The COLORADO Engineer

Since 1904

DESIGN MEETS DISCOVERY

Fall 2025

Exploring innovation, ethics, and engineering at the interstection of creativity, technology, and human curiosity

Photo by Alessandro Valente

Photo by Boulder Community Alliance

THE PAST AND FUTURE ISSUE

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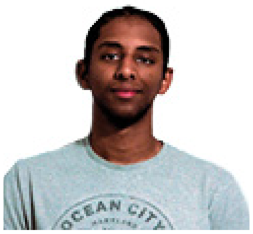

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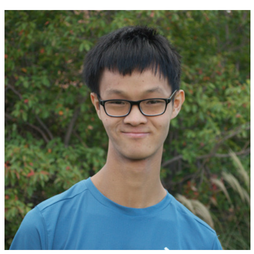

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OUR CEM MISSION

As staff of The Colorado Engineer, our mission is to inform and educate our readers and reflect pride in CU's College of Engineering & Applied Science worldwide. Our student-led magazine seeks to provide a voice for CU's engineering students while also carrying on the 125-year CEM tradition: by students for students.

The Colorado Engineer has been reporting on the "latest and greatest" from the engineering, science and technology community since 1904. We were there for the Model T, the jet engine, the IBM PC, the iPod — and we will continue to cover the future of human innovation. Today, we operate with a staff of 18 students and 2 advisors. We publish the magazine biannually, with a readership of over 10,000 individuals, reaching students at the university, researchers, professors and alumni. If you would like to join our staff or have questions and comments, email us at cem@colorado.edu. Alternatively, check out our website at http://www.colorado.edu/studentgroups/colorado-engineer/. We always enjoy hearing our readers' feedback!

A LETTER FROM THE EDITOR

DEAR READERS,

As the aspens changed colors this fall, I was reminded that looking back into the past can reveal a kind of beauty we often miss the first time.

Fall at CU Boulder invites us to honor what came before while preparing for the future.

When I first got the keys to the CEM office, I found myself drawn to the shelves lined with old issues of *The Colorado Engineer Magazine* (CEM). We've been publishing since 1904, so there are countless issues to organize and read. As I paged through the vintage magazines, it dawned upon me that we are so much more than just a club, we are an institution and a part of CU Boulder's history.

Over the course of 120+ years, thousands of people have contributed to The Colorado Engineer Magazine, and tens of thousands of people have read it. CEM has held important conversations and reporting for over a century, and we believe that today's writers and thinkers should remain in dialogue with the voices of the past. This issue is our way of acknowledging our legacy as we carry it into the present.

To bring that vision to life, we hired two photographers this semester: Shalom Busse and Alessandro Valente, whose work perfectly captures the spirit of this issue. Their "retro-future" aesthetic bridges eras by drawing inspiration from earlier decades while adding a distinctly modern edge. Shalom and Alessandro helped achieve our vision of creating not just another issue, but a link between generations.

Although this issue looks back, it is also a step forward. This semester, we launched something new: The Past Issue Project, which is an effort to digitize our archives. The project turned out to be far larger than expected, but thanks to Elizabeth Erickson, Aidan Magruder, Owen Wittner and Michael Chapp, it's finally coming to life. You can now access issues dating all the way back to the early 1900s on our website. This project has revealed that good engineering writing is timeless, as it asks hard questions and refuses easy answers.

One of our past mottos was "Prove that engineers can do more than just math." The magazine has always been about more than technical skill—it's about engineers grappling with their role in society, questioning assumptions, and building community. This edition recalls that tradition while addressing today's engineering challenges.

The editors before us challenged readers to think beyond formulas, and we have worked hard to renew this challenge.

To our alumni: thank you for the foundation that you built and the dedication you poured into every issue. I invite you to visit our website to reminisce, explore past issues, and share your memories, stories, or feedback with us through the "Contact Us" page.

And to our photographers, Shalom and Alessandro, thank you for your artistic vision and for embracing this experimental direction with creativity and passion. You have brought the past to life and beautifully captured the present.

Finally, to our readers, both those who remember or created earlier editions and those discovering our legacy for the first time, thank you for joining our story.

Here's to honoring our past while building our future.

MALENA GARCIA

Malena Garcia

EDITOR-IN-CHIEF

Photo by Shalom Busse

OVER A CENTURY OF ENGINEERING

THE COLORADO ENGINEER
PUBLISHING SINCE 1904

EXPLORE OUR DIGITAL ARCHIVE

For more than a century, *The Colorado Engineer Magazine* has stood as a chronicle of innovation, creativity, and the relentless curiosity that defines CU Boulder's engineering community. Since its founding in 1904, the magazine has captured technological progress—from the earliest days of civil and mining engineering to the modern frontiers of aerospace, computing, and biotechnology.

Each issue reflects the spirit of its time. In the early decades, hand-inked diagrams and typewritten articles documented the struggles and triumphs of a growing campus and an expanding field. Wartime editions carried the urgency of national defense and the ingenuity of students answering the call to serve. Later issues charted the rise of automation, the computer revolution, and the dawn of space exploration. Through every era, *The Colorado Engineer* has remained a testament to the minds who shaped the future with pencil, slide rule, and imagination.

SCAN TO EXPLORE THE ARCHIVES

Today, we are working to preserve that living history through "The Past Issue Project." A long-term effort to digitize every past edition of the magazine and make it freely available online. Our goal is to ensure that the ideas, designs, and stories captured within these pages remain accessible to students, researchers, and alumni for generations to come. By bringing this archive to the digital space, we're bridging the gap between our institution's legacy and its future.

The archive is a treasure that offers a rare window into the evolution of engineering education and culture at CU Boulder. Within its pages, readers will find early discussions of renewable energy, reflections on the ethics of technology, and detailed records of the student projects that pushed the boundaries of what was possible.

Whether you're an alumni remembering your first published article or a current student exploring the lineage of your field, these archives are an open invitation to reconnect with the people and ideas that built the foundation of CU Engineering (To explore the archives scan the QR code and select "Past Issues").

Explore our history. Shape our future.

GROUNDING ETHICAL BREAKTHROUGHS IN SCIENCE: EMBRYONIC STEM STELL RESEARCH

ANAHITA KHORASHAHI

Embryonic stem cell (ESC) research holds the potential to completely revolutionize the world of regenerative medicine, yet it is often met with ethical resistance. Here I would like to argue that embryonic stem cell research is both ethically permissible on rational grounds *and* ethically essential due to its scientific, economic, and social benefits.

What exactly binds some people to the idea that utilizing an embryo before it has any ability to feel pain, for the betterment of research, is so inherently wrong despite its benefits to society? In some cases, the answer is religious or spiritual beliefs. In a religious sense, life is viewed as a sacred gift from a divine source, imbued with purpose and meaning, with the soul understood to begin at conception[1]. Therefore, from this point of view any practice which deliberately destroys human embryos is inherently wrong.

With this information, it is important to note that the point of this paper is not to argue for or against religious beliefs in science, but instead to provide a nuanced argument for ESC research. It is important to include and respect diverse viewpoints and thought processes in the world of regenerative medicine and innovation; however, it cannot reasonably be argued that an individual's personal religious belief should interfere with the transformative potential ESC research has. Ultimately, it is not the responsibility of engineers and scientists to try to persuade religious individuals to abandon their convictions, but instead to articulate a nuanced and ethical stance with clarity and integrity.

Addressing misinformation is an essential first step; without a clear understanding of embryonic stem cell research, from the use of embryos to its potential impacts, many form opinions based on misconceptions rather than facts. ESC research is the study of stem cells from the inner mass of human embryos due to the regenerative properties of these pluripotent cells[2]. ESCs have the potential to develop into any cell type in the body as they continuously undergo cell division[3], offering the potential to replace damaged or diseased tissues and organs. Additionally, embryos used in embryonic stem cell research come from eggs that were lab-formed and fertilized at in vitro fertilization clinics but never implanted in women's uteruses; therefore the gametes used are donated with informed consent from donors. In turn, these ESCs provide an opportunity to understand human and disease development, all while aiding in the development of new therapies.

Understanding ESC research involves recognizing the significance of regulations, such as the 14-day rule, which is essential to the ethical framework of the field. The 14-day rule is an ethical limit that restricts in vitro research on human embryos to the first 14 days after fertilization[4] meaning this embryo is no larger than a poppy seed when ESC research is conducted[5]. This rule exists to be a compromise between ethical considerations, scientific progress, and public opinion. Therefore, human embryos are used in ESC research long before the development of cognitive abilities, sentience, pain receptors, or a cerebral cortex. Embryos are unable to feel pain until at least 24-25 weeks of gestation[6], the cerebral cortex at its earliest forms during the second month of pregnancy[7], complete homeostasis is typically achieved from week 13 to week 27[8], and finally, embryos are not considered sentient,

1 Staples, Tim. "A Person from the Moment of Conception." Catholic Answers, 17 Jan. 2015

2 Romito, Antonio & Gilda Cobellis. "Pluripotent Stem Cells: Current Understanding and Future Directions." U.S. National Library of Medicine, 20 Dec. 2016

3 "Adult and Embryonic Stem Cells" *BBC*, 23 Oct. 2023

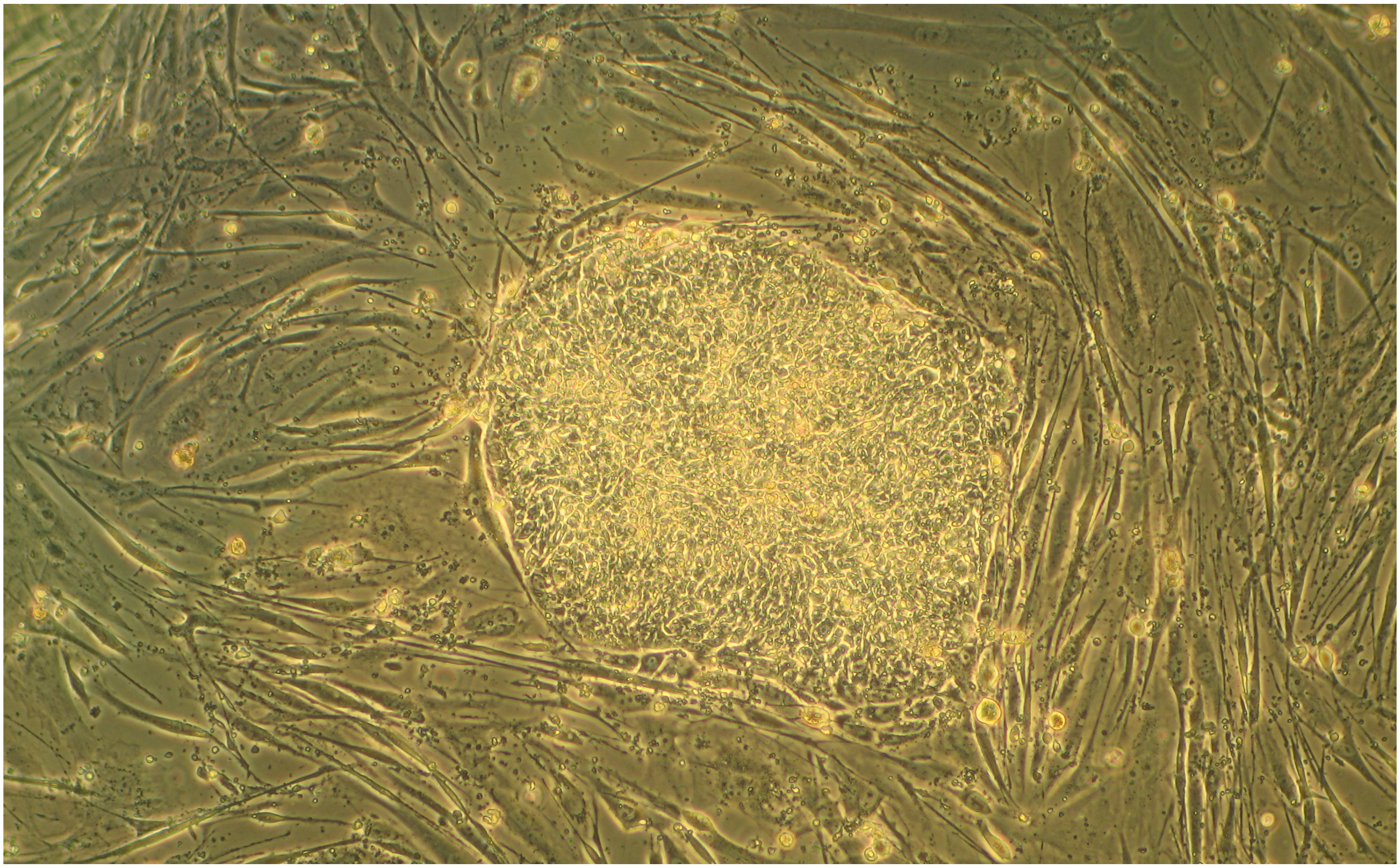
4 M'hamdi, H.I. & G.D. Wert. "Reconsidering the 14-Day Rule in Human Embryo Research: Advice from the Dutch Health Council." *Science Direct*, 7 Nov. 2024

