力は著しく向上し、修得した技術は完全に定着したと思われる。当初協力の終了後3年間（1996～1998年）の研究・教育活動においても、予想以上に活発であったことがうかがわれた。

(1) 酵素／発酵分野の活動状況

アフターケア協力の酵素／発酵の課題にかかわるスタッフについても、活発な研究活動を行っていたことが、①学会等での学術研究発表数が約70数回、公表論文数が約50編であること、②IRPA研究費補助制度等へ申請した採択されたプロジェクト課題が10件、獲得した研究費総額が約150万RM（邦貨：約5000万円）であることから理解できる。さらに、マレーシア国のみならず、近隣諸国の人材育成を目的とした微生物あるいは酵素関連のワークショップやセミナーを開催するなどの活動も行っている。

なお、この間の研究成果（有用な化合物の微生物生産、微生物による環境浄化、微生物由来の酵素リパーゼの利用など）の一部は、マレーシア国内の私企業から注目され、実用化をめざした共同研究が進められているとの報告を受けた。

(2) バイオプラスチック分野の活動状況

当初協力における最終年度（1994年）の研究活動において、マレーシア国の農業分野における問題点の一つであるパームオイル廃液（POME）、及びサゴヤシ廃液を培地として、光合成微生物を培養することにより、バイオプラスチックの素材として知られているポリヒドロキシアルカノイド（PHA）の生産が可能であることが示された。

プトラ大学（UPM）では、この予備的検討の結果に基づいてDr.Ali Hassan（カウンターパート：C/P）を中心とするグループが日本側専門家（九州工業大学白井、岡山大学中西）と共同研究を行い、さまざまな基礎的観点からPOMEさらにはサゴヤシ廃液からのPHAの効率的生産のための条件検討が続けられてきた。この基礎的検討により、実用化への可能性を示唆する多くの知見が得られた。これらの知見は実用的観点からだけでなく、基礎研究としても意義深く、その成果は5報の国際誌に発表されている。

Dr.Ali Hassanは本成果により、岡山大学よりPh.D.（論文博士；主査岡山大学高木、副査中西ほか）の学位を授与されている。さらに、Dr.Ali Hassanは講師から助教授に昇任し、現在同学科の教育研究分野において指導的な役割を果たしており、同学科の発展になくてはならない存在となっている。

(3) パームカロチン回収分野の活動状況

当初協力において、Mr.Badlishah (C/P) と日本側専門家（岡山大学高木）は、実験室レベルの研究ではあるが、粗パームオイルから食油精製を行う最初の工程でカロチンを回収することに成功した。架橋ポリスチレン樹脂を充填したラカムにより、カロチンを160倍という高濃度で回収可能であることを示した。本研究成果は同分野の国際誌であるアメリカ油化学協会誌（JAOCS）に発表され、1996年には本件に関連してUPMからマレーシア特許が申請されている。さらに、本成果は1995年のマレーシア発明コンクールにおいてGold Medalを授与され、同年の学内コンクールにおいても3位に入賞した。パームカロチンの回収は貴重な生物資源の有効利用と同時に廃棄物量の削減にも寄与する。

1995年以降に、本件でMr.Badlishah (C/P) に何らかの形で接触した企業数は計6社（マレーシア企業4社、ドイツ企業2社）であるが、具体的な実用化への段取りはまだ立てられていない。この理由は実験室レベルの成果を工業化につなげるためには、越えなければならない多くのハードルがあり、これらの点が十分には解明されていないことによる。

(4) 研究組織とカウンターパートの配置状況

当初協力におけるカウンターパート12名のうち4名がUPM大学を離れ、私企業あるいは他大学で活躍中である。しかし、残った者（8名）は、バイオテクノロジー学科の4研究グループ（酵素／発酵：5名、組織培養：3名、分子生物学／遺伝子工学：3名、生化学プロセス：3名、複数グループへの重複所属：5名）に、その専門性に基づいて配置され、それぞれのグループにおける研究活動の中心的役割を果たすとともに、後進の若手研究者の育成にも力を注いでいる。

(5) 予算措置状況

各研究者の研究費は、2種の研究費補助制度に申請・採択されることによって得られる。このような状況下で、当初協力終了後の3年間（1996～1998年）にバイオテクノロジー学科のスタッフが獲得した研究費は約300万RMであり、上記のように、酵素／発酵グループの主要スタッフが獲得した研究費総額が約150万RMであった。また、生化学／バイオプロセス分野のスタッフが獲得した研究費総額は、約80万RMに達する。このことはスタッフの自助努力の成果であると同時に、大学当局及び学部・学科の強力なサポートがあったことによるものと考えられる。

6. アフターケア協力計画

マレーシア国から要請されたアフターケア協力内容は、当初協力の対象となった4分野であった。しかし、予算枠と期間の制限、日本側の支援機関の受容能力と協力者が限定されることなどから、パームオイル産業と関連の深い課題（生化学／プロセス）を中心として、これにバイオテクノロジーの化学産業への応用の観点に立脚した課題（酵素／発酵）を研究対象に加えることを用意して、バイオテクノロジー学科のスタッフとの協議を行い、日本側の提案で合意に至った。

(1) アフターケア要請の背景

マレーシア国の農業関連分野においては、従来の一次生産物の高収量化や高品質化に止まらず、生産物の加工あるいは付加価値の付与など食品加工産業や化学工業への展開をめざすと同時に、産業発展に伴う環境汚染の防御あるいは除去、副産物・廃棄物のバイオマスとしての利用なども重要課題となっている。また、大学の独立法人化が進む状況のもとで、研究者は産業界との連携を望み、研究成果を産学共同研究または実用化にまで発展させたいと考えている。これらの状況を背景として、農業関連産業の発展にかかわる研究の展開に対する当初協力(1990～1995年)に続く、実用化に向けた技術向上と研究方針の立案及び取り組み姿勢などの修得を目的とするアフターケア協力要請であると受け止められた。

(2) 上位計画との整合性

マレーシア国における第2次長期総合計画OPP2(1991～2000年)では、貧困の軽減、社会構造の再編成、人的資源の開発、民間部門の役割強化を開発基本戦略に掲げている。これに対して、我が国は、①戦略的工業化推進、②環境及び自然資源の保全、③諸格差の是正／均衡型発展の促進を目標に、持続的経済社会の発展のための支援を、重点課題に取り入れている。

一方、OPP2の後半部分を引き継ぐものとなる第7次マレーシア計画(1996～2000年)で重点分野に位置づけられている主要政策の中には、生産性向上型成長による国際競争向上のための官民協力促進、教育・訓練機関・研究機関の民営化促進等が掲げられており、プトラ大学(UPM)の法人化もこの政策に基づいたものといえ、マレーシア国内においては、公共機関の民営化、官民の接近が進んでいる。

また、現在、工業化が急速に進展しており、特に民間部門の同国経済全般に果たす役割はますます拡大していくことが見込まれ、さらに、公共・公益事業の公社化や民営化も急速に進められている。

マレーシア国における高等教育と民間との関係については、上述のとおり官民協力による産業界の発展が期待されており、重要農産物であるパームオイル産業に対するUPMの研究開発の

貢献には、大きな期待がかけられていると言える。

そのため、本体協力で確立した基礎技術をもとに、バイオテクノロジーを化学産業へ応用するのに必要な技術指導を、アフターケア協力で行うこと、第7次マレーシア計画との整合性があり、また、同国内及びUPMにおけるニーズも高いものと判断される。

(3) 協力の必要性

当初協力の対象となった酵素／発酵グループにおいては、酵素や微生物を用いた食品・食品素材の開発、澱粉からの異性化糖、有機酸、工業用アルコールの製造あるいはパーム食油のリパーゼによる品質向上を目的とした研究が続けられており、それらの実用化に向けての展開が強く望まれている。しかし、上記の研究の大部分は、現時点で実用化に結び付けることは困難であると思われる。諸外国におけるこの分野の産業技術は高度に発展し、マレーシア国の産業界もそれらの導入をもくろむことが容易に考えられる。

それゆえ、一次生産物の加工あるいは付加価値の付与など食品加工産業や化学工業への展開、また、環境浄化、副産物・廃棄物のバイオマスとしての有効利用に酵素や微生物を利用しようとするならば、バイオテクノロジーと化学の知識と技術を連結するアイデアが必要になる。ところがマレーシア国のバイオテクノロジーは、当初協力で基本技術と知識こそ確立したものの、産業界のニーズに応える問題意識とそれへの取り組み姿勢については不十分であり、この点に対する協力が必要であると思われる。なお、バイオテクノロジー学科のスタッフもこれに同意した。

生化学／プロセス分野では、前回の当初協力において、①パームオイル廃液（POME）及びサゴヤシ廃液を活用するバイオプラスチックの生産、及び②パームカロチン回収の2プロジェクトにおいて大きな成果を上げた。さらに、これらのプロジェクトは、当初協力終了後も日本側専門家との共同研究等により、研究が続けられた。その結果、基礎的にも実用的にも有意義な成果が得られた。研究成果が6報（バイオプラスチックの生産に関しては5報、パームカロチン回収に関しては1報）国際誌に発表された事実は、本プロジェクトの成果が基礎研究の立場からも意義深いことを示している。

一方、パームオイルの利用とパームオイル廃液の処理は、マレーシア国の農業分野の最大の課題となっている。そのため、これらに関するプロジェクト成果が、実用レベルで適用されることが強く期待されている。しかしながら、基礎研究で得られた成果を実用レベルで応用するためには、多岐にわたる技術的並びにプロセス工学的諸課題の解決が必要不可欠である。UPMでは、基礎研究に関しては前回の当初協力において日本側専門家の指導・助言により十分な研究体制ができているが、基礎研究の成果を実用化するために必要な研究の進め方に関しては、ほとんど経験や実績をもっていないのが実情である。

このような視点からカウンターパートを指導することを目的としているアフターケア協力は、マレーシア国における農業分野へのバイオテクノロジー技術の導入を加速し、ひいては同国の農業分野の発展に大きく寄与するものと期待される。以上の理由により、本アフターケア協力が是非にも必要であると考えられる。

(4) 協力の内容

1) 酵素／発酵の課題

酵素／発酵の課題としては、バイオテクノロジー産業への応用の観点から次の2つの研究テーマを定めた。なお、この2研究テーマは、バイオテクノロジーを化学産業に応用することを意図しており、このような研究方向の設定はバイオテクノロジー研究の更なる発展を促すものと期待される。

① 有用酵素 (L-methionine γ -lyase) の検索

機能性成分や医薬品など各種生理活性が期待される含硫あるいは含セレンアミノ酸の生産に利用される酵素を、好熱性微生物を中心として検索するとともに、その耐熱性酵素の応用を検討する。本研究を通して、好熱性微生物の単離、有用酵素の検出、酵素の精製単離にかかわる最新の技術、酵素の作用機構の論理的と解明、微生物由来の合成酵素の化学産業への適用についての認識など、新たな技術と知識の修得につながるものと期待される。

② パームオイル廃液からの生理活性物質の生産

パームオイル廃液中には多種の有機成分が多量に含まれており、生理活性を有する化合物も存在すると考えられる。また、微生物による変換反応によって有用な生理活性物質が生成されることも予想される。本研究では、人由来の培養細胞を検定に用い、機能性成分や医薬品への利用が可能な生理活性物質を検索あるいは生成することを目的としている。なお、現在、世界各国で健康につながる有用化合物の探索が続けられており、本研究もその流れに沿ったものである。

2) 生化学／プロセスの課題

アフターケア協力の中心がパームオイル産業と関連の深い生化学／プロセス分野になったことから、本分野の研究協力課題は、パームオイル産業と直結する次の2つとなった。

① バイオプラスチック

前回のプロジェクト終了後4年間の研究成果により、パームオイル廃液 (POME) 及びサゴヤシ廃液からのバイオプラスチック (PIA) 生産を実用化する可能性が著しく増大した。同時に、環境保全の観点から、マレーシア国におけるPOMEやサゴヤシ廃液処理の重要性が高まっているなかで、本研究プロジェクトがますます注目されている。本プロジェクトは、前回の当初協力が端緒となったテーマであり、しかもプロジェクト終了後も日本

側専門家との共同研究が続けられていることから、本アフターケア協力で取り上げるに値するテーマである。日本側専門家の協力体制も万全である。本協力では、過去4年間の基礎研究の成果に基づき、実用化のために必要不可欠な問題点の解決に着目する。具体的には、廃液処理と生分解性プラスチック生産を組み合わせたゼロエミッションシステムの構築を最終目的として、(a)バイオプラスチックの効率的生産のための条件の最適化、(b)POME中に含まれる大量のスラッジの処理方法の解決とその利用、(c)POMEあるいはスラッジの有効利用を目的とした新規培養法（膜面液体培養法）による有用物質生産の検討を行う。

② パームカロチン抽出分離

当初協力で確立したパームカロチン回収方法を実際の工業レベルで応用するには、実験室レベルの成果を工業化につなげるために解決する必要がある問題点を探り、工学的アプローチを駆使して解決する必要がある。

本アフターケア協力では、パイロットスケール程度の規模の実験装置（クロマト分離カラム）を試作し、各種の実用化性能テストとデータ解析を行う計画である。また、工業化に関する豊富な経験を有する企業の技術者による協力も予定しており、日本側専門家の協力体制も万全であるといえる。

UPMでは、1995年の大学法の改正に伴う法人化（Corporatization）への移行により、民間企業との共同作業が可能となった。現在のところ法人化の割合は50%程度であるが、10年後には完全に独立法人化される予定である。上記の2課題は、このような状況下で時宜を得たテーマである。

(5) 研究組織とカウンターパート等の配置状況

酵素／発酵の課題には、精力的に研究活動を行っている2名の助教授（Dr.Hasanah Ghazali, Dr.Abd.Manaf Ali）、バイオテクノロジー学科長で教授でもあるDr.MohamedIsmail Abd.Karimと3名の若手研究者（いずれも博士の学位保持者）がカウンターパートを務めることとなる。2年間の協力期間中に若手研究者3名（うち1名追加要求）を日本での研修に受け入れる予定である。

また短期専門家としては、岡山大学農学部生物資源化学講座の教官3名（医学博士 高畑京也教授、農学博士 木村吉伸助教授、農学博士 田村隆助手）が予定されている。

生化学／バイオプロセス分野のカウンターパートはDr.Mohd.Ali Hassan（助教授）を中心に、Dr.Abrakariya Ariff（助教授）、若手のMr.Badlishah S.Baharin、Mr.Azmuddin Abdullah、Dr. Buraini A.Aziz、Dr.Hirzun Mohd.Yusofの6名からなる。日本への研修員としてはDr.Mohd.Ali Hassan及びMr.Badlishah S.Baharinら5名（うち1名は追加要求）を予定している。

一方、短期専門家としては、岡山大学工学部生物機能工学科の教官（未定）、九州工業大学情報工学部白井義人助教授らが予定されている

(6) プロジェクトの予算措置

食品科学・バイオテクノロジー学部及びバイオテクノロジー学科における予算措置は表-1のとおりである。

表-1 食品科学・バイオテクノロジー学部及びバイオテクノロジー学科予算
(1RM=約30円、1999年3月)

	1997	1998	1999 (予定)
人件費 (RM)	2,986,400 995,466	3,475,900 1,158,633	3,856,300 1,285,433
施設・機材等 維持管理費 (RM)	600,000 75,000	731,000 75,000	511,800 90,000
施設・機材費 (RM)	202,326 25,000	253,720 25,000	267,200 30,000

上段：食品科学・バイオテクノロジー学部、下段：バイオテクノロジー学科

マレーシア国においては、1995年に大学法が改正され、高等教育機関の法人化(Corporatization)が認められ、大学の自主運営化が進んでいる。UPMにおいても、大学法の改正にともない、大学の運営戦略の見直しが図られており、具体的には、1998年1月に大幅な学部構成の再編が計画されていた。しかし、経済危機による財政難等により、調査時点までに改組は行われていない状況である。

また、一般に研究経費については、上記運営経費とは別枠として計上されることとなっており、基本的には下記2種類の研究費補助制度がある。これらはいずれも、申請ベースである。

1) Short-term Research Project Funds

大学の特別予算が財源となっており、1プロジェクトの平均支給額は8,000~12,000RMである。

2) IRPA grant

The Intensification of Research in Priority Areas (IRPA) schemeと呼ばれる重点研究分野の研究費補助で、管轄省庁である科学省から支給される。プロジェクトの期間は3年間であり、1プロジェクト平均支給額は100,000RM程度である。

バイオテクノロジー学科においては、1996~1998年においてIRPA grantをはじめとする研究費が3年間で3百万RM計上された(表-2)。また、1999~2001年の研究経費については、現在申請中であり、明確な額は不明であるが、カウンターパートとなる教授、助教授は、上記の

表-2 Research Grants (1996~1998年)

