THE SOCIAL RESPONSIBILITY OF SCIENTISTS

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May 23, 2021

INTRODUCTION[1]

Three major threats to human society

Science and technology have conferred many benefits on human society, but as we start the 21st century, most thoughtful observers believe that our science-driven and information-driven industrial civilization has entered a period of crisis.

All indices are increasing rapidly - population, total wealth, industrial output, rates of scientific discovery, and so on. But it is clear that the total human footprint on the face of nature has become too great. A sixth mass extinction of plants and animals is already in progress, Insects are disappearing, and with them, birds. Tropical rain-forests are being lost at an alarming rate. Ice loss at both poles is increasing. Temperatures worldwide are rising at an accelerating rate because of greenhouse gas emissions. There is a great danger that if immediate and drastic action is not taken, feedback loops will be initiated which will make human efforts to prevent climate change useless. Thus there is a threat of an ecological megacatastrophe, of which catastrophic climate change is a part.

Another serious threat comes from nuclear war. Despite the Treaty on the Prohibition of Nuclear Weapons, which makes them illegal, the nuclear powers retain their weapons and even spend enormous amounts of money "modernizing" them.

A third threat is an extremely widespread famine, which could occur by the middle of the 21st century from a combination of population growth, climate change and the end of the fossil fuel era.

Catastrophic climate change

A major problem with mobilizing the political will needed to take strong action to prevent the catastrophe is a contrast between time-scales. Action must be taken immediately if feedback loops, such as the albedo effect or the methane-hydrate feedback loop are to be avoided, because if these feedback loops take hold, human attempts to avoid disaster will become useless. But although drastic action must be taken immediately, the most disastrous

[1]This book uses some of my previously published book chapters, but much new material has been added.

effects of climate change lie in the long-term future, centuries, or even thousands of years from now.

I personally do not believe that catastrophic climate change will lead to the extinction of the human species; but I think that since it threatens to make most of the earth's surface uninhabitable, it could lead to a drastic reduction in the global population of humans.

An all-destroying nuclear war

Mr. Javier Pérez de Cuéllar, former Secretary-General of the United Nations, emphasized the insanity of nuclear war in one of his speeches: "I feel", he said, ' 'that the question may justifiably be put to the leading nuclear powers: by what right do they decide the fate of humanity? From Scandinavia to Latin America, from Europe and Africa to the Far East, the destiny of every man and woman is affected by their actions. No one can expect to escape from the catastrophic consequences of a nuclear war on the fragile structure of this planet. ..."

' 'No ideological confrontation can be allowed to jeopardize the future of humanity. Nothing less is at stake: todays decisions affect not only the present; they also put at risk succeeding generations. Like supreme arbiters, with our disputes of the moment, we threaten to cut off the future and to extinguish the lives of innocent millions yet unborn. There can be no greater arrogance. At the same time, the lives of all those who lived before us may be rendered meaningless; for we have the power to dissolve in a conflict of hours or minutes the entire work of civilization, with all the brilliant cultural heritage of humankind.

"...In a nuclear age, decisions affecting war and peace cannot be left to military strategists or even to governments. They are indeed the responsibility of every man and woman. And it is therefore the responsibility of all of us... to break the cycle of mistrust and insecurity and to respond to humanity's yearning for peace."

The eloquent words of Javier Pérez de Cuéllar express the situation in which we now find ourselves: Accidental nuclear war, nuclear terrorism, insanity of a person in a position of power, or unintended escalation of a conflict, could at any moment plunge our beautiful world into a catastrophic thermonuclear war which might destroy not only human civilization but also much of the biosphere.

An extremely widespread famine

Unless efforts are made to stabilize and ultimately reduce global population, there is a serious threat that climate change, population growth, and the end of the fossil fuel era could combine to produce a large-scale famine by Uthe middle of the 21st century.

As glaciers melt in the Himalayas and the Andes, depriving India, China and South America of summer water supplies; as sea levels rise, drowning fertile rice-growing regions of Southeast Asia; as droughts reduce the food production of North America and Southern Europe; as ground-water levels fall in China, India, the Middle East and the United States; and as high-yield modern agriculture becomes less possible because fossil fuel inputs are lacking, the 800 million people who are currently undernourished may not survive at all.

The duty of scientists is to prevent these catastrophes

The three threatened dangers to human civilization just mentioned are linked to the rapid changes that have resulted from advances in science and engineering. Therefore scientists have some responsibility for helping to prevent the disasters that threaten us today.

Many scientists have accepted this duty to act. For example, Pugwash Conferences on Science and World Affairs is an organization which was set up by scientists to deal with the global problems that scientific work had created.

Scientists who have consciences, and those who don't

In this book, we look at the lives of several scientists who had a social conscience - for example Albert Einstein and Linus Pauling. However, not all scientists and engineers have a sense of social responsibility, and many seem to have no conscience of any kind. They prostitute their talents to the war industry and to the fossil fuel corporations which offer them lucrative jobs. Without them, modern warfare would be impossible. Without them the dangerous extraction of fossil fuels would be impossible.

We must educate our scientists in such a way that the acquisition of a sense of social responsibility will be part of their education. It has been suggested that graduates in these fields should take an oath, analogous to

the oath taken by medical students, never to use their education in a way that could harm human society or the biosphere.

Contents

Chapter 1

THE THREATS AND COSTS OF WAR

1.1 The special responsibility of scientists and engineers

Modern warfare would be impossible without the cooperation of scientists and engineers, who accept lucrative jobs in weapons industries. Therefore, international organizations of scientists, such as Pugwash Conferences, have proposed that young graduates in science and engineering ought to take an oath analogous to the oath taken by graduates in medicine. Graduates in science and engineering should swear never to use their education in the service of war.

As we start the 21st century, our scientific and technological civilization seems to be entering a period of crisis. Today, for the first time in history, science has given to humans the possibility of a life of comfort, free from hunger and cold, and free from the constant threat of infectious disease. At the same time, science has given us the power to destroy civilization through thermonuclear war, as well as the power to make our planet uninhabitable through pollution, overpopulation and climate change. The question of which of these alternatives we choose is a matter of life or death to ourselves and our children. Scientists and engineers have a special responsibility for ensuring that their work is used in a way that benefits human civilization and the biosphere, rather than harmfully.

Genetically we are almost identical with our Neolithic ancestors; but their world has been replaced by a world of quantum theory, relativity, supercomputers, antibiotics, genetic engineering and space telescopes - unfortunately also a world of nuclear weapons and nerve-gas. Because of the slowness of genetic evolution in comparison to the rapid and constantly-accelerating rate of cultural change, our bodies and emotions are not adapted to our new way of life. They still reflect the way of life of our hunter-gatherer ancestors.

In addition to the contrast between the slow pace of genetic evolution when compared with the rapid and constantly accelerating rate of cultural evolution, we can also notice a contrast between rapidly- and slowly-moving aspects of cultural change: Social institu-

tions and structures seem to change slowly when compared with the lightning-like pace of scientific and technological innovation. Thus, tensions and instability characterize our information-driven contemporary society, not only because the human nature we have inherited from our ancient ancestors is not appropriate to our present way of life, but also because science and technology change so much more rapidly than institutions, laws, and attitudes.

Space-age science and stone-age politics make an extraordinarily dangerous mixture. It seems probable that in the future, the rapidity of scientific and technological change will produce ethical dilemmas and social tensions even more acute than those we experience today. It is likely that the fate of our species (and the fate of the biosphere) will be made precarious by the astonishing speed of scientific and technological change unless this progress is matched by the achievement of far greater ethical and political maturity than we have yet attained.

Science and technology have shown themselves to be double-edged, capable of doing great good or of producing great harm, depending on the way in which we use the enormous power over nature, which science has given to us. For this reason, ethical thought is needed now more than ever before. The wisdom of the world's religions, the traditional wisdom of humankind, can help us as we try to insure that our overwhelming material progress will be beneficial.

The crisis of civilization, which we face today, has been produced by the rapidity with which science and technology have developed. Our institutions and ideas adjust too slowly to the change. The great challenge which history has given to our generation is the task of building new international political structures, which will be in harmony with modern technology. At the same time, we must develop a new global ethic, which will replace our narrow loyalties by loyalty to humanity as a whole.

Ethical considerations have traditionally been excluded from scientific discussions. This tradition perhaps has its roots in the desire of the scientific community to avoid the bitter religious controversies which divided Europe following the Reformation. Whatever the historical reason may be, it has certainly be- come customary to speak of scientific problems in a dehumanized language, as though science had nothing to do with ethics or politics.

The great power of science is derived from an enormous concentration of attention and resources on the understanding of a tiny fragment of nature; but this concentration is at the same time a distortion of values. To be effective, a scientist must believe, at least temporarily, that the problem on which he or she is working is more important than anything else in the world, which is of course untrue. Thus a scientist, while seeing a fragment of reality better than anyone else, becomes blind to the larger whole. For example, when one looks into a microscope, one sees the tiny scene on the slide in tremendous detail, but that is all one sees. The remainder of the universe is blotted out by this concentration of attention.

The system of rewards and punishments in the training of scientists produces researchers who are highly competent when it comes to finding solutions to technical problems, but whose training has by no means encouraged them to think about the ethical or political consequences of their work. Scientists may, in fact, be tempted to escape from the intractable

Figure 1.1: **Enormous concentration of attention on a small fragment of reality blinds the researcher to the larger whole. Looking through a microscope, he sees what is on the slide in great detail, but he sees nothing else.**

moral and political difficulties of the world by immersing themselves in their work. Enrico Fermi, (whose research as much as that of any other person made nuclear weapons possible), spoke of science as "soma" - the escapist drug of Aldous Huxley's Brave New World. Fermi perhaps used his scientific preoccupations as an escape from the worrying political problems of the 30's and 40's.

The education of a scientist often produces a person with a strong feeling of loyalty to a particular research discipline, but perhaps without sufficient concern for the way in which progress in that discipline is related to the general welfare of humankind. To remedy this lack, it would be very desirable if the education of scientists could include some discussion of ethics, as well as a review of the history of modern science and its impact on society.

The explosive growth of science-driven technology during the last two cen- turies has changed the world completely; and our social and political institu- tions have adjusted much too slowly to the change. The great problem of our times is to keep society from being shaken to pieces by the headlong progress of science, the problem of harmonizing our social and political institutions with technological change. Because of the great importance of this problem, it is perhaps legitimate to ask whether anyone today can be considered to be educated without having studied the impact of science on society. Should we not include this topic in the education of both scientists and non-scientists?

Science has given us great power over the forces of nature. If wisely used, this power will contribute greatly to human happiness; if wrongly used, it will result in misery. In the words of the Spanish writer, Ortega y Gasset, "We live at a time when man, lord of all things, is not lord of himself"; or as Arthur Koestler has remarked, "We can control the movements of a spaceship orbiting about a distant planet, but we cannot control the situation in Northern Ireland."

To remedy this situation, educational reforms are needed. Science and engineering

students ought to have some knowledge of the history and social impact of science. They could be given a course on the history of scientific ideas; but in connection with modern historical developments, such as the in- dustrial revolution, the global population explosion, the development of nuclear weapons, genetic engineering, and information technology, some discussion of social impact could be introduced. One might hope to build up in science and engineering students an understanding of the way in which their work is related to the general welfare of humankind. These elements are needed in science education if rapid technological development is to be beneficial rather than disastrous.

1.2 Modern war has become prohibitively dangerous

In the long run, because of the enormously destructive weapons, which have been produced through the misuse of science, the survival of civilization can only be insured if we are able to abolish the institution of war.

Modern warfare has become prohibitively dangerous and destructive because of the enormously powerful weapons that scientists and engineers have developed. The institution of war could not continue without their cooperation. Thus, scientists and engineers throughout the world have a special responsibility.

Wars are driven by the collective paranoia of voters, who are willing to allow colossal sums to be spent by ‘ ‘Defense Departments”. But are civilians really defended? Absolutely not!

We can see this most clearly if we think of nuclear war. Nations threaten each other with “Mutually Assured Destruction”, which has the very appropriate acronym MAD. What does this mean? Does it mean that civilians are being protected? Not at all. Instead they are threatened with complete destruction. Civilians here play the role of hostages in the power games of their leaders. Those leaders’ goal is not protection of ordinary people, but rather protection of the gargantuan profits of the military-industrial complex. As the Indian writer Arundhati Roy put it, “Once weapons were manufactured to fight wars. Now wars are manufactured to sell weapons.”

If a thermonuclear war occurs, it will be the end of human civilization and much of the biosphere. This will definitely happen in the future unless the world rids itself of nuclear weapons, since, in the long run, the finite chance of accidental nuclear war happening due to a technical or human failure during a given year will gradually build up into a certainty of disaster. Scientists and engineers must not sell their knowledge and talents to this march towards the precipice.

1.3 The direct and indirect costs of war

The costs of war, both direct and indirect, are so enormous that they are almost beyond comprehension. We face a direct threat because a thermonuclear war may destroy human civilization and much of the biosphere, and an indirect threat because the institution of

Figure 1.2: **Children born with birth defects due to the US use of Agent Orange during the Vietnam War. Source: stopwarcoalition.org**

war interferes seriously with the use of tax money for constructive and peaceful purposes.

Today, despite the end of the Cold War, the world spends roughly 1.7 trillion (i.e. 1.7 million million) US dollars each year on armaments. This colossal flood of money could have been used instead for education, famine relief, development of infrastructure, or on urgently needed public health measures.

The World Health Organization lacks funds to carry through an antimalarial program on as large a scale as would be desirable, but the entire program could be financed for less than our military establishments spend in a single day. Five hours of world arms spending is equivalent to the total cost of the 20-year WHO campaign that resulted in the eradication of smallpox. For every 100,000 people in the world, there are 556 soldiers, but only 85 doctors. Every soldier costs an average of $20,000 per year, while the average spent on education is only $380 per school-aged child. With a diversion of funds consumed by three weeks of military spending, the world could create a sanitary water supply for all its people, thus eliminating the cause of almost half of all human illness.

A new drug-resistant form of tuberculosis has recently become widespread in Asia and in the former Soviet Union. In order to combat this new and highly dangerous form of tuberculosis and to prevent its spread, WHO needs $500 million, an amount equivalent to 1.2 hours of world arms spending.

Today's world is one in which roughly ten million children die every year from starvation or from diseases related to poverty. Besides this enormous waste of young lives through malnutrition and preventable disease, there is a huge waste of opportunities through inadequate education. The rate of illiteracy in the 25 least developed countries is 80%, and the total number of illiterates in the world is estimated to be 800 million. Meanwhile every 60 seconds the world spends $6.5 million on armaments.

It is plain that if the almost unbelievable sums now wasted on the institution of war were used constructively, most of the pressing problems of humanity could be solved, but today the world spends more than 20 times as much on war as it does on development.

Figure 1.3: **A little girl cries as medics attend to her injuries at al-Shifa hospital in Gaza in 2014, during the conflict. Photo: UNICEF/Eyad El Baba**

1.4 Medical and psychological consequences; loss of life

While in earlier epochs it may have been possible to confine the effects of war mainly to combatants, in the 20th century the victims of war were increasingly civilians, and especially children. For example, according to Quincy Wright's statistics, the First and Second World Wars cost the lives of 26 million soldiers, but the toll in civilian lives was much larger: 64 million.

Since the Second World War, despite the best efforts of the UN, there have been over 150 armed conflicts; and, if civil wars are included, there are on any given day an average of 12 wars somewhere in the world. In the conflicts in Indo-China, the proportion of civilian victims was between 80% and 90%, while in the Lebanese civil war some sources state that the proportion of civilian casualties was as high as 97%.

Civilian casualties often occur through malnutrition and through diseases that would be preventable in normal circumstances. Because of the social disruption caused by war, normal supplies of food, safe water and medicine are interrupted, so that populations become vulnerable to famine and epidemics.[1]

1.5 Effects of war on children

According to UNICEF figures, 90% of the casualties of recent wars have been civilians, and 50% children. The organization estimates that in recent years, violent conflicts have driven

[1] http://www.cadmusjournal.org/article/volume-2/issue-2-part-3/lessons-world-war-i
http://www.truth-out.org/opinion/item/27201-the-leading-terrorist-state

20 million children from their homes. They have become refugees or internally displaced persons within their own countries.