5 Marple, K. "Fetal development week by week." Babycenter 10 Apr. 2025

6 "Facts Are Important: Gestational Development and Capacity for Pain." *ACOG*

7 "Neural Mechanisms (Cortex)." *LibreTexts*, 5 Oct. 2024

8 Liu, Ai-Xia, et al. "Physiology of Embryonic Development." *Springer Nature Link*, 1 Jan. 2013



A colony of embryonic stem cells in a cell culture. (Only the colony in the center are human embryonic stem cells. The cells in the background are mouse fibroblast cells.)

as the necessary neural connections for experiencing consciousness are not yet developed[9]. Therefore, these embryos are nowhere near having developed any of these biologically defining factors during the allotted 14-day rule. However, this is not to say that the embryo should be disregarded entirely; instead, the ethical values of both parties should be reasonably weighed against the potential benefits that could come from using embryos for research.

Through understanding these embryonic capabilities, another common ethical concern arises; using embryos in research denies them a potential future. However, this position overlooks the practical realities surrounding unused embryos, which are rarely destined for a lived existence; "if they are not destroyed in the process of research, they are instead destined to languish in freezers until they are destroyed for some other reason"[10]. Thus, their application represents a valuable contribution to scientific progress at a minimal ethical cost.

ESC research shows great promise in improving understanding of disease development and mechanisms due to the pluripotency of these cells, allowing scientists to model disease processes, study cellular mechanisms, and identify potential therapeutic targets, therefore improving human development[11]. ESCs can be used to create disease models by introducing genetic mutations or exposing them to environmental stressors, mimicking the conditions that lead to disease[12]. Understanding disease development allows us to promote new breakthroughs in the field of medicine and further advance human development.

> **" If they are not destroyed in the process of research, they are instead destined to languish in freezers until they are destroyed for some other reason.**

One core issue that hinders one's well-being, negatively impacting human development, are disease-induced premature deaths. For example, cardiovascular diseases (CVDs) are the "leading cause of death globally with an estimated 19.8 million deaths in 2022, representing approximately 32% of all global deaths." Intrinsically, disease-induced premature deaths rob one's freedom and opportunity to live a fulfilling life, significantly decreasing well-being, quality of life, and gradually diminishing human development. However, ESC research has the potential

9 Lavazza, Andrea & Massimini, Marcello. "Cerebral Organoids: Ethical Issues and Consciousness Assessment." *U.S. National Library of Medicine*, 28 Feb. 2018

10 Douglas, T., & Savulescu, J. "Destroying unwanted embryos in research. Talking Point on morality and human embryo research. EMBO reports." *U.S. National Library of Medicine*, 10 Apr. 2009

11 Halevy, Tomer & Achia Urbach. "Comparing ESC and IPSC-Based Models for Human Genetic Disorders." *U.S. National Library of Medicine*, 3 Oct. 2014

12 Bai, X., "Stem Cell-Based Disease Modeling and Cell Therapy" *U.S. National Library of Medicine*, 29 Sep. 2020

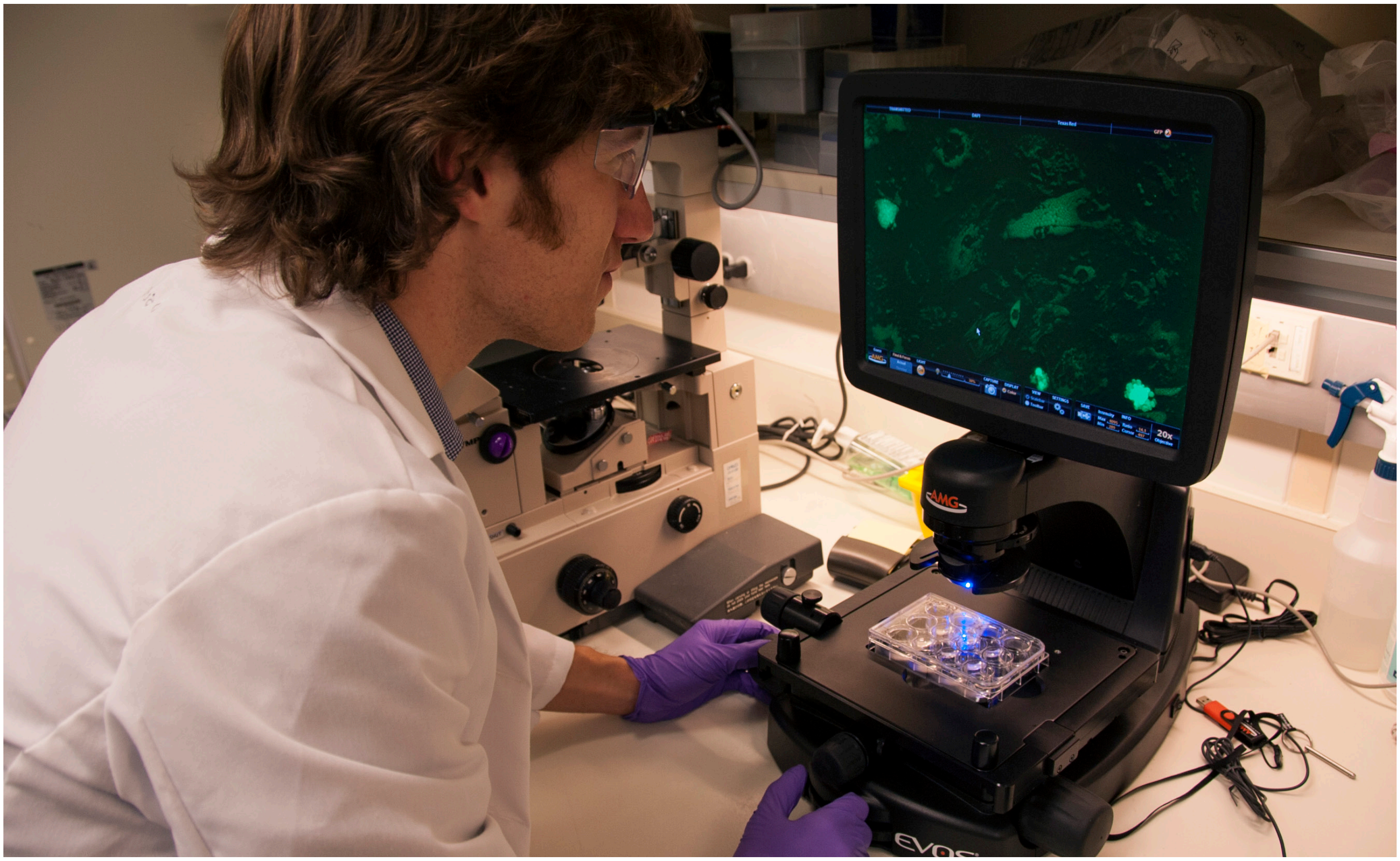
and has demonstrated its ability to improve human development.

ESC research can be used in drug testing by utilizing these cells' pluripotent characteristics to mimic human tissues and organs. This allows scientists to test drug efficacy, therapeutic effects, and potential toxicity on these ESC models before moving onto clinical trials, accelerating the drug development process and improving safety. ESCs can additionally be differentiated into 3D structures called organoids, which mimic the structure and function of specific human organs[13]. Through organoids, scientists can directly test a drug's potential effects on specific cell types or organs, aiding in the production of drugs that target different diseases[14].

Some may argue that while ESC research has brought plenty of promising results, it can also be done by using non-embryonic adult stem cells or induced pluripotent stem cells (iPSCs), offering a viable alternative to living donor stem cells. However, simply because these stem cells are obtained without the inclusion of embryos does not necessarily make them the better option. Adult stem cells are limited to differentiating into different cell types of their tissue of origin[15] and are also difficult to isolate in their pure form[16], therefore proving difficult to use to treat a larger range of diseases[17]. On the other hand, while iPSCs increase genetic instability leading to chromosomal abnormalities and tumorigenic cells[18] iPSCs also have the ability to create patient-specific stem cells in turn enabling "advancement in cardiovascular precision medicine."[19] Therefore, in the case of iPSCs, it is reasonable to argue that ESCs and iPSCs should coexist in a scientific setting as they are both essential resources in research and medicine.

