

Timeline and glossary

Nuclear timeline, 1945–1963

16 July 1945	Alamogordo, New Mexico, USA	United States conducts first-ever nuclear test, codenamed 'Trinity.'
6 August 1945	Hiroshima, Japan	US aircraft <i>Enola Gay</i> drops the atomic weapon 'Little Boy' on Hiroshima, killing 80,000 people immediately and an estimated 100,000 people within six months.
9 August 1945	Nagasaki, Japan	US aircraft <i>Bockscar</i> drops the atomic weapon 'Fat Man' on Nagasaki, killing 70,000 people immediately and tens of thousands in following months.
30 June 1946	Bikini Atoll, Marshall Islands	Under Operation Crossroads, United States conducts the first of two atomic tests at Bikini Atoll in the Marshall Islands. 'Able' and 'Baker' are the first of 67 atmospheric tests in the Marshall Islands between 1946–1958.
6 August 1948	Hiroshima, Japan	Hiroshima's first Peace Festival.
29 August 1949	Semipalatinsk, Kazakhstan	USSR conducts first atomic test RDS-1 in Operation <i>Pervaya molniya</i> (Fast lightning), dubbed 'Joe-1' by United States.
1950–1954	Korean peninsula	United States, Britain and Australia, under a United Nations mandate, join military operations in Korea following clashes between forces from the south and north of Korea. The Democratic People's Republic is backed by the newly created People's Republic of China.
3 October 1952	Monte Bello Islands, Western Australia	Under Operation Hurricane, United Kingdom begins its nuclear testing program in Australia with a 25 kiloton atomic test.

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1 November 1952	Bikini Atoll, Marshall Islands	United States conducts its first hydrogen bomb test, codenamed 'Mike' (10.4 megatons) as part of Operation Ivy.
12 August 1953	Semipalatinsk, Kazakhstan	USSR tests first hydrogen bomb RDS-6 ('Joe-4').
15–27 October 1953	Emu Field, South Australia	Under Operation Totem, United Kingdom conducts two atomic tests ('Totem One' with an 8 kiloton yield and 'Totem Two' with 10 kilotons) in the South Australian desert.
1 March 1954	Bikini Atoll, Marshall Islands	United States conducts hydrogen bomb test at Bikini Atoll, codenamed 'Bravo'. The test showers radioactive fallout over the country, especially northern atolls and Japanese fishing vessel <i>Lucky Dragon</i> (six H-bomb tests under Operation Castle between February and May).
6–8 August 1955	Hiroshima, Japan	First World Conference against Atomic and Hydrogen Bombs held on anniversary of atomic attacks.
16 May and 19 June 1956	Monte Bello Islands, Western Australia	United Kingdom conducts two atomic tests ('Mosaic One' – 15 kilotons and 'Mosaic Two' – 60 kilotons) off coast of Western Australia under Operation Mosaic.
June 1956	Christmas Island (Kiritimati), British Gilbert and Ellice Islands Colony	United Kingdom begins construction of airstrip, military encampment and scientific bunkers to prepare for Operation Grapple hydrogen bomb tests.
27 September–22 October 1956	Maralinga, South Australia	United Kingdom conducts four atomic tests ('One Tree', 'Marcoo', 'Kite', 'Breakaway') in South Australian desert under Operation Buffalo.
October–December 1956	Egypt and Hungary	Cold War political tensions rise following United Kingdom, French and Israeli attack on Egypt during Suez crisis, and crushing of Hungarian uprising by Soviet troops.
9 January 1957	London, England	United Kingdom Prime Minister Sir Anthony Eden resigns over Suez crisis; replaced the next day by Harold Macmillan, who restructures UK strategic, colonial and nuclear policy.
15 May 1957	Malden Island, British Gilbert and Ellice Islands Colony	Under Operation Grapple, United Kingdom conducts Grapple 1 'Short Granite' atomic test (0.3 megaton).
31 May 1957	Malden Island, British Gilbert and Ellice Islands Colony	United Kingdom conducts Grapple 2 'Orange Herald' atomic test (0.72 megaton).