During the last decade 2 million children have been killed and 6 million seriously injured or permanently disabled as the result of armed conflicts, while 1 million children have been orphaned or separated from their families. Of the ten countries with the highest rates of death of children under five years of age, seven are affected by armed conflicts. UNICEF estimates that 300,000 child soldiers are currently forced to fight in 30 armed conflicts throughout the world. Many of these have been forcibly recruited or abducted.

Even when they are not killed or wounded by conflicts, children often experience painful psychological traumas: the violent death of parents or close relatives, separation from their families, seeing family members tortured, displacement from home, disruption of ordinary life, exposure to shelling and other forms of combat, starvation and anxiety about the future.[2]

1.6 Refugees

Human Rights Watch estimates that in 2001 there were 15 million refugees in the world, forced from their countries by war, civil and political conflict, or by gross violations of human rights. In addition, there were an estimated 22 million internally displaced persons, violently forced from their homes but still within the borders of their countries.

In 2001, 78% of all refugees came from ten areas: Afghanistan, Angola, Burma, Burundi, Congo-Kinshasa, Eritrea, Iraq, the Palestinian territories, Somalia and Sudan. A quarter of all refugees are Palestinians, who make up the world's oldest and largest refugee population. 45% of the world's refugees have found sanctuaries in Asia, 30% in Africa, 19% in Europe and 5% in North America.

Refugees who have crossed an international border are in principle protected by Article 14 of the Universal Declaration of Human Rights, which affirms their right "to seek and to enjoy in other countries asylum from persecution". In 1950 the Office of the High Commissioner for Refugees was created to implement Article 14, and in 1951 the Convention Relating to the Status of Refugees was adopted by the UN. By 2002 this legally binding treaty had been signed by 140 nations. However the industrialized countries have recently adopted a very hostile and restrictive attitude towards refugees, subjecting them to arbitrary arrests, denial of social and economic rights, and even forcible return to countries in which they face persecution.

The status of internally displaced persons is even worse than that of refugees who have crossed international borders. In many cases the international community simply ignores their suffering, reluctant to interfere in the internal affairs of sovereign states. In fact, the United Nations Charter is self-contradictory in this respect, since on the one hand it calls for non-interference in the internal affairs of sovereign states, but on the other hand, people everywhere are guaranteed freedom from persecution by the Charter's Universal

[2]http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2080482/

Figure 1.4: **Asylum-seekers in a holding centre on Greece's Samos Island.**

Declaration of Human Rights.[3]

[3]https://www.hrw.org/topic/refugees

1.7 Damage to infrastructure

Most insurance policies have clauses written in fine print exempting companies from payment of damage caused by war. The reason for this is simple. The damage caused by war is so enormous that insurance companies could never come near to paying for it without going bankrupt.

We mentioned above that the world spends 1.7 trillion dollars each year on preparations for war. A similarly colossal amount is needed to repair the damage to infrastructure caused by war. Sometimes this damage is unintended, but sometimes it is intentional.

During World War II, one of the main aims of air attacks by both sides was to destroy the industrial infrastructure of the opponent. This made some sense in a war expected to last several years, because the aim was to prevent the enemy from producing more munitions. However, during the Gulf War of 1990, the infrastructure of Iraq was attacked, even though the war was expected to be short. Electrical generating plants and water purification facilities were deliberately destroyed with the apparent aim of obtaining leverage over Iraq after the war.

In general, because war has such a catastrophic effect on infrastructure, it can be thought of as the opposite of development. War is the greatest generator of poverty.[4]

1.8 Ecological damage

Warfare during the 20th century has not only caused the loss of 175 million lives (primarily civilians) - it has also caused the greatest ecological catastrophes in human history. The damage takes place even in times of peace. Studies by Joni Seager, a geographer at the University of Vermont, conclude that "a military presence anywhere in the world is the single most reliable predictor of ecological damage".

Modern warfare destroys environments to such a degree that it has been described as an "environmental holocaust." For example, herbicides use in the Vietnam War killed an estimated 6.2 billion board-feet of hardwood trees in the forests north and west of Saigon, according to the American Association for the Advancement of Science. Herbicides such as Agent Orange also made enormous areas of previously fertile land unsuitable for agriculture for many years to come. In Vietnam and elsewhere in the world, valuable agricultural land has also been lost because land mines or the remains of cluster bombs make it too dangerous for farming.

During the Gulf War of 1990, the oil spills amounted to 150 million barrels, 650 times the amount released into the environment by the notorious Exxon Valdez disaster. During the Gulf War an enormous number of shells made of depleted uranium were fired. When the dust produced by exploded shells is inhaled it often produces cancer, and it will remain

[4] https://www.wsws.org/en/articles/2002/11/iraq-n04.html
http://www.globalresearch.ca/crimes-against-humanity-the-destruction-of-iraqs-electricity-infrastructure-the-social-economic-and-environmental-impacts/5355665
http://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/00157630-EN-ERP-48.PDF

Figure 1.5: **Image source: Greenpeace**

in the environment of Iraq for decades.

Radioactive fallout from nuclear tests pollutes the global environment and causes many thousands of cases of cancer, as well as birth abnormalities. Most nuclear tests have been carried out on lands belonging to indigenous peoples. Agent Orange also produced cancer, birth abnormalities and other serious forms of illness both in the Vietnamese population and among the foreign soldiers fighting in Vietnam[5]

1.9 The threat of nuclear war

As bad as conventional arms and conventional weapons may be, it is the possibility of a catastrophic nuclear war that poses the greatest threat to humanity. There are today roughly 16,000 nuclear warheads in the world. The total explosive power of the warheads that exist or that could be made on short notice is approximately equal to 500,000 Hiroshima bombs.

To multiply the tragedy of Hiroshima by a factor of half a million makes an enormous difference, not only quantitatively, but also qualitatively. Those who have studied the question believe that a nuclear catastrophe today would inflict irreversible damage on our civilization, genetic pool and environment.

Thermonuclear weapons consist of an inner core where the fission of uranium-235 or plutonium takes place. The fission reaction in the core is able to start a fusion reaction in the next layer, which contains isotopes of hydrogen. It is possible to add a casing of ordinary uranium outside the hydrogen layer, and under the extreme conditions produced by the fusion reaction, this ordinary uranium can undergo fission. In this way, a fission-fusion-fission bomb of almost limitless power can be produced.

[5]http://www.dailymail.co.uk/news/article-2401378/Agent-Orange-Vietnamese-children-suffering-effects-herbicide-sprayed-US-Army-40-years-ago.html

Figure 1.6: **The 15 megaton explosion detonated by the United States at Bikini Atoll in 1954 produced lasting biological damage to humans and animals living on the distant Marshall Islands. Today, half a century later, the islanders still experience radiation sickness in the form of leukemia and birth defects. Source: www.theguardian.com**

For a victim of severe radiation exposure, the symptoms during the first week are nausea, vomiting, fever, apathy, delirium, diarrhoea, oropharyngeal lesions and leukopenia. Death occurs during the first or second week.

We can perhaps be helped to imagine what a nuclear catastrophe means in human terms by reading the words of a young university professor, who was 2,500 meters from the hypocenter at the time of the bombing of Hiroshima: "Everything I saw made a deep impression: a park nearby covered with dead bodies... very badly injured people evacuated in my direction... Perhaps most impressive were girls, very young girls, not only with their clothes torn off, but their skin peeled off as well. ... My immediate thought was that this was like the hell I had always read about. ... I had never seen anything which resembled it before, but I thought that should there be a hell, this was it."

One argument that has been used in favor of nuclear weapons is that no sane political leader would employ them. However, the concept of deterrence ignores the possibility of war by accident or miscalculation, a danger that has been increased by nuclear proliferation and by the use of computers with very quick reaction times to control weapons systems.

Recent nuclear power plant accidents remind us that accidents frequently happen through human and technical failure, even for systems which are considered to be very "safe." We must also remember the time scale of the problem. To assure the future of humanity, nuclear catastrophe must be avoided year after year and decade after decade. In the long run, the safety of civilization cannot be achieved except by the abolition of nuclear weapons, and ultimately the abolition of the institution of war.

In 1985, International Physicians for the Prevention of Nuclear War received the Nobel Peace Prize. IPPNW had been founded in 1980 by six physicians, three from the Soviet Union and three from the United States. Today, the organization has wide membership

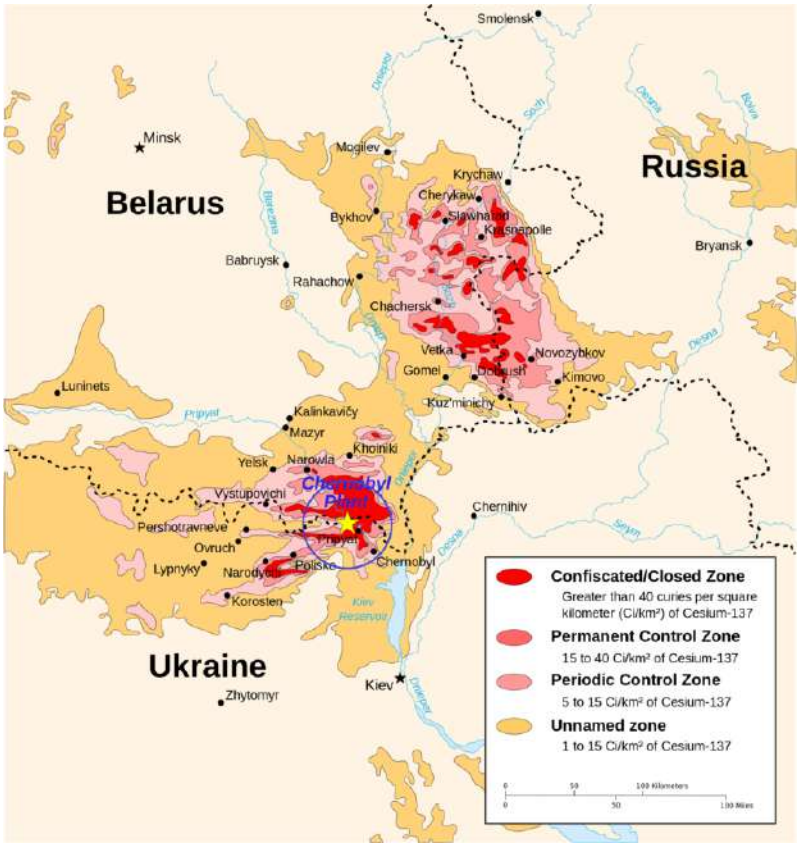

Figure 1.7: **A nuclear war would be an ecological disaster, making large portions of the world permanently uninhabitable because of long-lasting radioactivity. Chernobyl radiation map 1996 30km zone by CIA Factbook. Licensed under CC BY-SA 2.5 via Wikimedia Commons.**

Figure 1.8: **Sculpture depicting Saint George slaying the dragon. The dragon is created from fragments of Soviet SS-20 and United States Pershing nuclear missiles. UN Photo/Milton Grant**

among the world's physicians. Professor Bernard Lowen of the Harvard School of Public Health, one of the founders of IPPNW, said in a recent speech:

"...No public health hazard ever faced by humankind equals the threat of nuclear war. Never before has man possessed the destructive resources to make this planet uninhabitable... Modern medicine has nothing to offer, not even a token benefit, in the event of nuclear war..."

"We are but transient passengers on this planet Earth. It does not belong to us. We are not free to doom generations yet unborn. We are not at liberty to erase humanity's past or dim its future. Social systems do not endure for eternity. Only life can lay claim to uninterrupted continuity. This continuity is sacred."

The danger of a catastrophic nuclear war casts a dark shadow over the future of our species. It also casts a very black shadow over the future of the global environment. The environmental consequences of a massive exchange of nuclear weapons have been treated in a number of studies by meteorologists and other experts from both East and West. They predict that a large-scale use of nuclear weapons would result in fire storms with very high winds and high temperatures, which would burn a large proportion of the wild land fuels in the affected nations. The resulting smoke and dust would block out sunlight for a period of many months, at first only in the northern hemisphere but later also in the southern hemisphere.

Temperatures in many places would fall far below freezing, and much of the earth's plant life would be killed. Animals and humans would then die of starvation. The nuclear winter effect was first discovered as a result of the Mariner 9 spacecraft exploration of Mars in 1971. The spacecraft arrived in the middle of an enormous dust-storm on Mars, and measured a large temperature drop at the surface of the planet, accompanied by a heating of the upper atmosphere. These measurements allowed scientists to check their theoretical models for predicting the effect of dust and other pollutants distributed in planetary atmospheres.

Using experience gained from the studies of Mars, R.P. Turco, O.B. Toon, T. Ackerman, J.B. Pollack and C. Sagan made a computer study of the climatic effects of the smoke and dust that would result from a large-scale nuclear war. This early research project is sometimes called the TTAPS Study, after the initials of the authors.

In April 1983, a special meeting was held in Cambridge, Massachusetts, where the results of the TTAPS Study and other independent studies of the nuclear winter effect were discussed by more than 100 experts. Their conclusions were presented at a forum in Washington, D.C., the following December, under the chairmanship of U.S. Senators Kennedy and Hatfield. The numerous independent studies of the nuclear winter effect all agreed of the following main predictions:

High-yield nuclear weapons exploded near the earth's surface would put large amounts of dust into the upper atmosphere. Nuclear weapons exploded over cities, forests, oilfields and refineries would produce fire storms of the type experienced in Dresden and Hamburg after incendiary bombings during the Second World War. The combination of high-altitude dust and lower altitude soot would prevent sunlight from reaching the earth's surface, and the degree of obscuration would be extremely high for a wide range of scenarios.

A baseline scenario used by the TTAPS study assumes a 5,000-megaton nuclear exchange, but the threshold for triggering the nuclear winter effect is believed to be much lower than that. After such an exchange, the screening effect of pollutants in the atmosphere might be so great that, in the northern and middle latitudes, the sunlight reaching the earth would be only 1% of ordinary sunlight on a clear day, and this effect would persist for many months. As a result, the upper layers in the atmosphere might rise in temperature by as much as 100 °C, while the surface temperatures would fall, perhaps by as much a 50 °C.

The temperature inversion produced in this way would lead to superstability, a condition in which the normal mixing of atmospheric layers is suppressed. The hydrological cycle (which normally takes moist air from the oceans to a higher and cooler level, where the moisture condenses as rain) would be strongly suppressed. Severe droughts would thus take place over continental land masses. The normal cleansing action of rain would be absent in the atmosphere, an effect which would prolong the nuclear winter.

In the northern hemisphere, forests would die because of lack of sunlight, extreme cold, and drought. Although the temperature drop in the southern hemisphere would be less severe, it might still be sufficient to kill a large portion of the tropical forests, which normally help to renew the earth's oxygen.

The oxygen content of the atmosphere would then fall dangerously, while the concentration of carbon dioxide and oxides of nitrogen produced by firestorms would remain high. The oxides of nitrogen would ultimately diffuse to the upper atmosphere, where they would destroy the ozone layer.

Thus, even when the sunlight returned after an absence of many months, it would be sunlight containing a large proportion of the ultraviolet frequencies which are normally absorbed by the ozone in the stratosphere, and therefore a type of light dangerous to life. Finally, after being so severely disturbed, there is no guarantee that the global climate would return to its normal equilibrium.

Even a nuclear war below the threshold of nuclear winter might have climatic effects very damaging to human life. Professor Paul Ehrlich, of Stanford University, has expressed this in the following words:

"...A smaller war, which set off fewer fires and put less dust into the atmosphere, could easily depress temperatures enough to essentially cancel grain production in the northern hemisphere. That in itself would be the greatest catastrophe ever delivered upon Homo Sapiens, just that one thing, not worrying about prompt effects. Thus even below the threshold, one cannot think of survival of a nuclear war as just being able to stand up after the bomb has gone off."[6]

[6]http://www.voanews.com/content/pope-francis-calls-for-nuclear-weapons-ban/2909357.html
http://www.cadmusjournal.org/article/issue-4/flaws-concept-nuclear-deterrance
http://www.countercurrents.org/avery300713.htm
https://www.wagingpeace.org/author/john-avery/
http://www.commondreams.org/news/2015/08/06/70-years-after-bombing-hiroshima-calls-abolish-nuclear-weapons
http://www.informationclearinghouse.info/article42488.htm

1.10 Nuclear weapons are criminal! Every war is a crime!

War was always madness, always immoral, always the cause of unspeakable suffering, economic waste and widespread destruction, and always a source of poverty, hate, barbarism and endless cycles of revenge and counter-revenge. It has always been a crime for soldiers to kill people, just as it is a crime for murderers in civil society to kill people. No flag has ever been wide enough to cover up atrocities.

