REBUILDING SIR: FROM THE GROUND UP

REMEMBERING DR. CLANCY

NANOPARTICLES IN FUEL PRODUCTION

hadron

PILOT ISSUE

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REBUILDING SIR: FROM THE GROUND UP

Since 1989, IMSA's Student Inquiry and Research program has been guiding students in research, both on and off campus, with the goal of "increased knowledge, deeper understanding, and skill development". IMSA's inquiry-based academic philosophy results in students only having school four days a week, with Wednesday reserved as Inquiry days. This academic opportunity has allowed students to actively engage in their fields of interest and conduct undergraduate-level research while still in high school.

The SIR department went through a transition in leadership in the 2018-19 school year, providing a fresh start from the prior leadership of three years. IMSA teachers Dr. Don Dosch, Dr. Dave Devol, and Dr. Eric Smith from the biology, chemistry, and history departments, respectively, have stepped up to be the new head directors of the program.

We interviewed Dr. Don Dosch regarding his goals and struggles in directing the SIR program. The following interview has been edited for clarity, but everything printed has been approved by Dr. Dosch.

Q: What were the initial problems that you faced when you first took over the program?

A: "The first problem that I recognized was that I had no idea what I was doing. I've been working with students in SIRs for a very long time, Devol has as well, and so has Smith, but we really had no sense of the… the overwhelming need of students. I suppose when the program is running very smoothly year after year after year it becomes more routine, and you add students as they come to you. But we did not have a lot of contacts, and so it's been all brand new."

Q: You mentioned something about the overwhelming need of students. So you don't think there are enough students involved in the program?

A: "I do not. I think we will double it next year. That's a bold prediction!"

Q: How many students are in the program this year?

A: "I think we're running about 180-ish kids. ***But I'm going to double it.***"

REBUILDING SIR: FROM THE GROUND UP

CONTINUED

Q: Does that count include students in internships?

A: “No, internships are completely separate from SIR. Although, I will say that there was been interest from the internship program to make that program much more like SIR in terms of student responsibilities. Students from last year wanted it to be on their transcripts, and for that to happen, it had to be a little more… academic.”

Q: You mentioned that we didn’t have many contacts. There have been rumors around campus that we’ve lost contacts, and that people don’t want to work with us. Is that true?

A: “Yes, that is correct. I had talked with some people who had been previously working with our students, and the sense that I get from that is that the expectations that students had under the previous leadership… could not be met.”

Q: Like what?

A: “Publishing. Publishing papers. And I can appreciate that. If a student has been working in a molecular biology lab one day a week, that’s not going to lead to publication. It’s just not. One of the reasons I did volunteer was because there was not enough diversity in the choice that students had. Nobody in English was doing an SIR. Even though they used to do a lot. A few faculty in History were doing SIRs in the past two or three years. Even though, before, they used to do a whole lot. Very few people on the science team could work under the restrictions of having to publish. Even internally, the program fell apart.”

> ***“That doesn't mean it's a bad experience”***

“I understand the aim to publish. When you do science, you share your results, you share your knowledge with the community, and if you don’t do that you haven’t accomplished anything. However, when you’re sending a 17-year-old into a lab situation, you want them to have a great experience. In science that doesn’t always lead to quickly publishing. That doesn’t mean it’s a bad experience.”

REBUILDING SIR: FROM THE GROUND UP

CONTINUED

Q: Have we had to rebrand after making changes to get back some of our lost contacts?
A: “I’ve had to do that. I’ve contacted some of the old mentors who would always be reliable, they’d take 4 or 5 kids every year. Those relationships will be born again.”
Q: Has it been hard to rebrand?
A: “It’s embarrassing. No, it’s not hard to rebrand. I think the program is good. But. the program was not always good. You just extend your apologies, because people were insulted. The old program was not respectful sometimes. And that was unfortunate.”

> ***“It's embarrassing.”***

Q: Is there anything that the students don’t know but the faculty knows that you can tell us?
A: “In the science department, we have talked as a team, and 6 members of the science team are offering research courses starting in the fall of 2019. Each person can take up to 15 students! Didn’t I tell you I was going to double this program? There will be two research courses offered by History/Social Science faculty. We are starting with science and history because historically those have been the two programs of IMSA that have done the most on-campus SIRs. Everyone should be in an SIR. It’s ridiculous that we say no to people. And in past years, we’ve said no to students if their interests are in an area where you can’t publish.”

> ***“Everybody should be in an SIR.”***

Q: What are your plans for IMSAloquium this year?
A: “I think some things we agree on are students presenting with posters. We agree that presentations are important. We agree that the freedom to visit your friends in their presentations is a good thing. How that all comes together? That’s where we still have to talk. IMSAloquium is an expensive day.

