Proceedings from the 2023 indicium conference

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Indicium is an annual research competition geared towards introducing inexperienced students to the process of independent research. Through this mentorship program, undergraduate students are grouped with PhDs, professors, graduate students, medical students, etc. who are experienced in STEM research fields. Mentors actively guide and support students through a research project in their field of expertise and prepare them for the final Indicium Research Conference. The program also includes workshops focusing on various aspects of project development as well as networking opportunities within the greater scientific community.

This year, Indicium was hosted at four university branches across Canada including McMaster University, York University, University of Toronto St. George, and University of Toronto Mississauga. Every branch held a university-level conference where participating teams were granted abstract publications in the National peer-reviewed STEM Fellowship Journal. Ten teams selected from these branches moved forward to participate in the National Indicium Research Conference held on August 12, 2023. Winning teams from this competition have been granted a full manuscript publication.

We are pleased to be showcasing the conference proceedings from the four participating Canadian Indicium branches. Working alongside the incredible group of mentors, mentees, judging panel, and executive team on this initiative was an honour. Indicium would not be possible without the drive of those who chose to indulge in this platform in the pursuit of knowledge, mentorship, and future opportunities.

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Disclaimer

These abstracts are provided for all student teams that have submitted project reports for the 2023 Incidium Competition. The STEM Fellowship Journal editorial board has made every effort to ensure proof and English editing of these abstracts in a limited amount of time, and neither organization as a whole or any of its volunteer members can be held accountable for inaccuracies that may have occurred in the abstract publication. Abstracts are published in no particular order.

STEM Fellowship Journal

Development of biocompatible tissue scaffold by decellularization

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Chronic wounds characterized an imbalance in growth factors, impaired cell migration, and persistent inflammation present a substantial healthcare challenge, demanding innovative treatment approaches. In this regard, fish skin extracellular matrix (ECM) scaffolds are emerging as a promising strategy for promoting efficient wound healing and tissue regeneration. Fish skin ECM is a suitable substitute for mammalian-derived ECM scaffolds, offering high tensile strength, biocompatibility, and antimicrobial activity for effective wound healing. The sample used was derived from fish skin due to its rich content of Omega 3 fatty acids, biocompatibility, and similarity in pore structure to human skin. The fish skin was mechanically processed to separate it from the muscle tissue and remove scales. Sodium dodecyl sulphate (SDS) was employed to induce cell lysis, while Dispase I enzyme degraded proteins. The sample was then assessed for three key properties: structural integrity, residual DNA, and cell viability. The structural integrity was evaluated using scanning electron microscopy (SEM) and transmission electron microscopy (TEM), which revealed compressed pores resulting from processing and damage to the ECM. Residual DNA was quantified using nanodrop-based DNA quantification, indicating a DNA content of 211.4 ng/mg after processing, surpassing the allowable limit. This excessive genetic material may have elicited an adverse immune response and thus had to be reduced. Cell viability was determined through the trypan blue assay, demonstrating a non-toxic range of 95.6%. Optimizing the protocol became necessary to lower the genetic content within the acceptable range while maintaining the desired cell viability.

Automatization of liquid handler sterilization for strain characterization of microbial cultures in deep well plates

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A need for synthetically produced biofuels has arisen to counteract climate change; this process involves the preparation, monitoring, and sampling of microorganisms, such as the bacteria Escherichia coli. The lengthy process has trended towards an automated approach to ensure that biofuel production is commercially viable, which has also provided the precision that these sensitive tasks necessitate. Previous studies have found success by utilizing an airgap within the pipettes, which was twice the effective media volume of 250 µl. Pipettes in current automated systems typically hold a maximal volume of 1000 µl, so this study aimed to establish a consistent and precise decontamination process for larger media volumes. Plates were tested using 3%, 6%, or 9% sodium hypochlorite and an effective airgap of 50 µl, 100 µl, 150 µl, 250 µl, or 350 µl. The decontamination of wells within the plates was successful, though inconsistent at times, even when using controls that favoured decontamination. There was also a statistically significant difference between the wells sterilized first and the wells sterilized last ($p = 0.024$). Thus, the results demonstrate that the system becomes contaminated over time, regardless of the controls, which supports previous findings regarding the relationship between the airgap and the effective media volume. While the capacity to synthetically produce biofuels is beneficial, further studies are needed to develop an optimal decontamination process for larger media volumes that overcomes current limitations.

Implementing a large language model for enhanced tumour phenotypic & treatment recommendations from electronic medical records

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In recent years, there has been increasing interest in applying Large Language Models (LLMs) to advance research in the biological sciences. Specifically, by using LLMs to extract relevant information from a range of Electronic Medical Records (EMRs), researchers have been able to accurately identify tumour phenotypes. This study aimed to evaluate the effectiveness of GPT-3.5-Turbo in accurately diagnosing and suggesting treatment options for various tumours based on EMRs. Using the GPT-3.5-Turbo API, a custom application was developed with fine-tuned parameters. The system generated a treatment plan based on the Institute of Medicine's National Cancer Policy Forum by incorporating the first 30 oncology reports from the Medical Transcription Samples' Hematology & Oncology dataset. According to the scoring framework developed for this study, the output achieved an average score of 8.57/10 for all prompts assessed on a scale of 1-10 and an accuracy rate of 97.67% for all prompts assessed. While these results are promising, the lack of context and nuance in some outputted diagnoses and treatment recommendations suggest that the GPT-3.5-Turbo system is intended to assist healthcare professionals, not to replace them. Future research directions involve including a larger input dataset from official medical institutions, having oncology experts evaluate the results, and integrating agents-based LLMs and few-shot prompting to improve clinical decision-making accuracy and effectiveness.