But today, the development of all-destroying modern weapons has put war completely beyond the bounds of sanity and elementary humanity.

Today, war is not only insane, but also a violation of international law. Both the United Nations Charter and the Nuremberg Principles make it a crime to launch an aggressive war. According to the Nuremberg Principles, every soldier is responsible for the crimes that he or she commits, even while acting under the orders of a superior officer.

Nuclear weapons are not only insane, immoral and potentially omnicidal, but also criminal under international law. In response to questions put to it by WHO and the UN General Assembly, the International Court of Justice ruled in 1996 that "the threat and use of nuclear weapons would generally be contrary to the rules of international law applicable in armed conflict, and particularly the principles and rules of humanitarian law." The only possible exception to this general rule might be "an extreme circumstance of self-defense, in which the very survival of a state would be at stake". But the Court refused to say that even in this extreme circumstance the threat or use of nuclear weapons would be legal. It left the exceptional case undecided. In addition, the Court added unanimously that "there

http://www.informationclearinghouse.info/article42492.htm
http://www.commondreams.org/views/2015/08/06/hiroshima-and-nagasaki-remembering-power
http://human-wrongs-watch.net/2015/07/22/israel-iran-and-the-nuclear-non-proliferation-treaty/
http://human-wrongs-watch.net/2015/06/25/militarisms-hostages/
http://human-wrongs-watch.net/2015/05/24/the-path-to-zero-dialogues-on-nuclear-dangers-by-richard-falk-and-david-krieger/
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exists an obligation to pursue in good faith and bring to a conclusion negotiations leading to nuclear disarmament in all its aspects under strict and effective international control."

Can we not rid ourselves of both nuclear weapons and the institution of war itself? We must act quickly and resolutely before everything that we love in our beautiful world is reduced to radioactive ashes.

Suggestions for further reading

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Some organizations working for peace and international law

- Pugwash Conferences on Science and World Affairs, https://pugwash.org/
- International Network of Engineers and Scientists for Global Responsibility (INES), http://www.ippnw.org/
- The Nuclear Age Peace Foundation, https://www.wagingpeace.org/
- The International Peace Bureau (IPB), http://www.ipb.org/
- UNESCO Campaign for a Culture of Peace, http://en.unesco.org/events/national-campaign-promotion-culture-peace-among-youth-cameroon
- Global Zero, https://www.globalzero.org/
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- Nuclear Abolition Forum, http://www.abolitionforum.org/
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- Campaign for Nuclear Disarmament (CND), http://www.cnduk.org/
- World Association of World Federalists, http://www.wfuna.org/partner/world-federalist-movement-institute-for-global-policy-wfm-igp
- Stoccckholm International Peace Research Institute (SIPRI), https://www.sipri.org/
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- Hiroshima Peace Memorial Museum, http://hpmmuseum.jp/?lang=eng
- United Nations Integrated Peacebuilding Office, https://uniogbis.unmissions.org/en

- The Committee for a Sane Nuclear Policy, https://sites.google.com/a/nyu.edu/nuclearnyc/antinuclea movement-1950s-1960s/sane
- Middle Powers Initiative, http://www.middlepowers.org/
- Bertrand Russell Peace Foundation, http://www.russfound.org/
- Gandhi International Institute of Peace, http://www.gandhianpeace.com/
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- Parliamentarians for Nuclear Nonproliferation and Disarmament, http://www.pnnd.org/
- Doctors Without Borders, https://www.msf.org/
- The Transnational Foundation for Peace and Future Research, www.transnational.org
- Global Zero, https://www.globalzero.org/
- International Physicians for the Prevention of Nuclear War, https://www.ippnw.org/
- Lawyer's Committee for Nuclear Policy, http://lcnp.org/

Chapter 2

SCIENTISTS WORKING FOR PEACE

Some organizations of scientists, engineers or doctors, working for peace and international law:

2.1 Pugwash Conferences on Science and World Affairs

https://pugwash.org/

The Russell-Einstein Manifesto

The year 2015 marked the 60th anniversary of the Russell-Einstein Manifesto, which contains the following words: "There lies before us, if we choose, continual progress in happiness, knowledge and wisdom. Shall we, instead, choose death, because we cannot forget our quarrels? Remember your humanity, and forget the rest. If you can do so, the way lies open to a new Paradise. If you cannot, there lies before you the risk of universal death."

The background for the Russell-Einstein Manifesto is as follows: In March, 1954, the United States had tested a hydrogen bomb at the Bikini Atoll in the Pacific Ocean. It was 1,000 times more powerful than the Hiroshima bomb. The Japanese fishing boat, the Lucky Dragon, was 130 kilometers from the Bikini explosion, but the radioactive fallout from the test killed one crew member, and made all the others seriously ill.

In England, Professor Joseph Rotblat, a Polish scientist who had resigned from the Manhattan Project for moral reasons when it became clear that Germany would not develop nuclear weapons, was asked to appear on a BBC program to discuss the Bikini test. He was asked to discuss the technical aspects of H-bombs, while the Archbishop of Canterbury and the philosopher, Lord Bertrand Russell, were asked to discuss the moral aspects.

Rotblat had become convinced that the Bikini bomb must have involved a third stage,

in which fast neutrons from the hydrogen thermonuclear reaction produced fission in an outer casing of ordinary uranium. Such a bomb would produce enormous amounts of highly dangerous fallout, and Rotblat became extremely worried about the possibly fatal effects on all living things if large numbers of such bombs were ever used in a war. He confided his worries to Bertrand Russell, whom he had met on the BBC program.

After discussing the Bikini test and its radioactive fallout with Joseph Rotblat, Lord Russell became concerned for the future of the human gene pool. After consulting a number of leading physicists, including Albert Einstein, he wrote what came to be known as the Russell-Einstein Manifesto.

Russell was convinced that in order for the Manifesto to have maximum impact, Einstein's signature would be absolutely necessary; but as Russell was flying from Italy to France, the pilot announced to the passengers that Einstein had just died. Russell was crushed by the news, but when he arrived at his hotel in Paris, he found waiting for him a letter from Einstein and his signature on the document. Signing the Manifesto had been the last act of Einstein's life. Others who signed were Max Born, Percy W. Bridgman, Leopold Infeld, Frederic Joliot-Curie, Hermann J. Muller, Linus Pauling, Cecil F. Powell, Joseph Rotblat, Hideki Yukawa and Bertrand Russell. All of them, except Infeld and Rotblat, were Nobel Laureates.

On July 9, 1955, with Rotblat in the chair, Russell read the Manifesto to a packed press conference. The document contains the words: "Here then is the problem that we present to you, stark and dreadful and inescapable: Shall we put an end to the human race, or shall mankind renounce war?... There lies before us, if we choose, continual progress in happiness, knowledge and wisdom. Shall we, instead, choose death because we cannot forget our quarrels?..." Lord Russell devoted much of the remainder of his life to working for the abolition of nuclear weapons.[1]

In 1957, with the Russell-Einstein Manifesto as a background, a group of scientists from both sides of the Cold War met in the small village of Pugwash, Nova Scotia. The meeting was held at the summer residence of the Canadian-American financier and philanthropist Cyrus Eaton, who had given money for the conference. The aim of the assembled scientists was to reduce the danger of a catastrophic nuclear war.

From this small beginning, a series of conferences developed, in which scientists, especially physicists, attempted to work for peace, and tried to address urgent problems related to science. These conferences were called Pugwash Conferences on Science and World Affairs, taking their name from the small village in Nova Scotia where the first meeting was held. From the start, the main aim of the meetings was to reduce the danger that civilization would be destroyed in a thermonuclear war.

It can be seen from what has been said that the Pugwash Conferences began during one of the tensest periods of the Cold War, when communication between the Communist and Anti-communist blocks was difficult. During this period, the meetings served the important purpose of providing a forum for informal diplomacy. The participants met, not as representatives of their countries, but as individuals, and the discussions were confidential.

[1] http://www.umich.edu/ pugwash/Manifesto.html

This method of operation proved to be effective, and the initial negotiations for a number of important arms control treaties were aided by Pugwash Conferences. These include the START treaties, the treaties prohibiting chemical and biological weapons, the Nuclear Nonproliferation Treaty (NPT), and the Comprehensive Test Ban Treaty (CTBT). Former Soviet President Gorbachev has said that discussions with Pugwash scientists helped him to conclude that the policy of nuclear confrontation was too dangerous to be continued.

Over the years, the number of participants attending the annual Pugwash Conference has grown, and the scope of the problems treated has broadened. Besides scientists, the participants now include diplomats, politicians, economists, social scientists and military experts. Normally the number attending the yearly conference is about 150.

Besides plenary sessions, the conferences have smaller working groups dealing with specific problems. There is always a working group aimed at reducing nuclear dangers, and also groups on controlling or eliminating chemical and biological weapons. In addition, there may now be groups on subjects such as climate change, poverty, United Nations reform, and so on.

Invitations to the conferences are issued by the Secretary General to participants nominated by the national groups. The host nation usually pays for the local expenses, but participants finance their own travel. Besides the large annual meeting, the Pugwash organization also arranges about ten specialized workshops per year, with 30-40 participants each. Although attendance at the conferences and workshops is by invitation, everyone is very welcome to join one of the national Pugwash groups. The international organization's website is at www.pugwash.org.

In 1995, the Nobel Peace Prize was awarded jointly to Prof. Joseph Rotblat and to Pugwash Conferences on Science and World Affairs as an organization, " ...for their efforts to diminish the part played by nuclear arms in international politics and in the longer run to eliminate such arms." The award was made 50 years after the tragic destruction of Hiroshima and Nagasaki.

In his acceptance speech, Sir Joseph Rotblat (as he soon became) emphasized the same point that has been made by the Russell-Einstein Manifesto, that war itself must be eliminated in order to free civilization from the danger of nuclear destruction. The reason for this is that knowledge of how to make nuclear weapons can never be forgotten. Even if they were eliminated, these weapons could be rebuilt during a major war. Thus the final abolition of nuclear weapons is linked to a change of heart in world politics and to the abolition of war.

"The quest for a war-free world", Sir Joseph concluded, "has a basic purpose: survival. But if, in the process, we can learn to achieve it by love rather than by fear, by kindness rather than compulsion; if in the process we can learn to combine the essential with the enjoyable, the expedient with the benevolent, the practical with the beautiful, this will be an extra incentive to embark on this great task. Above all, remember your humanity"

I vividly remember the ceremony in Oslo when the 1995 Nobel Peace Prize was awarded jointly to Sir Joseph and to Pugwash Conferences. About 100 people from the Pugwash organization were invited, and I was included because I was the chairman of the Danish

National Pugwash Group. After the ceremony and before the dinner, local peace groups had organized a torchlight parade. It was already dark, because we were so far to the north, and snow was falling. About 3,000 people carrying torches marched through the city and assembled under Sir Joseph's hotel window, cheering and shouting "Rotblat! Rotblat! Rotblat!". Finally he appeared at the hotel widow, waved to the crowd and tried to say a few words. This would have been the moment for a memorable speech, but the acoustics were so terrible that we could not hear a word that he said. I later tried (without success) to persuade the BBC to make a program about nuclear weapons and about Sir Joseph's life, ending with the falling snow and the torch-lit scene.

Full text of the Russell-Einstein Manifesto

In the tragic situation which confronts humanity, we feel that scientists should assemble in conference to appraise the perils that have arisen as a result of the development of weapons of mass destruction, and to discuss a resolution in the spirit of the appended draft.

We are speaking on this occasion, not as members of this or that nation, continent, or creed, but as human beings, members of the species Man, whose continued existence is in doubt. The world is full of conflicts; and, overshadowing all minor conflicts, the titanic struggle between Communism and anti-Communism.

Almost everybody who is politically conscious has strong feelings about one or more of these issues; but we want you, if you can, to set aside such feelings and consider yourselves only as members of a biological species which has had a remarkable history, and whose disappearance none of us can desire.

We shall try to say no single word which should appeal to one group rather than to another. All, equally, are in peril, and, if the peril is understood, there is hope that they may collectively avert it.

We have to learn to think in a new way. We have to learn to ask ourselves, not what steps can be taken to give military victory to whatever group we prefer, for there no longer are such steps; the question we have to ask ourselves is: what steps can be taken to prevent a military contest of which the issue must be disastrous to all parties?

The general public, and even many men in positions of authority, have not realized what would be involved in a war with nuclear bombs. The general public still thinks in terms of the obliteration of cities. It is understood that the new bombs are more powerful than the old, and that, while one A-bomb could obliterate Hiroshima, one H-bomb could obliterate the largest cities, such as London, New York, and Moscow.

No doubt, in an H-bomb war, great cities would be obliterated. But this is one of the minor disasters that would have to be faced. If everybody in London, New York, and Moscow were exterminated, the world might, in the course of a few centuries, recover from the blow. But we now know, especially

since the Bikini test, that nuclear bombs can gradually spread destruction over a very much wider area than had been supposed.

It is stated on very good authority that a bomb can now be manufactured which will be 2,500 times as powerful as that which destroyed Hiroshima. Such a bomb, if exploded near the ground or under water, sends radio-active particles into the upper air. They sink gradually and reach the surface of the earth in the form of a deadly dust or rain. It was this dust which infected the Japanese fishermen and their catch of fish. No one knows how widely such lethal radio-active particles might be diffused, but the best authorities are unanimous in saying that a war with H-bombs might possibly put an end to the human race. It is feared that if many H-bombs are used there will be universal death, sudden only for a minority, but for the majority a slow torture of disease and disintegration.

Many warnings have been uttered by eminent men of science and by authorities in military strategy. None of them will say that the worst results are certain. What they do say is that these results are possible, and no one can be sure that they will not be realized. We have not yet found that the views of experts on this question depend in any degree upon their politics or prejudices. They depend only, so far as our researches have revealed, upon the extent of the particular expert's knowledge. We have found that the men who know most are the most gloomy.

Here, then, is the problem which we present to you, stark and dreadful and inescapable: Shall we put an end to the human race; or shall mankind renounce war? People will not face this alternative because it is so difficult to abolish war.

The abolition of war will demand distasteful limitations of national sovereignty. But what perhaps impedes understanding of the situation more than anything else is that the term "mankind" feels vague and abstract. People scarcely realize in imagination that the danger is to themselves and their children and their grandchildren, and not only to a dimly apprehended humanity. They can scarcely bring themselves to grasp that they, individually, and those whom they love are in imminent danger of perishing agonizingly. And so they hope that perhaps war may be allowed to continue provided modern weapons are prohibited.

This hope is illusory. Whatever agreements not to use H-bombs had been reached in time of peace, they would no longer be considered binding in time of war, and both sides would set to work to manufacture H-bombs as soon as war broke out, for, if one side manufactured the bombs and the other did not, the side that manufactured them would inevitably be victorious.

Although an agreement to renounce nuclear weapons as part of a general reduction of armaments would not afford an ultimate solution, it would serve certain important purposes. First, any agreement between East and West is to the good in so far as it tends to diminish tension. Second, the abolition

of thermo-nuclear weapons, if each side believed that the other had carried it out sincerely, would lessen the fear of a sudden attack in the style of Pearl Harbor, which at present keeps both sides in a state of nervous apprehension. We should, therefore, welcome such an agreement though only as a first step.

Most of us are not neutral in feeling, but, as human beings, we have to remember that, if the issues between East and West are to be decided in any manner that can give any possible satisfaction to anybody, whether Communist or anti-Communist, whether Asian or European or American, whether White or Black, then these issues must not be decided by war. We should wish this to be understood, both in the East and in the West.

There lies before us, if we choose, continual progress in happiness, knowledge, and wisdom. Shall we, instead, choose death, because we cannot forget our quarrels? We appeal as human beings to human beings: Remember your humanity, and forget the rest. If you can do so, the way lies open to a new Paradise; if you cannot, there lies before you the risk of universal death.

Resolution

We invite this Congress, and through it the scientists of the world and the general public, to subscribe to the following resolution:

"In view of the fact that in any future world war nuclear weapons will certainly be employed, and that such weapons threaten the continued existence of mankind, we urge the governments of the world to realize, and to acknowledge publicly, that their purpose cannot be furthered by a world war, and we urge them, consequently, to find peaceful means for the settlement of all matters of dispute between them."

