

A woman with dark hair, wearing a dark long-sleeved shirt, is shown from the chest up, holding a black assault rifle. She is looking directly at the camera with a serious expression. The scene is framed by a large, irregular hole in a dark surface, with bright, hazy light shining through the opening behind her. The foreground is a dark, textured surface, possibly snow or debris.

CINEMA SCIENCE

The Dangerous Biology of *Annihilation*



A thought-provoking, high-concept sci-fi thriller, Alex Garland's film touches on real-world phenomena such as Hox genes, the Hayflick limit and the Mandelbrot set. While its science is complex and its subject matter can be intense, the film provides many excellent opportunities for discussions about biology in senior secondary classrooms, as DAVE CREWE describes.

Typically, the films selected for Cinema Science are relatively mainstream – movies you can expect the average high school student to have heard of, if not seen. *Annihilation* (2018) is different. Despite its formidable pedigree (written and directed by Alex Garland, starring the likes of Natalie Portman, Jennifer Jason Leigh and Tessa Thompson), this sci-fi film proved too cerebral for Paramount, which infamously dumped the end product onto Netflix. Consequently, *Annihilation* only received a theatrical release in North America and China¹ – hardly the typical trajectory of a mainstream movie.

But *Annihilation* boasts something not necessarily shared by its blockbuster competitors: accessibility. Some 38 per cent – and rising – of the Australian population have access to Netflix,² so many of your students will be able to watch *Annihilation* ... even if they haven't yet. *Annihilation* also possesses a robust scientific spine; adapted from Jeff VanderMeer's eponymous 2014 novel and inspired by thoughtful sci-fi forebears like *Stalker* (Andrei Tarkovsky, 1979),³ *2001: A Space Odyssey* (Stanley Kubrick, 1968)⁴ and *The Thing* (John Carpenter, 1982),⁵ Garland's film slithers through cellular biology, optical phenomena and our genetic code on its way to a decidedly ambiguous conclusion.

Annihilation is best suited to senior secondary Science classrooms, both for the complexity of its scientific subject matter and for the graphic nature of its content: the film features some gory and legitimately horrific scenes.



PREVIOUS SPREAD: Lena (Natalie Portman) ABOVE, FROM TOP: Lena with Josie (Tessa Thompson); Lena

CELL YOUR SOUL

Annihilation's protagonist, Lena (Portman), is a professor at Johns Hopkins University researching 'the genetically programmed life cycle of a cell'.⁶ That research isn't what leads her into the 'Shimmer' – an iridescent, extraterrestrial area. She's there searching for clues to save her husband, Kane (Oscar Isaac), a soldier who's the first to safely return from within the Shimmer but is shortly thereafter afflicted with an unexplained ailment. But Lena's

As teachers, we become proficient at spinning simple stimuli like this scene into an extended exploration of a topic within the curriculum, allowing the germ of an idea to – much like a dividing cell – multiply into bigger and more sophisticated concepts. *Annihilation's* interest in the cell and its reproductive process extends beyond this short scene. Within the Shimmer, on more than one occasion Lena observes an apparently normal cell split into a second one: a cell pulsing with colour, its rainbow cilia flailing. At the film's climax, Lena encounters the 'Entity': an enigmatic organism that mimics her movements. We watch it form from a single cell dividing, growing and, ultimately, mirroring its progenitor. At its thematic core, the film features the key processes of reproduction: doubling, mirroring, mutation.

Annihilation is a perfect starting point to explore how intimately mutation is intertwined with such reproductive processes. The film is filled with extraordinary, inexplicable mutations. Some of these are beautiful, as when a single plant sprouts into a bounty of colourful flowers, or different species grow from the same root. Lena stumbles upon an elk with flowers sprouting from its antlers and then watches as – almost imperceptibly – it splits into a second elk.⁷ More often, the mutations are horrific: An albino crocodile's maw filled with shark's teeth. Human intestines contorting into writhing eels. A terrifying bear-like creature mimicking the screams of its human victims.

