FILMS FROM THE FUTURE

The Technology and Morality of Sci-Fi Movies

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CHAPTER TWO

JURASSIC PARK: THE RISE OF RESURRECTION BIOLOGY

"God help us, we're in the hands of engineers!"
—Dr. Ian Malcolm

When Dinosaurs Ruled the World

The Butterfly Effect

Michael Crichton started playing with the ideas behind *Jurassic Park* in the 1980s, when "chaos" was becoming trendy. I was an undergraduate at the time, studying physics, and it was nearly impossible to avoid the world of "strange attractors" and "fractals." These were the years of the "Mandelbrot Set" and computers that were powerful enough to calculate the numbers it contained and display them as stunningly psychedelic images. The recursive complexity in the resulting fractals became the poster child for a growing field of mathematics that grappled with systems where, beyond certain limits, their behavior was impossible to predict. The field came to be known informally as chaos theory.

Chaos theory grew out of the work of the American meteorologist Edward Lorenz. When he started his career, it was assumed that the solution to more accurate weather prediction was better data and better models. But in the 1950s, Lorenz began to challenge this idea. What he found was that, in some cases, minute changes in atmospheric conditions could lead to dramatically different outcomes down the line, so much so that, in sufficiently complex systems, it was impossible to predict the results of seemingly insignificant changes.

In 1963, when he published the paper that established chaos theory,[14] it was a revolutionary idea—at least to scientists who still hung onto the assumption that we live in a predictable world. Much as quantum physics challenged scientists' ideas of how predictable physical processes are in the invisible world of atoms and subatomic particles, chaos theory challenged their belief that, if we have enough information, we can predict the outcomes of our actions in our everyday lives.

At the core of Lorenz's ideas was the observation that, in a sufficiently complex system, the smallest variation could lead to profound differences in outcomes. In 1969, he coined the term "the Butterfly Effect," suggesting that the world's weather systems are so complex and interconnected that a butterfly flapping its wings on one side of the world could initiate a chain of events that ultimately led to a tornado on the other.

Lorenz wasn't the first to suggest that small changes in complex systems can have large and unpredictable effects. But he was perhaps the first to pull the idea into mainstream science. And this is where chaos theory might have stayed, were it not for the discovery of the "Mandelbrot Set" by mathematician Benoit Mandelbrot.

In 1979, Mandelbrot demonstrated how a seemingly simple equation could lead to images of infinite complexity. The more you zoomed in to the images his equation produced, the more detail became visible. As with Lorentz's work, Mandelbrot's research showed that very simple beginnings could lead to complex, unpredictable, and chaotic outcomes. But Lorentz, Mandelbrot, and others also revealed another intriguing aspect of chaos theory, and this was that complex systems can lead to *predictable* chaos. This may seem counterintuitive, but what their work showed was that, even where

14 The paper was titled "Deterministic Nonperiodic Flow" and was published in the *Journal of the Atmospheric Sciences*. Edward N. Lorenz (1963). "Deterministic Nonperiodic Flow". *Journal of the Atmospheric Sciences*. 20 (2): 130–141. http://doi.org/10.1175/1520-0469(1963)020<0130:DNF>2.0.CO;2

chaotic unpredictability reigns, there are always limits to what the outcomes might be.

Mandelbrot fractals became all the rage in the 1980s. As a new generation of computer geeks got their hands on the latest personal computers, kids began to replicate the Mandelbrot fractal and revel in its complexity. Reproducing it became a test of one's coding expertise and the power of one's hardware. In one memorable guest lecture on parallel processing I attended, the lecturer even demonstrated the power of a new chip by showing how fast it could produce Mandelbrot fractals.

This growing excitement around chaos theory and the idea that the world is ultimately unpredictable was admirably captured in James Gleick's 1987 book *Chaos: Making a New Science*.[15] Gleick pulled chaos theory out of the realm of scientists and computer geeks and placed it firmly in the public domain, and also into the hands of novelists and moviemakers. In *Jurassic Park*, Ian Malcolm captures the essence of the chaos zeitgeist, and uses this to drive along a narrative of naïve human arrogance versus the triumphal dominance of chaotic, unpredictable nature. Naturally, there's a lot of hokum here, including the rather silly idea that chaos theory means being able to predict when chaos will occur (it doesn't). But the concept that we cannot wield perfect control over complex technologies within a complex world is nevertheless an important one.

