INTRODUCTION

By Robert P. Crease

In an unforgettable passage of Sylvia Plath’s novel *The Bell Jar*, the protagonist, a writer named Esther, describes her difficult time making it through science class.

“What I couldn’t stand was this shrinking everything into letters and numbers. Instead of leaf shapes and enlarged diagrams of the holes the leaves breath through and fascinating words like carotene and xanthophyll on the blackboard, there were these hideous, cramped, scorpion-lettered formulas in Mr. Manzi’s special red chalk.”

Esther is missing out. Many artists have found beauty and mystery in formulas and equations. *Shakespearean Equations*, a series of paintings by the American painter Man Ray, incorporates mathematical models and occasionally formulas. Not long ago, this very gallery exhibited a hand-bound, limited edition book -- *Equations*, by the British artist-designer Jacqueline Thomas, of the Stanley Picker Gallery at Kingston University – which consisted entirely of designs inspired by specific graphical representations of equations.

Someone with even a rudimentary ability to speak the language of mathematics realizes that equations are among the most powerful forms of human communication. Scientists and engineers, students and educators use them as tools for simplifying, organizing, and unifying features of our world. Equations are highly effective for this purpose because they condense volumes of information with precision. They can allow us to see deep into nature, far beyond ourselves, and to grasp otherwise inaccessible truths concisely and efficiently.

Over centuries, a small number of equations have done their job so excellently that they have become iconic – symbols in themselves. Some of these equations revolutionized the scientific fields from which they sprang, others transformed the wider world. Most such equations emerged in quiet locations, such as studies and libraries, removed from distractions and encroachments. Maxwell wrote down his world-transforming equations in his study, while Heisenberg began to piece together his on an isolated island. A few equations had more dramatic origins. The German-Jewish mathematician and astronomer Karl Schwarzchild wrote down the first exact solution to Einstein’s equations of general relativity -- before Einstein himself -- as a diversion while fighting as a German soldier on the Russian front during World War I; a few weeks later, he contracted a rare skin disease and shortly died. These and other iconic equations achieved a special presence not only in science but also in culture and history, where they materialize in art, literature, and other media.

Everyone will recognize at least several of the iconic equations on this wall. Einstein’s celebrity expression at the upper left -- which the Dalai Lama says is “the only scientific equation I know” – has appeared in literature, plays, films, poems, and art – and on the cover of *Time* magazine – since it was born (though using different symbols) in 1905. It was the title of a 1948 play by Hallie Flanagan, the American playwright who had headed the Federal Theatre Project during the Depression, and of a pop album by Maria Carey (2008). It appears in popular fiction (Dan Brown’s *Angels & Demons*), movies (*School of Rock*), and cartoons and video games, as well as far more serious scholarly contexts.

Down at the lower right is the familiar wordless proof of the Pythagorean Theorem, consisting simply of two diagrams. To the far bottom left are the five Platonic solids (cube, octahedron, tetrahedron, icosahedron, dodecahedron), which the ancient Greek philosopher Plato in his dialogue the *Timaeus* associated with the four elements earth, air, fire, and water; he saw the fifth, the dodecahedron, as representing the broader architecture of the heavens.

Crossing the wall from upper left to bottom right is a figure that demarcates an internal and external space on the wall. Many people will recognize this as an elongated ellipse with a Sun‐like object at one focus, which is how Johannes Kepler, the German mathematician and astronomer, characterized planetary motion. The wavy lines emanating from that Sun suggest light and illumination; coursing through the wall, these waves seem to draw its spaces back together.

To the right of Einstein’s equation is a set of four equations, each beginning with the term \nabla, whose discovery had a far greater impact on human history than Einstein’s and predated it by about 40 years. These equations, which provide a complete description of electromagnetism, were compiled (though in a different and more elaborate form) by James Clerk Maxwell. In his famous *Lectures on Physics*, Richard Feynman wrote that:

From a long view of the history of mankind—seen from, say, ten thousand years from now—there can be little doubt that the most significant event of the 19th century will be judged as Maxwell’s discovery of the laws of electrodynamics. The American Civil War will pale into provincial insignificance in comparison with this important scientific event of the same decade.

Though Feynman was known for his jokes and prankish remarks, this was not one. Maxwell’s equations described electromagnetism completely, and the resulting understanding helped transform electromagnetism from a curiosity into a structural foundation of the modern era. They gave birth to new technology that is behind any device based on electromagnetic waves, from radio, television, and microwave devices to computers and today’s social media. Maxwell’s equations affected human beings – how we live and interact with each other and with the world– far more profoundly than any war ever did, or could.

Another equation whose impact stretched far beyond science is one that appears in the ellipse, just underneath and a little to the right of the Sun. It asserts that gravity exists in all bodies universally, and its strength between two bodies depends on their masses and inversely as the square of the distance between their centers. (When Newton wrote out this conclusion, in 1687, he did not do so as an equation but in words; it was transformed into the familiar equation by which we know it only decades later.) Feynman called this idea “one of the most far‐reaching generalizations of the human mind.” In the next decade, it strongly influenced political theory and the modern conception of democracy through its promotion of the idea of universal law. It remains a symbol of the achievement of knowledge and rationality. In George Orwell’s novel *1984*, the final sign that the protagonist Winston Smith (after accepting that 2 + 2 = 5) had fully capitulated to the thought police – had been thoroughly broken and had ceased to think – is that he denies the law of gravity.

Several equations here have special significance for Stony Brook in particular. The pair of equations that is second to last in the ellipse is the Yang‐Mills equation, the first of whose authors is C. N. Yang, the Nobel‐prizewinning physicist who came to Stony Brook in 1965. The Yang‐Mills equations have a fascinating history. When proposed in 1954, they had a show‐stopping flaw: a key term in them had to be zero in theory, but had to be non-zero if the theory were to have any application to the world. The Yang-Mills equations therefore seemed doomed to remain only a mathematical curiosity. Then a series of discoveries unexpectedly opened the door to its application, allowing these equations to become the foundation for modern elementary particle physics.

If you cross all the way to the left of the wall from the Yang-Mills equations you will see a diagram that looks something like a trampoline would if a cannonball were put in its center. This is an image of Schwarzchild’s discovery, the “dent” in spacetime made by a single mass according to Einstein’s equations. Just to the right of that is another equation, the Heisenberg uncertainty principle, that transformed our understanding of the world far beyond the particular field in which it was discovered. Though its name suggests that it describes an irreducible squishiness in the world around us, its effect is precisely the opposite. The uncertainty principle explains why all atoms of a particular species are absolutely alike and structured the way they are, and therefore the solidity of matter. Not only that, this principle describes the persistence and development of life itself, in accounting for the fact that DNA molecules for the most part hold together firmly even in difficult environments – but that these molecules are also occasionally vulnerable to change, thus making evolution possible.

Yes, Esther definitely missed out. Shrinking things into letters and numbers can vastly enlarge our grip on the world. The iconography on this wall show many ingenious ways – worthy of our fascination and awe -- that human beings, for thousands of years, have devised to do this.