

1. Biology

1.1 SARS-Cov-2 Mechanism

Following a public lecture by Ian Gold from *McGill* during the COVID-19 pandemic. I applied my literature search skills to shed light onto the virus to social media. I tried to bridge the gap between Expert Knowledge and public perception as my country was facing a crisis and I wanted to help against harmful misinformation.

This was done before I started my B.Sc., and it would prove helpful as a module in my studies, 3 years later would have us implement computational tools to analyse the virus, extending my ability to communicate as a scientist and my research skills.

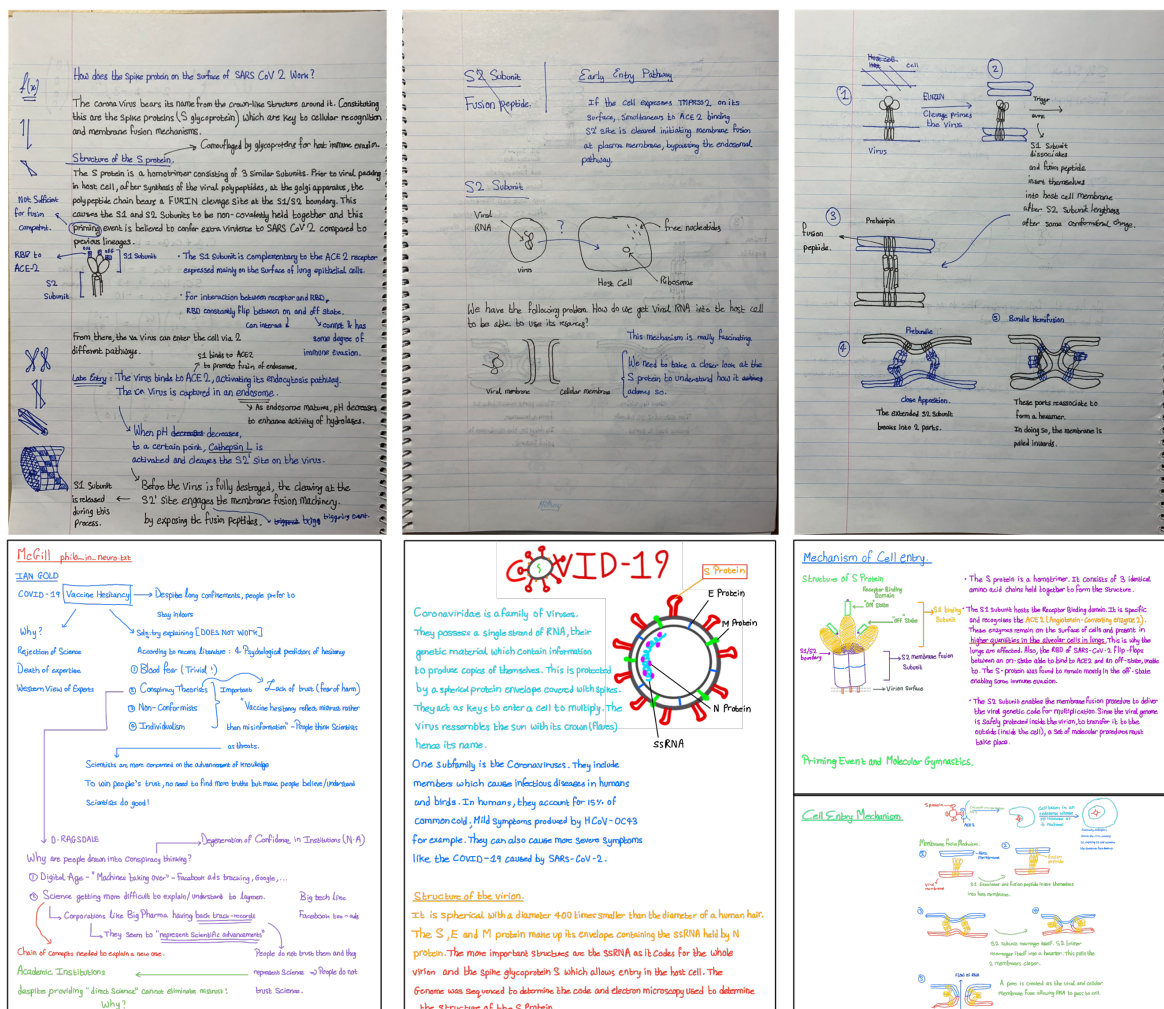


Figure 1: Only partial excerpts of document were included owing to document length considerations. Top figures represent molecular mechanisms gathered from 2020 and prior papers, and Dr. Paul Bates from Penn *Un*'s symposium. Bottom left are notes from Ian Gold's Lecture on Vaccine Hesitancy and bottom middle and right some pages on my attempt to democratize scientific knowledge in times of need.