California Proposition 71 exemplifies ESC research's transformative impact through real world results. This proposition legalized and funded stem cell research, creating the California Institute for Regenerative Medicine (CIRM) to oversee this research[20]. Proposition 71 has enabled over 90 clinical trials involving over 4,000 patients for over 75 neurodegenerative diseases and various cancers[21], created

13 "How Stem Cells Are Changing Drug Development and Research." *Americord Registry*
14 "How Are Stem Cells Used?" *Stem Cells Australia*
15 "Stem Cell Basics." *U.S. National Library of Medicine*
16 "Adult Stem Cells", *U.S. National Library of Medicine*, 1 Jan. 1970
17 "Stem Cell Transplants in Cancer Treatment." *National Cancer Institute*, 5 Oct. 2023
18 Vaz, I.M., et al. "Chromosomal aberrations after induced pluripotent stem cells reprogramming." *U.S. National Library of Medicine*, 3 Sep. 2021
19 Paik, D.T., et al. "Patient and Disease-Specific Induced Pluripotent Stem Cells for Discovery of Personalized Cardiovascular Drugs and Therapeutics", *U.S. National Library of Medicine*, Jan. 2020
20 "Proposition 71: Stem Cell Research. Funding. Bonds. Initiative Constitutional Amendment and Statute." *California Legislative Analyst's Office*, July 2004
21 Snyder, E.Y. "Stem Cell Prop. 71 Saved Lives. Its Successor, Prop. 14, Will Save More-Maybe Yours." *Sanford Burnham Prebys*, 2 Nov. 2020

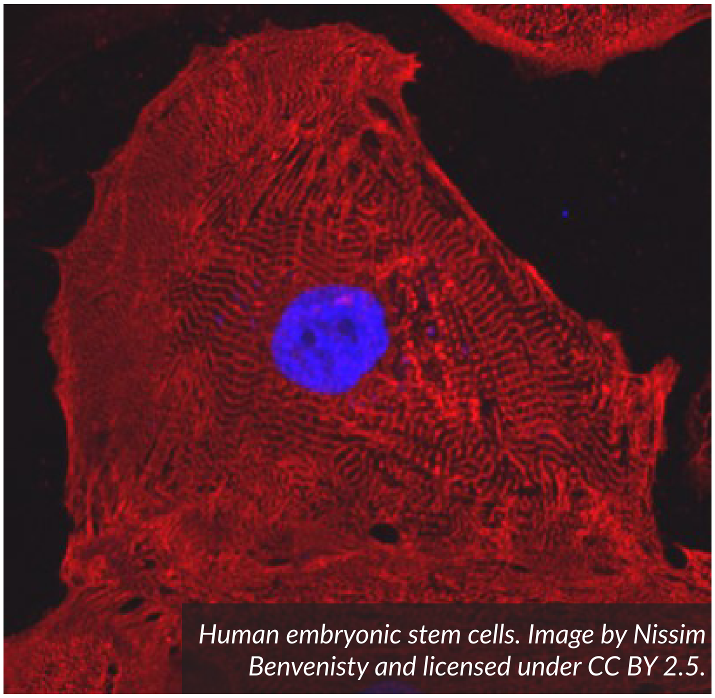


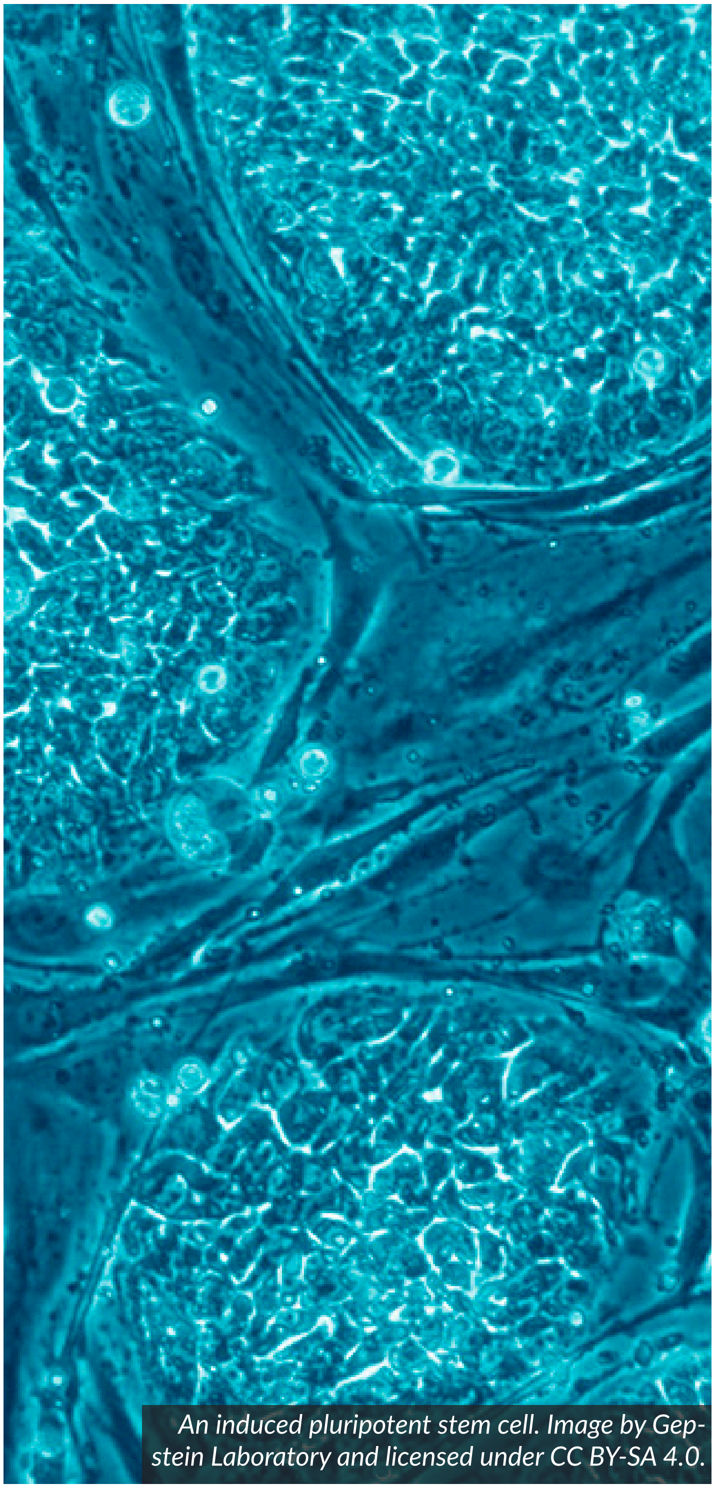
over 56,000 full-time jobs (with salaries higher than the state average), and generated an estimated $10.7 billion increase in gross revenue for the state's economy by the end of 2018[22]. Meaning, with funding and permission by the government, the CIRM was able to effectively create therapies meant to treat diseases that lack an effective remedy, therefore reducing medical spending and improving the quality of life for people in the state of California[23].

> **ESCs and iPSCs should coexist in a scientific setting as they are both essential resources in research and medicine.**

In an ideal world, scientific progression would not call for these discussions that require human lives to be weighed; however, giving up embryos that would have been discarded for the benefits of many is a necessary compromise to be made. Amidst ongoing ethical debates, ESC research has paved the way for revolutionary breakthroughs in regenerative health; from offering hope to those suffering from rare immune deficiency diseases[24] to restoring movement and speech in stroke survivors[25], the possibilities of ESC research are endless. The regenerative abilities of these stem cells hold the power to do unimaginable things for those burdened by these debilitating diseases, all while providing medical, economic, and individual benefits through ESC research.

22 "Frequently Asked Questions (FAQs)." *CIRM*
23 "Frequently Asked Questions (FAQs)." *CIRM*
24 Allday, Erin & Joaquin Palomino. "Lofty Promises, Limited Results." *The San Francisco Chronicle*, 6 Sept. 2018
25 Chrostek, M.R., et al. "Efficacy of Stem Cell-Based Therapies for Stroke." *U.S. National Library of Medicine*, 1 Nov. 2019


Human embryonic stem cells. Image by Nissim Benvenisty and licensed under CC BY 2.5.

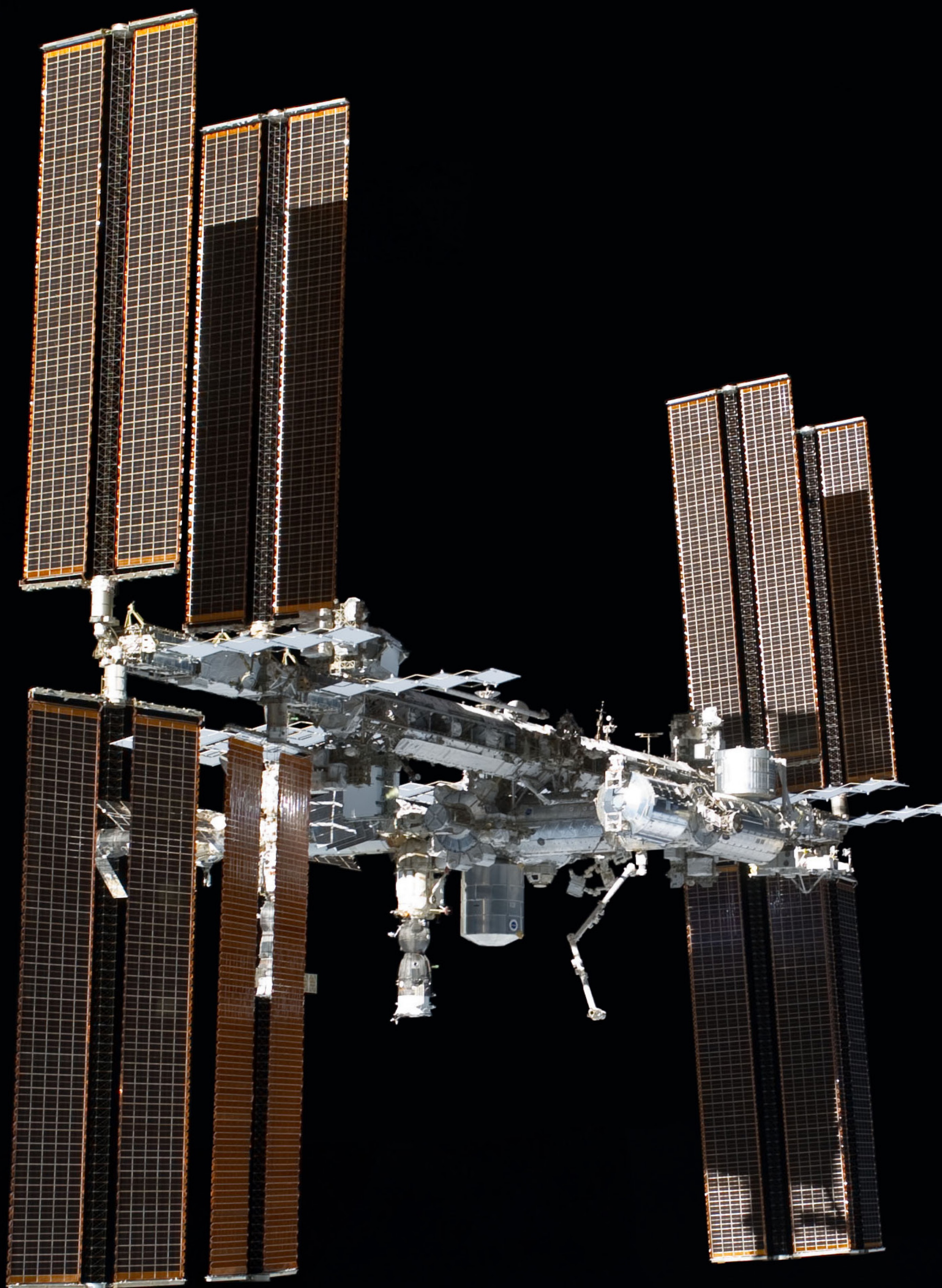

An induced pluripotent stem cell. Image by Gepstein Laboratory and licensed under CC BY-SA 4.0.

