Penguin Random House | Secondary Education

Teacher's Guide

Project Hail Mary
A Novel

by Andy Weir

Ballantine Books
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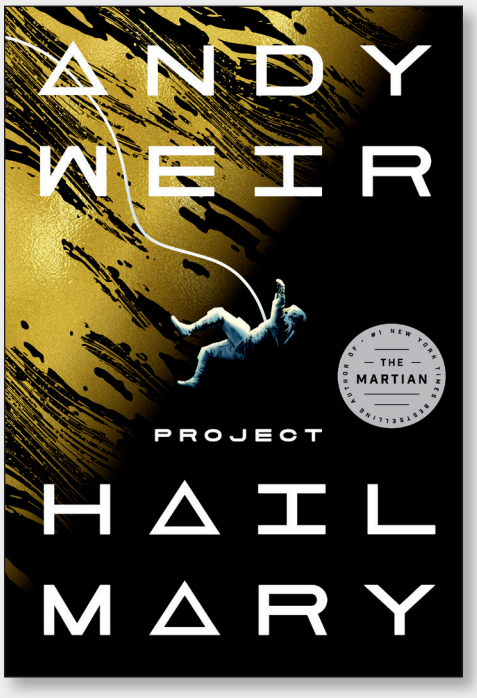

ABOUT THE BOOK

When junior high science teacher Dr. Ryland Grace wakes up from a coma, he can't remember who he is, where he is going, or why he is there. As his memory slowly returns, he realizes that he is the only surviving member of the crew of the starship *Hail Mary* and part of Project Hail Mary: a last-ditch effort to save Earth from an extinction-level event caused by Astrophage, an extraterrestrial life-form that is rapidly consuming the sun's energy.

If he is able to discover the secret to the only known star that appears resistant to Astrophage, he'll be able to send the information back to Earth in time. With only enough food and fuel for a one-way voyage, Grace and the crew of the *Hail Mary* were on a mission to save humanity from which they were never meant to return. When he discovers that Earth is not the only planet with a population at risk, Grace forms an alliance that just might save two planets and give him a chance to travel home.

Project Hail Mary is a fast-paced scientific mystery and survival story that applies real-world science to a high-stakes sci-fi adventure.

ABOUT THE AUTHOR

ANDY WEIR built a two-decade career as a software engineer until the success of his first published novel, *The Martian*, allowed him to live out his dream of writing full-time. He is a lifelong space nerd and a devoted hobbyist of such subjects as relativistic physics, orbital mechanics, and the history of manned spaceflight. He lives in California.

NOTE TO TEACHERS

Andy Weir is known for writing thoroughly researched and scientifically plausible fiction. For this reason, *Project Hail Mary* is applicable both in Language Arts/Reading curriculum and as a selection for reading across the curriculum in STEM classes.

This guide features guided reading and discussion topics and activities that do not require prior knowledge of the science concepts introduced in the book but also contains a STEM-specific section of questions and activities that facilitate the connection of STEM knowledge to scenarios from the novel. Because of the range of content covered (biology, physics, chemistry), teachers are encouraged to pick and choose questions and activities relevant to their courses.

PRE-READING ACTIVITY

In a 1987 speech to the United Nations advocating an increased awareness of our common humanity, President Ronald Reagan said, "Perhaps we need some outside universal threat to make us recognize this common bond. I occasionally think how quickly our differences worldwide would vanish if we were facing an alien threat from outside this world."

As a class, discuss what you think would happen if we faced a universal threat from an alien life-form. Would, as Reagan hoped, nations and people unite and work together or would the threat sow division and discord? Encourage students to develop detailed accounts of possible scenarios and speculate on the series of events that might unfold over time.

(The video of this speech is available courtesy of the Reagan Library at tinyurl.com/bzkpct4z. These remarks start at 28:30.)

