



# Nuclear Weapons and the Environment

# Nuclear Winter

## Suggested Curriculum Links

### Scotland - Curriculum for Excellence:

Topical Science (Science): SCN 3-20b, SCN 4-20b

People in society, economy and business (Modern Studies): SOC 3-15a, SOC 4-15a, SOC 3-18a

People, past events and societies (History): SOC 3-06a, SOC 4-01a, SOC 4-06a, SOC 4-06b

Information handling Data and analysis (Numeracy): MNU 4-20a

Listening and talking (Literacy): LIT 3-09a, LIT 4-09a, LIT 3-10a

### England - Key Stages:

KS3 Physics, KS3 Citizenship - Dealing with conflict, KS3 English - Speaking & Listening, KS3 History - World War Two & Aftermath, KS4 Citizenship - Environmental change & sustainability, KS4 English - Speaking & Listening, KS4 History - The Cold War, KS4 Other subjects - Land and environment, KS4 Physics - Radioactivity

## Teacher's Notes

The manufacture, testing and disposal of nuclear weapons causes environmental damage. These activities run the risk of accidents resulting in further pollution. The use of nuclear weapons in war would cause death, destruction and lasting contamination on a worldwide scale which could threaten our survival.

This unit is part of a series of resources that will enable pupils to have informed views and take part in discussions on the risks to the human life and the environment from the use of nuclear weapons.

### Booklet

Information and activities on 'Nuclear Winter & Climate Change', concentrates on the climatic effects of a nuclear exchange but also refers to other environmental implications of nuclear weapons. The term 'nuclear winter' is taken to be a period of abnormal cold and darkness which follows a nuclear war - caused by a layer of smoke and dust, from forest and city fires, in the atmosphere blocking the sun's rays.

### Presentation

In this module we refer to the work of Professor Brian Toon, and his 15min TEDx Talk "I have studied nuclear war for 35 years – you should be worried". Some challenges can be completed without reference to this talk however the module will work best when pupils have viewed it first.

### References & Further Resources

Further Information and suggested research sources are provided for 'Nuclear Winter'. In the final pages of this module, research sources are provided for other environmental effects from the development, manufacture and possession of nuclear weapons.

### Challenges

#### Emergency Planning

Role Playing scenario - You are a member of COBRA (Cabinet Office briefing room A – the government's emergency response group). You are given an agenda to discuss managing the effects of nuclear winter

#### Nuclear Winter Cartoon

An activity to analyse the effectiveness of a cartoon on nuclear winter. The cartoon is trying to emphasise the enormity of the consequences of using nuclear weapons, dwarfing the environmental issues surrounding them in the past and present.

#### Crossword

An activity to reinforce some of the vocabulary used in this unit.

### Further Challenges

#### Nuclear accidents and incidents

A timeline to complete showing some civil and military events.

## Teacher's Notes

### Resources and References

#### References for Booklet - Nuclear Winter & Climate Change

Professor Brian Toon TEDx talk "I've studied nuclear war for 35 years -- you should be worried" most relevant section begins 2min22sec - <https://www.youtube.com/watch?v=M7hOpT0IPGI> (Prof Toon is from the Department of Atmospheric and Oceanic Sciences at the University of Colorado – Boulder, USA)

Professor Alan Robock - American climatologist "Climatic Consequences of Nuclear Conflict" <http://climate.envsci.rutgers.edu/nuclear/>  
216 MB PowerPoint [climate.envsci.rutgers.edu/robock/talks/NuclearWinter96Princeton.pptx](http://climate.envsci.rutgers.edu/robock/talks/NuclearWinter96Princeton.pptx)  
TEDx "Nuclear winter - still possible but preventable" [www.youtube.com/watch?v=qsrEk1oZ-54](http://www.youtube.com/watch?v=qsrEk1oZ-54)  
(Prof Robock is Distinguished Professor in the Department of Environmental Sciences at Rutgers University, New Jersey, USA).

