Introduction

GRO NYSTUEN AND STUART CASEY-MASLEN

Unlike biological and chemical weapons – the other 'weapons of mass destruction' (WMDs)[1] – nuclear weapons are not subject to a specific prohibition under international law. The 1968 Nuclear Non-Proliferation Treaty (NPT)[2] bans the possession and production of nuclear weapons by all non-nuclear weapon states that are party to the NPT, but it does not impose a prohibition on the use of nuclear weapons, and it is unspecific when it comes to disarmament obligations. In contrast, the other WMD treaties prohibit the possession, production and transfer of biological and chemical weapons, respectively,[3] and oblige states parties to destroy all stockpiles within specific timelines.[4] Given the assumed larger potential for harm and destruction that use of nuclear weapons could cause compared to other WMDs, this legal situation seems difficult to comprehend. In fact, despite the inherently dangerous nature of nuclear weapons, the fabric of the world's security politics as it has evolved since 1945 (including the significant link between nuclear weapons and the five permanent members of

[1] See the 1972 Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction (1972 Biological Weapons Convention), London, Moscow, and Washington DC, 10 April 1972, in force 26 March 1975, 1015 UNTS 163; and the 1992 Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on their Destruction (1992 Chemical Weapons Convention), Geneva, 3 September 1992, in force 29 April 1993, 1974 UNTS 45.

[2] 1968 Treaty on the Non-Proliferation of Nuclear Weapons, London, Moscow, and Washington DC, 1 July 1968, in force 5 March 1970, 729 UNTS 161.

[3] It should be noted that the text of Article I of the 1972 Biological Weapons Convention itself does not explicitly prohibit use. The Convention's Review Conference has, however, specified that use of biological weapons 'is effectively a violation of Article I'. See, e.g. Final Document of the Fourth Review Conference, UN Doc. BWC/CONF/.IV/9 (25 November–6 December 1996). Moreover, the 1925 Geneva Gas Protocol already outlawed the use of bacteriological methods of warfare.

[4] In September 2013 Syria adhered to the 1992 Chemical Weapons Convention, but in an agreement forged between the Russian Federation and the United States was allowed only one year for the destruction of its huge chemical weapons stockpiles. See, e.g., 'Syria's chemical weapons stockpile', BBC, 20 September 2013, available at: www.bbc.co.uk/news/world-middle-east-22307705. Of UN member states, only Israel and Myanmar still have to ratify the Convention, while Angola, the Democratic People's Republic of Korea (DPR Korea), Egypt and South Sudan have neither signed nor acceded to it.

the Security Council) has made it very difficult to discuss nuclear weapons as weapons rather than as an overpowering political and security issue.

Many international legal rules do, however, apply to nuclear weapons, their unique political status notwithstanding. Some apply explicitly, such as the NPT and treaties on nuclear weapon-free zones. A number of other customary and conventional international legal rules apply generally or have an impact on use, possession, testing, transfer or production of nuclear weapons. These rules are the subject of this book. Before embarking on the legal discussions, however, it may prove useful to take a closer look at the more factual aspects of nuclear weapons. This introduction will proceed with an overview of the functioning and types of nuclear weapons, and a short history of use and testing of nuclear weapons and estimated stockpiles of nuclear weapons, before providing an overview of the layout of the book.

The functioning and types of nuclear weapons

A nuclear weapon[5] is an explosive device whose destructive force results from either nuclear fission chain reactions or combined nuclear fission and fusion reactions.[6] Nuclear weapons whose explosive force results exclusively from fission reactions are commonly referred to as atomic bombs,[7] while those that derive much or most of their energy in nuclear fusion reactions are termed thermonuclear weapons (or hydrogen bombs).[8]

[5] The precise date of origin of nuclear weapons is the subject of debate. Bernstein suggests that 3 March 1939, when two scientists first observed traces of 'prompt' neutrons (excess neutrons that are shed when uranium is fissioned), was the date when an atomic bomb first seemed a real possibility. J. Bernstein, *Nuclear Weapons: What You Need to Know* (Cambridge University Press, 2010), p. 74. Other key dates are 24 December 1938, when two scientists – one man, one woman – worked out how fission worked, reportedly while sitting on a tree trunk, and 2 December 1942, when a nuclear reactor being built by the Project was made to go critical for 28 minutes. *Ibid.*, pp. 112–14. See also B. Cameron Reed, *The Physics of the Manhattan Project* (Heidelberg/Dordrecht/London/New York: Springer, 2010).