GUIDED READING AND DISCUSSION QUESTIONS

1. When the narrator wakes up from a coma, what clues does he use to try to remember who and where he is? Why does he suspect that he is not on Earth? What experiment does he design to test his hypothesis?
2. What is the Petrova line? What observation about the Petrova line causes scientists to realize that Earth may be in danger?
3. Why would the *Hail Mary* be designed to keep astronauts in the sleeping area until they are able to remember their names?
4. Why is the Petrova Taskforce established instead of having nations work independently? Why is Dr. Grace selected to work with the Petrova Taskforce? What is his initial job? What qualifications does he have?
5. Why do experts suspect that the Petrova line is made of an alien life-form? What precautions are taken with the sample that Dr. Grace works with initially?
6. Explain the purpose of the tests that Dr. Grace runs on the first sample of Astrophage (48–52). Can you think of any additional tests that you would have wanted to conduct on the sample? What initial discoveries does he make? Based on root word meanings, explain why he names the life-form "Astrophage."
7. Describe the burial that Grace gives Yáo and Ilyukhina. What does he remember about them? How can you tell that he cares about his crewmates?
8. Based on the memories of being in his classroom, what do you think Dr. Grace's strengths were as a teacher? What do you think it would have been like to take his class? How can you tell that he enjoyed being a teacher?
9. Why do you think the project to save Earth was given the name Project Hail Mary?

GUIDED READING AND DISCUSSION QUESTIONS (CONTINUED)

10. What makes Grace realize that the *Hail Mary* mission was not designed to include a return to Earth?
11. What is significant about Tau Ceti? What do scientists hope they will discover if they travel to Tau Ceti?
12. Why does Stratt decide to put the crew of the *Hail Mary* into comas during their voyage? What are the risks associated with an extended medically induced coma? How does she plan to mitigate these risks?
13. When Grace makes first contact with the alien ship, how does he communicate? Do you agree with his decision to allow further contact with the alien ship at the risk his own safety? Explain your answer.
14. Explain the observations and discoveries about Erid and Eridians that Grace makes during his first meeting with Rocky in Chapter 10.
15. How do humans manage to breed enough Astrophage for the *Hail Mary* mission? What are the risks associated with their plan?
16. How did the other Eridians on *Blip-A* die? Why wasn't Rocky affected? Why didn't Eridians need to worry about radiation on Erid?
17. Describe Rocky's theory explaining why human and Eridian science is similar. Do you agree with his hypothesis? Explain your answer.
18. How is Rocky able to visit the *Hail Mary* even though he needs a different atmosphere to survive?
19. How does Stratt justify her guideline that all members of the *Hail Mary* crew be heterosexual men? Why does Grace find this problematic? Was her guideline followed or overruled?
20. Grace and Rocky develop an unspoken rule that differences in their cultures have to be accepted. Why would this rule be helpful for friends, crewmates, or team members?
21. What does the Astrophage sample taken from the Tau Ceti Petrova line reveal? What theory does Rocky develop about why Adrian is able to live in balance with Astrophage based on this discovery? Using this theory, what plan do they develop to save Earth and Erid?
22. What theories do Rocky and Grace come up with to explain why they evolved in such a way that they can hear similar frequencies, have similar intelligence, and both are willing to risk their lives to save others? Do you find their theories plausible? Explain your answer.
23. After Grace remembers what his mission is, he wonders, "Why would I, of all people, be a part of this mission. . . . Surely there were more qualified people" (101). What does he eventually realize about why he was a part of the crew of the *Hail Mary*?
24. Why do you think Stratt did not tell Grace that he was the tertiary science specialist at the beginning of the project? Do you think it would have made a difference if she had? Explain your answer.
25. What "gifts" do Rocky and Grace exchange before they depart for their respective voyages home? How do you think Eridians and humans will use the knowledge they glean from the alien technology?
26. Do you find the book's conclusion satisfying? Explain your answer.

