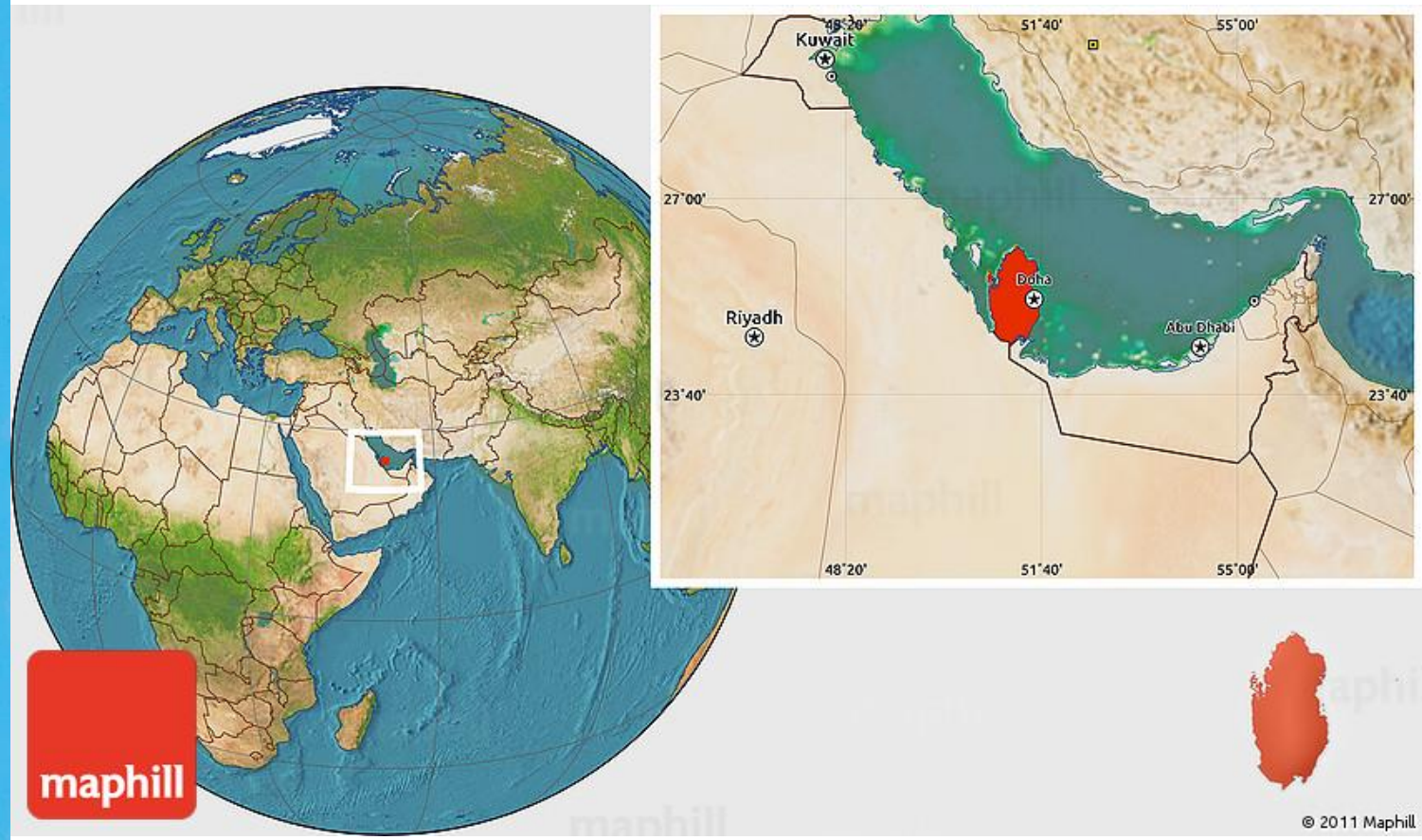
Introducing High School Students to Biotechnology and Biomedical Engineering

A case study from Qatar

About the country



About the Country: QATAR

Qatar, one of the greatest economies in the Arabian Gulf is witnessing a rapid development in different state industries including transport, sports, health, and educational.

2,657,333

Total Population inside State of Qatar
June 2022

176.225 Billion QR

GDP at Current Prices
Third Quarter 2021

101.77 point

Consumer Price Index (CPI)
April 2022

93.32 Points

Producer Price Index
January 2022

About the country

Because of its high-level living standards, Qatar has become a favorable place to live and work for hundreds of thousands of skillful manpower coming from all over the world. This has rendered the Qatari society and consequently the schools' environment into a multicultural heterogeneous one.

The starting point of the school

Qatar National Vision 2030:

To transform Qatar into a knowledge-based economy characterized by sustainable development based on research, development and innovation, excellence in entrepreneurship and high-level education.

Studies about the needs in Qatar

WISE Conference

Allowing educational organizations to deliver customized learning programs that fulfill males' educational needs instead of providing general educational programs

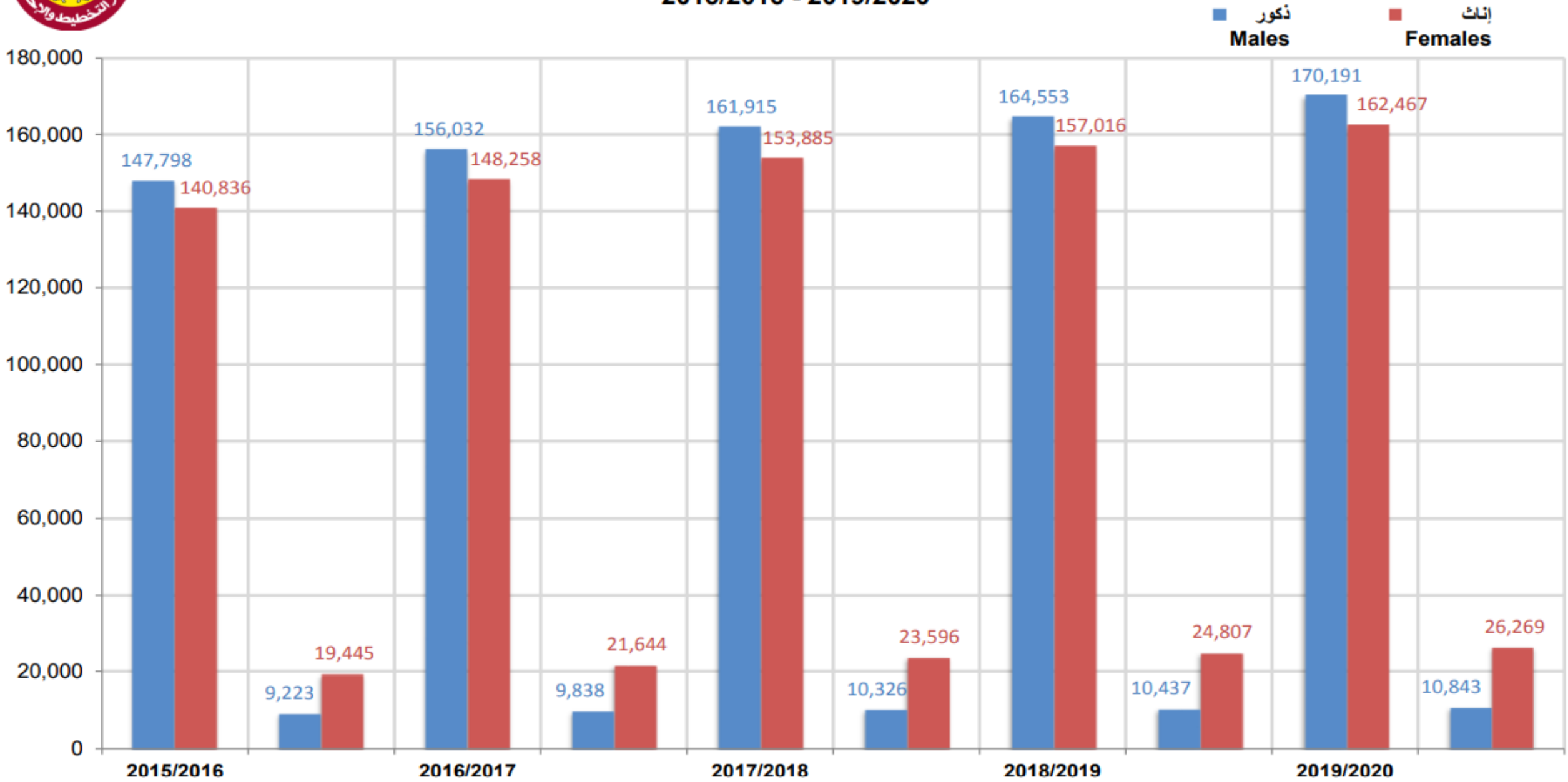
The World Bank

Importance of increasing the enrollment in tertiary education and increasing the published scientific research

PISA Recommendations

Enrichment of curriculum with breakthroughs in science and mathematics

الطلاب في المدارس والجامعات الحكومية والخاصة حسب النوع
STUDENTS IN PUBLIC AND PRIVATE SCHOOLS AND UNIVERSITIES BY GENDER
2015/2016 - 2019/2020



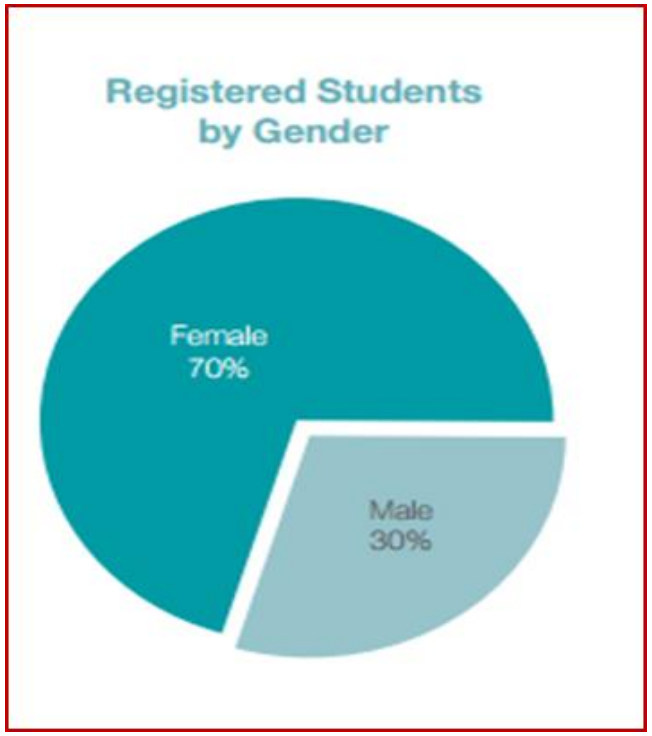
طلاب الكليات والجامعات الحكومية[1] حسب الكلية والنوع
٢٠١٥/٢٠١٦ - ٢٠١٩/٢٠٢٠

STUDENTS OF PUBLIC[1] COLLEGES AND UNIVERSITIES BY COLLEGE AND GENDER
2015/2016 - 2019/2020

TABLE (76)

Year & Gender / College	2019/2020		2018/2019		2017/2018		2016/2017		2015/2016	
	إناث Females	ذكور Males	إناث Females	ذكور Males	إناث Females	ذكور Males	إناث Females	ذكور Males	إناث Females	ذكور Males
Education	2,257	138	2,095	132	1,929	74	1,694	85	1,413	62
Art and Science	5,796	971	5,504	1,005	5,389	1,091	5,058	1,064	5,387	1,000
Sharia	778	109	845	143	956	177	843	200	616	188
Engineering	1,770	1,460	1,615	1,334	1,443	1,389	1,442	1,396	1,400	1,467
Administration & Economics	3,423	1,232	3,269	1,274	3,214	1,288	3,203	1,345	2,808	1,172
Law	1,431	481	1,306	472	1,147	445	947	400	806	347
Pharmacy	226	0	196	0	204	0	177	0	167	0
Medicine	279	114	215	86	169	61	126	46	64	23
Health Sciences	505	0	503	0	509	0	456	0	_	_
Dentist	25	8	_	_	_	_	_	_	_	_
Courses Study	117	49	186	66	136	108	201	84	253	89
Postgraduate studies Qatar University	814	478	751	477	706	445	642	395	571	386
Community College	3,717	1,327	3,789	1,331	3,568	1,613	3,248	1,323	2,655	1,043
Ras Laffan Emergency and Safety College	13	157	2	141	1	38	1	50	_	_
Jossor Institute / Higher Diploma Bocconi College	40	37	_	_	_	_	_	_	_	_
Qatar Leadership Center / Executive Master McDonough School of Business	10	15	_	_	_	_	_	_	_	_
Total	**21,201**	**6,576**	**20,276**	**6,461**	**19,371**	**6,729**	**18,038**	**6,388**	**16,140**	**5,777**

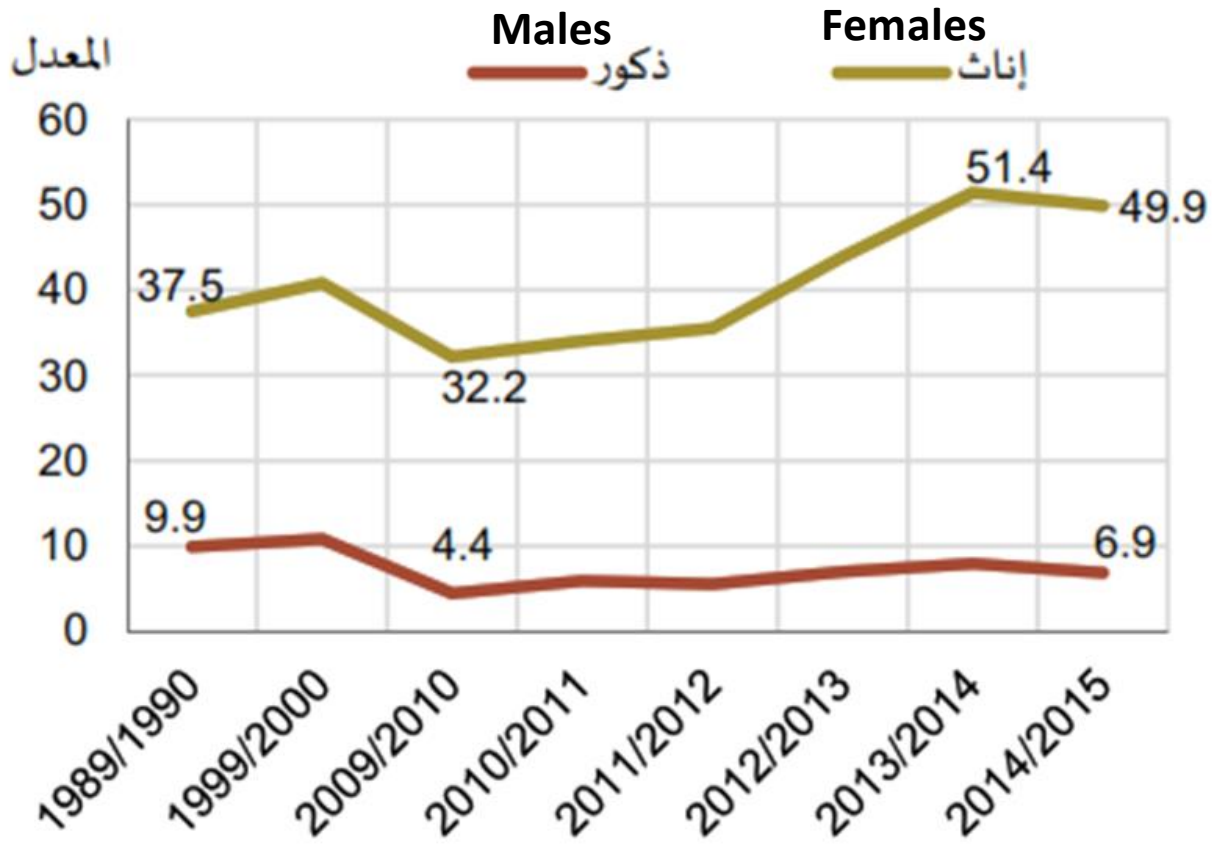
Why we started with “Boys” school



Qatar University

The Enrollment rate according to gender (1989/1990 – 2014/2015)

شكل رقم (٢/٦): معدل الالتحاق الإجمالي حسب الجنس (١٩٨٩/١٩٩٠ – ٢٠١٤/٢٠١٥)



خريجو الجامعات والكليات الحكومية حسب الدرجة العلمية والجنسية والنوع
٢٠١٩/٢٠٢٠

GRADUATES OF PUBLIC COLLEGES AND UNIVERSITIES BY ACADEMIC DEGREE, NATIONALITY AND GENDER
2019/2020

TABLE (78)

Academic Degree / Nationality & Gender		المجموع Total			غير قطريين Non-Qataris			قطريون Qataris		
		المجموع Total	إناث Females	ذكور Males	المجموع Total	إناث Females	ذكور Males	المجموع Total	إناث Females	ذكور Males
Pre-University Diploma										
	Community College	652	433	219	37	27	10	615	406	209
	Ras Laffan Emergency & Safety College	19	0	19	0	0	0	19	0	19
Bachelor										
	B.A In Education	331	324	7	98	94	4	233	230	3
	B.A In Art & science	955	792	163	243	183	60	712	609	103
	B.A In Sharia & Islamic Studies	81	61	20	36	20	16	45	41	4
	B.Sc. In Engineering	427	205	222	284	95	189	143	110	33
	B.Sc. In Admin, & Economics	811	582	229	194	112	82	617	470	147
	B.Sc. In Law	239	177	62	24	16	8	215	161	54
	B.Sc Health Sciences	91	91	0	75	75	0	16	16	0
	B.Sc. Pharmacy	21	21	0	21	21	0	0	0	0
	B.Sc. Ras Laffan Emergency and Safety College	13	0	13	1		1	12	0	12
Diploma										
	Primary Education	30	30	0	8	8	0	22	22	0
	Special Education	12	5	7	9	2	7	3	3	0
	Jossor Institute / Higher Diploma Bocconi College	77	40	37	45	22	23	32	18	14
Masters										
	Applied Statistics	6	4	2	6	4	2	0	0	0
	Arabic Language & Literature	5	4	1	1	0	1	4	4	0
	Environmental Sciences	8	7	1	6	6	0	2	1	1
	Material Sci and Technology	10	5	5	10	5	5	0	0	0
	Accounting	16	12	4	11	8	3	5	4	1
	Business Administration	29	21	8	14	10	4	15	11	4
	Marketing	20	16	4	15	12	3	5	4	1
	Curriculum,Instruc. & Assessm.	6	5	1	2	2	0	4	3	1
	Education Leadership	8	8	0	2	2	0	6	6	0
	Master of Special Education	1	1	0	1	1	0	0	0	0
	Special Education	9	6	3	4	1	3	5	5	0

To fulfill the requirements of Qatar vision, the MOEHE set a major goal to provide the learners with high quality educational experiences and to implement a lifelong learning for all students. To implement the education reform, the MOEHE started establishing several government-funded STEM Schools over a multi-year period and implements annual assessments to measure student learning and school performance.

مـدرســة قـطـر لـلـعـلـوم و التـكـنـولـوجـيـا الثـانـويـة لـلـبـنـيـن
Qatar Science & Technology Secondary School for Boys

مدرســة قـطـر لـلـعـلـوم والتـكـنـولـوجـيـا الثـانـويـة لـلـبـنـيـن
Qatar Science & Technology Secondary School for Boys

www.qstssboys.qa | E: qsst.boys@edu.gov.qa | Tel: +974(40362888)

About the school: Here we are

Who we are?

Qatar Science & Technology Secondary School for Boys (QSTSS), is a one-of-a-kind specialized STEM governmental school in Qatar that runs under the umbrella of the Ministry of Education & Higher Education (MOEHE).

QSTSS was launched in August 2018, and it offers a trans-disciplinary STEM program that focuses on hands-on science skills, creativity and innovative thinking, which will allow students to apply their knowledge to real-world challenges using cutting edge technologies. Students have access to specialized laboratories, led by highly-qualified STEM teachers, engineers and experienced educators.

STEM Science, Technology, Engineering, Mathematics

Vision & Mission

Vision:

Empowering students to develop the 21st century skills and preparing them to contribute effectively to building a national economy that relies on knowledge along with scientific and technological advancements.

Mission :

To provide innovative, engaging and challenging learning experiences in science, technology, engineering and mathematics in an interdisciplinary way that enables students to develop their skills in research, design, critical thinking and problem solving, and contributes to building their creativity and competitive capabilities globally.

School Goals

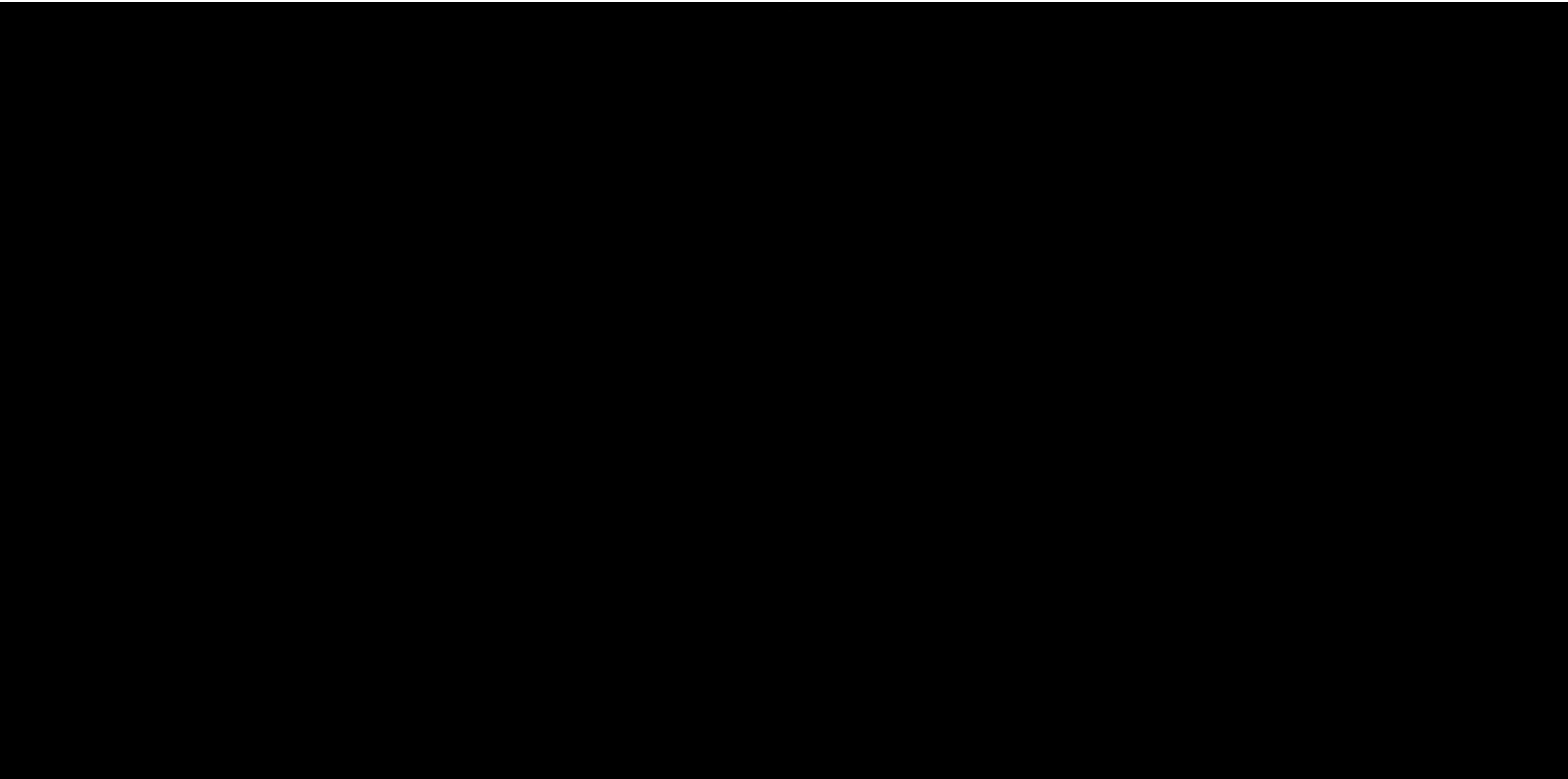
1. Provide learning outcomes that possess 21st century skills to build a knowledge-based national economy

2. Deliver a high quality educational level in science, technology, engineering and mathematics

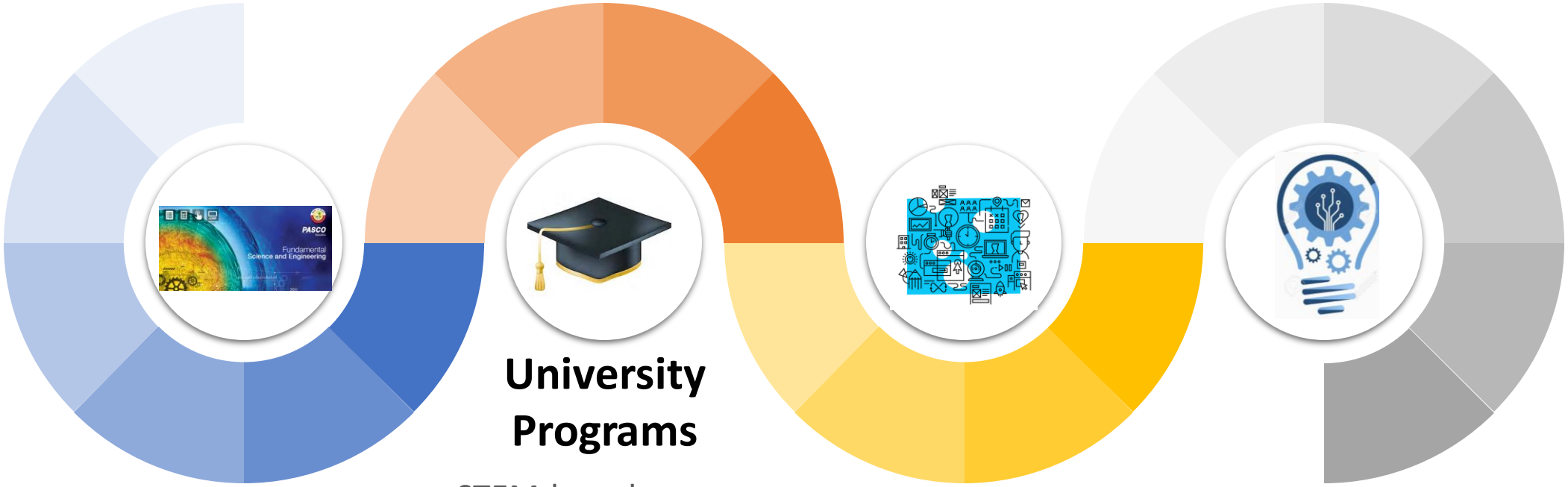
3. Prepare students to join the most prestigious universities that qualify them to become distinguished scientists, researchers and inventors.

