STEM SPECTRUM

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INNOVATION
Through Insight

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Here's some exciting things that happened recently in the scientific community!

Welcome to this issue of the STEM Newsletter!
We are thrilled to bring to you the latest developments and groundbreaking research currently being conducted by the scientific community across the world. Each issue is dedicated to keeping you informed about the exciting discoveries, technological advancements and innovative solutions from all different fields of STEM.
Our mission is to keep you updated on the ongoings in the complex world of STEM, in hopes of providing a platform where knowledge meets curiosity. We hope this issue helps you foster a deeper understanding of the world around you, inspire you to become the next generation of thinkers and innovators.

In addition to updates the newsletter will also explore the constant discussions of current scientific issues, offering nuanced perspectives on topics that are beginning to and will shape our future.
Whether you're a seasoned professional, an educator, a student, or simply someone passionate about STEM, there's something here for everyone. We hope you find this newsletter both informative and inspiring, and we look forward to exploring the world of STEM with you.
Enjoy this issue, and let's dive into the wonders of science together!

Rosalyn C

In this newsletter you can expect:

"FOR THOSE WHO UNDERSTAND THE FUNDAMENTAL PHYSICS BEHIND THIS, IT MAKES SENSE; BUT IF YOU AREN'T FAMILIAR WITH IT, IT LOOKS LIKE A MAGIC TRICK," OU SAID.

Latest innovations: Researchers transform living skin to transparent, in an article published online Sept. 5 in Science, Ou and his colleagues report that they safely made the skin of live mice transparent by applying the dye solution. The process is reversible.

The "magic" behind this is the key to making skin temporarily transparent lies in how the dye interacts with light. Normally, our skin looks solid because it scatters and absorbs light. The way light behaves in any material, including skin, is determined by its *refractive index*, which is a measure of how much the material bends light.

When the scientists dissolved light-absorbing dye molecules in water, this solution changed its refractive index to closely match that of the skin's natural components, like lipids (fats). This matching effect is crucial because when the refractive indices of two substances are similar, light passes through them more easily without scattering as much. It's like how fog on a window makes it hard to see through, but when the fog goes away, the glass becomes clear again. Here, the dye helps "clear" the light scattering in the skin, making it look transparent.

In their experiments, the researchers applied this water and dye solution onto the skin of mice, specifically on their skulls and abdomens. As the dye molecules diffused into the skin, the skin became see-through because the scattering of light was reduced. The interesting part is that this process is reversible. Washing the skin removes any dye on the surface, and the dye that soaked into the skin is eventually broken down by the body, metabolized, and removed through urine.

This technique is a safe, temporary way to make skin clear, allowing scientists to see deeper into tissues without invasive procedures, which can be very helpful in medical research.

"It takes a few minutes for the transparency to appear," Ou said. "It's similar to the way a facial cream or mask works: The time needed depends on how fast the molecules diffuse into the skin."

By making the skin of mice temporarily transparent, researchers were able to directly observe internal structures, such as the blood vessels on the surface of the brain and monitor peristalsis in the digestive system.

The transparency was achieved using FD&C Yellow #5 dye, generating an orangish colour. Ou explained that the dye used in the solution is commonly known as FD&C Yellow #5 and is frequently used in orange- or yellow-colored snack chips, candy coating, and other foods. He suggested, *"It's important that the dye is biocompatible — it's safe for living organisms." The dye's advantages include being "very inexpensive and efficient; we don't need very much of it to work."*

Ou suggests one of the first applications of this technique to be used mostly in improving existing research methods in optical imaging. *He says, "Many medical diagnosis platforms are very expensive and inaccessible to a broad audience, but platforms based on our tech should not be." He believes that this breakthrough could "completely revolutionize existing optical research in biology."*

The National Science Foundation has created an experiment for those who want to try this at home: https://nsf-gov-resources.nsf.gov/files/USNSF-YellowNumber5_Activity.pdf

Breaking Research Updates

A recent breakthrough involves a new robotic leg designed by researchers from ETH Zurich and the Max Planck Institute. Instead of using traditional motors, this leg employs artificial muscles powered by *electro-hydraulic actuators.* These actuators are oil-filled plastic bags with electrodes, similar to the way static electricity makes a balloon stick to your hair. *“As soon as we apply a voltage to the electrodes, they are attracted to each other due to static electricity,”* explained researcher Thomas Buchner. This mechanism allows the robotic leg to move efficiently, perform high jumps, and react to obstacles without needing complex sensors.