	Project Title	Source	Project Leader	Grant Value(RM)
1	Treatment of food processing and domestic waste waters	IRPA	Prof. Mohd. Ismail Abd Karim	170,000
2	Bioconversion of sago starch and cocoa juice	IRPA	Prof. Mohd. Ismail Abd Karim	93,000
3	Screening of antiviral, anticancer and antimicrobe from medicinal plants	IRPA	Assoc. Prof. Abdul Manaf Ali	70,000
4	Development of bioreactor system for metabolize production by plant cells culture	IRPA	Assoc. Prof. Abdul Manaf Ali	298,440
5	Biosorption of heavy metals using microbial biomass	IRPA	Dr. Abakariya Ariff	271,000
6	Cloning of genes for engineering increased resistance to pest and disease in vegetables and other crops	IRPA	Dr. Suhaimi Napis	225,000
7	Characterization and utilization of Reoselle Hibiscus sabariffa L.	IRPA	Assoc. Prof. Hasanah M.Ghazali	223,000
8	Preparation, characterization and application of lipase catalyzed interesterified fats and oils	IRPA	Assoc. Prof. Hasanah M.Ghazali	155,000
9	Production of flavor compounds from 'Kari'(Muraya Koenichi spring) by cell suspension culture	IRPA	Assoc. Prof. Hasanah M.Ghazali	143,768
10	Enzymatic characterization and detection of ---biotics organisms, the b--bacteria	IRPA	Assoc. Prof. Hasanah M.Ghazali	193,000
11	Production of biodegradable plastics from industrial waste waters	IRPA	Assoc. Prof. Mohd.Ali Hassan	145,120
12	Recovery of palm carotene from crude palm oil by chromatographic adsorption	IRPA	Mr. Badlishah Sham Bahrin	85,500
13	Development of enzyme electrodes	IRPA	Dr. Junainah Abd Hamid	253,000
14	Isolation of microbes from extreme environments	Land & General Bhd.	Prof. Mohd. Ismail Abd Karim	200,000
15	Biological hydrolysis of sago starches to fermentable sugars	National Biotechnology Directorate	Dr. Abakariya Ariff	165,000
16	Food biotechnology	National Biotechnology Directorate	Assoc. Prof. Hasanah M.Ghazali	48,000
17	Molecular characterization of <i>Salmonella enteridis</i> isolated from human, animal avian and environmental sources	UPM	Dr. Son Radu	12,500
18	Conjugal transfer of antibiotic resistance and plasmid among <i>E.coli</i> isolated from imported beef	UPM	Dr. Son Radu	12,500

とおり研究費の獲得に実績があり、マレーシア国の経済状態が低迷しているものの、2年間のアフターケア協力期間中の研究費の確保は可能であると思われる。なお、彼らも最大限の努力を払うことを表明していた。

(7) プロジェクト実施体制

UPM学長（Vice-Chancellor）がプロジェクトダイレクターとして実施上の総責任を負い、食品科学・バイオテクノロジー学部長がプロジェクトマネージャーとして、運営管理面における責任を負う。

本協力では、長期専門家を派遣せずに、短期専門家のみの派遣により現地にて技術指導を行う。専門家の執務環境の整備や通勤等について調査を行った結果は次のとおりである。

専門家の執務室は、バイオテクノロジー科学の建物内に1室用意され、コピーやファックス機については、UPMのものが利用可能である。また、電話機については、JICAマレーシア事務所より携帯電話の貸与を受けることとする。国際電話・ファックスの必要が生じた際には、バイオテクノロジー学科もしくは、UPM環境科学部で実施中の「水産資源・環境研究計画」に使わせてもらい、電話代については、現地業務費にて対応する。

通勤については、UPMにて、以前供与した車両による送迎が可能とのことから、UPM近隣のホテルに宿泊し、朝夕時間を決めて、ホテルとUPM間を送迎してもらう。そのため、2名以上の専門家が一度に派遣される際には、送迎の都合上、同一ホテルへの宿泊が望ましい。

(8) プロジェクト名称

マレーシア プトラ大学（UPM）は、前回のプロジェクト当時、農業分野唯一の高等教育機関として、マレーシア農科大学（Universiti Pertanian Malaysia）と称されていた。その後1997年に、化学技術分野に重点を置いた総合大学として、現在の名称となるマレーシア プトラ大学（Universiti Putra Malaysia）となった。

そのため、本アフターケア協力では、プロジェクト名称を「マレーシア プトラ大学バイオテクノロジー学科拡充計画アフターケア」としたい。

(9) 活動における留意点

本アフターケア協力で目的とするものは、農業分野で得られたバイオテクノロジーの成果を、化学産業に応用することを意図したものであるが、得られる成果が直ちに産業界で実用化されるとは限らない。そのような成果よりも、このような研究を進める過程で得られる思考方法や目的へのアプローチ方法の修得に力を注ぎたいと考えている。したがって、カウンターパートには、このような発想を含めて指導を行う必要がある。

資 料

1. ミニッツ
2. UPM組織図
3. 質問表回答
4. 生化学研究所 (Institute of Bioscience : IBS)
5. カレンダー (食品・バイオテクノロジー学部部分のみ)

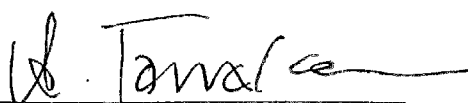
MINUTES OF DISCUSSION
ON
THE AFTERCARE TECHNICAL COOPERATION
FOR
DEVELOPMENT OF THE DEPARTMENT OF BIOTECHNOLOGY
AT THE FACULTY OF FOOD SCIENCE AND BIOTECHNOLOGY,
UNIVERSITI PUTRA MALAYSIA

The Japanese Aftercare Study Team (hereinafter referred to as "the Team") organized by Japan International Cooperation Agency (hereinafter referred to as "JICA") and headed by Dr. Hidehiko TANAKA visited Malaysia from March 11, 1999 to March 18 for the purpose of working out the details of the Aftercare Technical Cooperation for the Development of the Department of Biotechnology at the Faculty of Food Science and Biotechnology, Universiti Putra Malaysia (hereinafter referred to as "Aftercare Programme").

During its stay in Malaysia, the Team carried out a field survey, exchanged views and had a series of discussions with the Malaysian authorities concerned in respect of desirable measures to be taken by both Governments for the successful implementation of the above-mentioned Project.

As a result of the discussions, in accordance with provisions of the Agreement on Technical Cooperation between the Government of Japan and the Government of Malaysia, the Team and the Malaysian authorities concerned agreed to recommend to their respective Governments the matters referred to in the document attached hereto.

Serdang, Selangor, March 18, 1999



Prof. Dr. Hidehiko TANAKA
Leader,
Aftercare Study Team,
Japan International Cooperation Agency



Prof. Dato' Dr. Ir. Mohd. Zohadie bin Bardaie
Deputy Vice-Chancellor, (Development)
Universiti Putra Malaysia,
Malaysia

ATTACHED DOCUMENT

I. OBJECTIVES OF THE AFTERCARE PROGRAMME

The Government of Japan and the Government of Malaysia will cooperate with each other in implementing the Aftercare Programme for the purpose of supporting and developing the achievement acquired by "Development of the Department of Biotechnology at the Faculty of the Food Science and Biotechnology, Universiti Putra Malaysia" which terminated on May 31, 1995.

II. COOPERATION ACTIVITIES OF THE AFTERCARE PROGRAMME

In order to attain the above mentioned objectives, activities of the Aftercare Programme will be carried out as described in the Tentative Schedule of Implementation (Annex I) and Plan of Operation (Annex II).

III. MEASURES TO BE TAKEN BY THE GOVERNMENT OF JAPAN

In accordance with the laws and regulations in force in Japan, the Government of Japan will take, at its own expenses, the following measures through JICA according to the normal procedures under the Colombo Plan Technical Cooperation Scheme.

1 DISPATCH OF JAPANESE EXPERTS

The Government of Japan will dispatch a few Japanese short-term experts when necessary arises for smooth implementation of the Aftercare Programme.

2 PROVISION OF MACHINERY AND EQUIPMENT

The Government of Japan will provide such machinery, equipment and other materials (hereinafter referred to as "the Equipment") necessary for the implementation of the Aftercare Programme. This will include the replacement of already available machinery which was donated by the Government of Japan at the Universiti Putra Malaysia and provision of necessary spare parts of them. The actual provision will be subject to change according to the budgetary allocation of the Government of Japan. The Equipment will become the property of the Government of Malaysia upon being delivered C.I.F. to the Malaysian authorities concerned at the ports and/or airports of disembarkation.

The Government of Malaysia requested to Government of Japan to provide the machinery and equipment as listed in the Annex III.

3 TRAINING OF MALAYSIAN COUNTERPART PERSONNEL IN JAPAN

The Government of Japan will accept a few trainees of the Malaysian personnel concerned with the Aftercare Programme in Japan.

IV. MEASURES TO BE TAKEN BY THE GOVERNMENT OF MALAYSIA

The Government of Malaysia will take necessary measures,

- (1) to ensure that the self-reliant operation of the project will be sustained during and after the period of Japanese technical cooperation, through the full and active involvement in the Project by all related authorities.
- (2) to ensure that the technologies and knowledge acquired by the Malaysian nationals as a result of the Japanese technical cooperation will contribute to the economic and social development of the Malaysia.
- (3) to ensure that the Equipment referred to in III-2 above will be utilized effectively for the implementation of the Project in consultation with the Japanese experts referred to in III-1 above.

In accordance with the laws and regulations in force in Malaysia, the Government of Malaysia will take the following measures to provide at its own expense.

1 MALAYSIAN COUNTERPART AND ADMINISTRATIVE PERSONNEL

The Government of Malaysia will secure qualified Malaysian counterparts, administrative personnel and supporting staff. The counterparts personnel is listed as Annex IV.

2 PROVISION OF THE UPM FACILITIES

The Government of Malaysia will make the facilities of the Universiti Putra Malaysia available for the implementation of the Aftercare Programme.

3 SUPPLY OF NECESSARY MATERIALS AND SERVICES

The Government of Malaysia will supply necessary materials, equipment and services such as repair, maintenance and operation for the implementation of the Aftercare Programme.

4 RUNNING EXPENSE

The Government of Malaysia will allocate running expenses necessary for the implementation of the Aftercare Programme including local official travel, electricity, water supply, fuel and etc.

V. ORGANIZATION OF THE AFTERCARE PROGRAMME

1 RESPONSIBILITY AGENCY

Vice-Chancellor of Universiti Putra Malaysia, as the Project Director, will take overall

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responsibility for implementation of the Aftercare Programme.

Dean of Faculty of Food Science and Biotechnology, UPM, as the Project Manager, will be responsible for administrative and managerial matters of the Aftercare Programme.

2 EXECUTING AGENCIES

Universiti Putra Malaysia

3 SITE OF THE AFTERCARE PROGRAMME

Universiti Putra Malaysia

VI. MUTUAL CONSULTATION

There will be mutual consultation between the two governments on any major issue arising from or in connection with this Attached Document.

VII. TERM OF AFTERCARE PROGRAMME

The duration of the Aftercare Programme will be two(2) years from April 1, 1999.

VIII. OTHERS

(1) The Government of Malaysia should make necessary arrangements for requesting the dispatch of Japanese experts, the provision of equipment and training of Malaysian counterpart personnel in Japan by submitting the application forms (A1, A2-3 and A4 Form).

UPM will arrange transportation for internal travel for short-term Japanese experts.

(2) The Aftercare programme under this Minutes will be implemented according to the articles in the Record of Discussions signed on April 19, 1990, except for the matters stipulated above.

Annex I Tentative Schedule of Implementation

ITEM	F.Y.1999	F.Y.2000
I. PROJECT ACTIVITIES 1. Enzyme / Fermentation 1-1) Production of useful Enzyme 1-2) Waste treatment 2. Biochemical / Process 2-1) Bioplastics 2-2) Extraction and isolation of Carotene		
II. JAPANESE INPUTS 1. Dispatch of Short-term Experts (when necessary arises) 2. Provision of Machinery and Equipment 3. Training of Malaysian counterpart personnel in Japan		
III. MALAYSIAN INPUTS 1. Counterparts and administrative personnel 2. Land, Facilities and Buildings 3. Allocation of running costs		

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Annex II Plan of Operation

ACTIVITIES	TARGET	F.Y.1999	F.Y.2000
1. ENZYME / FERMENTATION			
1-1) Production of useful Enzyme	1) Screening, isolation and application of L-met.γ-lyase.	◆6-8	○5-7 ◆8-9
1-2) Waste treatment	1) Production of bioactive compounds from waste.	○8-10	◆8-9
2. BIOCHEMICAL / PROCESS			
2-1) Bioplastics	1) Development of bioplastic production system from palm oil effluent 2) Analysis of cultivation behaviour of bioplastic production using membrane-surface liquid culture.	◆ ○ ◆ 8-9,9-10,11-12	○7-8 ◆8-9
2-2) Extraction and isolation of Carotene	1) Establishment and development of a palm carotene recovery method.	○6-7 ◆8-10	○6-7 ◆8-10

— research period
 ◆ dispatch of short-term expert
 (four experts per year)
 ○ training of Malaysian personnel in Japan
 (three C/Ps per year)

MT

Annex III. List of equipment

A. Enzyme/Fermentation Group

No.	Item	Estimated cost (RM)	Note
1	FPLC- (PHARMACIA)	75,000	Repair for controller, & additional accessories (pump, columns, & computer
2	GC SHIMADZU	50,000	Repair for controller & system for capillary column
3	ELISA reader (BIOTEK)	40,000	Replacement
4	Photo Dynamic Array detector for HPLC (SHIMADZU)	25,000	Additional accessory for upgrading function
5	Bead mill homogeniser (B. BRAUN)	20,000	Replace with French pressure cell
6	Ampule sealer as attachment for freeze-dryer (B. BRAUN)	10,000	Additional accessory for lyophilising organisms
7	Shaker incubator (NEW BRUNSWICK)	20,000	Replacement
8	CO ₂ incubator (SANYO)	30,000	Replacement
9	Autoclave (40 L) (HIRAYAMA)	35,000	Replacement
10	Autoclave (ASTEL)	5,000	Repair for temperature and pressure controller
11	PCR (EPPENDORF)	20,000	Replacement
12	2-D Electrophoresis (BIORAD)	20,000	Replacement
13	Milli Q & ultra pure water system (MILLIPORE)	20,000	Repair for pump and cartridges for reverse osmosis
14	Recorder chromatogram scanner (SHIMADZU)	10,000	Replacement of recorder
15	-80°C freezer (SANYO)	30,000	Replacement
16	Benchtop centrifuge (HETTISCH)	25,000	Replacement
17	UV transilluminator with polaroid camera (POLAROID)	10,000	Replacement

Total cost RM445,000



WTF

Annex III. List of equipment

B. Biochemical/Bioprocess Group

No.	Item	Estimated cost (RM)	Note
1	Adsorption chromatography system (LOCAL) a. Adsorption column b. Centrifugal pumps c. Reservoir tanks d. Valves e. Pipelines f. vacuum evaporator	200,000	Replacement
2	Incubator unit (LOCAL)	70,000	Replacement of broken units of shaker
3	HPLC-GC (SHIMADZU)	50,000	Repair of detector, plus HPLC columns
4	UV-VIS spectrophotometer (SHIMADZU)	20,000	Replacement of software
5	Electronic analytical balance (METTLER)	10,000	Replacement
6	FTIR (PERKIN ELMER)	30,000	Replacement of laser beam producer & upgrading of software
7	Laminar airflow cabinet - 3 units (ESCO)	30,000	Replacement of HEPA filter
8	Fermentor 50 L (B. BRAUN)	30,000	Repair of spindles and upgrading of computer connecting system
9	Baby jar fermentor (B. BRAUN)	30,000	Replacement of culture vessels, & computer control unit
10	Viscometer (BROOKFIELD)	10,000	Repair of spindles, & upgrading of computer connecting system
11	Atomic absorption spectrometer PERKIN ELMER)	30,000	Replacement of detector system to improve measurements of molecules

Total cost RM510,000



7

Annex IV. Counterpart Lists.

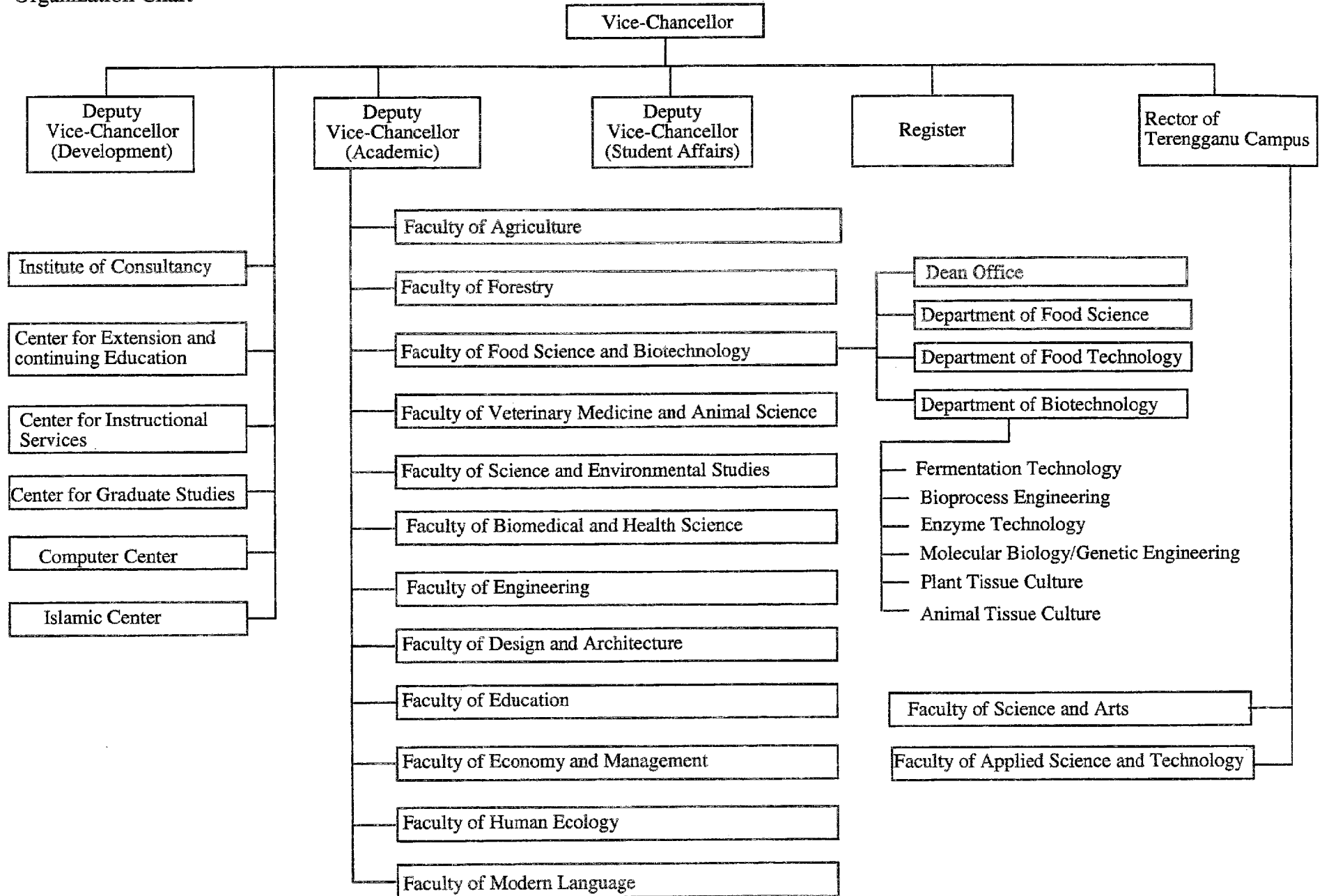
Field	Name of Counterpart.	Responsible Person
Enzyme/Fermentation	Mohamed Ismail Abd. Karim. Hasanah Mohd Ghazali. Lai Oi Ming. Foo Hooi Ling. Abd. Manaf Ali. Raha A. Rahim.	Hasanah Mohd Ghazali.
Biochemical/Process.	Mohd. Ali Hassan. Arbakariya Ariff. Badlishah Sham Baharin. Azmuddin Abdullah. Suraini A. Aziz. Hirzun Mohd. Yusof.	Mohd. Ali Hassan

AT

8



Organization Chart



資料 2. UPM組織図

JICA AFTER-CARE PROGRAM
Department of Biotechnology, Faculty of Food Science &
Biotechnology, UPM.