Research by Michael Mills of the US National Center for Atmospheric Research is quoted in this article from February 2019 "If India and Pakistan have a 'limited' nuclear war, scientists say it could wreck Earth's climate and trigger global famine" [www.businessinsider.com/india-pakistan-kashmir-nuclear-weapons-climate-cooling-2019-2](http://www.businessinsider.com/india-pakistan-kashmir-nuclear-weapons-climate-cooling-2019-2)  
'Multidecadal global cooling and unprecedented ozone loss following a regional nuclear conflict' <https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2013EF000205>

#### References for Challenge - Crossword Puzzle

Crossword Puzzle solution: **Across:** 5:destruction, 6:biological, 8:military, 10:chain. **Down:** 1:powered, 2:depleted, 3:starvation, 4:chemical, 7:winter, 9:armed, 10:civil

#### Other References & Challenges

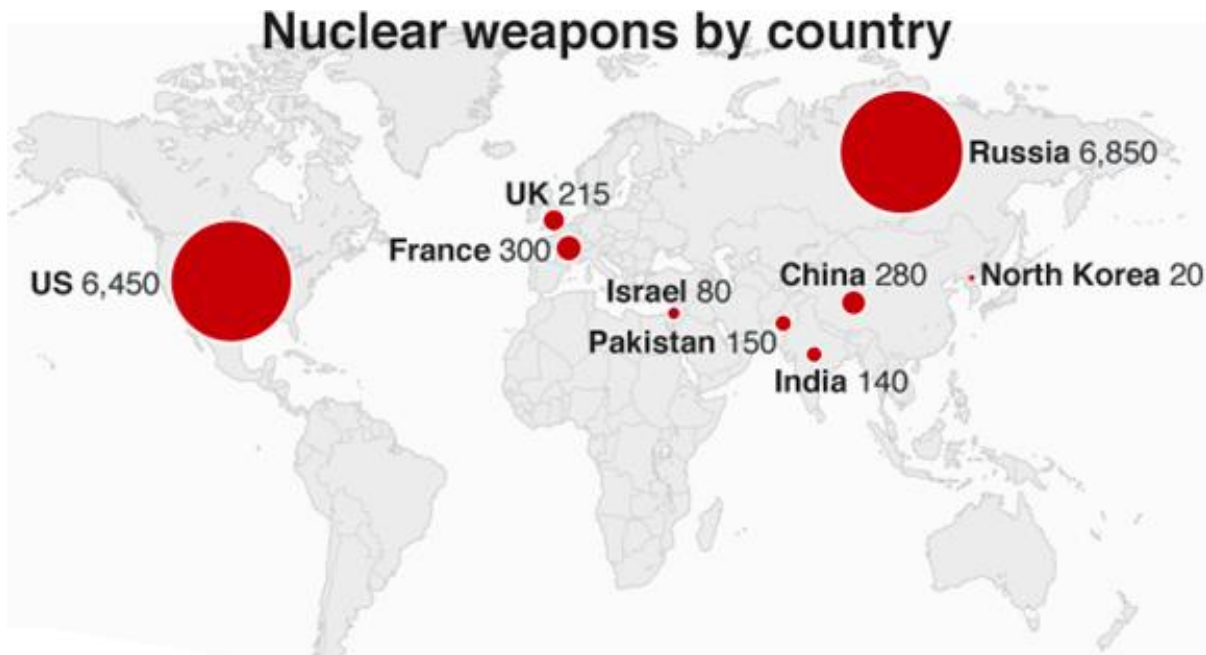
##### Useful introductory video:

BBC: "The Atomic Bomb" GCSE history - exploring the development and deployment of the first atomic bomb, the moral dilemma faced by scientists of the Manhattan Project, and the fallout from the detonation of the bomb over the Japanese city of Hiroshima. [Warning: Contains upsetting and disturbing scenes] <https://www.bbc.com/teach/class-clips-video/history-ks3-gcse-the-atomic-bomb/z6nyrj6>

## Booklet

### Nuclear Winter & Climate Change

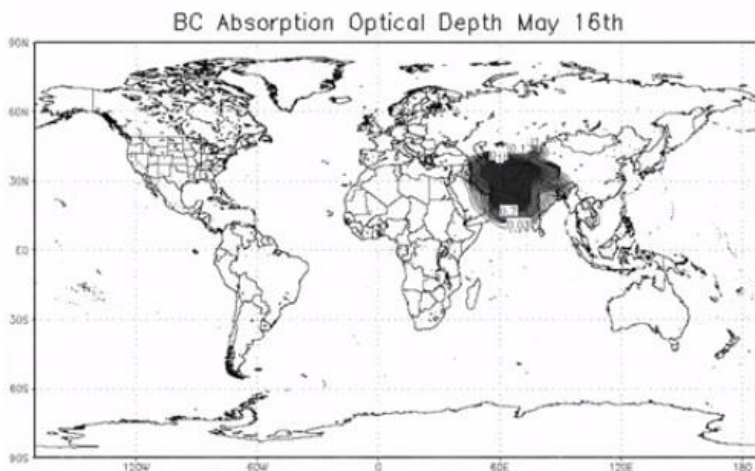
If nuclear weapons were ever used they would have a devastating effect on the world's climate. Nuclear weapons are very powerful and there are large numbers of them around the world.