Compared to motor-powered robots, this new leg is more energy-efficient. Buchner pointed out, “*On the infrared image, it's easy to see that the motorized leg consumes much more energy if it has to hold a bent position.”* The artificial muscles don’t generate excess heat, making them simpler and cheaper to use.

The robotic leg’s adaptability is also notable. It can adjust its movements based on the terrain, similar to how humans naturally adjust their steps. *“Adapting to the terrain is a key aspect,”* said researcher Toshihiko Fukushima. Unlike motor-driven robots that need sensors to determine position, this leg adapts automatically based on its environment.

Though the technology is promising, it’s not yet ready for heavy tasks. “*The leg is currently attached to a rod, jumps in circles, and can't yet move freely,”* noted Robert Katzschmann. Future advancements could lead to versatile walking robots for various applications, including rescue missions.

Use the QR code here to learn more about how artificial muscles propel robot leg to walk and jump!

Emerging Technology: Generative AI

In 2023, MIT researchers developed Style2Fab, a generative AI tool enabling users to customize 3D models by integrating design elements through natural language prompts while ensuring that the functional aspects of the object, such as the nature of different materials, remain intact. This innovation targets both novice and experienced users, allowing them to personalize objects like assistive devices, where aesthetics and functionality are equally important.

Style2Fab’s foundation lies in deep learning algorithms that automatically decomposes 3D models into two main components: *aesthetic and functional segments.* This segmentation process is crucial, as it allows users to modify the appearance of non-functional elements (e.g., color, texture) without altering the functionality of the object (e.g., structural integrity or physical connections). To classify these segments, Style2Fab uses *machine learning* to analyze the model's topology, which refers to the way its geometry—like curves, edges, and surfaces—changes across the structure. The system identifies significant topological variations, such as where two planes intersect or where a curve forms, which often correspond to functional elements of the design.

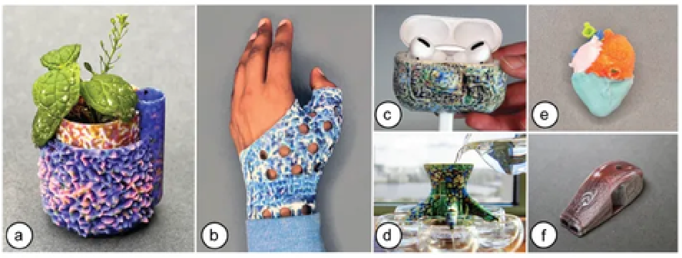


Figure 8: Application scenarios for Style2Fab (all models sourced from Thingiverse): (a) A multi-component self-watering planter styled as "*A rough multi-color Chinoiserie Planter*". (b) A personalized Thumb Splint styled like "*a blue knitted sweater*". (c) A personalized AirPods cover "*in the style of Moroccan Art*". (d) A Drinks Dispenser model styled as "*made of vintage mosaic glass tiles*". (e) A color-coded, textured educational model of the human heart. (f) A functional whistle styled as "*A beautiful whistle made of mahogany wood*"

The functional segments are classified into two categories:

1. External functionality: Parts of the model that interact directly with the external environment. For example, the opening of a cup or the mounting points of an object.
2. Internal functionality: Parts that are crucial for the internal structure or for connecting components after fabrication, such as hinges, joints, or internal slots.

Once Style2Fab analyzes these segments, it compares them against a curated dataset of 3D models. Each model in this dataset is annotated with labels marking whether segments are functional or aesthetic. This comparison helps the AI to label the segments within a new model. While the system provides these classifications as recommendations, users can manually adjust them if they feel a segment has been misclassified.

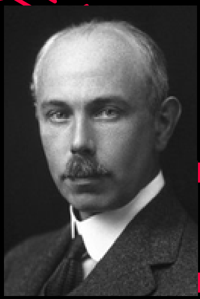
Given the variability in 3D models and their use cases, Style2Fab implements a human-in-the-loop process. This approach allows users to *review and refine* the segmentation, making it possible to handle context-dependent cases. For instance, the same object—a vase—might have different functionalities depending on whether it is placed on a table or hung from a ceiling. The AI's automated classification serves as a starting point, but the user has the final control over which parts of the object are treated as functional or aesthetic.

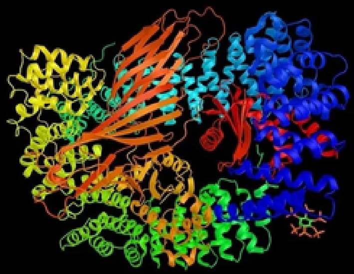
After segmentation, users can input natural language prompts describing the desired design elements. For instance, a user might request *"a rough, multicolor Chinoiserie planter" or a phone case "in the style of Moroccan art."* Text2Mesh, a separate AI system, interprets these prompts and modifies the aesthetic segments of the model based on the description. This includes changing textures, colors, or shapes to match the requested style. However, the functional segments remain untouched to preserve the model's usability.

