Nuclear fusion

with Dr Kurt F. Schoenberg

Talking *points*

Knowledge & Comprehension

1. What is the difference between nuclear fission and nuclear fusion?
2. What fuels are used for nuclear fusion (in the Sun and on Earth)?
3. Why has nuclear fusion energy not yet become a practical reality?
4. What two fundamental forces have to be contended with for nuclear fusion?
5. What are the differences between magnetic confinement fusion and inertial confinement fusion?
6. What natural resources are vital for a fusion energy economy but rare and/or very difficult to produce?

Analysis

7. Why do you think nuclear fusion is proving more challenging to harness than nuclear fission?
8. How do you think careers within fusion energy development will change in years to come? What areas will become more in-demand, and which will become less so?

Evaluation

9. If nuclear fusion energy does become a practical reality, how do you think the world will change – at the societal and personal levels?
10. Imagine that scientists find an effective and practical method of nuclear fusion energy production. What do you think would be the next steps for making it a usable energy source for society?
11. There are many ways in which future scientists and researchers could contribute to fusion energy development. Referring to the information in the 'Pathway' box in Kurt's article, which subject area interests you the most, and why? How would you like to contribute to the development of fusion energy?

More *resources*

There are excellent fusion energy resources accessible online. To get started, Kurt recommends:
The US Department of Energy: **tinyurl.com/fy3vuzr4**
Princeton Plasma Physics Laboratory (PPPL): **tinyurl.com/8vdzdmfk**
ITER: **tinyurl.com/mr2djepb**
National Ignition Facility: **tinyurl.com/5n9bnwm5**

For more advanced information, Kurt recommends these online courses to begin your scientific journey:
PPPL's Interactive Plasma Physics Experience: **tinyurl.com/mtceznkm**
MIT OpenCourseWare: **tinyurl.com/4pdz7nn7**

Activity

Nuclear fusion facilities around the world are collectively addressing the challenges of making fusion energy a reality. Each has its own role and its own major achievements.

The table below introduces a selection of nuclear fusion facilities, their types and their significance. Use Kurt's article and the internet to complete the table. If you come across terminology you are not familiar with ('stellarator', for example), look it up and make a note of the definition.

Once you have finished the table, reflect on and write answers to the questions below:

- Which of the breakthroughs do you think are the most significant?
- What might be the next major breakthrough in nuclear fusion energy? At which facility (or facilities) do you think it might happen?
- Which facility would you most like to visit, and why?
- Given that these facilities are highly expensive to build and operate, why do you think there are many facilities around the world, rather than just a few?
- How do you think the different facilities collaborate together? To what extent do you think that political relations affect collaboration, and why?
- Given what you have learnt, how optimistic are you that fusion energy will become a worldwide reality within your lifetime, and why?

Facility	Location	Type/Approach	Significance
International Thermonuclear Experimental Reactor (ITER)	France	Designed to demonstrate deuterium and tritium fusion ignition in a tokamak reactor	
Joint European Torus (JET)			
EAST (Experimental Advanced Superconducting Tokamak)			Holds the record for high-temperature, long-duration plasmas: 100 million °C for over 1,000 seconds
	Germany		Largest stellarator in the world
SPARC (Commonwealth Fusion Systems)		A proposed compact high-field tokamak reactor	
Z-machine		Pulsed power approach to inertial fusion	
NIF (National Ignition Facility)	USA		