*There are approx. 15,000 nuclear weapons around the world, 1,800 of which are capable of being launched within minutes (Source: SIPRI, 2018)*

[See video clip: [TEDx "I've studied nuclear war for 35 years - you should be worried"](#)]

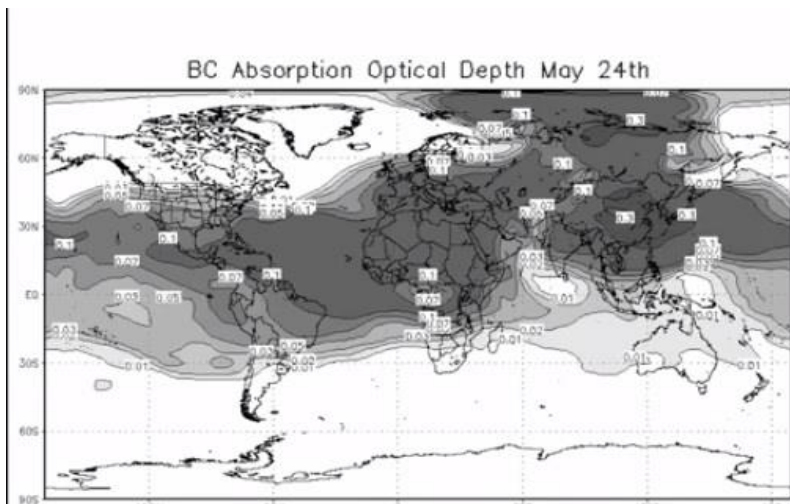
Professor Brian Toon is a scientist who has studied what would happen to the climate if nuclear weapons were ever used. He and his colleagues simulated what would happen if there was a small war using nuclear weapons, choosing Pakistan and India as an example.



*Simulation showing plume of light-absorbing Black Carbon (BC) particulate matter rising from a regional nuclear conflict.*

Booklet

Nuclear Winter & Climate Change (contd.)



*Projected worldwide spread of light absorbing Black Carbon (BC) particulate matter caused by a regional nuclear conflict*

*8 days later*

*\* Absorption optical depth is a measure of how much sunlight is absorbed by the ash cloud*

After the explosions and initial death and destruction, a large number of buildings and forests would continue to burn producing vast quantities of smoke.

This smoke, which would not be radioactive, would stay high up in the atmosphere for years and restrict light and heat reaching the world.

**Fill in the blanks in the following text passage, using numbers from the table:**

10 to 40	60	90	100,000,000 to 2,000,000,000
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Professor Toon explained that we would lose between \_\_\_\_\_% of the yields of corn, wheat and rice for years after because of the bad weather. The entire world only has enough food to feed the population for \_\_\_\_\_ days unless farmers can produce more food. It is estimated that between \_\_\_\_\_ people worldwide would die of starvation after a nuclear war between Pakistan and India.

He also considered what would happen if more nuclear weapons were used and there was a full-scale nuclear war.

If this happened there would be a **nuclear winter**, with temperatures plunging below Ice Age conditions with no crops being able to grow. \_\_\_\_\_ % of the population would starve.

**Think about the following questions and discuss in groups or pairs:**

Some people have different opinions about a nuclear winter, they argue that the worldwide ash cloud would block the sun less than simulations suggest. **Do you think it is worth the risk?**

Brian Toon said there were things that could be done to prevent a nuclear war and therefore prevent a nuclear winter. **What do you think those things could be?**

## Challenge Emergency Planning

You are a member of COBRA (Cabinet Office Briefing Room A – the government’s emergency response group). You are given an agenda to discuss managing the effects of nuclear winter. There has been a nuclear exchange. Britain was not involved, however the ash cloud has spread globally.

### Working in pairs or groups:

- Decide who has the role of:
  - Prime minister** – chairs the meeting and settles the final decisions
  - Army general** - martial law has been declared so the army is in charge of the police
  - Medical advisor** – responsible for public health and has a background as a doctor
  - Foreign secretary** – manages relations and trade with other countries
- **Plan** how to deal with the following and agree on a **public statement** to address your class:

### Food shortages

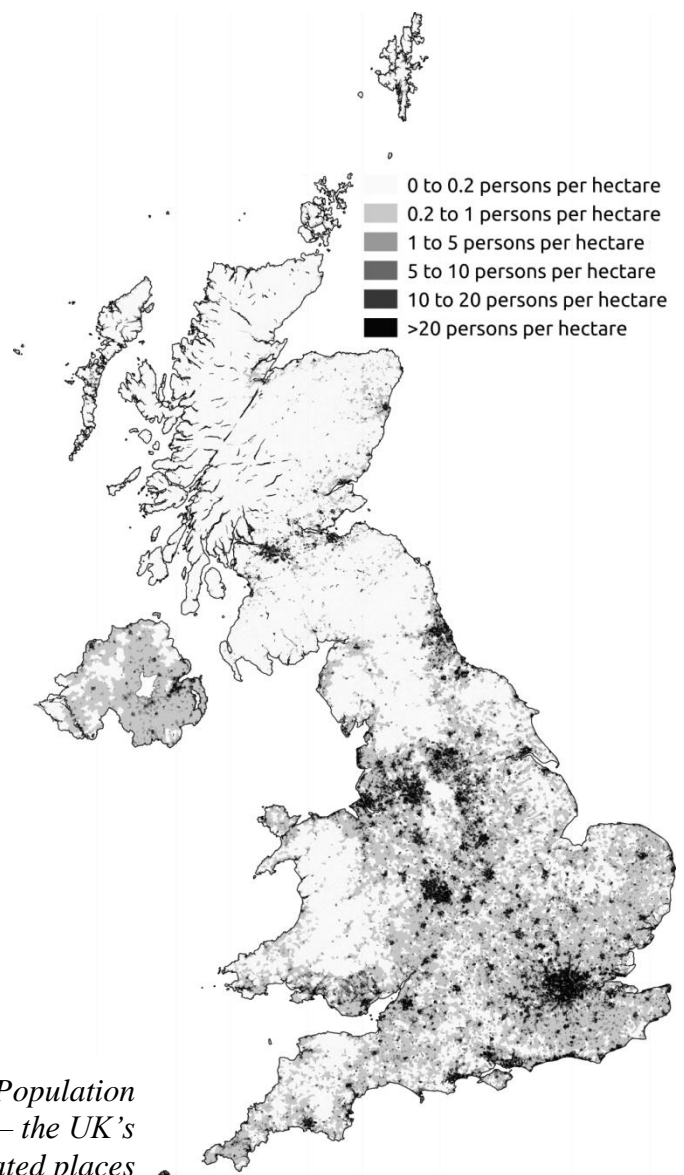
Britain has enough food stored to feed everyone for 15 days after this farming can sustain only 70% of the population.

### Rioting

The general public is aware of the nuclear exchange within hours of it happening because of the media, with a vague understanding of the risks they have taken to the streets in panic.