4. Reinforce Islamic values as well as the national and ethical values among students

QSTSS Video



QSTT STEM Programs



Fundamentals of Science & Engineering

Science-oriented STEM textbook that integrates the four pillars of STEM with the focus on Engineering design process

University Programs

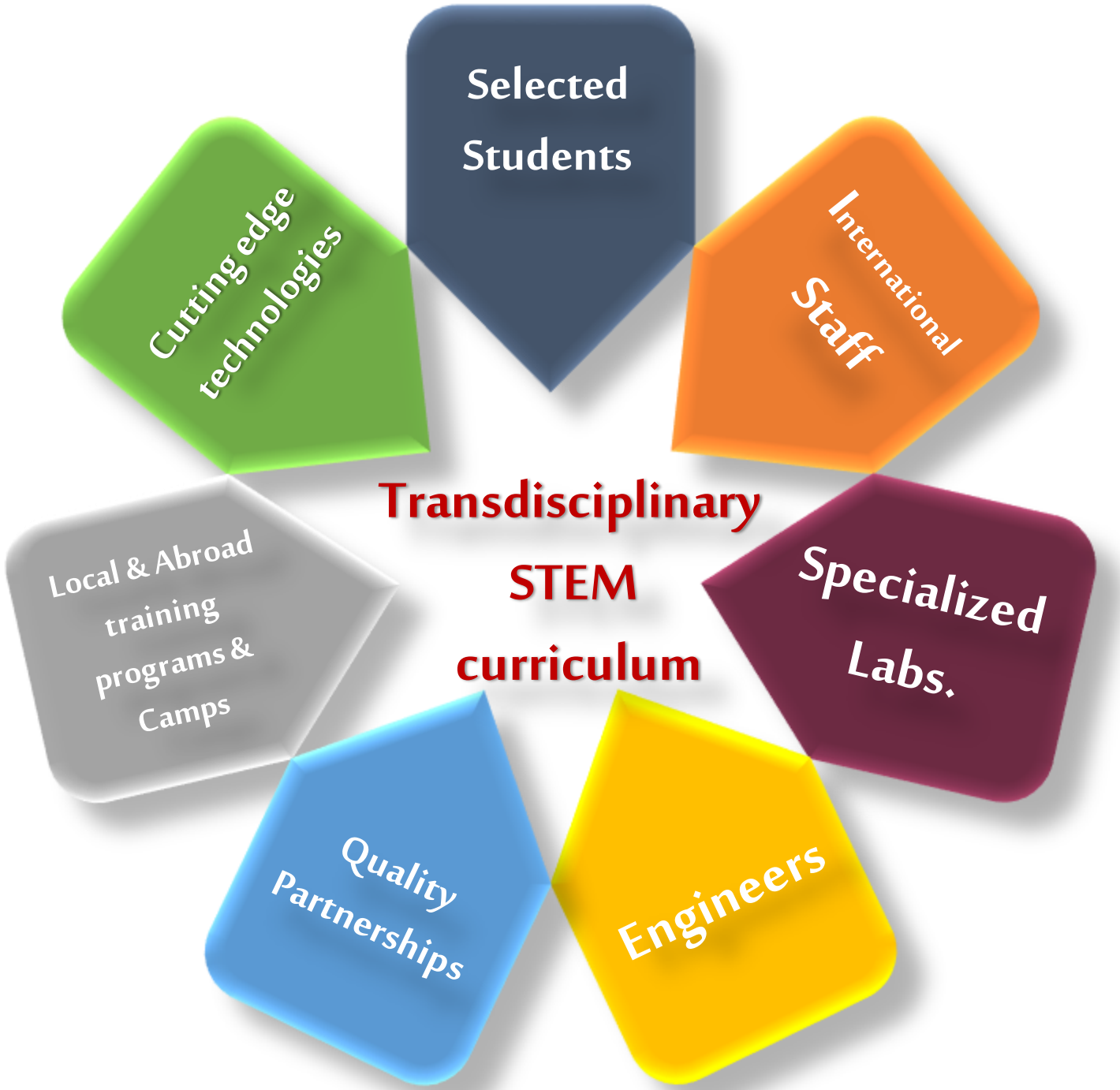
STEM-based projects designed and delivered by partner universities

Lab Applications

Project-based learning in the specialized labs focusing on the alignment between the labs curriculum and STEM lessons.

Researches & Projects

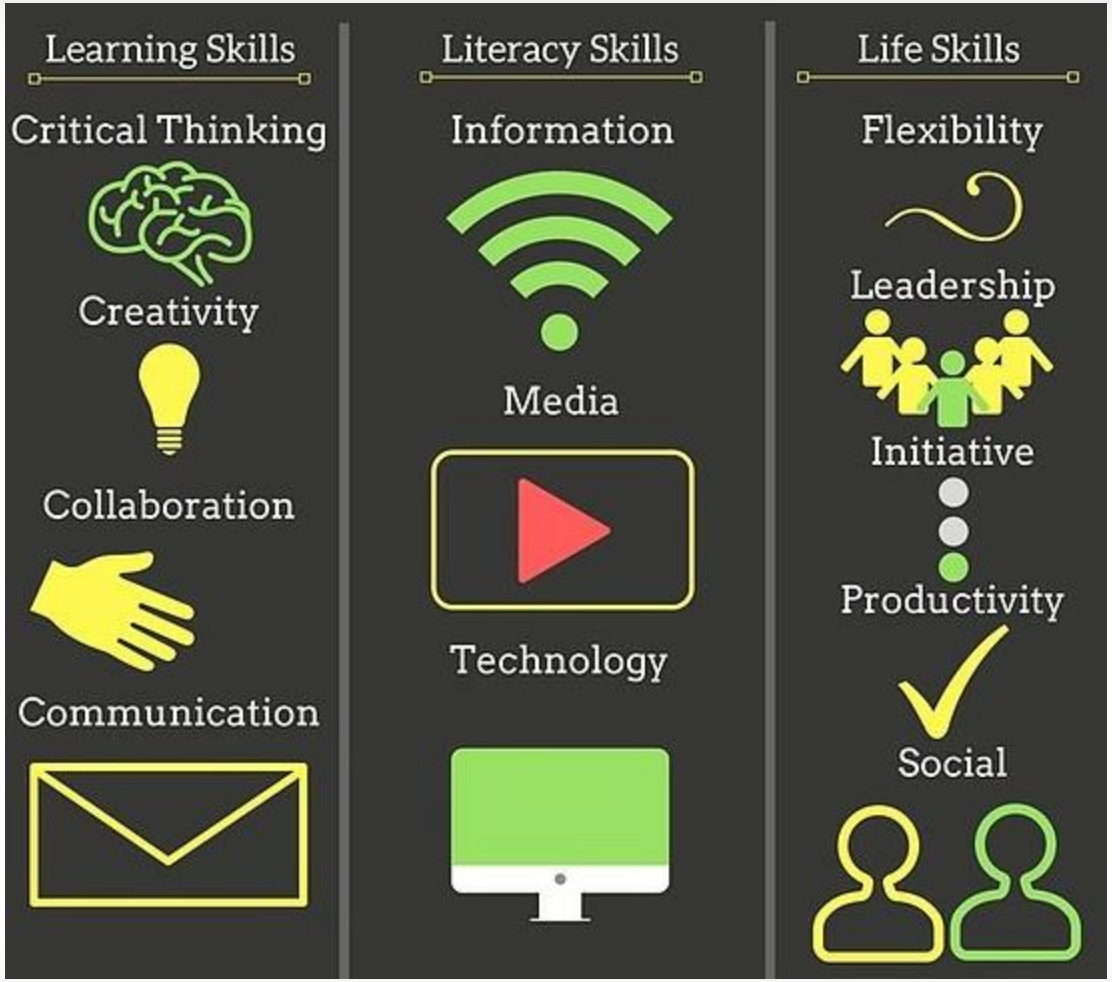
Problem-based learning experiences that allow students to apply their STEM acquired skills and knowledge to real-life applications through extended researches and projects.



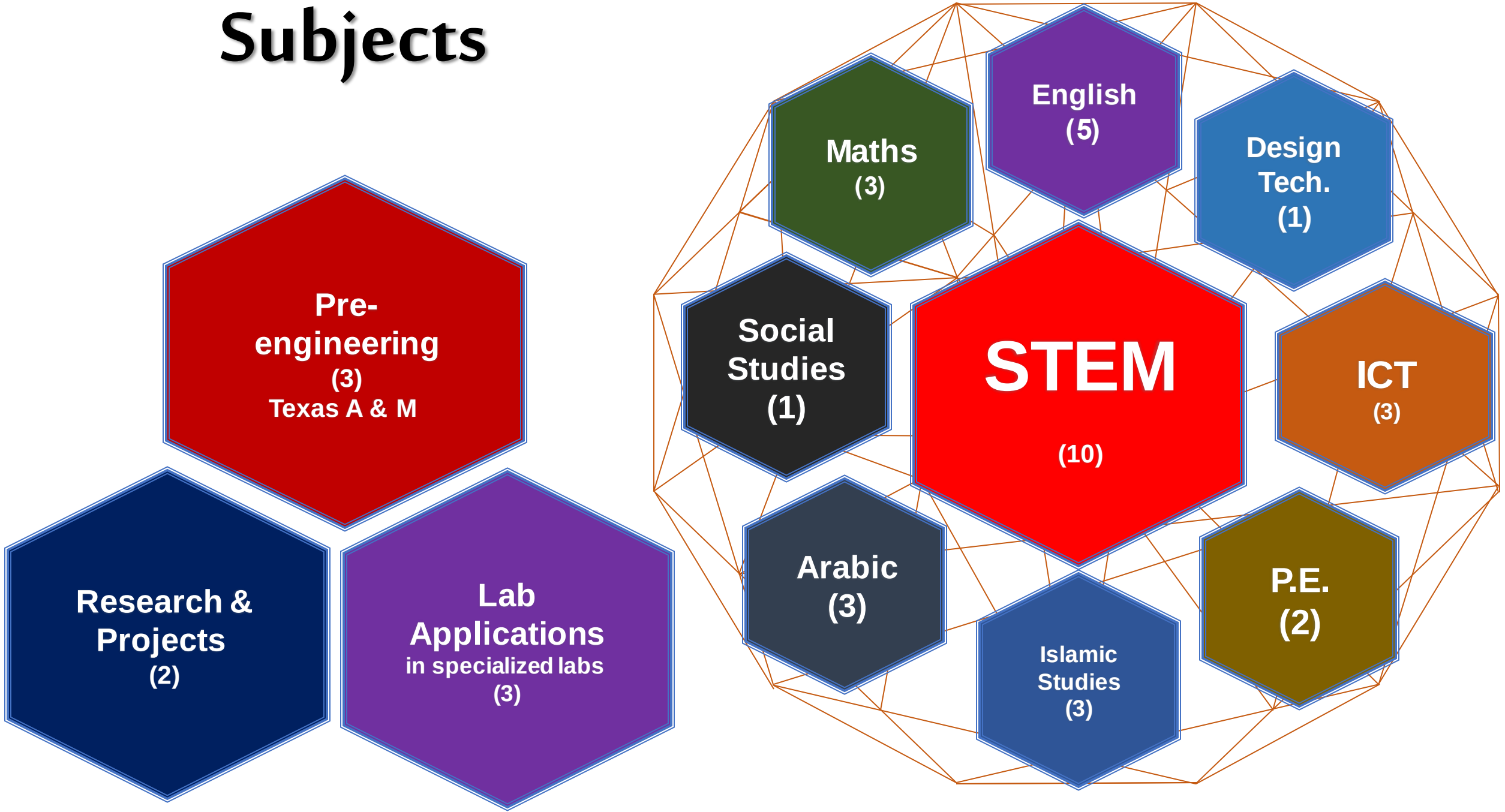
What is Special about the School?

مهارات القرن الواحد والعشرين

21st Century Skills



Subjects


Pre-engineering (3) Texas A & M
Research & Projects (2)
Lab Applications in specialized labs (3)
Maths (3)
English (5)
Design Tech. (1)
Social Studies (1)
STEM (10)
ICT (3)
Arabic (3)
Islamic Studies (3)
P.E. (2)

Generally, students at QSTSS use technology to:

1

Gather, evaluate, and/or use information for learning

2

Conduct research, solve problems, and/or create original works for learning

3

Communicate and work collaboratively for learning

Specialized Labs

مختبر الواقع المعزز

Augmented Reality Lab

Allows students to use the Z-Space devices to learn scientific concepts using 3D models and augmented reality technology

Specialized Labs

مختبر الطاقة

Energy Lab

Allows students to learn about energy sources and solutions for renewable energy such as wind energy and solar energy

Specialized Labs

مختبر الروبوت

Robotics Lab

Allows students to learn about the construction of robots and programming as well as the automation of processes.

Specialized Labs

مختبر التصنيع

Fabrication Lab

Allows students to learn about the principles of invention, engineering design, manufacturing and development of products.

Specialized Labs

مختبر تكنولوجيا المعلومات

Information Technology Lab

a fully equipped computer lab in order to serve the educational integration with the other subjects and scientific research

Specialized Labs

مختبر الحقيقة الافتراضية

Virtual Reality Lab

Allows students to use virtual reality glasses to learn different concepts in an interactive way.


VIRTUAL
REALITY
Lab

Specialized Labs

المكتبة الرقمية
Digital Library

The digital library allows students to enhance their reading and research skills by providing access to a range of digital resources.

مختبرات العلوم
Science Labs

The labs are equipped with specialized materials which provide an effective learning environment enabling students to keep abreast of the scientific and technological progress in all fields.

معمل اللغات
Language Lab

The language lab is equipped with state-of-the-art computers and headsets which enables students to improve their English language skills through interactive and fun activities.

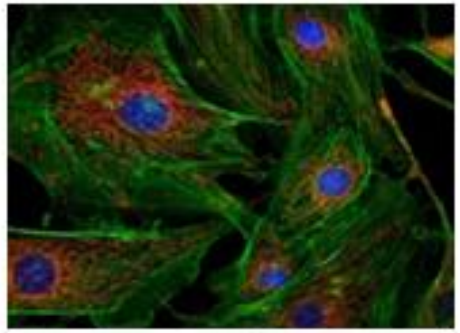
Course Description

Biotechnology and Biomedical Engineering

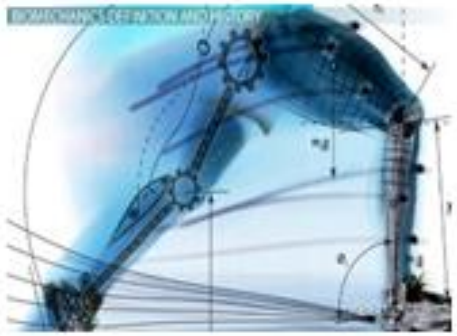
QSTSS

Biomedicine and Biotechnology Lab (BBME)

BIOTECHNOLOGY



MICROSCOPY



BIOMECHANICS

BIOSENSORS

BIOINFORMATICS

Course Description

The BBME curriculum includes 5 major strands (biotechnology, microscopy, biosensors, biomechanics, and bioinformatics). Under each of these strands there are several themes comprising the different topics of the course. All course strands and themes are well represented in all grades 9, 10, 11, and 12. However, there is more emphasis on projects-based learning in grade 12.

BACKGROUND

For a period of 4 years from grade 9 to grade 12, the students at QSTSS are exposed to different learning experiences in the fields of biotechnology, microscopy (microtechniques and digital imaging), biomechanics, biosensors, and bioinformatics. These five strands will be collectively referred to as Biotechnology and Biomedical Engineering (BBME).

What is it?

Traditionally, bioengineering is being only taught at the undergraduate level. However, the last ten years has seen a tremendous increase in the number of undergraduate institutions offering bioengineering degrees. The popularity of bioengineering is rapidly growing. According to recent statistics, bioengineering has shown a 72% growth in jobs between 2008 and 2018. This has stimulated us to initiate a biotechnology and biomedical engineering program at the school level.

The BBME course merges analysis and design principles from mechanical, electrical, and chemical engineering disciplines with the experimental methods from biology-based disciplines of life sciences and medicine such as anatomy and physiology.

OBJECTIVES

The main objective of this course is to enable the students to utilize engineering applications and advanced technology to solve complex biological and medical problems.

Subject: Biotechnology and Biomedical Engineering (BBME)					
STRANDS	**Biotechnology**	**Microscopy**	**Biosensors**	**Biomechanics**	**Bioinformatics**
THME 1	Genetic Engineering and Transformation	MICROTECHNIQUES	Biopotentials: Cell Membrane Modelling Using Sensors for biometric data collection	Gait Analysis	Using Biological Databases
THME 2	Forensic Medicine	Image Processing Techniques (IPT)	Designing sensors for biometric data collection	Sports Biomechanics	BLAST Bioinformatics – Primers Design & In silico PCR
THME 3	Biomedical Science, Neurobiology & Immunology	Tissue Culturing & Fluorescent Microscopy	Arduino Based Biomedical Project	Prosthetics: working with amputees	Phylogenetic trees and genetic relatedness
THME 4	Project: Designing and Planning a Biotechnology Investigation	Project: Designing and planning an Imaging Experiment	Project: Bio-Micro-electro-mechanical systems (BioMEMS) / Designing and Testing a Sensor	Project: (e.g. Boots design to help athletes)	Project: Designing an Investigation Using Bioinformatics Tools (e.g. Drugs Design using Molecular Docking)

Table 2: BBME course organization into strands and themes.

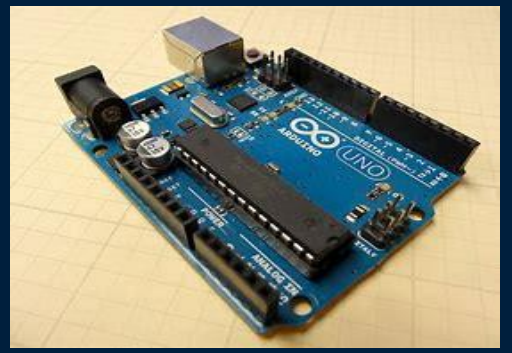
INSTRUCTIONS & TEACHING STRATEGIES

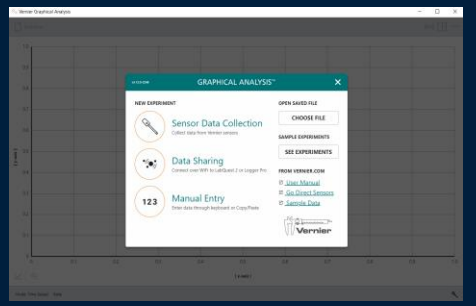
APROACH

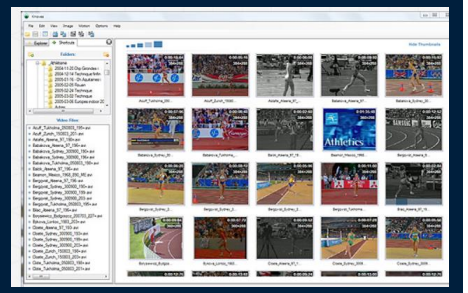
BBME is pure practical and creates the opportunity for students to conduct projects and researches. The overall strategy of the BBME course is to include a variety of learning modules, videos, demonstrations, internet resources and simulations, hand-on activities and active learning techniques to increase student engagement. The course highly relies on hands-on laboratory experiments.

Software Required

- Bioinformatics: Geneious
- Biomechanics: Kinovea
- Molecular: sparkvue
- Arduino IDE
- Python IDLE
- Vernier's LoggerPro
- Vernier's Graphical analysis

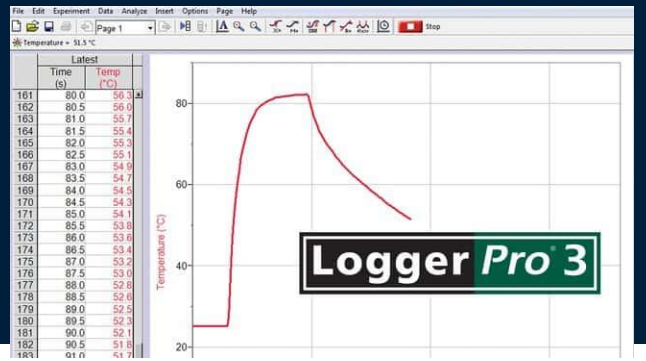






IDLE

SPARKvue Software



geneious

Kinovea

The overall goals of using technology in BBME are to enable the students to :

Use technology efficiently to solve biological and medical life related problems.

Produce technology.

BBME Recommended Timetable

Grade	Weight	Number of periods	Semester	Hrs per year
Grade 9	1.18%	3 periods / 2 weeks	2nd semester	27 hours
Grade 10	1.18%	3 periods / 2 weeks	1st semester	21 hours
Grade 11	8%	3 periods / week	1st & 2nd	48 hours
Grade12	8%	3 periods / week	1st & 2nd	48 hours

STRAND: BIOMECHANICS				
	THEME 1:	**THEME 2:**	**THEME 3:**	**THEME 4:**
GRADE	**Gait Analysis**	**Sports Biomechanics**	**Prosthetics: working with amputees**	**Designing & Planning an Investigation**
9	• Gait Force Profile Analysis	• Basketball Free-throw Arm Angle Analysis	Biomechanical Arm Muscle Analysis	-
10	• Taking Anthropometric Measurements	Muscle Fatigue Analysis	• Occupational Biomechanics Glove Fatigue Analysis	-
11	• Video Analysis Using Kinovea	• Breathing, Heart Rate, and Knee Motion Analysis • Auto Collision Analysis	• Orthopaedic Implant Mechanical Testing	-
12	• Using 3D Motion Analysis in Gait Analysis and Automobile Analysis	• Sprint Acceleration and Terminal Velocity Analysis	• Virtual Knee Replacement • Anterior Cruciate Ligament (ACL) Reconstruction	**PROJECT: Students Designed**

The Biomechanics Strand:

First, it is important to emphasize that this is an introductory, broad overview biomechanics course developed for students in secondary schools aiming to pursue their education in bioengineering degree programs. The labs are designed to be low cost and applicable in a teaching environment with groups of students rotating through stationary lab setups.

Strand Objectives:

- ✓ Introducing the students to the field of experimental biomechanics.
- ✓ Giving students experience with research techniques in biomechanics.
- ✓ Design image experiment.
- ✓ Initiating a digital media program to train students on motion capture.

Suggested biomechanics projects:

The biomechanics strand at QSTSS has the following labs (some are stationary while others can be performed in the class).:

1) Gait Force Profile Analysis.

2) Basketball Free throw Arm Angle Analysis.

3) Biomechanical Arm Muscle Analysis.

4) Muscle Fatigue Analysis.

5) Occupational Biomechanics Glove Fatigue Analysis.

6) Breathing, Heart Rate, and Knee Motion Analysis.