[6] For details of the science behind and use of nuclear weapons, see, e.g., Bernstein, *Nuclear Weapons*; J. Cirincione, *Bomb Scare: The History and Future of Nuclear Weapons* (New York, Chichester, West Sussex: Columbia University Press, 2008).

[7] This is so even though the energy that is released in an atomic bomb comes from the nucleus of the atom, as it does in combined fission and fusion weapons.

[8] This is because these weapons rely on fusion reactions between isotopes of hydrogen. Research has been conducted into the possibility of developing pure fusion bombs: nuclear weapons consisting of fusion reactions without the need for a fission bomb to initiate them. Pure fusion weapons would create significantly less nuclear fallout than other thermonuclear weapons, because they would not disperse fission products. In 1998 the US Department of Energy divulged that it had, in the past, 'made a substantial investment' with a view to developing pure fusion weapons, but affirmed that the USA 'does not have and is not developing a pure fusion weapon', asserting that '[n]o credible design for a pure fusion weapon resulted' from that investment. US Department of Energy, 'Restricted data

In fission weapons, a mass of fissile material (enriched uranium or plutonium) is turned into a supercritical mass,[9] either by shooting one piece of subcritical material into another (called the 'gun' method), or by using chemical explosives to compress a subcritical sphere of material into many times its original density (the 'implosion' method).[10] Fission weapons produce explosive yields ranging from the equivalent of around one ton of TNT[11] to 500,000 tons (500 kilotons) of TNT. The detonation of any nuclear weapon is accompanied by a blast of radiation. Fission also produces radioactive debris, more commonly known as fallout.

A thermonuclear weapon uses the heat generated by a fission bomb to compress and ignite a nuclear fusion stage.[12] Thus, fission is still required to trigger the fusion reactions, and the fusion reactions can themselves trigger additional fission reactions. Thermonuclear weapons typically have a far higher explosive yield than do fission weapons, in the range of megatons rather than kilotons.[13] Fusion reactions do not create fission products, but because all thermonuclear weapons contain at least one fission stage, and many high-yield thermonuclear devices also have a final fission stage, thermonuclear weapons can generate at least as much nuclear fallout as fission-only weapons. A 'neutron' bomb, however, is a thermonuclear weapon that yields a relatively small explosion but a large amount of neutron radiation.[14] A neutron bomb could be used to inflict

declassification decisions, 1946 to the present (RDD-8)', 1 January 2002, available at: www.fas.org/sgp/othergov/doe/decl/rdd-8.pdf.

9 This is the amount of material needed to start a nuclear chain reaction.

10 The implosion method is only possible if the fissile material is plutonium. The scientist Richard Tolman first suggested the method in the summer of 1942, but the idea was not followed through at the time. Bernstein, *Nuclear Weapons*, p. 122.

11 2,4,6-trinitrotoluene, whose explosive yield is the standard measure of strength of bombs and explosive devices.

12 In nuclear fusion two or more atomic nuclei collide at very high speed and join to form a new type of atomic nucleus.

13 'Greenhouse George', fired by the USA in Nevada in May 1951, was the first fusion nuclear weapon to be detonated. Russia detonated a hydrogen bomb in 1952, the UK in 1955, China in 1967 and France in 1968. The largest nuclear explosion ever is believed to be Russian in origin – its explosive yield amounted to 50 megatons. The largest US nuclear detonation, which was equivalent to 15 megatons of TNT, occurred on Bikini Atoll in May 1954. The explosion was far larger than expected and the resulting radiation poisoned the crew of a Japanese fishing boat, leading to an international outcry. Bernstein, *Nuclear Weapons*, pp. 217, 222.

14 BBC, 'Neutron bomb: Why "clean" is deadly', 15 July 1999, available at: http://news.bbc.co.uk/2/hi/science/nature/395689.stm. According to the BBC, research into the neutron bomb began seriously in the 1970s when military scientists in the USA sought to reduce the amount of blast produced by thermonuclear devices and increase the amount of gamma radiation emitted. Some of the lead work in the field is said to have been carried out in a French atmospheric detonation in 1967. The USA wanted to develop a nuclear weapon that would allow it to wipe out a Soviet army as it invaded Western Europe but leave towns and cities largely intact.

massive casualties while leaving infrastructure mostly intact and creating a minimal amount of fallout.