Developing an accessible diagnostic test for early pancreatic cancer detection

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Pancreatic cancer is a significant contributor to global cancer-related deaths due to limitations in diagnostic testing. Surgical biopsies are the gold standard for its detection, but they are invasive; in contrast, abdominal ultrasounds are non-invasive but largely inaccessible. Therefore, limited and delayed treatment causes poor post-diagnosis survival rates. To address the need for an accessible test for the detection of early pancreatic cancer, the NITEP (Non-Invasive Test for the Early Detection of Pancreatic Cancer) was developed. NITEP is a functional nucleic acid (FNA), paper-based, lateral flow assay that detects multiple salivary biomarkers in the early stages of pancreatic cancer. The biomarkers, Granulicatella adiacens, an opportunistic pancreatic cancer pathogen, along with KRAS mRNA and HOTAIR RNA, multiplex the detection, enhancing the test sensitivity and specificity. FNA components of NITEP include aptamers and a DNAzyme. In the presence of biomarkers, aptamers bind to mRNA and RNA biomarkers via complementary hydrogen bonding. An in vitro selection procedure generates an aptamer to bind the bacterial biomarker. Bound aptamer-biomarkers and heme addition allow the DNAzyme to form a peroxidase-active enzyme to catalyze ABTS oxidation and produce an observable green colour at the test line. To determine the diagnostic value of NITEP, a receiver operator characteristic curve plotted saliva true positives against false positives;the greater the area under the curve, the more accurate the test. If NITEP proves to be an accurate diagnostic test, it will be a tool readily accessible to the larger population, thereby reducing pancreatic cancer-associated deaths.

Improving accessibility of genomic RNA for rolling circle amplification using Norovirus as a model

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Rolling Circle Amplification (RCA) is an isothermal nucleic acid amplification method which can produce long, single-stranded reaction products using highly processive phi29 DNA polymerase to extend 3'-end of the target nucleic acid primer around a circular DNA template (CDT). However, the large genomic framework of molecules, such as Norovirus RNA, causes its 3' end to be sequestered within secondary

structural elements, preventing CDT hybridization and subsequent RCA. Previous research using 10-23 DNAzymes to cleave genomic RNA, generating primers for RCA, showed marginal improvement in RCA, as cleaved fragments also adopt secondary structures. We hypothesize the use of DEAD-box helicase to disrupt secondary structures and improve accessibility for DNAzyme cleavage and RCA. DNAzymes and CDTs were designed based on computational screening of the viral genome to reveal accessible target sites. Processed stool samples containing Norovirus RNA were incubated with DNAzymes at room temperature, followed by the addition of CDT, DEAD-box helicase, and RCA mix. Amplification products were then measured as fluorescence plots. We predicted that DEAD-box helicase would be an efficient tool for restructuring RNA, eliminating secondary structures, and allowing better hybridization to DNAzyme and CDT. Improved hybridization increases the relative fluorescence unit over time, denoting improved RCA yield because of better binding between RNA and CDT. In summary, we discuss a new strategy for improving DNAzyme cleavage and RCA efficiency to restructure any viral RNA. The goal of this project is to develop a paper-based biosensor to accurately detect viral RNA in stool samples.

Investigating the associated impacts of prenatal and early childhood exposure to phthalates and neurodevelopmental outcomes: A scoping review

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Phthalates are a widespread class of organic molecules that increase the solubility and durability of plastics and are present in baby care products and toys. Children and infants may experience adverse impacts from phthalates comparatively due to the developmental processes they actively undergo. This study highlights the risks associated with phthalate exposure during early-life stages in children aged 0-8 years. A scoping review with a systematic search was conducted from primary literature sources within the last five years from Embase and PubMed Databases. The search provided 1713 articles, which, followed by abstract analysis, was narrowed down to 54 articles for data extraction based on the relevant inclusion and exclusion criteria. A positive correlation was identified between prenatal and childhood phthalate exposure and the onset of neurodevelopmental conditions, primarily concerning autism, ADHD, and language development. A stronger association was found between boys with autism and DEHP exposure. Additionally, prenatal phthalate exposure may increase the risk of developing ADHD, especially in the case of elevated DEHP exposure found in maternal urine. A general correlation between phthalate exposure and poor language development was also found. Despite the associations identified between increased childhood phthalate exposure and poorer neurodevelopmental outcomes, the results were largely preliminary. As such, more studies are required to fill in the research gaps and ensure standardization and comparability across different methods of neurodevelopmental assessment. Due to the ubiquitous presence of phthalates and their potential detrimental impacts on children, additional effort should be made to define their impacts on early development.

The adverse health effects & social perceptions of vaping: A systematic literature review

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Vaping prevalence among students in grades 7 to 12 increased from 10% in 2016 to 20% in 2019. Many manufacturers claim that vaping has less harmful respiratory effects than smoking. This review aims to encourage further research on this topic and to provide insight into the clinical impacts and pathophysiology of vaping. A systematic methodology was followed in which a search strategy was developed and conducted on the OVID Medline database. Papers were screened based on relevance to the topic and potential for bias. Information was extracted from a total of 56 studies and consolidated. Various clinical implications were connected to vaping, including the increased risk of emergency room visits and death. Several studies proposed pathophysiological mechanisms by which vaping can

contribute to lung disease development. Research into social perceptions showed that there is a lack of knowledge on vaping and its effects on health. Despite the lack of information regarding the long-term health effects of e-cigarettes, the number of e-cigarette users is increasing every year. Further studies should be conducted to raise public awareness as vaping is linked to various pathophysiological mechanisms that adversely affect health. This systematic review reveals that young individuals are receiving inadequate information on the safety of e-cigarettes, and a dearth of research exists due to the assumption that they are safe. It also serves as a literature overview and introduction for researchers looking to analyze existing research on the subject.