REBUILDING SIR: FROM THE GROUND UP

CONTINUED

We are also going to introduce tiering of presentations, because we have students who are just beginning and others who have been at it for two years. It doesn't make sense that everybody has to present in the same way."

> ***"We wouldn't do it if we didn't think it was important work."***

Q: What are some of the most difficult challenges you're facing right now?
A: "Making the contacts is difficult. There are not enough people involved. We need to have someone to run the room here. We need staff. Between the three of us, we have other responsibilities. I'm half-time here. I have a class I need to teach. I have a responsibility to the science team. But I spend all of my time working on this stuff. But it's okay! We wouldn't do it if we didn't think it was important work."

Students' Frequently Asked Questions

Q: Mandatory assignments have been very restrictive in the past years. You had to pass phase 1, phase 2, complete concept maps, etc. is that going to change?
A: "The phases were fantastic. It describes the scientific process. We like concept maps because we want you to engage fully in the experiment. The only way you can do that is if you understand the field. The one phase that we have difficulty with is requiring phase 5 - requiring publication."
Q: There have been complaints about buses. What are the problems?
A: "Money. It costs $550 to send one bus off campus. Doesn't matter where it goes. We have five buses. It's the reality. I wouldn't mind spending on another bus… but we have to get more sites. There are 12 different sites, and some of these sites have 1 or 2 people on it. I can't afford to spend $550 to send one child. So we have to make a loop with several stops. And that makes the bus trip long sometimes."

REBUILDING SIR: FROM THE GROUND UP

CONTINUED

Q: Could trains be another option.
A: “I would not put a student on a train.”
Q: Why?
A: “Safety. It’s my name! EleMENT no longer puts students on trains either. We do not want students running around in Chicago looking for a train or bus. SIR is a school-sanctioned activity. Trains put the school in harm's way. The school bus company takes responsibility for you once you leave the door. It’s a safety factor. The safety of IMSA students leaving this building is a serious issue, and we will always run school buses. You are minors after all! And we have assumed responsibility for your safety.”
Q: There have been some rumors about Fermilab. Can you clarify?
A: “Fermi is a national laboratory. Access is restricted. They’re going to control who gets on campus and who doesn’t. The people who work there have jobs! And IMSA students are not their jobs. However, they like working with IMSA students - within reason. It’s unfortunate that there are students who want to work at Fermilab, but there are no positions. I’ve been sending resumes over there, Devol’s been sending resumes.

But on the other hand, there are thirty students working there as of right now. You should see them coming back. They’re so tired, their eyes are all so heavy because all they do is code! ***But damn, their smiles are huge***”

-Devika Prasad, Caitlyn Castillo

REMEMBERING DR. CLANCY

Dr. Peter Clancy has been a part of the IMSA community for ten years. Not only did he positively influence the students, but he was also a kind, reliable, genuine, and pun-loving person with all of his colleagues. Dr. Don Dosch shared that at the very start of Dr. Clancy's IMSA career, he "interviewed here for a physics position. But, you know, during an interview you're being super careful, you're looking for behaviors. Immediately I could tell that he was going to be approachable, supportive, and challenging of students. And, I must say that my first impressions really never changed with time. You know, sometimes during an interview people want to give you their best impression.

> ***"He was sincere, he was the person that we saw in the interview"***

Dr. Clancy truly had a personality that everyone could look up to. Dr. Mark Carlson expressed: "I consider myself privileged to share an office with him. We were just on the same wavelength. There was never any misunderstanding between us, so it made working together really easy. Spending nine years together in an office, I can never remember one harsh word ever uttered between us, or him towards anyone or anything. And, he was a good example on many fronts.

Photo Citation:
Imsa_. (2018, Nov 30). The IMSA Community shared heartwarming stories of Dr. Peter Clancy's kindness, sense of humor and never ending commitment to students at a celebration of life held on campus Thursday, November 29. Dr. Clancy will be greatly missed by the staff, faculty and students of IMSA. [Twitter Post]. Retrieved from https://twitter.com/IMSA_/status/1068529781564682240

REMEMBERING DR. CLANCY *CONTINUED*

He never got angry, he never was short with me or students. I think he was a remarkable model, a person you would like to emulate in terms of his patience, his willingness to help, his humility. I mean, there were so many good qualities that I felt it was very good for the students to see this person, because we're surrounded by so many bad examples that don't necessarily seem to have ramifications, but he modeled good behavior in so many ways."