Surrounding a nuclear weapon with materials such as cobalt-60[15] or gold-98 would create a weapon known as a salted bomb. This device would produce exceptionally large quantities of radioactive contamination. A salted bomb should not be confused with a 'dirty bomb', an ordinary chemical explosive device containing radioactive material that is spread over the area when the device explodes. A salted bomb would contaminate a much larger area than a dirty bomb.

Antimatter has been considered as a trigger mechanism for nuclear weapons or even as a weapon in itself, at least in theory.[16] If electrons or protons collide with their antimatter counterparts, they annihilate each other. In so doing, they unleash more energy than any other known energy source, even thermonuclear weapons: the energy from colliding positrons and antielectrons is said to be 10 billion times that of high explosives. Unlike standard nuclear weapons, such 'positron' bombs could eject an extremely hazardous burst of gamma radiation that could kill massive numbers of people without ejecting radioactive fallout. There is, however, a huge obstacle to any positron bomb: the difficulty of producing antimatter in large enough quantities.[17]

Use and testing of nuclear weapons

In 1939 the Nobel Prize-winning scientist Niels Bohr[18] informed the United States that the Germans had split the atom. The fear that the Nazis could

[15] In 1957 in Australia, the UK tested 'Pixie', a small diameter implosion system with a plutonium core. The test later became notorious because of the experimental use of cobalt metal pellets as a test diagnostic for measuring yield. Discovery of (mildly) radioactive cobalt pellets around the test site later gave rise to rumours that the British had been developing a cobalt bomb radiological weapon. (A radiological weapon is any weapon designed to spread radioactive material with intent to kill.)

[16] See, e.g., K. Davidson, 'Air Force pursuing antimatter weapons', *San Francisco Chronicle*, 4 October 2004, available at: www.sfgate.com/science/article/Air-Force-pursuing-antimatter-weapons-Program-2689674.php. Another possibility is an antimatter-powered 'electromagnetic pulse' that could destroy power grids and communications networks.

[17] The first atoms of antihydrogen – the antimatter counterpart of the simplest atom, hydrogen – were created at the European Organization for Nuclear Research (CERN) in 1995. In 2011 the 'ALPHA' experiment at CERN reported succeeding in trapping antimatter atoms for more than 16 minutes, long enough to begin to study their properties in detail. CERN, 'CERN experiment traps antimatter atoms for 1000 seconds', Press release, 5 June 2011, http://press.web.cern.ch/press-releases/2011/06/cern-experiment-traps-antimatter-atoms-1000-seconds; see also G. B. Andresen *et al.*, 'Confinement of antihydrogen for 1,000 seconds: The ALPHA Collaboration', *Nature Physics* 7 (2011), 558–64.

[18] From 1920 until his death in 1962, Bohr was head of the Institute for Theoretical Physics at Copenhagen University. Recognition of his work on the structure of atoms came with the award of the Nobel Prize for Physics in 1922. 'The Nobel Prize in Physics 1922: Niels Bohr; Niels Bohr – biographical', *Nobelprize.org*, undated but accessed on 12 October 2013 at: www.nobelprize.org/nobel_prizes/physics/laureates/1922/bohr-bio.html.

develop extremely powerful weapons prompted US President Theodore Roosevelt to establish the Manhattan Project[19] in 1941.[20] During the first week of April 1943, in Los Alamos, New Mexico, Robert Serber, assistant to the head of the Project's Los Alamos centre, J. Robert Oppenheimer, delivered a series of lectures summarising what was then known about the design of nuclear weapons. In his first lecture, Serber began: 'The object of the [Manhattan] project is to produce a practical military weapon in the form of a bomb in which the energy is released by a fast-neutron chain reaction in one or more of the materials known to show nuclear fission.'[21] The world's first detonation of a nuclear weapon, the result of their work, occurred just before 5.30 a.m. on 16 July 1945 at MacDonald's Ranch near Alamogordo in New Mexico.[22]