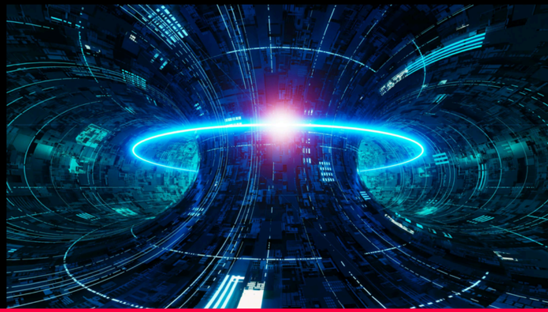
One of the most promising applications of Style2Fab is in the field of *"DIY assistive technology"*. Research has shown that assistive devices are more likely to be adopted by patients if they are both *functional and aesthetically appealing*. For example, a thumb splint could be customized to match the user's clothing or personal style without altering its mechanical performance. This personalization could increase the likelihood that the device will be worn consistently, improving the quality of life for users.

The research team, including Faraz Faruqi (lead author), Stefanie Mueller (co-senior author and professor at MIT), and Megan Hofmann (assistant professor at Northeastern University), conducted a study to evaluate Style2Fab. They worked with users of varying 3D modeling expertise and found that the tool was valuable to both novice and experienced users. Novice users could easily navigate the interface to customize designs, while more experienced users found that Style2Fab sped up their workflows and allowed for greater precision in design.

https://groups.csail.mit.edu/hcie/files/research-projects/style2fab/style2fab.pdf
https://news.mit.edu/2023/ai-driven-tool-personalize-3d-printable-models-0915
https://www.thingiverse.com/







Key Figures and Discoveries: FRANCIS WILLIAM ASHTON

Francis William Aston was awarded the *Nobel Prize in Chemistry in 1922* for his discovery of isotopes in a large number of non-radioactive elements using mass spectrograph. His work has fundamentally changed our understanding of the atomic structure and its implications in different fields of STEM.

The Road to the Nobel Prize
Aston's was awarded the Nobel Prize in Chemistry in 1922 specifically *"for his discovery, by means of his mass spectrograph, of isotopes, in a large number of non-radioactive elements, and for his enunciation of the whole-number rule."* His invention of the mass spectrograph in 1919 allowed for the precise measurement of the masses of isotopes (specifically the mass-to-charge ratio of ions), hence debunking the idea of elements having a single atomic mass. Through separating atoms and molecules based on their masses with high precision, his discovery demonstrated that some elements actually consisted of different isotopes—atoms of the same element that have different numbers of neutrons and, therefore, different atomic masses. Before Aston's work, it was known that some elements, such as uranium and thorium, had isotopes, but this was mostly limited to radioactive elements. Aston's work extended the concept of isotopes to stable, non-radioactive elements, heavily expanding our understanding of the atomic world. *Aston's method involved ionizing chemical elements, accelerating the ions through an electric field, and then passing them through a magnetic field. Based on their mass-to-charge ratio, the ions would deflect by different amounts. This separation enabled Aston to measure the exact masses of different isotopes and determine the atomic weight of elements more accurately.*