These mutations aren't realistic, necessarily; they represent the power of the Shimmer – and its threat. As a jumping-off point, though, these transformations allow for discussion around the intersection of cellular division, mutation and evolution. Without the imperfections in this process, we would've never progressed beyond simple organisms. The alacrity of the mutations within the Shimmer, then, suggests the magnitude of the threat offered to our species, even as Garland keeps his cards close to his chest regarding the Shimmer's nefarious intentions – or lack thereof.⁸

One of the film's most enduring images is a family of trees awkwardly arched into human poses, branches grasping like arms

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knowledge of cells proves crucial to understanding the nature of what's occurring within the Shimmer, just as cellular biology reveals itself as the thematic and narrative foundation of the film.

That's reflected in something as simple as the short scene showing Lena teaching a class. 'All cells were ultimately born from one cell,' she tells her students.

A single organism, alone on planet Earth, perhaps alone in the universe. About 4 billion years ago, one became two. Two became four. Then eight, sixteen, thirty-two. The rhythm of the dividing pair, which becomes the structure of every microbe, blade of grass, sea creature, land creature and human. The structure of everything that lives ... and everything that dies.

This scene could be used as stimulus for a lesson on cellular division – not just in a Biology or a Mathematics classroom, where you might model the exponential growth of a dividing cell.

– skeletons that never were bodies, solid shadows of humanity.

One of the scientists accompanying Lena into the Shimmer, Josie (Thompson), offers a hypothesis: 'Do you know what you'd get if you sequenced [that leaf]? [...] Human Hox genes.' Lena explains that Hox genes 'define the body plan, the physical structure'.

That isn't quite how human Hox genes work; you wouldn't expect a tree to grow into a person thanks to a bit of gene splicing. But it resembles reality closely enough to prompt classroom discussions and/or investigations. As Dr Adam Rutherford – scientific adviser on *Annihilation* (as well as on Garland's previous film, 2014's *Ex Machina*) – puts it, Hox genes 'lay out the polarity of the organism': 'When [Josie] is talking about them, she's trying to rationalize how you could be seeing plants growing in human form, because that runs counter to our own scientific understanding of the gene.'⁹ There's more than enough material here to allow for a research project wherein students explore the properties of Hox genes and how they're represented in *Annihilation*.



ABOVE, RIGHT: Dr Ventress (Jennifer Jason Leigh) BELOW: Lena with Anya (Gina Rodriguez)

Another question worth investigating: could we make cells immortal? No, I'm not engaging in idle conjecture; this is a question posed within the film itself. In a pre-Shimmer flashback, Lena explains the notion to her husband: 'You take a cell, circumvent the Hayflick limit, you can prevent senescence [...] It means the cell doesn't grow old; it becomes immortal.' Sure sounds like science fiction, but this isn't entirely outside the realm of possibility.

The Hayflick limit Lena is referring to describes cells' inability to divide forever. Each time a cell undergoes mitosis, its telomeres – genetic sequences found at the ends of chromosomes – degrade until, eventually, the consistency of the chromosome deteriorates beyond the point where reproduction can continue. Ageing, dying: senescence. But not all cells are subject to this phenomenon. In fact, the cell division Lena shows her class is that of a HeLa cell,¹⁰ an 'immortal' cell discovered in 1951 and subsequently widely used in scientific research due to its resistance to senescence.

- Lobsters are sometimes described as 'immortal' as their cells don't experience senescence. Evaluate this claim.
- How do Hox genes work? Is their representation in *Annihilation* scientifically accurate?
- What are the different types of cellular division?



CANCER AND SELF-DESTRUCTION

Alex Garland has said that he starts his films with a central idea. For Annihilation, it was self-destruction, so it's no coincidence that Lena has the profession she does and works with cancer cells.

– Zack Sharf, *IndieWire*¹¹

The HeLa cell isn't just any cell. It stems from a sample of cervical cancer cells taken from Henrietta Lacks, after whom the cells were named. And, while it's interesting to explore the ramifications of immortal cells both inside and outside the context of *Annihilation*, the HeLa cell mostly closely resonates with Garland's intentions because of its cancerous origins.

Fundamentally, *Annihilation* is a film about cancer. It's a film about unbridled growth and mutation, a film about how something as apparently innocent as cellular division can manifest itself as something terrifying, something fatal. The screenplay is dotted with explicit references to cancer in humans: Cass (Tuva Novotny) lost her daughter to the disease, while Dr Ventress (Leigh) has herself been diagnosed with terminal cancer. I regard these as Garland's signposts, providing his audience with a framework to make sense of an often-confusing narrative.

