The Code Breaker Summer Assignment

Directions: Please give thoughtful but concise answers in 5-7 sentences. Please make sure to use correct grammar and punctuation.

Discussion Questions

Introduction:

1**.** In The Code Breaker's introduction, we learn about Victoria Gray, who had sickle cell anemia and with CRISPR gene editing found herself improving. Gray said, "'High school graduations, college graduations, weddings, grandkids—I thought I wouldn't see none of that, now I'll be there to help my daughters pick out their wedding dresses.'" What is it like when you suddenly have a different life? We often celebrate people's fortitude in loss or diminished abilities, but What about unexpected healing and expanded abilities? How do you think Gray's approach to life changed? Why is Gray's story at the beginning of the book?

Part One: The Origins of Life

2**.** During her elementary years in Hawaii, Doudna felt alone and isolated. From chapter one:
In the third grade, she was so unloved by her classmates that she had trouble eating, and she developed all sorts of digestive problems that she later realized were stress related. Kids teased her every day—especially the boys, because unlike them she had hair on her arms. To protect herself, she escaped into books and developed a defensive layer.
There are many ways to escape hurt, stress, and discomfort. What are some ways that you have watched people escape and how do you escape? Was Doudna's escape into books good for her, or should she have spent her energy working things out with her classmates? How did this information in the book help you understand Doudna?

3. Doudna drew inspiration from and developed curiosity about her natural surroundings in Hawaii. We all see the wonders of nature every day, whether it be a plant that moves or a sunset that reaches its pink finger rays into a sky of deep blue. The key to true curiosity is pausing to think about the causes. What makes a sky blue or a sunset pink or a leaf of sleeping grass curl?

Review Chapter One: Hilo, and then imagine you are new to your town or neighborhood. What are the natural things in your environment that stand out to you? What inspires you? What are you curious about?

4. Isaacson writes how as a sixth-grader growing up in Hilo, Hawaii, Jennifer Doudna read a copy of The Double Helix, James Watson's account of how he and Francis Crick discovered the spiral-staircase structure of DNA in 1953, which inspired her to become a scientist.
Has any book had a similar life-changing effect on you?

5**.** After learning about James Watson and Francis Crick, who are credited with discovering the double helix structure of DNA, we learn a bit about Rosalind Franklin, a structural biologist and crystallographer whose work making clear X-rays of DNA molecules allowed Watson and Crick to make their discovery. Watson and Crick used Franklin's data without permission and did not credit her in their discovery. In fact, as the book points out, they and the larger scientific community were dismissive of women in science. Why did Watson and Crick believe they did not have to credit Franklin and her data in their discovery? How should Watson and Crick have credited Rosalind Franklin for aiding in their discovery?

6. Review Chapter Two: Genes and DNA. Notice that discoveries about genes and DNA are happening simultaneously in different places around the world. Throughout history we see this with inventions and discoveries as well as with political, social, and cultural movements. This was true before the internet and the access to global information we have today. What is something that has happened or is happening in your lifetime that seems to be a global occurrence? Think about discoveries, cultural and political movements, or social changes.

7. When Doudna told her high school counselor she wanted to study chemistry, he told her that "Girls don't do science." (Chapter three) Has anyone ever told you that you can't do something or are incapable of doing something? Did that discourage you or inspire you? How did you react when you were told you couldn't do something?

8. Doudna was struck by the diversity in modern science, and during her career she collaborated and communicated with diverse scientists around the globe. Why is diversity important in progress, scientific or otherwise?

9**.** From early in her career, Doudna worked collaboratively and always asked permission to use other people's work. Why was this important? Should all scientists ask permission? What could be the reasoning for scientists not to share their findings?

10. Doudna completed her PhD (Doctor of Philosophy) research under a scientist named Jack Szostak. Szostak's guiding principle was Never do something that a thousand other people are doing. What do you think is the purpose of this principle? Does it expand or limit possibilities? Why did it appeal to Doudna?

Part Two: CRISPR:

11. Doudna and her colleagues publish papers on their discoveries when they deem them important enough to share. Think about a process you went through that resulted in an outcome you were proud to announce. Do not limit this to school. Think about volunteer or paid work, home projects, creative projects, and extracurricular activities. What discovery or accomplishment would you publish a paper about?

12. Review Chapter Nine: Restless, in which Doudna reaches a point in her career when she thinks about focusing on applying knowledge rather than gaining it. What experiences have you had in which you gained knowledge and then applied it? At which point in your education were

you focused on gaining knowledge and at which points were you focused on using that knowledge?

13. Collaboration is a constant in Doudna's story. At the end of Chapter Twelve: Making Connections around the world, that collaboration is described: "Jinek and Chylinski soon connected, and the rest is history. Theirs was a meeting that would bring about great things, because—together—Jinek, Chylinski, Charpentier and Doudna would soon make one of the most important advances in modern science." Collaboration seems very important to Doudna. Why is collaboration important in science in general? What about in other fields? What are the benefits and challenges of collaboration?