Chaos theory suggests that, in a complex system, immeasurably small actions or events can profoundly affect what happens over the course of time, making accurate predictions of the future well-nigh impossible. This is important as we develop and deploy highly complex technologies. However, it also suggests that there are boundaries to what might happen and what will not as we do this. And these boundaries become highly relevant in separating out plausible futures from sheer fantasy.

Chaos theory also indicates that, within complex systems, there are points of stability. In the context of technological innovation, this suggests that there are some futures that are more likely to occur if we take the appropriate courses of action. But these are also futures that can be squandered if we don't think ahead about our actions and their consequences.

Jurassic Park focuses on the latter of these possibilities, and it does so to great effect. What we see unfolding is a catastrophic

15 James Gleick (1987) "Chaos: Making a New Science." *Viking*, New York.

confluence of poorly understood technology, the ability of natural systems to adapt and evolve, unpredictable weather, and human foibles. The result is a park in chaos and dinosaurs dining on people. This is a godsend for a blockbuster movie designed to scare and thrill its audiences. But how realistic is this chaotic confluence of unpredictability?

As it turns out, it's pretty realistic—up to a point. Chaos theory isn't as trendy today as it was back when *Jurassic Park* was made. But the realization that complex systems are vulnerable to big (and sometimes catastrophic) shifts in behavior stemming from small changes is a critical area of research. And we know that technological innovation has the capacity to trigger events and outcomes within the complex social and environmental systems we live in that are hard to predict and manage.

As if to press the point home here, as I'm writing this, Hurricane Harvey has just swept through Houston, causing unprecedented devastation. The broad strokes of what occurred were predictable to an extent—the massive flooding exacerbated by poor urban planning, the likelihood of people and animals being stranded and killed, even the political rhetoric around who was responsible and what could have been done better. In the midst of all of this, though, a chemical plant owned by the French company Arkema underwent an unprecedented catastrophic failure.

The plant produced organic peroxides. These are unstable, volatile chemicals that need to be kept cool to keep them safe, but they are also important in the production of many products we use on a daily basis. As Harvey led to widespread flooding, the plant's electric power supplies that powered the cooling systems failed one by one—first the main supply, then the backups. In the end, all the company could do was to remove the chemicals to remote parts of the plant, and wait for them to vent, ignite, and explode.

On its own, this would seem like an unfortunate but predictable outcome. But there's evidence of a cascade of events that exacerbated the failure, many of them seemingly insignificant, but all part of a web of interactions that resulted in the unintended ignition of stored chemicals and the release of toxic materials into the environment. The news and commentary site Buzzfeed obtained a logbook from the plant that paints a picture of cascading incidents, including "overflowing wastewater tanks, failing power systems, toilets that stopped working, and even a snake, washed in by rising waters. Then finally: 'extraction' of the crew by boat. And days later, blasts and foul, frightening smoke."[16]

Contingencies were no doubt in place for flooding and power failures. Overflowing toilets and snakes? Probably not. Yet so often it's these seemingly small events that help trigger larger and seemingly chaotic ones in complex systems.

Such cascades of events leading to unexpected outcomes are more common than we sometimes realize. For instance, few people expect industrial accidents to occur, but they nevertheless do. In fact, they happen so regularly that the academic Charles Perrow coined the term "normal accidents," together with the theory that, in any sufficiently complex technological system, unanticipated events are inevitable.[17]

Of course, if Hammond had read his Perrow, he might have had a better understanding of just how precarious his new Jurassic Park was. Sadly, he didn't. But even if Hammond and his team had been aware of the challenges of managing complex systems, there's another factor that led to the chaos in the movie that reflects real life, and that's the way that power plays an oversized role in determining the trajectory of a new technology, along with any fallout that accompanies it.

Visions of Power

Beyond the genetic engineering, the de-extinction, and the homage to chaos theory, *Jurassic Park* is a movie about power: not only the power to create and destroy life, but the power to control others, to dominate them, and to win.

16 Nidhi Subbaraman and Jessica Garrison (2017) "Here's What Happened In The Hours After Hurricane Harvey Hit A Chemical Plant, According To A Staff Log" *Buzzfeed*, November 16, 2017. https://www.buzzfeed.com/nidhisubbaraman/arkema-chemical-plant-houston-timeline

17 Charles Perrow developed his ideas in his 1984 book "Normal Accidents: Living with High-Risk Technologies," published by *Princeton University Press*.