1.2 Prey-Predator Dynamics

Following the success of my COVID-19 post, I aimed to make other areas of biology more fun. Before introducing epidemic models, I aimed to provide my audience with a simpler topic. The *Lotka-Volterra* model suited the aim. To keep up my credibility as I would be posting public and answering questions, I did some background work in getting a proper grasp of the topic, mainly linear algebra and differential equations and their applications to population biology. I had to be able to justify all the concepts used and explain them in laymen's term. This too was prior to starting my bachelor's degree.

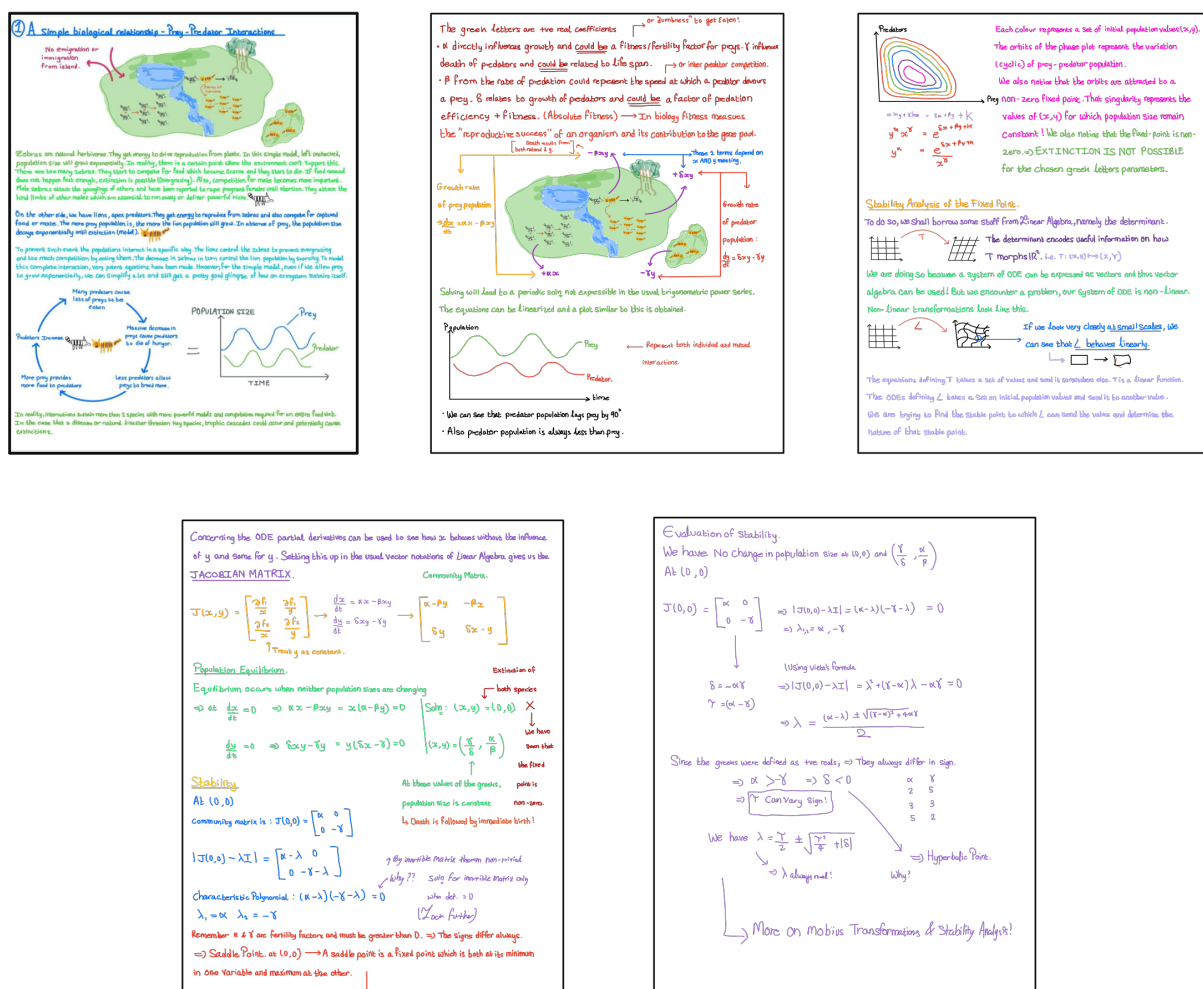


Figure 2: Top left panel was the work presented and the other panels are some of the background work, simplified if audience required more information on justification. I aimed at something more friendly compared to the heavy population dynamics textbooks while still maintaining consistency.