> ***"We talk about innovation, disruption, big changes, and that's all fine, but to recognize the value in coming and doing a job you enjoy, and to do it well, and to not need anything else besides that"***

Dr. Peter Dong added that "Dr. Clancy was always out of the spotlight. He wasn't trying to make waves, wasn't trying to make a name for himself. And, especially towards the end, he was getting very sick. He still came very faithfully, came to teach his classes, to do his work just as always, and he only missed class when he had to be physically gone at a doctor's appointment or the hospital. One time, he had to check into the hospital for a few days, and then as soon as he came out he came right back to work. You know, he really liked it here, he really enjoyed his job, but it was also a duty, and he took it very seriously. You know, this job is not high-paying. He has a Ph.D. in chemical engineering; he could do a lot of other things. He wasn't getting even recognition, particularly, because while a lot of people knew him as a teacher, he wasn't on the brochure. He was just here doing his job, and doing it well. That's something I think we underrate sometimes. We talk about innovation, disruption, big changes, and that's all fine, but to recognize the value in coming and doing a job you enjoy, and to do it well, and to not need anything else besides that; I feel like that's a lesson to learn."

REMEMBERING DR. CLANCY *CONTINUED*

Another aspect of his amazing personality was his sly sense of humor. When asked about a fondest memory of Dr. Clancy, Dr. Carlson stated that “We had put up some pictures of remarkable scientists, and there was a picture of this person who was responsible for a theory on symmetry relating symmetry to physical forces, and so this person was all about high symmetry and he said ‘You ever noticed how that person wears a monocle?’”

Dr. Dong shared one of his favorite memories of Dr. Clancy as well, and of course, it involved one of his jokes: “This is hard to explain, because it’s really geeky, but Dr. Clancy really liked puns and he would go out of his way to work them in. One time, when I first started teaching Computational Science, I was trying out a lot of things for the first time that I’d never done, and one of the things I tried was the thermodynamic model of water. So I had simulated molecules going around, and I was trying to make it so you heat it up, and when you heat it up sufficiently, it would start to boil, so the water molecules would evaporate off the top. I was trying to figure that out, but it wasn’t working. Dr. Clancy had studied chemical engineering, so I was asking him for suggestions. A day or two later, he came and he found me, and he said, ‘I figured out the problem.’ He said ‘I assume your program runs a loop and at every time increment it checks to see if the water is boiling.’ And I said, ‘Yeah, I guess I’m doing that.’ He said, ‘You must keep the time increment very short.’ I said, ‘Yeah, I do.’ And he said, 'Well, there’s your problem, then. A watched pot never boils.’”

From beginning to end, he was always someone to look up to, someone to learn from, both in and out of the classroom. Though he may not have been trying to make a name for himself, he definitely left a legacy with us here at IMSA. We are all grateful that Dr. Clancy chose to share a part of his life with us and be a part of our own little community. He will be dearly missed.

-Alana Depaz

2018 JAPAN STUDENT SCIENCE FAIR

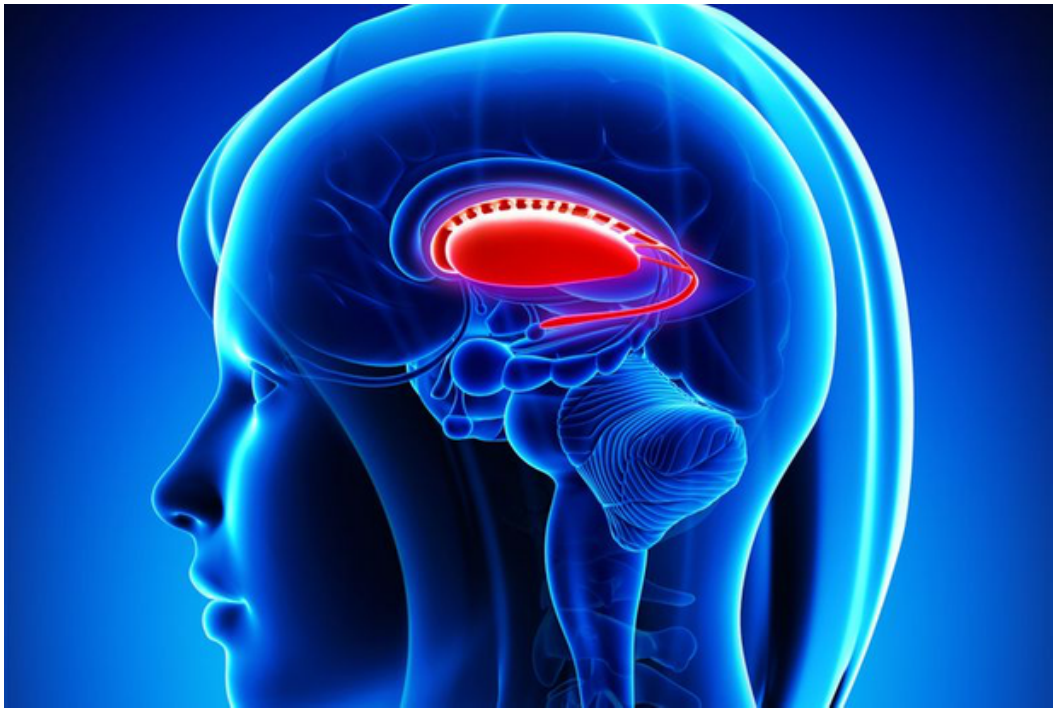
Pictured (from left to right): Louise Lima, Jake Sutter, Shubhi Verma