### Other shortages such as medicine, fuel, power / electricity

Many of these resources are acquired through trade with other nations who are suffering similar disturbances. Without a regular supply how will Britain manage the reserves? Who should receive essential supplies?



**Challenge**

**Nuclear Winter Cartoon**



This cartoon is trying to communicate a message.

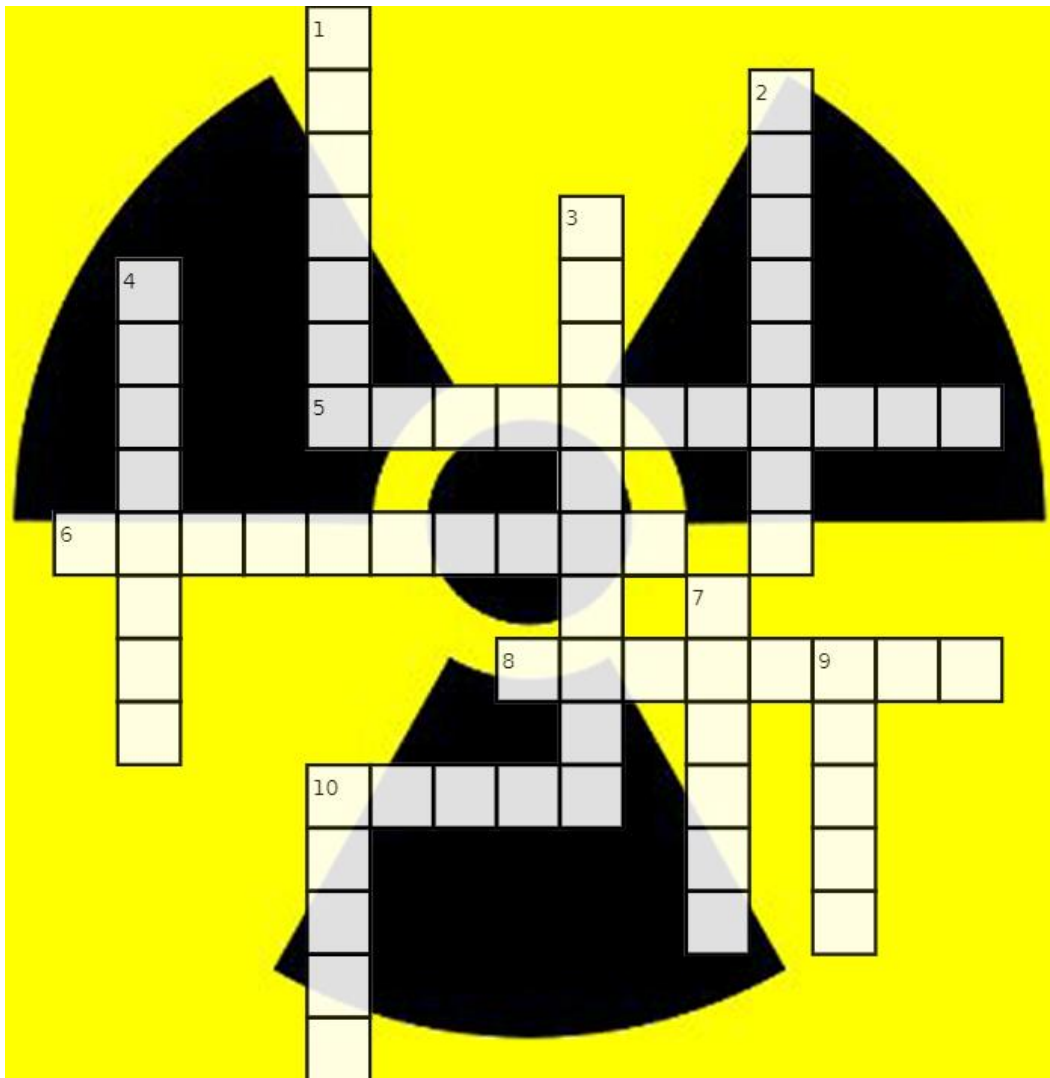
In groups or pairs, discuss the following questions:

- **What do you think the message is?**
- **How effective is the cartoon in communicating the message?**
- **Is it a fair representation of the issue?**



Challenge

Crossword Puzzle



**Across**

- 5. WMD are weapons of mass d\_\_\_\_\_
- 6. A type of illegal WMD
- 8. Armed forces are known as the m\_\_\_\_\_
- 10. A nuclear c\_\_\_\_\_ reaction is a series of nuclear fissions in which splitting one atom leads to the splitting of others. The process may be controlled (nuclear power) or uncontrolled (nuclear weapons).

**Down**

- 1. A nuclear p\_\_\_\_\_ submarine gets its energy to move from a nuclear generator
- 2. D\_\_\_\_\_ uranium is a very hard material used on explosive shells which leaves contamination when used
- 3. Global problem caused by a nuclear winter
- 4. Another type of illegal WMD
- 7. A nuclear w\_\_\_\_\_ is a period of cold and darkness following a nuclear war, caused by smoke and dust in the atmosphere blocking the sun's rays.
- 9. A nuclear a\_\_\_\_\_ submarine has nuclear weapons
- 10. C\_\_\_\_\_ nuclear power industry is involved in generating electricity



**Further Challenge**

**Nuclear Accidents and Incidents**

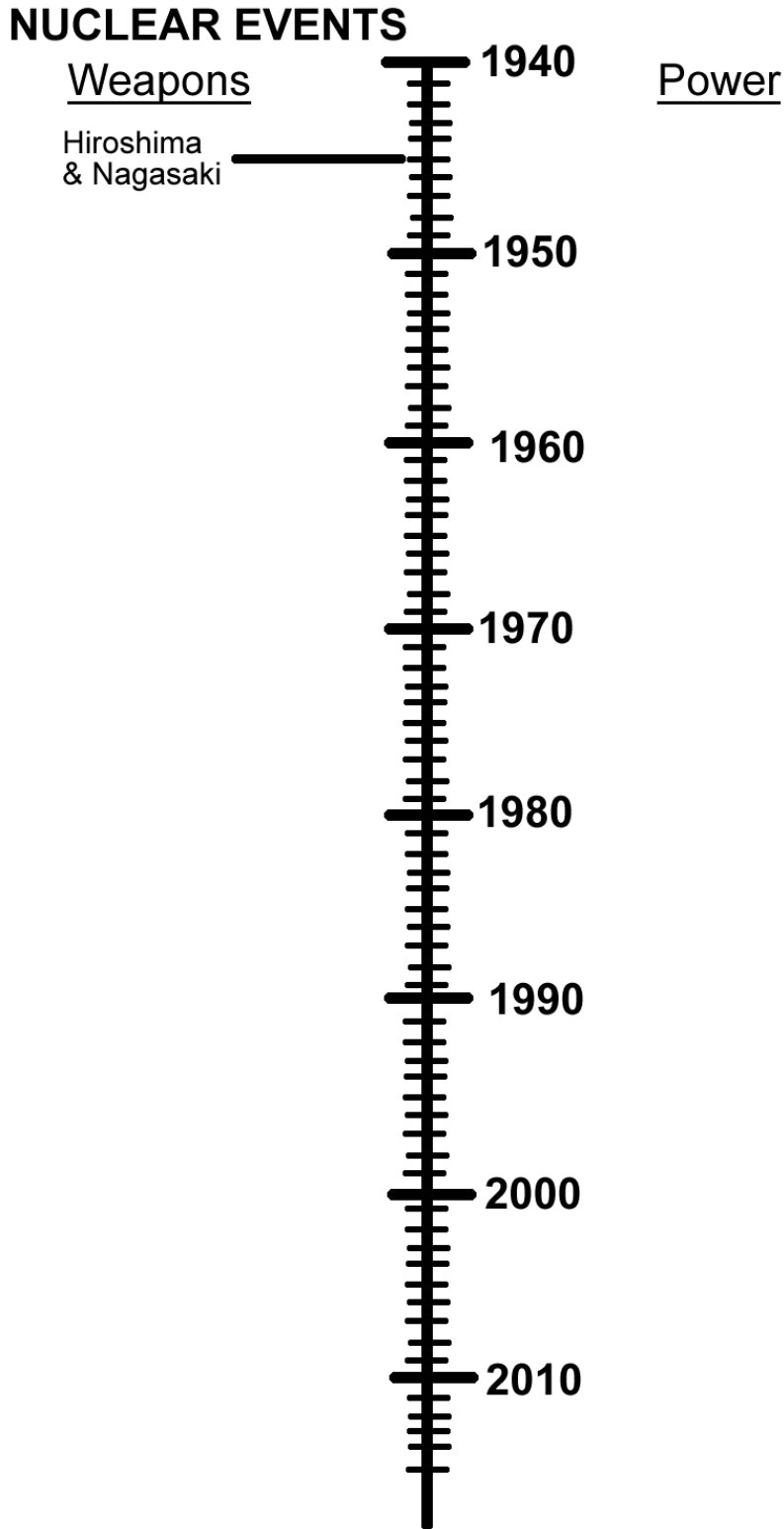
Read the following list of nuclear detonations, accidents and incidents - only a small fraction of the numerous incidents which have happened. Decide which incidents were to do with nuclear **power** (electricity made in a nuclear power station) and which ones were to do with nuclear **weapons**.

- In the table below, mark **W** for weapons and **P** for power
- Write each of the events on the timeline overleaf

<i>Weapons or Power ?</i>	<b>Year</b>	<b>Description</b>
	<b>1945</b>	Hiroshima and Nagasaki, Japan. Both cities destroyed by nuclear bombs.
	<b>1956</b>	A flight of swans nearly led to an attack by the USA on Russia.
	<b>1957</b>	Windscale in England which was a factory for producing nuclear material for weapons. A fire caused radioactive contamination of the surrounding land.
	<b>1962</b>	Cuban Missile Crisis. Russian weapons placed on the island of Cuba greatly increased the risk of nuclear war with USA.
	<b>1968</b>	An aircraft carrying nuclear material crashed on Greenland. This could have led to a nuclear explosion which would have looked like an attack by Russia.
	<b>1979</b>	Three Mile Island, USA. Nuclear material released into the atmosphere because of an accident at a nuclear power station, on the east coast of USA.
	<b>1986</b>	Chernobyl, Ukraine. Radioactive material released because of an accident at a nuclear power plant.
	<b>1995</b>	Norwegian rocket incident. A Norwegian rocket launched to collect weather information was mistaken by Russia as an attack from the USA. The mistake was recognised just in time to stop a counter attack.
	<b>2011</b>	Fukushima, Japan. A civil nuclear power plant damaged by an earthquake and tsunami released radioactive material into the sea and atmosphere.

Further Challenge

Nuclear Accidents and Incidents (contd.)