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19 June 1957	Malden Island, British Gilbert and Ellice Islands Colony	United Kingdom conducts Grapple 3 'Purple Granite' atomic test (0.2 megaton).
July 1957	London, England	After failure to reach megaton range at Malden Island tests, UK Cabinet agrees to proceed with further hydrogen bomb tests, but relocated to Christmas Island. Further atomic trigger tests to continue in Australia to support H-bomb program.
14 September–9 October 1957	Maralinga, South Australia	Under Operation Antler, United Kingdom conducts three atomic tests ('Tadje', 'Biak' and 'Taranaki') between 0.9 and 26.6 kilotons in South Australian desert.
4 October 1957	Tyuratam missile range, Kazakhstan	USSR launches Sputnik 1, the first artificial satellite to orbit the earth, highlighting Soviet technological advances and exacerbating Cold War fears in the West.
10 October 1957	Cumberland, United Kingdom	Fire at the Windscale nuclear reactor releases radioactive contamination across the United Kingdom and Europe. Windscale is being used to produce tritium for the UK H-bomb program.
8 November 1957	Christmas Island (Kiritimati), British Gilbert and Ellice Islands Colony	United Kingdom restarts Operation Grapple on Christmas Island, with Grapple X hydrogen bomb test (1.8 megatons).
31 March 1958	Moscow, USSR	USSR suspends its nuclear test program, in lead up to negotiations for a nuclear test ban treaty.
28 April 1958	Christmas Island (Kiritimati), British Gilbert and Ellice Islands Colony	United Kingdom conducts Grapple Y hydrogen bomb test (2.8 megatons), with radioactive fallout over Christmas Island and naval task force.
28 April–18 August 1958	Enewetak Atoll, Marshall Islands and Johnston Atoll	United States begins Operation Hardtack, a series of 35 atomic and hydrogen bomb tests on Bikini and Enewetak atolls, with two high-altitude detonations ('Teak' and 'Orange') from rockets launched from Johnston Atoll.
22 August 1958	London, England	United States and Britain announce one-year moratorium of nuclear tests to commence on 31 October (United Kingdom conducts four more tests before deadline).
22 August 1958	Christmas Island (Kiritimati), British Gilbert and Ellice Islands Colony	United Kingdom conducts Grapple Z atomic test codenamed 'Pennant' (24 kilotons), with the bomb on a tethered balloon.

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2 September 1958	Christmas Island (Kiritimati), British Gilbert and Ellice Islands Colony	United Kingdom conducts Grapple Z hydrogen bomb test codenamed 'Flagpole' (1 megaton).
11 September 1958	Christmas Island (Kiritimati), British Gilbert and Ellice Islands Colony	United Kingdom conducts Grapple Z hydrogen bomb test codenamed 'Haliard' (0.8 megaton).
23 September 1958	Christmas Island (Kiritimati), British Gilbert and Ellice Islands Colony	United Kingdom conducts Grapple Z atomic test codenamed 'Burgeon' (25 kilotons), with the bomb on a tethered balloon.
October–December 1958	Geneva, Switzerland	United States, United Kingdom and USSR hold talks in Geneva to establish a moratorium for nuclear testing.
13 February 1960–25 April 1961	Reggane, (French) Algeria	France begins its nuclear weapons program with four atmospheric atomic tests in the Sahara desert, codename 'Gerboise'.
7 May 1960	Nevada, USA	United States announces resumption of underground nuclear testing.
30 August 1961	Moscow, USSR	USSR announces it will end a three-year moratorium on atmospheric nuclear testing, and tests restart the next day.
30 October 1961	Severny Island, Novaya Zemlya	USSR tests the most powerful thermonuclear weapon ever detonated, at 58 megatons. The world's largest hydrogen bomb (RDS-220 code name 'Vanya' or 'Tsar Bomba') is the most powerful man-made explosion in human history.
7 November 1961	In Eker, (French) Algeria	France begins series of 13 underground atomic tests in the Hoggar Massif at In Eker in the Sahara desert, which continue after the Evian peace accords that end Algeria's independence struggle.
January 1962	Washington DC, USA	United States announces resumption of nuclear testing in the Pacific, to begin on Christmas Island in April.
22 April–11 July 1962	Christmas Island (Kiritimati), British Gilbert and Ellice Islands Colony and Johnston Atoll	In Operation Dominic 1, United States conducts 24 atmospheric nuclear tests using United Kingdom infrastructure on Christmas Island, combined with one successful rocket launch from Johnston Atoll (the 'Starfish Prime' high-altitude nuclear test on 9 July under Operation Fishbowl).