Three IMSA students: Shubhi Verma (’19), Jake Sutter (’19), and Louise Lima (’19), attended the Japan Super Science Fair (JSSF) held by Ritsumeikan University in Kyoto, Japan. This yearly science fair hosts high schools from around the world from countries such as India, China, Kenya, Iran, and many more, allowing a wide diversity of research to presented. The three students went with the SIR department during the week of November 12th, 2018 to present their research at the fair after being selected by the department. Their research ranged from topics in neuroscience, the overlap between physics and biology, and applied math.

2018 JAPAN STUDENT SCIENCE FAIR *CONTINUED*

Shubhi Verma

Shubhi Verma (’19) researched under Dr. Harry Xenias at Northwestern University, and her project revolves around understanding the mechanisms involved in Parkinson’s disease. She specifically looked at the basal ganglia, which is essentially a large group of nuclei in the brain. Her research focused on two of these nuclei: the external globus pallidus and the dorsal striatum, and examined the interactions between these two nuclei. One of the major factors in the development of Parkinson’s disease is the basal ganglia, since it is involved in how humans plan and execute different movements. Understanding the interactions in it, will give a clearer view in the pathogenesis involved in Parkinson’s disease, and hopefully develop better drugs to reduce its effects.



Depiction of the basal ganglia in the human brain (from Bailey, R. (n.d). The Role of Basal Ganglia in Motor Function. Retrieved from https://www.thoughtco.com/basal-ganglia-function-4086411)

2018 JAPAN STUDENT SCIENCE FAIR *CONTINUED*

Jake Sutter (’19) and Hanson Hao (’19)

Jake Sutter (’19) and Hanson Hao (’19) conducted their research at Benedictine University with Dr. Ellen Ziliak. Unlike, the other projects from IMSA that went to the fair that were focused on biology, their research was based on applied math. Their research was centered on matrices over a finite field, and how they are used to create the notion of symmetry. They considered three perpendicular vectors and the size of these vectors by using manual calculations and C++ programming. The set of these vectors is named SO(3,p) and it is seen in concepts like rotation and spin in physics.

Louise Lima (’19) and Alice Liu (’19)

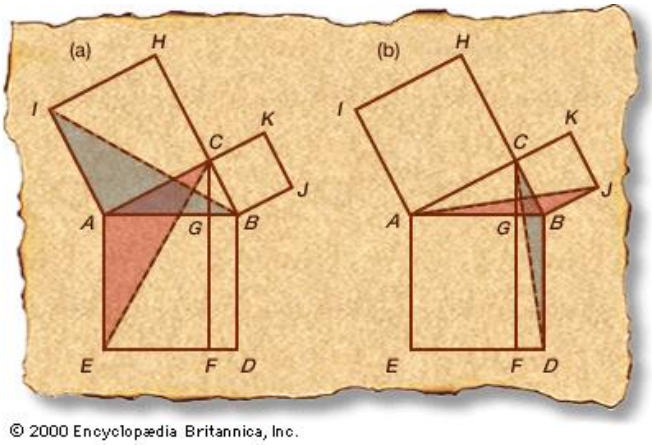
Louise Lima (’19) and Alice Liu (’19) conducted their research at Northwestern Medicine Chicago Proton Center with Drs. Steven Laub and Aditya Panchal. Their research lies between physics and medicine as they looked into proton therapy, a type of radiation therapy, for cancer. The goals behind this research is to develop more efficient methods behind treating cancer. They developed a program that classifies different cancer treatment plans based on their similarity to Single-Field Uniform Dose, which is another type of proton treatment plan. This classification can better help how cancer is targeted between patients.