Percy W. Bridgman
Albert Einstein
Leopold Infeld
Frederic Joliot-Curie
Herman J. Muller
Linus Pauling
Cecil F. Powell
Joseph Rotblat
Bertrand Russell
Hideki Yukawa

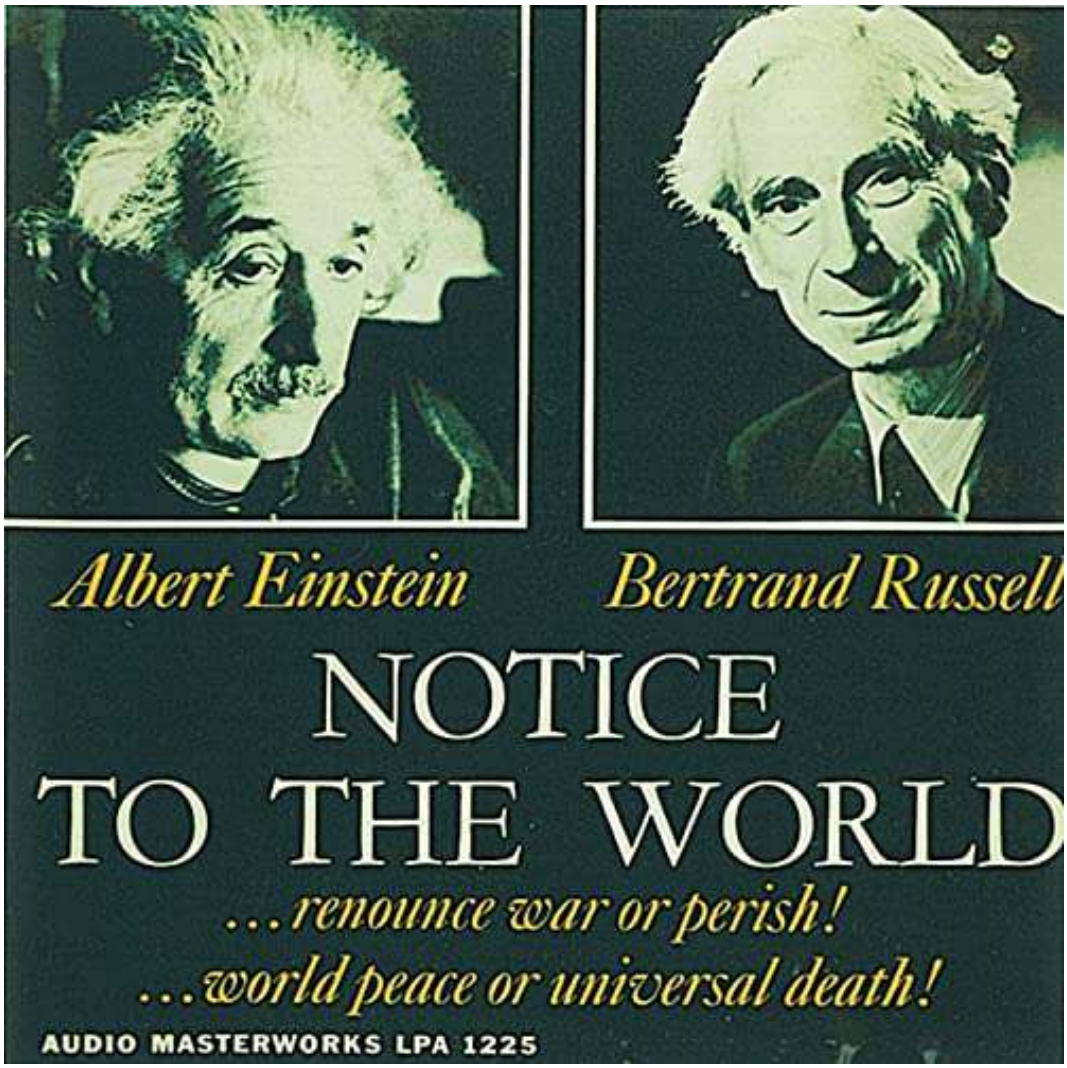

Figure 2.1: **An audio recording of Lord Bertrand Russell reading the Russell-Einstein Manifesto.**

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Figure 2.2: **Sir Joseph Rotblat (left) meets the famous Buddhist philosopher and world peace advocate, Daisaku Ikeda. Sir Joseph shared the 1995 Nobel Peace Prize with Pugwash Conferences on Science and World Affairs as an organization.**

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2.2 International Network of Engineers and Scientists for Global Responsibility

http://inesglobal.net/

History

The International Network of Engineers and Scientists for global responsibility (INES) was founded in 1991 in Berlin. It was founded by participants at a congress entitled *Challenges - Science and Peace in a Rapidly Changing Environment.*

Activities

- Lobbies for nuclear disarmament and sustainable science.
- Works for the reduction of military spending.
- Promotes the awareness of ethical principles and the specific responsibility of engineers and scientists.
- Participates in whistleblowing campaigns, which support those who have been victimized for acting upon such principles.
- Encourages and facilitates public discourse and international communication among concerned scientists.
- Organizes international conferences and regional workshops.
- Raises public awareness.
- Promotes environmentally sound technologies.
- Supports publishing books, e.g., Einstein, Peace Now!; Joseph Rotblat: Visionary for Peace.

Goals

- Abolition of nuclear weapons
- Promoting the responsible and sustainable use of science and technology
- Implementing ethical principles in the education of scientists and engineers

Figure 2.3: **The INES logo.**

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2.3 The Nuclear Age Peace Foundation

https://www.wagingpeace.org/

David Krieger, Founder of the Nuclear Age Peace Foundation

Here are some quotations from an article about Dr. Krieger:[2]

"Dr. Krieger served as president of the Foundation since 1982. For more than three decades he has been a leader in the global movement to abolish nuclear weapons and build a more peaceful world. Under Dr. Krieger's leadership the Nuclear Age Peace Foundation has initiated many innovative and important projects for building peace, strengthening international law, abolishing nuclear weapons and empowering new peace leaders. He has lectured throughout the United States, Europe and Asia on issues of peace, security, international law, and the abolition of nuclear weapons. He has received many awards for his work for a more peaceful and nuclear weapons-free world. He has been interviewed on CNN, MSNBC, BBC and many other national and international television and radio shows.

"He is a member of the Club of Rome and is a Fellow of the World Academy of Art and Science. He served as chair of the Executive Committee of the International Network of Engineers and Scientists for Global Responsibility from 2007 to 2015. He also served as vice-chair of the Middle Powers Initiative and as chair of its Executive Committee from 2010 to 2015. He is a longtime member of the Committee of 100 for Tibet. Dr. Krieger served as Panel Chair of the Citizens' Hearing on the Legality of U.S. Actions in Iraq, held in Tacoma,

[2]https://globalandinternationalstudies.com/advisory-council/david-krieger/

Washington in 2007, and as a member of the Jury of Conscience of the World Tribunal on Iraq, held in Istanbul in 2005. Dr. Krieger is the author or editor of many studies of peace in the Nuclear Age. He has written or edited 25 books and hundreds of articles and book chapters. Dr. Krieger has been nominated for the Nobel Peace Prize on several occasions. Among many others, he is the recipient of the Russian Academy of Natural Sciences Award for Saving Life on Earth (2012); the Citizens for Peaceful Resolutions' Earth Charter Award for Democracy, Nonviolence and Peace (2011); OMNI Center for Peace, Justice and Ecology Peace Writing Award for Poetry (2010); the Golden Dove Award (2009); etcetera."

Here is how the Nuclear Age Peace Foundation lists its resources;

- **NAPF Newsletter**: We send out a monthly newsletter via email with updates on our work for Peace Literacy and nuclear abolition, and much more.
- **Publications**: The Nuclear Age Peace Foundation regularly publishes books, reports and briefing booklets on issues related to nuclear disarmament and peace.
- **Article Archives**: Browse our archive of hundreds of articles on nuclear disarmament and peace that we have published online over the past 15+ years.
- **Videos**: The Nuclear Age Peace Foundation has produced a number of videos on nuclear weapons issues, from short animations to longer speeches by experts.
- **Links**: The Nuclear Age Peace Foundation works closely with many organizations around the world for peace and the abolition of nuclear weapons. Click here for the full list.

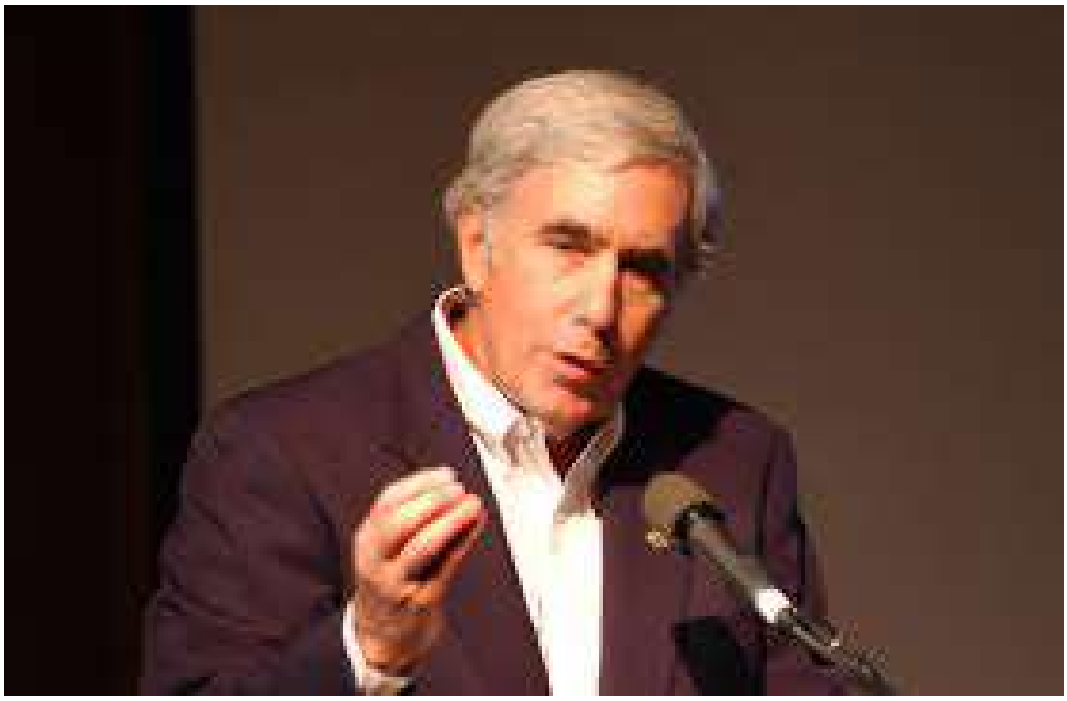

Figure 2.4: **Dr. David Krieger, founder of the Nuclear Age Peace Foundation, and for almost four decades its president.**

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Figure 2.5: **At the end of 2019, David Krieger retired from his position as president of the Nuclear Age Peace Foundation. He was replaced by Rick Wayman. who is shown in this picture.**

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This is how the Nuclear Age Peace Foundation describes its mission:

"The Nuclear Age Peace Foundation was founded in 1982. Our mission is to educate, advocate, propose, and pursue denuclearizing actions with the intention of achieving a just and peaceful world, free of nuclear weapons. NAPF is a non-partisan, non-profit organization with consultative status to the United Nations and is comprised of over 80,000 individuals and groups worldwide.

"NAPF is a proud Partner Organization of the International Campaign to Abolish Nuclear Weapons (ICAN), the winner of the 2017 Nobel Peace Prize.

"We educate, advocate, propose, and pursue denuclearizing actions with the intention of achieving a just and peaceful world, free of nuclear weapons."

2.4 Stockholm International Peace Research Institute (SIPRI)

https://www.sipri.org/

In 1964, the Swedish Prime Minister, Tage Erlander, proposed that a peace research institute should be set up to commemorate Sweden's 150 years of unbroken peace. His proposal was accepted, and Royal Commission was set up, under the leadership of Ambassador Alva Myrdal, to decide on the best form for the peace research institute.

The institute which resulted from these efforts was later named the Stockholm International Peace Research Institute. The Royal Commission had decided that the institute's research should contribute to "the understanding of the preconditions for a stable peace and for peaceful solutions of international conflicts" The Royal Commission also recommended that research should concentrate on armaments, their limitation, reduction, and arms control, adding that work of "an applied research character directed towards practical-political questions which should be carried on in a constant interchange with research of a more theoretical kind"

Table 2.1: **SIPRI Military Expenditure Database, 2016**

Rank	Country	Annual Spending $ Bn.	% of GDP
1	United State	611.2	3.3
2	China	215.7	1.9
3	Russia	69.2	5.3
4	Saudi Arabia	63.7	10
5	India	55.9	2.5
6	France	55.7	2.3
7	United Kingdom	48.3	1.9
8	Japan	46.1	1.0
9	Germany	41.1	1.2
10	South Korea	36.8	2.7
11	Italy	27.9	1.5
12	Australia	24.3	2.0

Table 2.2: **SIPRI List of arms manufacturers, 2016**

Rank	Company	Country	Annual Arms Sales $ Mn.
1	Lockheed Martin	United States	40,830
2	Boeing	United States	29,510
3	Raytheon	United States	22,910
4	BAE Systems	United Kingdom	22.700
5	Northrop Grumman	United States	21,400
6	General Dynamics	United States	19,230
7	Airbus	European Union	12,520
8	L-3 Communications	United States	8,890
9	Leonardo-Finmeccanica	Italy	8,500
10	Thales Group	France	8,170
11	United Technologies Corporation	United States	6,870
12	Huntington Ingalls Industries	United States	6,720

Figure 2.6: **The SIPRI Logo.**

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Figure 2.7: **Ambassador Alva Myrdal. She shared a Nobel Peace Prize in 1982. Her husband, Professor Gunnar Myrdal, shared the Nobel Memorial Prize in Economics in 1974.**

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Figure 2.8: **The SIPRI headquarters in Solna, Stockholm.**

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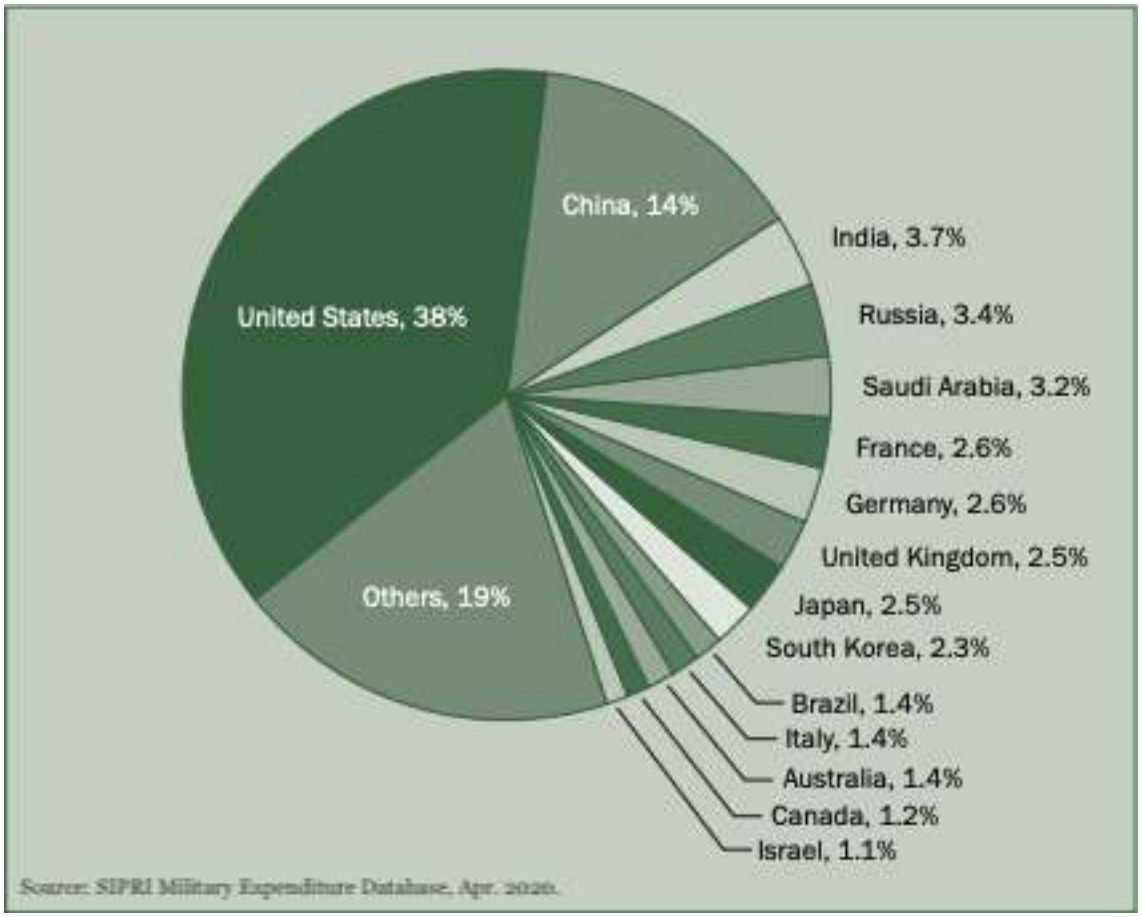