READ THE FULL ARTICLE HERE

www.colorado.edu/herbst/grounding-ethical-breakthroughs-science-embryonic-stem-cell-research

ETHICS AND EQUITY IN THE EMERGING SPACE ECONOMY

EMMA HERZOG



To many, the idea that equity, equal access to resources, and a voice should be a paramount concerns in access to space does not seem obvious. Space exploration is enormously expensive and high-risk, so it is often funded by entities like states, corporations, and investors who expect returns and must prioritize safety. Why, then, should they be concerned with equity at all? A more nuanced approach recognizes that equity does not compete with these priorities but instead fortifies them. Integrating equity considerations can foster stability, mitigate systemic risks, and expand the pool of talent and innovation, all while honoring existing international commitments and avoiding the brittle hierarchies that have historically characterized extractive regimes.

The emerging space economy is already shaped by a concentrated set of actors: powerful states such as the U.S. and China, corporations like SpaceX, and international standards bodies like the International Telecommunication Union (ITU). Capital markets amplify these dynamics by funding some projects and leaving others unfunded (European Commission; ITU). Lower launch costs have widened technical access, but access alone does not guarantee equitable participation. Access asks who can reach orbit; equity asks who benefits, who governs, and how benefits are shared. When the logic of terrestrial extraction is simply transplanted into orbit, the result is likely to be intensified divides and magnified shared risks (Jakhu and Pelton; United Nations Office for Outer Space (UNOOSA)).

Skeptics argue that if only a few nations and companies are investing “time, treasure, sweat, blood, and tears,” then they deserve the lion’s share of benefits. This view is intuitively compelling but incomplete. International commons (globally shared resources) governance provides a counterexample. Both the Outer Space Treaty and the UN Convention on the Law of the Sea treat shared domains as global commons, precisely because unilateral extraction generates instability and inequality (UNOOSA; UNCLOS). Concentration also produces fragile supply chains and leaves collective problems like debris cleanup unfunded. Hybrid governance models that combine competition with enforceable guardrails provide a more resilient equilibrium, aligning private incentives with broader stability (Jakhu and Pelton).

Acknowledging equity does not mean displacing safety and investment concerns. Rather, ignoring equity ultimately undermines them. Systems where benefits accrue to a narrow group are prone to geopolitical contestation, operational fragility, and public legitimacy crises. By contrast, systems that incorporate diverse stakeholders distribute risks more effectively, strengthen cooperative mechanisms, and ultimately create stable markets. From this perspective, equity is not a moral add-on but a strategic precondition for sustainable growth.

This strategic value becomes clearer when examining current participation patterns. Headlines often celebrate new “access” to space, yet most benefits remain concentrated among early entrants. Over 90 percent of registered satellite communications are controlled by just six nations (The Space Economy: Navigating the Challenges). Smaller states face well-documented administrative and financial barriers when navigating ITU processes for orbital slots (ITU).

Educational and infrastructural divides reinforce these gaps, with advanced STEM pipelines currently clustered in wealthy nations and marginalized groups facing exclusion from training (Stanford Emerging Technology Review). Without targeted interventions, the promise of “universal access” risks remaining a rhetorical mirage.

Legal and environmental frameworks have also lagged behind technological and commercial developments. While the Outer Space Treaty prohibits national appropriation, it is vague on private resource claims, allowing domestic laws in the U.S. and Luxembourg to create de facto property rights without broad international consent (Williamson; UNOOSA). At the same time, increasing congestion in low Earth orbit raises the risk of Kessler Syndrome, where cascading collisions render critical orbital zones unusable (Bole and Byers). Relying on voluntary self-regulation by dominant actors leaves these shared risks unmanaged, illustrating how concentration and legal ambiguity intersect with environmental vulnerability (Stanford Emerging Technology Review).

Cultural dimensions further complicate the picture. Mega satellite constellations, like Starlink, alter the night sky in ways that disrupt indigenous skywatching traditions, which Hamacher and colleagues describe as a form of cultural erasure (Hamacher et al.). Religious communities are also grappling with new ethical and practical questions, from prayer cycles in orbit to stewardship principles (“Religion in Space”; Johnson). These dynamics underscore that space is not an empty backdrop but a shared cultural commons whose transformation has both social and material consequences.

To address these overlapping challenges, several frameworks can operationalize equity without stifling innovation.

- Public-Private R&D Partnerships (PPRDPs)

These pool risk on projects where private capital alone underinvests, such as debris removal or on-orbit servicing. NASA's partnerships with smaller firms in lunar delivery and refueling show how state backing broadens participation without replacing competition (NASA).

- Circular Economy Approaches

In orbit, circularity refers to technologies such as in-situ resource use, 3D printing with regolith, and debris reclamation. On Earth, it means reinvesting a portion of space profits into global public goods such as health, education, and climate resilience. This is not charity; it expands the talent pool and stabilizes the market for future space activities (ESA; European Commission; New Space Economy).

- Decentralized Governance Tools

Blockchain-based systems and DAOs can transparently manage spectrum licenses or distribute research funds, lowering information asymmetry for smaller actors (Zubrin; Sims). These tools supplement, not replace, state authority.

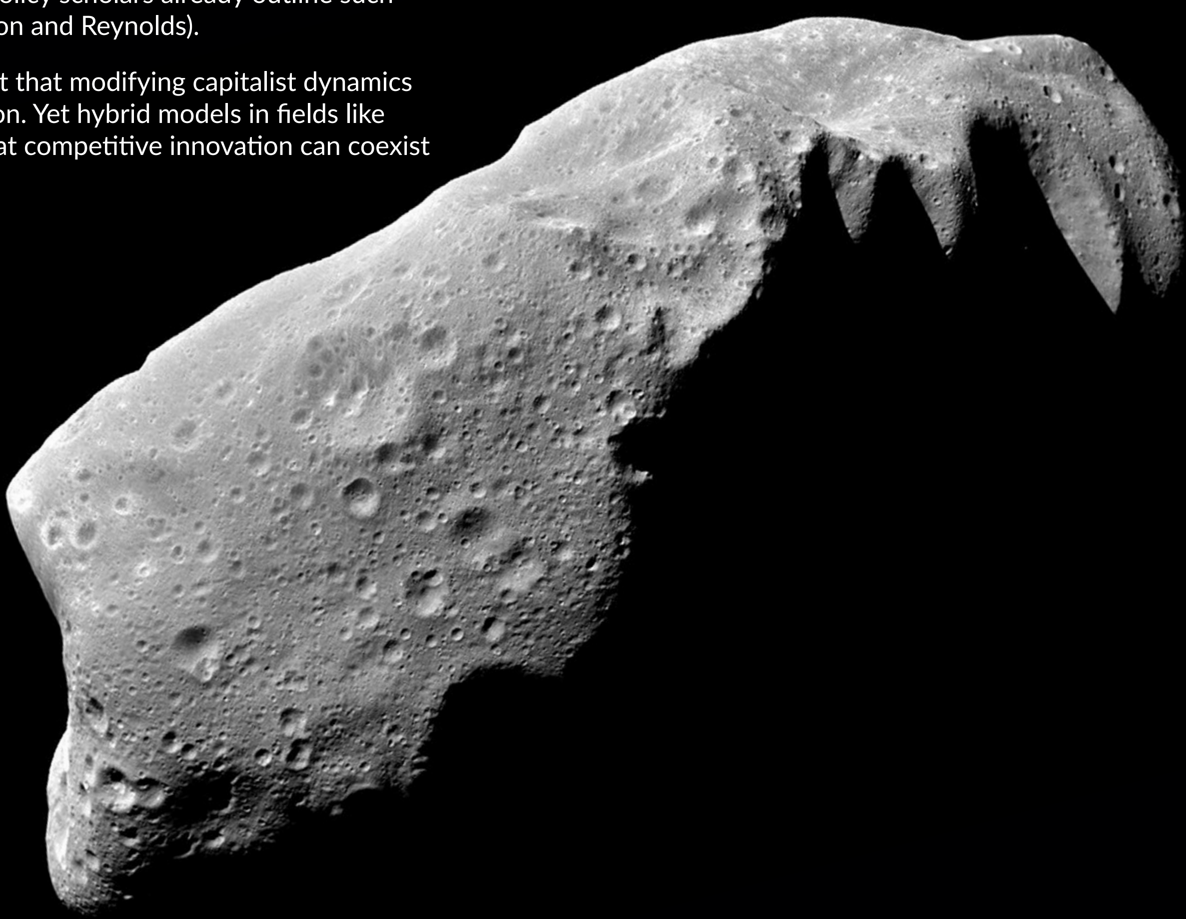
- Dynamic Spectrum Management

Transitioning from the "first-come, first-served" licensing approach to time-bound and shareable allocations would alleviate bottlenecks and provide latecomers with fairer access. The ITU and policy scholars already outline such proposals (ITU; Johnson and Reynolds).

Critics often suggest that modifying capitalist dynamics could hinder innovation. Yet hybrid models in fields like global health show that competitive innovation can coexist with redistributive frameworks. Space governance can follow a similar path, combining market efficiency with shared obligations (Johnson and Reynolds).

Equity, then, should not be dismissed as a sentimental aspiration. It is a pragmatic strategy for building a resilient, inclusive, and stable space economy. The choices made by states, firms, regulators, and investors today will determine whether space becomes another domain of exclusion or a shared commons shaped through cooperative stewardship. The path forward lies in hybrid models: competitive markets within guardrails, reinvestment through circular frameworks, and inclusive governance tools. The goal is not simply to decide who gets to space first, but to ensure that when we arrive, the benefits are broadly shared and the commons preserved (UNOOSA; Stanford Emerging Technology Review; New Space Economy).

> **"The goal is not simply to decide who gets to space first, but to ensure that when we arrive, the benefits are broadly shared and the commons preserved.**



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READ THE FULL ARTICLE HERE

www.colorado.edu/herbst/ethics-and-equity-emerging-space-economy

ENERGY BALANCES: AN ESSAY FOR LIFE

AIDAN MAGRUDER

In tandem with writing this article, I am studying for one of many exams this semester. It should be the all-consuming object of my focus. Instead, I am writing an article for a magazine. That might sound strange to people who are outside observers of a typical engineering student. The common perception is that of a quiet, reserved student willing to spend any number of hours to achieve the coveted A in a class that they may or may not enjoy. While that stereotype may have some truth behind it, the majority of students cannot keep up with it. There is simply not enough time in the day to spend it all on the schoolwork we are given and most certainly not enough energy.

A key concept that I have learned through climbing the ladder of the Chemical Engineering curriculum is "energy balance". The concept is simple in theory, and it has quite a simple formula but it can become incredibly complex very quickly. So here is the most basic formula:

Accumulation = Energy In - Energy Out + Generation

Simple right? Well, yes! It can be as simple as counting up how much energy is on each side of the equation, but it can also involve complex partial differential equations. This equation, very simply, allows us to account for the energy of a system. And that system can be as complex or as simple as the professor states.

In an ideal steady process the Accumulation term in the equation above is 0, nothing is building up inside and nothing is leaking out without replacement. That is the goal of any good engineer. Accumulation can lead to anything from a massive tank exploding to a pipe imploding and collapsing in on itself. Neither extreme is more preferable to the other, they both end badly. When the balance is off, the math doesn't work out and the process becomes dangerous. Without a good energy balance, school can become a student's worst enemy. The danger is not physically imploding or exploding (at least not most of the time) but it is burnout, draining weeks or months, storing away that little bit of stress for another week. It is not a pretty process. There are lost nights of sleep, pent up frustration, seemingly endless knowledge checks, and the stress that makes life so hard. And eventually something has to give, the accumulation of life has caught up. But that is the worst case scenario, what if there was a way to avoid it?