The first nuclear weapon attack occurred on 6 August 1945 over the city of Hiroshima in Japan.[23] According to one commentator, the use of the weapon was also simultaneously a test, as its design 'was considered to be so rudimentary'.[24] 'Little Boy', as the bomb was named, was famously dropped by parachute from the US Boeing B-29 Superfortress bomber aircraft Enola Gay, rendering an explosive yield of some 16 kilotons of TNT when it detonated. The bomb was dropped by parachute and exploded 580 metres (1,900 feet) above the ground.[25] No one knows exactly how many tens of thousands of people died.[26]

19 The project was so named as the US Army Corps of Engineers made responsible for developing the atomic bomb was headquartered on Manhattan Island (at 270 Broadway). W. J. Broad, 'Why they called it the Manhattan Project', *New York Times*, 30 October 2007, available at: www.nytimes.com/2007/10/30/science/30manh.html?pagewanted=all&_r=0. The director of the Project, Leslie Groves, the engineer who designed the Pentagon, reportedly gave it the name. Bernstein, *Nuclear Weapons*, p. 114.

20 PBS, 'People and discoveries: J. Robert Oppenheimer, 1904–1967', undated but accessed on 12 October 2013 at: www.pbs.org/wgbh/aso/databank/entries/baoppe.html.

21 'Manhattan Project history', The Manhattan Project Heritage Preservation Association, Inc., 3 August 2005, available at: www.mphpa.org/classic/HISTORY/H-06c10.htm.

22 See, e.g., R. Serber, *The Los Alamos Primer* (Berkeley: University of California Press, 1992); J. Miller, *Stockpile: The Story Behind 10,000 Strategic Nuclear Weapons* (Annapolis: Naval Institute Press, 2010), p. 1.

23 The initial recommendation by Manhattan Project staff – that of the ancient cultural city of Kyoto – was rejected by the US Secretary of State for War on the basis that it would complicate the post-war relationship with Japan. Miller, *Stockpile*, p. 9.

24 Bernstein, *Nuclear Weapons*, p. 5.

25 W. Wilson, *Five Myths About Nuclear Weapons* (Boston/New York: Houghton Mifflin Harcourt, 2013), p. 32. Ritchie asserts that the yield was closer to 14 kilotons. N. Ritchie, *A Nuclear Weapons-Free World: Britain, Trident, and the Challenges Ahead* (Basingstoke: Palgrave Macmillan, 2012), p. 11. Miller claims it was 15 kilotons. Miller, *Stockpile*, p. 195.

26 The BBC includes on its website claims that between 60,000 and 80,000 people were killed instantly, with the final death toll estimated at 135,000 as a result of radiation poisoning. 'Fact file: Hiroshima and Nagasaki, 6 and 9 August 1945', BBC, updated in March 2012, available at: www.bbc.co.uk/history/ww2peopleswar/timeline/factfiles/nonflash/a6652262.shtml. As one authority notes: 'Chaotic conditions made accurate accounts most difficult. Some victims were vaporized instantly, many survivors were horribly disfigured, and death from radiation was uncertain – it might not claim its victims for days, weeks,

Three days later the United States detonated 'Fat Man', a plutonium bomb with a larger 20-kiloton yield (a 'clone' of the test device of July 1945), 610 metres (2,000 feet) above a suburb of Nagasaki,[27] killing some 74,000 people.[28] The height had been chosen to maximise the blast wave on the ground, while the fallout was distributed in areas far away from 'ground zero'.[29]

The explosion of a nuclear weapon creates phenomenal quantities of heat upon detonation – between 60 and 100 million degrees centigrade.[30] Anyone within a radius of one and a half miles from ground zero and who is unprotected will receive third-degree (full thickness) burns,[31] which will almost certainly be fatal.[32] At Hiroshima, collapsed buildings became tinder for the fires started largely by overturned cooking stoves and a firestorm started. At Nagasaki, fires broke out at many locations. Such fires are common to any high explosives. What is unique about nuclear weapons is the radiation, which occurs at different times. 'Prompt' radiation comes first, soon after the explosion, consisting of neutrons, gamma rays and electrons. Neutron radiation is an especially hazardous form of radiation to humans.[33] In the explosion of a nuclear weapon, the fireball rises, sucking the cooler air below as well as radioactive debris up from the ground. Water drops are extracted from the cooler air to form clouds.[34] Fallout begins one to two hours afterwards and lasts for a day or so.[35]

months, or even years.' 'Counting the dead', *AtomicBombMuseum.org*, available at: http://atomicbombmuseum.org/3_health.shtml.