2 October– 3 November 1962	Johnston Atoll	United States conducts further nuclear tests in Operation Dominic. Nuclear warheads on rockets are fired from Johnston Island for high-altitude detonation (with several failed launches). Two submarine-launched missiles with nuclear warheads are test-fired. Five nuclear weapons are also dropped from aircraft for air bursts in the vicinity of Johnston Island.
14–28 October 1962	Worldwide	The Cuban Missile Crisis threatens global nuclear warfare, as John F. Kennedy and Nikita Khrushchev face off over nuclear missile deployments in Cuba and Turkey.
5 August 1963	Moscow, USSR	United States, Soviet Union and United Kingdom sign Partial Test Ban Treaty.

Over 50 years, the Western powers used the Pacific region as a laboratory for nuclear testing.

Between 1946 and 1958, the United States conducted 67 atomic and hydrogen bomb tests at Bikini and Enewetak atolls in the Marshall Islands. In 1962, there were 24 further US atmospheric nuclear tests at Christmas (Kiritimati) Island, as well as five atmospheric airbursts and nine high-altitude nuclear tests, with warheads launched on missiles from Johnston (Kalama) Atoll and submarines.

Britain tested nuclear weapons in Oceania between 1952 and 1958. There were 12 atomic tests at the Monte Bello Islands, Maralinga and Emu Field in Australia (1952–57). These were followed by nine hydrogen and atomic bomb tests in 1957–58 at Malden Island and Christmas (Kiritimati) Island in the British Gilbert and Ellice Islands Colony (GEIC)—today the Republic of Kiribati.

France conducted four atmospheric nuclear tests at Reggane and 13 underground tests at In Eker in the Sahara desert in Algeria between 1960 and 1966. France then moved its nuclear test sites to the South Pacific. From 1966 to 1996, France conducted 193 atmospheric and underground tests at Moruroa and Fangataufa atolls in French Polynesia.

Glossary of acronyms and abbreviations

A-bomb	Atomic bomb
AEC	Atomic Energy Commission
AFOAT-1	Air Force Office of Atomic Energy (US)
AMGi	Municipal Archives of Girona
ANU	The Australian National University
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
AWRE	Atomic Weapons Research Establishment
BBC	British Broadcasting Corporation
BNTVA	British Nuclear Test Veterans Association
BPC	British Phosphate Commission
Bq	Becquerel
CIA	Central Intelligence Agency
CND	Campaign for Nuclear Disarmament
DAC	Direct Action Committee Against Nuclear War
DSC	Distinguished Service Cross
DSO	Distinguished Service Order
DTRIAC	Defense Threat Reduction Information Analysis Center
ED	Efficiency Decoration
FCO	Foreign and Commonwealth Office
FRNVR	Fiji Royal Naval Volunteer Reserve
FRS	Fellow of the Royal Society
GCMG	Knight Grand Cross, Order of St Michael and St George
GEIC	Gilbert and Ellice Islands Colony
H-bomb	Hydrogen bomb
HMAS	Her Majesty's Australian Ship
HMG	Her Majesty's Government
HMNZS	Her Majesty's New Zealand Ship
HMS	Her Majesty's Ship
ICJ	International Court of Justice