JICA Questionnaire.

1. Introducing biotechnology to agriculture, food industry and palm oil industry.

For agriculture the focuss is towards increasing food production through strain improvement of plant , create new strain of plants and crops resistant to certain pests and diseases, plant tissue culture development of economic crops, development of biopesticides, treatment and utilization of agricultural wastes for the production of biopolymers, solvents, sugars , and organic aids, etc. and other useful products, screening of useful microbes for production of useful compounds or products.

Bioremediation work for removal of heavy metals from certain industry is also being emphasised.

For the **food indfustry** the emphasis is production of food ingredients, flavors and colours, bakers yeasts, and nutraceuticals of food and health drinks.

For the **palm oil industry** biotechnology play an important role especially in modification of fats and oil using novel enzymes, production of lipases from microbes for use in the oil industry, molecular biology of fruiting of palm fruits, extraction of carotene from palm oil, tissue culture and transgenic producton of oil palm with better yield and functional oil.

2. How to utilize R & D results after termination of the JICA After-care program.

- The aim is to get collaboration of industry from the beginning.
- We need to understand their needs.
- We should incorporate industrial set-up into current projects.

The following results can be use to help the following industry:

- to solve some of the waste problems from the palm oil industry such as production of biopolymers, organic acids and solvents from palm oil mill effluent (POME).
- extraction of carotene from palm oil can increase income generation and diversify the palm oil industry.
- molecular biology application for development of transgenic oil palm with better quality fruit and functional oil can be applied, development of pests and disease resistance plant trough genetic manipulation.
- application of lipases for production of modified oil e.g. synthesis of sugar fatty acid esters, and other products.
- production of useful bioactive compounds from plants and microbes for industrial use.
- methods for extraction of colour, flavor/pigments and other ingredients for the food industry will be introduced.
- technology for bioremediation of industrial effluent using microbial biomass will be introduced to industry.

3. How to introduce results and facilities into industry.

Research results can be introduced to other research and private industry. The carotene extraction process has been introduced to private Company who are interested in the technology. Similar interest was also shown on production of biopolymer and kojic acid by private industry.

Facilities of biotechnology was introduced to many researcher and industry people through the conduct of many workshops and training courses e.g. molecular tools workshop and training courses were conducted several times for industry and research personals.

Basic biotechnology equipments provided were very useful for the biotechnology program in UPM. Many undergraduate and postgraduate students has utilise the facilities in the department of Biotechnology which were recognised as one the best in this region of Malaysia.

4. Plan after the After-care Program.

- We need to identify industrial partners and work closely with them.

Research results obtained from the JICA and After-care Program will be expanded to the industry. Scaling-up process of the laboratory research results in collaboration with industry will be attempted.

Extraction and purification of carotene from palm oil with industrial partner will be attempted. Carotene will fetch a premium price and this will help to diversify and help the refining palm oil industry.

Scaling-up of laboratory results and field trials on utilization of POME for biopolymer and solvent production will be attempted.

Technologies for extraction of useful compounds especially colour/pigments, anthraquinones, flavors and other food ingredients will be introduced to the food industry.

Facilities provided will be fully utilized for further research work, training and other collaborative research projects sponsored by JSPS, NEDO, etc.

5. Any reform work done to Department of Biotechnology, UPM.

A Centre for Genetics and Biotechnology as well as a School of Biotechnology was proposed but all these did not materialised.

6. Establishment of Centre of Genetics and Biotechnology, UPM.

To broaden the scope of biological research an Institute of Biological Sciences was established instead in 1996/97. This will cover a broader scope on all biological sciences research work done in UPM.

7. Achievement of activities at Department of Biotechnology, UPM from 1995 - 1998.

Field/Title	research papers checked by referees	presentations at academic gatherings	publications	others
Enzyme and Fermentation Technology	> 50	> 70	> 50	
Tissue Culture	> 20	> 20	> 20	
Molecular Biology & Genetic Engineering	> 50	> 50	> 50	
Bioprocess Engineering	> 10	> 20	> 10	

8. Name of researchers and their occupation involved in research.

	Name of researchers (Current)	Occupation	Name of Passed JICA collaborators
Enzyme and Fermentation Technology	Mohamed Ismail Abdul Karim. Arbakariya Ariff. Mohd Ali Hassan. Hasanah Ghazali Suraini Abd. Aziz Azumuddin Abdullah. Lai Oi Ming. Abd. Manaf Ali. Foo Hoi Ling. Raha A. Rahim.	Professor/Head of Biotech. Dept. Assoc. Prof. Assoc. Prof. Assoc. Prof. Lecturer. Lecturer. Lecturer. Assoc. Prof. Lecturer Lecturer.	Dr. Junaidah* Dr. Lee Kong Hung* Dr. Baharuddin Ghani. *
Tissue Culture	Abd. Manaf Ali. Harikhrishna. Norihan Md. Salleh Suhaimi Napis. Tan Siang Hee.	Assoc. Prof. Lecturer. Lecturer. Lecturer. Lecturer.	Dr. Z. Christine.*
Molecular Biology and Genetic Engineering	Suhaimi Napis. Norihan Md. Salleh. Abd. Manaf Ali. Son Radu. Tan Siang Hee. Raha A. Rahim. Hirzun. Harikhrishna.	Lecturer. Lecturer. Assoc. Prof. Lecturer. Lecturer. Lecturer. Lecturer. Lecturer.	Dr. Noraini.* Dr. Gan*
Bioprocess Engineering	Badlishah Sham Baharin. Mohd Ali Hassan. Arbakariya Ariff. Azumuddin Abdullah. Suraini A. Aziz.	Lecturer. Lecturer. Lecturer. Lecturer. Lecturer	

* No longer with the Department.

9. If Japanese side is planning to cooperate in these two fields (Enzymes/Fermentation, Bioprocess).

Field	Name of counterparts	Occupation	Responsible person.
Enzyme/ Fermentation	T. Sugio (Okayama Univ.)	Professor.	Mohd Ali Hassan. Arbakariya Ariff.
	Suteaki Shioya (Osaka Univ.)	Professor.	
	Yoshito Shirai (Kyushu Univ.)	Assoc. Professor.	
Bioprocess	Shigeaki Takagi	Professor.	Badlishah Baharin. Mohd Ali Hassan.
	K. Nakanishi	Professor.	

10. Research projects required in each field.

Enzyme/Fermentation

A). Utilization/fermentation of agricultural wastes for production of valuable products e.g. biopolymers, organic acids, and solvents.

Expected output:

-Methods for effective treatment and utilization of agricultural waste couple with production of valuable products especially in the palm oil, sago and fish industry.

Bioprocess.

B). Use of adsorption and desorption phenomena or technology in extraction/purification of useful products from plant and animal sources.

Expected output:

-Methods for extraction/purification of carotenes from crude palm oil.
 - Method for extraction of colours/pigments from plant sources.
 -Method for extraction of flavors/medical and food ingredients from plant and animal sources.
 -Method of bioremediation of effluent using microbial biomass.

11. Overall responsibility.

Project Director: Assoc. Prof. Dr. Mohd Ali Hassan.
 Assoc. Prof. Dr. Arbakariya Ariff.
 Mr. Badlishah Sham Baharin.

Vice Chancellor, UPM.

Project Manager: Prof. Dr. Mohamed Ismail Abdul Karim.

12. Please refer to lists of attached equipment needed for repair/replacement.

LIST OF EQUIP. PROVIDED BY JICA

Bil	ITFM	Unit	Pledge	Arrival	Utili.	Mainte.	Kod	Location	P. in Charge	Note
1	TABLE TOP ULTRA CENTRIFUGE	1	1990	11/90	A	Good	JUBR 027	Genetic/Mkt Lab.	Dr. Norihan	Ok
2	FRENCH PRESSURE CELL	1	1990	12/90	D * 1	Good	JUDR 035	Fermentation Lab	En. Badlishah	Ok
3	BABY FERMENTOR	1	1990	3/91	C	Good	JUBR 153	Fermentation Lab	Dr. Ali Hasan	Need repair
4	CHROMATOGRAM-SCANNER	1	1990	12/90	C	Good	JUBR 033	Genetic/Mkt Lab.	Dr. Suhaimi	Ok
5	MICROMANIPULATOR	1	1990	11/90	C	Good	JUBR 040	Genetic/Mkt Lab.	Dr. Suhaimi	Ok
6	CELL CULTURE FERMENTOR	1	1990	12/90	C	Good	JUBR 025	Atcl Lab	Dr. Manaf Ali	Ok
7	ELECTRIC CELL FUSION	1	1990	12/90	C	Good	JUBR 036	Atcl Lab	Dr. Manaf Ali	Ok
8	HIGH SPEED REFRIG. CENTRIFUGE	1	1990	11/90	A	Good	JUBR 026	Enzyme Lab	Dr. Hasanah	Ok
9	PLC	1	1990	12/90	C	Good	JUBR 031	Enzyme Lab	E. Badlishah	Ok
10	GENERATOR	1	1990	3/91	C	Good	JUBR 052	Fac. Backyard	Faculty	Ok
11	SINGLE FERMENTOR CONTROL SYSTEM	1	1990	11/90	C	Good	JUBR 024	Atcl Lab	Dr. Manaf Ali	Ok
12	SCANNING SPECTROPHOTOMETER	1	1990	12/90	A	Good	JUBR 028	Genetic/Mkt Lab.	Dr. Ali Hasan	Need repair
13	SHAKER INCUBATOR	1	1990	12/90	A	Good	JUBR 046	Fermentation Lab	Dr. Ali Hasan	Ok
14	WATER PURIFICATION SYSTEM	3	1990	12/90	A	Good	JUBR 032	Genetic/Mkt Lab.	Dr. Norihan	Need repair
15	ULTRA LOW TEMPERATURE FREEZER	1	1990	2/90	A	Good	JUBR 047	Genetic/Mkt Lab.	Dr. Norihan	Ok
16	FRACTION COLLECTOR	2	1990	12/90	B	Good	JUBR 029	Enzyme Lab	Dr. Hasanah	Ok
17	FREEZE DRYER	1	1990	12/90	A	Good	JUBR 034	Enzyme Lab	Dr. Hasanah	Ok
18	AUTOCLAVE (HA-300M)	1	1990	3/91	A	Good	JUBR 051	Enzyme Lab	Dr. Hasanah	Ok
19	AUTOCLAVE (HA-240M)	1	1990	3/91	A	Good	JUBR 038	Genetic/Mkt Lab.	Dr. Suhaimi	Ok
20	GROWTH CABINET	1	1990	12/90	D	Good	JUBR 037	Genetic/Mkt Lab.	Dr. Suhaimi	Need repair
21	MICROFLEX FULLY AUTO. CAMERA	1	1990	12/90	C	Good				Ok
22	INVERTED MICROSCOPE	1	1990	12/90	C	Good	JUBR 039	Genetic/Mkt Lab.	Dr. Suhaimi	Ok
23	FIBER OPTICS BIFURCATED ILLUMI.	1	1990	12/90	C	Good	JUBR 041	Genetic/Mkt Lab.	Dr. Suhaimi	Ok
24	STEREOSCOPIC ZOOM MICROSCOPE	1	1990	12/90	C	Good	JUBR152	Fermentation Lab	Prof. Ismail	Ok
25	CO2 INCUBATOR	1	1990	3/91	A	Good	JUBR 048	Atcl Lab	Dr. Manaf Ali	Ok
26	AIR CONDITIONER	2	1990	1/91	A * 2	Good	JICA 061	Genetic/Mkt Lab.	Dr. Suhaimi	Ok
27	ROTARY VACUUM EVAPORATOR	1	1990	7/90	A	Good	JICA 005	Fermentation Lab	Dr. Arbakariya	Ok
28	TEST TUBE CONCENTRATOR	1	1990	7/90	B	Good	JICA 007	Genetic/Mkt Lab.	Dr. Norihan	Ok
29	PROTEIN SEQUENCER	1	1991	10/91	D * 3	Good	JUBR 073	Genetic/Mkt Lab.	Dr. Norihan	Ok
30	DNA SYNTHESIZER	1	1991	12/91	D * 3	Good	JUBR 093	Genetic/Mkt Lab.	Dr. Norihan	Ok
31	ELECTROPHORESIS	1	1991	12/91	B	Good	JUBR 079	Genetic/Mkt Lab.	Dr. Norihan	Ok
32	ELISA READER	1	1991	10/91	B	Good	JUBR 072	Atcl Lab	Dr. Manaf Ali	Ok
33	FERMENTOR CONTROL SYSTEM	1	1991	10/91	C	Good	JUBR 071	Fermentation Lab	Dr. Ali Hasan	Ok
34	UNIVERSAL RESEARCH MICROSCOPE	1	1991	11/91	C	Good	JUBR 075	Genetic/Mkt Lab.	Dr. Suhaimi	Ok
35	FT-IR SPECTROPHOTOMETER	1	1991	12/91	D * 3	Good	JUBR 083	Flir Lab	En. Badlishah	Need Upgrade. Non Y2K compliance
36	GAS CHROMATOGRAPH	1	1991	1/92	B	Good	JUBR 084	Enzyme Lab	Dr. Hasanah	Accessory need. Non Y2K compliance
37	PCR (DNA THERMAL CYCLER)	1	1991	10/91	C	Good	JUBR 070	Genetic/Mkt Lab.	Dr. Norihan	Need replacement
38	MICRO REFRIGERATED CENTRIFUGE	1	1991	12/91	A	Good	JUBR 076	Genetic/Mkt Lab.	Dr. Norihan	Ok
39	WATER PRESSURE PUMP	1	1991	9/91	D * 2	--				Broken down
40	CELL MILL/HOMOGENIZER	1	1991	10/91	A	Good	JUBR 069	Genetic/Mkt Lab.	Dr. Ali Hasan	Ok
41	BIOLOGICAL SAFETY CABINET	1	1991	9/91	A	Good	JUBR 068	Atcl Lab	Dr. Manaf Ali	Ok
42	HOLLOW FIBER CONCENTRATOR	1	1991	11/91	B	Good	JUBR 074	Enzyme Lab	Dr. Hasanah	Ok
43	ULTRASONIC WAVE WASHER	1	1991	12/91	C	Good	JICA 012	Genetic/Mkt Lab.	Dr. Arbakariya	Ok
44	AIR LIFT FERMENTOR	1	1992	12/92	B	Good	JUBR 096	Phyto. Lab	En. Badlishah	Ok
45	JAR FERMENTOR (Bioslat MD)	1	1992	11/92	B	Good	JUBR 107	Fermentation Lab	Dr. Ali Hasan	Accessory need