Figure 2.9: **Military budgets in 2020.**

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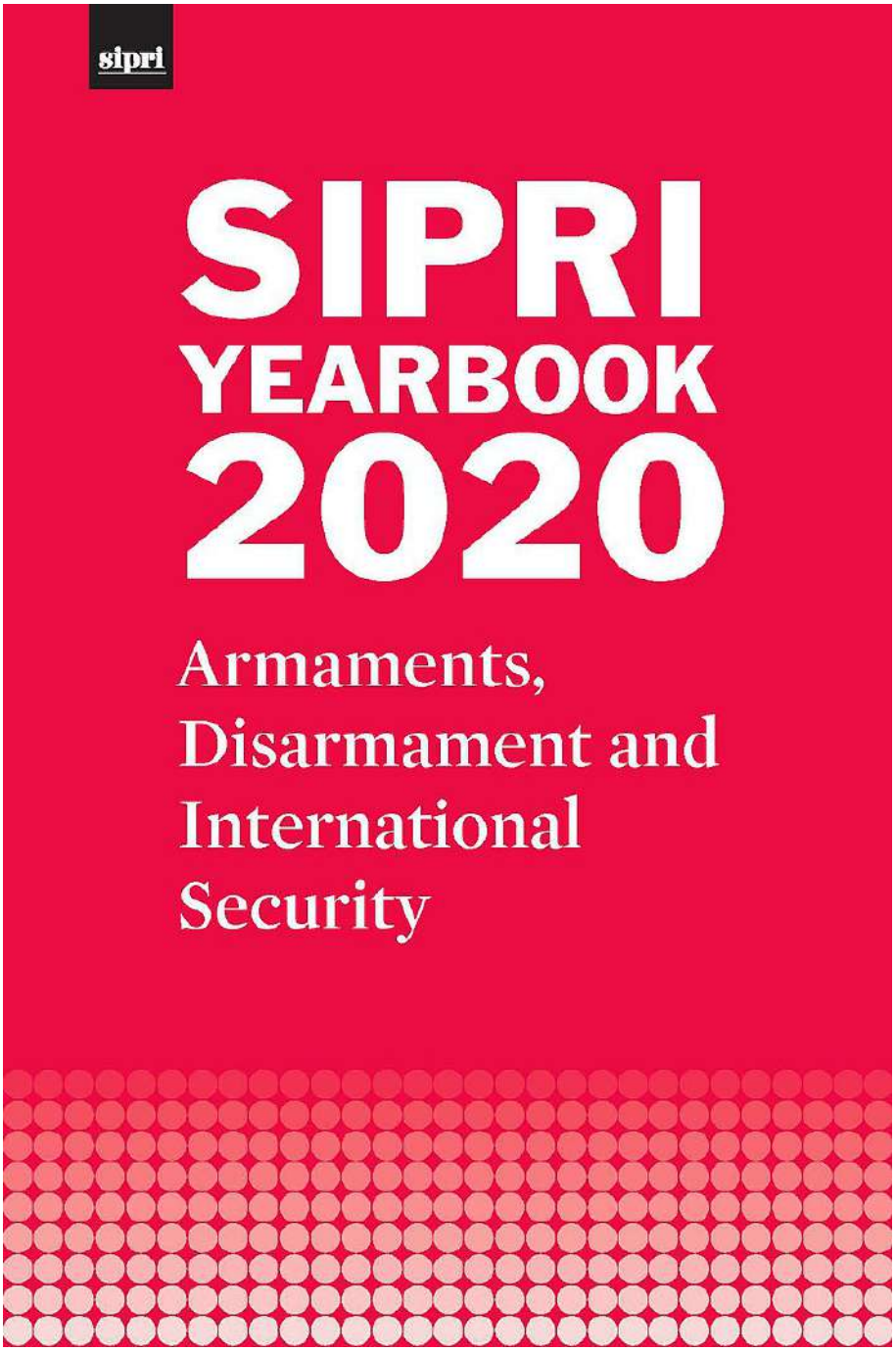

Figure 2.10: **SIPRI Yearbook 2020.**

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2.5 Peace Research Institute Oslo

The Peace Research Institute Oslo (PRIO) was founded in 1959 by a group of researchers in Norway led by Johan Galtung. Since 1964, PRIO has published the *Journal of Peace Research*, also founded by Professor Galtung.

Johan Galtung was originally a mathematician, but he later studied sociology and founded a new field: Peace and Conflict Research. He is the author of more that 100 books, and more than 1000 research articles. A few of his books and articles are the following:

- Statistisk hypotesepröving (Statistical hypothesis testing, 1953)
- Gandhis politiske etikk (Gandhi's political ethics, 1955, with philosopher Arne Næss)
- Theory and Methods of Social Research (1967)
- Violence, Peace and Peace Research (1969)
- Members of Two Worlds (1971)
- Fred, voldeog imperialisme (Peace, violence and imperialism, 1974)
- Peace: Research - Education - Action (1975)
- Europe in the Making (1989)
- Global Glasnost: Toward a New World Information and Communication Order? (1992, with Richard C. Vincent)
- Global Projections of Deep-Rooted U.S Pathologies (1996)
- Peace By Peaceful Means: Peace and Conflict, Development and Civilization (1996)
- Johan uten land. På fredsveien gjennom verden (Johan without land. On the Peace Path Through the World, 2000, autobiography for which he won the Brage Prize)
- 50 Years: 100 Peace and Conflict Perspectives (2008)
- Democracy - Peace - Development (2008, with Paul D. Scott)
- 50 Years: 25 Intellectual Landscapes Explored (2008)
- Globalizing God: Religion, Spirituality and Peace (2008, with Graeme MacQueen)

Figure 2.11: **The Norwegian mathematician and sociologist Johan Galtung (born 1930), pioneer of the discipline Conflict Resolution. He also founded the Peace Research Institute, Oslo and the Journal of Peace Research. He has published over 1000 articles and more than 100 books. Originally a mathematician, Professor Galtung later studied sociology, and he became the founder of a new discipline - Preac Research. He was the principal founder of the Peace Research Institute Oslo, and the founder of the Journal of Peace Research. Professor Galtung has taught at many universities throughout the world.**

Figure 2.12: **Mrs. Fumiko Galtung, Transcend Media Service Weekly Digest editor Antonio C.S. Rosa, and Johan Galtung in Norway, 2007.**

Figure 2.13: **The Peace Research Institute Oslo. PRIO was founded in 1959 by a group of Norwegian researchers led by Johan Galtung. The institute originally was a department of the Norwegian Institute for Social Research in Oslo and became an independent institute in 1966. About 100 people work at PRIO. Their research is funded by a core grant, and by ad hoc grants for specific projects. Donors include the Norwegian Foreign Ministry and the European Union.**

2.6 Bertrand Russell Peace Foundation

http://www.russfound.org/

Here is a quotation from the Bertrand Russell Peace Foundation's description of its history and purpose:

Origins

"The Bertrand Russell Peace Foundation was launched in 1963 after twelve months of preparation. It was established in order to carry forward Russell's work for peace, human rights and social justice. This had been assisted by a small secretariat in earlier years, but its rapid growth and increasing cost made the burden larger than could be carried by one person, however distinguished. Preoccupied with the danger of nuclear war, Russell had always been deeply concerned with the defense of civil rights, and the institutionalization of his work made it possible to create a number of desks which could specialize on different areas or particular problems.

Aims

"The Foundation was formed to further the cause of peace, and to assist in the pursuit of freedom and justice. It sought to identify and counter the causes of violence, and to identify and oppose the obstacles to worldwide community. It was designed to promote research into disarmament, wars and threats of war, and to publish the results. It has consistently laboured to carry on the work of its founder in a spirit of fidelity to the standards of reason and tolerance which he did so much to advance. Accordingly, it has always struggled for freedom of thought and opinion, and for non-exploitative forms of human association.

The Spokesman

"The Spokesman journal was founded by Bertrand Russell near the end of his life. It not only concerns itself with the many matters of peace and social justice which preoccupied Russell, but also examines in depth the present order, its structures, its beneficiaries and its victims. It includes the Peace Dossier and an extensive review section.

"Noam Chomsky recently described The Spokesman as "really first rate". Selections from The Spokesman, in PDF format are available for you to download at www.spokesmanbooks.com where you can also purchase individual copies or take out a subscription. You can also use our online shop at www.spokesmanbookshop.com to purchase titles using PayPal. Members of the public are welcome to visit by appointment."

Some biographical notes on Bertrand Russell

Bertrand Arthur William Russell, 3rd Earl Russell, OM, FRS, (1872-1970), was born into a wealthy and influential English family, whose members had been active in politics since the time of the Tudors. Bertrand Russell's grandfather, Lord John Russell, the third son of the Duke of Bedford and 1st Earl Russell, had twice served as Prime Minister during Queen Victoria's reign.

Because of the early death of his parents (Viscount and Viscountess Amberly) Bertrand Russell was brought up by his grandparents, Lord John Russell and Lady Russell, who lived at Pembroke Lodge near Richmond Park, about fifteen miles west of London. Bertrand Russell's grandfather soon died too, and his grandmother became the dominant influence on the boy's early life. Although she was a religious conservative, Russell's grandmother nevertheless believed in independence of thought, accepted Darwinism, and supporter Irish Home Rule. She also had the motto (taken from the Bible) "Thou shalt not follow a multitude to do evil."

Bertrand Russell and his elder brother Frank were educated at home by tutors, and they had rather lonely and unhappy childhoods in the emotionally repressed atmosphere of Pembroke Lodge. However, when Bertrand was eleven years old, Frank introduced him to the work of Euclid. Bertrand Russell later described this event in his autobiography as "one of the great events of my life, as dazzling as first love". It is interesting that Albert Einstein had similar feelings when he encountered the works of Euclid at almost the same age.

During these early years Russell also discovered the writings of the poet Shelley, and he later wrote:"I spent all my spare time reading him, and learning him by heart, knowing no one to whom I could speak of what I thought or felt, I used to reflect how wonderful it would have been to know Shelley, and to wonder whether I should meet any live human being with whom I should feel so much sympathy".

In 1890, when Bertrand Russell was 18, he started his studies in mathematics at Trinity College, Cambridge University. He graduated with distinction, but because of his agnostic religious beliefs, he encountered difficulties. Nevertheless he continued to teach at Cambridge University, his most notable student being the Austrian-British philosopher Ludwig Wittgenstein (1889-1951).

During the years 1910-1913, Russell collaborated with his former teacher. Alfred North Whitehead (1861-1947) to write a 3-volume treatise entitled *Principia Mathematica*, which dealt with the logical foundations of mathematics and languages. At the end of the huge effort which he had devoted to writing this enormous work, Russell underwent a sudden conversion, during which all the aims of his life changed completely. Observing the terrible isolation of Whitehead's wife while she suffered an attack of angina, he had a sudden insight into the isolation of each human being and the need for better communication to break this isolation. As a result of this moment of intuition, Bertrand Russell resolved to abandon mathematics, and instead devote his life to making human existence happier and better.

Russell's idealism, honesty and humor shine from the pages of the enormous number of

books, articles and letters that he wrote during the remainder of his life. His wide-ranging and influential writing won him not only great fame, but also the 1950 Nobel Prize in Literature.

Bertrand Russell was the author of the Russell-Einstein Declaration of 1955, the founding document of Pugwash Conferences on Science and World Affairs, an organization which won the Nobel Peace Prize in 1995. Russell devoted much of the last part of his life to working for the complete abolition of nuclear weapons.

Here are a few things that Bertrand Russell said:

War does not determine who is right, but only who is left.

The world is full of magical things patiently waiting for our wits to become sharper.

Men are born ignorant, not stupid. They are made stupid by education.

To fear love is to fear life, and those who fear life are already three parts dead.

The only thing that will redeem mankind is cooperation.

The trouble with the world is that the stupid are cocksure, and the intelligent are full of doubt.

Love is something more than desire for sexual intercourse; it is the principle means of escape from the loneliness which afflicts men and women throughout the greater part of their lives.

The good life is one inspired by love and guided by knowledge.

Those who have never known the deep intimacy and the intense companionship of mutual love have missed the best thing that life has to give.

Science is what you know, philosophy is what you don't know.

I would never die for my beliefs, because I might be wrong.

Extreme hopes are born from extreme misery.

To conquer fear is the beginning of wisdom.

The fact that an opinion has been widely held is no evidence whatever that it is not utterly absurd.

I have made an odd discovery. Every time I talk with a savant, I am convinced that happiness is no longer possible. Yet when I talk with my gardener, I'm convinced of the opposite.

Patriotism is the willingness to kill and be killed for trivial reasons.

Three passions, simple but overwhelmingly strong, have governed my life: the longing for love, the search for knowledge, and unbearable pity for the suffering of mankind.

There lies before us, if we choose, continual progress in happiness, knowledge, and wisdom. Shall we, instead, choose death, because we cannot forget our quarrels? We appeal, as human beings, to human beings: Remember your humanity, and forget the rest. If you can do so, the way lies open to a new Paradise; if you cannot, there lies before you the risk of universal death.

Figure 2.14: **Pembroke Lodge, near Richmond Park, Bertrand Russell's childhood home.**

Figure 2.15: **Russell at the age of four.**

Figure 2.16: **Russell at Trinity College Cambridge in 1893.**

Figure 2.17: **Russell with two of his children, John and Kate. His second son, Conrad (1937-2004, not shown here) became the 5th Earl Russell, and had a very distinguished career as a liberal parliamentarian and historian.**

2.7 Médecins Sans Frontières (Doctors Without Borders)

https://www.msf.org/

Foundation of Médicines Sans Frontièrs

According to Wikipedia,

"Médecins Sans Frontières was founded in 1971, in the aftermath of the Biafra secession, by a small group of French doctors and journalists who sought to expand accessibility to medical care across national boundaries and irrespective of race, religion, creed or political affiliation. To that end, the organization emphasizes 'independence and impartiality', and explicitly precludes political, economic, or religious factors in its decision making. For these reasons, it limits the amount of funding received from governments or intergovernmental organizations. These principles have allowed MSF to speak freely with respect to acts of war, corruption, or other hindrances to medical care or human well-being. Only once in its history, during the 1994 genocide in Rwanda, has the organization called for military intervention."

In 1999 the work of MSF was recognized by the award of a Nobel Peace Prize.

Some quotations from the 1999 Nobel Peace Prize award

"Médecins Sans Frontières is an independent, neutral and impartial emergency aid organization that was founded in France in 1971. It demands full and unimpeded freedom to carry out its work in accordance with medical ethics and the rights of human beings to humanitarian aid. The organization is a frequent critic of violence and violations of human rights in areas of conflict where it has stationed doctors and aid workers.

"MSF has been involved in a large number of aid operations, both at scenes of natural disasters and in theatres of war. The organization's current budget amounts to NOK 2 billion. It annually sends out 2,500 doctors and nurses, who are well assisted by 15,000 local employees in 80 countries. MSF annually carries out 6 million consultations and 200,000 surgical interventions. Such figures make it one of the world's largest emergency aid organizations."