ICRP	International Commission on Radiological Protection
IGY	International Geophysical Year
ISD	Intelligence and Security Department, UK Colonial Office
JARS	<i>Johnston Atoll Radiological Survey</i>
JTF7	Joint Task Force 7
KBE	Knight Commander of the Most Excellent Order of the British Empire
KCVO	Knight Commander of the Royal Victorian Order
KStG	Knight of the Order of St John
mFISH	multicolour fluorescent in situ hybridisation
MI5	British domestic intelligence agency
MI6	British overseas intelligence agency (also known as SIS)
MINDD	Marshall Islands Nuclear Documentation Database
MN	micronucleus
MoD	Ministry of Defence
MP	Member of Parliament
MSD	Meritorious Service Decoration (Fiji)
mSv	millisievert
MV	Motor Vessel
NAAFI	Navy, Army and Air Forces Institute
NCANWT	National Council for the Abolition of Nuclear Weapons Tests
NCCF	Nuclear Community Charity Fund
NCT	Nuclear Claims Tribunal
NFIP	Nuclear Free and Independent Pacific
NLA	National Library of Australia
NRPB	National Radiological Protection Board
NZ	New Zealand
NZDF	New Zealand Defence Force
NZNTVA	New Zealand Nuclear Test Veterans Association
NZRSA	New Zealand Returned Services Association

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OAM	Medal of the Order of Australia
OBE	Order of the British Empire
OM	Order of Merit
ONZM	Officer of the New Zealand Order of Merit
PAMBU	Pacific Manuscripts Bureau
PC	Privy Council of the United Kingdom
PCC	Pacific Conference of Churches
PCRC	Pacific Concerns Resource Centre
PPU	Peace Pledge Union
QFE	Quartz Fibre Electroscope
QSM	Queen's Service Medal
RAAF	Royal Australian Air Force
RAF	Royal Air Force
RFMF	Royal Fiji Military Forces (pre-1987)/Republic of Fiji Military Forces (post-1987)
RMI	Republic of Marshall Islands
RN	Royal Navy
RNZAF	Royal New Zealand Air Force
RNZN	Royal New Zealand Navy
RVS	Royal Voluntary Service
SCAP	Supreme Command for the Allied Powers
SEC	Safety and Ecology Corporation Ltd
SIS	Security Intelligence Service
SPAL	South Pacific Air Lines
SPREP	South Pacific Regional Environmental Program
TT	Troop transport
TTPI	Trust Territory of the Pacific Islands
UK	United Kingdom
UKAEA	United Kingdom Atomic Energy Authority
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization

US	United States
USDTRA	United States Defense Threat Reduction Agency
USS	United States Ship
USSR	Union of Soviet Socialist Republics
WRA	Woomera Rocket Area
WVS	Women's Voluntary Service

A note on terminology

As I read archival documents from the 1950s, I had the mental image of some poor British squaddie typing out long lists of Fijian soldiers deployed for Operation Grapple, and cursing when he got to Sapper Silivakadua Naikawakawakawavesi. There are quite a few mistakes in the files, from the days before electric typewriters and correcting fluid.

Beyond obvious errors, the archival documents cited in this book use a variety of spellings, such as Eniwitok instead of Enewetak for the nuclear test site in the Marshall Islands. There are also many examples where Europeans have used different names for atolls than those used by indigenous communities, such as Penrhyn/Tongareva, Fanning/Tabuaeran or Johnston/Kalama. For consistency throughout the book, I have retained the name 'Christmas Island', in spite of local usage. The current name in the i-Kiribati language of the Republic of Kiribati is 'Kiritimati', while Fijians spell Christmas as 'Kirisimasi'.

This book will not go into detailed analysis of the different prototypes for British atomic and hydrogen bombs, nor provide complete data on the types of radiation generated during the Grapple nuclear detonations—the footnotes provide a number of sources for readers interested in greater technical detail.

However, for a general audience, here are a few brief definitions of terms used in the book:

Atomic weapons rely on nuclear fission, where the nucleus of uranium or plutonium splits into lighter elements, instantly releasing massive amounts of energy. A nuclear detonation differs from conventional explosives due to the generated heat, blast and especially radiation.

In contrast to atom bombs, **thermonuclear** or **hydrogen weapons** rely instead on nuclear fusion. Some early hydrogen bombs in the 1950s, using a mixture of tritium and deuterium, relied on **atomic triggers** to generate the massive heat and pressure required start the fusion process.