27 The original target was Kokura, but this was obscured by cloud so the bomb was dropped on nearby Nagasaki, an important port.

28 The BBC reported claims that about 40,000 people were killed instantly and a third of the city was destroyed. The final death toll was calculated as at least 50,000. 'Fact File: Hiroshima and Nagasaki, 6 and 9 August 1945', BBC. The plutonium bomb used against Nagasaki was more powerful than the one used against Hiroshima, but its destructive range was limited by surrounding hills and mountains. Whatever the true figure, the massive loss of life in the bombing of a city was not the largest recorded in human history. A night attack on Tokyo on 9–10 March 1945 is believed to have killed up to 120,000 people or even more. Wilson, *Five Myths About Nuclear Weapons*, p. 32. Miller suggests the figure was closer to 100,000. Miller, *Stockpile*, p. 195.

29 Bernstein, *Nuclear Weapons*, pp. 137–8.

30 *Ibid.*, pp. 171–3. In comparison, the temperature of the surface of the sun is approximately 60,000 degrees centigrade.

31 A burn that destroys both the epidermis and the dermis, often also involving the subcutaneous tissue. *Mosby's Medical Dictionary*, 8th edn (St Louis: Elsevier, 2009).

32 Bernstein, *Nuclear Weapons*, p. 184.

33 Neutron particles are released following nuclear fission of uranium or plutonium. In fact, it is neutrons that trigger the nuclear chain reaction to explode an atomic bomb. The human body contains a large amount of hydrogen, and when neutrons hit the nucleus of hydrogen, the proton causes ionisations in the body, leading to various types of damage. At equivalent absorbed doses, neutrons can cause more severe damage to the body than gamma rays. Radiation Effects Research Foundation, 'Basics about radiation', 2007, available at: www.rerf.jp/radefx/basickno_e/whatis.html.

34 Bernstein, *Nuclear Weapons*, pp. 181–2.

35 *Ibid.*, p. 184.

There were very high levels of short-term mortality in both Hiroshima and Nagasaki, with more than 90 per cent of those within 500 metres of ground zero in both cities dying. At 1.5 kilometres, more than two-thirds were casualties, and about one-third died. Of those at a distance of 2 kilometres, about half were casualties, 10 per cent of whom died. Casualties dropped to approximately 10 per cent at distances over 4 kilometres. Most of those close to ground zero who received high radiation dosages died immediately or during the first day. About one-third of all fatalities occurred by the fourth day; two-thirds by the tenth day; and 90 per cent by the end of three weeks. Four injury phases were discerned following the two attacks:

- During the first two weeks, injuries were mainly burns from rays and flames, and wounds (trauma) from blast and falling structures.
- In the third through eighth weeks, there were symptoms of damage by radioactive rays, for example, loss of hair, anaemia, loss of white cells, bleeding and diarrhoea. Approximately 10 per cent of cases in this group were fatal.
- In the third and fourth months, there was some improvement in burn, trauma, and even radiation injuries. But then came secondary injuries of disfiguration, severe scar formations (keloids), blood abnormalities, sterility (both sexes) and psychosomatic disorders.
- After more than half a century had passed, many after-effects remained: leukaemia; A-bomb cataracts; cancers of the thyroid, breast, lungs and salivary glands; birth defects, including mental retardation, and fears of birth defects in their children; and disfiguring keloid scars.[36]

Whether or not conventional wisdom is correct in holding that the United States' use of nuclear weapons against these two Japanese cities was the critical factor in prompting Japan's unconditional surrender a few days later is contested strongly by Ward Wilson. He argues that the declaration of war by Russia on Japan and Russia's invasion of Japanese territory was far more determinative in the Japanese Emperor's decision that Japan should surrender unconditionally.[37]

The second state after the United States to test a nuclear bomb successfully was Russia, which in 1949 detonated an atomic bomb, made with plutonium as its nuclear material.[38] In 1957 the United Nations established the International Atomic Energy Association (IAEA) as the world's 'Atoms for Peace' organisation within the UN family. The IAEA works with its member states and partners 'to promote safe, secure and peaceful nuclear technologies'.[39] According to the IAEA, its safeguards 'are generally acknowledged as the single credible