Figure 2.18: **Médecins Sans Frontières logo.**

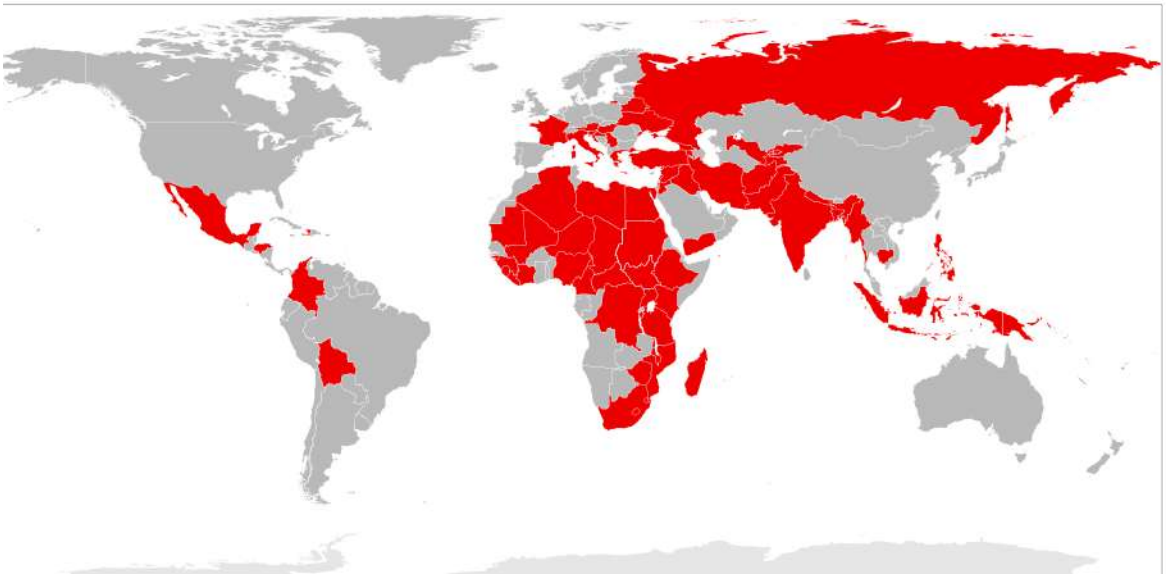

Figure 2.19: **Countries where MSF had missions in 2015.**

2.8 The Transnational Foundation for Peace and Future Research

www.transnational.org

TFF Articles on Militarism and Environment

Pentagon's own map of U.S. bases in Africa contradicts its claim of "light" footprint

Here is a quotation from and an article by Nick Turse:

"...Where there are U.S. bases, there is the potential for such attacks, because bases are not just launching pads for offensive military operations, but targets for them too. Since 9/11, the U.S. military has built a sprawling network of outposts in more than a dozen African countries. The Intercept has obtained U.S. military documents and a set of accompanying maps that provide the locations of these African bases in 2019, including the one at Manda Bay. These formerly secret documents, created by the Pentagon's Africa Command and obtained via the Freedom of Information Act, offer an exclusive window into the footprint of American military operations in Africa..."

No Warming, No War: How Militarism Fuels the Climate Crisis and Visa Versa

Here are some quotations from an article by Lorah Steichen and Lindsay Koshgarian[3]:

"In a strange twist, it has taken a global pandemic to significantly reduce the world's fossil fuel emissions.

"The COVID-19 pandemic has utterly changed life as we know it - but it's also laid bare how Washington's militaristic budget priorities have left the country woefully unprepared for a crisis. With massive shortages in public health resources and shocks to the broader economy throwing Americans off their health care, states are left clamoring for help from the military to cope.

"All this could be a preview of shocks to come as our climate crisis continues unabated.

"While meaningful climate action has stalled on Capitol Hill and in the White House, planners at the Pentagon have been quietly preparing a militarized,

[3]https://ips-dc.org/climate-militarism-primer/

'armed lifeboat' response to climate chaos for years. Unfortunately, the tendency to understand climate change as just another national security issue has misdirected resources away from the programs that we need to mitigate and adapt to a warming climate.

"In this report, we'll lay out how militarism and the climate crisis are deeply intertwined and mutually reinforcing. The military itself, we explain, is a huge polluter - and is often deployed to sustain the very extractive industries that destabilize our climate. This climate chaos, in turn, leads to massive displacement, militarized borders, and the prospect of further conflict.

"True climate solutions, we argue, must have antimilitarism at their core.

"In the face of both COVID-19 and the climate crisis, we urgently need to shift from a culture of war to a culture of care. Funneling trillions into the military to wage endless wars and project military dominance has prevented us from investing in true security and cooperation. If we don't transform our society and the way we confront crises, we will face even more unjust and inhumane realities in a climate-changed future.

Key Findings

- **The Pentagon is a major polluter. U.S. Militarism degrades the environment and contributes directly to climate change. The Pentagon is the world's largest institutional user of petroleum; just one of the military's jets, the B-52 stratofortress, consumes about as much fuel in an hour as the average car driver uses in seven years. Plans to confront climate change must address militarization, but 'greening the military' misses the point entirely. Militarism and climate justice are fundamentally at odds.**

- **The United States has a well-known history of fighting wars for oil. The fossil fuel industry relies on militarization to uphold its operations around the globe. Oil is the leading cause of war: An estimated one-quarter to one-half of all interstate wars since 1973 have been linked to oil. And all over the world, those who fight to protect their lands from extractive industries are often met with state and paramilitary violence.**

- **Climate change and border militarization are inextricably linked. It is clear that on a warming planet, cross-border migration will rise. Estimates project that around 200 million people will be displaced by the middle of century due to climate change. As the U.S. continues to ramp up border security, so do threats to all people's freedom to move and stay. Immigrant**

justice is climate justice, and challenging militarism is critical to achieving both.

- **Over-investment in the military comes at the high cost of under-investing in other needs, including climate. For decades, the U.S. has invested in military adventurism and prioritized military threats above all over threats to human life. Compared to the $6.4 trillion spent on war in the past two decades, the cost of shifting the U.S. power grid to 100% renewable is an estimate $4.5 trillion. The bloated U.S. war economy presents an opportunity to redirect significant military resources, including money, infrastructure, and people, toward implementing solutions to climate change.**

- **Workers need a way out. The fossil fuel and military sectors mirror each other in the way that workers frequently end up funneled into lethal work due to limited options. We need a Just Transition for workers and communities in both sectors. In order to rapidly transition to a green economy, we must fund millions of jobs in the green economy. Funding the green economy instead of a bloated military budget would be a net job creator; for the same level of spending, clean energy and infrastructure create over 40% more jobs and energy efficiency retrofits create nearly twice the level of job creation.**

- **Racism and racial oppression form the foundation for both the extractive fossil fuel economy and the militarized economy. Neither could exist without the presumption that some human lives are worth less than others, and racial justice would undermine the foundations of both.**

Nomination for the Nobel Peace Prize

Here is the text of the most recent nomination of Dr. Oberg:

Oslo, January 31, 2020
The Norwegian Nobel Committee
postmaster@nobel.no
Oslo

NOBEL PEACE PRIZE NOMINATION 2020 - JAN OBERG

I would once again like to nominate Jan Oberg, Sweden, referring to earlier nominations and materials submitted.

During 2019 Dr. Oberg has renewed, expanded and refashioned his unique and extensive global network of highly qualified peace experts under the name

"The Transnational", see https://transnational.live/about/mission/

Dr. Oberg continued, in 2019, to give the principle of peace by peaceful means practical application, in particular in the most important interface for peace efforts in the world today, ensuring that the relation between the cultures east and west will develop along constructive and peaceful lines. I will refer primarily to his various articles on the TFF websites, www.transnational.org [old] and [from January 1, 2018] https://transnational.live.

Oberg's endeavours in developing an innovative project depicting the emerging new and potentially more peaceful Chinese-initiated Belt and Road Initiative (BRI), is illustrative of the permanently, almost restless, experimenting that Oberg, working through the Transnational Foundation for Peace and Future Research (TFF), has practised since 1985 - all based on the UN Charter's Article 1 that peace shall be created by peaceful means. Building on earlier work in China and experience from peacebuilding missions in Africa and West Asia he devoted his time to promoting peace-building and co-operation, deeply dedicated to positive relations with China. He visited China in 1983 and again, in 2018, spent 6 weeks traveling the country extensively, including its two poorest provinces and interviewed hundreds of people about their lives and the immense changes over only 35 years. He did this as part of a new project to let art assist politics. The "Silk Peace Art Road", described here: https://obergphotographics.com/spar-project/, is an innovative project in the sense that it combines field research and network creation in the focal country. During 2019 the result was reported in the usual form, via research articles and reports, but also through a rather large photo-based, multi-media art installation at The European Cultural Centre (ECC) in Palazzo Mora, during the Venice biennale, lasting from May to November 2019. By this Oberg is experimenting with a fundamentally new way of bridging research and art.

Sincerely yours,
Kristian Andenæs,
Professor em., dr. philos., UiO

An appeal

Here is the text of an appeal, written by Jan Oberg and other TFF board members, and signed by members of Transcend:

We've likely only seen the beginnings of the worldwide economic consequences of the Coronavirus. For those who want to see, there are forecasts of a deep economic crisis written on all the walls.

Figure 2.20: **Jan Oberg.**

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Figure 2.21: **An oil fire and tank in Kuwait.**

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Before the Corona, the world faced huge problems that - among other resources - require funds to solve: huge sums. Think the 17 UN Development Goals, think technological innovation; think the global climate/warming crisis; think the rebuilding of war-torn countries and think the reduction towards zero and repatriation of the world's 80 million displaced people.

And think funds to convert the present military systems towards another, less costly way of creating security. We have just experienced how the outdated non-human security has deprived us of the needed resources when the Corona hit. Recklessly, virtually all governments had ignored a predictable civilian challenge but wasted billions of taxpayer money for weapons and war.

The Corona should be a wake-up call.

So we ask: Where are the funds going to come from to solve humanity's most urgent problems before they become too big to solve?

It seems that most governments believe that the annual world military expenditures - ranging around US$ 2000 billion, the highest ever - can be maintained. Some even believe their national expenditures must increase substantially.

The same governments believe that the world's most important organization of which they are all members - the United Nations and its organizations - can do what it must on a regular budget of US$ 3 billion and total annual expenditures of US$ 50-60 billion. That is 3 per cent of the costs of global militarism.

Those are the priorities of our world. It's not sustainable in Corona times - if it ever were. It is ethically indefensible too. And it produces neither security nor peace.

Perhaps the incomprehensible sum of US$ 2000 billion would be justified if the world experienced solid defense and security as well as trust, cooperation and peace. But the fact is that there are more tension, hatred, dominance attempts, new kinds of wars added to old ones and much more terrorism than before the US-led Global War on Terror.

Furthermore, one country after the other has been destroyed since the end of the First Cold War in 1989-90. It has been possible thanks to a systematic violation of international law, including in particular the UN Charter.

What to do?

Imagine that every country in the world would reduce its military expenditures by at least 50%. Then you would have US$ 1000 billion.

Is it a large or small sum?

It's equivalent to what China in 2013 put behind the Belt and Road Initiative, BRI - a cooperative effort around infrastructure, fast physical and digital communication, sea and land transport, education and cultural exchange, and much more. Today it involves around 80 countries, some on all continents and it is open to everyone.

The philosophy behind it is, at least theoretically, one of peace. It dates back to the Panchsheel Treaty of 1954, the five principles of peaceful coexistence.

Beyond doubt, this is the largest and most positive cooperation project in today's world. It is the project that will give birth to - if it has not already? - a new multi-polar world order based more on cooperation than confrontation.

There is, therefore, no doubt that a substantial conversion of, say, US$ 1000 billion from the military to the solution of humanity's common problems would provide a desperately needed boost for the common good. (This argument does not rest on any assumption that money is the primary tool to solve problems; that takes lots of non-material qualities. But with economies falling apart at a moment when all economies need funds for "rebooting humanity," this is a straightforward thing to do with a rather large bang for the buck).

Additionally, lots of human and other resources, knowledge, experience and equipment today operated by the military could be converted and put to civilian tasks. Such a conversion would boost employment - as there exists no documentation for the often-stated assertion that military investments boost employment more than civilian investments. It is, rather, comparatively wasteful.

Ours is not the time for more militarism, warfare and antagonism. The net effect of military investments is suffering, destruction (of lives, capital and property) and unavoidable environmental destruction.

Furthermore, every military dollar stands in the way of precisely that global cooperation without which we are doomed. And it is not matched by a security or peace effect.

Time is up for those who strut about and try to master others by violence or the threat of it. Militarism and warfare are now as outdated and indefensible as is slavery, absolute monarchy, dictatorship, child labour, rape and discrimination. These are phenomena we have decided, in the name of civilization, to abolish or condemn.

If you feel we cannot, very quickly, reduce or abolish militarism, nuclearism and warfare but should uphold at least some self-defensive military capacity, that should be discussed. It's in line with Article 51 of the UN Charter.

That would mean much more dis-armament than the suggested 50% and it would mean trans-armament toward a new way of handling our unavoidable conflicts, create security in diversity and with defensive military and civilian means, and - thereby - realize the peaceful future which 99% of citizens around the world strongly desire.

There are, indeed, alternatives. But minds, as well as other resources, need to be liberated before it's too late.

So, to begin with: Reduce everybody's military expenditures equally much, say 50%. And see the marvelous positive results - politically, economically and in terms of peace. Then move on. A better world is possible. And the Corona is a benign wake-up call compared with World War III.

We need to use the Corona crisis constructively. In this 11th hour, humanity's situation makes it abundantly clear to us that it is either cooperation and coexistence or destruction and no existence.

Signed by

Roger D. Harris
Richard Falk
John Scales Avery
Ravi P. Bhatia
Ambika Roshan
Biljana Vankovska
David Loy
David Swanson
Jens Jørgen Nielsen
Shastri Ramachandaran
Chantal Mutamuriza
Hans-Christof von Sponeck
David Krieger
Radmila Nakarada
Jesper Munk Jakobsen
Kamran Mofid
Brajna Greenhalgh
Mairead Maguire
Elaheh Pooyandeh
Tim Hayward

2.9 International Physicians for the Prevention of Nuclear War

https://www.ippnw.org/ Dr. Bernard Lown (1921-2021), a Lithuanian-American cardiologist, and Dr. Yevgeniy Ivanovich Chazov (born in 1929) were the two main founders of IPPNW. They knew each other well, and had collaborated on problems of mutual interest in cardiology. In 1961, Dr. Lown had founded Physicians for Social Responsibility, an American organization dedicated to reducing the dangers of nuclear war, and ultimately to the abolition of nuclear war.

In 1080 Lown and Chazov were the two main founders of International Physicians for the Prevention of Nuclear War. IPPNW was dedicated to the task of gathering authoritative information about the effects of nuclear weapons on populations and on the global environment, and the task of educating the public regarding these matters. In 1985 the work of IPPNW was recognized by the award of the Nobel Peace Prize. In announcing

Figure 2.22: **Dr. Yevgeniy Ivanovich Chazov is a prominent physician of the Soviet Union and Russia, specializing in cardiology, Chief of the Fourth Directorate of the Ministry of Health of the USSR, Academician of the Russian Academy of Sciences and the Russian Academy of Medical Sciences, a recipient of numerous awards and decorations, Soviet, Russian, and foreign. He is a graduate of Kiev Medical Institute.**

the award, the Nobel Committee said the IPPNW "has performed a considerable service to mankind by spreading authoritative information and by creating an awareness of the catastrophic consequences of atomic warfare."

In 2007, IPPNW launched the International Campaign for the Abolition of Nuclear Weapons (ICAN) a federation of more than 200 NGO's dedicated campaigning for a treaty to ban nuclear weapons. ICAN was successful in its efforts and was awarded the 2017 Nobel Peace Prize. (See Appendix A).