1.3 Physiology & Mutagenesis

Concluding the courses of Physiology and Mutagenesis and DNA repair, I wanted to consolidate my knowledge for future applications. I found sharing knowledge a good way to keep things fresh in my head. I tidied up and filled up some holes in my understanding in some physiology notes. I ensured it was accessible to a first-year audience by anchoring concepts on what I learned in *Cambridge's A Level Physics and Biology* and bringing it together to naturally and simply explain more complex processes. I was satisfied in my preservation of information for my future use. It was also appealing to students in other fields like engineering, who could understand what I shared with them due to us originating from a common base.

I also prepared one from my mutagenesis course. DNA damage and repair mechanisms was a frequent topic of discussion in papers and with the research supervisors I encountered. I wanted to be able to keep these in mind and simplifying them while maintaining accuracy would help. Since it is something, I am pursuing research in, I found it worthy to do so. It also allowed me to communicate more clearly with my professors and understand papers faster. This document had less popularity than the other ones; maybe owing to its niche nature. I am currently doing another one on apoptosis.

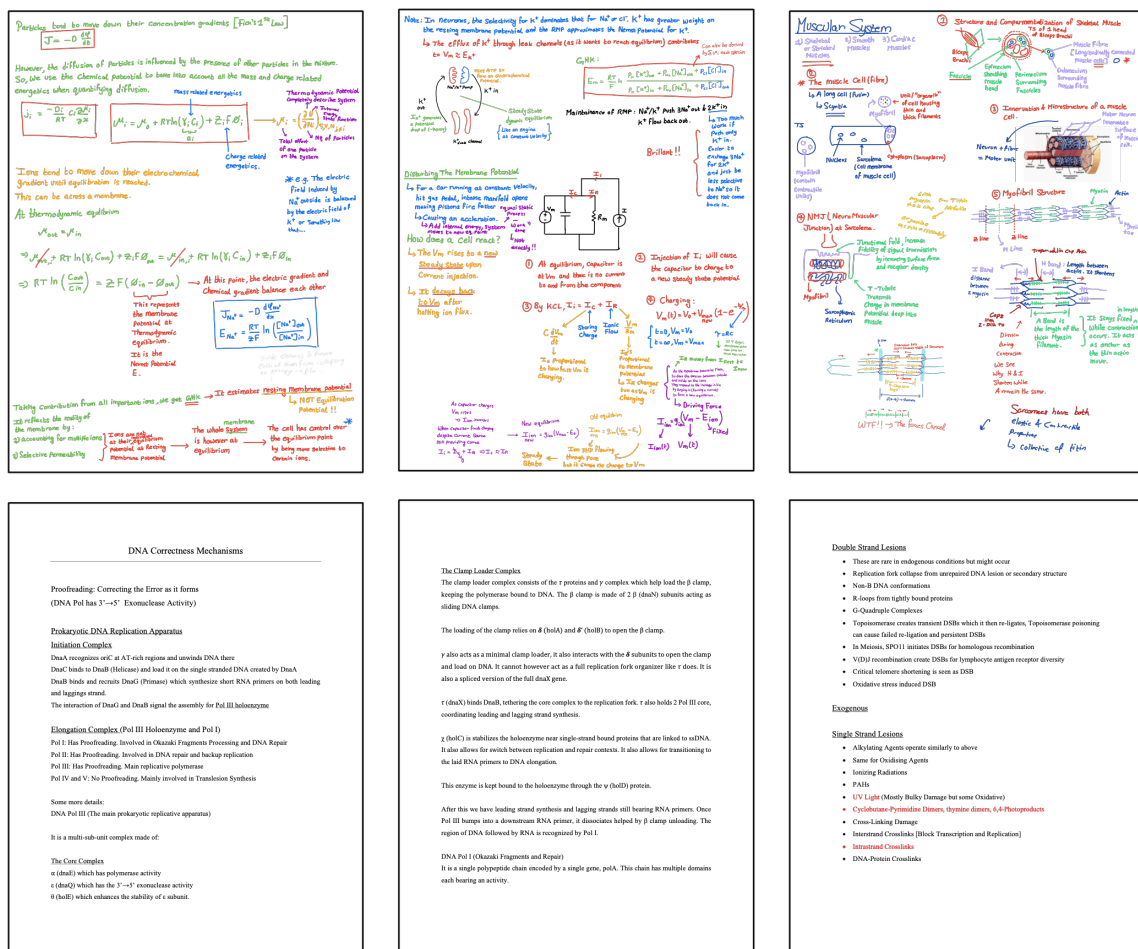


Figure 3: Top panels some of the physiology documents. Excerpts from two topics are included, and full document includes other systems. Bottom panels are highlights from the DNA repair section and some mechanisms involved

2. Physics

2.1 Visibility of Universe Expansion

This was my first attempt at diversifying my science communication into physics in 2020 Lockdown. I only had a *Cambridge A-Level* exposure to the subject then, and I managed to cobble together something to explain some astronomy phenomena. It received great feedback, beyond my expectations. It gave me more confidence in pursuing my passion for physics and mathematics. I borrowed from some explanations on YouTube and furnished it with some established cosmological model which I thought would complement neatly and give the audience a taste into how the abstract manifests into phenomena we take for granted.