7) Sprint Acceleration and Terminal Velocity Analysis.

8) Auto Collision Analysis.

9) Orthopaedic Implant Mechanical Testing.

Subject: Biomechanics
Grade: 12 ( )
GAIT ANALYSIS
Book reference: Module 1

Name: Date: / /

Group members:
1. ----------
2. ----------
3. ----------

Basic Concept: Gait analysis can be used to design shoes to solve medical problems.

Objectives: By the end of the lesson (90 min), the students are expected to			
1- Describe and analyze the walking and running gait.	D.K	I.N.E	I.K
2. Use the engineering design cycle to design and produce a shoe.	D.K	I.N.E	I.K

Activity No.	1	Activity type:	Edpuzzle	Target:	Whole class	Time	5 min

Video / Teacher modified

Watch the video on Edpuzzle and answer the following questions.

https://edpuzzle.com/assignments/61f618f7f5487342c44625ed/watch

1- What are the two phases of Gait Cycle?

2- How gait cycle can be useful?

Prelab: Force and Pressure

The students distinguish between force and pressure and be able to calculate them.

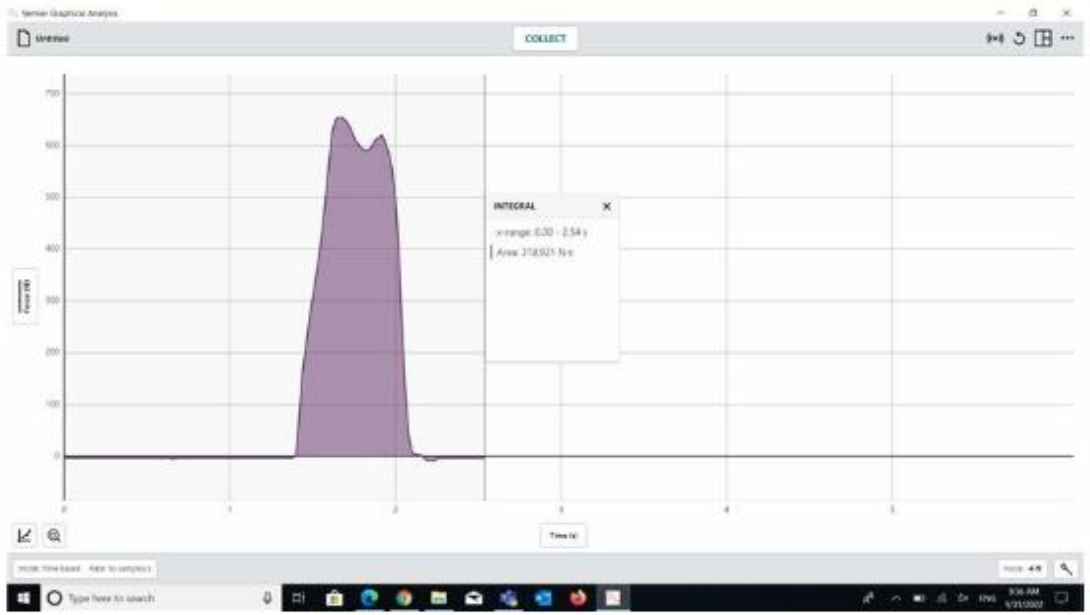
A. Force and Pressure Quiz

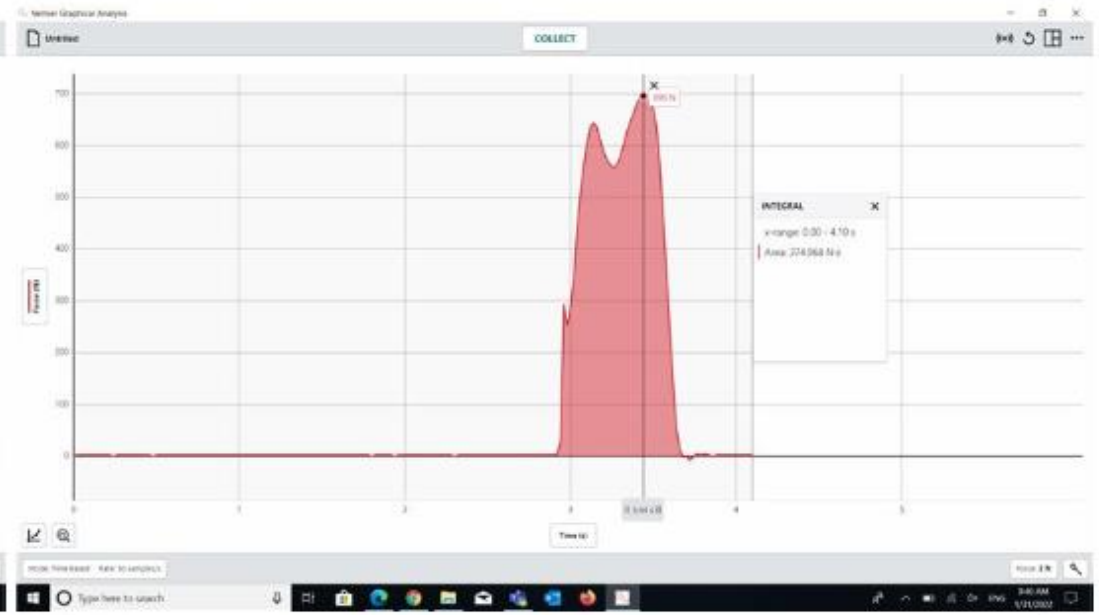
1. **Which would exert a higher force on a scale: A grown elephant or a baby elephant? Why?**

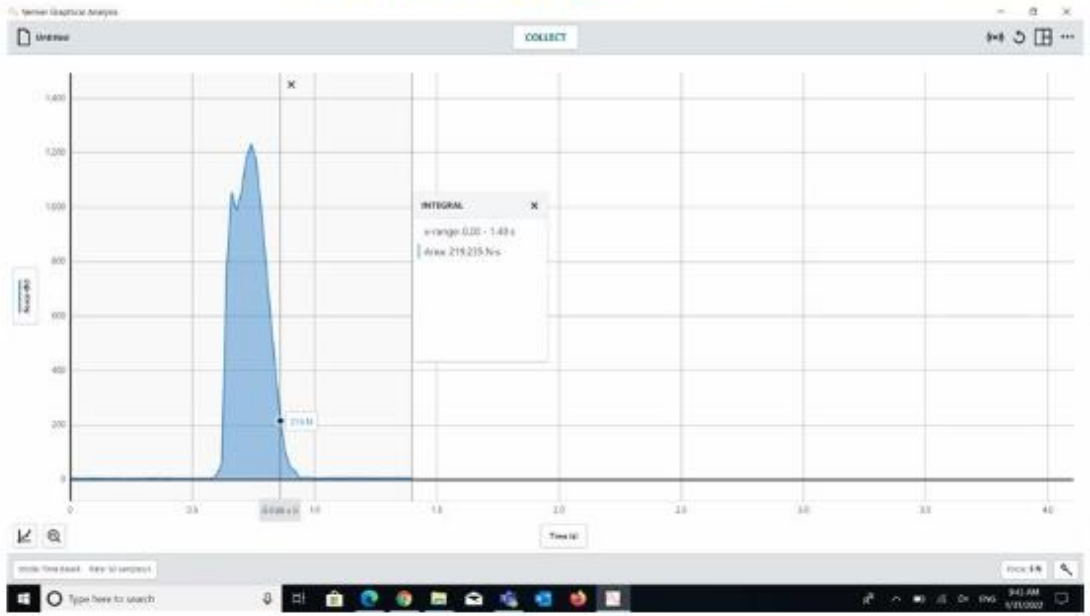
2. **Would an elephant standing on one leg exert a higher force on a scale than an elephant standing on four legs? Why?**

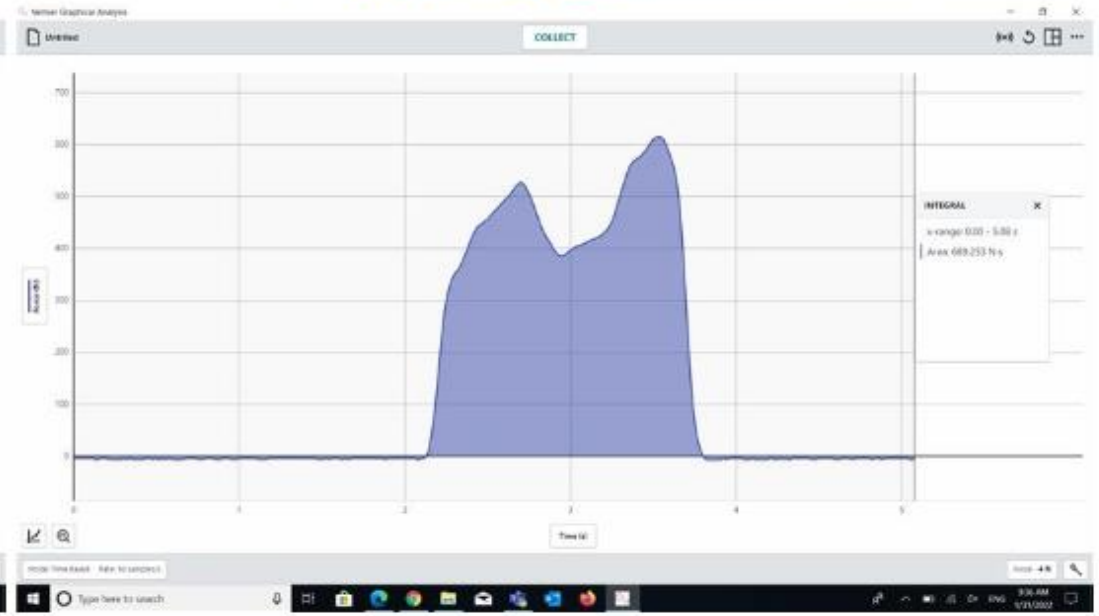
3. **Would an elephant standing on one leg exert a higher pressure on the scale than an elephant standing on all four legs?**

ناصر عبدالله ابراهيم على شهبيك 2/28 7:32 AM



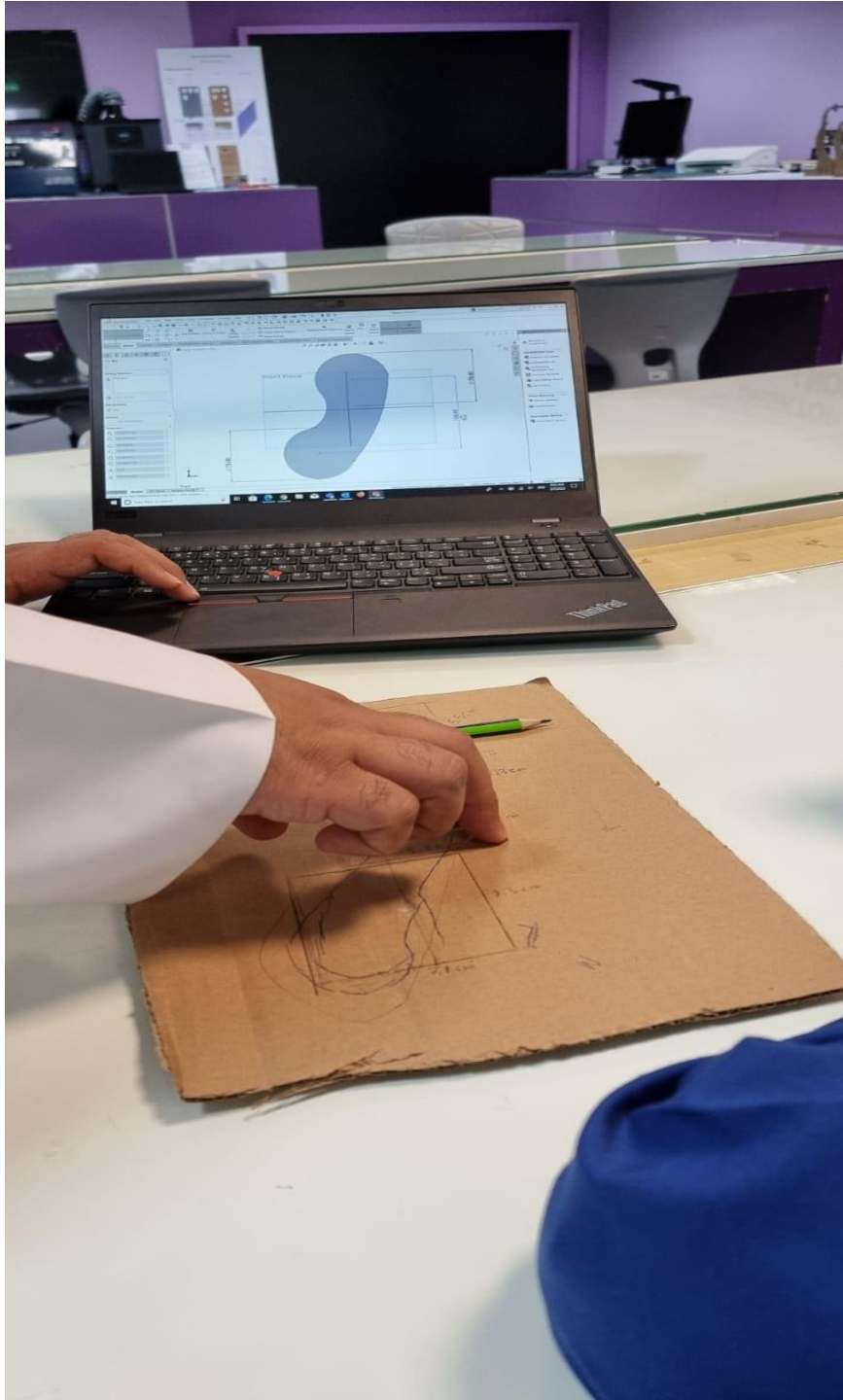


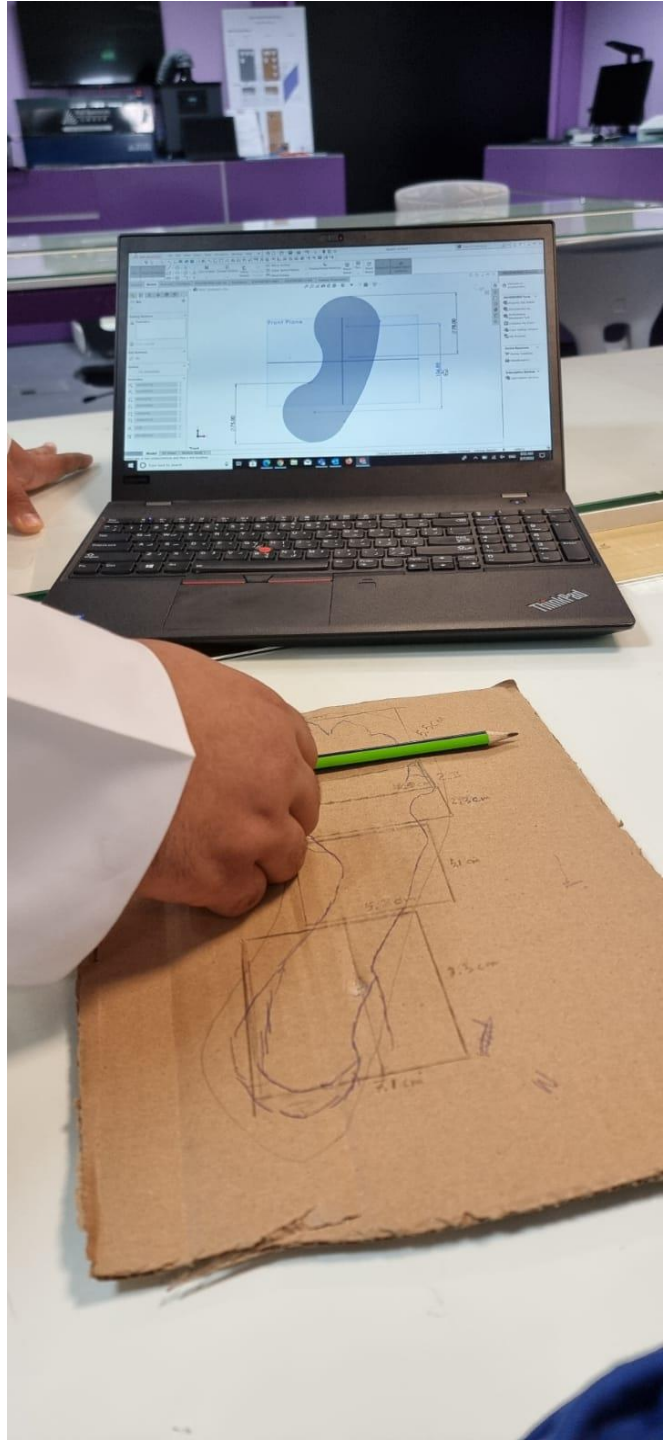




Reply


CAROLINA





Kinovea

File Edit View Image Video Tools Options Help

00000 1920×1080 px 23.98 fps

Folders

- G9 revisions
- Grade reg
- IBO_2022 Trainin
- IJSO 2022
- ImageJ
- Kids
- Kinovea
  - Biomech L1
  - BiomL2
    - biomech3

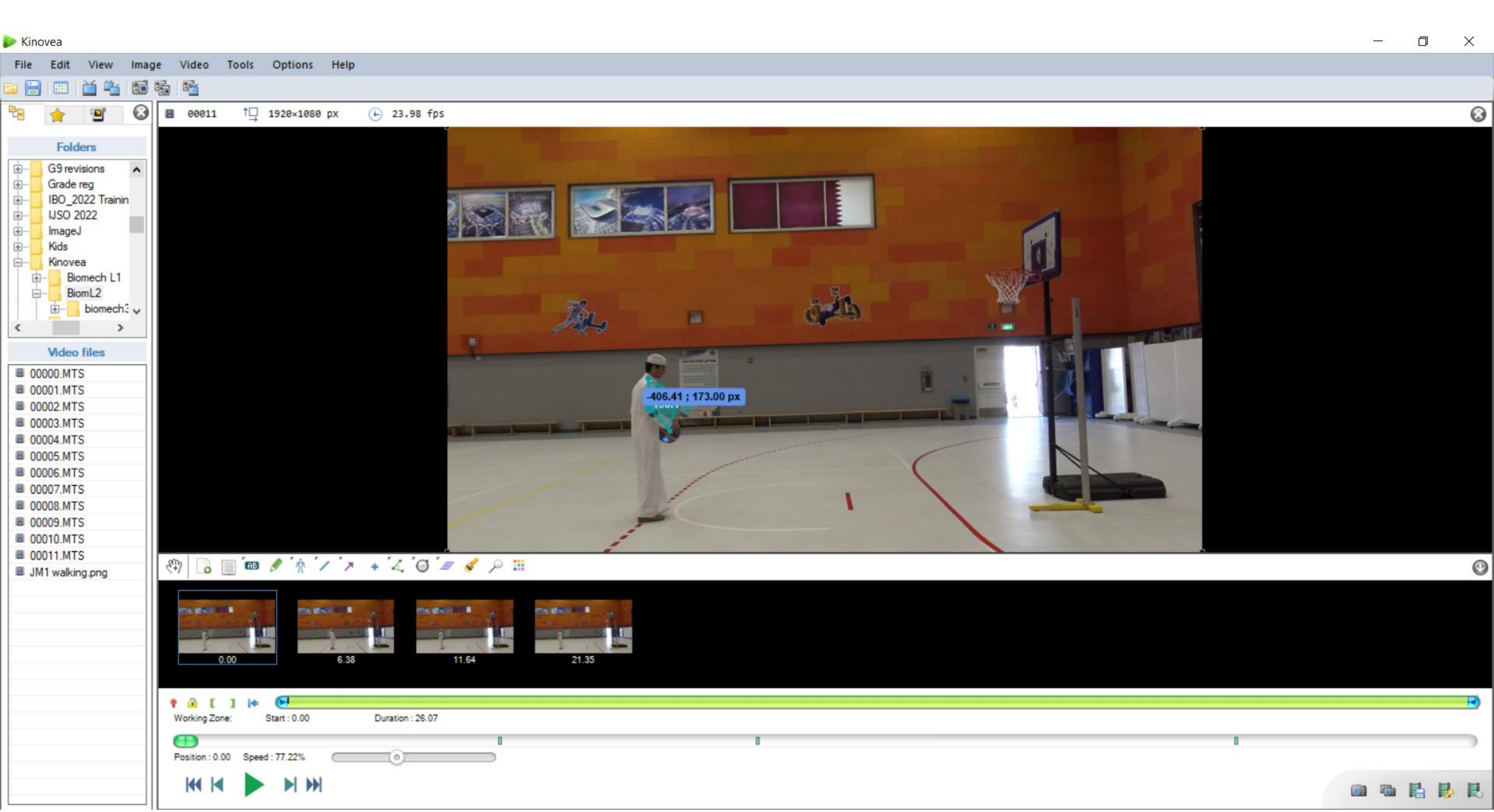
Video files

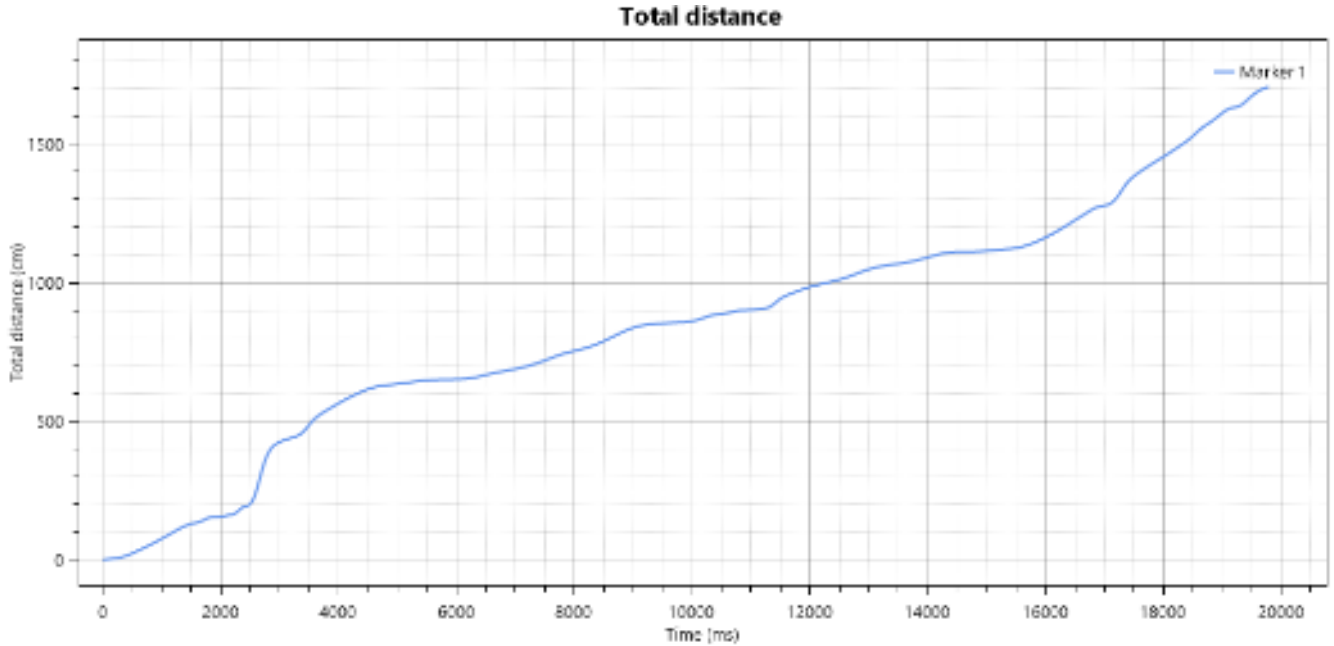
- 00000.MTS
- 00001.MTS
- 00002.MTS
- 00003.MTS
- 00004.MTS
- 00005.MTS
- 00006.MTS
- 00007.MTS
- 00008.MTS
- 00009.MTS
- 00010.MTS
- 00011.MTS
- JM1 walking.png