In addition, the students enjoyed the experience listening to other students’ research, and being able to meet international students. This opportunity was made possible by the SIR department and was fully paid through alumni donations.

-Meghana Karan

SYNTHETIC GEOMETRY AND EUCLID'S ELEMENTS

Records on the study of geometry date back thousands of years. Between 2000 and 1600 BC, ancient Babylonians studied the properties of triangles regarding ratio and proportion, and developed what would become the Pythagorean Theorem long before Pythagoras ("The Origins of Geometry," n.d.). Similar geometric analysis took place independently in other ancient civilizations--the Egyptians, for example, utilized their relatively advanced understanding of geometry to study astronomical bodies. Ancient civilizations often documented their discoveries on clay tablets and papyrus, some of the earliest of which coming from ancient Egypt. It was not until the 3rd century BC, however, that a truly definitive mathematical text on geometry was written.



Euclid of Alexandria's *Elements* (just 'Elements', not 'The Elements' nor 'Euclid's Elements') is perhaps the most impactful and transformative mathematical text in antiquity. *Elements* is an index of the extreme, rigorous evaluation of geometry (and, to an extent, elementary number theory) which the ancient Greeks are well known for. The 13 books of Elements are lists of largely synthetic geometrical statements, or geometric 'axioms', in order of increasing complexity. These 'axioms' are statements on geometric properties which are reasoned to be true, and are then used to support more complex statements.

SYNTHETIC GEOMETRY AND EUCLID'S ELEMENTS

CONTINUED

What is incredibly striking about *Elements* is that it uses close to no algebraic equations; it is largely a compilation of synthetic proofs, which by definition do not use coordinate systems or algebraic equations in their analysis. The text expands on some otherwise intuitive ideas to articulate astonishingly advanced proofs where numerical labels and coordinates are completely absent.
It is trivial to say that a line ends at two points--but how can such simple statements become the basis of advanced spherical geometry? How can it be used in the analysis of tetrahedrons inscribed in spheres? Such is the level of rigor to which the ancient Greeks studied geometrical structures, as compiled in Euclid's *Elements*.

-Matthew Niemiro

Citations:
University of Kentucky (2011). The Origins of Geometry. Retrieved from www.msc.uky.edu/droyster/courses/fall11/MA341/Classnotes/Chapter 01-The Origins of Geometry.pdf
Figure 1. Euclid's Windmill proof [Image]. Retrieved from https://www.britannica.com/biography/Euclid-Greek-mathematician

ARTIFICIAL INTELLIGENCE IN RADIOLOGY

Artificial intelligence (AI) is the manipulation of data to get information, particularly from large data sets. At the moment, AI is used for ‘narrow’ tasks; while it can perform with greater efficiency, an AI cannot mimic the complex processes by which the brain functions. Radiology is the study and treatment of diseases using medical imaging, using tools such as x-rays.

Artificial intelligence can be used to much better analyze images of different types of nodules, lesions, polyps, tumors, and more in radiological study. It is estimated that a radiologist needs to analyze approximately 3-4 images per second in an eight hour work week; the use of artificial intelligence could provide drastically needed improvements regarding efficiency. Within oncology imaging, AI can be used to detect lesions, characterize qualities like size and internal texture, and monitor treatment such as radiation to determine correct dosage.

Under this supposedly marvelously effective system, artificial intelligence would be trusted with vast amounts of data pertaining to persons medical health. Such an AI would need to be meticulously constructed and reviewed to verify their accuracy and comprehension. Ethical dilemmas also arise; with the technological handling of medical information, restricted databases could more easily be breached and the question or whether or not an artificial intelligence should be trusted with a person’s life becomes relevant. However, as the amount of data to evaluate increases and performance benchmarks are raised, artificial intelligence will undoubtedly become necessary in radiological study and surpass human capacity in its ability to process and understand data.

-Zoe Berthold

Citation:

Hosny, A., Parmar, C., Quackenbush, J., Schwartz, L. H., & Aerts, H. J. (2018). Artificial intelligence in radiology. Nature Reviews Cancer, 18(8), 500-510. doi:10.1038/s41568-018-0016-5

PARTITIONS IN MATH

A partition of a natural number is the way of writing these numbers as the sum of other natural numbers. The first mathematician to introduce the topic of partitions was Gottfried Wilhelm Leibniz, who is more famously known as one of the "Fathers of Calculus." He asked J. Bernoulli about the number of "divulsions," a tearing or pulling apart, of any natural number. Essentially, he was asking about the modern equivalent of partitions of these numbers. As Bernoulli viewed these partitions, he noticed that the partitions prime values:

P(3) = 1+1+1	P(4) = 1+1+1+1	P(5) = 1+1+1+1+1	P(6) = 1+1+1+1+1+1
2+1	1+1+2	3+2	1+1+1+1+2
3+0	2+2	2+2+1	1+1+3
;3 ways	3+1	4+1	1+1+4
	4+0	2+1+1+1	1+5
	;5 ways	3+1+1	6+0
		5+0	2+2+2
		;7 ways	2+1+3
			2+4
			3+3
			2+1+1+2
			;11 ways

There were some exceptions such as the partitions of 7, which is 15, and 15 is not a prime number; however, there is an infinite amount of natural numbers of which the number of partitions are a prime number.

The next man who had some compelling research, Leonhard Euler, created generating functions which allowed for the product(∏) to be found, which gave the number of partitions:

$\sum_{n=0}^{\infty} p(n)q^n = \frac{1}{(a;q)_\infty}$ where, $(a;q)_\infty = (1-a)(1-aq)(1-aq^2)$ for any positive integer n, , $(a;q)_\infty = \prod_{n=0}^{\infty}(1-aq^n)$

Figure 1

PARTITIONS IN MATH
CONTINUED

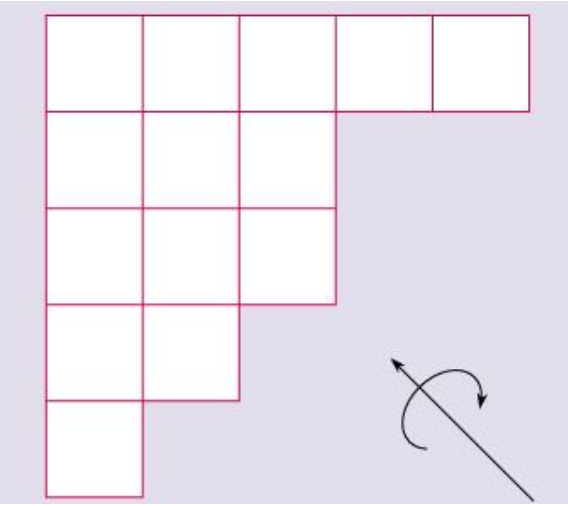


Figure 2

By using this approach, Sylvester brought up a new way of approaching partitions.

By far, the most important contributor to partitions was Srinivasa Ramanujan.Using modular arithmetic, Ramanujan created some restrictions to the values of the partitions of natural numbers.

P(5n+4)=0(mod 5)
P(7n+4)=0(mod 7)
P(11n+6)=0(mod 11)

Motivated by this discovery, other mathematicians began to invest more time in studying partitions.

Extensive study had been dedicated to better understanding partitions. However, as a highly complex subject, their relevance and behavior are still topics to be better understood; new research which develops in the coming years may contribute to a more comprehensive understanding of both the nature and applications of mathematical partitions.

-Madhav Parthasarathy

Citations:
Andrews, George E. "Partitions."
https://www.math.psu.edu/vstein/alg/antheory/preprint/andrews/chapter.pdf
Figure 1. Boruah, Chayanika. "Partition Theory of Numbers: An interesting research area in Mathematics." Good Morning Science, 27 May 2018
Figure 2. Bose, Raj C., and Branko Grünbaum. "Combinatorics." Encyclopedia Britannica.

STEM CELLS AND CANCER TREATMENT

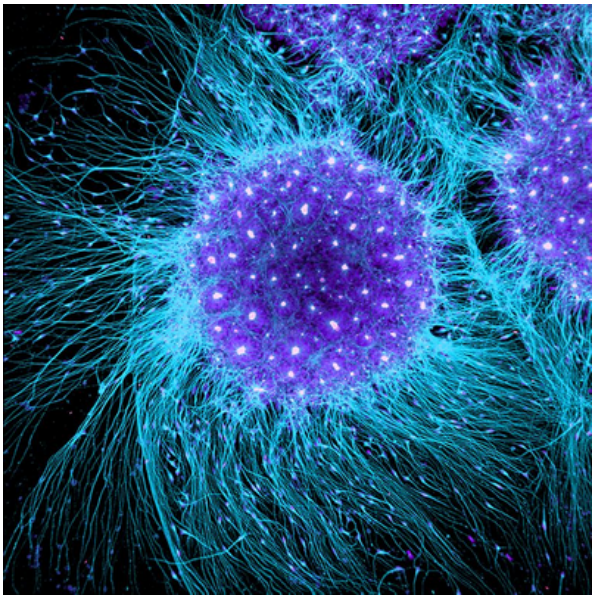


Figure 1. Embryonic stem cells that aid in resemble LPCs

Throughout the last few years, stem cells have been identified as being a potential cure to many types of cancers and diseases. However, it has now come to light that they may promote liver cancer instead of fighting it. During the process of disease-modelling in cell culture with primary liver progenitor cells (LPCs), we find indicators of β-catenin. Adult LPCs work to replenish hepatocytes and biliary epithelial cells in the organisms such as rats and the liver of humans in cases such as chronic injury.