LIST OF EQUIP. PROVIDED BY JICA

46	HIGH SPEED CENTRIFUGE	1	1992	11/92	A	Good	JUBR 100	Genetic/Mkt Lab.	Dr. Suhaimi	Need repair
47	ULTRACENTRIFUGE	1	1992	2/93	B	Good	JUBR 112	Genetic/Mkt Lab.	Dr. Ali Hasan	Ok
48	HPLC	1	1992	3/93	A	Good	JUBR 095	Enzyme Lab	Dr. Hasanah	Non Y2K compliance
49	POTENTIOSTAT	1	1992	2/93	C	Good	JUBR 113	Enzyme Lab	Dr. Hasanah	Ok
50	PROGRAMMABLE DEEP FREEZER	1	1992	12/95	C	Good	JUBR 106	Genetic/Mkt Lab.	Dr. Suhaimi	Ok
51	CELL COUNTER & ANALYSER	1	1992	11/92	B	Good	JUBR 098	Atcl Lab	Dr. Manaf Ali	Ok
52	DNA SEQUENCER	1	1992	12/92	D * 3	Good	JUBR 093	Genetic/Mkt Lab.	Dr. Norihan	Non Y2K Comp. Need repair. Replacement
53	NUCLEIC ACID SEQUENCING GEL SYM	1	1992	11/92	C	Good	JUBR 094	Genetic/Mkt Lab.	Dr. Norihan	Ok
54	ICE FLAKE MACHINE	1	1992	12/92	A	Good	JUBR 097	Corridor	Dr. Norihan	Need repair
55	POLAROID CAMERA	1	1992	10/92	A	Good	JUBR 102	Genetic/Mkt Lab.	Dr. Norihan	Ok
56	BLOTTING SYSTEM	1	1992	3/93	C	Good	JUBR 119	Genetic/Mkt Lab.	Dr. Norihan	Ok
57	SONICATOR	1	1992	12/92	C	Good	JUBR 117	Fermentation Lab	Dr. Norihan	Ok
58	LAMINAR FLOW CABINET	1	1992	10/92	A	Good	JUBR 110	Fermentation Lab	Dr. Ali Hasan	Need service
59	FILTRATION SYSTEM	1	1992	11/92	C	Good	JUBR 103	Enzyme Lab	Dr. Arbakariya	Ok
60	OXYGEN CONTROLLER	1	1992	5/93	B	Good	JUBR 115	Fermentation Lab	Dr. Arbakariya	Ok
61	PH CONTROLLER	1	1992	3/93	C	Good	JUBR 120	Fermentation Lab	Dr. Arbakariya	Need repair
62	VISCOMETER	1	1992	2/93	C	Good	JUBR 118	Fermentation Lab	Dr. Ali Hasan	Need service calibration
63	SPECTROPHOTOMETER	1	1992	10/92	B	Good	JUBR 111	Enzyme Lab	Dr. Hasanah	Ok
64	SWING OUT ROTOR FOR CENTRIFUGE	1	1992	2/93	B	Good	JUBR 099	Genetic/Mkt Lab.	Dr. Suhaimi	Ok
65	FUME CUPBOARD	1	1992	11/92	A	Good	JUBR 101	Fermentation Lab	Dr. Ali Hasan	Ok
66	AUTOCLAVE (120L)	1	1992	8/93	A	Good	JUBR 108	Genetic/Mkt Lab.	Dr. Suhaimi	Need repair
67	AUTOCLAVE (47L)	1	1992	12/92	A	Good	JUBR 109	Genetic/Mkt Lab.	Dr. Arbakariya	Ok
68	COOLING ASPIRATOR	1	1992	3/93	A	Good	JUBR 114	Enzyme Lab	Dr. Hasanah	Ok
69	VOLTAGE STABILIZER	3	1992	10/92	A	Good	-	-	-	Ok
70	TRANS ILLUMINATOR	1	1992	7/92	C	Good	JICA 014	Genetic/Mkt Lab.	Dr. Norihan	Ok
71	HPLC WITH RI DETECTOR	1	1993	3/94	A	Good	JUBR 121	Fermentation Lab	En . Badlishah	Non Y2K compliance
72	INCUBATOR SHAKER	4	1993	3/94	A	Good	JUBR 122	Fermentation Lab	Dr. Ali Hasan	2 unit Need repair
73	ORBITAL SHAKER	2	1993	3/94	A	Good	JUBR 123	Fermentation Lab	Dr. Ali Hasan	Accessory need
74	ELECTROPORATOR	1	1993	2/94	C	Good	JUBR 130	Genetic/Mkt Lab.	Dr. Norihan	Ok
75	MICROTOME & TISSUE PROCESSING	1	1993	1/94	C	Good	JUBR 133	Atcl Lab	Dr. Manaf Ali	Ok
76	ATOMIC ABSORPTION SPECTROPHOTO.	1	1993	3/94	D	Good	JUBR 136	Flir Lab	Prof. Ismail	Accessory need. Non Y2K Compliance
77	BENCH TOP REFRIG. CENTRIFUGE	1	1993	12/93	B	Good	JUBR 124	Fermentation Lab	Dr. Ali Hasan	Need repair
78	DEEP FREEZER	1	1993	2/94	A	Good	JUBR 125	Corridor	Dr. Arbakariya	Ok
79	ANGLE ROTOR FOR CENTRIFUGE	1	1993	12/93	A	Good	JUBR 126	Genetic/Mkt Lab.	Dr. Suhaimi	Ok
80	REFRIGERATOR (500L)	1	1993	11/93	A	Good	JUBR 128	Fermentation Lab	Dr. Arbakariya	Ok
81	REFRIGERATOR (1000L)	1	1993	12/93	A	Good	JUBR 129	Phyto. Lab	Dr. Suhaimi	Ok
82	BENCH TOP AUTOCLAVE	3	1993	11/93	A	Good	JUBR 131	Genetic/Mkt Lab.	Dr. Norihan	Ok
83	ULTRAFILTRATION SYSTEM	1	1993	1/94	C	Good	JUBR 132	Fermentation Lab	En . Badlishah	Ok
84	GEL ELECTROPHORESIS & POWER PACF	1	1993	1/94	B	Good	JUBR 134	Genetic/Mkt Lab.	Dr. Norihan	Ok
85	CELL CENTRIFUGE	1	1993	2/94	C	Good	JUBR 135	Atcl Lab	Dr. Manaf Ali	Ok
86	PROCESS CONTROLL PACKAGE	1	1993	1/94	C	Good	JUBR 137	Fermentation Lab	Dr. Ali Hasan	Accessory need
87	HYBRIDIZATION OVEN	1	1993	1/94	A	Good	JUBR 138	Genetic/Mkt Lab.	Dr. Suhaimi	Ok
88	DEHUMIDIFIER	4	1993	11/94	A	Good	JUBR 139	Flir Lab	En . Badlishah	Ok
89	MICROCENTRIFUGE	1	1993	12/93	C	Good	JUBR 140	Genetic/Mkt Lab.	Dr. Norihan	Ok
90	ILLUMINATED GROWTH RACK	1	1993	12/93	A	Good	JUBR 141	Phyto. Lab	Dr. Suhaimi	Need repair
91	DARK INCUBATOR	1	1993	3/94	A	Good	JUBR 143	Phyto. Lab	Dr. Suhaimi	Ok

LIST OF EQUIP. PROVIDED BY JICA

92	CO2/O2/N2 INCUBATOR	1	1993	3/94	A	Good	JUBR 144	Atcl Lab	Dr. Manaf Ali	Ok
93	ROLLER BOTTLE SYSTEM	1	1993	2/94	C	Good	JUBR 145	Atcl Lab	Dr. Manaf Ali	Ok
94	EXTERNAL FILTER	1	1993	3/94	C	Good	JUBR 146	Atcl Lab	Dr. Manaf Ali	Ok
95	PERISTALTIC PUMP	1	1993	1/94	C	Good	JUBR 147	Fermentation Lab	En . Badlishah	Need repair
96	FILTER STERILIZATION	1	1993	1/94	C	Good	JUBR 148	Genetic/Mkt Lab.	Dr. Norihan	Ok
97	FPLC COLUMN	1	1993	2/94	A	Good	JUBR 149	Enzyme Lab	En. Badlishah	Ok
98	ROTOR FOR HIGH SPEED CENTRIFUGE	1	1993	3/94	C	Good	JUBR 150	Genetic/Mkt Lab.	Dr. Ali Hasan	Ok
99	GRADIENT & MIXING PUMP FOR HPLC	1	1993	3/94	C	Good	JUBR 151	Enzyme Lab	Dr. Hasanah	Ok
100	TRANSILLUMINATOR CAMERA	1	1993	7/93	C	Good	JICA 020	Genetic/Mkt Lab.	Dr. Norihan	Ok
101	BABY JAR FERMENTOR	1	1994	10/94	C	Good	JUBR 153	Fermentation Lab	Dr. Ali Hasan	Need repair (same Item JUBR 153)
102	MEMBRANE SEPARATOR	1	1994	8/3/95	D	Good	JUBR 157	Fermentation Lab	En . Badlishah	Ok
103	HPLC	1	1994	25/12/95	A	Good	JUBR 165	Fermentation Lab	En . Badlishah	Accessory need. Non Y2K compliance
104	GAS CHROMATOGRAPHY	1	1994	10/94	A	Good	JUBR 170	Fermentation Lab	Dr. Ali Hasan	Accessory need. Non Y2K compliance
105	STEREOSCOPIC MICROSCOPE	1	1994	9/94	C	Good	JUBR 152	Fermentation Lab	Prof. Ismail	Ok
106	PREPARATIVE FRACTION COLLECTOR	1	1994	10/94	C	Good	JUBR 154	Enzyme Lab	Dr. Hasanah	Ok
107	DEEP FREEZER	1	1994	10/94	A	Good	JUBR 155	Genetic/Mkt Lab.	Dr. Suhaimi	Ok
108	LAMINAR FLOW CABINET	2	1994	10/94	A	Good	JUBR 156	Fermentation Lab	Dr. Ali Hasan	Need service
109	2-D PAGE ELECTROPHORESIS	1	1994	10/94	C	Good	JUBR 158	Genetic/Mkt Lab.	Dr. Suhaimi	Need repair
110	ISOELECTRIC FOCUSING SYSTEM	1	1994	10/94	C	Good	JUBR 159	Genetic/Mkt Lab.	Dr. Suhaimi	Ok
111	ICE FLAKE MACHINE	1	1994	10/94	A	Good	JUBR 160	Genetic/Mkt Lab.	Dr. Norihan	Ok
112	FUME CUPBOARD	1	1994	10/94	A	Good	JUBR 161	Genetic/Mkt Lab.	Dr. Norihan	Need repair
113	UV VISIBLE SPECTROPHOTOMETER	1	1994	10/94	A	Good	JUBR 162	Fermentation Lab	Dr. Ali Hasan	Accessory need. Non Y2K compliance
114	HOMOGENIZER	1	1994	10/94	C	Good	JUBR 163	Enzyme Lab	Dr. Hasanah	Ok
115	GROWTH CABINET	1	1994	10/94	A	Good	JUBR 164	Genetic/Mkt Lab.	Dr. Norihan	Ok
116	ELECTRONIC ANALYTICAL BALANCE	2	1994	10/94	A	Good	JUBR 167	Fermentation Lab	En . Badlishah	1 unit need repair
117	ELECTRONIC TOP PAN BALANCE	2	1994	10/94	A	Good	JUBR 168	Fermentation Lab	En . Badlishah	Ok
118	VACUUM OVEN	1	1994	10/94	C	Good	JUBR 169	Genetic/Mkt Lab.	Dr. Suhaimi	Ok
119	VEHICLE (FORD)	1	1990	10/90	A	Good	JUBO 018	Fac. Car Parking	Faculty	Ok
120	VEHICLE (SUBARU)	1	1990	11/90	A	Good	JUBO 019	Fac. Car Parking	Faculty	Ok
121	WORDPROCESSOR			8/90	A	Good	JUBO 001	JICA Off.	Faculty	Non Y2K compliance
122	COPY MACHINE	1	1990	9/90	A	Good	JUBO 004	Biotech Off.	Faculty	Ok
123	FACSIMILE MACHINE	1	1990	8/90	A	Good	JUBO 006	Dean Off	Faculty	Ok
124	PERSONAL COMPUTER (NEC)	1	1990	11/90	A	Good	JUBO 008	JICA Off.	Faculty	Non Y2K compliance
125	PERSONAL COMPUTER (MCCINTOSH)	1	1990	12/90	A	Good	JUBO 013	JICA Off.	Faculty	Need repair
126	CAMERA	1	1991	91	C	Good		Fermentation Lab	Rosli	Ok
127	WORDPROCESSOR	1	1991	1/92	A	Good	JUBO 002	JICA Off.	Faculty	Non Y2K compliance
128	VEHICLE (TOYOTA)	1	1992	1/93	A	Good	JUBO 020	Fac. Car Parking	Faculty	Ok
129	COPY MACHINE	1	1992	9/92	A	Good	JUBO 005	JICA Off.	Faculty	Need repair
130	WORDPROCESSOR	1	1992	10/92	A	Good	JUBO 003	JICA Off.	Faculty	Non Y2K compliance
131	FACSIMILE MACHINE	1	1993	12/93	A	Good	JUBO 007	JICA Off.	Faculty	Ok
132	COMPUTER	1	1994	10/94	A	Good	JUBR 166	Dr. Suhaimi Off.	Dr. Suhaimi	Non Y2K compliance

Note Utili (Utilization) A = Daily Used B = Weekly Used C = Occasionally Used for Its Function D = Seldom Used
 * 1 = Function is not sufficient for the present research * 2 = Unit was broken down * 3 = No sample available yet.

LIST OF EQUIP. PROVIDED BY JICA

ITEM	Unit	Pledge	Arrival	Util.	Mainte.	Kod	Location	P. in Charge	Note
PERISTALTIC PUMP	1	1993	1/94	C	Good	JUBR 147	Fermentation Lab	En . Badlishah	Need repair
ELECTRONIC ANALYTICAL BALANCE	2	1994	10/94	A	Good	JUBR 167	Fermentation Lab	En . Badlishah	1 unit need repair
INCUBATOR SHAKER	4	1993	3/94	A	Good	JUBR 122	Fermentation Lab	Dr. Ali Hasan	2 unit Need repair
JAR FERMENTOR (Biostal MD)	1	1992	11/92	B	Good	JUBR 107	Fermentation Lab	Dr. Ali Hasan	Accessory need
ORBITAL SHAKER	2	1993	3/94	A	Good	JUBR 123	Fermentation Lab	Dr. Ali Hasan	Accessory need
PROCESS CONTROLL PACKAGE	1	1993	1/94	C	Good	JUBR 137	Fermentation Lab	Dr. Ali Hasan	Accessory need
GAS CHROMATOGRAPH	1	1991	1/92	B	Good	JUBR 084	Enzyme Lab	Dr. Hasanah	Accessory need. Non Y2K compliance
ATOMIC ABSORPTION SPECTROPHOTO.	1	1993	3/94	D	Good	JUBR 136	Flir Lab	Prof. Ismail	Accessory need. Non Y2K Compliance
HPLC	1	1994	25/12/95	A	Good	JUBR 165	Fermentation Lab	En . Badlishah	Accessory need. Non Y2K compliance
GAS CHROMATOGRAPHY	1	1994	10/94	A	Good	JUBR 170	Fermentation Lab	Dr. Ali Hasan	Accessory need. Non Y2K compliance
UV VISIBLE SPECTROPHOTOMETER	1	1994	10/94	A	Good	JUBR 162	Fermentation Lab	Dr. Ali Hasan	Accessory need. Non Y2K compliance
WATER PRESSURE PUMP	1	1991	9/91	D * 2	--				Broken down
BABY FERMENTOR	1	1990	3/91	C	Good	JUBR 153	Fermentation Lab	Dr. Ali Hasan	Need repair
SCANNING SPECTROPHOTOMETER	1	1990	12/90	A	Good	JUBR 028	Genetic/Mkt Lab.	Dr. Ali Hasan	Need repair
WATER PURIFICATION SYSTEM	3	1990	12/90	A	Good	JUBR 032	Genetic/Mkt Lab.	Dr. Norihan	Need repair
GROWTH CABINET	1	1990	12/90	D	Good	JUBR 037	Genetic/Mkt Lab.	Dr. Suhaimi	Need repair
HIGH SPEED CENTRIFUGE	1	1992	11/92	A	Good	JUBR 100	Genetic/Mkt Lab.	Dr. Suhaimi	Need repair
ICE FLAKE MACHINE	1	1992	12/92	A	Good	JUBR 097	Corridor	Dr. Norihan	Need repair
PH CONTROLLER	1	1992	3/93	C	Good	JUBR 120	Fermentation Lab	Dr. Arbakariya	Need repair
AUTOCLAVE (120L)	1	1992	8/93	A	Good	JUBR 108	Genetic/Mkt Lab.	Dr. Suhaimi	Need repair
BENCH TOP REFRIG. CENTRIFUGE	1	1993	12/93	B	Good	JUBR 124	Fermentation Lab	Dr. Ali Hasan	Need repair
ILLUMINATED GROWTH RACK	1	1993	12/93	A	Good	JUBR 141	Phyto. Lab	Dr. Suhaimi	Need repair
2-D PAGE ELECTROPHORESIS	1	1994	10/94	C	Good	JUBR 158	Genetic/Mkt Lab.	Dr. Suhaimi	Need repair
FUME CUPBOARD	1	1994	10/94	A	Good	JUBR 161	Genetic/Mkt Lab.	Dr. Norihan	Need repair
PERSONAL COMPUTER (MCCINTOSH)	1	1990	12/90	A	Good	JUBO 013	JICA Off.	Faculty	Need repair
COPY MACHINE	1	1992	9/92	A	Good	JUBO 005	JICA Off.	Faculty	Need repair
BABY JAR FERMENTOR	1	1994	10/94	C	Good	JUBR 153	Fermentation Lab	Dr. Ali Hasan	Need repair (same item JUBR 153)
PCR (DNA THERMAL CYCLER)	1	1991	10/91	C	Good	JUBR 070	Genetic/Mkt Lab.	Dr. Norihan	Need replacement
LAMINAR FLOW CABINET	1	1992	10/92	A	Good	JUBR 110	Fermentation Lab	Dr. Ali Hasan	Need service
LAMINAR FLOW CABINET	2	1994	10/94	A	Good	JUBR 156	Fermentation Lab	Dr. Ali Hasan	Need service
VISCOMETER	1	1992	2/93	C	Good	JUBR 118	Fermentation Lab	Dr. Ali Hasan	Need service calibration
FT-IR SPECTROPHOTOMETER	1	1991	12/91	D * 3	Good	JUBR 083	Flir Lab	En . Badlishah	Need Upgrade. Non Y2K compliance
DNA SEQUENCER	1	1992	12/92	D * 3	Good	JUBR 093	Genetic/Mkt Lab.	Dr. Norihan	Non Y2K Comp. Need repair. Replacement
HPLC	1	1992	3/93	A	Good	JUBR 095	Enzyme Lab	Dr. Hasanah	Non Y2K compliance
HPLC WITH RI DETECTOR	1	1993	3/94	A	Good	JUBR 121	Fermentation Lab	En . Badlishah	Non Y2K compliance
WORDPROCESSOR			6/90	A	Good	JUBO 001	JICA Off.	Faculty	Non Y2K compliance
PERSONAL COMPUTER (NEC)	1	1990	11/90	A	Good	JUBO 008	JICA Off.	Faculty	Non Y2K compliance
WORDPROCESSOR	1	1991	1/92	A	Good	JUBO 002	JICA Off.	Faculty	Non Y2K compliance
WORDPROCESSOR	1	1992	10/92	A	Good	JUBO 003	JICA Off.	Faculty	Non Y2K compliance
COMPUTER	1	1994	10/94	A	Good	JUBR 166	Dr. Suhaimi Off.	Dr. Suhaimi	Non Y2K compliance
TABLE TOP ULTRA CENTRIFUGE	1	1990	11/90	A	Good	JUBR 027	Genetic/Mkt Lab.	Dr. Norihan	Ok
FRENCH PRESSURE CELL	1	1990	12/90	D * 1	Good	JUBR 035	Fermentation Lab	En . Badlishah	Ok
CHROMATOGRAM-SCANNER	1	1990	12/90	C	Good	JUBR 033	Genetic/Mkt Lab.	Dr. Suhaimi	Ok
MICROMANIPULATOR	1	1990	11/90	C	Good	JUBR 040	Genetic/Mkt Lab.	Dr. Suhaimi	Ok
CELL CULTURE FERMENTOR	1	1990	12/90	C	Good	JUBR 025	Alcl Lab	Dr. Manaf Ali	Ok

Questionnaire 2.