## Teacher's Notes

### Further Resources & Topics

- Radioactive pollution (civilian)
  - Mining (Uranium mines, Grand Canyon pollution etc.)
  - Processing (Sellafield, Convoys & transportation dangers etc.)
  - Accidents (Chernobyl, Fukushima)
- Radioactive pollution (military)
  - Nuclear Winter (climate change & environmental consequences of nuclear war)
  - Nuclear Testing (Marshall Islands, Semipalatinsk)
  - Leaks & Accidents (Faslane & Convoys)
  - Depleted Uranium (Scottish coastal shelling)
- Civil Nuclear links to Nuclear Weapons
- Climate Change and 'Green' Nuclear power

### **Radioactive pollution (civilian)**

**Mining** - The main radioactive substance in nuclear reactors and nuclear bombs is the element uranium, which is mined in Canada, Russia, Africa and Australia. During the mining process, uranium escapes into the atmosphere and into the ground, where it is spread by water movement. The resulting contamination of air, land and sea will continue for thousands of years.

**Processing** - More uranium escapes when it is separated from its ore, during transportation and when it is included in nuclear reactors and nuclear weapons. After its use in nuclear reactors the nuclear material is treated in reprocessing plants such as Sellafield (formerly Windscale) in Cumbria.

Convoys <https://theferret.scot/safety-mishaps-nuclear-bomb-convoys-record-high/>

**Accidents** - in 1957 a fire at the Windscale/Sellafield site caused widespread atmospheric pollution. The Irish Government has complained and continues to complain about the contamination of the Irish Sea due to the radioactive waste entering it from Sellafield. Radioactive contamination from the 1986 Chernobyl accident spread over 40% of Europe. Scottish sheep were being tested for contamination until 2012.

### **Radioactive pollution (military)**

**Nuclear Tests** – Marshall Islands - [Nuclear "coffin" may be leaking radioactive material into Pacific Ocean, U.N. chief says](#) Semipalatinsk [www.nationalgeographic.com/photography/proof/2017/10/nuclear-ghosts-kazakhstan/](http://www.nationalgeographic.com/photography/proof/2017/10/nuclear-ghosts-kazakhstan/) "This Is What Nuclear Weapons Leave in Their Wake - A remote area of Kazakhstan was once home to nearly a quarter of the world's nuclear testing. The impact on its inhabitants has been devastating."

**Nuclear Bombs** - Two nuclear bombs destroyed the cities of Hiroshima and Nagasaki in 1945. Nuclear weapons cause blast, fire, release of lethal radiation and the dispersal of radioactive material. In the event of nuclear war thousands would die while those who survived would not be able to eat crops from affected areas and would be subject to disease. Homes, hospitals and schools would be destroyed. Food and help could not be sent because transport would also be destroyed.

Environmental and human consequences of nuclear weapons [www.medact.org/project/nuclear-weapons/](http://www.medact.org/project/nuclear-weapons/)

**Faslane** - Channel 4 News report on Faslane radiation leaks: "If this was a nuclear power station it would have been shut down. We've had discharges that would be totally intolerable in a civil nuclear plant."

[www.channel4.com/news/articles/science\\_technology/radioactive+leaks+from+naval+base/3108267.html](http://www.channel4.com/news/articles/science_technology/radioactive+leaks+from+naval+base/3108267.html)

**Depleted Uranium** - Depleted Uranium (DU) is a by-product of the process that produces enriched uranium for use in nuclear weapons and nuclear power stations. Because it is very hard it is used in the tips of shells containing high explosives to give them more penetrating power. On impact the uranium disperses as fine particles, which can be breathed into the lungs.

[www.nature.com/news/2002/020312/full/news020311-2.html](http://www.nature.com/news/2002/020312/full/news020311-2.html)

[ec.europa.eu/health/scientific\\_committees/environmental\\_risks/docs/scher\\_o\\_123.pdf](http://ec.europa.eu/health/scientific_committees/environmental_risks/docs/scher_o_123.pdf)

[www.theguardian.com/environment/earth-insight/2013/oct/13/world-health-organisation-iraq-war-depleted-uranium](http://www.theguardian.com/environment/earth-insight/2013/oct/13/world-health-organisation-iraq-war-depleted-uranium)

Herald: "MoD 'places' its toxic tank shells in Solway Firth"

<https://www.heraldscotland.com/news/13095462.mod-places-its-toxic-tank-shells-in-solway-firth/>

## **Civil Nuclear links with Nuclear Weapons**

Nuclear energy and nuclear bombs need fuel. The fuel used is either uranium or plutonium. Uranium is mined then processed for it to be used. In civilian nuclear power stations the **controlled** chain reaction in the uranium releases heat which is used to produce steam to drive the turbines that generate electricity. The nuclear technology and expertise used in power stations can be adapted to manufacture nuclear weapons - civilian uranium enrichment facilities can also be used to produce material for nuclear weapons. The **uncontrolled** chain reaction in the weapons grade uranium or plutonium releases a blast wave and heat used to kill and destroy on a massive scale.