Tumor-initiating stem-like cells (TISCs) that emerge in chronic liver injury have the same expression of signaling pathways, like the β-catenin. Through signals guiding hepatic specification in development, there has been a production of extremely similar mouse LPCs and human stem cells. Hence, there is reason to suspect that stem cells may be a cause of liver cancer. Moreover, concerns have risen that there are epigenetic differences between induced pluripotent stem cells (iPSCs) and human embryonic stem cells (ESCs). Yet, evidence further suggests that there is no difference between the two at producing hepatocytes in culture. Despite all of this, there is evidence of TISCs helping with cancer. Tumor eradication processes require TISC therapy; this works by using an epithelial membrane protein called CD133 to create markers on the skin's surface. However, there are discrepancies with this method as well. The reduced rates of proliferation and phenotype of TISCs remain in question and must be identified for this debate to come to a satisfactory end.

-Hiteshi Patel

MODELING CELLULAR EVOLUTION THROUGH ENGINEERED ENDOSYMBIOSIS

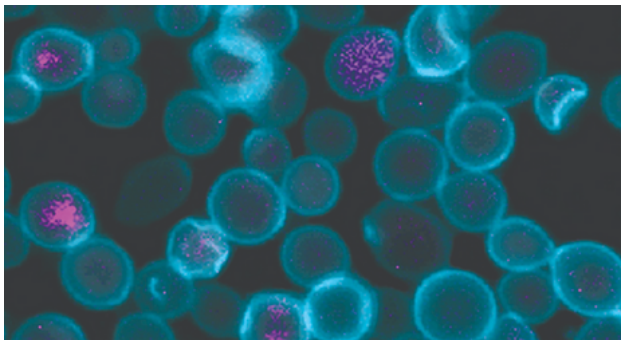


Figure 1. The endosymbiotic bacterium inside each yeast cell serves as a mitochondria to produce ATP for the yeast.

Scientists at the Scripps Research Institute genetically modified and examined two different microorganisms. Scientists have theorized that before DNA, RNA was used as the primary genetic information and that RNA could catalyze biochemical reactions due to its less stable nature compared to DNA. In order for this to be true, there had to have been a transition at some point from RNA to DNA. Escherichia coli bacteria containing both DNA and RNA in its genetic sequence allowed the researchers to study the evolutionary transition from RNA to DNA as the primary genetic material of most organisms. The bacteria were genetically engineered such that they were able to rebuild their own DNA using ribonucleotides rather than deoxyribonucleotides. Ribonucleotides contain a ribose sugar and are found in RNA while deoxyribonucleotides contain deoxyribose sugar and are found in DNA.

In a separate paper on the same study, yeast containing a endosymbiotic bacterium were used by the researchers to study the evolution of eukaryotes through examining the origins of the mitochondria. The yeast and the bacteria exhibited a mutualistic relationship; the yeast relied on the bacteria for cellular energy while the bacteria relied on the yeast for essential nutrients. The researchers inhibited the function of the yeasts' mitochondria, so any ATP present would be produced by the bacteria. The bacteria within the yeasts contained surface proteins on the membranes, which prevented them from being destroyed by the yeast. The results of this study showed that the bacteria and yeast were able to coexist through mutualism for at least 40 generations.

MODELING CELLULAR EVOLUTION THROUGH ENGINEERED ENDOSYMBIOSIS

CONTINUED

Random mutations caused some bacteria to have a stronger resistance towards degradation within the yeast; these small changes in the gene sequence of the bacteria allowed for the reproduction of the bacteria and inheritance of these adaptations to the next generation.

This research will be continued as the researchers continue to investigate the evolution of organisms that caused DNA to be the main genetic code and the mitochondria to be present within cells to perform cellular respiration. This will be accomplished by genetically engineering E. coli and adding these bacteria to new cells to function as mitochondria. Scientists hope to uncover more information about the evolution of cell structures by genetically engineering microorganisms and closely observing the endosymbiotic relationships between the microorganisms.