1. Please refer to answer given to questionnaire no. 8 as above.
2. Please refer to short lists of projects applied for 1999-2001 (3 year project) and are awaiting for approval.
3. Budget for the Faculty of Food Science and the Department of Biotechnology, UPM.

Faculty of Food Science and Biotechnology (RM).

	1997	1998	1999(estimate)
Emoluments	2,986,400	3,475,900	3,856,300
Service and Supply	600,000	731,000	511,800
Asset	202,326	253,720	267,200
Scholarship	Centralised	Budget	
Percentage in UPM's total budget	2.8%	2.9%	2.4%

Department of Biotechnology (RM)

	1997	1998	1999(estimate)
Emoluments	995,466	1,158,633	1,285,433
Service and Supply	75,000	75,000	90,000
Asset	25,000	25,000	30,000
Scholarship	Centralised	Budget	
Percentage in Faculty's total budget.	29.0%	28.2%	30.0%

4. Number of various staffs, undergraduate and postgraduate students in each Department.

	Prof.	Assoc. Prof.	Lecturer	Tutor	Admin. staffs	Lab. staffs	under-grad. student	post-grad. student.
Dept. Biotech	1	4	12	2	2	7	300	30
Dept. Food Sc.	2	2	6		2	11	650	60
Dept. Food Tech.	2	4	5		2	6	combin-ed with Dept. of Food Sc.	together with Dept. Food Sc.

Dean's Office

7

5. Name of Consignee and address.

Dean, Faculty of Food Science & Biotechnology
Universiti Putra Malaysia
43400, UPM, Serdang, Selangor
MALAYSIA.

6. Please refer to attached Chart.

資料 4 . 生化学研究所 (Institute of Bioscience : IBS)

Vision

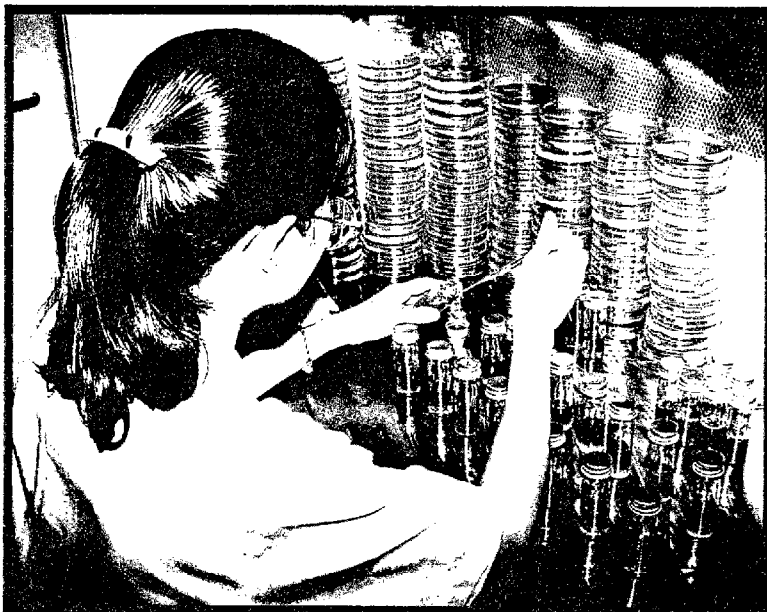
To become a leading international centre for research in Bioscience

Mission

To provide leadership in strategic areas of biological science relevant to the country, and to facilitate, coordinate and promote research, information dissemination and human resource development which will support the Industrial and Agriculture Master Plans.

Goals

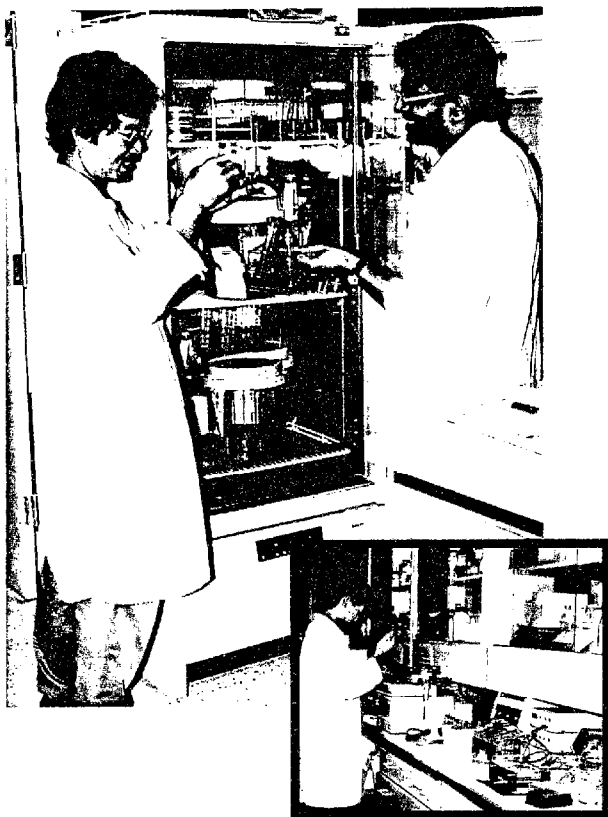
1. To become a centre of excellence for research by building on areas of strength available in the university.
2. To promote and develop research and postgraduate training in priority areas which will strengthen the national science and technology capability and human resource development in support of the Industrial and Agriculture Master Plans.
3. To strengthen research management, coordination and collaboration, and identify new research opportunities.



4. To develop networking, partnerships and linkages with national and international institutions, organisations and industries which will facilitate research and accelerate commercialisation of discoveries and inventions.
5. To manage and provide excellent central research service facilities.
6. To develop a viable financial system by seeking and developing additional and/or alternative sources of funding.

Organisational Structure

1. The Institute is governed by a Scientific Advisory Committee, chaired by the Vice Chancellor. The Scientific Advisory Committee has the mandate to:
 - a) review the policies of the Institute,
 - b) decide on the interests and activities of the Institute, and
 - c) approve the budget of the Institute.
2. The Institute is advised by an International Advisory Board which consists of eminent scientists in areas related to bioscience from universities or research institutions abroad.
3. All staff of the Institute, including the Director and Deputy Director, are appointed by the Vice Chancellor.
4. The Institute comprises Research Laboratories and Central Research Service Facilities. Each Laboratory is managed by a Head who is supported by Fellows, science officers, research assistants, technicians and postgraduate students. The Institute will also be responsible for coordinating National Research Centres.



Directorate

The Directorate consists of the Director and Deputy Director, and such other persons appointed by the Vice Chancellor when necessary. The Director and Deputy Director are permanent staff of the Institute.

Scientific Advisory Committee

The Committee consists of internal members from the University and external members from private sectors and other institutions.

Internal members from the University are: the Vice Chancellor (Chairman), Deputy Vice Chancellors (Academic and Development), Deans of Faculties related to bioscience (Deans of Food Science and Biotechnology, Forestry, Medicine and Health Sciences, Science and Environmental Studies, Veterinary Medicine and Animal Science, and Agriculture), Dean of Faculty of Engineering, Dean of Faculty of Economics and Management, Dean of the Graduate School, and Director of the University Business Centre.

External members are representatives of companies with joint ventures with the Institute and local eminent scientists in related fields.

International Advisory Board

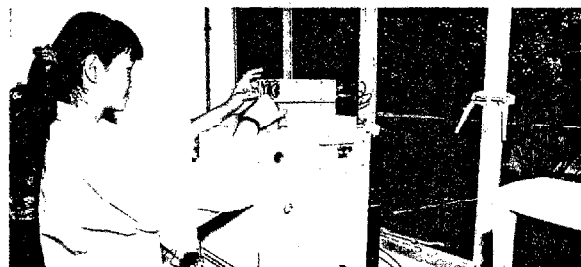
The Board comprises members who are eminent scientists in areas related to bioscience from universities or research institutions abroad. The members will not be paid an annual honorarium but will be paid for their visits to the Institute.

Research and Postgraduate Programmes

The Institute is a platform for fundamental research that could generate useful products and processes for the industries. The research is multidisciplinary, market-driven, and top-down in key areas such as food, crops, health, aquaculture, genetic resources utilisation and conservation, natural products and forestry.

The Institute co-ordinates and monitors performance of all the research undertaken at the Institute, identifies strategic opportunities and encourages and facilitates fruitful collaboration with Faculties, research centres and industries, locally and abroad. Research in each of the key areas is conducted in individual Laboratories.

Each Laboratory is managed by a Head who is either a permanent staff of the Institute or a Faculty staff on secondment or on joint appointment. The Head is assisted by a Science Officer and Laboratory Technicians in the management and operation of the Laboratory. Attached to the Laboratories are Fellows of the Institute. They are either visiting scientists or Faculty staff who conduct research in the Institute. Their research time spent at the Institute can be from 10% to full time.



Research degrees, MSc and PhD, are offered in the Institute. Supervisors of postgraduate students are either permanent staff or Fellows of the Institute. A student reading for the MSc or the PhD degree may begin a course of study at any time during the year, but it is usual for students to be accepted at the beginning of each semester.



Central Research Service Facilities

The Institute is responsible for the administration and operation of the Central Research Service Facilities (e.g. Electron Microscopy Unit) and to ensure that they are operated to the general satisfaction of all the departments. All Central Research Service Facilities recover consumable and running costs for research and teaching from individual research workers or departments.



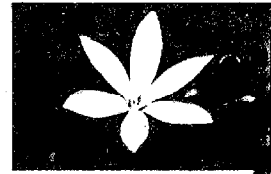
Electron Microscopy Unit

The Unit provides training and facilities to enable users to carry out their own work in electron microscopy. It also provides services to the industries. Care will be taken to ensure that both "major" and "intermittent" users have equal priority. The Unit is managed by a Head who is either a permanent staff of the Institute, a Fellow or a Faculty staff on secondment.

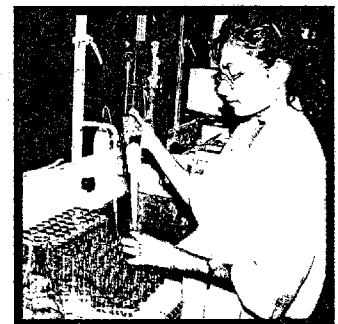
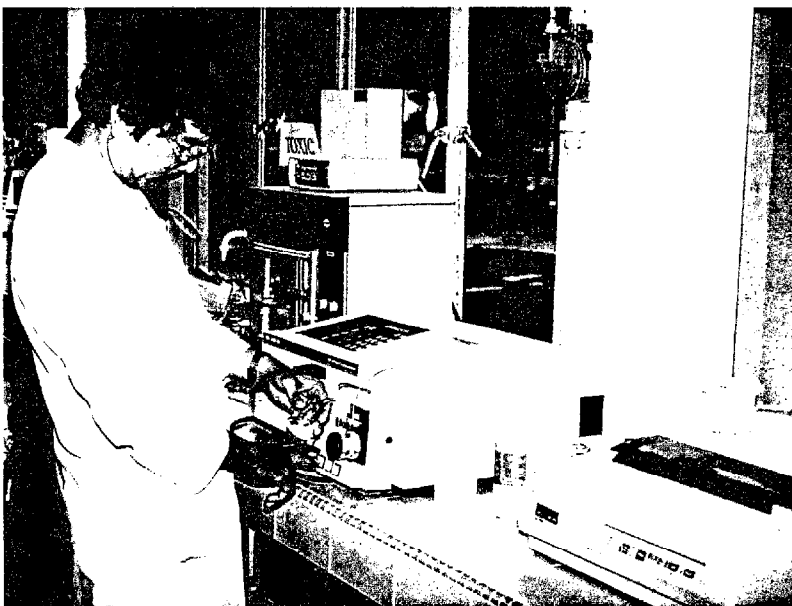
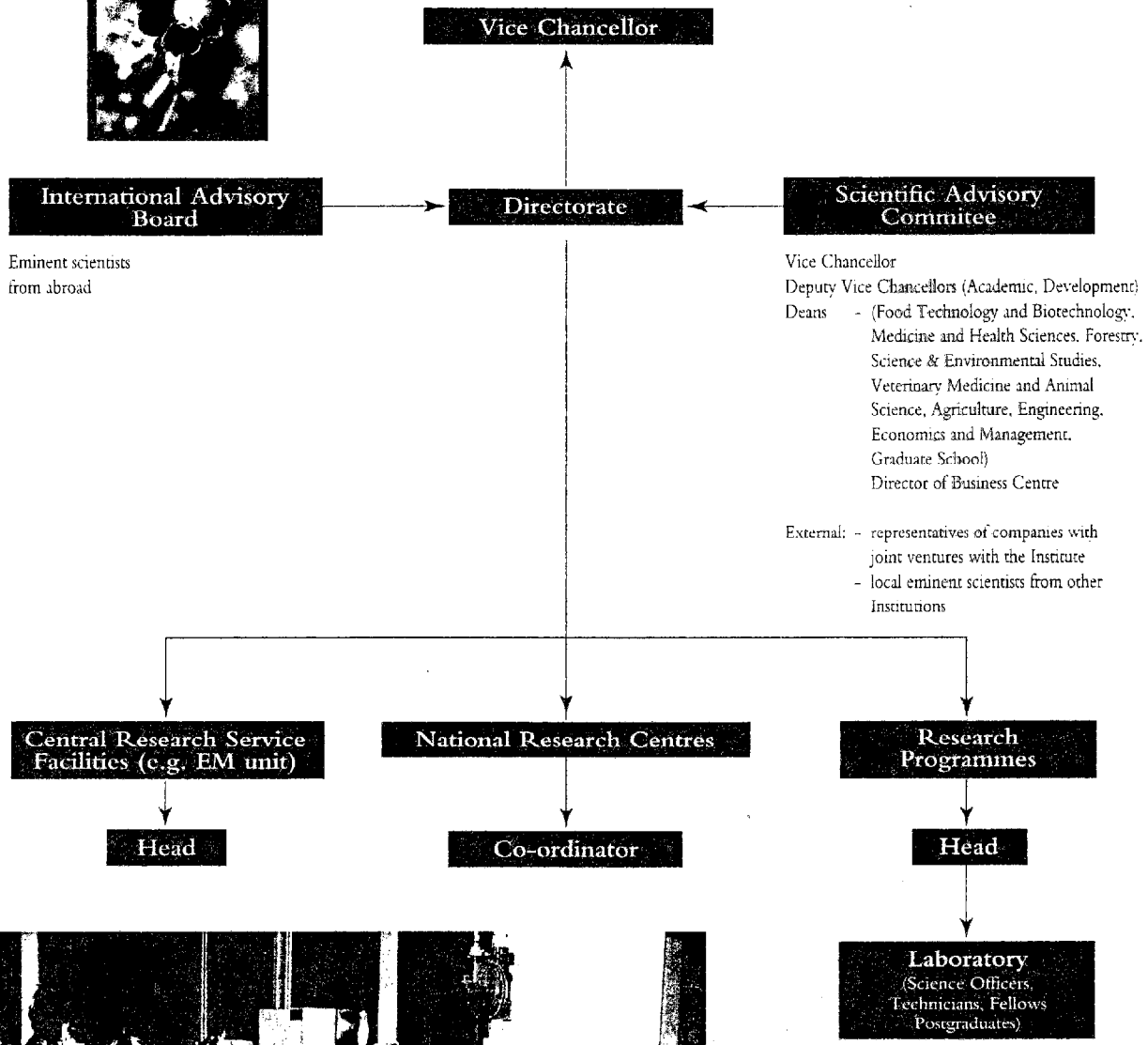
Finance

1. The University will provide the cost for development and administration of the Institute.
2. The Institute will solicit research funds from the Government through the IRPA (Intensification of Research in Priority Areas) programmes, and from industries and international organisations.
3. A portion of the cost for management of the Institute will be recovered through overhead charges on the projects conducted in the Institute.

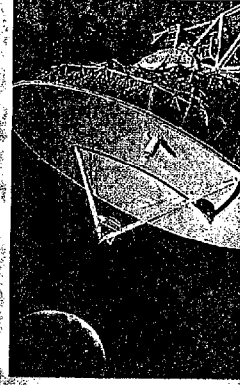




Organisational Structure of the Institute



CALENDAR 1997-1998



Universiti **P**utra **M**alaysia

CALENDAR 1997-1998

Universiti **P**utra **M**alaysia

FHU 4204 Techniques in Forest Hydrology 2 credits

Prerequisite : FHU 310 Watershed Management

Introduction to the basic hydrological processes and the various measurements especially with regards to rainfall, streamflow and evaporation. Micro watershed studies such as interception and runoff plots will also be included. Analysis of hydrological data. Watershed workplan.

