Avatar: the real-life science behind the fantasy

The Christian Science Monitor (https://www.csmonitor.com/Science/2009/1228/Avatar-the-real-life-science-behind-the-fantasy) · by Mark Sappenfield Staff writer

The producer of "Avatar" is fond of saying that writer and director James Cameron (https://www.csmonitor.com/tags/topic/James+Cameron) does not write science fiction, he writes science fact.

From the reclining, cup-holdered seat of a local multiplex, that seems a generous statement. Neither mountains floating in midair or fauna that lights up like the Las Vegas Strip (https://www.csmonitor.com/tags/topic/Las+Vegas+Strip) at night would seem to have the slightest foundation in reality.

And yet they do.

To be sure, Mr. Cameron likes to bring his fair share of Hollywood to the cosmos, painting his scenes with the brush of fantasy. But beneath some of his most outlandish visions is often a kernel of scientific possibility.

The floating Hallelujah Mountains

The topic of how an entire mountain range can bob over the landscape like corks is never explicitly addressed in the film, yet the explanation is woven throughout the story.

It all has to do with superconductors.

When superconductors are in the presence of a magnetic field, they can float (http://farm1.static.flickr.com/169/422323147_c33645a7ca.jpg). "Avatar (https://www.csmonitor.com/tags/topic/Avatar)'s" alien world of Pandora, it turns out, is simply a massive superconductor.

At the very beginning of the story, we are told that humans have come to Pandora to mine unobtanium. Unobtanium is the ultimate superconductor. (The very name, "unobtanium (http://www.space.com/entertainment/091221-avatar-science.html)," is a nod to sci-fi afficionados, who coined the word to describe a material with mythical properties.)

In Cameron's world, unobtanium can conduct electricity without resistance at room temperature; the best current superconductors work only when the temperature is below minus 200 degrees F.

The discovery of unobtanium, which exists only on Pandora, revolutionized technology on Earth, the story goes, and the future human economy is dependent upon it.

On Pandora, however, entire mountains loaded with unobtanium float in the world's massive magnetic field.

In a glimpse of how thoroughly Cameron has thought through the science behind his creation, he and his team have written a 380 page "Pandorapedia" that explains (among other things) the tectonics behind how such mountains could form.

In effect, they crumble upward.

This happens because Pandora is not a planet but a moon of a gas giant the size of Saturn (https://www.csmonitor.com/tags/topic/Saturn+(Planet)) – the fictional planet Polyphemus. Moons of gas giants are constantly tugged and deformed by the stresses of gravity.

One of Jupiter's moons, Io, is pulled so violently by the gravitational forces of both Jupiter and Jupiter's other large moons, that it has ground tides – the ground literally rises and falls like a sea tide on Earth. On a second moon of Jupiter, Europa, these tidal forces have heated the interior of the moon to the point that part of its crust has melted, creating a sea of liquid water beneath a surface of ice, scientists say.

On Cameron's Pandora, those tidal stresses have fractured the landscape, and, in the case of the Hallelujah Mountains, sent it up into the sky. A companion book to the movie (http://browseinside.harpercollins.com/index.aspx?isbn13=9780061896750) explains the larger process: "This ... energy drives continental drift at a much faster rate than on Earth, causing tectonic plates to fracture more extensively because of the increased stress."

Glowing plants

Cameron's fascination with the deep sea has already led to one of the most successful films of all time: "Titanic (https://www.csmonitor.com/tags/topic/Titanic+(Movie))." It appears to have shaped "Avatar," too. The oceans' depths have a curious answer to sunlight, which has never been seen there. It's called bioluminescence – organisms' ability to create their own light.

Fireflies are perhaps the most obvious example, but the bioluminescent fish of the deep sea tell a different story – that nature, when deprived of light, sometimes creates its own.

On Pandora, where the nights can be many Earth days long, Cameron has suggested that an entire bioluminescent ecosystem could emerge.

This is where Cameron's decision to make Pandora a moon – and not a planet – comes in. Moons, including Earth's, are typically "locked" to their planets, with one side eternally facing the planet and one side eternally facing out into space. What this means is that one day on a moon equals the time it takes to orbit its parent planet – a long time.

To watch the phases of our Moon is actually to watch the lunar day in real time. A full moon is midday for the side of the Moon facing the Earth. A new moon is midnight for the side of the Moon facing the Earth. In other words, a lunar day takes more than 27 Earth days. And that means a very long night.

Home Sweet Moon

But could a moon hold life?

Potentially, yes. Actually, making Pandora a moon appears to be an acknowledgment of recent science. Astronomers are still looking for planets like Earth – small and rocky – within the so-called "Goldilocks zone": Not so close to its star that its life-giving water evaporates, yet not so far away that it freezes into ice.

But small planets are hard to find. Instead, scientists have found gas giants like Saturn in the habitable zone around stars. Those planets are not inhabitable – but their moons could be.

That makes moons a good place to start looking for alien life. "All of the gas giant planets in our solar system have rocky and icy moons," Lisa Kaltenegger (https://www.csmonitor.com/tags/topic/Lisa+Kaltenegger) of the Harvard-Smithsonian Center for Astrophysics (https://www.csmonitor.com/tags/topic/Harvard-Smithsonian+Center+for+Astrophysics) in Cambridge, Mass. (https://www.csmonitor.com/tags/topic/Cambridge+(Massachusetts)), told AP (http://www.google.com/hostednews/ukpress/article/ALeqM5jyzR1e-btlOy_bwt8X7cTh9gah9w). "That raises the possibility that alien Jupiters will also have moons. Some of those may be Earth-sized and able to hold onto an atmosphere."

The problem is that gas giants emit tremendous amounts of radiation. The daily radiation on Jupiter's Io, for instance, is 4,000 times the lethal dose.

Yet here again, Cameron uses science to solve science's own problems. The robust magnetic field created by Pandora's superconductivity deflects the radiation.

At one point in the film, a spectacular aurora dances overhead. Striking filmmaking, yes. But also pure science. The companion book, "Avatar: A Confidential Report on the Biological and Social History of Pandora," adds that the interaction of the magnetic fields of Pandora and its parent planet "causes a giant increase in electrical activity on both bodies, with massive auroral storms and other electromagnetic phenomenon."

Such a magnetic field could also be responsible for the telltale arcing formations of rock apparent at the climax of the film.

Other tidbits

• Everything on Pandora – including the 10-foot, blue-skinned Na'vi (https://www.csmonitor.com/tags/topic/Na+vi) – is big because the gravity is 80 percent of what it is on Earth.

• Cameron has put Pandora and Polyphemus in the real Alpha Centauri star system, the closest star system to Earth. The system is actually three stars all revolving around one another. The biggest is 20 percent larger than the Sun, the second is 15 percent smaller than the Sun, and the third is a red dwarf 80 percent smaller than the Sun.

• Polyphemus is named for the one-eyed Cyclops in Homer's "Odyssey." In the film, a gigantic storm similar to Jupiter's Great Red Spot (http://photography.nationalgeographic.com/photography/wallpaper/great-red-spot-photography.html) is visible.

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