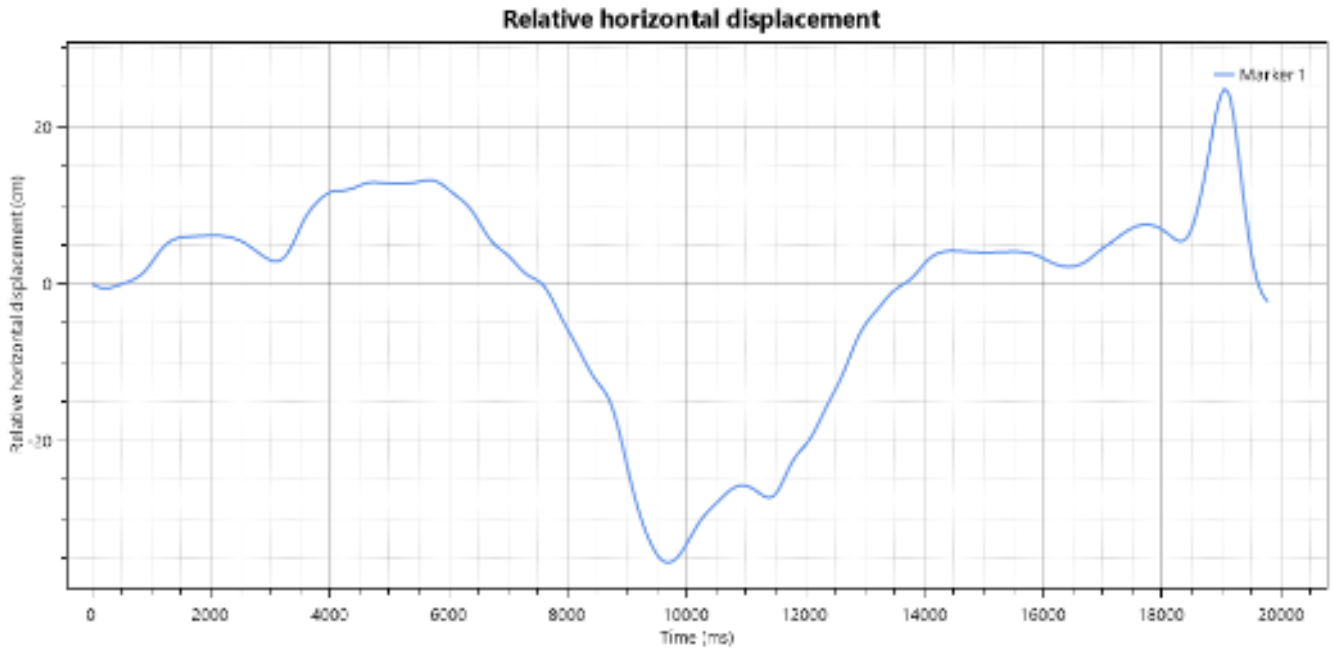
0.00

Working Zone: Start : 0.00 Duration : 22.06

Position : 2.96 Speed : 77.22%


Kinovea
File
Edit
View
Image
Video
Tools
Options
Help
Folders
G9 revisions
Grade reg
IBO_2022 Trainin
IJSO 2022
ImageJ
Kids
Kinovea
Biomech L1
BiomL2
biomech3
Video files
00000.MTS
00001.MTS
00002.MTS
00003.MTS
00004.MTS
00005.MTS
00006.MTS
00007.MTS
00008.MTS
00009.MTS
00010.MTS
00011.MTS
JM1 walking.png
00011
1920×1080 px
23.98 fps
-406.41 ; 173.00 px
0.00
6.38
11.64
21.35
Working Zone:
Start : 0.00
Duration : 26.07
Position : 0.00
Speed : 77.22%


Total distance
Marker 1
Total distance (cm)
1500
1000
500
0
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000
Time (ms)


Relative horizontal displacement
Marker 1
Relative horizontal displacement (cm)
20
0
-20
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000
Time (ms)

STRAND: MICROSCOPY		
	THEME 1:	**THEME 2:**
GRADE	**MICROTECHNIQUES**	**Image Processing Techniques (IPT)**
9	• Specimen Preparation: Dissection Skills (Dissection of Mammalian Organs)	Examination of prepared slides and image acquisition
10	• Specimen Preparation: Dissection Skills (Earthworm/Chicken wings and legs) • Preparing plant samples	Staining of fixed slides and image capturing
11	• Preparing animal samples • Bacterial Growth Curves and Giemsa Stain • Sectioning (Microtomy) -fixation-Staining • Fluorescent Microscopy	• Image Acquisition-Preprocessing-segmentation-Feature extraction-Classification • Medical Imaging: Visit to Hospital • Using Python, OpenCV, and AI in analyzing microscopic images
12	• Animal Tissue Culture Fluorescent Microscopy	• Designing an imaging experiment

Table 4: The main themes and topics covered by the microscopy strand.

The Microscopy Strand:

- This course includes the detailed preparation of the histological samples to be examined under light microscope using the routine H&E stain. The preparation & use of special stains for histological specimens. Other techniques e.g. cytological preparation, E.M, cytochemistry, and immunofluorescence are also discussed.

- This strand includes an introduction to microscopy and microtechniques. It provides the students with the necessary experimental background to prepare a permanent microscopic slide and to carry out a digital-images based investigation. In this course the students go through the killing and fixation methods, dehydration, clearing, embedding, sectioning and mounting. In addition, the staining processes with different types of stains, synthetic and histochemical stains are discussed. the course starts by discussing the principles and various types of microscopy then the students prepare whole mounts, squashes and smears of different specimens. The course reaches the peak by introducing the optical and computational methods of image processing (digital imaging) and their applications in biology.

Strand Objective:

• The objective of the microscopy strand is to enable the students to manage the techniques of preparing microscopic slides, taking microscopic measurements and using digital imaging to process and analyze the microscopic slides. At the end of this course, the student will be able to:

- ✓ Differentiate among various methods of microtechniques.
- ✓ Identify the tools and instruments used in the microtechniques.
- ✓ Preserve & storage of histological specimens.
- ✓ Prepare different types (plants and animal specimens) of glass slides.
- ✓ Prepare all solutions & stains used for processing.
- ✓ Prepare microscopical sections & smears from different body tissues & fluids.
- ✓ Use the vital, histochemical and artificial stains.
- ✓ Prepare the films, squashes and completely mounted slides.
- ✓ Differentiate the different types of microscopes and their uses in the field of biology.
- ✓ Apply digital photography in microscopy.

Strand Outcomes:

The student should be able to prepare a variety of cytological & histological preparation, the required solutions, identification of common encountered technical errors & application of immediate remedies & prevention

After finishing this course, students should be able to:

- prepare temporary microscopic slides, using different cutting techniques.
- Prepare permanent microscopic slides using paraffin method.
- Perform microscopic measurements using image analyzing software.

Strand Topics:

• The microscopy strand comprises two obligatory themes (microtechniques and image processing techniques) and two elective themes (tissue culture and fluorescent microscopy). The following topics will be covered in this strand:

Microtechnique:

1. Preparing plant and animal materials for microscopic slides: preparing wet mount (onion, elodea, cheek, tomato, frog liver…etc.).
2. Types of microscopic slides.
3. Sectioning methods.
4. Types of microtomes and their principles of work.
5. Microscopy – slide preparations of animal and plant tissues – microtomes – sectioning – and staining
6. Methods of temporary microscopic slides: maceration and squash methods
7. Methods of permanent microscopic slides: paraffin method. Special methods.

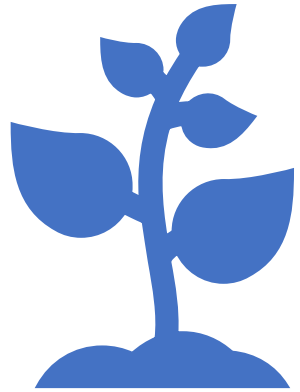
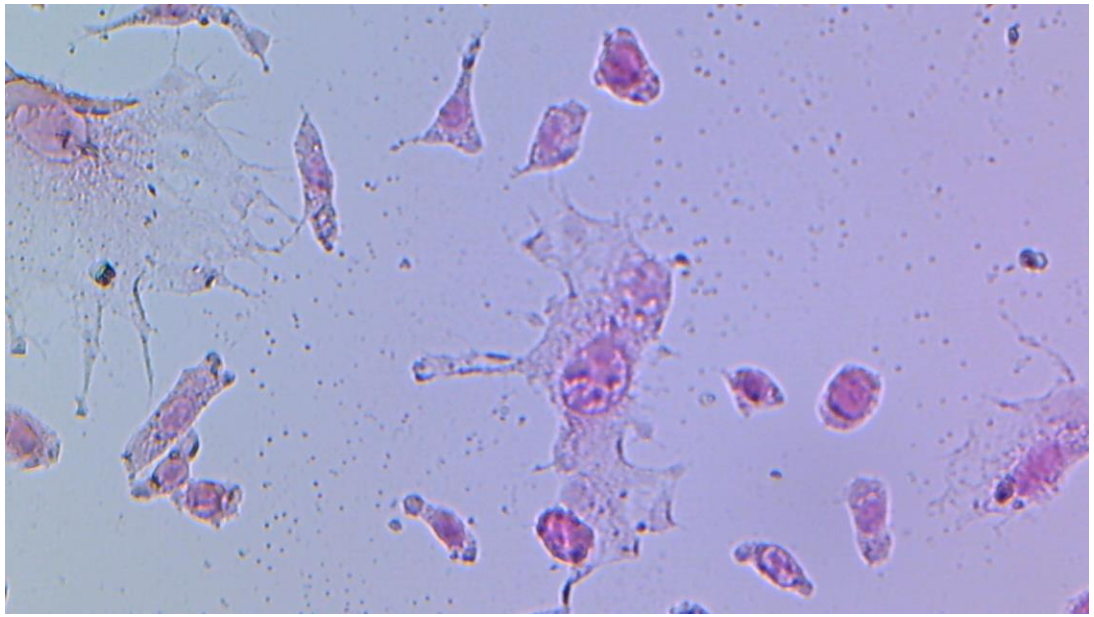
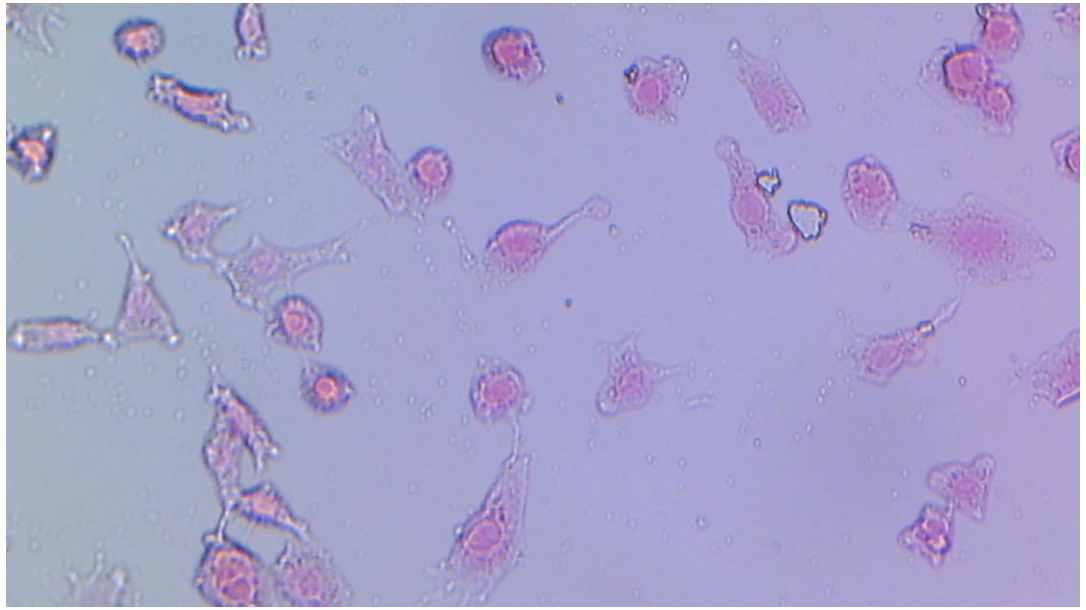
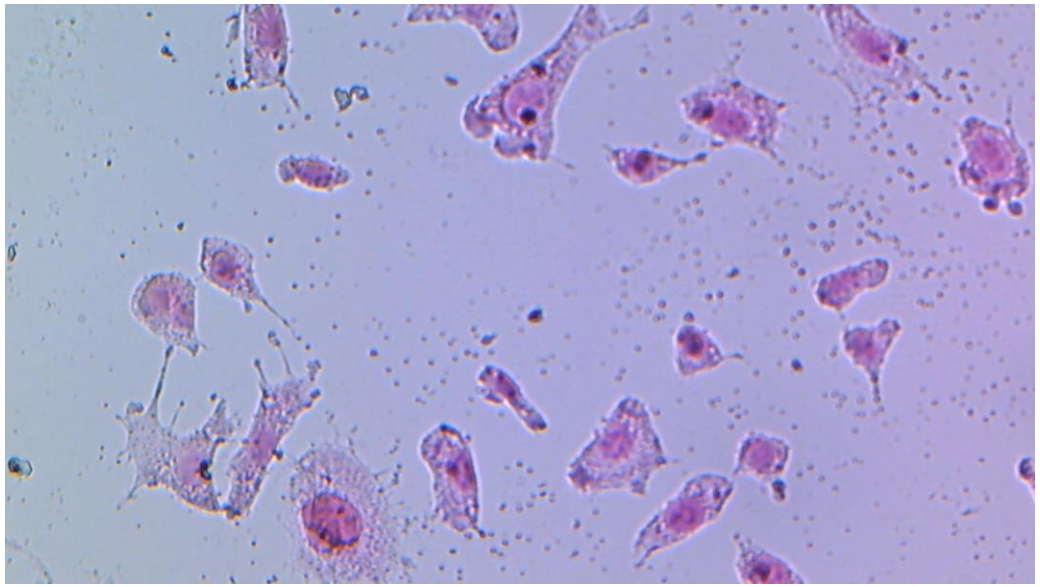


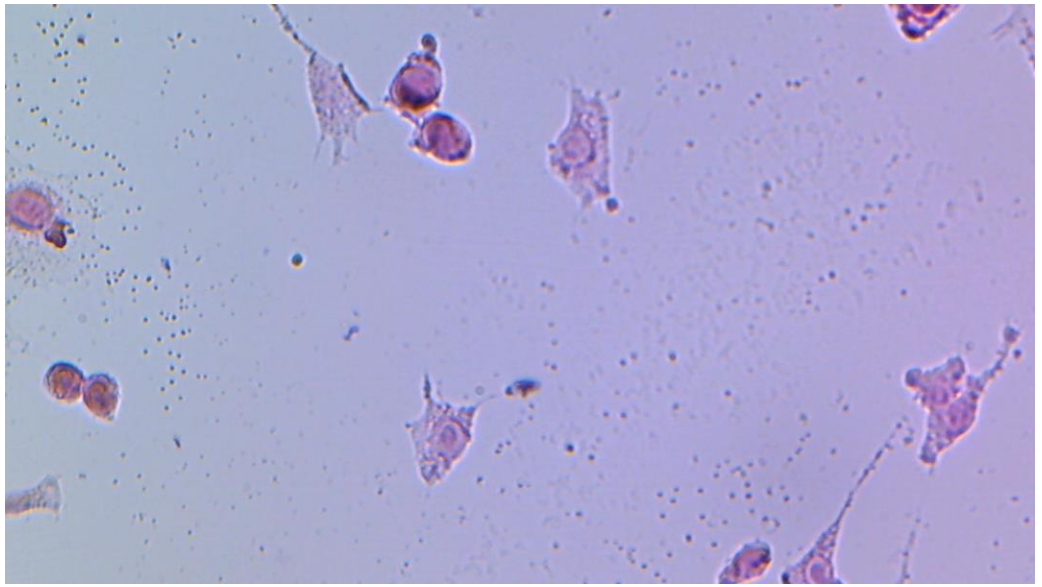
Image Processing Techniques:

1. Using Image processing techniques to interpret the images: filtering, feature extraction, artificial intelligence and machine learning, Python and OpenCV.
2. Perform microscopic measurements: Methods of microscopic measurement and data processing (standard and stereological method; measurements using Image Analyzing System and light microscope).
3. Basic histological methods.









Cancer Epithelial Cells Identification in Microscopic Images Using Image Processing Techniques

Research Problem

- How can OpenCV, python, and machine learning be used to detect and identify the BC cells?
- image processing techniques were used to detect and identify breast cancer cells in microscopic images. Better identification methods of cancer cells will help in the diagnosis and prognosis of BC.

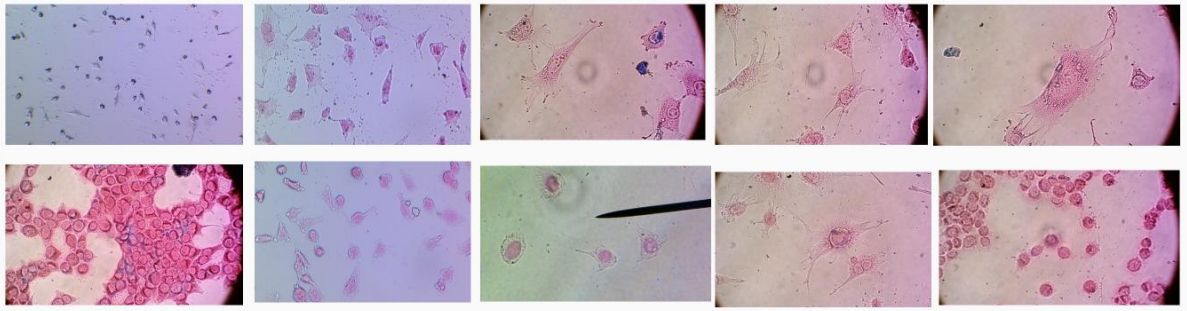
Project Idea

We assume that breast cancer cells are morphologically different from normal healthy cells and these differences can be used by OpenCV, python, and machine learning to distinct them from healthy cells.

Scientific Theory

The objective of the current research is to utilize image processing techniques to analyze microscopic images to contribute to a better understanding, diagnosis and prognosis of breast cancer. More precisely, the present study aims at evaluating the usage of OpenCV, python, and machine learning to differentiate between cancer and normal cells.

Photos of cancer and Normal Cells



Experimental Design & Design tools

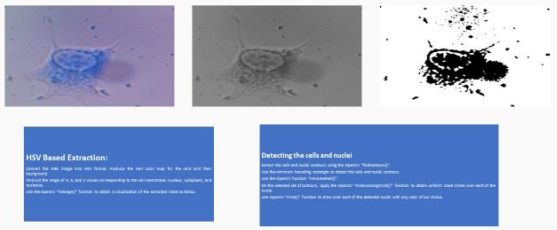
The methodology adopted in this study can be divided into 4 parts:

I. Microscopic slide preparation. II. Image taking and pre-processing. III. Cells detection.

IV. Features extraction V. Using python OpenCv for image segmentation and extraction.

VI. Using AI and machine learning to identify the cells.

Results



Criteria	Normal epithelial cells	Cancer cells
Shape	Uniform, compact	Random shapes, irregular, larger cells, disorganized arrangement
Nucleus shape	Spheroid, uniform with smooth appearance, single	Random, irregular, misshapen, bulges can often be observed in cells' nuclear membranes, many.
Nucleus size	Small	Larger
Spreading of cells	Some spreading	Very spread cells
Cell-cell contact	Many cell-cell junctions	Fewer cell-cell junctions
Contact inhibition	more contact form a monolayer	No inhibition, does not form uniform monolayer
chromatin	fine, evenly distributed	coarse aggregates of irregular clumps that vary in both size and shape.
Nucleolus	Smaller, regular, one nucleolus per nucleus	increasingly enlarged and more irregular, multiple nucleoli.
Cytoplasm	Large volume	Small volume

The overall accuracy of supervised machine learning in identifying the cancer cells was 85%. This percentage could be raised if a dataset with a larger size was used. We tried different segmentation and extraction methods, among which separating the cells from image background at the level of image pixels was the most efficient.

Importance of Project

-The high incidence of BC in Qatari females and the advances in image processing techniques has stimulated us to deploy it in processing and identification cancer cells in microscopic images.

-The project specifically aims at improving the methods of early detection, prognosis, and development of cancer cells as this would increase the survival rates of BC patients.

-Moreover, it would contribute to a better understanding of the mechanisms of tumor development as many questions related to breast cancer still unsolved.

-The results of the research will also benefit the cancer patients because the morphology of the cancer cell has implications on the treatment and prognosis of the cancer.

-Identification of tumor cells in a sample consisting of mixed tumor and normal cells is a major challenge for pathologists especially if the percentage of tumor cells is low.

-The frequency of errors in identifying the disease in histologic or cytologic specimens by pathologists ranges from 1% to 43% and the error percentage in tumor specimens identification ranged between 1% to 5%. This high percentage of misidentification of the cells can have serious consequences on the treatment plan for cancer patients.

Conclusion or Recommendations

Based on the study results, we recommend the following:

1. Using automated analysis for digital microscopic image in cancer diagnosis instead of manual traditional methods specially when the amount of cells available is few and / or the slide contains mixed cells of normal and cancer cells.
2. Using a dataset with a larger size.
3. The use of bioimage informatics methods including machine learning and Python OpenCV in cytology studies as they offer powerful solutions for specific image analysis tasks, such as object detection.
4. The development of more accurate algorithms that can detect cells when they are touching each other and to extract features from cells.

STRAND: BIOSENSORS		
	THEME 1:	**THEME 2:**
GRADE	**Biopotentials**	**Designing and Testing a Sensor**
9	• Cell Membrane Modelling • Biosensor and Medical Devices	• Building a temperature Sensor
10	• Measuring Vital Signs	• Building Particle Sensor
11	• Understanding Brainwaves and Mindwave® Activity	• Building WIRELESS OXIMETER
12	• Arduino Based Biomedical Project	•Project: Bio-Micro-electro-mechanical systems (BioMEMS)

Table 5: The main themes and topics covered by the biosensors strand.

The Biosensors Strand:

- Designing a sensor from recycled materials for creatinine detection

I. Biomedical devices: Principles and applications: Biosnsors, Biopotentials, Voltage and current in living systems: Na+ channel, Na currents in in myocytes and local currents in nerve impulse, (Practical: electric circuits components)

- Arduino and microcontrollers: EDVOTEK®'s Digital Orbital Shaker offers precise control with a

I. microprocessor-based keypad with digital display

Logger Pro - 10A Blood Press Vital Sign.cmbl*

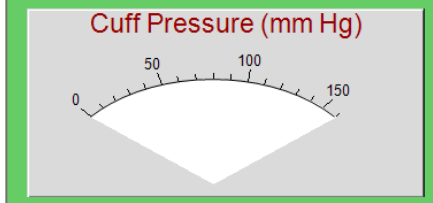
File Edit Experiment Data Analyze Insert Options Page Help

Page 1 Collect

No device connected.

Start data collection.

Pump cuff pressure to 160 mm Hg.