This post was intended to have a sister too; namely explaining white dwarves, neutron stars, and blackhole formation and physics.

But at that time, I unfortunately lacked the skills to understand deeply Electron degeneracy pressure and could only understand concepts like *Heisenberg's* Uncertainty Principle, *Pauli* Exclusion Principle, superficially. I lacked the insight and physics/mathematical maturity to explain it in simple terms at that time.

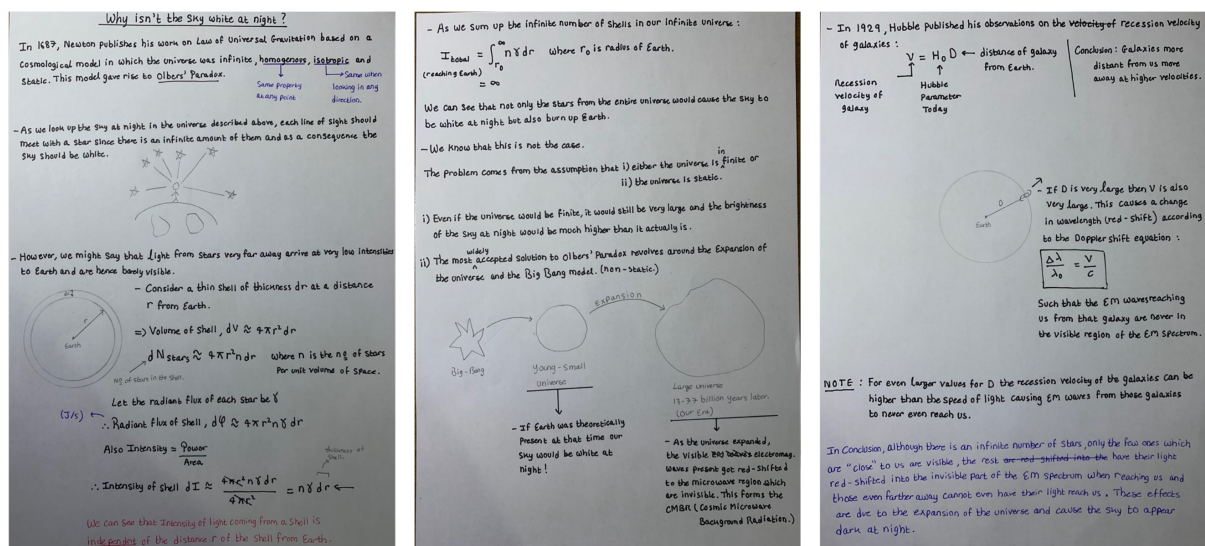


Figure 4: The three panels from left to right makes use of mathematics which I had good command on. It was a simple enough method to explain the cosmological phenomena while giving the audience a little insight about the expansion of the universe which is so often talked about but rarely understood. Grounding that concept into everyday phenomena could offer an appreciation for a possible explanation that science provides, I thought so.

2.2 Entropy

I was curious about entropy. I wanted to frame my findings in a pop-sci context; heat death was a common enough denominator. This one proved one of the hardest research projects I carried out; spanning 3 months, while I had to learn classical thermodynamics from *Yale's* Online courses, Entropy in the context of information theory, and finally, I was forced into statistical mechanics from *Stanford's* lectures and quantum explanations for the microscopic explanations. The result was fruitful, endowing me with a notion of entropy which was so useful in all my scientific judgement throughout my degree. I was happy to make my audience mature from entropy as being “the amount of disorder” to “number of configurations” and the second law being a “natural” statistical consequence akin to a physical version of law of large numbers.