To understand these signposts, one needs to understand the properties of cancer itself. As explained by the Australian Cancer Council, cancer

*is a disease of the body's cells. Normally cells grow and multiply in a controlled way, however, if something causes a mistake to occur in the cells' genetic blueprints, this control can be lost. Cancer is the term used to describe collections of these cells, growing and potentially spreading within the body.*¹²

Essentially, cancer is a genetic error – much like the mutations that drive evolution – that turns our cells' multiplicative tendency against us. In other words: self-destruction.

The antagonist of *Annihilation* – the Entity, the Shimmer, whatever you want to call it – embodies these mechanics. The influence of the Shimmer is mutative, twisting and warping genetic code. But the Entity itself, which mirrors Lena's and Kane's movements and assumes their forms, strikes me as cancerous on a global scale. While the Entity's intentions remain unclear, the

conclusion of the film, with Entity-Kane and Lena (perhaps herself an offshoot of the Entity) tentatively reunited, suggests that it exists to reproduce and consume Earth organisms – including, naturally, humanity.

Cancer is a fascinating subject for any Biology classroom. To examine cancer is to understand the incredible potential of our biological processes and the multivalent possibilities of mutation, but also to recognise the threat of unbridled reproduction. Understanding cancer is more than academic, of course. The better we understand a disease, the better we can fight it. Recognising that cancer is, fundamentally, our own cells turned against us will allow students to comprehend the need for debilitating treatments like radiation therapy, whereby we poison our cells in order to fight the cancer.

‘The cure for cancer’ remains science’s holy grail, so why not spend a lesson – or an entire assessment task – with your class exploring scientists’ attempts to refine cancer treatments. Just recently, for instance, a woman was cured of advanced breast cancer through a trial that used gene therapy to, in essence, rewrite her



ABOVE: Dr Ventress, Lena, Cass (Tuva Novotny), Josie and Anya OPPOSITE: Josie and Anya

this phenomenon requires an understanding of refractive index, focal points and other key features of optics. Linking back to *Annihilation*, you could tie these principles into the multicoloured

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immune system to target the cancer cells specifically. As reported by *New Scientist*, ‘It’s the first time this type of therapy has worked in breast cancer, suggesting that it may be able to help many more people with common types of cancer’.¹³ Understanding this therapy requires a sophisticated grasp of genetics, the human immune system and cancer – an excellent opportunity for a senior secondary Biology activity.

- What kinds of methods are currently used to treat cancer? What are the limitations and side effects of these treatments?
- How is cancer an example of ‘self-destruction’?

MUNDANE INVERSION

For me, the most enduring image of *Annihilation* isn’t the iridescent sheen of the Shimmer, nor the corrupted bear-creature that stalks our heroines. Rather, I remember the simple, repeated shot of a hand (or hands) through a glass of water, reflected by the bending of the light. This mundane inversion characterises the sensation of watching *Annihilation*, seeing the ordinary flipped into something ambiguously sinister.

There’s nothing miraculous about these images. They’re a simple example of how refraction can cause reflection, as the light bends while travelling through the glass and the water within. It’s trivially easy to replicate this phenomenon with your class; all you need is a glass of water and a piece of paper.¹⁴ Draw an arrow – or any shape for which the reflection will be obvious – and observe it through the water. From the right vantage point, the image will be reflected horizontally. But ask your students to adjust the position of the paper, the glass and/or themselves, and they should find that it isn’t *always* reflected.

This simple experiment is an engaging introduction to a Physics unit on optics – specifically, refraction. Investigating

appearance of the Shimmer: we observe similarly colourful displays in, say, soap bubbles. The applications for these phenomena are manifold; for instance, without the principles of refraction, we wouldn’t have access to the optical-fibre technology that powers the fast internet that allows you to stream *Annihilation* in HD – well, depending on your provider. (Rather cleverly, Garland and director of photography Rob Hardy incorporate refractive phenomena into the very look of the film. For example, they’re not shy about keeping lens flares in their shots – flares caused by the refraction of bright light.)