**BBC News June 2019** - Nuclear: Energy bills 'used to subsidise submarines' [www.bbc.co.uk/news/science-environment-48509942](http://www.bbc.co.uk/news/science-environment-48509942) "It is clear that the costs of maintaining nuclear submarine capabilities are insupportable without parallel consumer-funded civil nuclear infrastructures."

**No2NuclearPower** [http://www.no2nuclearpower.org.uk/reports/Civil\\_Nukes\\_Proliferation.pdf](http://www.no2nuclearpower.org.uk/reports/Civil_Nukes_Proliferation.pdf)

"**The link between nuclear weapons and civil nuclear power is often denied by the nuclear energy industry.** <https://wiseinternational.org/nuclear-monitor/509-510/link-between-nuclear-energy-and-nuclear-weapons> The spread of nuclear weapons and/or nuclear weapons technology is called nuclear proliferation. The civil nuclear industry is more often than not the source of proliferation. Nuclear proliferation risks will be among us as long as the civil and military nuclear industry continue to exist."

Civil nuclear industry, nuclear weapons [cnduk.org/resources/links-nuclear-power-nuclear-weapons/](http://cnduk.org/resources/links-nuclear-power-nuclear-weapons/)

## **Countries which had civilian nuclear programs that led directly to nuclear weapons...**

[http://core.csu.edu.cn/NR/rdonlyres/Nuclear-Engineering/22-812JSpring2004/DA39D9C3-72E5-426E-840C-712594207E23/0/prolif\\_history.pdf](http://core.csu.edu.cn/NR/rdonlyres/Nuclear-Engineering/22-812JSpring2004/DA39D9C3-72E5-426E-840C-712594207E23/0/prolif_history.pdf) "France's initially civilian nuclear program provided the base of expertise (and some key advocates) for its later dedicated military program"

"Israel's plutonium production reactor and reprocessing plant at Dimona were provided by France, ostensibly for civilian purposes"... "Heavy water was provided by Norway under peaceful use assurances (later violated)"

"**Converting a civilian enrichment plant into a nuclear weapons material facility**" Bulletin of Atomic Scientists <https://thebulletin.org/converting-civilian-enrichment-plant-nuclear-weapons-material-facility>

"Exactly the same machines that produce nuclear fuel can produce weapons material. That is why uranium enrichment technology is inherently dual-use. Any civilian enrichment facility can be used to produce nuclear weapons material. Because of this danger, all nuclear material in civilian enrichment facilities owned by non-nuclear weapons states is under International Atomic Energy Agency (IAEA) safeguards."

## **Opposing view... "Nuclear Energy Programs Rarely Lead to Nuclear Weapons"**

[https://motherboard.vice.com/en\\_us/article/a374p8/nuclear-energy-programs-rarely-lead-to-nuclear-weapons](https://motherboard.vice.com/en_us/article/a374p8/nuclear-energy-programs-rarely-lead-to-nuclear-weapons)

"According to the study's author Nicholas Miller, a nuclear security researcher and assistant professor at Dartmouth College, the reason that nuclear energy programs don't tend to lead to the development of nuclear weapons has to do with improved international scrutiny and surveillance of such programs, as well as political fears of international sanctions. "When a country announces it is pursuing nuclear energy, it's a sign to other nations that maybe they should start paying more attention to what that country is doing"

## **Climate Change and 'Green' nuclear power**

Nuclear power is not 'green' - it doesn't belch smoke but the process of mining uranium releases **high amounts of carbon dioxide** into the environment. Carbon dioxide is also released into the environment when new nuclear power plants are built. Finally, the transport of radioactive waste also causes carbon dioxide emissions.

**Thorium reactors** have been suggested as 'green' reactor technology but this has been questioned: <https://whatisnuclear.com/thorium-myths.html> Thorium molten salt reactors can also make fuel for bombs. Although sometimes suggested as a 'solution' to climate change, a 2019 industry report showed Nuclear power was becoming less successful than renewables in terms of both cost and capacity as its reactors were increasingly seen as less economical and slower to reverse carbon emissions:

[uk.reuters.com/article/us-energy-nuclearpower/nuclear-energy-too-slow-too-expensive-to-save-climate-report-idUKKBN1W909J](http://uk.reuters.com/article/us-energy-nuclearpower/nuclear-energy-too-slow-too-expensive-to-save-climate-report-idUKKBN1W909J)

The debate on using nuclear power to reduce CO2 emissions and address climate change is covered in this **TEDx Debate 'Does the world need nuclear energy?'** with Stewart Brand & Mark Z. Jacobson <https://www.youtube.com/watch?v=UK8ccWSZkic>