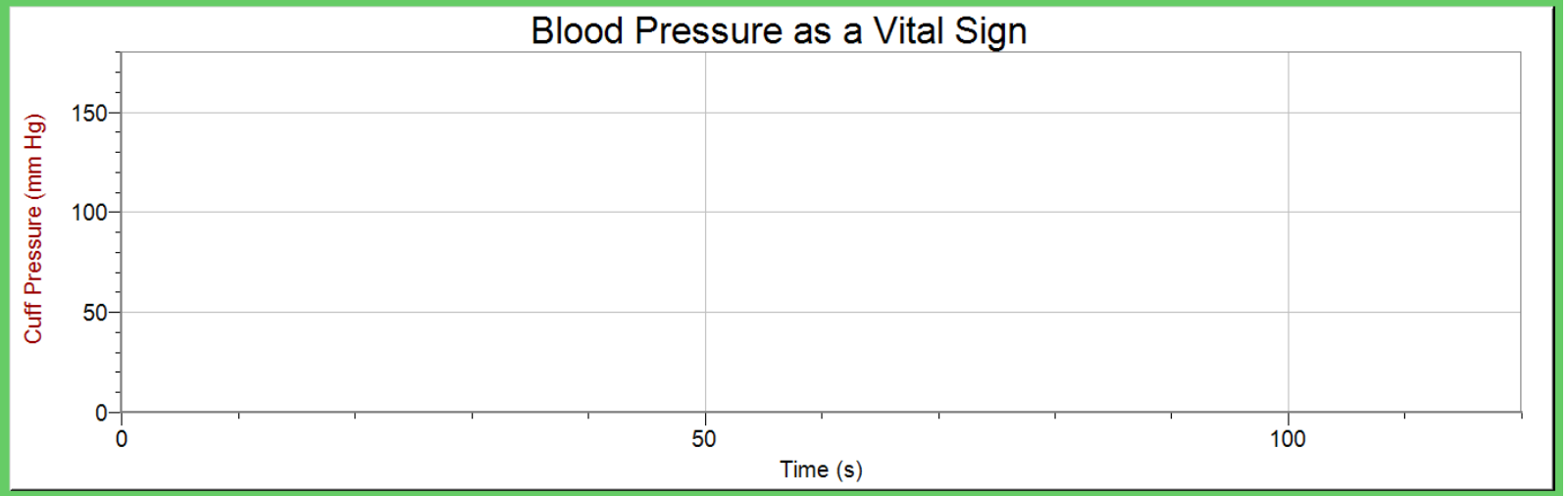


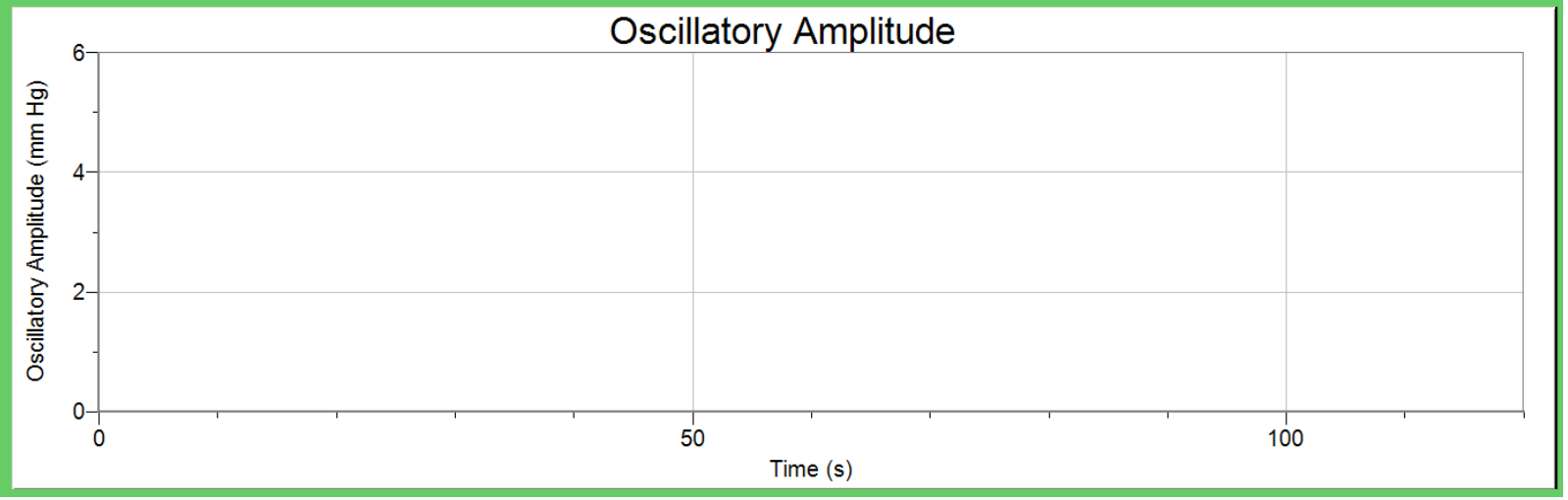
Systolic mm Hg

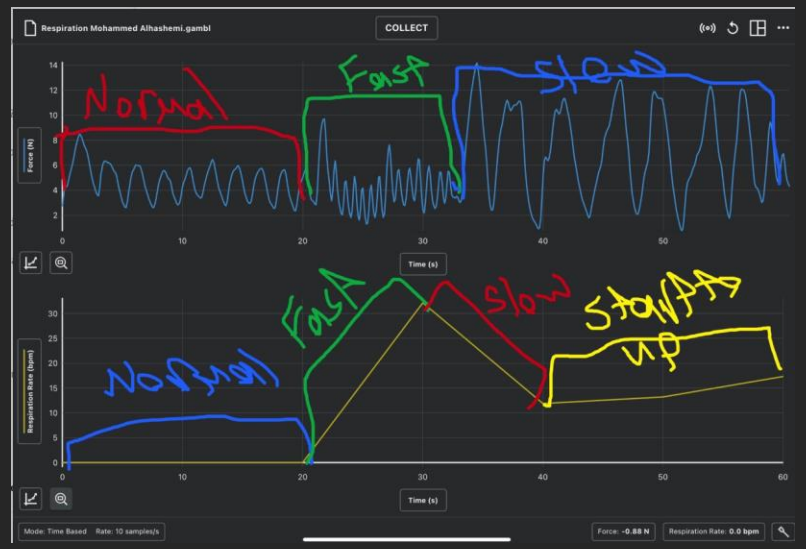
Diastolic mm Hg

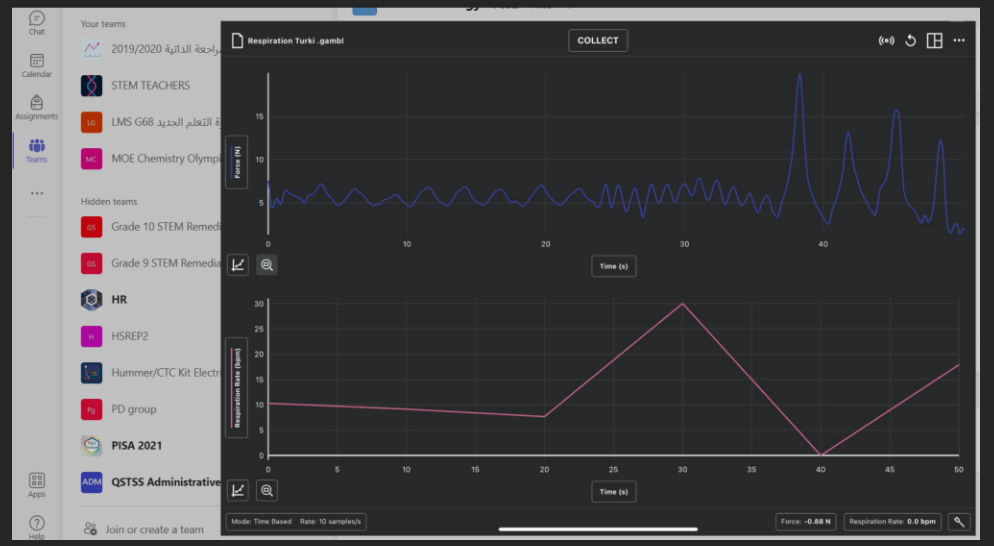
Mean mm Hg

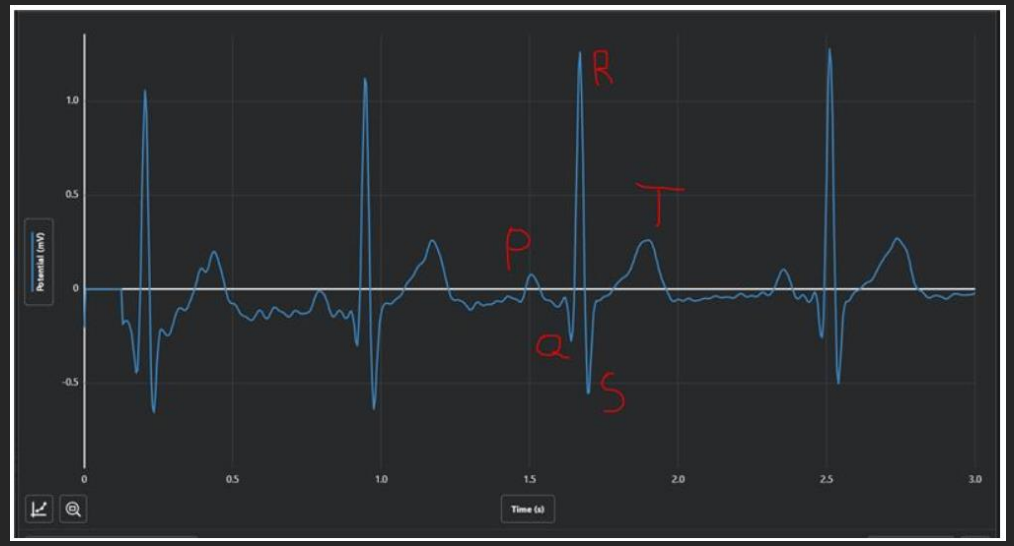
Pulse BPM






Respiration Mohammed Alhashemi.gambl
COLLECT
Normal
Fast
slow
Normal
Fast
slow
stopped up
Force (N)
Respiration Rate (bpm)
Time (s)
Mode: Time Based
Rate: 10 samples/s
Force: -0.88 N
Respiration Rate: 0.0 bpm


Chat
Calendar
Assignments
Teams
Apps
Help
Your teams
2019/2020
STEM TEACHERS
LMS G68
MOE Chemistry Olymp
Hidden teams
Grade 10 STEM Remed
Grade 9 STEM Remedia
HR
HSREP2
Hummer/CTC Kit Electr
PD group
PISA 2021
QSTSS Administrative
Join or create a team
Respiration Turki .gambl
COLLECT
Force (N)
Respiration Rate (bpm)
Time (s)
Mode: Time Based
Rate: 10 samples/s
Force: -0.88 N
Respiration Rate: 0.0 bpm


R
T
P
Q
S
Potential (mV)
Time (s)


عبدالله محمد عبدالله على العبيدلى
3/28 1:36 PM
Potential (mV)
Time (s)
Heart Rate
Reply

STRAND: BIOINFORMATICS				
	THEME 1:	**THEME 2:**	**THEME 3:**	**THEME 4:**
GRADE	**Using Biological Databases**	**BLAST Bioinformatics**	**Phylogenetic trees and genetic relatedness**	**Designing and Planning a Investigation**
9	• Browsing NCBI	• Using GENEIOUS software: import/export files, trimming, alignment, and sequence search	Using GENEIOUS to construct phylogenetic trees	• ORFfinder, Expasy translate • Assembly and Mapping
10	• Browsing OMIM • Browsing PDB	• Using BLASTn, BLASTx, BLASTp	• Sequence conservation	• Using Ensembl, RasMol (RasWin),
11	• Learn To Code! Introduction to Python for Detecting Disease	• Using Sequence analysis tools - Clustal Omega – COBALT. • Sequence similarity search. • Translation of mRNA to protein sequence.	• Analyzing Phylogenetic Tree • Protein sequence analysis	• Designing primers using Prime3 and GENEIOUS • Designing Cloning experiment using GENEIOUS, Webcutter and In silico PCR
12	• Case study		**PROJECT: Students Designed**	

Table 7: The main themes and topics covered by the bioinformatics strand.

The Bioinformatics Strand

- Bioinformatics:

primers design, construction and analysis of phylogenetic tree

1- NCBI
provide information about the intron / exon structure, the coding sequences, and references
2- OMIM
provide all the allelic variants of the *BRCA1* gene and the corresponding disorders.
3- Ensembl
Ensembl data base will be used to determine the domains of the gene in a graphical view
4- PDB
The protein data bank (PDB) was used to download the amino acid sequence coded by the *BRCA1* gene
5- RasMol (RasWin)
The RasMol (RasWin) program will be used to view the protein sequence in 3D.
6- BLASTn
to get the sequence identity, accession number, global pairwise alignment of the nucleotide sequence against a nucleotide sequence database, as well as a set of information about the gene.
7- BLASTx
to convert the DNA sequence into amino acid sequence in all six reading frames against a protein sequence database.
8- BLASTp
to compare the amino acid sequences against a protein sequence database.

9- ORFfinder
to get all 6 possible open reading frames.
10- Expasy translate
Translation of the nucleotide sequences.
11- Clustal Omega
Will be used to carry out multiple sequence alignments by comparing the amino acid sequences to the reference one.
12- COBALT
Constraint-based Multiple Alignment Tool
13- COSMO
to obtain the complementary DNA sequence (cDNA) that contains the exon sequences only and to obtain the amino acid sequence coded by the BRCA1 gene as well as to determine the position of the mutations in the BRCA1 gene.
14- Webcutter
to generate the restriction sites and to construct the restriction map.
15- Prime3
to generate the primers for the given DNA sequences.
16- In silico PCR
to validate and confirm the success of the designed primers.

Table 8. List of the bioinformatics tools other than GENIOUS software covered in the

Using Bioinformatics Docking Tools for Modifying, Repurposing, and Evaluating TKIs Gefitinib and Erlotinib

Problem

Mutations occurring to the *EGFR* gene can cause non-small cell lung carcinoma (NSCLC). Exon 19 deletions and exon 21 L858R mutations can be treated using TKIs such as gefitinib and erlotinib. Unfortunately, the known TKIs are insensitive to exon 20 insertion mutations. The current study aims at modifying the structure of gefitinib and erlotinib by adding oxadiazole rings to them.

Research objectives

The broad objective of the current research is to use the SBDD method to elucidate the mechanism of TKIs-EGFR interaction with respect to NSCLC. Therefore, the current study aims specifically at using autodocking and virtual screening to:

- Evaluate the interaction of the two TKIs gefitinib and erlotinib with the TK domain of EGFR.
- Evaluate the interaction of the 1,3-bis(5-benzylthio-1,3,4-oxadiazol-2-yl) benzene with the TK domain of the EGFR.
- Modifying the chemical structures of gefitinib and erlotinib by conjugating them to oxadiazole and thiooxadiazole rings.
- Evaluate the interaction of the modified gefitinib and erlotinib drugs with the TK domain of EGFR.

Project Idea

Though TKIs are efficient in treating NSCLC patients with mutations occurring to exons 19 and 21 of the EGFR gene, they are insensitive towards exon 20 insertion mutations. Analyzing the action mechanism of TKIs reveals that the mutated protein exposes a pocket where drugs like gefitinib and erlotinib can bind and inhibit the tyrosine kinase activity. However, in the case of exon 20 insertion mutations, the binding pockets of the tyrosine kinase domain remain hidden and inaccessible for the TKIs.

We, in the current study, aim at modifying the structures of gefitinib and erlotinib by attaching thiooxadiazole rings to them with the sulfur moiety acting as a connecting hinge between the main drug and the oxadiazole ring. When the modified drug reaches the protein target and attempts to bind to it, the drug will break down at the sulfur hinge. As a result of the breakage event, the oxadiazole ring will become free in the vicinity of the TK domain and have the potential to reach the binding pockets of the TK domain, bind to it, and render it inactive.

In the study, the gefitinib and erlotinib are used as a delivery method for the oxadiazole ring.

Research questions

Would modifying gefitinib and erlotinib by attaching thiooxadiazole rings to them enable them to be sensitive towards EGFR exon 20 insertion mutations?

Hypothesis

The pharmaceutical, biological, and medical applications of oxadiazoles as well as our understanding of the mechanism of TKIs allow us to hypothesize that the modifying TKIs would confer these molecules the ability to deal with exon 20 insertion mutations

Procedure

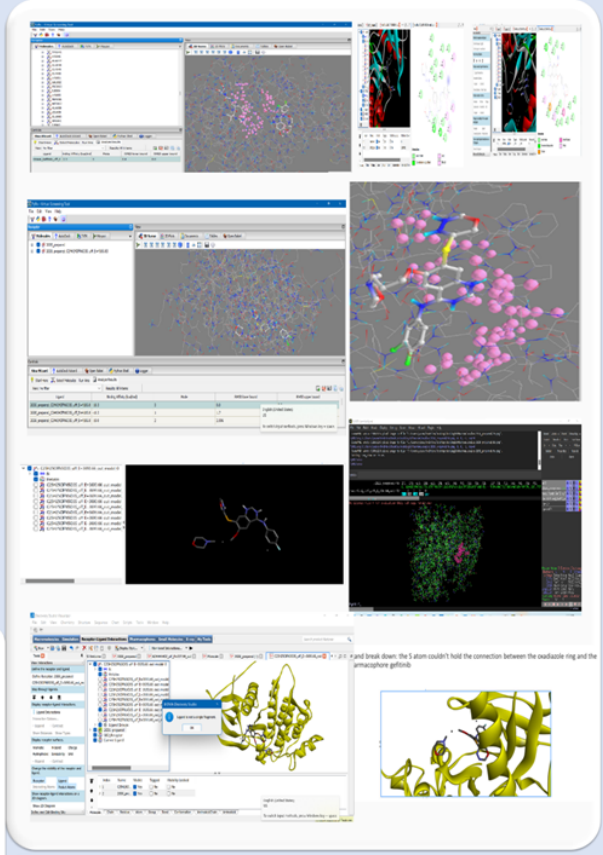
1. Identify Target Disease
2. Study the Lead Compounds
3. Identify the gene and the gene mutations
4. Retreival of the desired protein in PDB format
5. Downoading the ligands from ZINC15, PUBCHEm, DRUGBANK...etc
6. Modify the shape of the ligand as necessary using computer aided drug design techniques
7. Convert the STD files into PDB
8. Perform docking using Autodock 4, VINA, DS or PyRx orothers
9. Analyze the results using discovery studio and PYMOL
10. Refinement of drug compounds
11. Retesting
12. Characterize the tested molecule

Conclusion

Several TKIs were successfully docked into the TK domain of the EGFR protein. The structures of the gefitinib and erlotinib were modified by adding different oxadiazole rings to them via a sulphur group. One gefitinib-oxadiazole complex, was broken down into two parts when the complex compound reached the target protein. The oxadiazole ring managed to penetrate the EGFR protein and bind to its active site. This deactivates the protein making such chemicals possible inhibitor against exon 20 insertion mutations. Based on the above, we recommend the following:

- Synthesizing the modified erlotinib/oxadiazole and gefitinib/oxadiazole complexes.
- Testing the modified complexes in prokaryotic systems and animal systems.
- Investigating the pharmacokinetic properties of the modified gefitinib and erlotinib structutres.
- Investigating the metabolism of the modified gefitinib and erlotinib.

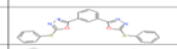
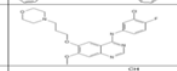
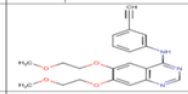
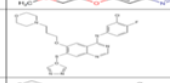
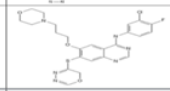
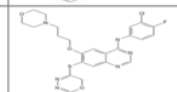
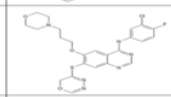
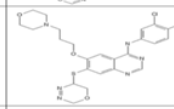
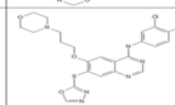
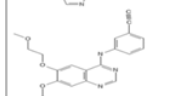
Results and analysis



References

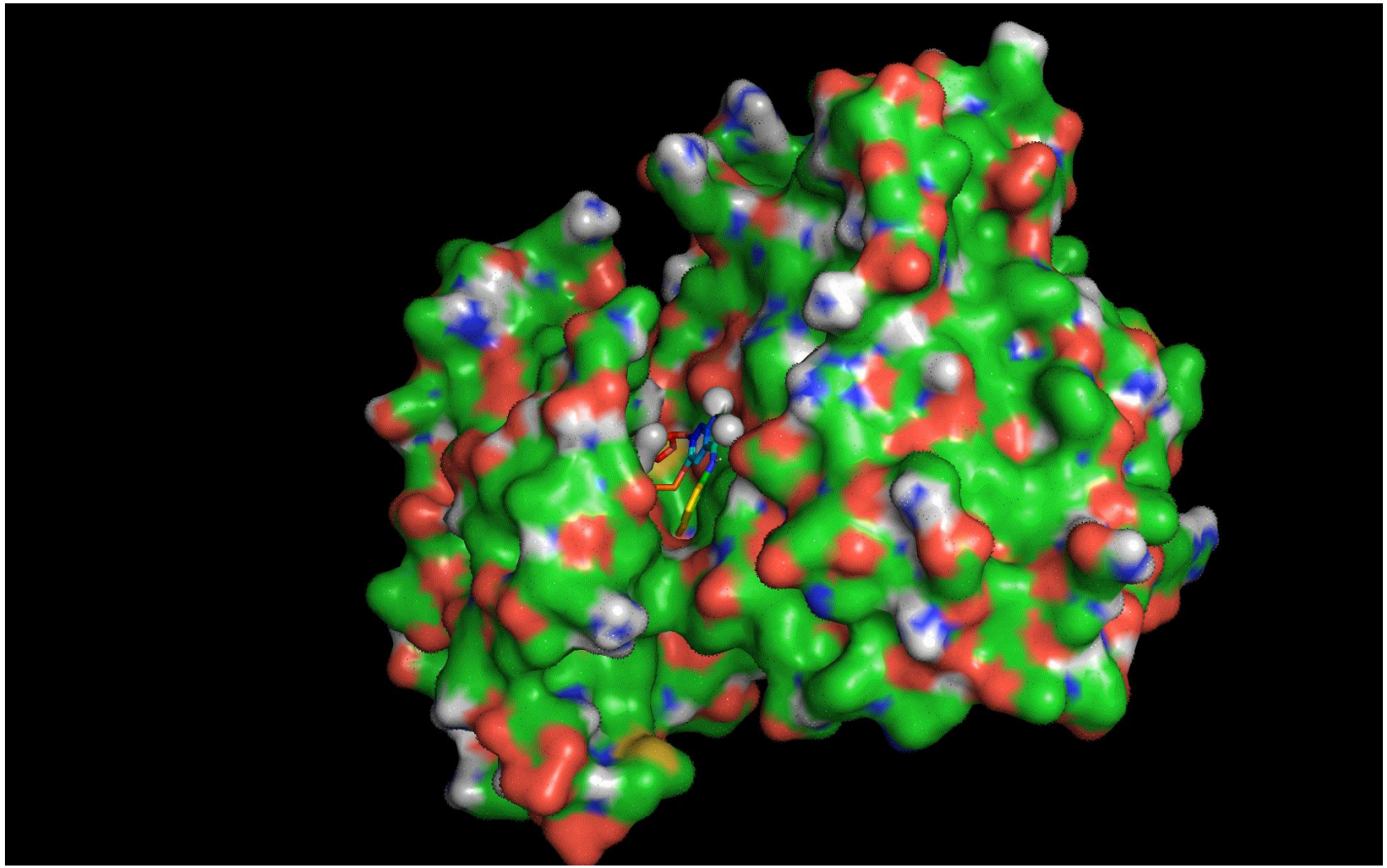
Gomez, G. & Wykosky, Jill & Zanca, Ciro & Furnari, Frank & Cavenee, Webster. (2013). Therapeutic resistance in cancer: microRNA regulation of EGFR signaling networks. Cancer biology & medicine. 10. 192-205. 10.7497/j.issn.2095-3941.2013.04.003.