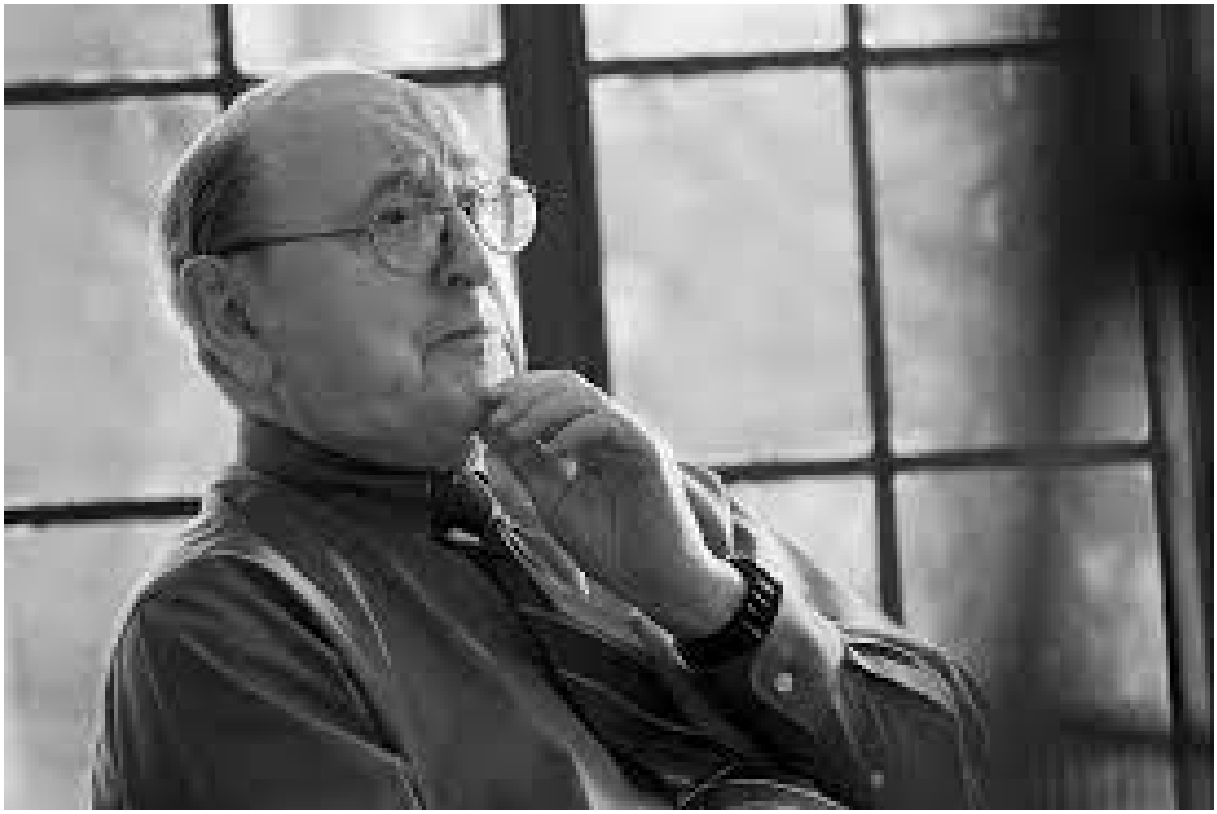

Figure 2.23: **Dr. Bernard Lown, one of the two principal founders of IPPNW. He had previously founded Physicians for Social Responsibility in 1961. He was born in 1921, and lived until 2021.**

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Chapter 3

CATASTROPHIC CLIMATE CHANGE

3.1 The climate emergency

Global warming is occurring much faster than the IPCC's scientists expected. The 2020 winter in Europe has been the warmest ever recorded, with February daytime temperatures averaging about 6 degrees C in Copenhagen. On March 3, 2020, the temperature reached 13 degrees C in Moscow, and 14 degrees in Kiev. Normally these two cities would be snowbound at the start of March. Temperatures of 20 degrees C were recorded in Antarctica! The 2018 IPCC Climate Report made it clear that we have only a decade to drastically reduce CO2 emissions. If we fail to do this, irreversible feedback loops will take over and make any human efforts to avoid catastrophe useless. While some governments have responded to this challenge, a number of large greenhouse gas emitters have not. These include the United States, Canada, Brazil, India, China and Saudi Arabia. While India and China have strong renewable energy programs, they are also building many new coal-fired power plants.

3.2 Understatement of existential climate risk

Here are some excerpts from a 44-page report entitled *What Lies Beneath: The Understanding of Existential Climate Risk*, by David Spratt and Ian Dunlop[1]:

Three decades ago, when serious debate on human-induced climate change began at the global level, a great deal of statesmanship was on display. There was a preparedness to recognize that this was an issue transcending nation states, ideologies and political parties which had to be addressed pro-actively in the long-term interests of humanity as a whole. This was the case even

[1]https://www.breakthroughonline.org.au/

though the existential nature of the risk it posed was far less clear cut than it is today.

As global institutions, such as the United Nations Framework Convention on Climate Change (UNFCCC) which was established at the Rio Earth Summit in 1992, were developed to take up this challenge, and the extent of change this would demand of the fossil-fuel-dominated world order became clearer, the forces of resistance began to mobilize. Today, as a consequence, and despite the diplomatic triumph of the 2015 Paris Agreement, the debate around climate change policy has never been more dysfunctional, indeed Orwellian.

In his book 1984, George Orwell describes a double-think totalitarian state where most of the population accepts "the most flagrant violations of reality, because they never fully grasped the enormity of what was demanded of them, and were not sufficiently interested in public events to notice what was happening. By lack of understanding they remained sane."

Orwell could have been writing about climate change and policymaking. International agreements talk of limiting global warming to 1.5-2 degrees Celsius (^{o}C), but in reality they set the world on a path of 3-5^{o}C of warming. Goals are reaffirmed, only to be abandoned. Coal is "clean". Just 1^{o}C of warming is already dangerous, but this cannot be admitted. The planetary future is hostage to myopic national self-interest. Action is delayed on the assumption that as yet unproven technologies will save the day, decades hence. The risks are existential, but it is "alarmist" to say so.

A one-in-two or one-in-three chance of missing a goal is normalized as reasonable. Moral hazard permeates official thinking, in that there is an incentive to ignore the risks in the interests of political expediency.

Climate policymaking for years has been cognitively dissonant, "a flagrant violation of reality". So it is unsurprising that there is a lack of understanding amongst the public and elites of the full measure of the climate challenge. Yet most Australians sense where we are heading: three-quarters of Australians see climate change as catastrophic risk, and half see our way of life ending within the next 100 years.

Politics and policymaking have norms: rules and practices, assumptions and boundaries, that constrain and shape them. In recent years, the previous norms of statesmanship and long-term thinking have disappeared, replaced by an obsession with short-term political and commercial advantage. Climate policymaking is no exception. Since 1992, short-term economic interest has trumped environmental and future human needs.

The world today emits 50% more carbon dioxide (CO_2) from the consumption of energy than it did 25 years ago, and the global economy has more than doubled in size. The UNFCCC strives "to enable economic development to proceed in a sustainable manner", but every year humanity's ecological footprint becomes larger and less sustainable. Humanity now requires the biophysical capacity of 1.7 Earths annually as it rapidly chews up natural capital.

A fast, emergency-scale transition to a post-fossil fuel world is absolutely necessary to address climate change. But this is excluded from consideration by policymakers because it is considered to be too disruptive. The orthodoxy is that there is time for an orderly economic transition within the current short-termist political paradigm. Discussion of what would be safe - less warming than we presently experience - is non-existent. And so we have a policy failure of epic proportions.

Policymakers, in their magical thinking, imagine a mitigation path of gradual change to be constructed over many decades in a growing, prosperous world. The world not imagined is the one that now exists: of looming financial instability; of a global crisis of political legitimacy and "fake news"; of a sustainability crisis that extends far beyond climate change to include all the fundamentals of human existence and most significant planetary boundaries (soils, potable water, oceans, the atmosphere, biodiversity, and so on); and of severe global energy-sector dislocation.

In anticipation of the upheaval that climate change would impose upon the global order, the IPCC was established by the United Nations (UN) in 1988, charged with regularly assessing the global consensus on climate science as a basis for policymaking. The IPCC Assessment Reports (AR), produced every five-to-eight years, play a large part in the public framing of the climate narrative: new reports are a global media event.

AR5 was produced in 2013-14, with AR6 due in 2022. The IPCC has done critical, indispensable work of the highest standard in pulling together a periodic consensus of what must be the most exhaustive scientific investigation in world history.

It does not carry out its own research, but reviews and collates peer-reviewed material from across the spectrum of this incredibly complex area, identifying key issues and trends for policymaker consideration. However, the IPCC process suffers from all the dangers of consensus-building in such a wide-ranging and complex arena. For example, IPCC reports, of necessity, do not always contain the latest available information. Consensus-building can lead to "least drama", lowest-common-denominator outcomes, which overlook critical issues. This is particularly the case with the "fat-tails" of probability distributions, that is, the high-impact but lower-probability events where scientific knowledge is more limited.

Vested-interest pressure is acute in all directions; climate denialists accuse the IPCC of alarmism, whereas many climate action proponents consider the IPCC to be far too conservative. To cap it all, the IPCC conclusions are subject to intense political oversight before being released, which historically has had the effect of substantially watering-down sound scientific findings.

These limitations are understandable, and arguably were not of overriding importance in the early period of the IPCC. However, as time has progressed, it is now clear that the risks posed by climate change are far greater than

previously anticipated. We have moved out of the twilight period of much talk, but relatively limited climate impacts, into the harsh light of physically-evident existential threats. Climate change is now turning nasty, as we have witnessed recently in the North America, East and South Asia, the Middle East and Europe, with record-breaking heatwaves and wildfires, more intense flooding and more damaging hurricanes.

The distinction between climate science and risk is the critical issue, for the two are not the same. Scientific reticence - a reluctance to spell out the full risk implications of climate science in the absence of perfect information - has become a major problem. Whilst this is understandable, particularly when scientists are continually criticized by denialists and political apparatchiks for speaking out, it is extremely dangerous given the fat-tail risks of climate change. Waiting for perfect information, as we are continually urged to do by political and economic elites, means it will be too late to act. Time is not on our side. Sensible risk management addresses risk in time to prevent it happening, and that time is now.

Irreversible, adverse climate change on the global scale now occurring is an existential risk to human civilization. Many of the world's top climate scientists - Kevin Anderson, James Hansen, Michael E. Mann, Michael Oppenheimer, Naomi Oreskes, Stefan Rahmstorf, Eric Rignot, Hans Joachim Schellnhuber, Kevin Trenberth and others - who are quoted in this report well understand these implications and are forthright about their findings, where we are heading, and the limitations of IPCC reports.

This report seeks to alert the wider community and business and political leaders to these limitations and urges changes to the IPCC approach, to the wider UNFCCC negotiations, and to national policymaking. It is clear that existing processes will not deliver the transformation to a carbon-negative world in the limited time now available. We urgently require a re-framing of scientific research within an existential risk-management framework. This requires special precautions that go well beyond conventional risk management. Like an iceberg, there is great danger in "what lies beneath".

Existential Risk to Human Civilization

In 2016, the World Economic Forum survey of the most impactful risks for the years ahead elevated the failure of climate change mitigation and adaptation to the top of the list, ahead of weapons of mass destruction, ranking second, and water crises, ranking third. By 2018, following a year characterized by high-impact hurricanes and extreme temperatures, extreme-weather events were seen as the single most prominent risk. As the survey noted: "We have been pushing our planet to the brink and the damage is becoming increasingly clear."

Climate change is an existential risk to human civilization: that is, an ad-

verse outcome that would either annihilate intelligent life or permanently and drastically curtail its potential.

Temperature rises that are now in prospect, after the Paris Agreement, are in the range of 3-5 ^{o}C. At present, the Paris Agreement voluntary emission reduction commitments, if implemented, would result in planetary warming of 3.4 ^{o}C by 2100, without taking into account "long-term" carbon- cycle feedbacks. With a higher climate sensitivity figure of 4.5 ^{o}C, for example, which would account for such feedbacks, the Paris path would result in around 5 ^{o}C of warming, according to a MIT study.

A study by Schroeder Investment Management published in June 2017 found - after taking into account indicators across a wide range of the political, financial, energy and regulatory sectors - the average temperature increase implied for the Paris Agreement across all sectors was 4.1 ^{o}C.

Yet 3 ^{o}C of warming already constitutes an existential risk. A 2007 study by two US national security think-tanks concluded that 3 ^{o}C of warming and a 0.5 meter sea-level rise would likely lead to "outright chaos" and "nuclear war is possible", emphasizing how "massive non-linear events in the global environment give rise to massive nonlinear societal event".

The Global Challenges Foundation (GCF) explains what could happen: "If climate change was to reach 3 ^{o}C, most of Bangladesh and Florida would drown, while major coastal cities - Shanghai, Lagos, Mumbai - would be swamped, likely creating large flows of climate refugees. Most regions in the world would see a significant drop in food production and increasing numbers of extreme weather events, whether heat waves, floods or storms. This likely scenario for a 3 ^{o}C rise does not take into account the considerable risk that self-reinforcing feedback loops set in when a certain threshold is reached, leading to an ever increasing rise in temperature. Potential thresholds include the melting of the Arctic permafrost releasing methane into the atmosphere, forest die-back releasing the carbon currently stored in the Amazon and boreal forests, or the melting of polar ice caps that would no longer reflect away light and heat from the sun."

Warming of 4 ^{o}C or more could reduce the global human population by 80% or 90%, and the World Bank reports "there is no certainty that adaptation to a 4 ^{o}C world is possible."

Prof. Kevin Anderson says a 4 ^{o}C future "is incompatible with an organized global community, is likely to be beyond 'adaptation', is devastating to the majority of ecosystems, and has a high probability of not being stable".

This is a commonly-held sentiment amongst climate scientists. A recent study by the European Commission's Joint Research Centre found that if the global temperature rose 4 ^{o}C, then extreme heatwaves with "apparent temperatures" peaking at over 55 ^{o}C will begin to regularly affect many densely populated parts of the world, forcing much activity in the modern industrial world to stop. ("Apparent temperatures" refers to the Heat Index, which

quantifies the combined effect of heat and humidity to provide people with a means of avoiding dangerous conditions.)

In 2017, one of the first research papers to focus explicitly on existential climate risks proposed that "mitigation goals be set in terms of climate risk category instead of a temperature threshold", and established a "dangerous" risk category of warming greater than 1.5 ^{o}C, and a "catastrophic" category for warming of 3 ^{o}C or more. The authors focussed on the impacts on the world's poorest three billion people, on health and heat stress, and the impacts of climate extremes on such people with limited adaptation resources. They found that a 2 ^{o}C warming "would double the land area subject to deadly heat and expose 48% of the population (to deadly heat). A 4 ^{o}C warming by 2100 would subject 47% of the land area and almost 74% of the world population to deadly heat, which could pose existential risks to humans and mammals alike unless massive adaptation measures are implemented."

A 2017 survey of global catastrophic risks by the Global Challenges Foundation found that: "In high-end [climate] scenarios, the scale of destruction is beyond our capacity to model, with a high likelihood of human civilization coming to an end."

84% of 8000 people in eight countries surveyed for the Foundation considered climate change a "global catastrophic risk".

Existential risk may arise from a fast rate of system change, since the capacity to adapt, in both the natural and human worlds, is inversely proportional to the pace of change, amongst other factors. In 2004, researchers reported on the rate of warming as a driver of extinction...

At 4 ^{o}C of warming "the limits for adaptation for natural systems would largely be exceeded throughout the world".

Ecological breakdown of this scale would ensure an existential human crisis. By slow degrees, these existential risks are being recognized. In May 2018, an inquiry by the Australian Senate into national security and global warming recognized "climate change as a current and existential national security risk... defined as 'one that threatens the premature extinction of Earth-originating intelligent life or the permanent and drastic destruction of its potential for desirable future development'".

In April 2018, the Intelligence on European Pensions and Institutional Investment think-tank warned business leaders that "climate change is an existential risk whose elimination must become a corporate objective".

However the most recent IPCC Assessment Report did not consider the issue. Whilst the term "risk management" appears in the 2014 IPCC Synthesis Report fourteen times, the terms "existential" and "catastrophic" do not appear...