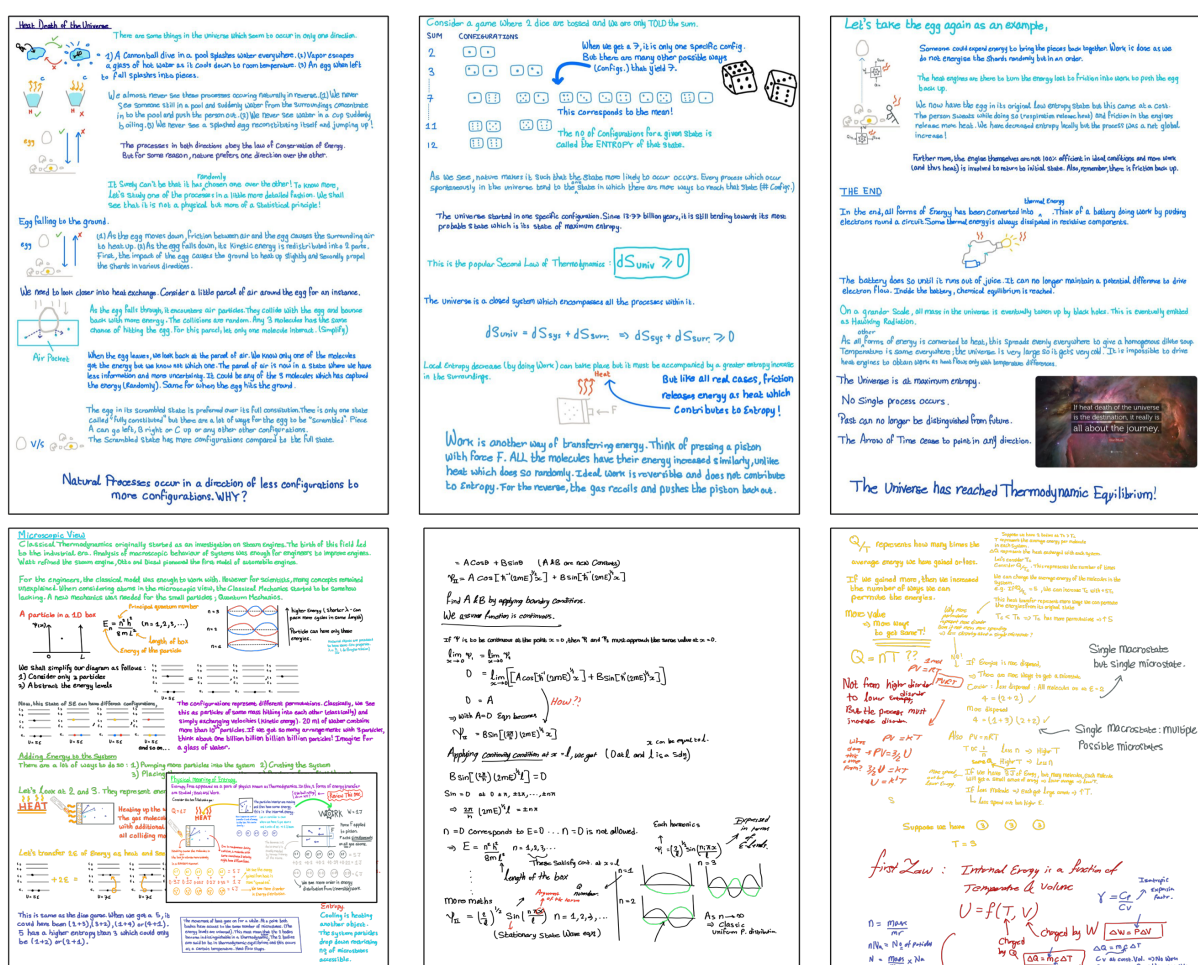


Figure 5: Top panels represented what I presented to audience. Bottom panels are some pages of my works/research spanning 3 months, mainly owing to the need to grasp the mathematical insights of statistical mechanics. Quantum mechanics was used sparingly, only the particle in a box to explain energy levels and microstates. I ensured I got a solid grasp of the concept in case I would be caught off-guard with questions. I also built intuition on the difference between heat and work and provided an acceptable explanation to the lay person.

2.3 Geodynamo

After gaining some confidence in my ability, I set my eyes to the geodynamo. I initially completed the “simple” explanation to provide to my audience but later came back to it after around 3 years to formalize it, after maturing in my scientific ability. Before when I just mention that different latitudes travelled at different velocities, I got to understand the *Coriolis Effect* mathematically, and I was also able to conceptualize it with the *Magnetohydrodynamics (MHD) Equations* after getting more familiar with *Maxwell's Equations*, and vector calculus. My motivation for doing this one was awe upon seeing atmospheric electric phenomena and in YouTube videos, how the shape of Earth's magnetic field change when interacting with a solar flare. The shape shown was very different from what I learned about magnets in textbooks and I was curious.