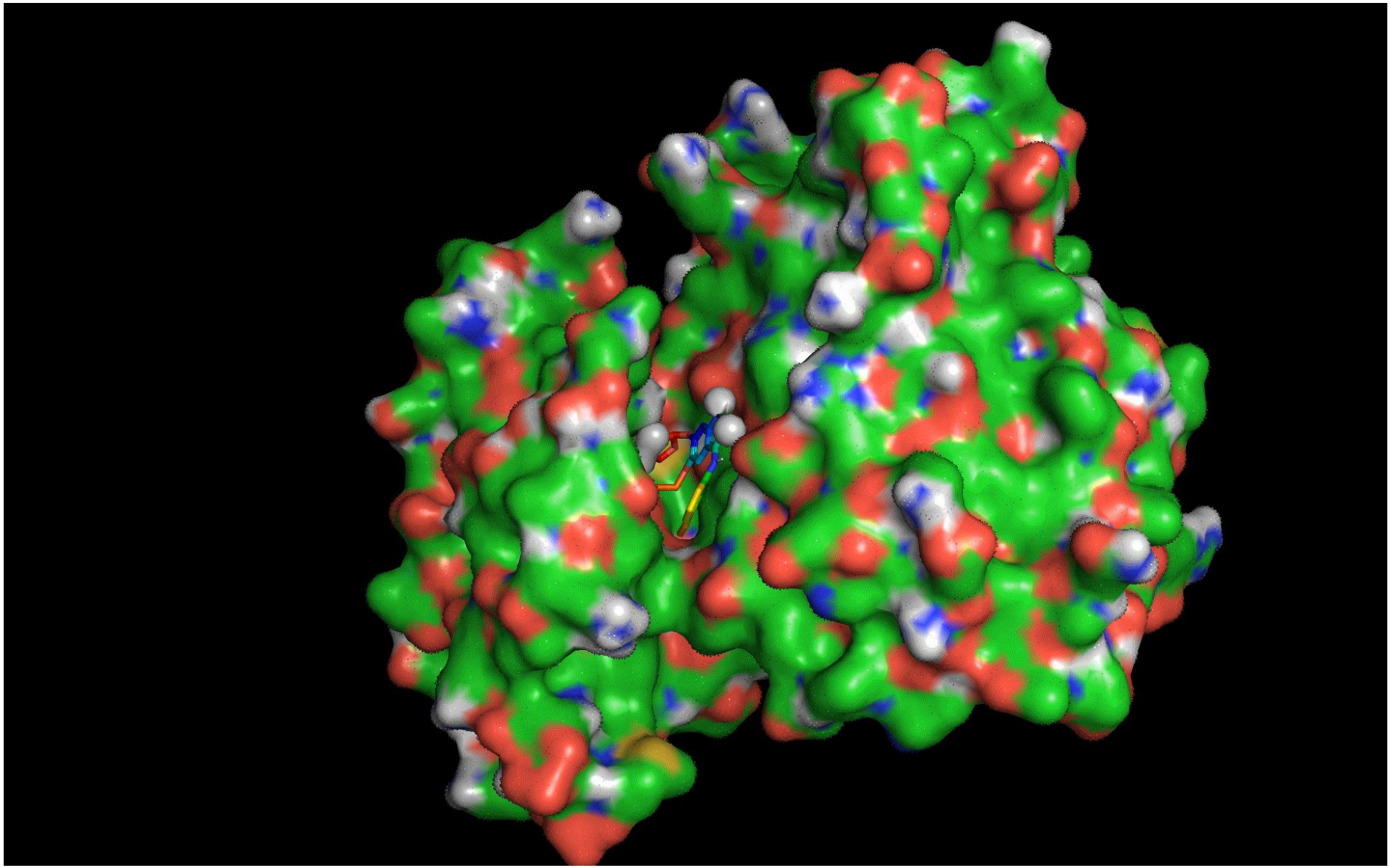
Tested Compounds

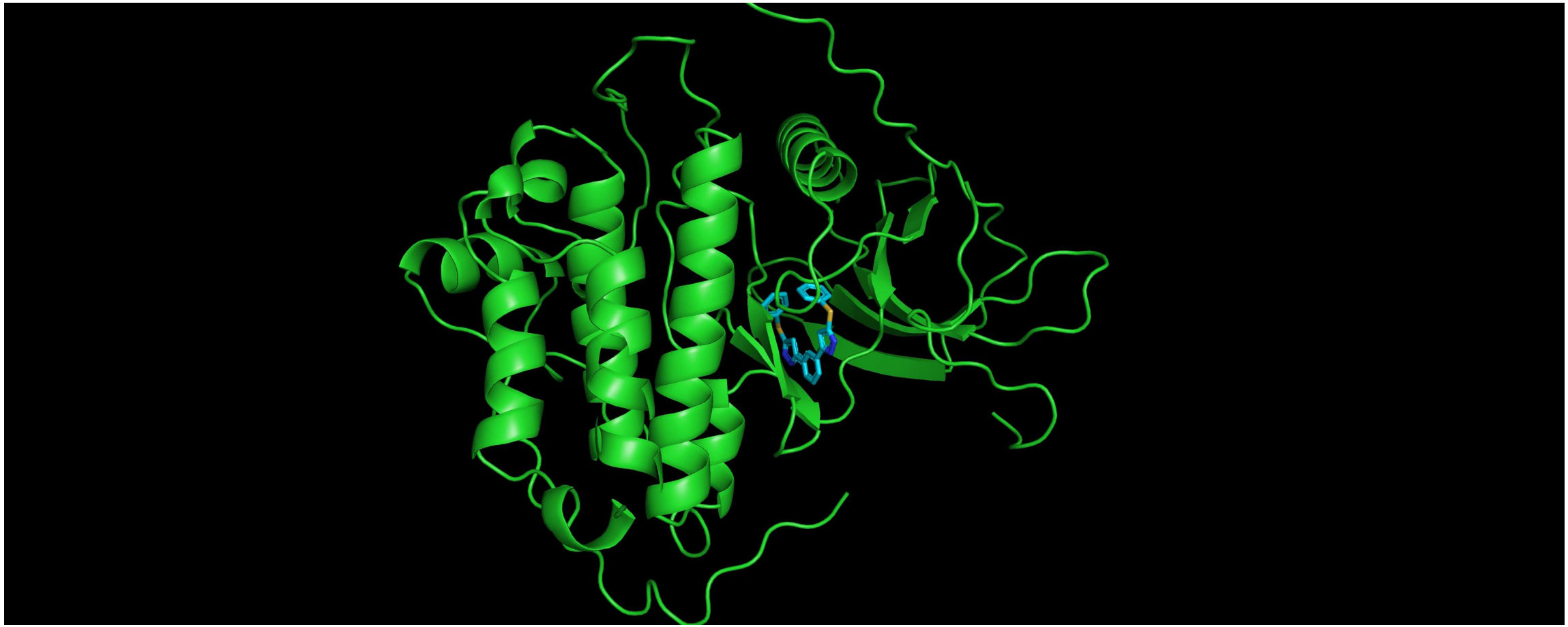
Tested compound	Ch. structure	IUPAC name / SMILES	Mol. Formula M. Wt. (g/mol)
M1		[1,3-bis(5-benzylthio-1,3,4-oxadiazole-2-yl)benzene]	C24H18N4O2S2 (458)
Gefitinib		N-(3-Chloro-4-fluorophenyl)-7-methoxy-6-(3-morpholinopropoxy) quinazolin-4-amine	$C_{22}H_{24}ClFN_4O_3$ (446.9)
Erlotinib		N-(3-Ethynylphenyl)-6,7-bis(2-methoxyethoxy)quinazolin-4-amine	$C_{22}H_{23}N_3O_4$ (393.4)
Modified Gefitinib		O5CN=N-C(SC3=C(OCCCN1CCOCC1)C=C2C(=NC=NC2=C3)NC4=CC(=C(F)C=C4Cl)C5	C23H23CLFN6O3S (517.985)
Modified Gefitinib		C5-O-C=N-N=C5SC3=C(OCCCN1CCOCC1)C=C2C(=NC=NC2=C3)NC4=CC(=C(F)C=C4)Cl	C24H24ClFN6O3S (531.003)
Modified Gefitinib		C5-O-C=N-N=C5SC3=C(OCCCN1CCOCC1)C=C2C(=NC=NC2=C3)NC4=CC(=C(F)C=C4)Cl	C24H24ClFN6O3S (531.003)
Modified Gefitinib		C1OC=NN=C1SC4=C(OCCCN2CCOCC2)C=C3C(=NC=NC3=C4)NC5=CC(=C(F)C=C5)Cl	C24H24ClFN6O3S (531.003)
Modified Gefitinib		O5CN=NC(SC3=C(OCCCN1CCOCC1)C=C2C(=NC=NC2=C3)NC4=CC(=C(F)C=C4)Cl)C5	C24H26ClFN6O3S (533.019)
Modified Gefitinib		O5-C=N-N=C5SC3=C(OCCCN1CCOCC1)C=C2C(=NC=NC2=C3)NC4=CC(=C(F)C=C4)Cl	C23H23CLFN6O3S (517.985)
Modified Erlotinib		O4CN=NC4OC5=CC6=C(C=C5OCCOC)C(=NC=N6)NC7=CC(=CC=C7)C#C	C21H19N5O4 (405.412)

Done by

Saoud A-rahman A M Al-malik & Mohammed Al Emadi







Department of Science, Technology, Engineering, and Math (STEM), Qatar Science and Technology School

Bioinformatics Analysis of BRCA1 Founder Mutations for Breast Cancer Diagnosis

ABSTRACT

Aims: to investigate the potential use of founder mutations occurring to exons 2 and 20 of BRCA1 gene as genetic biomarkers in the diagnosis of BC.
Tools: Bioinformatics online tools and software for mutation analysis and validation including webcutter, primer3, and In silico PCR.
The results: Forward and reverse primers were successfully designed to detect 187delAG and 5385insC mutations occurring to exons 2 and 20, respectively in BRCA1. In silico PCR has validated the success of the designed primers. Analyzing exons 2 and 20 of the BRCA1 gene revealed that the reference sequence has *18* different restriction sites for a wide range of restriction enzymes such as Alw21I, ApaLI, BstXI and others. The restriction sites can be used in the detection of mutant BRCA1.
CONCLUSION
BRCA1 single nucleotide polymorphisms in exons 2 and 20 could be useful biomarkers of BC.

The objective of the current research is to evaluate the usage of exon 2 and 20 somatic and inherited mutations 187delAG and 5385insC of BRCA1 as biomarkers in the diagnosis and prognosis of Breast cancer.

INTRODUCTION

Breast cancer usually results from an accumulation of many mutations thus the incidence increases with age. At the DNA level, a cancerous cell is usually characterized by at least one active oncogene and the mutation of several tumor-suppressor genes. Breast cancer results from a series of dyseregulated mechanisms involving the gain-of-function of oncogenes (OCGs) and the loss-of-function of tumour suppressor genes (TSGs) including BRCA1, BRCA2, P53, PTEN, STK11, CHEK2, ATM, BRIP1, and PALB2. Abnormal repression of tumour suppressor gene (BRCA1) results in deregulation of the cell cycle or fail to repair DNA damage mainly through the modification in the protein products types and quantities thereby leading to the mutations in other genes and thus developing the transformed phenotypes of the breast cancer cells.

Materials and Methods

1. NCBI
provide information about the intron / exon structure, the coding sequences, and references.
1. OMIM
provide all the allelic variants of the BRCA1 /2 genes and the corresponding disorders.
1. Ensembl
Ensembl data base will be used to determine the domains of the gene in a graphical view.
1. PDB
The protein data bank (PDB) was used to download the amino acid sequence coded by the BRCA1 /2 gene.
1. RasMol (RasWin)
The RasMol (RasWin) program will be used to view the protein sequence in 3D.
1. COSMO
This tool was used to obtain the complementary DNA sequence (cDNA) that contains the exon sequences only and to obtain the amino acid sequence coded by the BRCA1 /2 gene as well as to determine the position of the mutations in the BRCA1 /2 gene.
1. Webcutter
Webcutter was used to generate the restriction sites and to construct the restriction map.
1. Prime3
Primer3 was used to generate the primers for the given DNA sequences.
1. In silico PCR
In silico PCR was used to validate and confirm the success of the designed primers.

Table 1. Workflow of the project.

Results

The BRCA1 gene (gene ID: 1956) is located on the short arm of chromosome 7 with the cytogenetic location (7p11.2) as indicated by the arrow on figure 1. The size of the BRCA1 gene is 189,060 bp comprising 31 exons (table 2). The exact molecular location of the BRCA1 gene is between the base pairs 55,019,021 to 55,208,080 (Homo sapiens Annotation Release 109, GRCh38.p12).

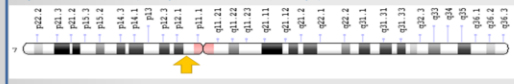


Fig. 1. Cytogenetic location of the BRCA1 gene as indicated by the arrow.

1: * 113705. BRCA1 DNA REPAIR-ASSOCIATED PROTEIN; BRCA1
Cytogenetic location: 17q21.31, Genomic coordinates (GRCh38): 17:43,044,294-43,125,363
Matching terms: brca1
► Gene-Phenotype Relationships ► Links

OMIM Allelic Variants - 113705 BREAST CANCER 1 GENE, BRCA1

Number	Phenotype	Mutation	SNP	gnomAD SNP
.0001	BREAST-OVARIAN CANCER, FAMILIAL, SUSCEPTIBILITY TO, 1	BRCA1, CYS64GLY	rs80357064	rs80357064
.0002	BREAST-OVARIAN CANCER, FAMILIAL, SUSCEPTIBILITY TO, 1	BRCA1, CYS61GLY	rs28897672	rs28897672
.0003	BREAST-OVARIAN CANCER, FAMILIAL, SUSCEPTIBILITY TO, 1; PANCREATIC CANCER, SUSCEPTIBILITY TO, 4, INCLUDED	BRCA1, 2-BP DEL, 185AG	rs80357914,rs155500876	
.0004	BREAST-OVARIAN CANCER, FAMILIAL, SUSCEPTIBILITY TO, 1	BRCA1, 59-BP INS	rs67284903	
.0005	BREAST-OVARIAN CANCER, FAMILIAL, SUSCEPTIBILITY TO, 1	BRCA1, 1-BP INS	rs80357569	rs80357569

Table 2. Some of the allelic variants of BRCA1.

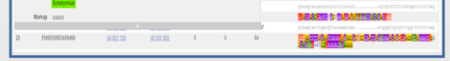
Homo sapiens chromosome 17, GRCh38.p13 Primary Assembly

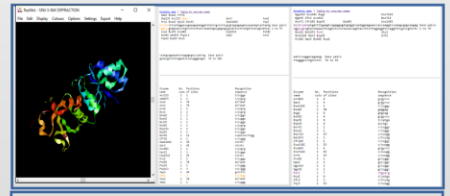
Results

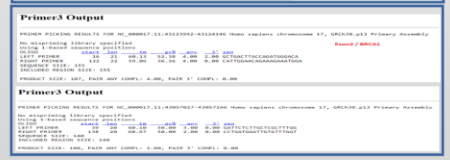
Complementary DNA sequence of BRCA1 and mutation analysis..

Founder mutation	Gene	Exon	Length of sequence	Primer (literature reported)
187delAG (c.68_69delAG, 185delAG)	BRCA1	2	340 bp	Forward: TTCGTATTCTGAGAGGCTGCT Reverse: ACGCCTCTCAGGTTCCG
5385insC (c.5266dupC, 5382insC)	BRCA1	20	271 bp	Forward: TGCAGATGCTGAGTTTGTGT Reverse: AGCTTATCTGAACAAAGTGATATT
6174delT (c.5946delT)	BRCA2	11	270 bp	Forward: ATATGTCTGGATTGGAGAAAGTT Reverse: AGCTGGTCTGAATGTTCGTT

Table 3. The studied founder mutations in BRCA1.







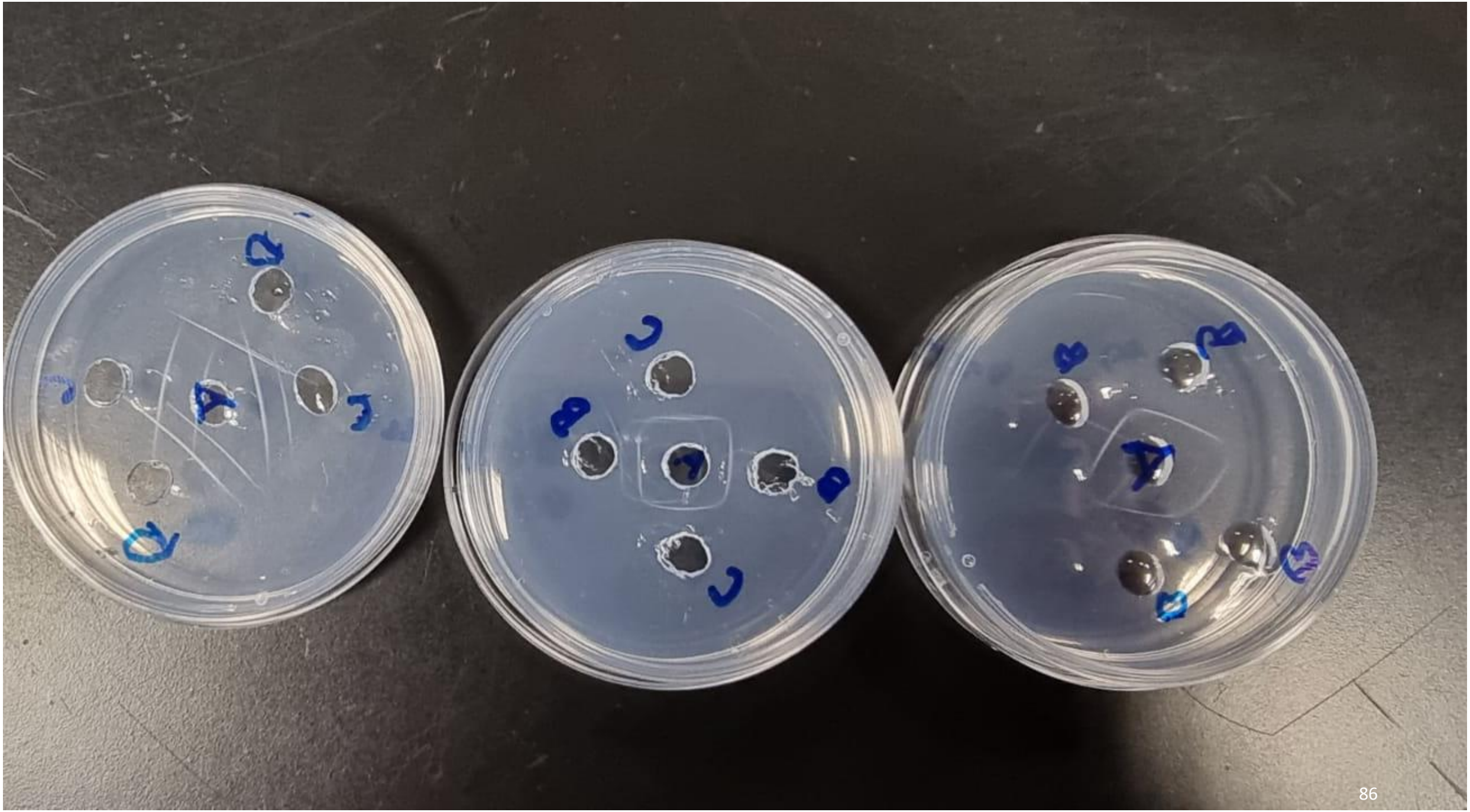
Lab Name: Biotechnology		**Grade Levels: 11**
Description: In Biotechnology, students will apply advanced academic knowledge and skills to the emerging fields of biotechnology such as genetic engineering and transformation, Biomedical science and immunology, Neurobiology and forensics. Students will have the opportunity to use sophisticated laboratory equipment and perform statistical analysis. Students will conduct laboratory and field investigations, use scientific methods during investigations, and make informed decisions using critical thinking and scientific problem solving.		
Total Number of Periods	**47 Periods**	*Schedule calculations based on 135 min per **16 weeks** for grade 10 and 135 min per **40 weeks** for grade 11. Scope and sequence allow additional time for guest speakers, student presentations, field trips, remediation, extended learning activities, etc.

Investigation Title	**# of Class Periods*** (assumes 135-minute periods) Total minutes per investigation	**Knowledge and skills (Experiment Description)**

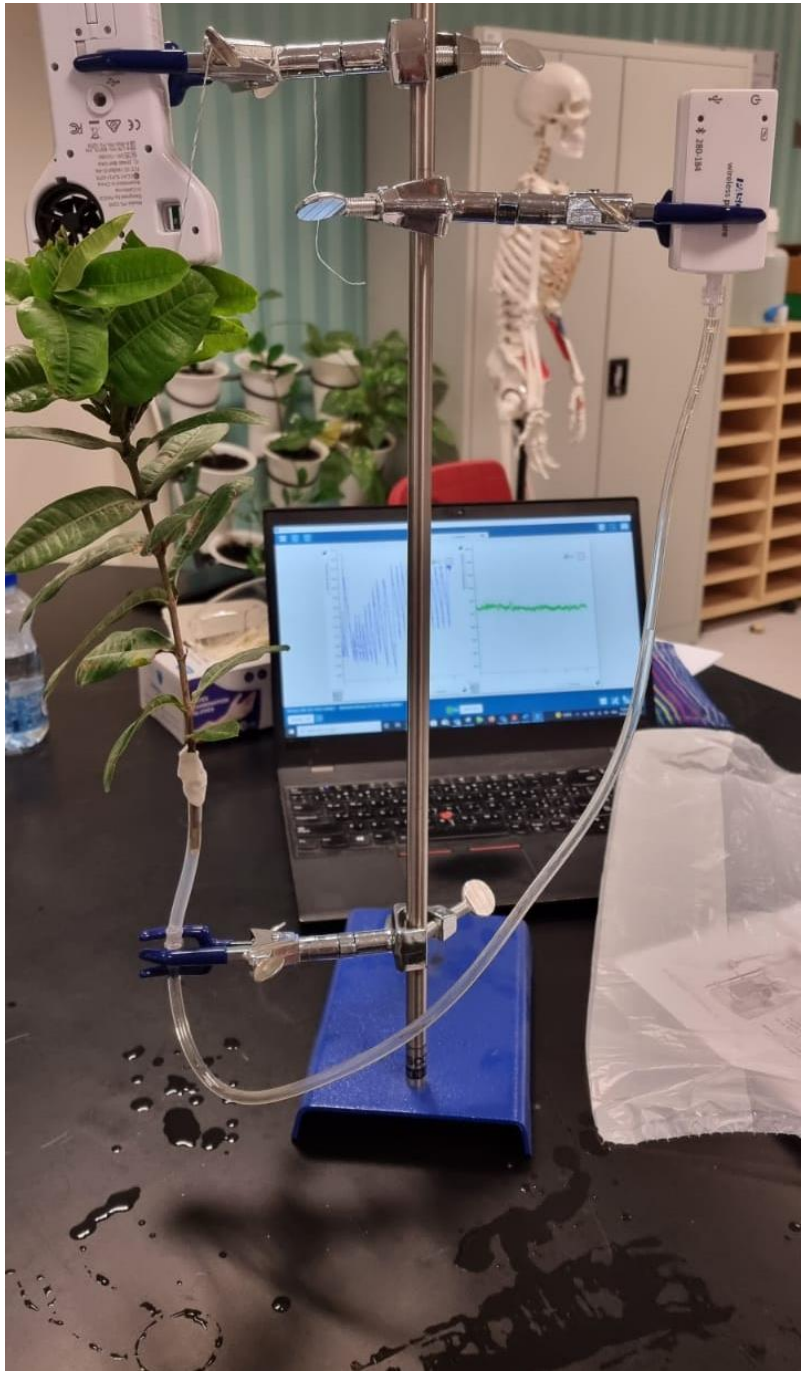
STRAND: BIOTECHNOLOGY				
	THEME 1:	**THEME 2:**	**THEME 3:**	**THEME 4:**
GRADE	**Genetic Eng. and Transformation**	**Forensic Medicine**	**Neurobiology & Immunology**	**Designing & Planning an Investigation**
9	• Biotechnology Basic Skills. • DNA Isolation	• Forensic Enzymology • Forensic Enhancement Techniques	Scents & Sense-ability	–
10	• Biotechnology Advanced Skills. • Plasmid Isolation • DNA/RNA Microarrays • Transformation of E. coli with pGAL	• Forensic Blood Typing • Antigen-Antibody Interaction: The Ouchterlony Procedure Forensic Toxicology	• Cholesterol Diagnostics • Simulation of HIV Detection by Protein Electrophoresis • Simulation of HIV Detection by ELISA • Radial Immunodiffusion • Detecting the Silent Killer: Clinical Diagnosis of Diabetes • Cell Types in the Brain • Diagnosing Huntington's Using PCR	–
11	• Search of the Cancer Gene • Construction & Cloning of DNA Recombinant • Transformation of E. Coli with Green Fluorescent Proteins (GFP) Search of the Sickle Cell Gene by Southern Blot	• DNA Fingerprinting Using Restriction Enzymes. Forensic Antigen Detection.	• Detection of the Influenza Virus • Blood-based Cancer Diagnostics • Going Un-Viral: Quantification Using Plaque Assays • What's in My Lunch? Quantitative Food Allergy ELISA • Simulation of HIV Detection by Western Blot Researching Alzheimer's Disease by ELISA	–
12	Investigating Synthetic Biology	PROJECT: Students Designed		

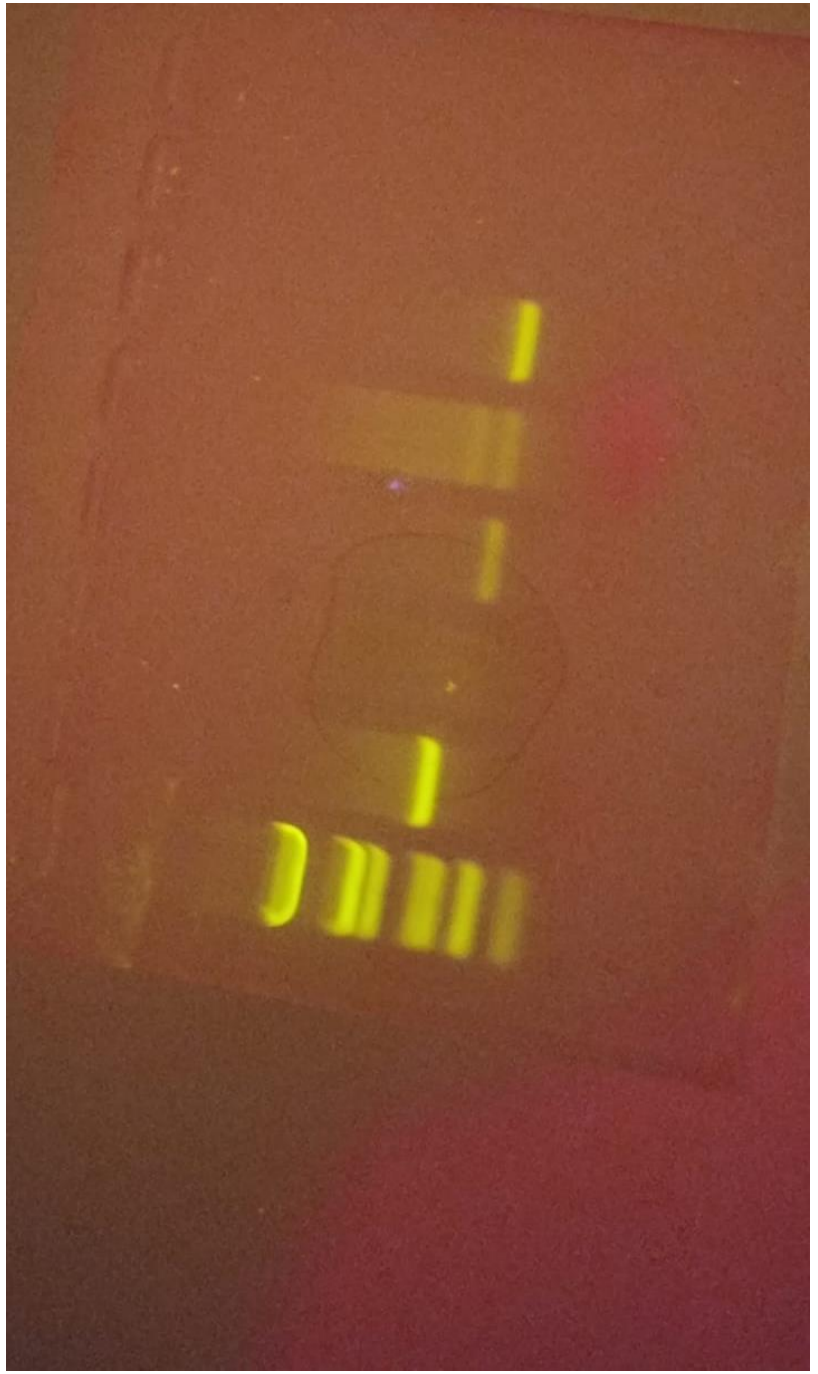
Table 3: The main themes and topics covered by the biotechnology strand.