There are two ways to think of this energy

balance: the implosion and the explosion. When accumulation builds, it causes an explosion. Think of a rampant reaction in a tiny bottle. When accumulation is negative or drains, it causes an implosion. Think of a vacuum attached to a water bottle. Keep the energy balanced and the accumulation remains zero. Life is a steady process, always moving, always flowing continuously at the same rate and no day passes faster than the last no matter how it may seem. So harness the energy balance to bring balance to school and life around it. This harnessing doesn't come naturally to anyone, let alone students with as much on their plates as engineering students. The steps can be as simple or as complex as life demands, but to take them is key to a rewarding life both in and out of the classroom.

Start with Energy In. It is the food we eat, the sleep we get, the relaxation we can find. It is the joy, both big and small. It can also be our friendships, our relationships, our family, our communities. Sometimes it can be hard to maintain our incoming energy, sometimes things that are supposed to provide us energy can drain us. That is why diversifying the things that give energy is key! When something becomes an energy loss, it may be time to consider shifting, at least temporarily, to another energy source. But it is still key to get the basics down: food, sleep, and relaxation. Without these sources of energy, our bodies and minds can't get the minimum energy to keep the system running. It may be hard to find time for food or sleep or even a 10 minute break, but it may be easier than initially thought. When the system is given the right amount of energy, it can more efficiently convert energy into work and effort.

Energy out is next. It is the work one does, the studying, the homework, the projects. It is a bad day, or a mean person. It is the internal struggles and daily challenges. But energy out is not always negative. It can be the small amount of work needed to smile at strangers, to be a kinder friend, to make a difference in our communities. The key is to make sure that the losses don't outweigh the gains. Whether that means better time management, asking for help, or maybe less responsibilities, it is important to not let the outlet of energy become a gaping hole. The other key to remember is that failure is inevitable, whether big or small, and it can be crushing, but that is okay, the point is not perfection but a balance.

Generation is last. Generation is a tricky term in an energy balance, it can mean a variety of things in various contexts. Here generation is the aspect of life that helps one with energy recuperation. Whether it is listening or playing music, spirituality, meditation, playing a sport, working out, or reading, generation is something that may not seem like it gives energy, but is key to keeping energy up. Like an inevitable exothermic chemical reaction, generation is something that may take a catalyst or starting energy, but produces far more energy than the starting point. Generation is the extra kick to balance the math and make the system steady. If a reactor design is a little off balance, a cooling system might be the needed part to prevent explosion. A student cannot exist in a steady state without some kind of generation, big or small. There is much more to life than studies and school, and to balance their importance, something creative or expressive or exerting is key. So join a rec-league or sing in a choir or spend time in the mountains, because life is so beautiful and that reminder might just keep you from burning out or giving up on a homework assignment.

Ultimately, behind the engineering laden language and frankly lame metaphors, there is a message that I want to impart: be more than an engineering student, be a person who has feelings and emotions and breaks down, be someone who knows how an energy balance works. Use the tools of life to their fullest potential, take breaks, eat well, sleep because life is not just the present, and the balance today ensures smooth operation for the rest of the process that is life.

Photo by Shalom Busse


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BUILT WITH HEART: THE BAJA STORY

ETHAN NEVILLE
CO. AARON SHRAY

Most days in the Drop In Design Lab at the Idea Forge at the Miramontes and Leonard Baca building look different for every visitor. Component Design students get their first real taste of the design process as they build their fleet of drill-powered tricycles. In the manufacturing labs, students listen to Professor Tsai's guidance during sand casting and heat treatment labs. Meanwhile, the senior design groups focus on understanding how to keep their industry sponsors informed and happy with their progress. There is, however, one team that practically lives in the DIDL—constantly working in CAD, tackling hands-on projects, and living the engineering dream we all hope to achieve.

That team is CU Boulder's mechanical engineering senior design Society of Automotive Engineers (SAE) Baja team. For the past 10 years, the Baja team has been pushing the boundaries of what 10 to 15 students can build in just two semesters, both on campus and on the competition field. At just 5 and a half weeks into the 2025 fall semester, there are members of the team who have spent more than ~200 individual hours combined working on the previous year's car, designing their new iteration. As the last days of summer fade into fall, they learn just how big the project ahead of them is.

Unlike most senior design teams, CU Boulder's Baja team is known for working on weekends, pulling all-nighters, occasionally sleeping in the DIDL, and somehow balancing it with senior year engineering coursework. They spend more hours in the machine shop than nearly every other team, with the 2024-2025 Baja team having upwards of 1000 cumulative hours between welding, machining and consulting with the machine shop staff. However, the work isn't only confined to just the designing and building. Every Baja team has to fundraise to support both their material needs and their cost to travel to competition. This year, the team plans to raise between 15 and 20 thousand dollars to support their endeavors.

But the story of Baja isn't only about the work of every senior and the underclassmen who reach out to get involved with the project. It's really about all the incredible people around them who work year after year to support every engineer's development and dreams. These individuals work tirelessly, dedicating themselves every day in ways most people never see.

For the Baja team, Peter Himpsel, the team's director, who has worked with the team since its beginning, pulls the team together out of the pool of excited applicants in May and gives them a mission. In the fall, they step into an environment shaped by Dr. Daria Kotys-Schwartz, director of the Idea Forge and leader of Baja's senior design section for the past nine years. She embodies what the space stands for: transforming engineering education into a truly hands-on experience for every student who walks through its doors. Program and event coordinator Victoria Lanaghan makes sure the team's competitions, reviews, and travel logistics stay on track. In the classroom, Byron Rudisil leads the competition section of senior design, guiding students through the academic side of a project that stretches far beyond the syllabus.

Andy Kain manages the bigger picture of project teams across the Idea Forge. He ensures that Baja's needs align with the dozens of other design groups using the same space. On the financial side, Morgan Black, a Baja alum now serves as assistant director of finance. He helps the team navigate the complicated world of budgets, purchasing, and sponsorships, bringing both insider knowledge and administrative expertise.

And when it comes to turning designs into reality, the machine shop team, Greg Potts, Chase Logsdon, and Patrick McSpadden (another Baja alum), are the ones who keep students safe, train them on equipment, and share the craft of precision manufacturing. Their patience and experience form the bridge between raw student enthusiasm and reliable engineering.

Each of these people leave their fingerprints on the project in ways that often go unseen, but never go unfelt. The car may carry the name of the team, but its success reflects the incredible community of staff who make sure students have the chance to push limits, learn deeply, and thrive.

For those who want to follow along with the team's journey this year, we're sharing updates, photos, and videos on Instagram at @cuboulderbaja. We're also working to grow our presence online, so if you're interested in contributing through editing or filming, we'd love to have your help.

BIOPRINTING: INNOVATING LAYER BY LAYER

SHREEYA ROY

Technology that once belonged in sci-fi novels is now revolutionizing modern healthcare. One such innovation is bioprinting, a process that merges 3D printing technology and biological materials with the potential to create transplantable organs. 3D printing is a process where material is deposited layer by layer to produce a physical object. Bioprinting replaces plastic and allows for printing with biologically compatible materials, often including living cells. This breakthrough brings the once-distant idea of printing human organs closer to reality.

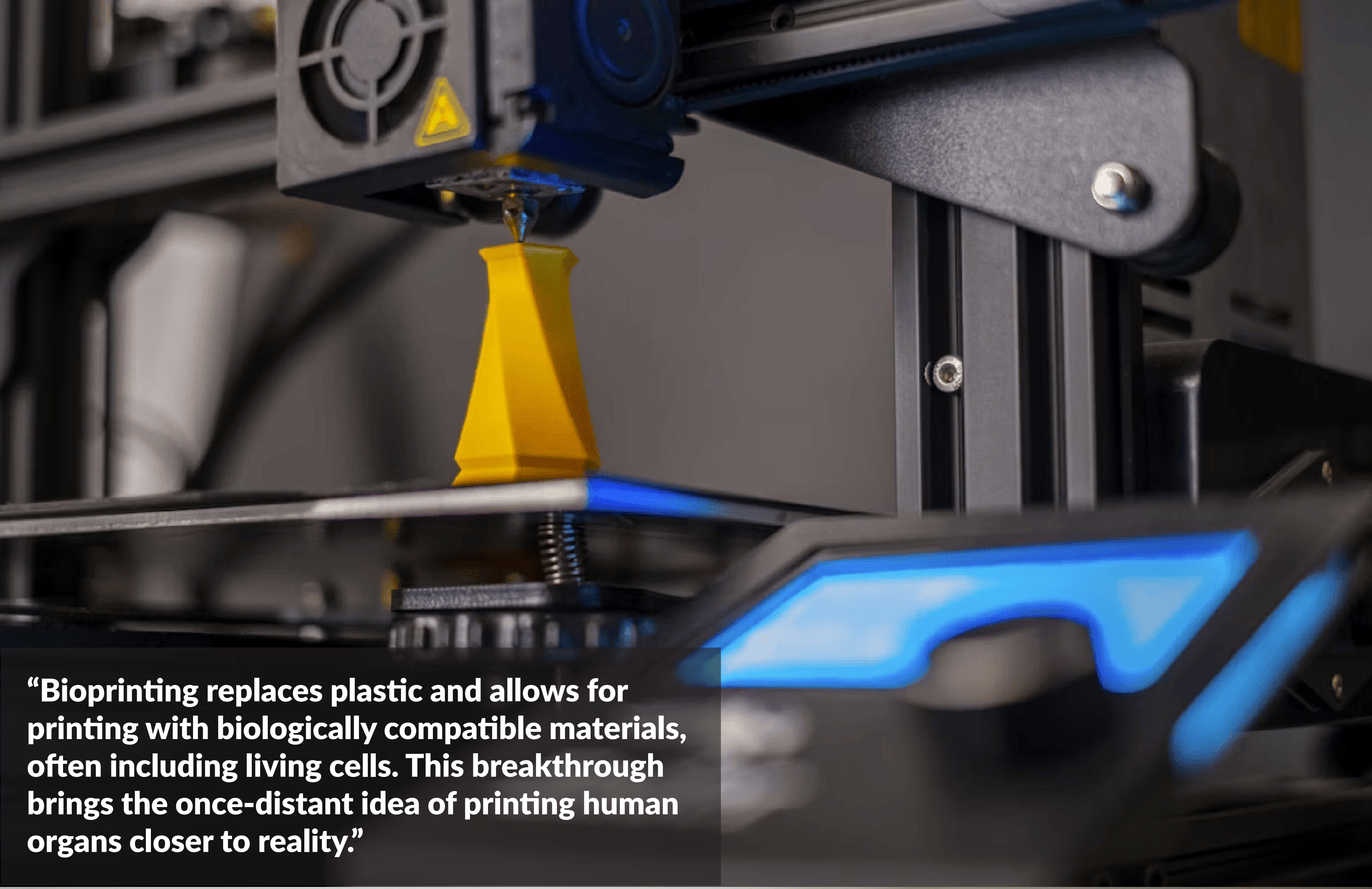
To begin the 3D printing process, a model must be acquired. 3D models can be created by scanning objects or using CAD software to develop a design. 3D models are then sliced horizontally into two-dimensional layers so that they can be printed with each layer printed on top of the previous one.