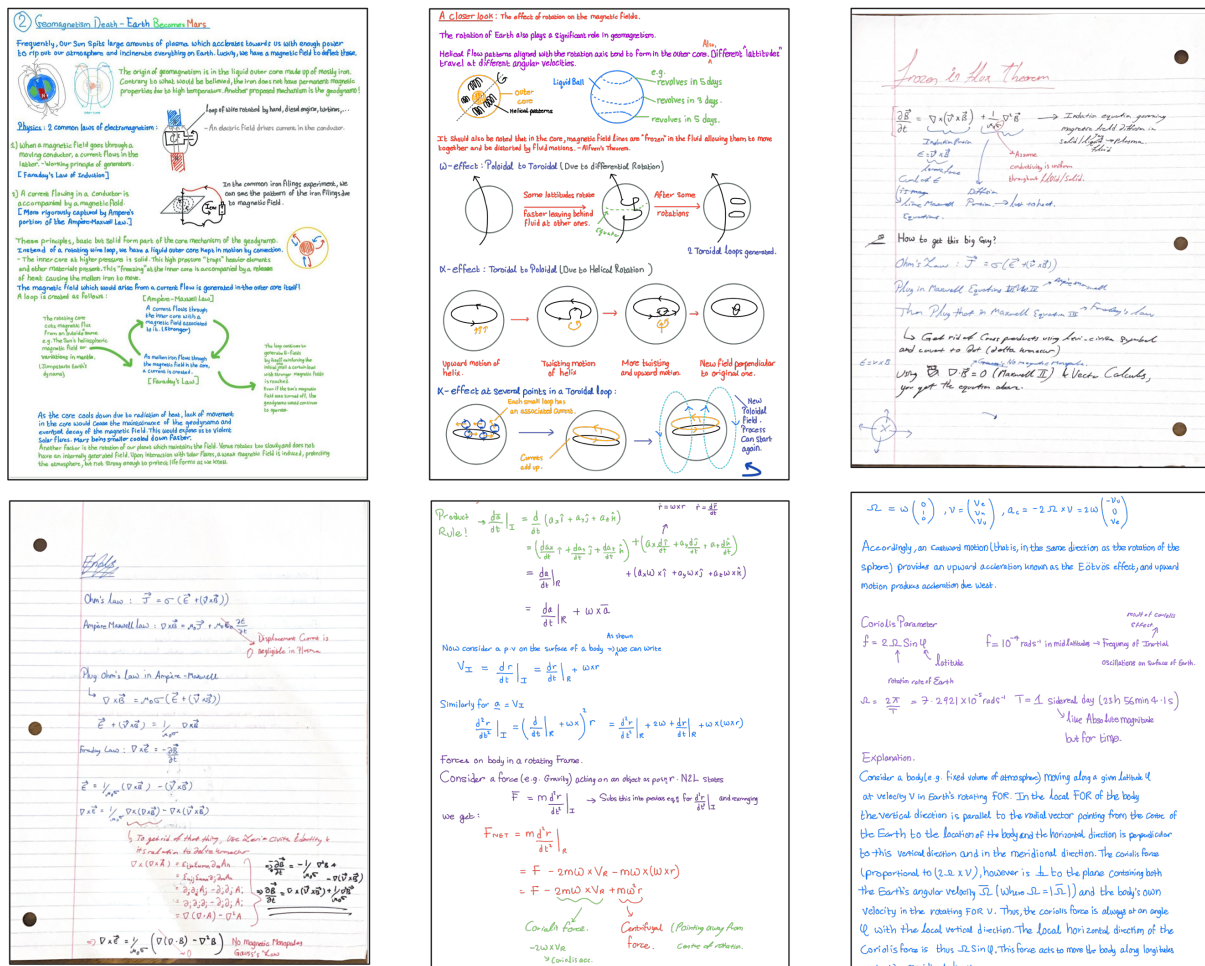


Figure 6: Top left panel is my original publication on the subject; the top middle one was a remnant of my initial research. The remaining are excerpts from what I gathered from *Alfven's Theorem*, *MHD*, *Coriolis Effect*. This allowed me to form the model in my head, through first principles about the Geodynamo.

3. Mathematics

3.1 Statistics and Linear Algebra

I am not trained mathematician. Through physics I got some appreciation for it. I can handle connecting concepts and making mathematical models borrowing from some areas of pure maths, but I am not well trained in proof-writing like my peers. I wanted to do something in the field; I tried to remain humble about so and chose something which was likely to reach a broad audience. The Normal Distribution was my choice, and I attempted its derivation through simple thought experiments, relying on YouTube, and Mathematical texts I could lay my hands on. I went to some of my peers to review it before publishing to my audience. Studying statistics naturally gave me so much leisure when doing data treatment for my lab experiments; I was able to justify my hypothesis testing methods, and what drawbacks each had, and explaining what ANOVA interactions meant when doing my thesis presentation. It is not something I regret, and this post sparked my interest in statistics.