FHU 4205 International Forestry 2 credits

World's forest resources; status, classification and dynamics. Roles of forest resources in socio-economic expansion and sustainable development. International trade in wood and non-wood forest products. Forest and global environment. International institutions and agreements.

FACULTY OF FOOD SCIENCE AND BIOTECHNOLOGY

ACADEMIC STAFF

Dean

Associate Professor Gulam Rusul bin Rahmat Ali *Food Safety*
D.V.M. (Pakistan), M.Sc. (Reading),
M.Ed., Ph.D. (Wisconsin)

Deputy Dean

Associate Professor Hasanah bte Mohd. Ghazali *Enzyme Technology*
B.Sc. (Hons)(Otago), M.Sc. (Reading), Ph.D. (UPM)

DEPARTMENT OF FOOD SCIENCE

Head

Associate Professor Jinap bte Selamat *Cocoa Technology*
Dip. Sci. & Educ. (UPM), B.Sc., M.Sc. (Louisiana State),
Ph.D. (Pennsylvania State)

Professor

Suhaila bte Mohamed *Food Chemistry*
B.Sc. (Hons), Ph.D. (Leeds)

Associate Professors

Gulam Rusul bin Rahmat Ali *Food Safety*
D.V.M. (Pakistan), M.Sc. (Reading),
M.Ed., Ph.D. (Wisconsin)

Jinap bte Selamat *Cocoa Technology*
Dip. Sci. & Educ. (UPM), B.Sc., M.Sc. (Louisiana State),
Ph.D. (Pennsylvania State)

Lecturers

Azizah bte Osman *Postharvest
Physiology*
B.Sc. (Hons), Dip. Ed. (Malaya),
M. App. Sci. (UNSW), Ph.D. (London)

Azizah bte Hj. Abd. Hamid B.S., M.S. (Indiana), Ph.D. (Wisconsin)	<i>Food Chemistry</i>
Fatimah bte Abu Bakar B.S. (Hons)(UKM), M.Sc. (London)	<i>Food Microbiology</i>
Nazamid bin Saari B.S. (Food Tech.)(UPM) M.S., Ph.D. (Yokohama, Japan)	<i>Food Enzymology</i>
Sharifah Kharidah bte Syed Muhammad B.Sc. (Hons)(Melbourne), Ph.D. (Deakin)	<i>Analytica Chemistry</i>
Zaiton bte Hassan Dip. Agric. (Malaya), B.S., M.S. (Louisiana State) Ph.D. (Texas A&M)	<i>Food Microbiology</i>

DEPARTMENT OF FOOD TECHNOLOGY**Head**

Russly bin Abdul Rahman B.Sc. (Hons)(Nottingham), M.Sc., Ph.D. (Reading)	<i>Food Engineering</i>
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Professor

Yu Swee Yean B.Sc. (Hons), Ph.D. (Nottingham)	<i>Fish & Meat Technology</i>
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Associate Professors

Asbi bin Ali B.Sc. (Hons) (Leeds), M.Sc. (Reading), Ph.D. (Illinois)	<i>Food Engineering</i>
Asiah bte Mohd. Zain B.S. (Iowa State), M.Sc. (Reading)	<i>Product Development</i>
Salmah bte Yusof Dip. Agric. (Malaya), B.S. (Louisiana State), M.S. (Ohio State), Ph.D. (UPM)	<i>Postharvest/ Processing</i>
Yaakob bin Che Man Dip. Food Tech. (ITM), B.Sc. (Hons), M.S. (Tennessee), Ph.D. (Illinois)	<i>Food Technology</i>

Lecturers

Abdullah bin Abu Bakar Dip. Ani. Hlth. & Prod. (ITM), B.S.A. (Hons), M.S. (Florida), Ph.D. (Georgia)	<i>Fish & Meat Technology</i>
Dzulkifly bin Mat Hashim B.Sc. (Hons), M.Sc. (Leeds)	<i>Food Rheology</i>
Jamilah bte Bakar B.S. (Oregon), M.S. (Louisiana State), Ph.D. (UPM)	<i>Food Technology</i>
Mohd. Yazid bin Abd. Manap Dip. Ani. Hlth. & Prod. (ITM), B.S., M.S. (Minnesota), Ph.D. (Glasgow)	<i>Dairy Technology</i>
Mohd. Yusop bin Abu Dip. Agric. (Malaya), B.S., M.S., Ph.D. (Louisiana State)	<i>Dairy Technology</i>

DEPARTMENT OF BIOTECHNOLOGY**Head**

Professor Mohamed Ismail bin Abdul Karim Dip. Agric. (Malaya), B.S.A. (Florida), M.S., Ph.D. (Arkansas)	<i>Fermentation Technology</i>
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Professor

Professor Mohamed Ismail bin Abdul Karim Dip. Agric. (Malaya), B.S.A. (Florida), M.S., Ph.D. (Arkansas)	<i>Fermentation Technology</i>
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Associate Professor

Hasanah bte Mohd. Ghazali B.Sc. (Hons)(Otago), M.Sc. (Reading), Ph.D. (UPM)	<i>Enzyme Technology</i>
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Lecturers

Abdul Manaf bin Ali B.S. (UKM), M.Sc. (Dundee), Ph.D. (St. Andrews)	<i>Molecular Biology</i>
Arbakariya bin Ariff B. Food Sc. & Tech. (UPM), M.Phil., Ph.D. (Birmingham)	<i>Fermentation Technology</i>
Badlishah Sham bin Baharin B.Sc. (Hons)(Leeds), M.Sc. (UMIST)	<i>Food Engineering</i>

Harikrishna s/o Kulaveerasingam B.Sc. (Hons)(London), Ph.D. (Leicester)	<i>Plant Biotechnology</i>
Junainah bte Abdul Hamid B.Sc. (Hons)(Manchester), M.Sc., Ph.D. (Cardiff)	<i>Biosensor</i>
Mohd. Ali bin Hassan B.Sc., M.Sc. (Leeds), M.Phil. (Birmingham)	<i>Bioprocess Engineering</i>
Raha bte Abdul Rahim B.S., M.S. (Oklahoma), Ph.D.	<i>Molecular Genetic</i>
Norihan K.T. bte Mohd. Saleh B.S., M.S. (Wisconsin), Ph.D. (Nottingham)	<i>Plant Biotechnology</i>
Son Radu B.Sc. (Hons), M.Sc. Ph.D. (UM)	<i>Molecular Biology</i>
Suhaimi bin Napis B.S., M.S. (Iowa State), Ph.D. (Durham)	<i>Plant Biotechnology</i>
Tutors	
Abdul Reezal bin Abdul Latif B.S. (Hons)(Strathclyde)	<i>Bioprocess Engineering</i>
Clementi Micheal Wong Vui Ling B.S. (Hons), M.S. (UPM)	<i>Bacterial Molecular Biology</i>
Foo Hooi Ling B.S. (Hons)(UPM)	<i>Molecular Biology</i>
Hirzun bin Mohd. Yusof @ Hassan B.Sc. (Hons)(Manchester)	<i>Molecular Biology</i>
Johnson Stanslas B.S. (Hons)(UKM)	<i>Animal Cell Biotechnology</i>
Lai Oi Ming B.S. (Hons), M.S. (UKM)	<i>Fats and Oils</i>
Mohd. Azmuddin bin Abdullah B.Sc., M.Sc. (UMIST)(Manchester)	<i>Plant Cell Chemical Engineering</i>
Seow Teck Keong B.S., M.S. (Biotech.) (UPM)	<i>Applied Microbiology</i>
Tan Siang Hee B.S. (Agric), M.S. (UPM)	<i>Molecular Biology</i>

SYNOPSIS OF COURSES

DEPARTMENT OF FOOD SCIENCE

FST 3301	(FOOD PROCESSING AND PRESERVATION PRINCIPLES)	4 (3+1)
	This course will introduce to the students the importance of food processing industry to the nation, important characteristics of processed food and the causes of food spoilage. The technology for preserving and processing of food will be discussed.	
FST 3501	INTRODUCTION TO FOOD SERVICE	2 (2+0)
	A survey course providing an overview of the industry, its history, development of the food service and restaurant industry, career opportunities and scope. Operating executives from the fields of hotel, restaurant, foodservice, travel and tourism will be invited to share their experiences and discuss current issues in the food service and hospitality industry.	
FST 3502	FOOD SERVICE MANAGEMENT	3 (3+0)
	A general management course where the theory and principles of organization, management techniques and decision making, as well as food service and hospitality management process will be taught.	
FST 3503	QUANTITY FOOD PRODUCTION	4 (2+2)
	Principles and methods of preparing food in quantity, considerations of menu planning, quality food, food acceptability, working methods, sanitation, safety, and production control.	
FST 3504	PURCHASING AND MENU PLANNING	3 (2+1)
	Basic information on sources, grades and standards, criteria for selection, purchasing and storage of the major foods, including the development of specification. Consideration of the menu pattern with particular emphasis on costing, pricing and work load placed on production staff. Item analysis and merchandising features are emphasized.	

FST 3505	FOOD SERVICE	3 (2+1)
	Arrangement of foodservice equipment for efficient use of space. An introduction to computer aided design for equipment placement within space constraints. Development of work flow patterns and human engineering considerations.	
FST 3506	FOOD SERVICE SANITATION	2 (2+0)
	The application of sanitary and public health engineering principles to foodservice and lodging operations. Emphasis on the current problem confronting the industry, with recent food development as they relate to sanitation.	
FST 3507	COMMERCIAL FOOD SERVICE MANAGEMENT	3 (2+1)
	Provide an introduction to commercial product preparation, presentation and service in commercial operations, tableside cookery, cooking to order, buffets, banquets, customer relations and teamwork.	
FST 3508	BEVERAGE MANAGEMENT	3 (2+1)
	Principles and practices regarding the production, selection, purchasing, storage and serving of wines spirit in the food service industry. Include methods of creative dining room merchandising and promotion.	
FST 3509	RESTAURANT MANAGEMENT	3 (3+0)
	Analysis of principle operating procedures in the restaurant field. Procedures, approaches and techniques of management are explored in various categories of restaurants ranging from fast food to gourmet.	
FST 3510	FOODSERVICE INDUSTRY LAW	2 (2+0)
	Legal aspects of operating hotels and restaurants, rights and responsibilities of the operation, patroncivil rights, government regulations, franchising contracts and commercial transactions.	
FST 3511	FOODSERVICE IFORMATION SYSTEM	3(2+1)
	Study of information system in the food service and hospitality industry. Design and development of an information system based on user needs. Identification and specification of user requirements and the selection of appropriate design.	

FST 3512	HUMAN RELATIONS IN THE FOODSERVICE	2 (2+0)
	Problems faced by the supervisor and the executive in the food service and hospitality field. Varied social and psychological factors present in any employee-employer relationship.	
FST 4810	FOOD TOXICOLOGY	4 (4 + 0)
	Concept of toxicity and its measurement. Effect of toxin on metabolism and health. Naturally occurring non-microbial food toxin. Toxicity of nutrient. Health hazard of food contaminants, including pesticides, antibiotics, microbes and packaging material. Toxin formation due to processing and preservation procedures. Food sensitivity including allergy.	
FST 4106	FOOD ANALYSIS	3 (2+1)
	The course will deal with chemical, microbiological, physical and instrumental analyses of foods to assure product specifications and quality standards are met. The analytical methods will be introduced according to the various categories of food industries. These will include the cereal and cereal product, dairy and dairy product, meat and meat product, fish and fish product, edible oil and fat, cocoa and cocoa product, fruits and vegetables, and beverage industries.	
FST 4802	QUALITY MANAGEMENT SYSTEM)	4 (4+0)
	This course will encompass for an overview of current concepts in quality management systems employed in different industries and the principles of quality. Quality Functions; Quality Philosophies; Quality Service; Designing and Developing Quality Specification; Basic Tools for Monitoring and Controlling Quality. Introduction to halal food concept in Islam. Sources of halal food. Slaughtering. Food processing. Halal ingredients and food additives. Regulations related to halal food. Certification and halal label. Role of government and non-government regulatory bodies.	
FST 4513	SPECIAL TOPIC)	4 (0+4)
	Students will be guided to identify current issues in his/her field of specialisation, devise a plan of action, gather and analyse data and propose a solution to an identified issue based on sound knowledge. Students are required to submit a complete report on the study.	

FST 3101 FOOD BIOCHEMISTRY 3 (3 + 0)

To introduce plant and animal cells and their sub-cellular components. The structure and function of carbohydrates, lipids, proteins and nucleic acid are discussed. The course then deals with the way in which catabolic processes break down large molecules to provide energy for driving anabolic reactions. This is followed by an account of the main metabolic pathways including electron transport, the citric acid cycle, fatty acid oxidation, glycolysis, gluconeogenesis, pentose-phosphate pathway, fatty acid biosynthesis and protein synthesis.

FST 3102 FOOD CHEMISTRY 4 (4 + 0)

This course covers the chemical and physical properties of the major and minor components of foods like protein, lipid, carbohydrate and dietary fibre, vitamins, minerals, pigment, flavour, food enzymes, additives and undesirable constituents of foods. The relationship between structure and function of these components in food will also be discussed.

FST 3103 FOOD CHEMISTRY LAB 2 (0 + 2)

This course will encompass the chemical methods used in analysing the major and minor components of foods.

FST 3104 NUTRITIONAL CHANGE IN FOOD 2 (2 + 0)

The nutrient quality and content of raw food during harvesting and storage. Changes occurring to the nutrient content and quality during food processing. Changes occurring to the nutrient content and quality of food during storage of processed food. The importance of nutrient content and quality of food to health. Nutrient fortification in food.

FST 4105 INSTRUMENTAL METHOD FOR FOOD ANALYSIS 4 (2 + 2)

The course covers chromatographic (column chromatography, thin-layer chromatography, paper chromatography, high pressure liquid chromatography, gas chromatography), electrophoretic, spectroscopic (UV-VIS spectroscopy, atomic absorption spectroscopy), colorimetric and fluorimetric techniques.

FST 3201 BASIC FOOD MICROBIOLOGY 3 (2 + 1)

Introductory course in microbiology and basic techniques used in the laboratory. Characteristics of microorganisms and classification. Structures and functions of cell prokaryote and eukaryote. Cultivation of bacteria. Reproduction and growth. Metabolism and biosynthesis. Destruction of microorganisms. Mutation and genetics. Immune Response. General characteristics of yeast, fungi and virus. Microorganisms important in foods.

FST 3202 FOOD MICROBIOLOGY 4(3+1)

Role and significance of microorganisms in foods and environment. Factors affecting their growth in foods. Effects of food processing and preservation techniques on the growth and survival of microorganisms. Microbial activities as a causal agent for food poisoning and food spoilage. Microbial quality of food and water. Indicator organisms. HACCP. Fermented foods.

FST 4302 FOOD TECHNOLOGY 4 (4 + 0)

The course will touch on the physico-chemical and biochemical changes of selected commodities during handling prior to processing and also during the processing of related products. Course content covers the appropriate technology for processing of meat and poultry, fish, dairy, fats and oils, fruits and vegetables, cereals and legumes will be discussed.

FST 4303 FOOD TECHNOLOGY LAB 2(2 + 0)

Food processing practicals to develop skill and hands-on experience in food processing practices through raw material handling, selection, and specification. Formulation and ingredient preparation, parameter and preservation process, the operation of food processing equipment, packaging and storage. Testing and analyzing product quality. In depth discussion to understand the effect of processing on product quality and to relate laboratory experience to some of the practices in relevant food industries.

FST 3401 BASIC FOOD ENGINEERING 3 (2 + 1)

Topics covered will include introduction to food engineering, unit operations in Food Engineering, units and dimensions, mass and energy balances, thermodynamics, fluid mechanics and heat and mass transfer. Laboratory practicals emphasise basic principles of Food Engineering.

FST 4801 QUALITY MANAGEMENT & FOOD LAW 4 (4+0)

The language and economics of quality. Quality philosophies. Quality Management, quality assurance and quality control. Hazards Analysis and Critical Control Point (HACCP) concept. Variation and process capability. Development of process and product specification. Just in time (JIT) concept and its relationship with supplier and quality. Principle of sampling plan, operating characteristic curve and selecting sampling curve for attribute and variable. Principle of statistical process control, developing and analyzing process control charts for attribute and variable characteristics. Laws of Malaysia. Food Act 1983 and Food Regulations 1985. Administration and enforcement. Appointment of analysts and authorised officers. Power and procedures for taking samples. Standards and food labelling. Food additives and incidental constituents. Power to make regulations. Offences and evidence. Laws of Malaysia applicable to the food industry. The involvement of the Department of Customs and Excise. Consumer movement.

FST 4803 SENSORY EVALUATION 2 (1 + 1)

This course covers the following topics: Sensory evaluation concept and uses, explanation on method, format and technique for obtaining data through sensory evaluation forms, preparation of sample for presentation, factors which influence measurement of sensory evaluation, statistical data analysis, selection and training of panel members.

FST 4804 STATISTIC FOR FOOD SCIENCE 3 (2 + 1)

This course provides an introduction to the basic concepts and definitions of statistics, the design of planned experiments, the analysis of the experimental data, decision-making from the analysis of data, and some statistical procedures on the analysis of data. The course will place emphasis on application of statistical knowledge in the food science and technology research areas.

FST 4806 FOOD HYGIENE & SANITATION 2 (2 + 0)

This course introduces the student to principles of hygiene in food industries, food service institutions and at food retail outlets. This course will cover various aspects of sanitation such as water quality, types of soil technology, surface technology, detergents, disinfectants and sanitizing agents in different food industries. Aspects relating to hygienic design will also be discussed.