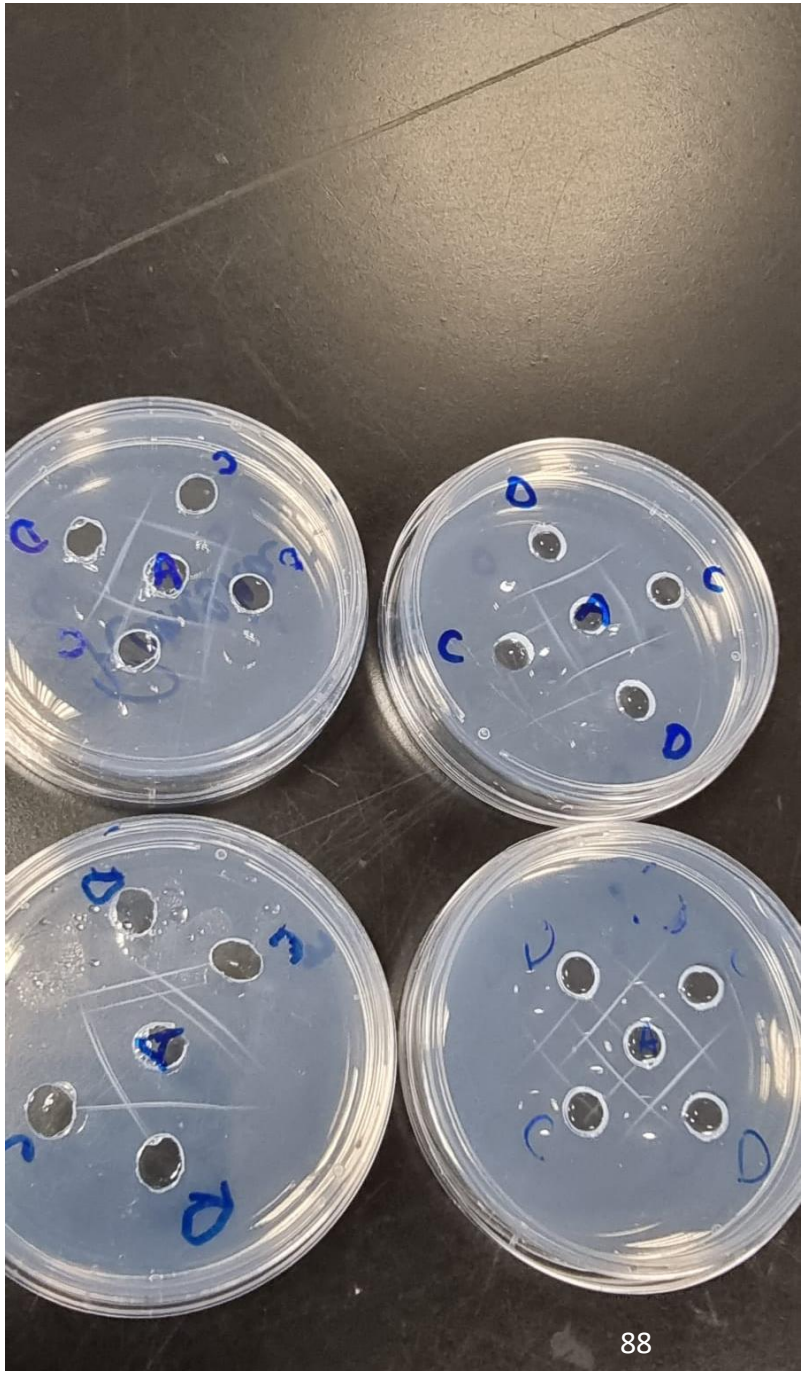
Theme "Biomedical Science & Immunology", [12 Periods]		
Investigation 12: #118 (Cholesterol Diagnostics)	**1** Period: **45 Min**	Week 28: 9/5/2021 - 13/5/2021
Investigation 13: #122 (Detection of the Influenza Virus)	**1** Period: **90 Min**	Week 20: 28/2/2021 - 4/3/2021
Investigation 14: #141 (Blood-based Cancer Diagnostics)	**1** Period: **35 Min**	Week 27: 2/5/2021 - 6/5/2021
Investigation 15: #151 (Simulation of HIV Detection by Protein Electrophoresis)	**1** Period: **180 Min**	Week 19: 21/2/2021 - 25/2/2021
Investigation 16: #209 (Going Un-Viral: Quantification Using Plaque Assays)	**1** Period: **120 Min**	Week 18: 14/2/2021 - 18/2/2021
Investigation 17: #266 (What's in My Lunch? Quantitative Food Allergy ELISA)	**1** Period: **120 min**	Week 26: 25/4/2021 - 29/4/2021
Investigation 18: #271 (Simulation of HIV Detection by ELISA)	**1** Period: **60 Min**	Week 21: 21/3/2021 -25/3/2021
Investigation 19: #273 (Radial Immunodiffusion)	**1** Period: **35 min**	Week 23: 4/4/2021 - 8/4/2021
Investigation 20: #275 (Simulation of HIV Detection by Western Blot)	**1** Period: **70 Min**	Week 22: 28/3/2021 -1/4/2021
Investigation 21: #280 (Detecting the Silent Killer: Clinical Diagnosis of Diabetes)	**1** Period: **90 Min**	Week 29: 16/5/2021 - 20/5/2021
Investigation 22: #986 (Comparison of Mammalian Cell Types)	**1** Period	Week 24: 11/4/2021 - 15/4/2021
Investigation 23 #990 (Morphology of Cancer Cells)	**1** Period	Week 25: 18/4/2021 - 22/4/2021



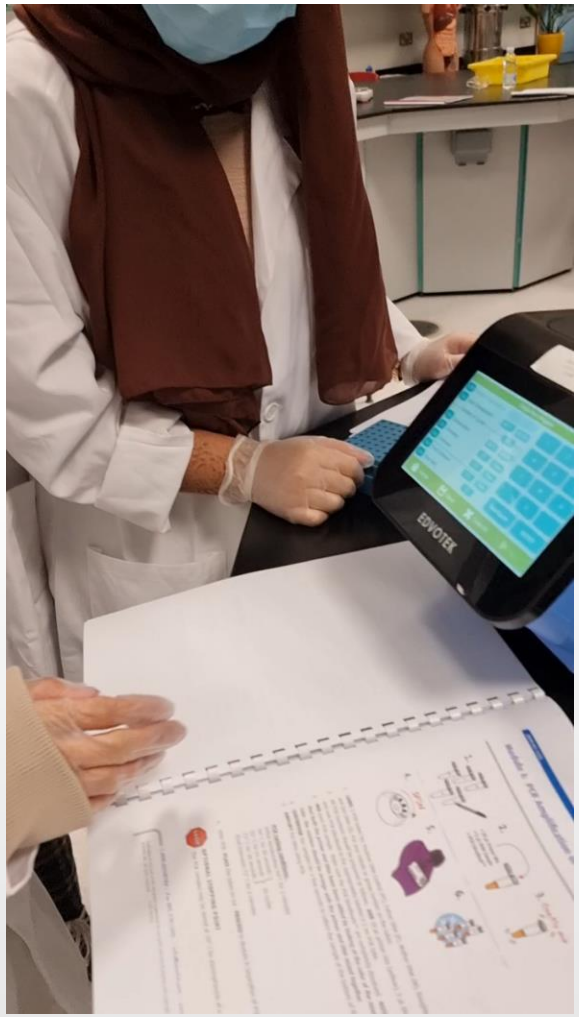

B
4
B
B

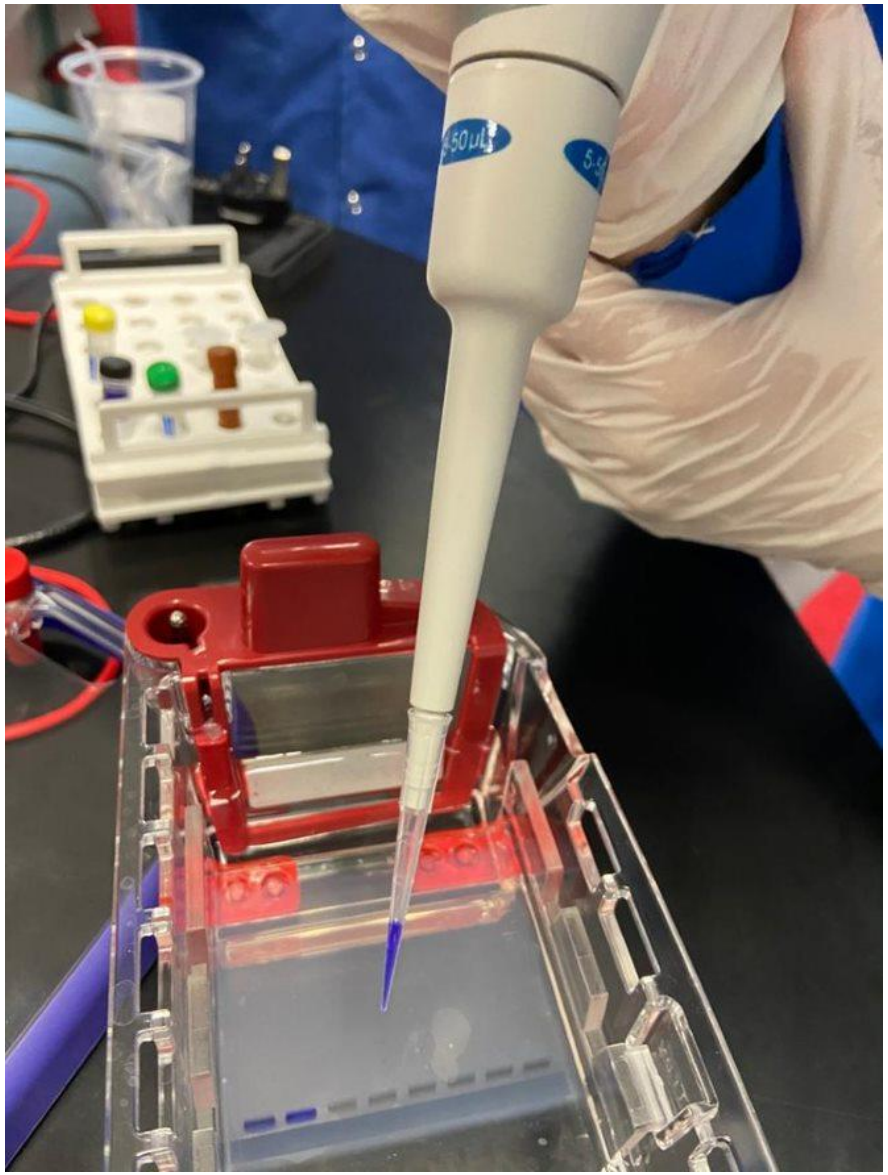


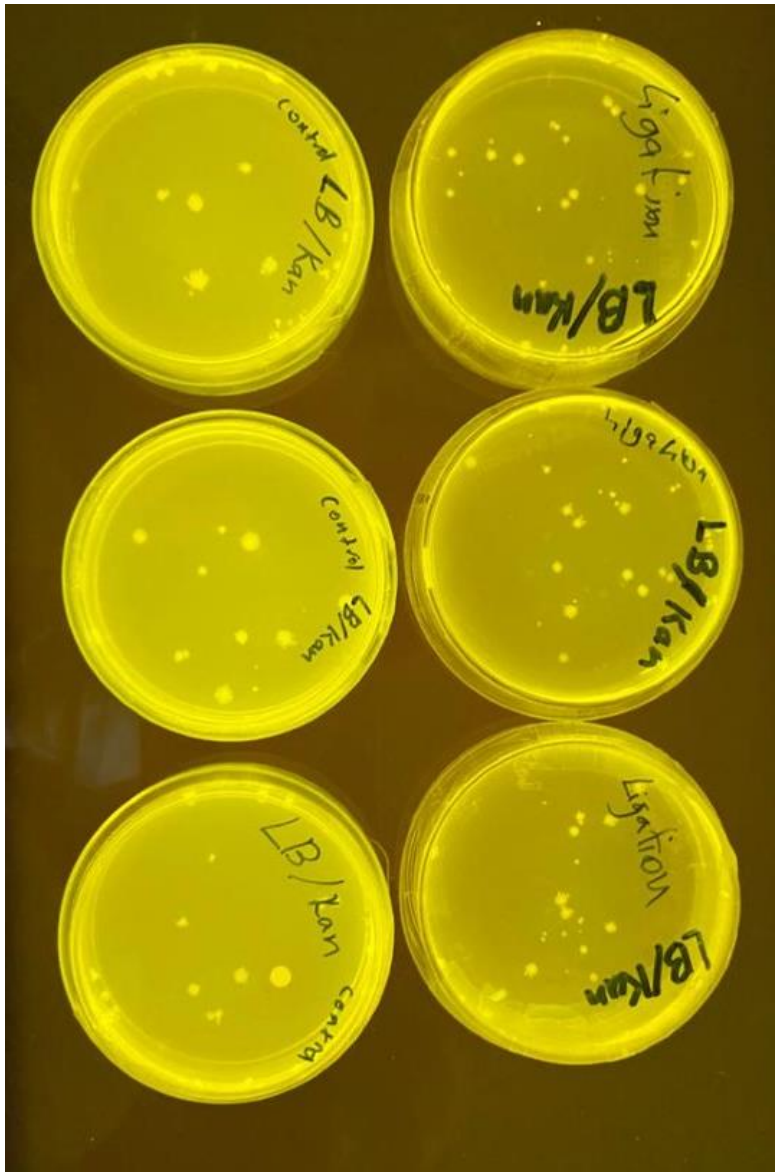




Theme "Genetic Engineering & Transformation", [9 Periods]		
Investigation 1: #221 (Transformation of E. coli with pGAL™ (Blue Colony))	**1** Period: **50 min**	Weeks 1& 2: 30/8/2020 - 3/9/2020 6/9/2020 - 10/9/20
Investigation 2: #301 (Construction & Cloning of DNA Recombinant).	**3** Periods - **300 min**	Weeks 3,4 &5: 13/9/2020 - 17/9/2020
Investigation 3: #331 (Investigating Synthetic Biology)	**5** Periods: **695 min**	Weeks 6, 7, 8, 9, & 10:

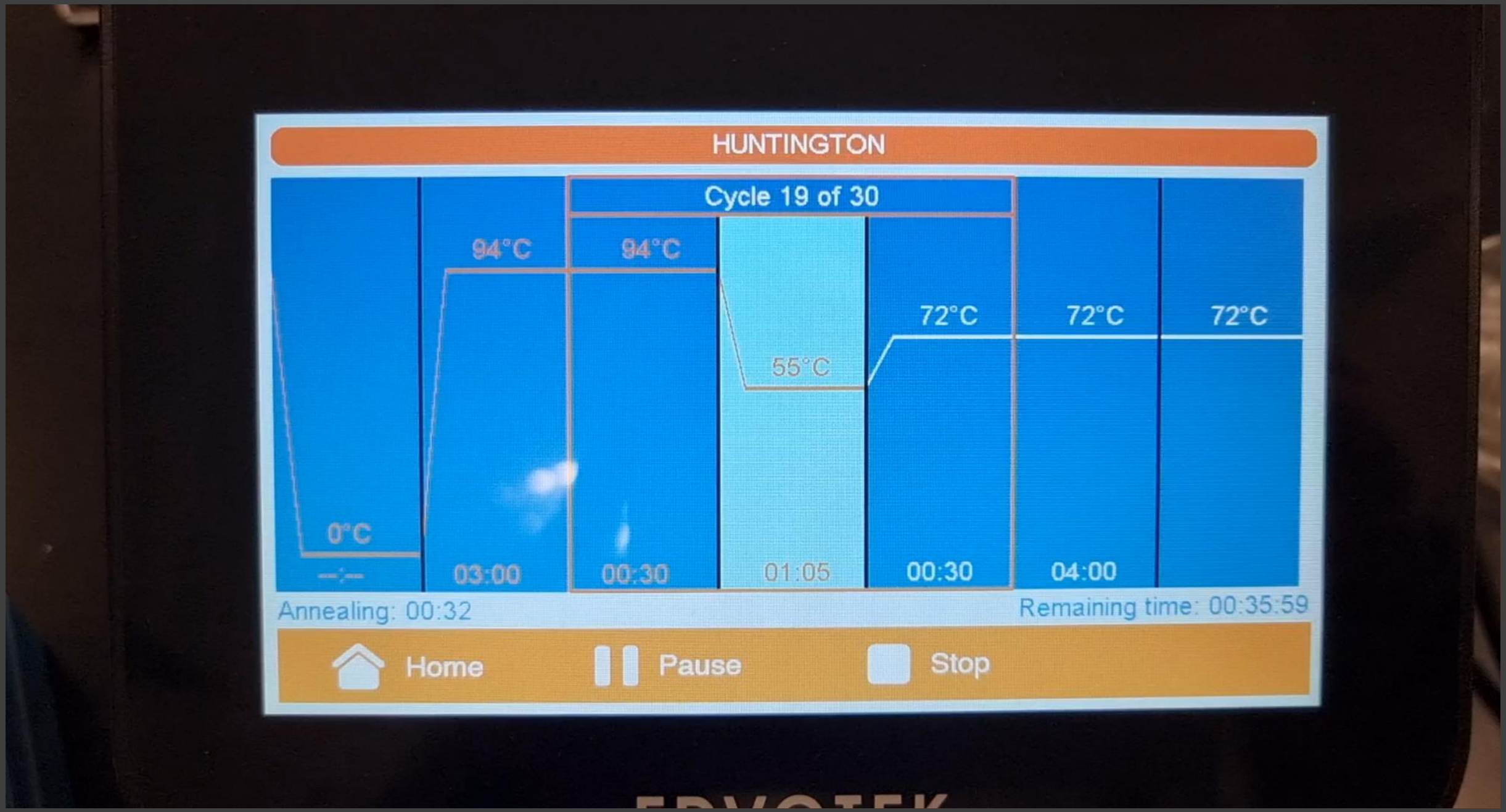

EDVOTEK




LB/Kan
Control
LB/Kan
Ligation
LB/Kan
Control
LB/Kan
Ligation
LB/Kan
Control
LB/Kan

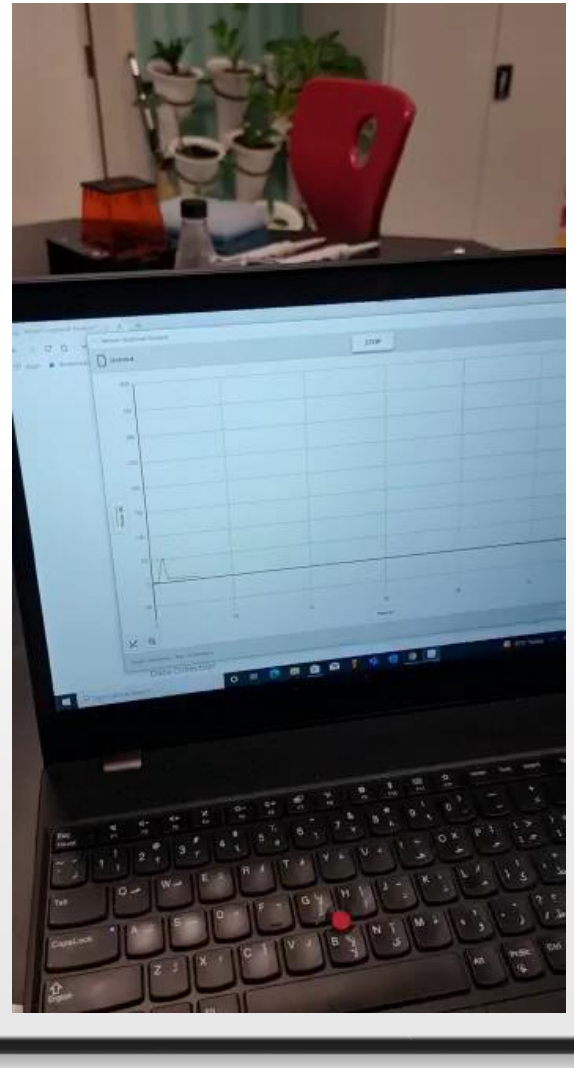

Source
Plates

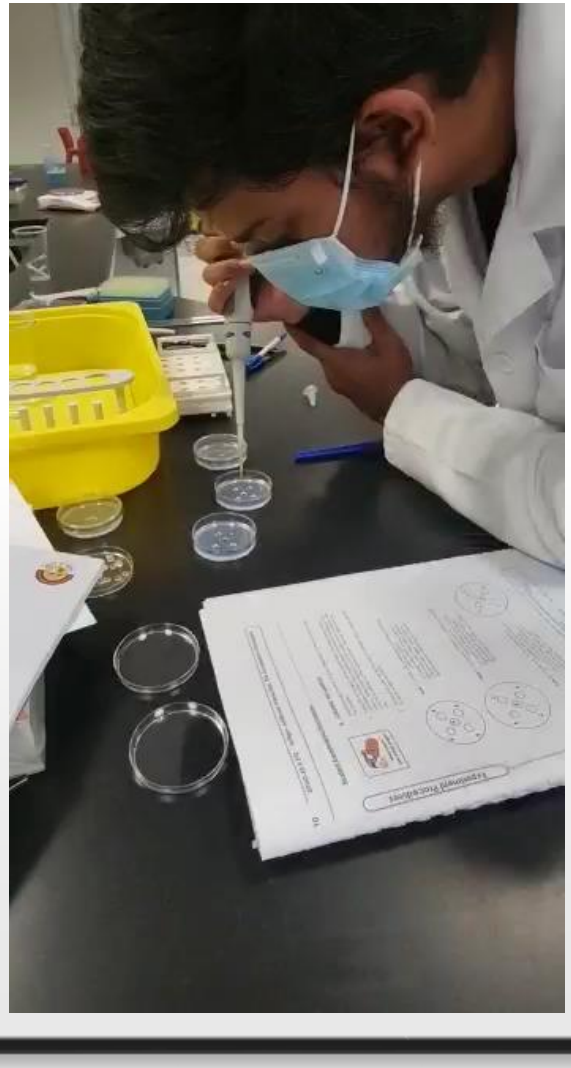

LB/Kan
Ligation
LB/Kan
Control
LB/Kan
Ligation
LB/Kan
Control
LB/Kan
Control
LB/Kan
Ligation

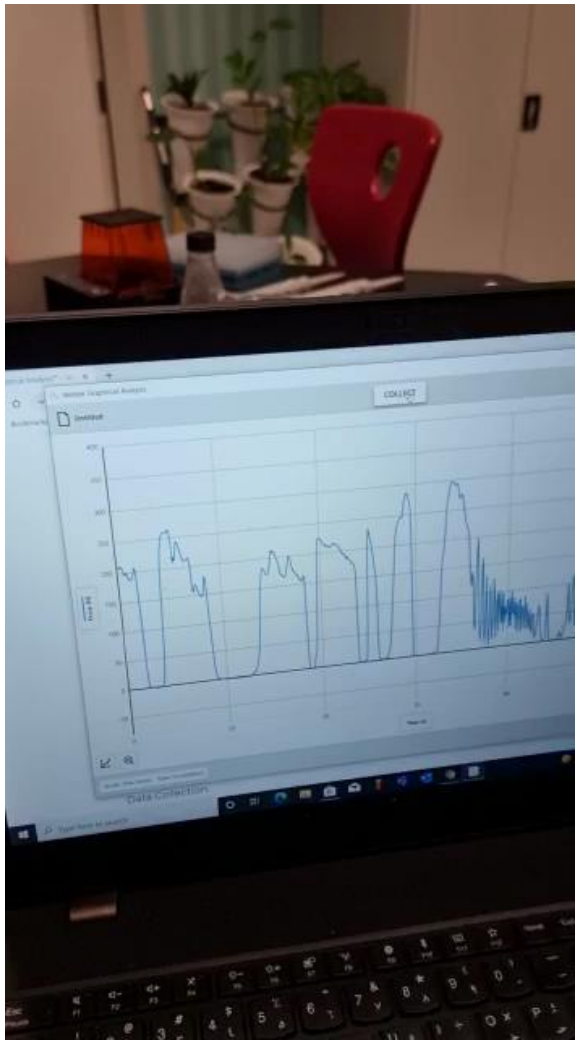

HUNTINGTON
Cycle 19 of 30
94°C
94°C
72°C
72°C
72°C
55°C
0°C
—:—
03:00
00:30
01:05
00:30
04:00
Annealing: 00:32
Remaining time: 00:35:59
Home
Pause
Stop