Another consideration is the material that will be used to print. Bioprinting applications can range from printing implants that are biocompatible to printing living cells. Therefore, as is expected, there is a range of materials that can be utilized for bioprinting, including hydrogels, collagen, or bio-inks, which are combinations of various biomaterials. Each material has different mechanical properties such as yield strength, ultimate strength, ductility, and elasticity. Different materials are better suited for certain applications, and their intended use needs to be considered to determine the best printing medium.

> "13 people die each day waiting for an organ transplant."

Once the file and material are ready for printing, the model will be printed one layer at a time, and each subsequent layer will be stacked on top of the previous layer to develop a physical object. Although this technology is still developing, the applications are already present and promising.

Bioprinting can accelerate innovation within drug discovery and regenerative medicine. Drugs are generally tested on animal tissues or 2D cell cultures. However, using a 3D bioprinted tissue can better mimic human tissue to help researchers gain a better understanding of how new medications metabolize in the human body. Another important application of bioprinting is regenerative medicine. According to the Health Resources and Services administration, in 2025, 13 people die each day waiting for an organ transplant. Scientists are hopeful that one day this technology can be used to print organs from the patients own cells, mitigating the organ donor crisis and reducing the likelihood of transplant rejection. While this process is yet to be perfected, in 2022, 3D BioTherapeutics successfully 3D printed and implanted an ear into a patient with a congenital disorder. Simpler organs like the cornea, skin, and bone are being engineered and the results seem encouraging.



“Bioprinting replaces plastic and allows for printing with biologically compatible materials, often including living cells. This breakthrough brings the once-distant idea of printing human organs closer to reality.”

SEARCH FOR EXTRATERRESTRIAL LIFE

MARTÍN SIERRA-PASTOR

Arthur C. Clarke, creator of 2001: A Space Odyssey, once stated, “Two possibilities exist: either we are alone in the Universe or we are not. Both are equally terrifying.” For many years, we have defended the thesis that indeed we are alone. However, in the past years, we have seen evidence that may lead us to believe that we are not that unique across the universe. Here is some of that evidence:

APOLLO 12: MOON BACTERIA

In November 1969, astronauts Pete Conrad and Alan Bean performed the second manned lunar landing in human history. Contrary to the plan of Apollo 11, the objective of this landing was to demonstrate the ability of the Space Program to perform a “pinpoint landing." In this landing, the Lunar Module lands on a very small area, like a Helipad. This spot was humorously called “Pete’s Parking Lot,” and had a big particularity. The spot was on the border of a crater where two years before, the probe Surveyor 3 landed.

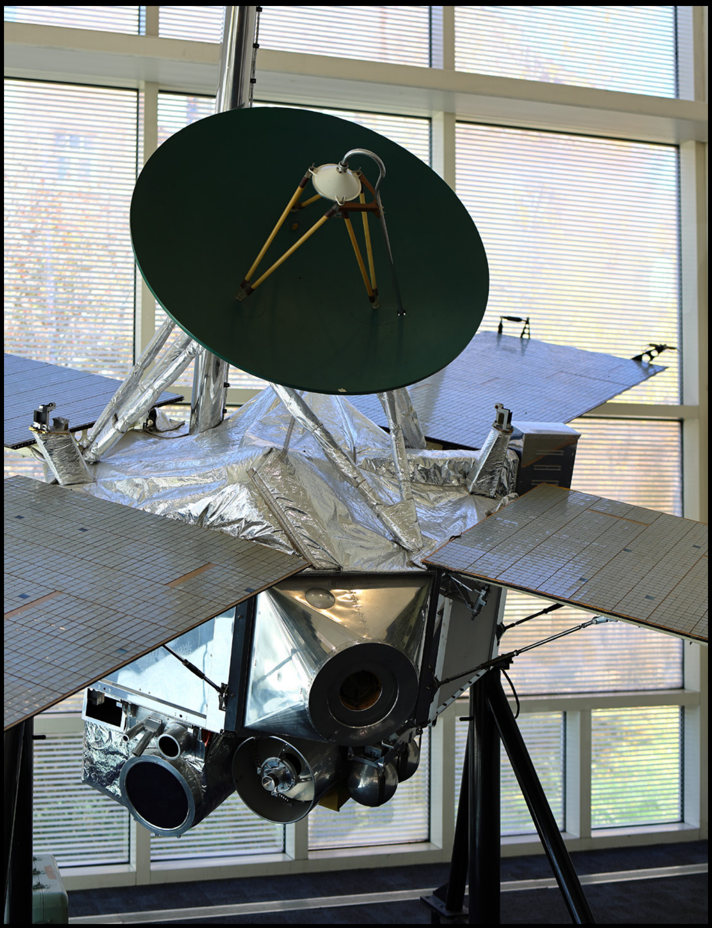


Photo by Alessandro Valente

The astronauts performed the best landing in history in terms of accuracy and fuel margin, and were even able to recover instruments from the dead probe. These instruments (including a TV camera) were sealed in plastic bags and after the mission splashed down in the Pacific Ocean, the instruments were sent to Houston for analysis.

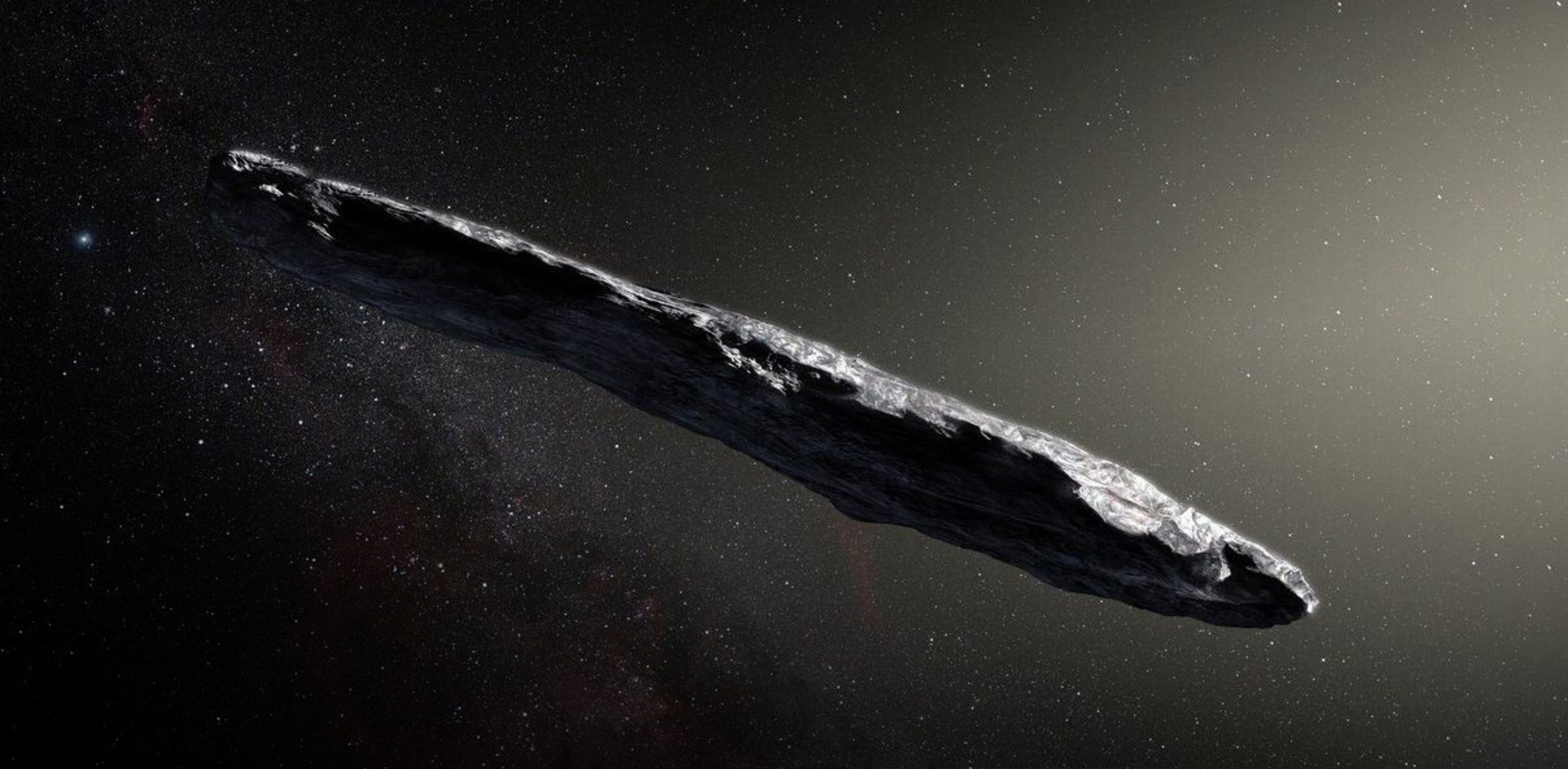
The scientists could not believe their eyes. All the instruments were completely contaminated by the bacteria Streptococcus Mitis, a common bacterium on Earth. It contaminated the probe before liftoff and against all odds, thrived in the lunar environment without air, water, and food and withstood extreme temperatures in complete vacuum and radiation.

From that moment on, a very strict sterilization protocol was applied to any spacecraft sent to other worlds because if we were ever going to find life on another planet, how would we be sure that it was not brought by us?

MOON TARDIGRADES

A few years ago, a spacecraft broke that rule. On April 11th, 2019, Israel was monitoring their Beresheet probe that was about to make the first soft landing in its history. Aboard, there was a box full of tardigrades: tiny organisms that were known for being extremophiles, able to survive in the hardest environments imaginable. Everything in the mission control was going well. The spacecraft approached its landing site in the Sea of Serenity flawlessly, but a malfunction in one of the inertial measurement units (gyroscopes) made it crash against the surface, losing contact with mission control.

As for today, we do not know the state of the probe and the container of the tardigrades. There is reason to believe that it opened upon crash and that the tardigrades are now on the Moon. Did they survive the crash? If so, are they still thriving in the harsh lunar environment? These questions are not answered, but if they are as resilient as we have seen them to be, we have reason to believe that they are still there. Are they a problem for future visits? Not for now.



Artist's rendition of Oumuamua

LIFE ON MARS?

Mars is a fascinating environment for astrobiologists. In 1976, the Viking orbiters found evidence of erosion by liquid in some areas of the Martian northern hemisphere, suggesting the existence of an ancient sea that covered the whole north pole. This Paleo-Ocean was called Oceanus Borealis (Ocean of the North) and disappeared over the years due to the loss of the magnetic field and the continuous leaking of Mars' atmosphere into outer space, leaving the inhospitable arid planet we know today.

Mars is the only planet (outside of Earth) that orbits inside the known Habitable Zone, which is an imaginary ring where planets can orbit around a star far enough to keep water from boiling, but close enough to keep it in a liquid state. Scientists see that this region is the one that has the biggest potential to harbor life. So, in the last couple of decades, we have sent several probes and rovers to the planet to search for those traces of ancient life.