Refraction is referenced in *Annihilation* outside of these moments. It’s offered as an explanation for why the squad can’t communicate outside the Shimmer with their radios. As Josie explains, ‘The light waves aren’t blocked; they’re refracted, and ... it’s the same with the radios. Signals aren’t gone. They’re scrambled.’ She extrapolates this observation to apply to the fantastic mutations seen within the Shimmer: ‘The Shimmer is a prism, but it refracts everything. Not just light and radio waves. Animal DNA. Plant DNA. All DNA.’

We’re venturing further into science fiction than accepted science here – and it’s worth clarifying that Josie’s explanation is a *hypothesis* that remains unproven within the diegesis – but the notion of refracted matter is far from fiction. At the core of quantum mechanics is wave-particle duality: simply put, every piece of matter is at once a particle and a wave. By definition, waves are subject to refraction, so every piece of matter *can*, in fact, be refracted. Exploring the associated physics of this is perhaps beyond the scope of a typical high school classroom, but it could be a worthy extension activity for interested pupils.

- How does refraction explain a glass of water reflecting the image behind it?
- Investigate how fibre optics uses refractive properties to transmit information.
- What causes a lens flare?

ODDS AND ENDS

A common misconception about Mathematics is that it is dry and deterministic, lacking beauty and artistry. There are few better ways to dispute this viewpoint than the Mandelbrot set: a beautiful, fractal picture of infinite possibilities. This set is, in fact, what the Entity's appearance was modelled after; per Rutherford, 'The Mandelblob is an animated 3D manifestation of the Mandelbrot set. That's what the alien is when you see it.'¹⁵

For junior secondary Mathematics students, this represents a prime opportunity to simply show off the wonder of the Mandelbrot set and, perhaps, associated Julia sets. More advanced mathematicians might wish to explore the underlying mathematics of the Mandelbrot set: how it is generated through iterative series on the complex plane, and even its unexpected ties to chaos mathematics.

You would expect your students to be familiar with the term 'annihilation' as a synonym for 'destruction'. But, as part of the right Physics topic, you could hook into the scientific definition of the term: the collision of a particle and its antiparticle. What are antiparticles? Ah, well, that's a whole 'nother discussion ...

If you're really feeling like a deep dive into the foundations of science, *Annihilation* provides an opportunity to examine the core of scientific discovery. *The Hollywood Reporter's* Ciara Wardlow argues that *Annihilation* 'presents one of the best meditations I have ever seen on the metaphysics of scientific inquiry – about the fundamental nature of science that, ironically, cannot in itself be investigated through the scientific method'. Examining what Wardlow is talking about – that 'at the heart of good science is a vein of self-destruction', that our perception of science is torn between 'fascination and repulsion'¹⁶ – necessitates the kind of deep consideration of science that's simultaneously challenging and intensely rewarding.

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Endnotes

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- ⁵ Peter Debruge, 'Film Review: *Annihilation*', *Variety*, 21 February 2018, <<https://variety.com/2018/film/reviews/annihilation-review-natalie-portman-1202706321/>>, accessed 29 June 2018.
- ⁶ Dialogue from the film, as spoken by Dr Ventress.
- ⁷ A real 'blink-and-you'll-miss-it' moment. It wasn't until my third time through the film that I realised the second elk wasn't simply behind the first.
- ⁸ There are more than a few ways to interpret the film's ending, which is clearly intended to deliver more questions than answers. Whatever the Shimmer 'wants', it's not necessarily malicious. As Lena puts it in her debrief, 'It wasn't destroying. It was changing everything. It was making something new.'
- ⁹ Adam Rutherford, quoted in Zack Sharf, '*Annihilation* Is Fiction, but the Science "Isn't Bullshit": Alex Garland's Scientific Accuracy, Explained', *IndieWire*, 1 March 2018, <<http://www.indiewire.com/2018/03/annihilation-science-explained-adam-rutherford-alex-garland-1201934047/>>, accessed 27 June 2018.
- ¹⁰ This isn't made explicit within the film, but is identified by Rutherford in Cassidy Ward, 'Science Behind the Fiction: *Annihilation*', *Syfy Wire*, 27 February 2018, <<http://www.syfy.com/syfywire/science-behind-the-fiction-annihilation>>, accessed 27 June 2018.
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- ¹⁴ For a simple example of such an experiment, see 'Physics in a Glass: Reversing Arrows', *PhysicsCentral*, <<http://www.physicscentral.com/experiment/physicsathome/reversing-arrows.cfm>>, accessed 27 June 2018.
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