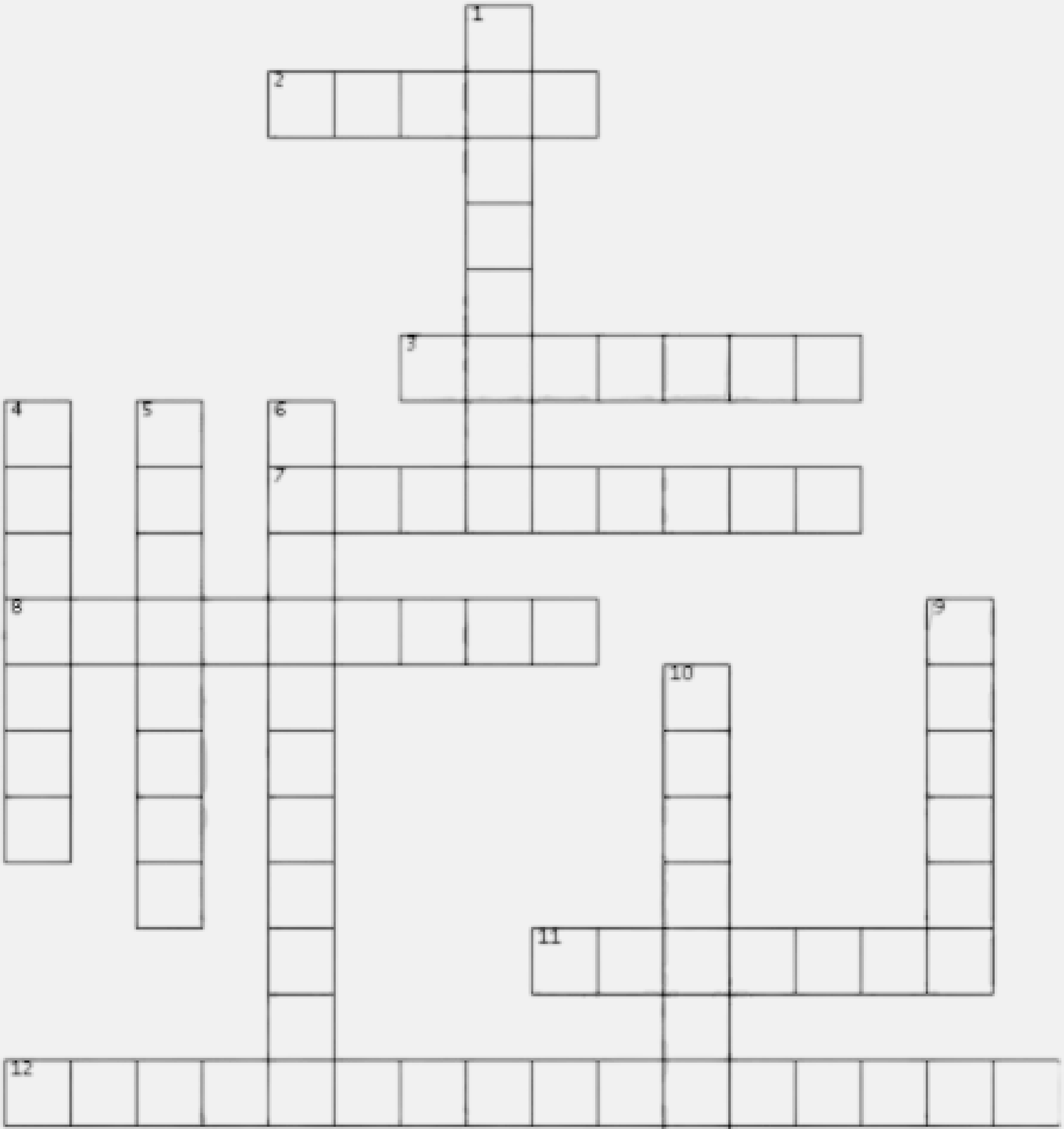
The concept of isotopes was introduced earlier by Frederick Soddy, but Aston provided the experimental proof by demonstrating that elements like neon, chlorine, and others existed in multiple isotopic forms. For instance, in 1920, Aston famously showed that neon consists of two isotopes: neon-20 and neon-22, with mass numbers 20 and 22, respectively. This discovery was vital, confirming that elements could exist with atoms of different atomic masses, despite having identical chemical properties, as the *number of protons-- an element defining feature-- remained the same.*

Famously, Aston's work led him to formulate the Whole Number Rule, which states that *the masses of the isotopes are whole number multiples of the mass of the hydrogen atom.* This rule was fundamental in suggesting that atomic masses are largely determined by the sum of protons and neutrons (since electrons contribute very little mass).

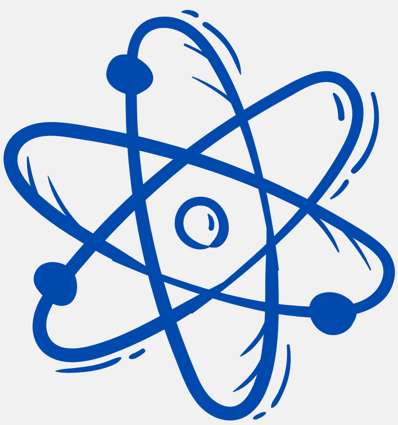
Aston also observed small deviations from whole numbers in atomic masses. These discrepancies were later explained by the concept of binding energy—the energy required to hold the nucleus together. The slight reduction in the actual mass compared to the sum of the individual protons and neutrons is known as the mass defect, which is a consequence of mass-*energy equivalence ($E=mc^2$)* as described by Einstein's theory of relativity. The mass defect corresponds to the binding energy released when the nucleus forms, and the greater the binding energy, the more stable the nucleus.