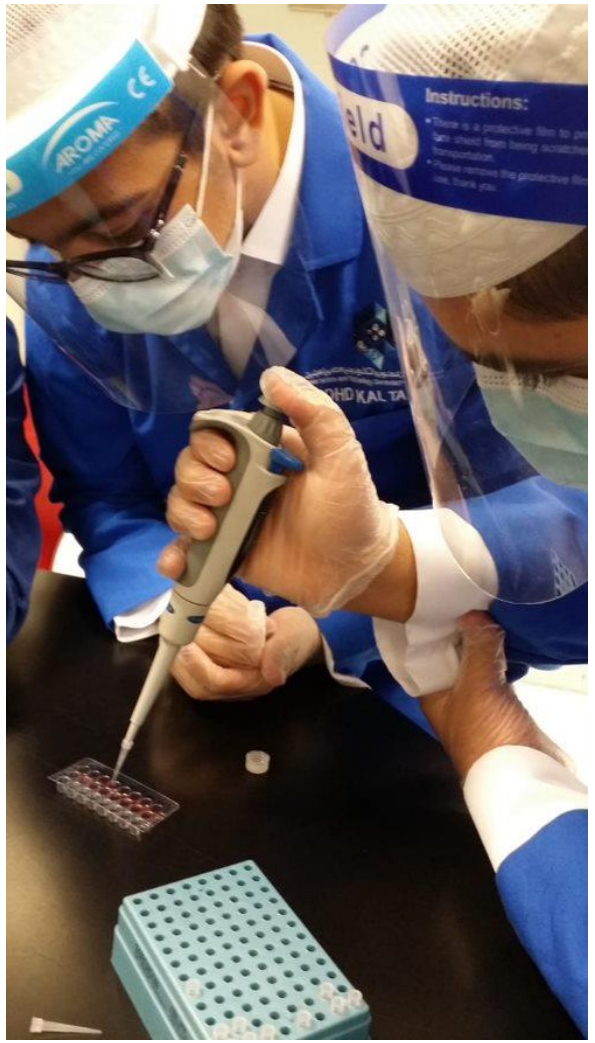
Theme "Forensic", [7 Periods]		
Investigation 4: #225 (DNA Fingerprinting Using Restriction Enzymes)	1 Period 105 Min	Week 12: 29/11/2020 - 3/12/2020
Investigation 5: #191 (Forensic Blood Typing)	**1** Period: **50 min**	Week 11: 22/11/2020 - 26/11/2020
Investigation 6: #270 (Antigen-Antibody Interaction: The Ouchterlony Procedure)	**1** Period; **35 min /** (Incubation overnight)	Week 13: (2nd Semester) 10/1/2021 - 14/1/2021
Investigation 7: #192 (Forensic Antigen Detection)	**1** Period: - **35 min** - Incubation overnight.	Week 14: 17/1/2021 - 21/1/2021
Investigation 8: #193 (Forensic Enzymology)	**1** Period: **90 Min**	Week 16: 31/1/2021 - 4/2/2021
Investigation 9: #194 (Forensic Enhancement Techniques)	**1** Period: **35 Min**	Week 15: 24/1/2021 -28/1/2021
Investigation 10: #195 (Forensic Toxicology)	**1** Period: **60 Min**	Week 17: 7/2/2021 - 11/2/2021


M 0.01 HTa
M 0.001 HTa

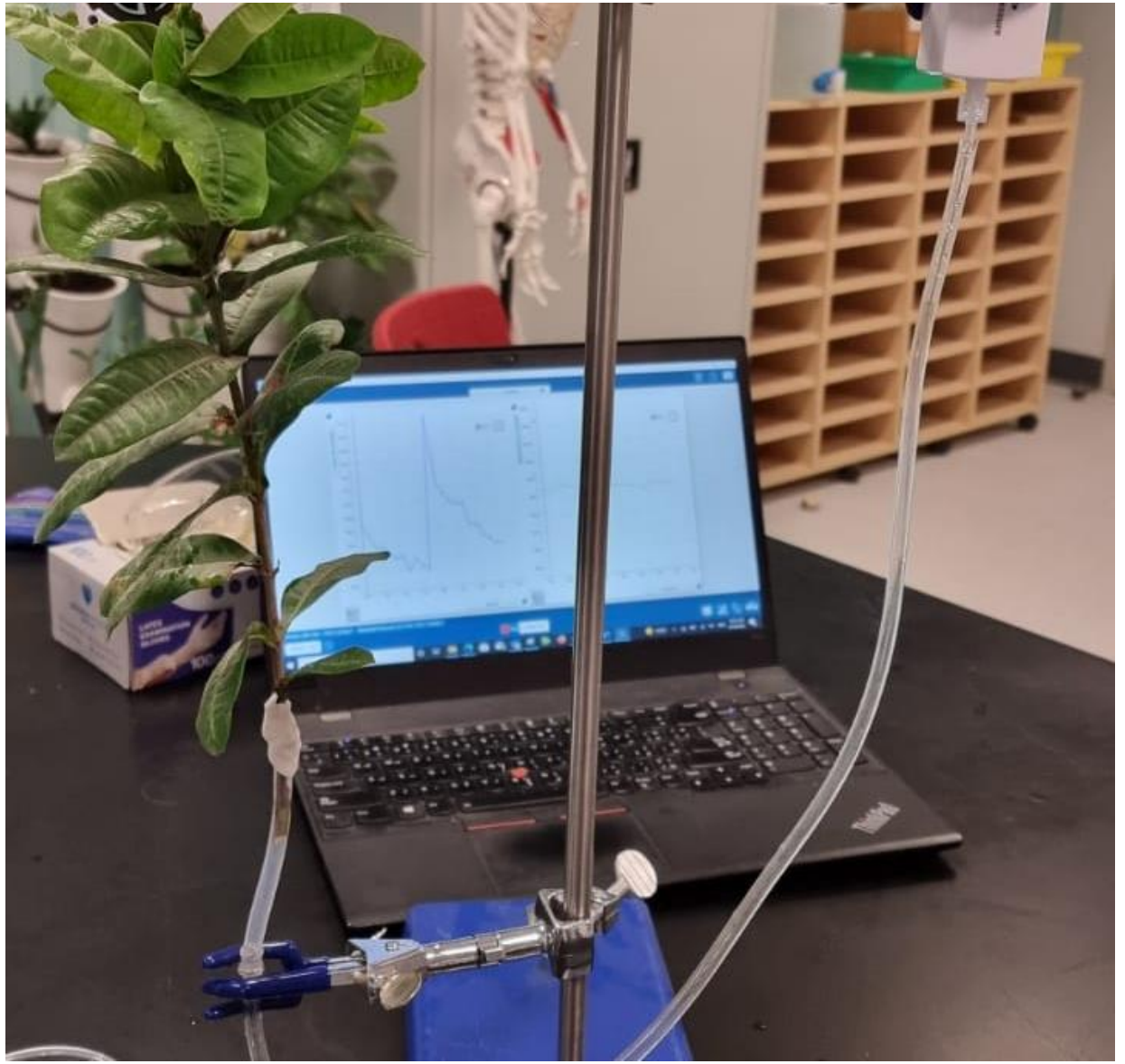


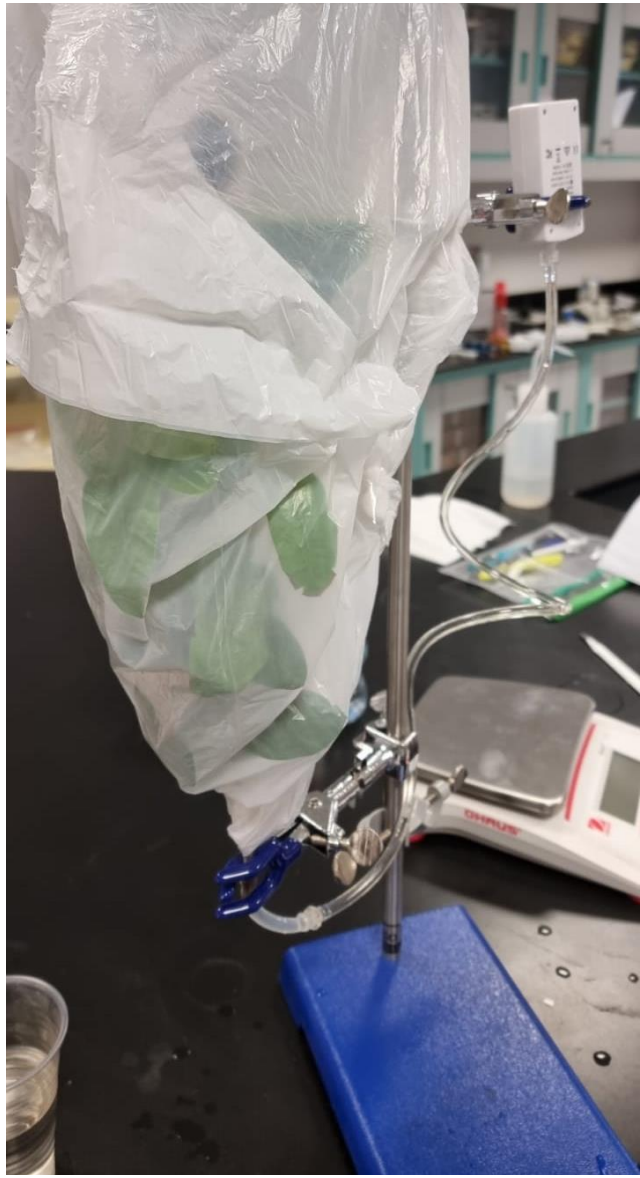




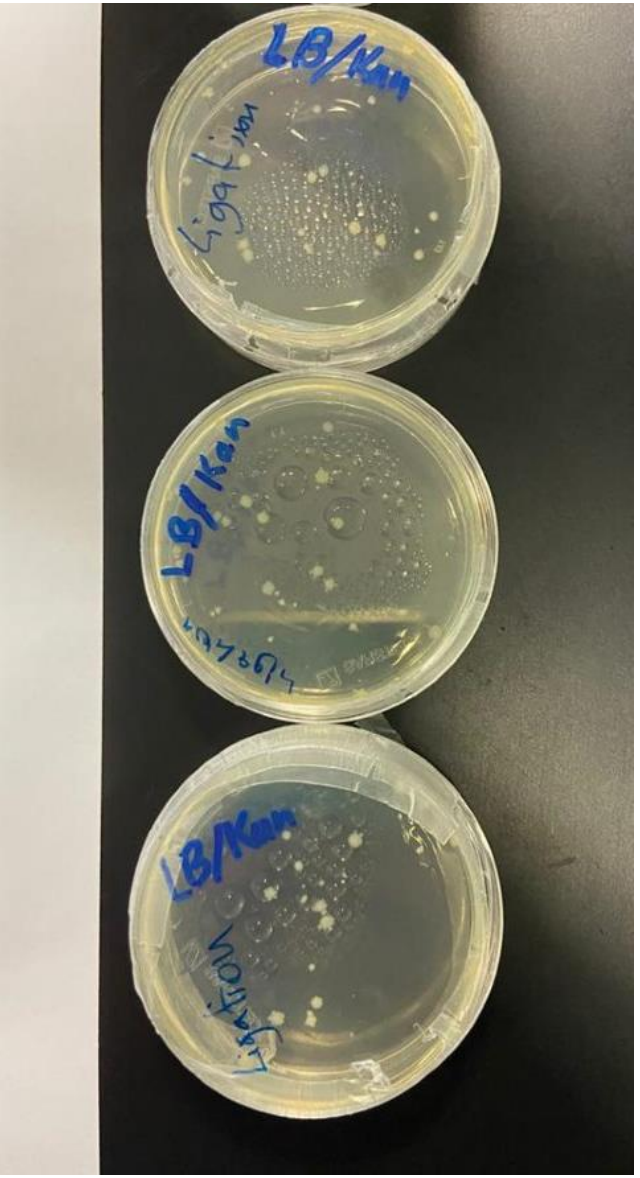

AROMA
Instructions:

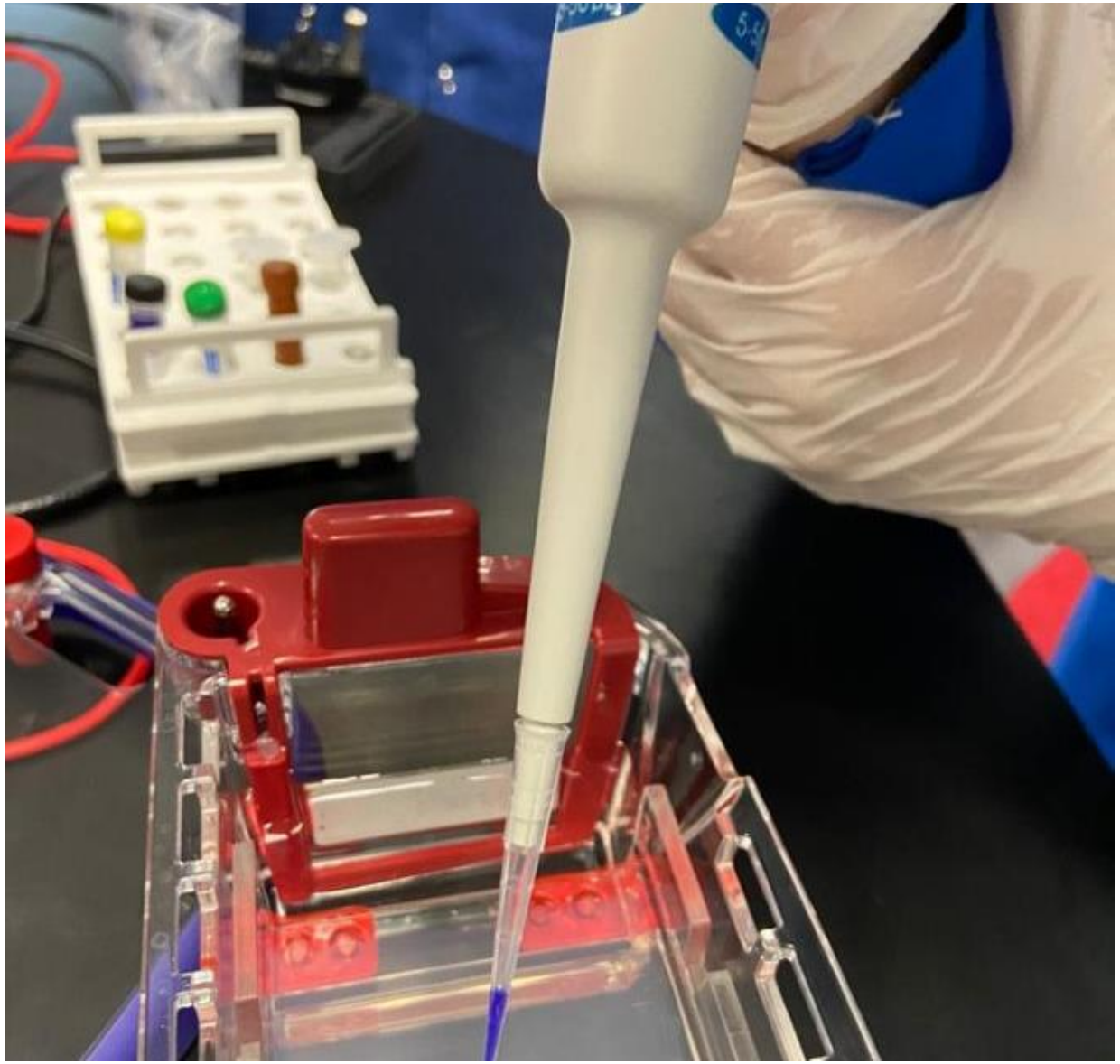

STERILE CONTAINER
Effluent



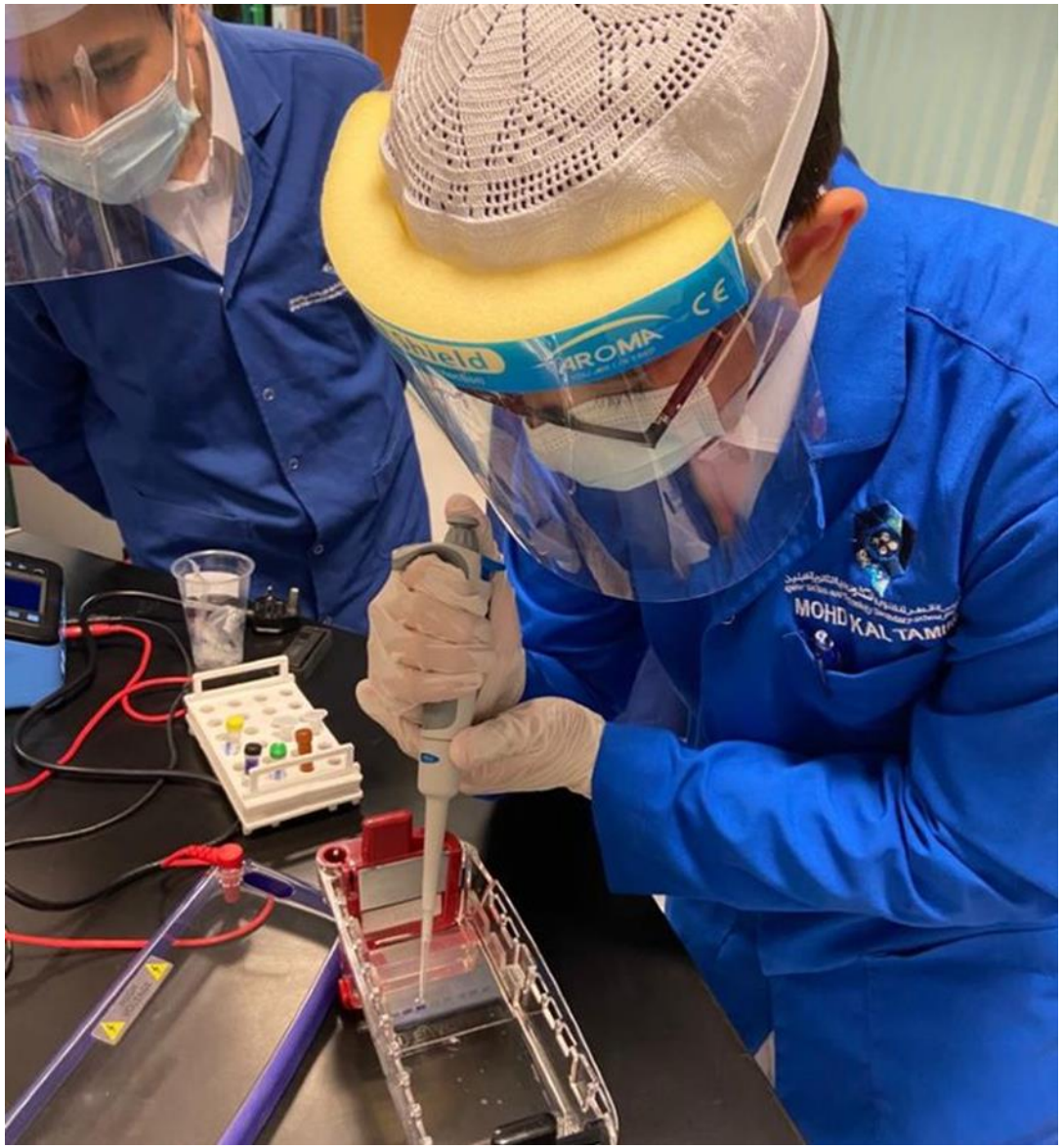


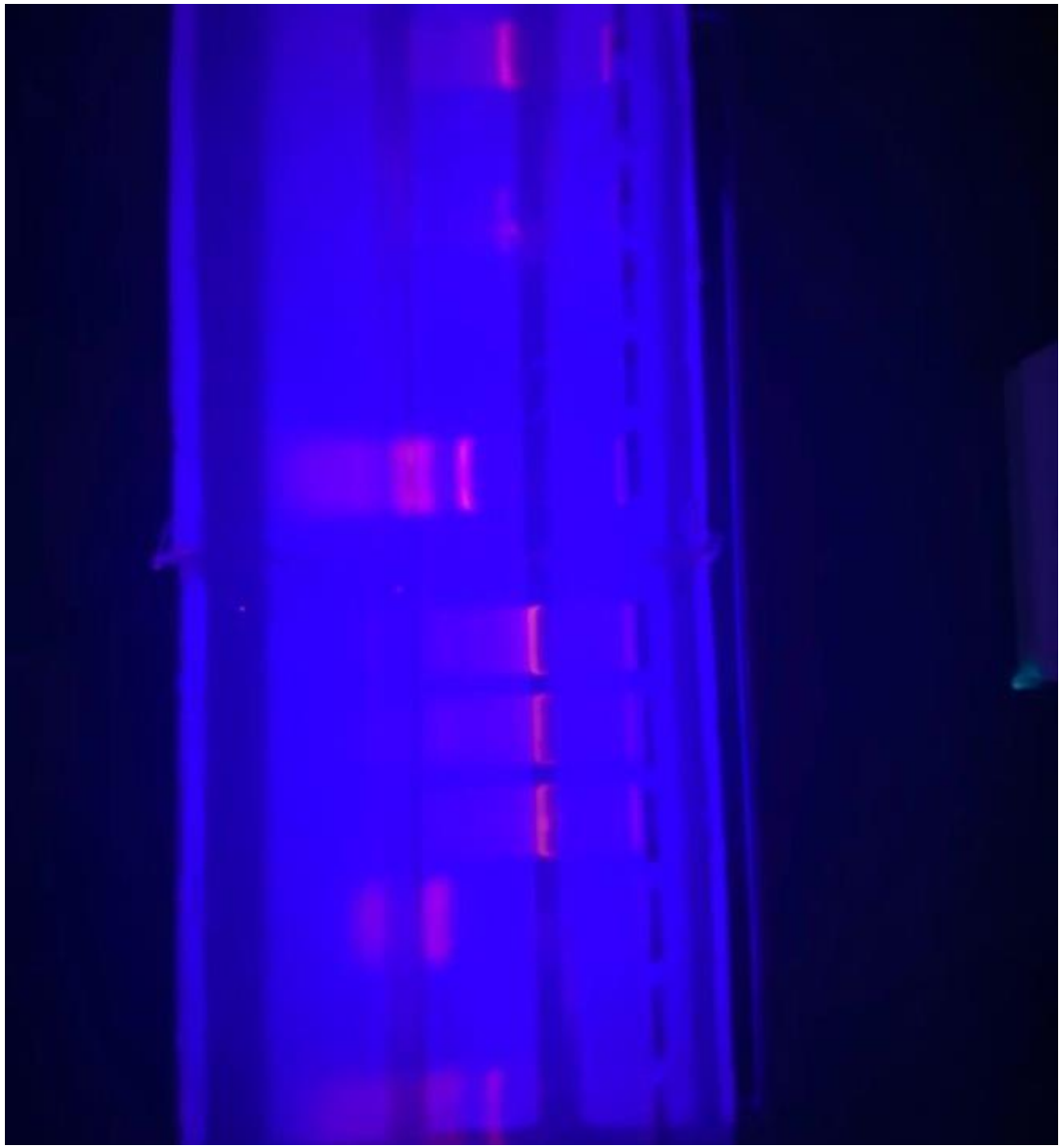
Theme “Neurobiology”, [5 Periods]		
Investigation 24: #1100 (Scents & Sense-ability)	**1** Period: **50 Min**	Week 30: 23/5/2021 - 27/5/2021
Investigation 25: #1110 (Cell Types in the Brain)	**1** Period: **135 Min**	Week 31:
Investigation 26: #1116 (Researching Alzheimer’s Disease by ELISA)	**1** Period	Week 32:
Investigation 27: #1125 (Diagnosing Huntington’s Using PCR)	**2** Periods: **200 Min**	Week 33:


LB/Kan
LB/Kan
LB/Kan




Face Shield
face shield


AROMA
CE



AQUAPONICS

Thank You for Listening