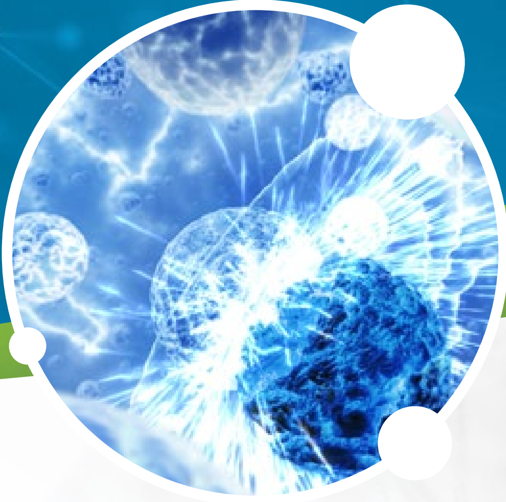
lesson plan

Fission vs. Fusion

How would you allocate funding between
(1) continuing to build and run fission reactors and
(2) research into the development of fusion reactors?



overview

LESSON CONTEXT

Currently, all of the nuclear reactors in Canada employ the process of nuclear fission to generate electricity. Since the 1950s, physicists and engineers have been attempting (using various techniques) to build fusion reactors for this same purpose. If successful, humanity will have an inexhaustible source of energy, but the technical challenges facing them are great.

LEARNING GOALS

- Understand the basics of the processes of nuclear fission and fusion.
- Discuss the implications of nuclear fission and fusion as potential energy sources.
- Evaluate evidence and consider alternative perspectives, ideas and explanations.

LEARNING ACTIVITIES

In this lesson, students will gather information from various online resources to gain an understanding of the differences between the processes of nuclear fission and fusion and will write a "mini-position paper" about the scientific and technological pros and cons to be considered when thinking of these two processes as meeting future energy needs.

BIG IDEAS

Nuclear fission involves the splitting of a heavy nucleus into lighter nuclei, while nuclear fusion involves the combining of light nuclei into a single heavier nucleus. Both processes produce vast amounts of energy, but each has its own unique set of advantages and disadvantages as an energy source.

time
45-60
MINUTES PLUS TIME OUTSIDE OF CLASS

subjects
PHYSICS
SCIENCE

skills
CRITICAL THINKING
COMMUNICATION

assessment & evaluation

PRIOR KNOWLEDGE AND SKILLS

- Experience using graphic organizers
- Experience working in cooperative small groups
- Experience locating legitimate information using internet sources

SUCCESS CRITERIA

- Students clearly express and organize ideas and information from various electronic sources using electronic research tools
- Student research demonstrates understanding of the processes, advantages and disadvantages of fission and fusion as energy sources

ASSESSMENT STRATEGIES

- Assessment of student graphic organizers
- Observation of group work
- Individual writing assignment (mini-position paper)

resources & materials required

- **BLM – Fission vs. Fusion Mini-Position Paper Assignment** – one per student
- **BLM – Fission vs. Fusion Mini-Position Paper Rubric** – one per student
- **BLM – Research Guide Sheet – Fission and Fusion** – one per student
- **BLM – Fission vs. Fusion Web Links** – one per student
- Curriculum alignment
- Large pieces of white paper – two per group of four students
- Electronic device with internet access

minds-on

15 MINUTES

- To assess what students already know about fission and fusion, each group will create and use a graphic organizer. Have each group print the word "fission" in the middle of one piece of paper and "fusion" in the middle of a second piece of paper. Have the students add their names to both pages.
- The students will then take turns writing on the papers everything that they know, or think they know, about nuclear fission and fusion.

IMPLEMENTATION OPTIONS

- The groups could create KWL, or similar, charts to assess and record knowledge instead of using graphic organizers.
- The graphic organizer may also be done digitally using a concept-mapping program such as Inspiration.

action

10 MINUTES PLUS TIME OUTSIDE OF CLASS

- Provide students with the **Research Guide Sheet BLM** and the **Fission vs. Fusion Web Links BLM**. These two pages can help the students to focus their research about the processes of nuclear fission and fusion and their technological advantages and disadvantages. Time permitting, the students could also locate information from additional internet sources.
- At the end of their research, have the students write new information on their graphic organizers. Have the group members discuss what they learned during their research to ensure that all members understand the concepts of nuclear fission and fusion and the technological advantages and disadvantages of each.

IMPLEMENTATION OPTION

- You may want to have each student use a different colour of pen or pencil to record his/her learnings so that you can monitor his/her progress and understanding of the concepts.

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consolidation

TIME OUTSIDE OF CLASS

- Students will demonstrate their understanding of the science and technology of nuclear fission and fusion by participating in an individual writing assignment. Based on their research as well as their own critical thinking and decision-making skills, each student will communicate his/her recommended allocation of funds towards current nuclear fission reactors and/or towards research for nuclear fusion reaction in a mini-position paper (see the **Fission vs. Fusion Mini-Position Paper Assignment** and **Rubric BLMs**).
- Each student will be required to construct arguments and defend his/her position on the issue using examples which demonstrate a thorough understanding of the processes of both nuclear fission and fusion, and the technological challenges as well as the implications of their funding decision (what if…?).

