

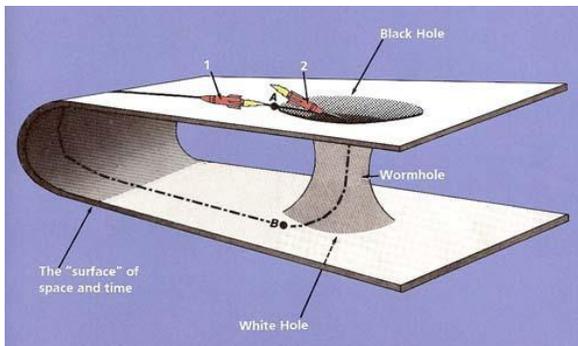
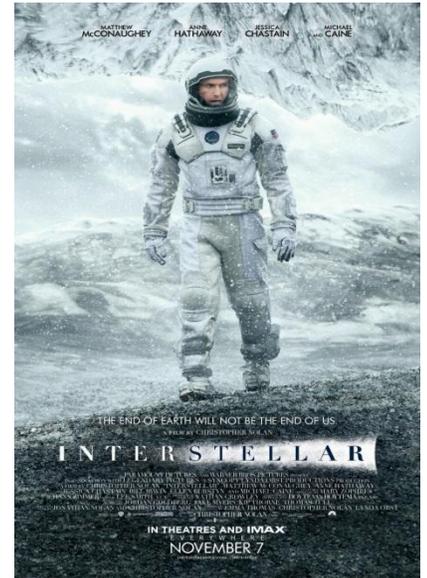
INTERSTELLAR

Enjoy the movie... but learn the astrophysics!

Interstellar is a 2014 science fiction film directed by Christopher Nolan (*Inception*) and starring Matthew McConaughey (*Contact*) and Anne Hathaway (*Dark Knight Rises*). The film follows a crew of astronauts who travel through a wormhole in space in search of a new home for humanity as a future Earth slowly dies.

Theoretical physicist **Kip Thorne** was a scientific consultant for the film to ensure the depictions of wormholes and relativity were as accurate as possible. *"For the depictions of the wormholes ... I worked on the equations that would enable tracing of light rays as they traveled through a wormhole or around a black hole—so what you see is based on Einstein's general relativity equations."* Thorne was also the science advisor on *"Contact"* and early in the process, he laid down two guidelines: *"First, that nothing would violate established physical laws. Second, that all the wild speculations... would spring from science and not from the fertile mind of a screenwriter."*

The plot of the film deals with hard to imagine but **real** physics, such as the effect of gravity and speed on time, an effect known as **time dilation**. This has been demonstrated on Earth by noting that atomic clocks at different altitudes (and thus different gravities) will eventually show different times. Greater speed and lesser gravity actually slows the passing of time!



a 3D hole, showing a distorted view of the target galaxy.

This movie packs a LOT of science in, but most of it hinges the fundamental relationship between what we call space and what we call time, and how the two concepts aren't as different as they appear to us.

Wormholes, or **Einstien-Rosen bridges**, as featured in this film, are hypotheticals 'tubes' through three dimensional space. Researchers have no observational evidence for wormholes, but the equations of the theory of general relativity have valid solutions that contain wormholes. So while we've never actually seen one, the laws of physics allow that they can exist. The portrayal of what a wormhole would look like is considered scientifically correct. Rather than a two-dimensional hole in space, it is depicted as a sphere, because it's

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1. What are the names of the main farmer/astronaut and his daughter?
2. Why does the school seem so “anti-science?” Why does this upset Cooper?
3. What does the ‘ghost’ show in the dust?
4. What is the ‘blight’ doing to Earth’s atmosphere?
5. What is **Plan A**?
6. What is **Plan B**?
7. What’s the name of the spaceship?
8. What is the time dilation effect compared to being on **Miller’s World** and being in space orbiting it?
9. Why does Dr. Amelia Brand feel so strongly about going to **Edmund’s World**?
 - a. Does this speech seem a little out of place to you?
10. Why can’t Dr. Grant get information from “the singularity”?
11. What makes Murph think that her father intentionally abandoned Earth?
12. Why did Dr. Mann lie about the readings?
13. In the end, who does Cooper think built the wormholes/Tesseract?

Post Movie Reflection Questions

14. At the beginning of the movie, corn is the only crop left. Why does having only one type of crop (a **monoculture**) make humanity so much more vulnerable to the 'Blight'? If you were a scientist on Earth, how would **genetic engineering** be used to try to save the corn?"
15. "In Plan B, they use frozen embryos instead of sending 5,000 adults. Why is it easier to transport embryos than living people from a biotech perspective? Also, if all 5,000 embryos came from the same small group of donors, what 'family tree' problems (**genetic diversity**) might the new colony face after a few generations?"
16. "If a pathogen like the Blight is better at using nitrogen than plants are, it basically 'starves' the plants of nutrients. If you could **gene-edit** a plant to be 'invisible' to the Blight, what part of the plant’s metabolism would you change?"