EXTENSION ACTIVITIES AND WRITING PROMPTS

1. Research the history, function, and design of NASA's mission patches. Based on the description of the *Hail Mary* patch on page 105, create an artistic rendering of Dr. Ryland Grace's patch.
2. Using details and descriptions from the book, create a 2-D, 3-D, or computer-rendered model of either the *Hail Mary* or the *Blip-A*. Label your model and, when possible, cite the page in the book that references each detail. These passages provide some details to get you started: pages 122–23, 140–41, 160, 229–30.
3. Working either alone or with a group, imagine that you are tasked with a presentation to an international panel of scientists to brief them on Eridian biology. Develop a PowerPoint presentation that includes as many scientifically relevant details as you can find in the text. For example, you can include facts about Eridian lifespan, sleep cycle, circulatory and digestive system, reproduction, body mass, etc. Your presentation should include diagrams based on the author's physical description of Rocky. (Pages 171–78 and 244–48 are a good starting point for descriptions, but you'll want to include details from elsewhere in the book in your presentation too.)
4. Using the facts that Grace discovers about the Eridian numerical system (182–84), create a chart that converts numbers 1–100 into Eridian numbers.
5. Using details from the text, create a chart or graphic illustrating the differences between the planets Earth and Erid. Include gravity, temperature, atmosphere, rotation, etc.
6. Steve Hatch and Dr. Ryland Grace have very different perspectives on the Astrophage crisis. Hatch is optimistic about humanity's ability to survive and believes Astrophage will bring about ultimately beneficial technological advances. Grace's perspective is more pessimistic, as he believes that Astrophage will be responsible for an apocalypse. (See pages 302–7). As a class, debate whose perspective is the most likely to prove accurate.
7. In *Project Hail Mary*, international cooperation makes the mission possible. As a class, debate whether cooperation or competition provides the best model for innovation.
8. Dr. Grace reflects that, in the immediate aftermath of the discovery that mankind is likely facing an extinction-level event, nothing substantially changed about the way people went about their day-to-day lives: "Life had changed surprisingly little since the announcement about the Petrova line. The situation was dire and deadly, but it was also the norm" (34). Later, he comments, "Human beings have a remarkable ability to accept the abnormal and make it normal" (157). Write a reflective essay about a time that you found yourself having to adjust to a new normal. What did you find the most challenging? How did you adjust? What did you learn in the process?
9. Facing the Astrophage crisis, world leaders agree to centralize power to execute Project Hail Mary, giving Stratt unlimited resources and authority as well as immunity from "any crime anywhere on Earth" (193). Write an argumentative essay about whether or not you think this was a good thing. Do you agree with Stratt's decisions and tactics? Do the ends justify the means? Use correctly cited textual evidence to support your analysis.
10. When Stratt explains why she contacted Ryland Grace for help, she

EXTENSION ACTIVITIES AND WRITING PROMPTS (CONTINUED)

tells him, "The field of speculative extraterrestrial biology is small—only five hundred or so people in the world" (40). While speculative biology/evolution is a characteristic of science fiction, it also has potential real-world applications. Write a persuasive letter arguing for or against the U.S. government funding a program in speculative extraterrestrial biology.

11. Write an explanatory essay tracing the evolution of shared language and communication between Dr. Grace and the Eridian spacecraft from first contact through the end of the novel. Use correctly cited textual evidence to support your analysis.

12. Write a literary analysis that looks at the narrative structure of the novel. What purpose do the flashbacks serve? What does the placement of specific flashbacks reveal about the chronological sections that precede or follow them? How does Weir use the structure to build suspense? How does the structure contribute to the development of Ryland Grace's character? Use correctly cited textual evidence to support your analysis

13. What do you think life on Earth was like during the years that it took Grace to complete his mission and send the Beetles back with an answer to the Astrophage crisis? Stratt predicts that the world Grace leaves behind will face "war, famine, pestilence, and death" (431). However, when Grace finds out that the sun has been restored, he hopes for the best, saying, "I bet they did work together. Maybe it's just the childish optimist in me, but humanity can be pretty impressive when we put our minds to it" (475). Write a short story from the perspective of someone on Earth that explains what life was like while people waited to hear from the *Hail Mary*.

14. Stratt tells Grace that she is willing to make unpopular and possibly unethical decisions to save life on Earth: "We all have to make sacrifices. If I have to be the world's whipping boy to secure our salvation, then that's my sacrifice to make" (244). She goes on to inform him that, in spite of the fact that the *Hail Mary* mission will end in death for the crew, tens of thousands of people were willing to volunteer (257). Write a reflective essay about what makes some people willing to make sacrifices for the good of others. What do you think you would have done if you had been in Stratt's position? What would you have done if you had to make the choices Grace has to make?

15. Write an analysis of Dr. Ryland Grace as a dynamic character. How does he change over the course of the book and what in the narrative precipitates these changes? Use correctly cited textual evidence to support your analysis.