IMPLEMENTATION OPTIONS

- Review essay writing strategies with students if necessary.
- Instead of doing a position paper, students could demonstrate their understanding of nuclear fission and fusion by developing a poster campaign to support either fission or fusion as the energy source of the future, by writing an op-ed piece (see the **Food Irradiation: What's the Scoop?** lesson for an op-ed assignment) or by writing an article for an online class newsletter.

extensions

- Compile the dollar values assigned by the students in favour of nuclear fission and fusion (on chart paper, on a graph, etc.). To which did they allocate the most money? Discuss these results as a class.
- Students could debate the issue of funding nuclear fission vs. fusion reactors by role-playing fission advocates (e.g. owners of nuclear reactors, energy association members, etc.) and fusion advocates (e.g. physics researchers, etc.).
- Students could individually, or in groups, research current fusion experimentation. The students could report about how the fusion was produced (including what is being fused), the controls used in the experiment, the status of the experiment and, if possible, the expectations of viability for sustained fusion. This project is best suited for upper grade science or physics students or as an enrichment project. Students could choose one of the following methods of nuclear fusion: Muon-catalyzed Fusion, Pyroelectric Fusion, Laser-driven Fusion, Cold Fusion (Pons & Fleishman), ICF (Inertial Confinement Fusion), Farnsworth-Hirsch Fusor, Magnetic Confinement: Tokamak, Stellarator, Reversed Field Pinch, Spheromak, JET (Joint European Torus), ITER (International Thermonuclear Experimental) – an international Tokamak.

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additional resources

CANADIAN NUCLEAR ASSOCIATION WEB PAGES

- How reactors work
- Types of reactors
- Fusion research

RELATED TEACHNUCLEAR LESSON PLANS

- Radioactive Half-Life: The Whole Story
- Understanding Isotopes

VIDEOS

- Taylor Wilson: My radical plan for small nuclear fission reactors – TED
- How will a fusion power plant work? – MaxPlanckSociety
- Nuclear Chemistry Part 2: Fusion and Fission: Crash Course Chemistry #39 – CrashCourse
- Fission vs. Fusion: Instant Egghead #5 – Scientific American

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background information

(Retrieved August 2019)

FISSION

- **Nuclear Fission: Basics – AtomicArchive.com**
  Information and graphics about the process of nuclear fission.
- **Nuclear Fission – European Commission**
  A look at nuclear fission research in the European Union.
- **How Nuclear Power Works – HowStuffWorks**
  Information about nuclear fission and nuclear power plants.
- **Physics of Uranium and Nuclear Energy – World Nuclear Association**
  Information about uranium, nuclear fission and the fission process.

FUSION

- **JET: EUROfusion's flagship device – EUROfusion**
  Learn about JET (Joint European Torus), the world's largest fusion experiment, located near Oxford, England.
- **ITER and fusion energy – European Commission**
  A look at ITER (Latin for "the way"), an International Thermonuclear Experimental Reactor in Cadarache, France used for researching cold fusion technology.
- **Nuclear Fusion – European Commission**
  A European roadmap for nuclear fusion.
- **Fusion Energy Education – FusEdWeb**
  Introductory educational materials in visual format on fusion energy and the physics of plasmas. This online fusion course was created by the Contemporary Physics Education Project (CPEP), a non-profit organization of teachers, educators and physicists. CPEP creates educational materials on contemporary physics topics for use in introductory physics classes.
- **Fusion Education – General Atomics**
  Resources for teachers including educational materials, fusion science slide shows and links to other fusion sites.
- **How Nuclear Fusion Reactors Work – HowStuffWorks**
  Information about the creation of nuclear fusion reactors and how they work.
- **10 Facts You Should Know About Fusion Energy – Princeton Plasma Physics Laboratory**
  Facts about the basics of fusion energy.
- **Fusion Energy Sciences – Office of Science, U.S. Department of Energy**
  Information about fusion research, including fusion facilities and institutions in the United States and around the world, that are participating in fusion research.

COMPARING FISSION VS. FUSION

- **Forget Nuclear Fission, How about Fusion? – 60-Second Earth, Scientific American**
  A short podcast from 2009 describing some of the promise, as well as the problems, involved with harnessing nuclear fusion.
- **Nuclear Reactions – University of Virginia Physics Department**
  In this interactive activity, students visualize the processes of fission and fusion using breakfast cereal.

NUCLEAR ENERGY:

- **The ABC's of Nuclear Science – Nuclear Science Division, Lawrence Berkeley National Laboratory**
  A brief introduction to nuclear science including information, experiments, a glossary, and wall chart on nuclear science.
- **Frequently Asked Questions about Nuclear Energy – Stanford University**
  This list was compiled and answered by John McCarthy, a professor emeritus of computer science from Stanford University.

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