The explosive **yield** of a nuclear weapon is measured in **kilotons** (**kt**, equivalent to 1,000 tons of TNT explosive) or **megatons** (**mt**, 1,000,000 tons equivalent). The bomb that destroyed Hiroshima was only 12 kt, whereas larger thermonuclear or hydrogen bombs have an explosive power greater than 1 megaton.

Fallout is tiny particles of dirt, weapon debris, fission products or other substances contaminated with radioactivity. These particles are spread into the atmosphere following a nuclear explosion, then return to earth, especially through rainfall. Fallout can be blown for some distance by atmospheric or stratospheric winds.

Some nuclear detonations are fired from a tower or low-level balloon and are defined as a **ground burst**, generating extensive radioactive fallout. Other tests are **air bursts**, detonated at higher altitudes in an attempt to limit the amount of irradiated soil and debris.

Unstable atoms have either an excess of energy or mass (or both). In order to reach a stable state, they release that extra energy or mass in the form of **radiation**. **Ionising radiation** describes the particles and electromagnetic radiations that have sufficient energy to cause ionisation as they interact with matter.

Alpha particles have little penetrating power, and can be blocked by a barrier as thin as a sheet of paper. However, they can cause significant cell damage and potential health risks if ingested or inhaled, because of the large amounts of energy deposited in short distances in tissues. **Beta particles** have slightly more penetrating power, but can be stopped by shielding from metal such as aluminium. In contrast, **gamma radiation** is penetrating electromagnetic radiation that can pass through most shielding (though stopped by dense materials such as lead or thick concrete).

There are different units of measurement for radiation.

First, the activity of radioactive material is the rate at which radioactive decay takes place. It is measured in **Becquerels (Bq)**, an international standard unit where 1 Bq is defined as one disintegration per second.

Second, measurements that reflect the different amounts of radiation energy absorbed by a mass of material are measured in **rad** or **gray (Gy)**.

Third, other units measure the relative biological damage in the human body. In the 1950s, many countries used the measurement **rem (R)**, but today, the **sievert (Sv)** is the standard unit to measure the health effect of low levels of ionising radiation on the human body. Small doses of radiation are measured in **millisievert (mSv)**.

As a rough guide, 1 rad = 0.01 Gy = 10 mGy and, similarly, 1 rem = 0.01 Sv = 10 mSv.

There is no accepted threshold below which there is no risk of cancer induction. The risk diminishes with a diminishing dose, but is not eliminated. Risk is cumulative over time with the dose. Regulatory dose limits reflect upper permitted (although not advisable) thresholds of exposures by workers and members of the public. For example, in many countries the legal limit for radiation exposure by nuclear workers is 50 mSv in any one year and 20 mSv per annum averaged over five years (by way of comparison, the average natural background radiation in the United States is 2.6 mSv). An acute radiation dose of 500 mSv or more can begin to cause symptoms of radiation poisoning.

Half-life is the time in which radioactivity will decline to half its initial value through decay. Some radioactive isotopes are long-lasting, such as **plutonium-239** with a half-life of 24,400 years. Other isotopes have relatively short half-lives, but can affect people's health when they are exposed to high-level doses in a short period (such as the way **radioactive iodine-131**, with a half-life of just eight days, which can be rapidly absorbed by the thyroid gland, poses a particular threat to children).

Ionisation in the human body may cause **cellular damage** that leads to the death of a cell, or the cell may be damaged in such a way that it cannot reproduce or fulfil its original function.

Where there is DNA damage in the nucleus of the cell, damaged cells may continue to reproduce and develop into **cancer**, after an interval (latent period) from a few years to many decades.

There is also a documented association between exposure to ionising radiation and adverse impacts including, but not limited to, **reproductive health** including effects on the developing embryo and foetus; **cardiovascular diseases**; **cataracts**; and **immunological diseases**.

This text is taken from *Grappling with the Bomb: Britain's Pacific H-bomb tests*, by Nic Maclellan, published 2017 by ANU Press,
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