FST 4807 SEMINAR 1 (1 + 0)

Students are required to present seminars on the research which they have conducted in the year and also some selected topics.

FST 4901 PATOGEN BAWAAN MAKANAN DAN KESIHATAN UMUM 4 (3+1)

Types of pathogen and food poisoning. Morphology, biochemical reactions, incidence and prevalence of food poisoning. Ecology, growth and destruction characteristics of pathogens. Food poisoning syndrome and prevention techniques. Fungi and mycotoxins. Food as an agent for diseases caused by virus and parasites. Indicator organisms: identification, enumeration, safety of foods, processing and water quality.

FST 4905 FOOD PACKAGING 4 (3 + 1)

The concept of food packaging; functions and types of packaging materials such as papers, plastics, metals and glass and the trend of their applications. Type of tests for packaging materials and their failures. Forms of packaging such as vacuum, gas, modified atmosphere and aseptic packaging. Equipment and design of packages. Packaging applications to materials such as dairy products, frozen, meat, cereals, snacks, etc. Laws and regulations concerning packaging including nutritional labelling. Present development in food packaging.

FST 3107 BASIC FOOD CHEMISTRY 3(2+1)

This course covers the chemical and physical properties of the major and minor components of foods like water, protein, lipid, carbohydrate and fibre, vitamins, minerals, additives and undesirable constituents of foods. The relationship between structure and function of these components in food will also be discussed.

DEPARTMENT OF FOOD TECHNOLOGY

FST 3101	FOOD BIOCHEMISTRY	3 (3 + 0)
	To introduce plant and animal cells and their sub-cellular components. The structure and function of carbohydrates, lipids, proteins and nucleic acid are discussed. The course then deals with the way in which catabolic processes break down large molecules to provide energy for driving anabolic reactions. This is followed by an account of the main metabolic pathways including electron transport, the citric acid cycle, fatty acid oxidation, glycolysis, gluconeogenesis, pentose-phosphate pathway, fatty acid biosynthesis and protein synthesis.	
FST 3102	FOOD CHEMISTRY	4 (4 + 0)
	This course covers the chemical and physical properties of the major and minor components of foods like protein, lipid, carbohydrate and dietary fibre, vitamins, minerals, pigment, flavour, food enzymes, additives and undesirable constituents of foods. The relationship between structure and function of these components in food will also be discussed.	
FST 3103	FOOD CHEMISTRY LABORATORY	2 (0 + 2)
	This course will encompass the chemical methods used in analysing the major and minor components of foods.	
FST 3104	NUTRITIONAL CHANGES IN FOOD	2 (2 + 0)
	The nutrient quality and content of raw food during harvesting and storage. Changes occurring to the nutrient content and quality during food processing. Changes occurring to the nutrient content and quality of food during storage of processed food. The importance of nutrient content and quality of food to health. Nutrient fortification in food.	
FST 4105	INSTRUMENTAL METHOD FOR FOOD ANALYSIS	4 (2 + 2)
	The course covers chromatographic (column chromatography, thin-layer chromatography, paper chromatography, high pressure liquid chromatography, gas chromatography), electrophoretic, spectroscopic (UV-VIS spectroscopy, atomic absorption spectroscopy), colorimetric and fluorimetric techniques.	

FST 3201	BASIC FOOD MICROBIOLOGY	3 (2 + 1)
	Introductory course in microbiology and basic techniques used in the laboratory. Characteristics of microorganisms and classification. Structures and functions of cell prokaryote and eukaryote. Cultivation of bacteria. Reproduction and growth. Metabolism and biosynthesis. Destruction of microorganisms. Mutation and genetics. Immune Response. General characteristics of yeast, fungi and virus. Microorganisms important in foods.	
FST 3202	FOOD MICROBIOLOGY	4(3+1)
	Role and significance of microorganisms in foods and environment. Factors affecting their growth in foods. Effects of food processing and preservation techniques on the growth and survival of microorganisms. Microbial activities as a causal agent for food poisoning and food spoilage. Microbial quality of food and water. Indicator organisms. HACCP. Fermented foods.	
FST 4204	FOOD PATHOGEN	2 (2+0)
	Types of bacteria that cause food poisoning. Characteristics of the bacteria, disease syndrome, sources, food involved and preventive measures. Fungi, aflatoxins and other mycotoxins, factors affecting growth of fungi, mycotoxin production and inactivation of aflatoxins. Food as a carrier for virus and parasites. Food poisoning from fish and other seafoods. Application of food processing and preservation technologies to prevent growth of pathogens and production of toxins.	
FST 4302	FOOD TECHNOLOGY	4 (4 + 0)
	The course will touch on the physico-chemical and biochemical changes of selected commodities during handling prior to processing and also during the processing of related products. Course content covers the appropriate technology for processing of meat and poultry, fish, dairy, fats and oils, fruits and vegetables, cereals and legumes will be discussed.	
FST 4303	FOOD TECHNOLOGY LABORATORY	2 (0 + 2)
	Food processing practicals to develop skill and hands-on experience in food processing practices through raw material handling, selection, and specification. Formulation and ingredient preparation, parameter and preservation process, the operation of food processing equipment, packaging and storage. Testing and analyzing product quality. In depth discussion to understand the effect of processing on product quality and to relate laboratory experience to some of the practices in relevant food industries.	

FST 3401 BASIC FOOD ENGINEERING 3 (2 + 1)

Topics covered will include introduction to food engineering, unit operations in Food Engineering, units and dimensions, mass and energy balances, thermodynamics, fluid mechanics and heat and mass transfer. Laboratory practicals emphasise basic principles of Food Engineering.

FST 3402 FOOD UNIT PROCESSING OPERATION 4 (4 + 0)

This course will cover the ancillary and unit operations in the food industry. Topics covered are materials handling, cleaning and grading of food, size reduction, mixing, filtration, centrifugation, solvent extraction and mechanical expression. This course will also focus on the principles of unit operation in food processing and preservation. The students will be exposed to the techniques of thermal processing, dehydration, evaporation and concentration, chilling and freezing and food irradiation.

FST 3403 FOOD UNIT LABORATORY OPERATION 2 (0 + 2)

This course provides an introduction to the practice of various unit operations in food processing. Unit operations to be introduced include material handling, solid/solid mixing, solid liquid extraction, homogenization, size reduction, phase separation, peeling techniques, mechanical extraction, handling of food solid and liquid, canning and Fo determination, seam examination, food concentration, food drying, and food freezing in the food science and technology research areas.

FST 4404 FOOD PLANT DESIGN 3 + 0

This course includes process evaluation, cost estimation, equipment selection and specification, plant layout and site selection, project planning, optimization techniques and scaling up of process equipment. Flowsheeting and technical drawing are also covered.

FST 4801 FOOD LEGISLATION AND QUALITY MANAGEMENT 4 (4+0)

The language and economics of quality. Quality philosophies. Quality Management, quality assurance and quality control. Hazards Analysis and Critical Control Point (HACCP) concept. Variation and process capability. Development of process and product specification. Just in time (JIT) concept and its relationship with supplier and quality. Principle of sampling plan, operating characteristic curve and selecting sampling curve for attribute and

variable. Principle of statistical process control, developing and analyzing process control charts for attribute and variable characteristics. Laws of Malaysia. Food Act 1983 and Food Regulations 1985. Administration and enforcement. Appointment of analysts and authorised officers. Power and procedures for taking samples. Standards and food labelling. Food additives and incidental constituents. Power to make regulations. Offences and evidence. Laws of Malaysia applicable to the food industry. The involvement of the Department of Customs and Excise. Consumer movement.

FST 4803 SENSORY EVALUATION 2 (1 + 1)

This course covers the following topics: Sensory evaluation concept and uses, explanation on method, format and technique for obtaining data through sensory evaluation forms, preparation of sample for presentation, factors which influence measurement of sensory evaluation, statistical data analysis, selection and training of panel members.

FST 4804 STATISTIC FOR FOOD SCIENCE 3 (2 + 1)

This course provides an introduction to the basic concepts and definitions of statistics, the design of planned experiments, the analysis of the experimental data, decision-making from the analysis of data, and some statistical procedures on the analysis of data. The course will place emphasis on application of statistical knowledge in the food science and technology research areas.

FST 4805 PRODUCT DEVELOPMENT 4 (2 + 2)

The place of product development in the food processing company. Product Ideas. Consumer survey. Evaluation of product ideas. Project planning. The prototype product - defining the problem. Experimental methods. Product testing in experimentation. Process development. Final product testing. Product specification. Product planning. Market planning. Setting up the product development in a company. Strategies for product development.

FST 4806 FOOD HYGIENE AND SANITATION 2 (2 + 0)

This course introduces the student to principles of hygiene in food industries, food service institutions and at food retail outlets. This course will cover various aspects of sanitation such as water quality, types of soil technology, surface technology, detergents, disinfectants and sanitizing agents in different food industries. Aspects relating to hygienic design will also be discussed.

FST 4807	SEMINAR	1 (1 + 0)
	Students are required to present seminars on the research which they have conducted in the year and also some selected topics.	
FST 4809	FINAL YEAR PROJECT	12 (0 + 12)
	Final year student will carry out a research project under the supervision of one or more lecturers in the Faculty. Students are required to submit a research proposal. Upon completion of the research project, a bound thesis is to be submitted to the Faculty and present the research findings in a seminar.	
FST 3808	INDUSTRIAL TRAINING	8 (0+8)
	The student is required to undergo a practical training for a period of four months at various companies or factories in the local food processing industry which will be determined by the course co-ordinator. The training at the industry will be organised by a supervisor or manager from the company or factory and the training program that shall be given will be the result of the discussion between the supervisor and the course co-ordinator. During the training the student is expected to abide all rules and regulations which are prepared by the company or the factory. The industrial practical program may consist of training in such areas as production, manufacturing, management, stock keeping or quality control. Upon completing the training, the student is required to write and submit a complete report about the training program which he has undergone at the industry.	
FST 4901	FOOD BORNE PATHOGEN AND PUBLIC HEALTH	4 (3+1)
	Types of pathogen and food poisoning. Morphology, biochemical reactions, incidence and prevalence of food poisoning. Ecology, growth and destruction characteristics of pathogens. Food poisoning syndrome and prevention techniques. Fungi and mycotoxins. Food as an agent for diseases cause by virus and parasites. Indicator organisms: identification, enumeration, safety of foods, processing and water quality.	
FST 4902	POST - HARVEST HANDLING OF FRUITS AND VEGETABLES	4 (3 + 1)
	Structure and composition of fruits and vegetables. Harvesting techniques. Biochemical and biophysical changes after harvest. Factors affecting quality of fruits and vegetables during storage and	

	distribution. Role of temperature and relative humidity during storage. Methods for controlling fruit ripening. Quality criteria. Commodity treatments. Wastage. Packing-house equipment and packaging materials for fruits and vegetables. Transportation.	
FST 4903	FOOD ENZYMOLOGY	4 (3 + 1)
	Introduction to fundamental aspects of enzymology, enzymology of the principal food groups - milk, meat, cereals, legumes, fruits, vegetables, beverages (beer, wine, tea, coffee, cocoa) and food ingredients (protein, fat and sugar). The principal enzymes in fruits and vegetables e.g. lipoxygenase, polyphenol oxidase, peroxidase and pectinolytic enzymes, and the role of ethylene in regulating the ripening of fruits. Enzymes in fermentation. Enzymes important in flavour development. Use of enzymes in food industry. Immobilised enzymes, enzymes in food analysis and the potential of genetic engineering to modify enzymes.	
FST 4904	NUTRITION AND HEALTH	4 (4 + 0)
	Chemistry, functions and symptoms of deficiency and excessiveness of proteins, lipids, carbohydrates, fibres, vitamins and minerals. Discussions on undesirable constituents of food constituents. Nutrition for special groups. Evaluation of protein quality and assessment of nutritional status. Nutritional problems in developing countries. Disorders related to nutrition. Nutritional surveys.	
FST 4905	FOOD PACKAGING	4 (3 + 1)
	The concept of food packaging; functions and types of packaging materials such as papers, plastics, metals and glass and the trend of their applications. Type of tests for packaging materials and their failures. Forms of packaging such as vacuum, gas, modified atmosphere and aseptic packaging. Equipment and design of packages. Packaging applications to materials such as dairy products, frozen, meat, cereals, snacks, etc. Laws and regulations concerning packaging including nutritional labelling. Present development in food packaging.	
FST 4906	CHEMISTRY AND TECHNOLOGY OF FATS AND OILS	4 (3 + 1)
	Physico-chemical properties of various fat and oils. Analysis of fats. Deteriorative reactions of fats and rancidity. Chemistry and technology of processes in the fat and oil industry-extraction, refining and modification. Application of fats and their functions in food products. Speciality fats. Non-food fat-based products. Environmental aspects of fat processing.	

FST 4907 CHEMISTRY AND TECHNOLOGY OF CEREALS AND LEGUMES 4 (3 + 1)

The structure and composition of cereals and legumes, detail account of the structure and functional properties of proteins, carbohydrates, fats, minerals, vitamins and other components in cereals and legumes. Toxic components and ways of detoxification, various techniques in post-harvest technology, processing and product development, with detail discussion on current problems involved in the cereals and legumes industry.

FST 4908 DAIRY TECHNOLOGY 4 (3 + 1)

Application of scientific principles in the processing technology of dairy products. Processing technique of fluid, dehydrated, concentrated and fermented dairy products. Demonstration of basic processing operations including heating, homogenization, evaporation, drying, crystallisation and freezing. Integration of chemical, microbiological and physical principles involved in the manufacture and storage of natural and processed cheese, and other fresh fermented products.

FST 4909 BEVERAGE TECHNOLOGY 4 (3 + 1)

Production of beverages from tropical fruits, alcoholic drinks, carbonated drinks, alcoholic drinks including coffee and tea. Design and construction of premise. Quality aspects, packaging and marketing trend.

FST 4910 MEAT TECHNOLOGY 4 (3 + 1)

The structure and composition of muscle and muscle contraction in relation to the conversion of muscle to meat, rigour mortis, cold shortening, thaw rigour and properties of fresh meat. The study and practice of commercial meat processing methods including slaughtering, curing, smoking, sausage manufacturing and packaging.

FST 4911 COCOA TECHNOLOGY 4 (3 + 1)

Changes during fruit maturation and ripening. Harvesting and pod splitting. Types and principles involved in pretreatment before fermentation. Physical, chemical and microbiological changes and factors affecting quality during fermentation. Development of flavour precursor. Importance of acid development. Principles and method of cocoa drying. Physical and chemical changes and factors affecting quality during drying. Storage of dried cocoa. Grading and quality measurement of dried cocoa. Grading. Secondary processing and factors affecting product quality.

FST 4912 CHOCOLATE AND SUGAR CONFECTIONARY 4 (3 + 1)

The course covers the process, physico-chemical changes and factors affecting the product quality during cocoa processing and manufacture of chocolate and sugar confectionaries. Cocoa processing includes fermentation, drying storage, grading, cleaning, roasting, winnowing, nib breaking, alkalization, grinding and cocoa butter separation. Type, physico-chemical properties of cocoa liquor, butter and powder. Chocolate manufacture covers types of chocolate and the ingredients used. Processing method involved such as mixing, grinding, tempering, cooling, panning, etc. Manufacture of sugar confectionaries cover formulation and processing of hard boiled candy, caramel, toffee, croquant, jelly, creme etc. Type and role of ingredients used such as egg, gelatizing agent, modified starch, milk, corn syrup, etc. and the effect on product quality. Recipes calculation of chocolate and sugar confectionaries.

FST 4913 TECHNOLOGY OF AQUATIC PRODUCT 4 (3 + 1)

Properties of aquatic food materials. Postharvest handling. Processing systems. Unit processes. Heat processing and canning. Low-temperature processing. Surimi and fish jelly products. Salting, drying, smoking. Fermented products, hydrolysates and fish oils, value-added products. Quality changes and evaluation.

MGT 2111 BUSINESS ORGANISATION & MANAGEMENT 4 (4 + 0)

Analysis on the basic theories, principles, techniques and tools of management with emphasis on management functions which relate to main functional areas of business and non business organization - more emphasis will also be given on the systems approach.

MGT 2101 BUSINESS COMMUNICATION 3 (3 + 0)

This course is designed to increase the students awareness of the functions and importance of communication in the business arena. This course will focus on the human as well as the technical applications of communication in achieving the goals of an organization. Special emphasis will be placed on the strategic communications.

MGT 3113 ORGANISATIONAL BEHAVIOR 4 (4 + 0)

This course informs that organizations like universities, government agencies, and the private sectors have a strong impact on the quality of our day-to-day lives through their influence on the feelings and behaviors of their employees and clients. Major discussions encompass topics such as effective management of organizations is significant, daily problems managers face at work, present theories and research on why organizations operate the way they do. This includes the perspectives and findings of the social science disciplines.

MGT 4139 DASAR PERNIAGAAN 4 (4 + 0)

This is a capstone course integrating the understanding of all the other functional subjects to be used in making strategic decisions for the organisations. The top management perspective will be focussed. Topics included elements and process of strategic planning, SWOT analysis, strategic advantage profile, strategic planning systems and strategic planning for non profit organizations.

MGT 4183 KEUSAHAWANAN 3 (3 + 0)

The course deals with the identification, development and function of the entrepreneur within a free enterprise system. The life-style of the entrepreneur will be examined in terms of his motivation, interpersonal orientation, role perception, work related experience and preparation, and other factors relevant to entrepreneurial-effectiveness in the small business context. The nature of entrepreneurial management and its relation to business dynamism and success will be studied. Various historical and contemporary studies of entrepreneurs as 'catalyst' in the economic development are presented. Lastly, the course examines the role of entrepreneurs in government, commerce and industry.