[36] 'Counting the dead', *AtomicBombMuseum.org*.
[37] See Wilson, *Five Myths About Nuclear Weapons*.
[38] Miller, *Stockpile*, p. 3.
[39] IAEA, 'About the IAEA: The "Atoms for Peace" Agency', undated but accessed on 12 October 2013 at: www.iaea.org/About/about-iaea.html.

means by which the international community can be assured that nuclear material and facilities are being used exclusively for peaceful purposes. This system functions not only as a confidence building measure, but also as an early warning mechanism.'[40]

In October 1962 the Cuban Missile Crisis brought the world to the brink of all-out nuclear war. Estimates suggested that had the United States struck first, it would still have suffered 100 million casualties, more than half of its 187 million population at the time.[41] The following month, the United States detonated a 10 megaton hydrogen bomb in space, 402 metres (250 miles) above the earth's surface.[42] As a result of Project Starfish, an electron belt was temporarily created that destroyed seven satellites, including the world's first communications satellite.[43] The following year, in August, the United States and the Soviet Union signed the Partial Test-Ban Treaty, prohibiting testing in the atmosphere. In 1966 a Comprehensive Test-Ban Treaty was adopted under United Nations auspices, but it has never entered into force, as it requires every single named state on a list annexed to the treaty to both sign and ratify it.[44]

In 1974 India tested its first nuclear weapon, while in 1998 Pakistan did the same.[45] In October 1986 Mordechai Vanunu, a former Israeli nuclear technician, publicly revealed in a British newspaper, the *Sunday Times*, that Israel had developed nuclear weapons. He was kidnapped in Rome by Israeli intelligence operatives and forcibly returned to Israel where he spent eighteen years in prison, more than half in solitary confinement.[46] The last above-ground test of a nuclear weapon is believed to have occurred in 1980, carried out by China.[47] In October 2006 the Democratic People's Republic of Korea conducted an underground test of a low-yield nuclear device, revealing it had joined the list of nuclear weapon states.[48]

Estimated stockpiles of nuclear weapons

No one knows (or agrees on) exactly how many nuclear weapons, or more pertinently how many nuclear warheads there are in the world.[49] Nine states

[40] IAEA, *IAEA Safeguards Agreements and Additional Protocols: Verifying Compliance with Nuclear Non-Proliferation Undertakings* (Vienna: IAEA, 2011), available at: www.iaea.org/Publications/Booklets/Safeguards3/safeguards0408.pdf, Foreword.

[41] Wilson, *Five Myths About Nuclear Weapons*, p. 73.

[42] Miller, *Stockpile*, p. 4.

[43] Bernstein, *Nuclear Weapons*, p. 178.

[44] As of 1 October 2013, China, DPR Korea, India and Pakistan had not signed the treaty, while Egypt, Iran, Israel and the United States had not ratified it.

[45] Bernstein, *Nuclear Weapons*, p. 5.

[46] M. Asser, 'Vanunu: Israel's nuclear telltale', BBC, 20 April 2004, available at: http://news.bbc.co.uk/2/hi/middle_east/3640613.stm.

[47] Bernstein, *Nuclear Weapons*, p. 4.

[48] Bernstein, *Nuclear Weapons*, p. 7.

[49] See Miller, *Stockpile*; S. N. Kile, 'World nuclear forces', *SIPRI Yearbook 2013* (Oxford University Press, 2013); Ritchie, *A Nuclear Weapons-Free World*, pp. 24–5; 'Get the facts',

Table I.1 *Global stockpiles of fissile material*

State	HEU, tonnes	Non-civilian Pu, tonnes	Civilian Pu, tonnes
Russia	695	128	50.1
USA	604	87	0
France	31	6	57.5
China	16	1.8	0.014
UK	21.2	3.5	91.2
Pakistan	3	0.15	0
India	0.8	5.2	0.24
Israel	0.3	0.84	0
DPR Korea	0	0.03	0
Others	15	0	61
TOTAL	1,390	234	260

are believed to have stockpiled a total of some 17,300 warheads.[50] The Russian Federation has the greatest number, believed to be around 8,500, closely followed by the United States (some 7,700). Far behind them are France (approximately 300), China (approximately 250), the United Kingdom (approximately 225), Pakistan (100–120), India (90–110), Israel (approximately 80) and the Democratic People's Republic of Korea (DPR Korea) (between 6 and 10). Of the total warheads in the world today, the Stockholm International Peace Research Institute (SIPRI) estimates that 4,400 are 'deployed' (i.e. potentially ready for use),[51] including 2,150 by the United States and approximately 1,800 by the Russian Federation.