> **Two possibilities exist: either we are alone in the Universe or we are not. Both are equally terrifying.**

The last and most famous case is the *Perseverance Rover*, which in July 2024 found traces of chemicals such as clay and silt, which are known to be excellent energy sources for microbial life on Earth. This finding, along with the location of the minerals, proved that this is one of the places where the water once covered Mars' surface. This leads us a step closer to finding biosignatures in other worlds.

THE FUTURE

But the quest goes on. CU Boulder's LASP (Laboratory for Atmospheric and Space Physics) is currently working with JPL (Jet Propulsion Laboratory) in one of the most ambitious scientific missions in human history: Europa Clipper. This mission, launched in October of 2024, is expected to arrive at Europa (one of Jupiter's four Galilean moons) in 2030. Europa is yet another paradise for astrobiologists. The Galileo probe found in 1995 that Jupiter's magnetic field was disrupted around that moon, implying that below the crust there might be an electrically conductive fluid capable of creating that disturbance. Since Europa's crust is made from water and ice, that ocean would most likely be a salt water ocean, just like ours. It is kept liquid thanks to the strong geothermal activity of the moon, the same activity found in other moons such as Io.

Once the probe arrives at Europa, it will make use of CU Boulder LASP's SUDA instrument (Surface Dust Analyzer) to analyze the traces of dust emitted by the plumes and surface of the moon. This instrument, supervised by Dr. Sascha Kempf, can identify the traces of both inorganic and organic substances found in the samples.

ARE WE ALONE?

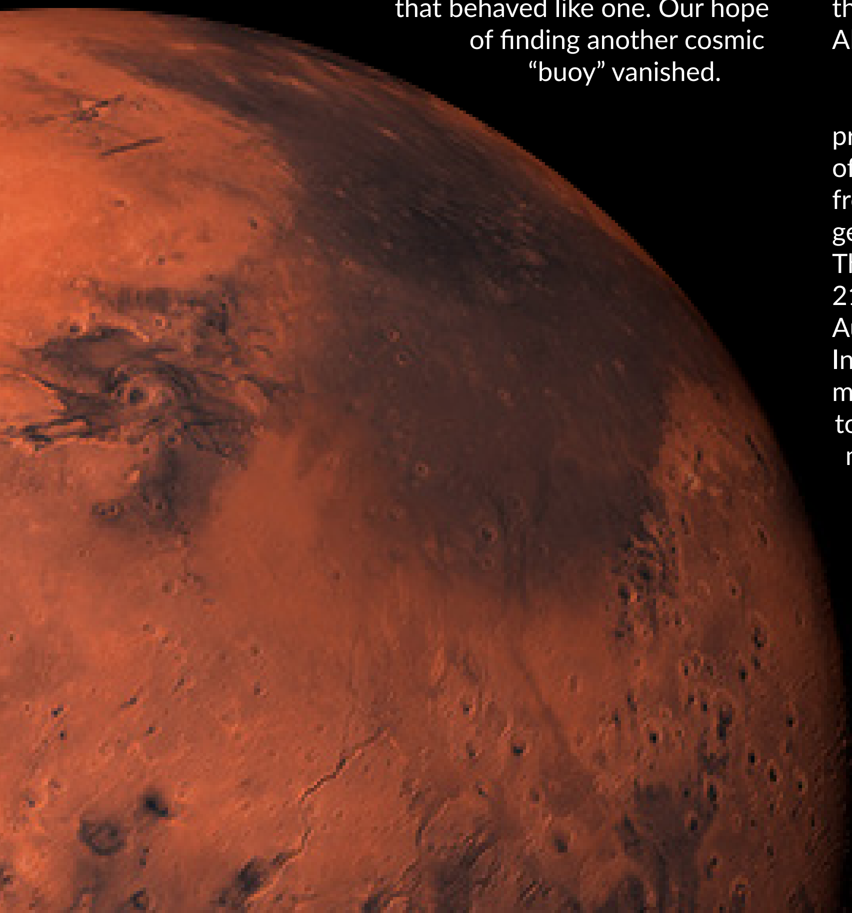
For decades, the scientific community has dismissed the question, "Is anybody (intelligent) out there?" The search for intelligent life outside of Earth has been treated as a joke, qualifying any scientific investigation into the issue as a chimera. But science's primordial job is to find evidence to support or deny a hypothesis.

Humanity's quest for intelligent extraterrestrial life has drawn us to send probes such as the Pioneers 10 and 11 or Voyager 1 and 2 to the vast infinity of space. These probes had messages attached to them in the hopes of being found in a distant future by a technologically advanced civilization. All of these probes have barely left our solar system but remain a symbol of our endeavor to find someone out there.

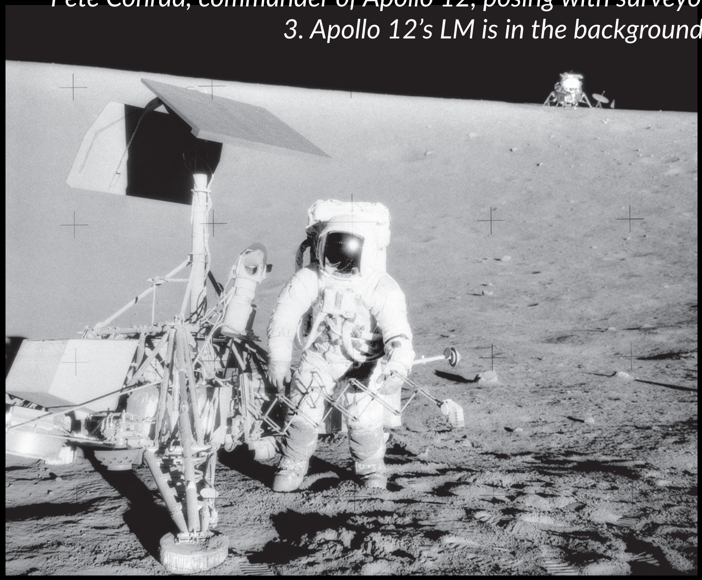
OUMUAMUA, OUR FIRST VISITOR

In 2017, the Pan-STARRS telescope in Hawaii found the first object ever recorded to reach our solar system from interstellar space. We called it 1I/'Oumuamua, Hawaiian for "explorer." This object sparked people's curiosity. Nothing like this had ever been seen before. However, our first visitor from another star was behaving quite oddly. As it approached the Sun, it did not accelerate as expected, and when it crossed it, it began accelerating more than the observations predicted. This anomaly, seemingly linked to an unusual brightness produced by the sunlight, raised many questions. Abraham Loeb, head of the astronomy department at Harvard, suggested that 'Oumuamua could be a solar sail developed by an alien civilization, or a Voyager made by another civilization, just like a bottle with a message thrown to the sea.

Loeb and other scientists proposed sending a probe to study the interstellar object, but at the time this meeting took place, 'Oumuamua was out of reach. 'Oumuamua kept its trajectory and is abandoning our cosmic neighborhood forever. In 2019, an amateur Russian astronomer discovered a second interstellar object, the comet 2I/Borisov, reactivating our interest in 'Oumuamua. But Borisov was nothing like 'Oumuamua: it was just a comet that behaved like one. Our hope of finding another cosmic "buoy" vanished.



Pete Conrad, commander of Apollo 12, posing with surveyor 3. Apollo 12's LM is in the background.



3I/ATLAS: THE MYSTERY CONTINUES

But on July 1st, 2025, the observatory ATLAS at Río Hurtado, Chile, found the third of these objects. 3I/ATLAS was expected to be another object like Borisov, but its composition and trajectory raised alarms.

The comet approached our solar system in a trajectory very close to the ecliptic plane (the plane in our solar system where all the planets lie). This meant that the comet could make use of the planets in our solar system to perform a gravitational assist. Just as we do to send our probes to the outer solar system, an extra push could be added to the already high velocity of 61 km/s relative to the Sun. Abraham Loeb once again drew his attention to this object.

Apart from the already odd trajectory, Loeb reported the presence of an anti-tail in the comet. This was an elongation of jetted material going towards the Sun instead of away from it. These kinds of anti-tails are usually optical illusions generated when Earth crosses the orbital plane of a comet. The data gathered by the Hubble Space Telescope on the 21st of July 2025, seems to differ from that hypothesis. By August 6th, the James Webb Space Telescope used its Near-Infrared Spectrograph to analyze the components of the material emitted by the comet, and the findings add mystery to the issue. The jetted material is composed of an unusual mix of volatile substances such as CO_2 and water, making the chemical signature of this comet unique.

3I ATLAS will continue its hyperbolic trajectory and get lost in the infinity of space, but before it leaves us forever, just as 'Oumuamua did, will we be able to solve all of its mysteries? Is this fake evidence that we have created to believe that there is someone out there? Or are we not alone, and all these signals are evidence that indeed life finds a way?

THE UNIVERSE DIED QUIETLY

MICHAEL CHAPP

The Ascalon was barely more than a tin can with a rocket taped to the back. Long-range, low-profile, and always cold.

Vara clamped her helmet to her mag-sling as she stepped inside, and was greeted by the eye stinging chemical stink of hot plastics and filtered sweat. The crew was already aboard: Jos at the helm, his boots up on a panel he didn't have clearance for, and Nyx hunched over a sensor suite like she didn't trust its readings.

"Alright," Vara said, letting the hatch seal behind her. "Here's the short version."

Nyx glanced up. "No briefing room?"

"No time. We're burning in ten."

Jos muttered something about Martian rush jobs, but Vara ignored him. She keyed her pad and flicked the screen to show a simplified ops brief.

"Need-to-know protocol. Site designation: ECHO-1. Located just past the Tyre fracture. Gravitational distortion at the surface. Intermittent signal scatter. Brief says it's shaped like a disk. You're not being told what it is because I'm not either."

"That's the second time Europa's screwed with us," Jos said, frowning. "Estimated time?"

"Just under 10 days at constant one third-g. Standard three-day observation window, then back."

"So just another quiet suicide run," he said, strapping in, "Copy that boss," Jos turned in his seat, "Elysium Tower, this is Ascalon M917, pad 12, IFR, one third g to Europa with information Sierra."

Vara tuned him out. She wasn't a pilot, and she didn't care about startup code. Soon, she felt the pressure build as thrust settled in.

Nyx tapped her screen. "What kind of signals do you want me scanning for?"

"Gravitational anomalies, lensing, and anything that doesn't fit. You'll know it when you see it."