-Phyllis Shen

Citations for Stem Cells and Cancer Treatment:

Rountree, C. B., Mishra, L., & Willenbring, H. (2011). Stem cells in liver diseases and cancer:
Recent advances on the path to new therapies. Hepatology, 55(1), 298-306. doi:10.1002/hep.24762

Cyranoski, D. (2018, April 26). How human embryonic stem cells sparked a revolution. Retrieved from https://www.nature.com/articles/d41586-018-03268-4

Citation for Modeling Cellular Evolution Through Engineered Endosymbiosis:

Scripps Research Institute. (2018, October 29). Synthetic microorganisms allow scientists to study ancient evolutionary mysteries: Scientists use the tools of synthetic biology to engineer organisms similar to those thought to have lived billions of years ago. ScienceDaily. Retrieved November 16, 2018 from *www.sciencedaily.com/releases/2018/10/181029164644.htm*

DISCOVERING THE EVOLUTION OF THE BICOID GENE

In Drosophila melanogaster, the bicoid, or Bcd, gene triggers the construction of the anterior portion of the organism during development. Cyclorrhapha, a taxa of organisms containing D. melanogaster, is individual in their possession of the bcd. The lack of this gene causes the posterior portion to duplicate itself in what would have been the position of the head. Cyclorrhapha possess a paralog of a duplication of the HOX3 gene named zen-- creating bcd and zen. The bicoid portion of this duplication appears to be from an evolutionary hand, while zen seems to be ancestral and passed down.

To get to the root of the evolution of bcd, the modern gene was removed from D. melanogaster embryos and replaced with the according ancestral genes, AncZB and AncBD. It was first found that the embryos possessing the two ancestral genes failed to produce a head and created two tails at each end of the organism. From here, historically accurate mutations were added--these mutations being the addition of lysine residue located at position 50 and glutamine residue also at 50. In conjunction with one another, these additions created a functioning head akin to the production of modern bicoid. From this, it was gathered that these genetic predecessors, plus other primordial mutations, were the cause of the evolution of the modern bcd gene.

-Ashley Koca

Citation:
Qinwen Liu, Pinar Onal, Rhea R Datta, Julia M Rogers, Urs Schmidt-Ott, Martha L Bulyk, Stephen Small, Joseph W Thornton. Ancient mechanisms for the evolution of the bicoid homeodomain's function in fly development. eLife, 2018; 7 DOI: 10.7554/eLife.34594 https://elifesciences.org/articles/34594#fig1s1

NANOPARTICLES IN FUEL PRODUCTION

Nanoparticles work as effective catalysts due to their high surface-volume ratio. The smaller the particle, the greater the surface-volume ratio, allowing for the nanoparticles to react quickly. Additionally, nanoparticles are so tiny that they have different properties than the same pieces. These different properties have a multitude industrial uses since they have tremendous potential in energy and fuel technologies. Much research with nanoparticle-based catalysts has to do with maximizing the effectiveness of nanoparticle coating in fuel cells. Fuel cells that primarily react hydrogen with oxygen and catalysts are needed to improve energy production in the reactions. Catalysts in the anodes and the cathodes produce electricity at a 40-60% efficiency by allowing these reactions to occur. Conventional fuel cells use sheets of catalyst nanoparticles mixed with a polymer for the electrodes; Platinum is most commonly used in this application. A recent discovery, deemed The Vanderbilt approach, replaced these sheets with polymer fiber mats. The catalyst nanoparticles were bonded to these fibers. This allowed for the catalyst to have a larger surface area and increased the number of reactions between hydrogen and oxygen gas in the fuel cell. The unique structure of the design also resulted in higher fuel cell power and it made the fuel cell more cost friendly. Overall, it was an impressive advancement in the field of nanoparticles that aided in fuel production.

-Shouri Bouchetty

Citations:
Nanoparticles Lower Fuel Cell Costs. (n.d.). Retrieved from https://www.asme.org/engineering-topics/articles/renewable-energy/nanoparticles-lower-fuel-cell-costs
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LETTER FROM THE EDITORS

Hello, and welcome to the very first issue of Hadron! The Hadron team consists of 11 hardworking students from the sophomore, junior, and senior class at the Illinois Mathematics and Science Academy. The students work to give you content on the current happenings at IMSA and summaries of topical articles in math, physics, technology, biology, and chemistry. From interviewing to writing, our ultimate vision is to recreate the same excitement that we have for math and science in our readers.

Happy reading, and make sure to stay in tune for our next issue.

Feel free to contact us with questions, comments, and concerns at hadronmagazine@gmail.com

Sincerely from the Editors-in-Chief,
Devika Prasad, Caitlyn Castillo