Significant quantities of fissile material also exist that could be used in a nuclear weapon.[52] According to one estimate,[53] as of January 2013 the global stockpile of highly enriched uranium (HEU)[54] was approximately 1,390 tonnes (see Table I.1). The global stockpile of separated plutonium is about 490 tonnes,

Global Zero, available at: www.globalzero.org/get-the-facts/FAQs; 'Nuclear arsenals', International Campaign to Abolish Nuclear Weapons, available at: www.icanw.org/the-facts/nuclear-arsenals/#.UiROvhY7b_Q; 'China', Nuclear Threat Initiative, available at: www.nti.org/country-profiles/china/. The authors would like to thank Lars Jørgen Røed for his background research on stockpiled nuclear weapons and fissile material, accessed October 2013

50 Wilson claims that the figure is more than 20,000. Wilson, *Five Myths About Nuclear Weapons*, p. 16.

51 According to SIPRI, deployed means warheads placed on missiles or located on bases with operational force. Almost 2,000 are said to be kept in a state of high operational alert. Kile, 'World nuclear forces'.

52 An isotope like uranium-235 is called fissile while an isotope like uranium-238 is called fissionable. Bernstein, *Nuclear Weapons*, p. 56.

53 International Panel on Fissile Materials: Fissile material stocks, 31 July 2013, available at: http://fissilematerials.org. This subsection is based on the data contained therein.

54 Enrichment is the process of separating, for example, uranium-235 from uranium-238.

of which about 260 tonnes is the material in civilian custody.[55] Production of military fissile materials is believed to continue in India, which is producing plutonium and HEU for naval propulsion; Pakistan, which produces plutonium and HEU for weapons; and Israel, which is believed to produce plutonium. DPR Korea has the capability to produce weapons-grade plutonium and HEU. France, India, Japan, Russia and the UK operate civilian reprocessing facilities that separate plutonium from spent fuel of power reactors. China is operating a pilot civilian reprocessing facility. A total of twelve states – Argentina, Brazil, France, Germany, India, Iran, Japan, the Netherlands, Pakistan, Russia, the UK and the United States – operate uranium enrichment facilities. DPR Korea is also believed to have an operational uranium enrichment plant.

The layout of the book

This book discusses nuclear weapons from the perspective of a number of international legal regimes. Starting with the law on the inter-state use of force (*jus ad bellum*), Part I begins by discussing the requirements of necessity and proportionality as well as the concept of threatening use of force. The separation between *jus ad bellum* and *jus in bello* and the rationale for maintaining this separation is also assessed.

Part II deals with the application of international humanitarian law (IHL) to nuclear weapons. The rules on conduct of hostilities including the rules of distinction and proportionality, as well as the prohibition on means of warfare of a nature to cause superfluous injury and unnecessary suffering are discussed with regard to nuclear weapons. The concept of whether threats of use of nuclear weapons might constitute a violation of IHL, and the use of nuclear weapons as a belligerent reprisal, are also discussed.

Part III, on nuclear weapons and international criminal law (ICL), discusses use of nuclear weapons as an act of genocide, a crime against humanity or a war crime. Another topic considered is the potential impact of the discrepancy between the 1998 Rome Statute of the International Criminal Court[56] and IHL when it comes to specific references to prohibited weapons.

Part IV, which deals with international environmental law, first discusses the requirements of IHL regarding protection of the environment. It goes on to discuss various international legal regimes pertaining to the environment and to the different aspects of nuclear weapons. Finally, it assesses the state

[55] Numbers for weapons plutonium for the UK and USA are based on official data. Most numbers for civilian plutonium are based on declarations submitted to the IAEA and reflect the status as of 31 December 2011. Other numbers are non-governmental estimates, often with large uncertainties. HEU amounts are 90 per cent enriched HEU equivalents (with the exception of the number for non-nuclear weapon states). The totals are rounded.

[56] Rome Statute of the International Criminal Court, Rome, 17 July 1998, entry into force 1 July 2002, 2187 UNTS 90.