Aston's precise measurements of isotopic masses contributed directly to the development of nuclear physics. Understanding isotopes was crucial for explaining nuclear reactions, including *nuclear fission and fusion.* Aston's discovery of the mass defect and binding energy laid the groundwork for the idea that energy could be released by either splitting heavy nuclei (fission) or combining light nuclei (fusion).

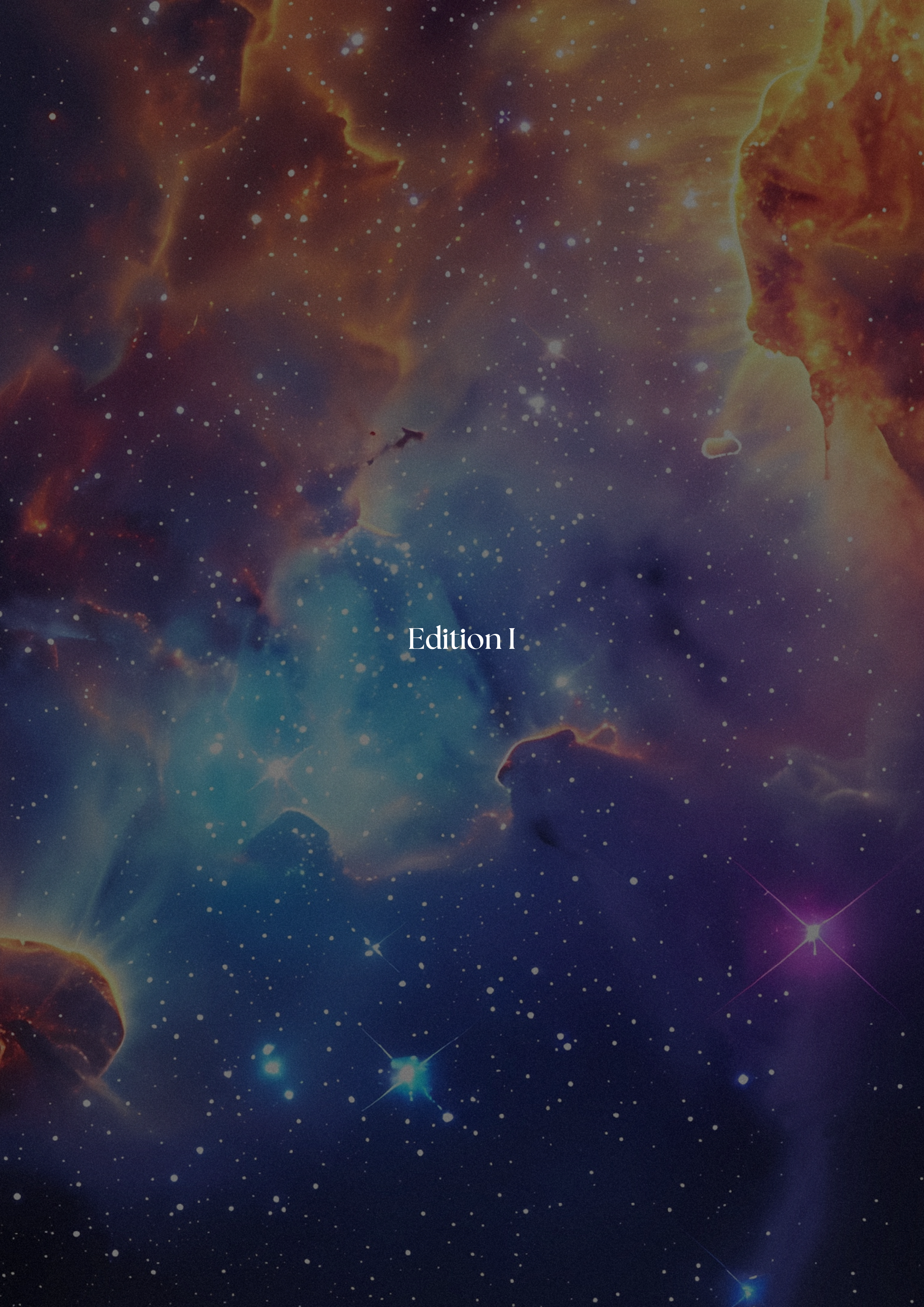
$E=m.c^2$



ACROSS
2. Mass spectrometer pioneer
3. Particle that contributes to isotope differences
7. Material used to mimic muscle contraction
8. Artificial muscles for robotics
11. Field focused on machines mimicking biological motion
12. Device for measuring atomic mass



DOWN
1. Flexible materials used in robotics
4. Skin pigment that affects light absorption
5. Atoms with different neutron counts
6. Cell type responsible for skin pigmentation
9. Skin layer that contains blood vessels
10. Study of tissues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