I also took Linear Algebra as part of my university courses. I could not take LAII or LAIII. This was a common experience by other biology students. It would have been hard to fit-in into a class with mostly maths/physics students. I set to make a document aimed at non-math majors like me, allowing us to appreciate the “true” meaning of concepts like transpose, vector spaces beyond matrices just being linear transformations, and revealing a deeper structure which I found beautiful and wanted to share with others

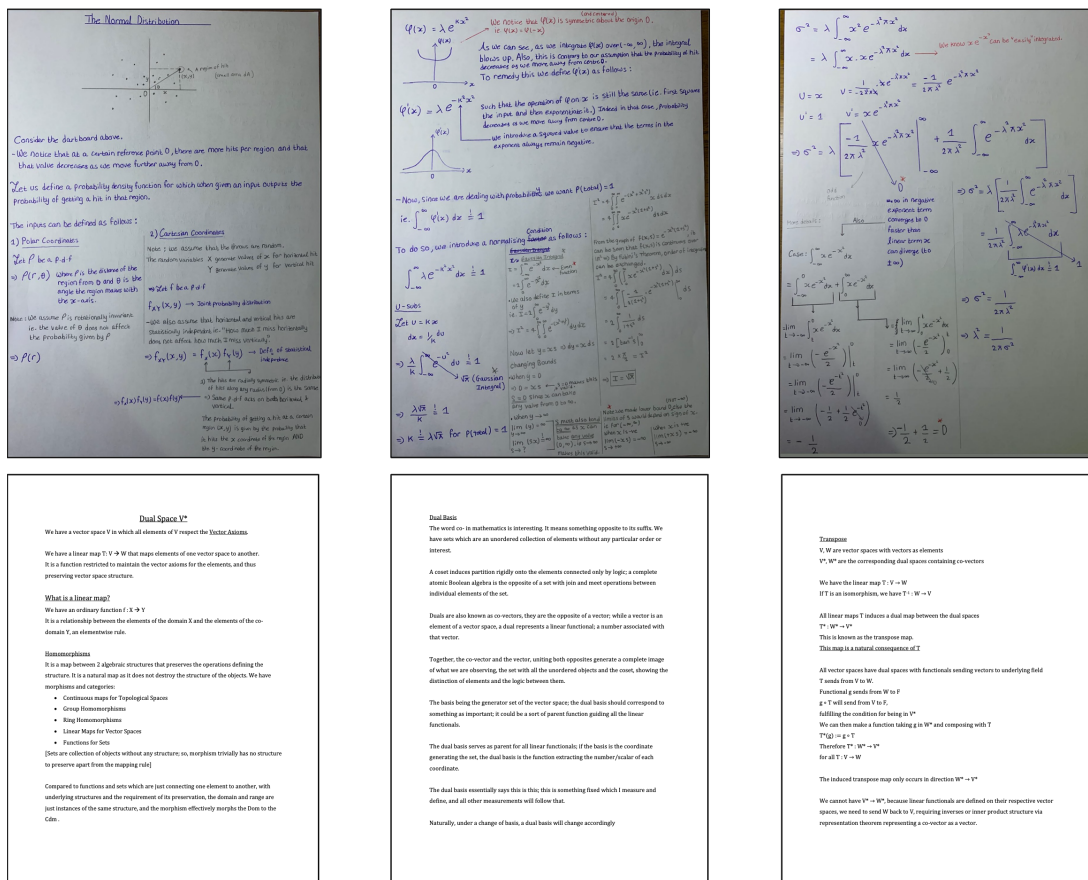


Figure 7: Top slides are parts of my derivation of the normal distribution. All pages could not be included. Same for the bottom panels and conceptualization of vector spaces in linear algebra. That document spanned 40 pages.

3.2 Cartesian Product and Topology

This is of my posts on abstract mathematical concepts which I wanted to make more “fun” by showing non-intuitive concepts can stem from familiar ideas like multiplication.

On a sidenote, this one proved useful in a video game puzzle detailed *Verity in Destiny 2: The Final Shape, Salvation's Edge* Raid. This was an encounter notorious for how long it took to solve. The combination of entries followed that logic, and I was so happy when I saw that something niche which I worked on was featured in such a place.

The collage consists of five hand-drawn notes, each illustrating a different mathematical concept or its connection to multiplication:

- Top Left:** Discusses the product as the result of a multiplication operation. It mentions that the product is present in all areas of mathematics. It defines multiplication as taking elements as input and producing another one based on a set of pre-defined rules. It notes that there are different kinds of products, some based on their ability and consistency with mathematics. It gives an example: $2 \times 3 = 6$. It also mentions that the product is usually introduced during the multiplication of natural numbers. It defines a function $S: \mathbb{N} \rightarrow \mathbb{N}$ such that S maps an element of $\mathbb{N}$ to the successor. It notes that this is the successor of zero, and it is the first element of $\mathbb{N}$. It defines a function $S: \mathbb{N} \rightarrow \mathbb{N}$ such that S maps an element of $\mathbb{N}$ to the successor. It notes that this is the successor of zero, and it is the first element of $\mathbb{N}$. It defines a function $S: \mathbb{N} \rightarrow \mathbb{N}$ such that S maps an element of $\mathbb{N}$ to the successor. It notes that this is the successor of zero, and it is the first element of $\mathbb{N}$.
- Top Middle:** Discusses the Cartesian Product. It notes that the Cartesian Product is a way to combine two sets into a new set. It gives an example: $\{1, 2\} \times \{a, b\} = \{(1, a), (1, b), (2, a), (2, b)\}$. It notes that the Cartesian Product is a way to combine two sets into a new set. It gives an example: $\{1, 2\} \times \{a, b\} = \{(1, a), (1, b), (2, a), (2, b)\}$. It notes that the Cartesian Product is a way to combine two sets into a new set. It gives an example: $\{1, 2\} \times \{a, b\} = \{(1, a), (1, b), (2, a), (2, b)\}$.
- Top Right:** Discusses the Cartesian Product. It notes that the Cartesian Product is a way to combine two sets into a new set. It gives an example: $\{1, 2\} \times \{a, b\} = \{(1, a), (1, b), (2, a), (2, b)\}$. It notes that the Cartesian Product is a way to combine two sets into a new set. It gives an example: $\{1, 2\} \times \{a, b\} = \{(1, a), (1, b), (2, a), (2, b)\}$. It notes that the Cartesian Product is a way to combine two sets into a new set. It gives an example: $\{1, 2\} \times \{a, b\} = \{(1, a), (1, b), (2, a), (2, b)\}$.
- Bottom Left:** Discusses the Cartesian Product. It notes that the Cartesian Product is a way to combine two sets into a new set. It gives an example: $\{1, 2\} \times \{a, b\} = \{(1, a), (1, b), (2, a), (2, b)\}$. It notes that the Cartesian Product is a way to combine two sets into a new set. It gives an example: $\{1, 2\} \times \{a, b\} = \{(1, a), (1, b), (2, a), (2, b)\}$. It notes that the Cartesian Product is a way to combine two sets into a new set. It gives an example: $\{1, 2\} \times \{a, b\} = \{(1, a), (1, b), (2, a), (2, b)\}$.
- Bottom Right:** Discusses the Cartesian Product. It notes that the Cartesian Product is a way to combine two sets into a new set. It gives an example: $\{1, 2\} \times \{a, b\} = \{(1, a), (1, b), (2, a), (2, b)\}$. It notes that the Cartesian Product is a way to combine two sets into a new set. It gives an example: $\{1, 2\} \times \{a, b\} = \{(1, a), (1, b), (2, a), (2, b)\}$. It notes that the Cartesian Product is a way to combine two sets into a new set. It gives an example: $\{1, 2\} \times \{a, b\} = \{(1, a), (1, b), (2, a), (2, b)\}$.

Figure 8: Building from ideas of natural number multiplication to cartesian product in topological spaces to yield absurd but funny concepts.

5 Humanities-Science Hybrids

5.1 Measure and Philosophy of Science

This is a branch of a current project. I was reading a short book on philosophy of science by *Samir Okasha*. I made me question much of what I took for granted when running experiments in science and how we agree to conventions as scientists, which philosophers leave as open questions.

The interpretation of probability is well established in philosophy. I wanted to take a deeper dive into the other aspect of measure theory, namely measuring, and the sigma algebra. I wanted to see the inbuilt assumptions on our system and if possible shed new light onto the subject.

If not, I am satisfied till now with how my perspective changed upon digging more into measurement and philosophy of science.

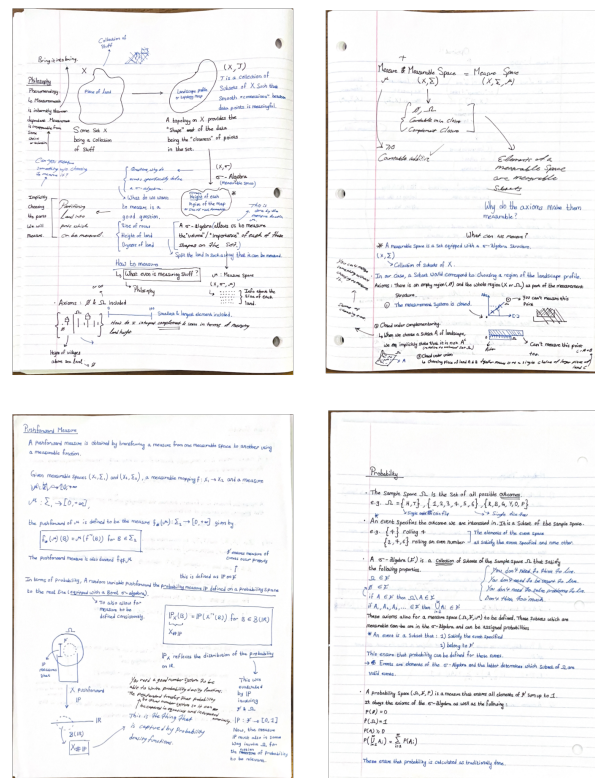


Figure 10: In the last lines of the top left paper, I list some of the things I found when measuring. They seem tautological. I did not include all the content as some was not relevant to the philosophy of science discussed here.