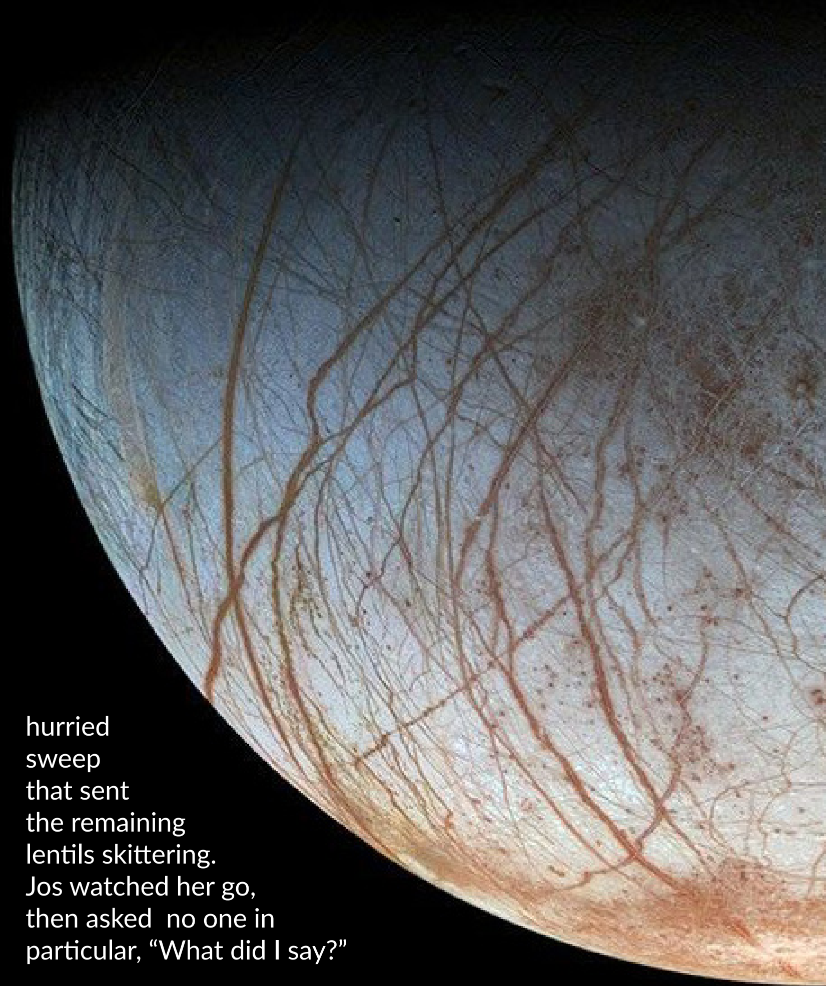
Jos leaned back in his seat and added, "Ascalon is away. Kiss Mars goodbye."

The ship hummed while air recyclers moved stale air that was thick with sweat. Nyx had been watching the comms panel for the last hour, more out of habit than expectation. The ship's sensor suite spit out ordinary telemetry, then a line indicating a tight beam error.

"Comms are down," Nyx said without looking up when Jos passed the console.

"They're rerouting through relay net 7, but latency is abnormally high and I'm seeing duplicate returns."

Vara tapped her console. "Confirmed. Timestamp error, probably a sync hiccup with the relay net."



"Is it them or us?" Jos asked.

"Both." Nyx's fingers turned the offending trace until it was centered in the UI. After a short pause she continued, "Maybe neither. Looking at this spectrum analysis, Europa is no longer acting like a black body. It's absorbing all radio waves, causing our signal to get scrambled along the way."

"So we're flying blind?" Jos asked.

"No we're flying with our mouth sewed shut and our ears ripped off," Nyx responded bluntly.

Jos stood then shoved back his chair and scanned the room with the false casualness of a man trying to keep the mood light. "Anyone hungry? I can field tacos from bag three. Or lentils. Real gourmet."

Vara looked up from her tablet. "I'll take whatever's less gruel and more food."

"Nyx?"

Nyx did not look away from the panel. "No. Keep the lentils."

Jos nodded and left to assemble lunch. Vara paused for a moment before following him.

The galley smelled faintly of protein paste and recycled coffee. Vara sat across from Jos, chewing a mouthful of rehydrated lentils, when he looked up and asked,

"You think it's alive?"

She frowned. "What?"

"The anomaly," he said, as if they'd been talking about it. "You said maybe it's alive."

"I didn't say that."

"You did. Just now."

Vara chuckled nervously. "Stop joking around. This is serious."

"I am serious," his eyes heavy with worry.

They stared at each other for a moment. Vara's mouth was set into a line. She leaned back and pushed her bowl aside with a fingertip, the action small and oddly precise.

"I, uh, should—," Vara stood abruptly, flustered. "I should—" She cut herself off. "Check the logs."

She shoved her tablet into her vest and left the mess in a hurried sweep that sent the remaining lentils skittering. Jos watched her go, then asked no one in particular, "What did I say?"

A gentle insistence pulled Vara's gaze back to the anomaly, again and again. She could feel it in her teeth. In the slow, warm beat of her pulse. Every equation, every law she'd trusted her whole life collapsed when she looked at it.

If it's asking to be understood, she thought, how can I refuse?

She didn't remember suiting up and stepping outside, yet she found herself standing on Europa's icy surface, setting up instruments along the hull.

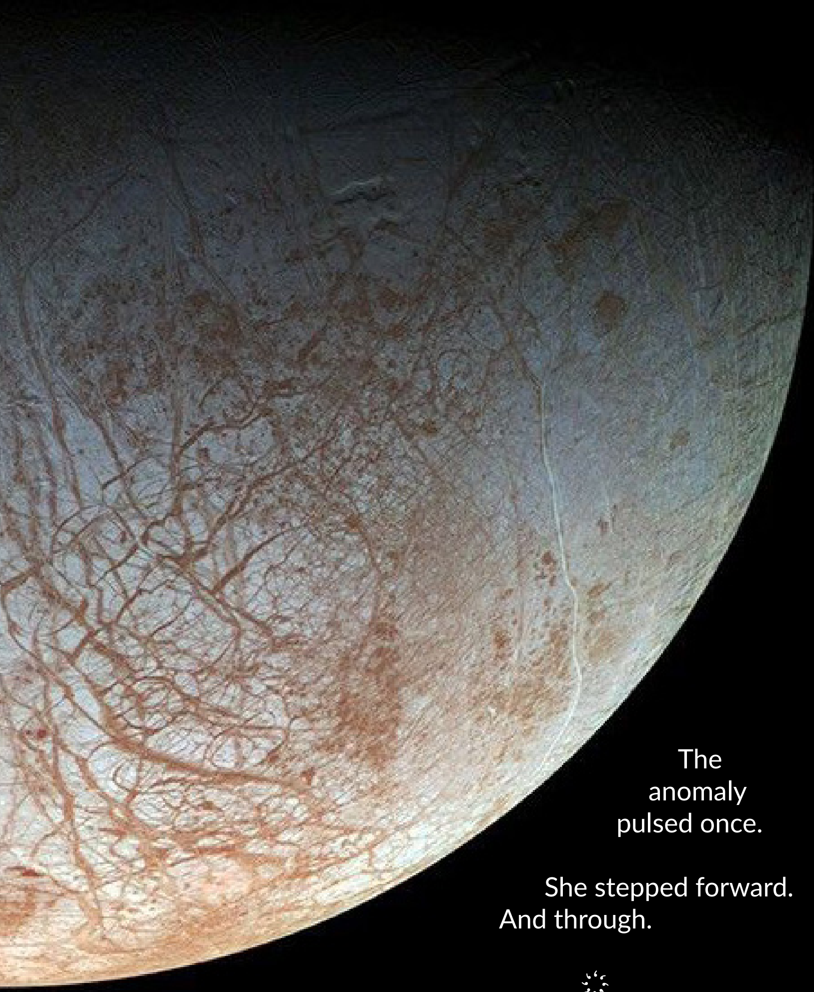
She recorded a set of numbers, then glanced back to find the same numbers already logged under a timestamp from minutes ago. Her stomach knotted. She blinked and found her glove halfway through a motion she hadn't started.

"Vara, status?" Jos's voice cracked over comms. It repeated, not from static, but like a record skipping. "Vara, status – status – status..."

"I'm fine," she said, with a pit deep in her stomach.

She drifted closer to the boundary. It wasn't a surface, but there was a place where space bent like molten glass. Light warped there, folding in on itself.

A panicked and distorted voice screamed through her headset. But she couldn't understand a word they said, and at this point she didn't care.



PERSONAL LOG 24-A / DR. VARA L. RENN / T-228:13:41 (UNVERIFIED)

The Universe died quietly.

I thought the collapse would sound like thunder. I thought it would give me an answer.

The Universe came back the same but different. Or I changed. I can't tell.

I thought understanding would save me. It didn't.

The
anomaly
pulsed once.

She stepped forward.
And through.

Inside the anomaly, there was no transition. One step, and the ice beneath Vara vanished. She was standing in a void, not empty, full of specks of light.

The first thing she noticed was heat. Not warmth. It moved across her skin in waves, but didn't burn.

Ahead of her, something flickered. A star, solitary and ancient, pulsed and shivered. She saw it collapse inward, and then rebound outward. Its red surface consumed the small planets orbiting it. Its light stretched from red into black, into nothing.

She was again surrounded by the void, this time dark and sterile. Then, like a breath, the void exhaled.

From the ashes, she saw another universe unfold. This would happen again.

Already had, and would again.

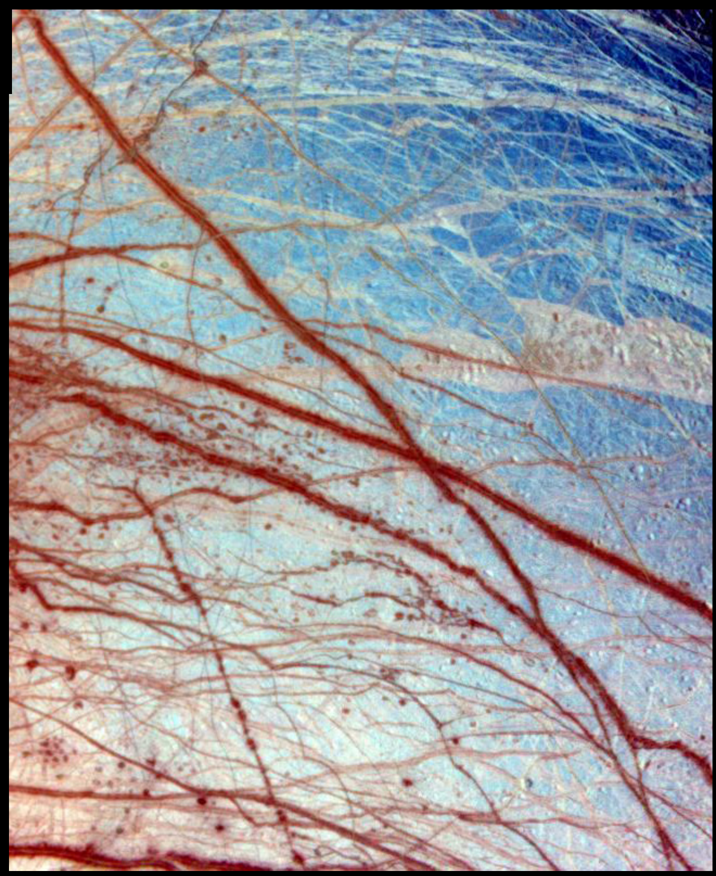
The star returned.

And then another.

And another.

A cascade of new beginnings.

She opened her mouth to scream or speak or weep, but there was no sound in the void.



False-color composite of Europa's Minos Linea, captured by NASA's Galileo in 1996. Reddish bands reveal impurities in the ice, while blue plains mark frozen expanses shaped by grain size and light. Each pixel spans up to two miles of this alien, fractured world.

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