**Unit 5** **Black Holes and speculating**

**1 How are the following items associated with black holes?**

quantum hair stars quasars Karl Schwarzschild

 galaxy event horizon gravity very long baseline interferometry

 accretion disc singularity

**2 True or false? / Likely or unlikely? Discuss the following statements:**

1 A black hole is an empty space

2 Black holes are the most fascinating objects in space

3 Black holes were predicted by Einstein's theory of general relativity

4 Black holes can be directly observed with telescopes

5 Black holes are passages to another universe

6 The existence of black holes cannot be explained by the quantum-mechanical laws

7 Most black holes form from the remnants of a large star

8 A black hole can destroy the Earth

**3 Video: Put the information from the video into the three categories** <https://www.nationalgeographic.com/science/article/black-holes>

|  |  |  |
| --- | --- | --- |
| Things I knew about black holes before watching the video | Things I learned in the video | Things I want to know about black holes and I hope I will one day |
|  |  |  |
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**4 Read three articles about the black hole paradox and answer the questions below:**

1 What seems to be the answer to Hawking’s paradox according to the latest articles?

2 What did Hawking suggest about black holes in 1976 and why is it against laws of [quantum mechanics](https://phys.org/tags/quantum%2Bmechanics/)?

3 What is Hawking radiation and what does it depend on?

4 Who is the author of the no-hair theorem and what does it say?

5 Why do scientists find it important to merge Einstein's theory of general relativity with quantum mechanics?

6 What was the purpose of the experiment?

<https://phys.org/news/2022-03-scientists-stephen-hawking-black-hole.html?fbclid=IwAR3QvqurJ0w4lLnQsKfHI-gYgoYgl4HQzBya1zDBZTCvHp37_E7gCKbS-iU>

**5 Listening. How did they actually take this picture?** (4:00 – 9:00)

<https://www.youtube.com/watch?v=Q1bSDnuIPbo>

1. The pictures of black holes were not made with \_\_\_\_\_\_\_\_\_\_\_, they were made with \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ with a wavelength of 1.3 mm.

2. When a radio telescope is pointed directly at a radio source, it produces \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

3. Being in phase means that \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ line up.

4. The telescope produces peak intensity only when aimed directly \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

5. The angular resolution of a telescope is its ability to \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

6. The angular resolution is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ to the diameter of the telescope.

7. The angular resolution is too \_\_\_\_\_\_\_\_\_\_\_\_\_ for any individual radio telescope on the Earth.

8. Instead of increasing the dish diameter of the telescope, it is easier to \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

9. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ is a global network of radio observatories.

10. Each telescope records the signal at its location and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

**6 Speculating and conditionals**

A If you jump in the water, you will get wet.

B If we constructed spacecraft moving at 64 000 kph, it would take us 77 000 years to get to the nearest star.

C If I didn't have a computer, my work would be much more difficult.

D I will use my phone, if there isn’t any computer in the classroom.

Sentences \_\_\_\_ and \_\_\_\_\_\_\_ express a real possibility.

Sentences \_\_\_\_ and \_\_\_\_\_\_ express an imaginary situation.

**a Complete the sentences – is it a possibility or imaginary situation?**

What would happen if you \_\_\_\_\_\_\_\_ (fall) into a black hole?

If he \_\_\_\_\_\_\_\_ (come) tomorrow, I will let you know.

If he had more money, he \_\_\_\_\_\_\_\_ (travel) around the world.

If you don’t hurry, you \_\_\_\_\_\_\_\_\_\_ (miss) the bus.

If she \_\_\_\_\_\_ (have) time, she’ll write the paper.

If I \_\_\_\_\_\_\_\_ (know) the correct answer, I’d tell you.

If I \_\_\_\_\_\_\_\_\_\_ (be) an astronaut, I would live aboard the ISS.

Nobody \_\_\_\_\_\_\_\_\_ (notice), if you make a mistake.

If I won the lottery, I \_\_\_\_\_\_\_\_\_\_ (buy) a new car.

If I \_\_\_\_\_\_\_\_\_ (be) you, I’d study more.

**b Complete the following sentences with your own ideas:**

If I could study abroad, I would study in \_\_\_\_\_\_\_ because ...

If I were a millionaire, the area of research I would support financially would be \_\_\_\_\_\_ because …

If I met Albert Einstein, the question I’d ask him would be \_\_\_\_\_\_\_\_\_\_ because ...

If I met Stephen Hawking, the topic I’d like to speak with him about would be \_\_\_\_\_\_ because …

If I didn’t study physics, I’d like to study \_\_\_\_\_\_\_ because ….

If I could be a superhero, I’d be \_\_\_\_\_\_\_ because ….

If I could travel back in time, I’d go to \_\_\_\_\_\_ because ..

**7 Speculation: What would happen if you fell into a black hole?**

<https://www.youtube.com/watch?v=lwe5KTdzSHg&t=205s>

From 1:50

a As you start being pulled toward a black hole, you would be moving\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ because\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

b When you cross the event horizon, your body would \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

c You would be squashed in the centre and become\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

d A person observing you from the outside of the event horizon would see \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

**A Black Hole Survival Guide:** In *Black Hole Survival Guide* physicist and novelist Janna Levin takes you on a journey into a black hole, explaining what would happen to you in there and why.

<https://www.penguin.co.uk/books/111/1118851/black-hole-survival-guide/9781847926166.html>

**8 Cloze test – complete the text with missing words (1 per gap)**

Black holes can come in a range of sizes, but there are three main 1\_\_\_\_\_\_\_\_ of black holes. The black hole's 2\_\_\_\_\_\_\_\_ and size 3\_\_\_\_\_\_\_\_\_\_ what kind it is.

The smallest ones are 4\_\_\_\_\_\_\_\_\_\_ as primordial black holes. Scientists believe this type of black hole is as small as a 5\_\_\_\_\_\_\_\_\_ atom but with the mass of a large mountain.

The most 6\_\_\_\_\_\_\_\_\_\_ type of medium-sized black holes is called "stellar." The mass of a stellar black hole can be up 7\_\_\_\_\_\_\_\_ 20 times greater than the mass of the sun and can fit inside a ball with a diameter of about 10 miles. Dozens of stellar mass black holes may exist within the Milky Way galaxy.

The largest black holes are called "supermassive." These black holes have masses greater than 1 million suns combined and would fit inside a ball with a diameter about the size of the solar system. Scientific 8\_\_\_\_\_\_\_\_\_\_ suggests that every large galaxy 9\_\_\_\_\_\_\_\_\_\_ a supermassive black hole at its center. The supermassive black hole at the center of the Milky Way galaxy is called Sagittarius A. It has a mass 10\_\_\_\_\_\_\_\_ to about 4 million suns and would fit inside a ball with a diameter about the size of the sun.

**HW for week 6:** Prepare a monologue  – **Speculate on an issue from your field of study** (approximate length – 2-3 mins).