Part Three: Gene Editing

14. Jennifer Doudna ws willing to take risks. This does not mean she did foolish or dangerous things, but she was willing to try new things and risk failing at them in order to learn and find success. This is an essential part of having a growth mindset. If you believe talent can be developed through hard work and trial-and-error exploration, then you also have a growth mindset. What are the advantages to having a growth mindset? Are there disadvantages, and if so, what are they?

15. As already noted, this story is full of collaboration, as well as healthy competition. It is also about ideas and discoveries and who owns them. Did Watson and Crick steal Rosalind Franklin's work? Did Feng Zhang steal Doudna's work? Did Doudna steal Charpentier's work? Can you steal ideas and discoveries?

16. Review Chapter Twenty One: Commercializing CRISPR, in which Doudna develops a bad feeling about Feng Zhang and loses trust in him. She tells him, "I'm done. I'm not going to work with people I can't trust, people who stab you in the back. You stabbed me in the back." Was her mistrust justified, or was she allowing emotions to dictate her decision? Was she fair to Zhang? Was he fair to her? Explain your reasoning.

Part Four: CRISPR in Action

17. Review Chapter Twenty-Four: Creating Happy, Healthy Babies, and think about the possibilities Doudna is weighing regarding the potential of CRISPR technology for good versus the potential dangers.These feelings are similar to those of scientists that worked on the atomic bomb. Was dropping the bomb to end WWII worth the loss of life? Did it ultimately save lives? Think of and list the pros and cons of CRISPR. What is the lifesaving potential and does that potential outweigh the dangers?

18. Scientists recognize the possibility of using Cas9 technology to prevent genetic diseases in in-vitro fertilization (IVF). This is when fertilization happens in a lab, Review Chapter Twenty-Four: Creating Happy, Healthy Babies and make a list of pros and cons related to using this technology in IVF.

19. In the book, gene editing is referred to as being “like the Wild West–a huge, promising frontier, but filled with uncertainty and danger.” (Chapter 24) Many people talk about the internet that way. Are these comparisons accurate? If so, how? If not, why not, and why are people making them?

Part Five: CRISPR Babies

20. Review Chapter Seventeen: Doudna’s First Competitor and Chapter Twenty Seven: He Jiankui. Compare the childhoods and education of Feng Zhang and He Jiankui. Which do you believe provides a stronger foundation for following your passion: growing up poor and struggling to develop ingenuity, or having material advantages readily available?

Part Six: The Moral Questions

21. Chapter Thirty-One: Doudna’s Ethical Journey, concludes with words from Jennifer Doudna. “‘We’ve never seen anything like this before, ‘We now have the power to control our genetic future, which is awesome and terrifying”’ Why is this both awesome and terrifying?

Part Seven: CRISPR and COVID-19

22. COVID-19 created both opportunity and need that dictated the direction of scientists’ work. Your lives have been very affected by COVID-19. What ingenuity and inspiration have you take from your experiences with this global pandemic?

23. During the Cold Spring Harbor Laboratory’s annual CRISPR conference in August 2020, Rosalind Franklin’s one hundredth birthday was celebrated. Unfortunately, Franklin died young and was not there to celebrate, but the gathered scientists recognized her pioneering work on the structure of DNA

The meeting also wove in another strand of this book. It celebrated the hundredth anniversary of the birth of Rosalind Franklin, whose pioneering work on the structure of DNA had inspired Doudna, when she’d read The Double Helix as a young girl, to believe that women could do science. The cover of the meeting’s program featured a colorized photograph of Franklin peering into a microscope

What strands do you follow? What event in your life do you carry a memory of and how has it informed your interests and pursuits?

24. During the Cold Spring Harbor conference, a discussion was held about Black people’s distrust of medical trials, which was traced back to the Tuskegee experiment. This experiment was ultimately deemed “ethically unjustified.” What makes an experiment ethical or unethical? Why are ethics important in science?

25. In 2020 Jennifer Doudna and Emmanuelle Charpentier were awarded the Nobel Prize in Chemistry. Five separate Nobel Prizes are awarded each year to people that, during the preceding year have contributed to work that benefits all people. Learn about the Nobel Prize

and other recipients over the years. Do you think their work was worthy of the Nobel Prize? Why or why not?

26. According to Chapter Forty-One: The Next Scientific Horizon:

Most of us someday will have selection devices in our homes that will allow us to check ourselves for viruses and many other health conditions. We will also have clothes or glasses or wristbands that can monitor all our biological functions, and they will be networked so that they can share information and create a global bio-weather map showing in real time the spread of biological threats. All of this has made biology an even more exciting field of study. The proof is in the data: in August 2020, applications to medical school had jumped 17 percent from the previous year.

Should we have independent access to such complete medical information, or is this dangerous as most of us lack medical training? What advantages and disadvantages do you see to this future possibility?

Epilogue

27. Review this quote from the book's epilogue:

After millions of centuries during which the evolution of organisms happened "naturally," we humans now have the ability to hack the code of life. Or, to confuse those who would label gene editing as "unnatural" and "playing God," let's put it another way: nature and nature's God, in their infinite wisdom, have evolved a species that is able to modify its own genome, and that species happens to be ours.

Just because we can do something, should we do it?