MGT 3197 INFORMATION SYSTEM MANAGEMENT 4 (4 + 0)

Basic concepts of Information Systems - IS and its operational, decision making and strategic roles. Development of IS solutions to business problems using a systematic and methodological approach. IT development and its implications to management (hardware, software, telecommunications and database management technologies). IS role in supporting end-user activities. The challenges facing managers in managing IS technologies, activities and resources.

PRN 410 PENGURUSAN PEMASARAN 3 (3 + 0)

The course outline an understanding of the basic concepts and theories of marketing management. The topics include the marketing concepts in modern business environment; consumer behavior and purchasing decisions; decisions and strategies pertaining to marketing mix such as product and pricing strategies, and promotional and distribution policies. Strategic marketing, planning, information and control of marketing program will also be discussed. In addition, the course will assess the major techniques in gathering information that determine the marketing objectives and policies of the companies.

MGT 4421 PENGURUSAN PERNIAGAANTANI 4 (4 + 0)

This course covers the basic managerial principles and human behavioral aspects in firms. Issues like long term planning for growth, the use of managerial principles to analyse the system and market structure of agribusiness and agribusiness policies will also be discussed.

ECO 3100 PRINSIP EKONOMI 3 (3 + 0)

Introduction to basic economic concepts, demand supply and price determination, role of government in national income and its distribution, composition and pricing of domestic output, distribution of factors of production. International trade and finance, current economic issues and problems.

MGT 3211 PRINSIP - PRINSIP PEMASARAN 4 (4 + 0)

Managerial approach in understanding marketing decision making with the emphasis of developing marketing mix and marketing strategies. Discussion in marketing; and analysis of marketing opportunities; product/service decision; distribution decision; promotional decision; pricing decision; marketing planning and management, and selected applications.

ACC 2112 PERAKAUNAN PENGENALAN 4 (4 + 0)

The course covers the role of accounting as a vital input in business, the accounting cycle and analysis of financial statements.

ACC 3211 PENGURUSAN KEWANGAN 4 (4 + 0)

Financial objectives and policies formulation, financial analysis, financial forecasting, planning and control, working capital management, time value of money, valuation theory, risk and return, capital budgeting and cost of capital.

SAK 2001 INTRODUCTION TO COMPUTER AND DATA PROCESSING 2 (1 + 1)

This course provides a basic understanding of the computer system organization including hardware and software. It exposes the students to basic computer programming and the usage of relevant application packages.

KIM 2101 INTRODUCTION TO CHEMISTRY 4 (3 + 1)

This is an introductory course on physical chemistry, which covers modern atomic theory, theory of bonding, state of matter, thermodynamics, chemical equilibrium, kinetics and nuclear chemistry.

KIM 2201 ORGANIC CHEMISTRY 1 4 (3 + 1)

This is an introductory course in organic chemistry designed to strengthen the students basic knowledge. Topics covered include structure, bonding, nomenclature, properties, reactions, synthesis and the importance of the various classes of organic compounds, as well as optical isomerism and polymerization.

MTK 3100 CALCULUS 4(3 + 1)

This course emphasises the building up of the concept in calculus with one variable and introduces the students to concept related to sets and functions which are the necessary tools for understanding ideas on continuity and derivatives of functions. The emphasis of the courses is on derivatives of functions and related theorems but integration as the anti-process of finding derivatives is also covered. Theorems and techniques of integration and finding derivatives are discussed at the end of the course.

FAL 2004 ISLAMIC CIVILISATION 4 (4 + 0)

Islam is a religion and civilization: Basic concept, criteria and major characteristics; the universalistic view of Islam; Al-Quran and al-Sunnah as a major source of Islamic civilization; Islamic epistemology and axiology, and the influence of Islamic civilization; the concept of family, community and education in Islam; the concept of economy in Islam; syariah as a basic foundation for the establishment of community in Islam; the concept of rule and administration in Islam; the philosophy of Islamic science and technology and its related fields; the concept and achievement of Islamic arts, architecture and environmental planning; Islam and contemporary issues.

POL 2002 KENEGARAAN MALAYSIA 3 (3 + 0)

Nation's history: The Struggle for independence, the formation of the Federation of Malaysia; Plural Society: history, characteristics and problems; System of Parliamentary democracy; Electoral System; The Malaysian Constitution; Rukunegara; The Constitutional Monarchy; Public Administration; the New Economic Policy; National Social Policies; Vision 2020.

BBI 2401 ENGLISH FOR ACADEMIC PURPOSES 1 2 (1 + 1)

Understanding the textual organisation of linear and non-linear texts; skimming texts for main ideas; scanning non-linear texts for information; vocabulary and development of study skills; discussion of reading texts and writing simple accounts related to reading materials.

BBI 2402 ENGLISH FOR ACADEMIC PURPOSES 11 2 (1 + 1)

Approaches to reading academic texts; text structure of subject-specific academic writing; vocabulary development; dictionary use; discussion related to academic settings, listening to subject-related spoken English and note-taking; summary writing and oral presentation.

BBI 2403 ENGLISH FOR ACADEMIC PURPOSES III 2 (1 + 1)

Using appropriate reading strategies to read complex texts; understanding the organisation of academic texts; participating in academically oriented seminars and meetings; developing vocabulary, using the dictionary; writing reports; writing critical comments related to issues; listening to academically oriented lectures and taped extracts.

BBI 2404	ORAL INTERACTIONS	2 (1 + 1)
	This course is designed to encourage students to speak fluently and accurately in English. Activities includes simulations, problem-solving, story-telling, interviews, group discussions and sketches.	
BBI 2405	PUBLIC SPEAKING IN ENGLISH	2 (1 + 1)
	Developing students' confidence and ability to give public speeches; practices on speech preparation, visual aids preparation, and speech presentation.	
BBI 2407	WRITTEN COMMUNICATION IN BUSINESS	2 (1 + 1)
	General principles of effective business writing; planning and preparing letters; various types of business letters; memoranda, and short business reports.	
BBI 2408	ACADEMIC WRITING SKILLS	2 (1 + 1)
	General organization and functions of written English for academic purposes, ample practice in the organization of content, and detection and correction to common errors and grammar, punctuation and diction.	
BBM 2404	BAHASA MELAYU DALAM PENULISAN AKADEMIK	2 (2 + 0)
	Technique of materials collection and organisation; technique of academic writing from the aspects of word choice, use of grammar, and technical aspects as well as editing academic writing.	

DEPARTMENT OF BIOTECHNOLOGY

BTE 3001	Introduction to Biotechnology	2(2+0)
	Concept and basis of biotechnology. Contribution by different disciplines of biology, biochemistry, microbiology, molecular biology and biochemical engineering to biotechnology. Application of biotechnology in fermentation technology, enzyme technology, cell and tissue culture technology in industry, agriculture, medicine and environmental science.	

BTE 3301	Biological Chemistry	4(4-0)
	This course will topics which will include organisation of the microbial, animal and plant cells; structures and metabolism (anabolism and catabolism) of carbohydrates (especially glucose) proteins, lipids including fatty acids, and other; synthesis of energy equivalence in cells; definition, classification, properties and kinetics of enzymes; structure, function and replication of genetic, relationship between these materials and protein, and their importance in biotechnology; mechanisms for protein secretion; structure, active forms and functions of micro-biomolecules such as vitamins, hormones.	
BTE 3302	Biophysical Chemistry	3 (2+1)
	This course covers the modern atomic/molecular theory, binding theory and intermolecular forces, solution chemistry, kinetic, electrochemistry, thermodynamics, physical techniques for determining the structure of molecules and biophysical method for isolating and identifying biomolecules.	
BTE 3401	Introduction to Microbial Biotechnology	4 (3+1)
	This course gives an introduction to the microbial world emphasizing on the structure, morphology, growth, biosynthesis, coordination of metabolism, genetics, genetic engineering and microbial biotechnology and also an understanding of common sequence of technical stages used in biotechnology.	
BTE 3501	Molecular and Cell Biology	4(4+0)
	To introduce cell theory, basic structure and differences between the physiology of prokaryotic and eukaryotic cells, including the techniques used to study various cells, and important physiological process of the cell. Mendelian genetics (Mendel's first and second laws, unit of heredity and its expression). biochemical aspects and the role of chromosomes; the concept of gene-coded protein; DNA and RNA as genetic materials; synthesis of polypeptides (transfer of biological information from gene to protein, role of mRNA as template, role of rRNA and tRNA, processing of RNA). DNA structure and protein components in chromosomes (types and functions). Plasmid DNA and organelle DNA (mitochondria and chloroplasts). Control of expression of prokaryotic genes (operon concept) and eukaryotic genome (repetitive gene sequences, structural genes, introns). Replications, restriction and DNA modification, recombination and transfer of genetic material (transposons.)	

BTE 4001 Writing Techniques in Biotechnology 2 (2+0)

This course will provide guidance and discussions on methods of data analysis and presentation, and preparation of various types of reports including research thesis.

BTE 4002 Commercialization of Biotechnology 2(2 + 0)

This course aims to expose students to issues and problems which need to be taken into account in the development of a product from the laboratory scale to the commercial marketplace. The numerous factors affecting the choice of research project for development into a commercial product for the highly competitive market will be presented. Specific case studies reflecting success and failure of products in various fields of biotechnology will be discussed.

BTE 4003 Seminar 1 (1+0)

Each student is required to present a seminar on his/her final year project and to attend seminars organised by the course coordinator on techniques of preparation and presentation of seminar materials, and on topics in biotechnology.

BTE 4101 Bioprocess Engineering 4(4+0)

Introduction to bioprocess engineering. Integration of the related disciplines in bioprocess engineering. Fundamentals and unit operations in engineering. Units and dimensions. Mass and heat balances. Heat transfer and its related equipment. Fluid mechanics: fluid properties, fluid flow behaviour and concepts. Bernoulli's equation. Mass transfer. Role of bioprocess engineering processes: the use of cells and enzymes, effluent treatment.

BTE 4102 Downstream Processes 3 (2+1)

This course covers downstream process procedures for the recovery and purification of fermentation products. Mechanical separation of cells from fermentation broth. Hindered settling in gravitational and centrifugal fields and filtration. Disruption of cells by mechanical methods, induction of lysis, desiccation. Mechanical extraction including countercurrent and multistage liquid-liquid extraction. Preliminary fractionation procedures, removal of nucleic acids and precipitation. High resolution techniques which covers ultra-filtration and chromatography. Crystallization processes, evaporation, drying and solvent recovery.

BTE 4103 Bioreactor Design 4 (3+1)

Introduction to principles of bioreactor design which covers biological reaction kinetics, heat and mass transfer and integration of these phenomena in gas and liquid mixing. Types of reactor for batch and continuous operation. Basic principles of scale-up and scaling up of bioreactor. Project planning, flowsheeting and technical drawing will also be covered.

BTE 4201 Waste Management and Utilization 3 (3 + 0)

Types of wastes and their sources. Properties and composition of wastes. Wastewater treatment involving pre-treatment, primary sedimentation, biological oxidation and secondary sedimentation. Treatment and ultimate disposal of sludge and solid wastes. Handling of toxic wastes. Utilisation of solid wastes and industrial effluents.

BTE 4301 Enzyme Technology 4 (2+0)

This course introduces to students various aspects of the production and application of industrial enzymes; definition, classification and general properties of enzymes; microbial enzymes (strain selection and improvement); methods of extraction and purification of intracellular and extracellular enzymes; sources, catalytic properties and areas of applications of industrial enzymes; immobilised enzymes and cells - techniques, of support, effects on properties and function of enzymes and cells, applications and potential of immobilised cells and enzymes in various fields; properties of enzymes in media like organic solvents and supercritical fluids; safety issues and regulations on the use of enzymes in the industry.

BTE 4302 Instrumentation in Biotechnology Research 3 (1 + 2)

This course comprises of several lectures and experiments which will explain to students about the principle of operation, characteristics and methods of using instruments such as SEM (scanning electron microscope), GC, HPLC, FTIR (Fourier Transform Infra-red Spectrometer), DSC (Differential Scanning Calorimeter), Elektrophoresis and iso-electric focusing units, biosensors, protein and DNA sequencers).

- BTE 4303 Food Technology** 4(3+1)
- This course will expose students to the application of biological catalysts in the preparation and modification of foods, and the production of food ingredients. Topics that will be covered will include preparation and modifications of traditional foods and beverages; enzymatic modifications of fats and oils, carbohydrates, protein and others; applications of biocatalysts in the production of compounds or secondary metabolites such as flavours; food colours, food gums, etc; application of enzymes as detection agents in foods and food processes; roles of genetic and protein engineering in improving the properties of enzymes or food sources; laws that regulate the use of biocatalysts in foods.
- BTE 4401 Fermentation Technology** 4 (4 + 0)
- This course expose students to the principles of fermentation technology. The course covers several important aspects in fermentation technology such as isolation of microbe, strain improvement for industrial applications, media formulation and sterilization process, inocula preparation, bioreactor design and process control in fermentation, fermentation kinetics, various modes of fermenter operation and modelling.
- BTE 4501 Genetic Engineering** 3 (2+1)
- This course provides knowledge of the basic techniques for the manipulation/cloning of genes. Well established procedures for cloning, screening and identification of heterologous genes in "Escherichia coli" will be presented. Areas that will be covered will include cloning vectors, restriction and ligation of vector to insert DNA, transformation into competent cells and screening for the cloned DNA. PCR technology and DNA sequencing will also be presented.
- BTE 4601 Principles of Cell and Tissue Culture** 4 (3+1)
- The history of tissue culture of plant and animal: laboratory requirements, organisation and general techniques; tissue culture media and preparation. Zygotic embryo culture; callus and free cell culture; evidence for totipotency; somatic embryogenesis; organogenesis; anther and pollen culture. Isolation, culture and fusion of protoplasts. Genetic stability and somaclonal variation. Experimental design and quantification of results. Quantification and determination of cell viability. Microbial contamination and prevention procedures. Establishment and characterization of cell line.

- BTE 4602 Applied Plant Cell and Tissue Culture** 4 (3+1)
- Clonal propagation - principles and methods for major groups of agricultural, horticultural and medicinal plants. The production of pathogen-free plants; selection of disease-resistant and stress-tolerant strains in vitro; the importance of haploids, triploids and in vitro pollination in crop improvement. Somatic hybridization in the production of new varieties. Importance of protoplasts in genetic engineering of plants, principles and importance of cryopreservation and germplasm storage. Industrial plant products, secondary metabolites from cell cultures, regulation of biosynthesis and biotransformation "in vitro" Cloning plant genes - progress and potential of genetic engineering in plants.
- BTE 4603 Applied Animal Cell and Tissue Culture** 4 (3+1)
- The importance and applications of animal cell and tissue culture in medicine, agriculture and pharmaceutical industry. Techniques in analyzing cell cycle and kinetic of cell population. Hybridoma technology and large scale culture of hybridoma cells. In-vitro culture of haemopoietic cells and its application. Cellular basis of immune system and cytokines. Cultivation of anchorage dependent cells and production of viral vaccines. Oncogenes in eukaryotic system. Cultivation of insect cells and its application. Organ culture and techniques in preserving organs.
- BTE 4604 Immunochemistry** 3(2+1)
- This course is designed to introduce students to the biochemical and chemical basis of various immunological methods available. The course will be laboratory-oriented and will be structured in the form of mini projects of a particular immunological method of choice. The immunological methods that will be covered are broadly categorized as serological techniques, monoclonal antibody production and purification, immunocytochemistry and immunological techniques in plant science.
- BTE 4701 Laboratory Practicals in Enzyme Technology** 1(0 +1)
- This course introduces to students various aspects of handling of free and immobilised enzymes: techniques of extraction of enzymes from microorganisms and plant organs; purification techniques and enzyme characterisation; methods of assay (determination) of enzyme activity; ways of expressing free and immobilised enzyme activity; techniques for immobilisation of biocatalysts (including microbial cells); secretion (signal hypothesis, etc), microbial enzymes (strain selection and improvement), application of immobilised enzymes. Questions related to each experiments will be included.

BTE 4702 Fermentation Technology and Bioprocess Engineering Laboratory 2 (0+2)

This course provides exercise on the basic technique in bioprocess engineering, operation of fermentation/bioprocess and the use of mathematical and computer method in analysing fermentation/bioprocess data. The experiments that will be carried out in the lab includes; preparation of stock culture, instalation and operation of bioreactor and various modes of bioreactor operation (batch, fed-batch and continuous) and also bacis technique in bioprocess engineering such as calibration of equipment, and determination of power consumption and oxygen transfer. Computer exercises that will be carried out are the use of "spreadsheed" (eg ASEASY) for the determination of kinetic parameter values and iterative computer program (ISIM) to solve modelling problem which involves several differential equations.

BTE 4703 LATIHAN PRAKTIK 8(0+8)

The student is required to undergo a pratical training for a continuous period of eight weeks during the vacation between after 6th semester. Placement shall be either in a research institution, other institutions of higher learning, or in a private firm that practices biotechnology-related activities including R&D (research and development). This shall be determined by the course coordinator, although the student may seek his/her own placement. The student will be placed under the supervision of a supervisor who will be responsible in planning the training, and at the end of training session, evaluate and reports to the course coordinators, the performance of the student. The course coordinator or any lecturer thus identified by the coordinator shall visit the student to ensure the training is carried out accordingly. Upon completion, the student is required to write and submit a complete report, and to present a seminar on the training he/she had undergone during the 7th semester.

BTE 4900 Project 12 (0+12)

In the final year, each student will be required to undertake a research project under the supervision of a faculty member. Before embarking on the project on the project, each student must present his/her research proposal orally at a seminar that will be organised by the course coordinator. On completion of the project, a bound thesis is to submitted to the faculty as partial fulfillment of the Degree of Bachelor of Science (Biotechnology) and for evaluation.

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