16. Analyze the development of the friendship between Rocky and Grace. What common values do they share? How are their personalities similar? For example, look at moments in the book where they demonstrate empathy, humor, and respect for one another. Use correctly cited textual evidence to support your analysis.

17. Early on, Grace is surprised to see scientists from Russia, China, and America working together. Historically, these three countries have been leaders in space exploration, but they have also been rivals. Research the history of the space programs in these countries and write about their individual roles in scientific discovery and progress.

STEM QUESTIONS AND ACTIVITIES

1. Explain what the Goldilocks Zone is and why the idea behind it assumes that life requires liquid water. Do you think the theory that life requires liquid water is correct?
2. Explain the scientific basis for how and why Astrophage can be used as fuel. How does this relate to mass–energy equivalence as expressed in the formula $E = mc^2$? Why might the discovery that Astrophage maintains an internal temperature of 96.14 degrees Celsius be a clue about the way Astrophage functions? In your own words, compose an explanation of how Astrophage stores energy based on scientific fact and theory (225–28).
3. Based on details in Chapter Five, create a scientifically plausible model of the basic life cycle of Microphage.
4. How does Grace determine the amount of energy emitted by Astrophage? (See page 103.) Based on his calculations, make a chart showing how much Astrophage would be needed to provide power in a variety of scenarios. (For example: how much Astrophage would it take to power an airplane, a large city, a cruise ship, etc.)
5. Explain the science behind Grace's comment that acceleration and deceleration are the same "from a physics standpoint" (105).
6. What are the effects of zero g on human beings? (See page 114.) How does the human body respond to differences in gravity? Why is it important for astronauts to learn to navigate in a zero-g environment?
7. Explain how the theory of relativity impacts the ways that Grace and Rocky experience time traveling to and from Tau Ceti.
8. Read pages 137–38 and respond to the question of whether Astrophage was the result of a panspermia event or evolved separately. What is the scientific evidence for each theory? Which do you think is more likely to be correct?
9. Why is Grace surprised to find that the cylinder from *Blip-A* is made of xenon? How does the element function on Earth? What are its uses?
10. Explain the science behind Stratt's decision to attempt to accelerate climate change on Earth. How does she attempt to increase global warming? Is this scientifically plausible? What would some scientifically plausible negative effects of her actions be? Explain your answer.
11. Provide an example that demonstrates Rocky's assertion, "Discrepancy is science. You think about discrepancy. Make theory" (279). Choose a theory and explain the discrepancy that led a scientist to develop the theory.
12. Explain what Grace means when he says, "The efficient way to leave a gravity well is laterally, to take advantage of the Oberth effect" (319). What is the Oberth effect? In theory, how could it help the *Hail Mary* escape a planet's gravitational pull?
13. Explain the chain of events that causes the *Hail Mary* to spin out of control. Why does this spin increase the force onboard? Explain how Grace reduces the spin.
14. Describe the experiment that Grace develops to determine whether or not Taumoeba can survive the atmospheres needed to save both Earth and Erid. What does he discover? Explain the process that he uses to breed Taumoeba resistant to varying degrees of nitrogen. What mistakes does he make in

STEM QUESTIONS AND ACTIVITIES (CONTINUED)

the process of breeding Taumoeba? How does this relate to the problem of antibiotic-resistant strains of bacteria?

15. What is an EVA? Explain why an EVA would be more difficult in non-zero gravity.
16. Explain the science that leads Rocky to suggest that Grace may be able to eat Taumoeba (469). Why is the fact that Taumoeba does the Krebs cycle important?

RESOURCES FOR FURTHER READING AND RESEARCH

The Martian: Classroom Edition by Andy Weir

Artemis by Andy Weir

Exhalation: Stories by Ted Chiang

A Brief History of Time by Stephen Hawking

Packing for Mars: The Curious Science of Life in the Void by Mary Roach

The Sparrow: A Novel by Maria Doria Russell

Contact: A Novel by Carl Sagan

The Age of Miracles: A Novel by Karen Thompson Walker

The Right Stuff by Tom Wolfe

Go to tinyurl.com/PHMKit to access a resource kit including an interview with Andy Weir, visual schematics for the *Hail Mary*, and more.

ABOUT THIS GUIDE'S WRITER

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NOTES

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