3.3 The UK declares a climate emergency

Introducing the motion in the House of Commons, Labour leader Jeremy Corbyn said: **"We have no time to waste. We are living in a climate crisis that will spiral dangerously out of control unless we take rapid and dramatic action now. This is no longer about a distant future. We're talking about nothing less than the irreversible destruction of the environment within our lifetimes of members of this house."**

Here are some excerpts from an article by Amy Goodman and Nermeen Shaikh of Democracy now published in Truthout on May 2, 2019.[2]:

On Wednesday, the House of Commons became the first parliament in the world to declare a climate emergency. The resolution came on the heels of the recent Extinction Rebellion mass uprising that shut down Central London last month in a series of direct actions. Activists closed bridges, occupied public landmarks and even superglued themselves to buildings, sidewalks and trains to demand urgent action to combat climate change. Police arrested more than 1,000 protesters. Labour Party Leader Jeremy Corbyn told Parliament, "We are witnessing an unprecedented upsurge of climate activism, with groups like Extinction Rebellion forcing the politicians in this building to listen. For all the dismissive and defensive column inches the processes have provoked, they are a massive and, I believe, very necessary wake-up call. Today we have the opportunity to say, 'We hear you.'" We speak with George Monbiot, British journalist, author and columnist with The Guardian. His recent piece for The Guardian is headlined "Only rebellion will prevent an ecological apocalypse." Monbiot says capitalism "is like a gun pointed at the heart of the planet. It will essentially, necessarily destroy our life-support systems. Among those characteristics is the drive for perpetual economic growth on a finite planet."

Spain has also recently declared a climate emergency.

[2]https://truthout.org/video/george-monbiot-on-the-uk-climate-emergency/

3.4 The 2018 IPCC report

Excerpts from an article summarizing the report

Here are excerpts from an article entitled **UN Experts Warn of 'Climate Catastrophe' by 2040** by Jesica Corbett. The article was published in Common Dreams on Monday, October 8, 2018.[3]:

"The climate crisis is here and already impacting the most vulnerable," notes 350.org's program director. "Staying under 1.5°C is now a matter of political will."

Underscoring the need for "rapid, far-reaching, and unprecedented" changes to life as we know it to combat the global climate crisis, a new report from the Intergovernmental Panel on Climate Change (IPCC) - the United Nations' leading body for climate science - details what the world could look like if the global temperature rises to 1.5°C versus 2°C (2.7°F versus 3.6°F) above pre-industrial levels, and outlines pathways to reducing greenhouse gas emissions in the context of sustainable development and efforts to eradicate poverty.

"Climate change represents an urgent and potentially irreversible threat to human societies and the planet," the report reads. "Human-induced warming has already reached about 1°C (1.8°F) above pre-industrial levels at the time of writing of this Special Report... If the current warming rate continues, the

[3]https://www.commondreams.org/news/2018/10/08/un-experts-warn-climate-catastrophe-2040-without-rapid-and-unprecedented-global

world would reach human-induced global warming of 1.5^{o}C around 2040."

Approved by the IPCC in South Korea on Saturday ahead of COP24 in Poland in December, Global Warming of 1.5^{o}C was produced by 91 authors and reviewers from 40 countries. Its release has elicited calls to action from climate campaigners and policymakers the world over.

"This is a climate emergency. The IPCC 1.5 report starkly illustrates the difference between temperature rises of 1.5^{o}C and 2^{o}C - for many around the world this is a matter of life and death," declared Karin Nansen, chair of Friends of the Earth International (FOEI). "It is crucial to keep temperature rise well below 1.5 degrees ... but the evidence presented by the IPCC shows that there is a narrow and shrinking window in which to do so."

The report was requested when the international community came together in December of 2015 for the Paris agreement, which aims to keep global warming within this century "well below" 2^{o}C, with an ultimate target of 1.5^{o}C. President Donald Trump's predecessor supported the accord, but Trump has vowed to withdraw the United States, even as every other nation on the planet has pledged their support for it. In many cases, however, sworn support hasn't led to effective policy.

"It's a fresh reminder, if one was needed, that current emissions reduction pledges are not enough to meet the long-term goals of the Paris agreement. Indeed, they are not enough for any appropriately ambitious temperature target, given what we know about dangerous climate impacts already unfolding even at lower temperature thresholds," Rachel Cleetus, lead economist and climate policy manager for the Union of Concerned Scientists (UCS), wrote ahead of its release.

"The policy implications of the report are obvious: We need to implement a suite of policies to sharply limit carbon emissions and build climate resilience, and we must do all this is in a way that prioritizes equitable outcomes particularly for the world's poor and marginalized communities," Cleetus added.

"We want a just transition to a clean energy system that benefits people not corporations," Nansen emphasized. "Only with a radical transformation of our energy, food and economic systems, embracing environmental, social, gender and economic justice, can we prevent climate catastrophe and temperature rises exceeding 1.5^{o}C."

Today we are faced with multiple interrelated crises, for example the threat of catastrophic climate change or equally catastrophic thermonuclear war, and the threat of widespread famine. These threats to human existence and to the biosphere demand a prompt and rational response; but because of institutional and cultural inertia, we are failing to take the steps that are necessary to avoid disaster.

3.5 Greta Thunberg

Only immediate climate action can save the future

Immediate action to halt the extraction of fossil fuels and greatly reduce the emission of CO_2 and other greenhouse gasses is needed to save the long-term future of human civilization and the biosphere.

At the opening ceremony of United Nations-sponsored climate talks in Katowice, Poland, Sir David Attenborough said "Right now, we are facing a man-made disaster of global scale. Our greatest threat in thousands of years. Climate change. If we don't take action, the collapse of our civilizations and the extinction of much of the natural world is on the horizon. The world's people have spoken. Their message is clear. Time is running out. They want you, the decision-makers, to act now."

Antonio Guterres, UN Secretary-General, said climate change was already "a matter of life and death" for many countries. He added that the world is "nowhere near where it needs to be" on the transition to a low-carbon economy.

Swedish student Greta Thunberg, is a 16-year-old who has launched a climate protest movement in her country. She said, in a short but very clear speech after that of UN leader Antonio Guterres: "Some people say that I should be in school instead. Some people say that I should study to become a climate scientist so that I can 'solve the climate crisis'. But the climate crisis has already been solved. We already have all the facts and solutions."

She added: "Why should I be studying for a future that soon may be no more, when no one is doing anything to save that future? And what is the point of learning facts when the most important facts clearly mean nothing to our society?"

Thunberg continued: "Today we use 100 million barrels of oil every single day. There are no politics to change that. There are no rules to keep that oil in the ground. So we can't save the world by playing by the rules. Because the rules have to be changed."

She concluded by saying that "since our leaders are behaving like children, we will have to take the responsibility they should have taken long ago."

Appearing among billionaires, corporate CEO's and heads of state at the Davos Economic Forum in Switzerland, like a new Joan of Arc, 16-year-old Swedish climate activist Greta Thunberg called on decision-makers to fulfil their responsibilities towards future generations. Here are some excerpts from her speech:

Greta's speech at Davos

Our house is on fire. I am here to say, our house is on fire. According to the IPCC, we are less than 12 years away from not being able to undo our mistakes. In that time, unprecedented changes in all aspects of society need to have taken place, including a reduction of our CO_2 emissions by at least 50%...

Here in Davos - just like everywhere else - everyone is talking about money. It seems money and growth are our only main concerns.

And since the climate crisis has never once been treated as a crisis, people are simply not aware of the full consequences on our everyday life. People are not aware that there is such a thing as a carbon budget, and just how incredibly small that remaining carbon budget is. That needs to change today.

No other current challenge can match the importance of establishing a wide, public awareness and understanding of our rapidly disappearing carbon budget, that should and must become our new global currency and the very heart of our future and present economics.

We are at a time in history where everyone with any insight of the climate crisis that threatens our civilization - and the entire biosphere - must speak out in clear language, no matter how uncomfortable and unprofitable that may be.

We must change almost everything in our current societies. The bigger your carbon footprint, the bigger your moral duty. The bigger your platform, the bigger your responsibility.

Figure 3.1: **Greta Thunberg on the cover of Time Magazine, The Intergovernmental Panel on Climate Change, in their October 2018 report, used strong enough language to wake up at least part of the public: the children whose future is at stake. Here is an excerpt from a speech which 16-year-old Swedish climate activist Greta Thunberg made at the Davos Economic Forum in January, 2019: "Our house is on fire. I am here to say, our house is on fire. According to the IPCC, we are less than 12 years away from not being able to undo our mistakes. In that time, unprecedented changes in all aspects of society need to have taken place, including a reduction of our CO2 emissions by at least 50%..."**

3.6 Worldwide school strike, 15 March, 2019

Over 1.4 million young students across all continents took to the streets on Friday March 15th for the first ever global climate strike. Messages in more than 40 languages were loud and clear: world leaders must act now to address the climate crisis and save our future. The school strike was the largest climate action in history. Nevertheless it went almost unmentioned in the media,

Here are some of the statements by the students explaining why they took part in the strikes:

In India, no one talks about climate change. You don't see it on the news or in the papers or hear about it from government. We want global leaders to declare a climate emergency. If we don't act today, then we will have no tomorrow. - Vidit Baya, 17, Udaipur, India.

We face heartbreaking loss due to increasingly extreme weather events. We urge the Taiwanese government to implement mitigation measures and face up to the vulnerability of indigenous people, halt construction projects in the indigenous traditional realm, and recognize the legal status of Plains Indigenous People, in order to implement environmental protection as a bottom-up approach - Kaisanan Ahuan, Puli City, Taiwan.

We have reached a point in history when we have the technical capacities to solve poverty, malnutrition, inequality and of course global warming. The deciding factors for whether we take advantage of our potential will be our activism, our international unity and our ability to develop the art of making the impossible possible. Whether we succeed or not depends on our political will - Eyal Weintraub, 18, and Bruno Rodriguez, 18, Argentina.

The damage done by multinationals is enormous: the lack of transparency, dubious contracts, the weakening of the soil, the destruction of flora and fauna, the lack of respect for mining codes, the contamination of groundwater. In Mali, the state exercises insufficient control over the practices of the multinationals, and it is us, the citizens, who suffer the consequences. The climate alarm has sounded, and the time has come for us all to realize that there is still time to act locally, in our homes, our villages, our cities - Mone Fousseny, 22, Mali.

3.7 Solar energy

Before the start of the industrial era, human society relied exclusively on renewable energy sources - but can we do so again, with our greatly increased population and greatly

increased demands? Will we ultimately be forced to reduce the global population or our per capita use of energy, or both? Let us now try to examine these questions.

Biomass, wind energy, hydropower and wave power derive their energy indirectly from the sun, but in addition, various methods are available for utilizing the power of sunlight directly. These include photovoltaic panels, solar designs in architecture, solar systems for heating water and cooking, concentrating photovoltaic systems, and solar thermal power plants.

Photovoltaic cells and concentrating photovoltaic systems

Solar power was the fastest-growing source of new energy in 2016, surpassing the net growth of all other energy sources including coal, according to a new report from the International Energy Agency (IEA).

The IEA report found new solar capacity increased by 50 percent in 2016, and IEA executive director Fatih Birol hailed solar's rapid growth. "What we are witnessing is the birth of a new era in solar photovoltaics [PV]. We expect that solar PV capacity growth will be higher than any other renewable technology up to 2022."[4]

The report also shows renewables as a whole accounted for two-thirds of all new energy capacity in 2016. "We see renewables growing by about 1,000 GW (gigawatts) by 2022, which equals about half of the current global capacity in coal power, which took 80 years to build," Birol said in a statement accompanying the report.[5]

Solar photovoltaic cells[6] are thin coated wafers of a semiconducting material (usually silicon). The coatings on the two sides are respectively charge donors and charge acceptors. Cells of this type are capable of trapping solar energy and converting it into direct-current electricity. The electricity generated in this way can be used directly (as it is, for example, in pocket calculators) or it can be fed into a general power grid. Alternatively it can be used to split water into hydrogen and oxygen. The gases can then be compressed and stored, or exported for later use in fuel cells. In the future, we may see solar photovoltaic arrays in sun-rich desert areas producing hydrogen as an export product. As their petroleum reserves become exhausted, the countries of the Middle East and Africa may be able to shift to this new technology and still remain energy exporters.

It is interesting to notice that the primary process of photosynthesis in plants is closely similar to the mechanism by which solar cells separate charges and prevent the back-reaction. We can see why a back-reaction must be prevented if we consider the excitation of a single atom. An absorbed photon lifts an electron from a filled atomic orbital to an empty one, leaving a positively-charged hole in the orbital from which the electron came. However, a back-reaction occurs almost immediately: The excited electron falls back into

[4]https://www.theguardian.com/environment/2017/oct/04/solar-power-renewables-international-energy-agency

[5]https://www.iea.org/newsroom/news/2017/october/solar-pv-grew-faster-than-any-other-fuel-in-2016-opening-a-new-era-for-solar-pow.html

[6]https://www.iea.org/renewables/

the orbital from which it came, and the absorbed energy is re-emitted. One can say that the electron and hole have recombined.

In higher plants, the back reaction is prevented because the photon is absorbed in a membrane which has a sandwich-like structure. Dye molecules (usually chlorophyll molecules) are sandwiched between a layer of charge donor molecules on one side of the membrane, and a layer of charge acceptor molecule on the other side. The electron quickly migrates to the acceptors, which are molecules with low-lying unfilled orbitals. Meanwhile the hole has quickly moved to the opposite side of the membrane. where it combines with an electron from a donor molecule. A donor molecule is a molecule whose highest filled orbital is high in energy. In this process, the back.reaction is prevented. The electron and hole are on opposite sides of the membrane, and they can only recombine after they have driven the metabolism of the plant.

In a photovoltaic solar cell, the mechanism by which the back-reaction is prevented is exactly similar. It too has a sandwich-like structure, with charge donors on one side, charge-acceptors on the other, and photon absorbers in the middle. Here too, the electron and hole quickly migrate to opposite sides. They can only recombine by traveling through the external circuit, which is analogous to a plant's metabolism, and performing useful work.

The cost of manufacturing photovoltaics continues to fall rapidly. In 2017, a homeowner paid approximately $3,360 per kilowatt to have rooftop solar panels installed Usually photovoltaic panels are warranted for a life of 20 years, but they are commonly still operational after 30 years or more. Using the fact that there are 8760 hours in a year, and thus 175200 hours in 20 years, we can calculate that the cost of electricity to a solar-using homeowner today is about 1.92 cents per kilowatt hour. This can be compared with electricity generated from coal, which in 2011 cost 3.23 cents per kilowatt hour, while electricity generated from natural gas cost 4.51 cents per kilowatt hour. We must also remember that photovoltaics are falling rapidly in price, and that the fossil fuel costs do not include externalities, such as their contribution to climate change.

Concentrating photovoltaic systems are able to lower costs still further by combining silicon solar cells with reflectors that concentrate the sun's rays. The most inexpensive type of concentrating reflector consists of a flat piece of aluminum-covered plastic material bent into a curved shape along one of its dimensions, forming a trough-shaped surface. (Something like this shape results when we hold a piece of paper at the top and bottom with our two hands, allowing the center to sag.) The axis of the reflector can be oriented so that it points towards the North Star. A photovoltaic array placed along the focal line will then receive concentrated sunlight throughout the day.

Photovoltaic efficiency is defined as the ratio of the electrical power produced by a cell to the solar power striking its surface. For commercially available cells today, this ratio is between 9% and 14%. If we assume 5 hours of bright sunlight per day, this means that a photo cell in a desert area near to the equator (where 1 kW/m^2 of peak solar power reaches the earth's surface) can produce electrical energy at the average rate of 20-30 W_e/m^2, the average being taken over an entire day and night. The potential power per unit area for photovoltaic systems is far greater than for biomass. However, the mix of

renewable energy sources most suitable for a particular country depends on many factors. We will see below that biomass is a promising future source of energy for Sweden, because of Sweden's low population density and high rainfall. By contrast, despite the high initial investment required, photovoltaics are undoubtedly a more promising future energy source for southerly countries with clear skies.

In comparing photovoltaics with biomass, we should be aware of the difference between electrical energy and energy contained in a the chemical bonds of a primary fuel such as wood or rapeseed oil. If Sweden (for example) were to supply all its energy needs from biomass, part of the biomass would have to be burned to generate electricity. The efficiency of energy conversion in electricity generation from fuel is 20%-35%. Of course, in dual use power plants, part of the left-over heat from electrical power generation can be used to heat homes or greenhouses. However, hydropower, wind power and photovoltaics have an advantage in generating electrical power, since they do so directly and without loss, whereas generation of electricity from biomass involves a loss from the inefficiency of the conversion from fuel energy to electrical energy. Thus a rational renewable energy program for Sweden should involve a mixture of biomass for heating and direct fuel use, with hydropower and wind power for generation of electricity. Perhaps photovoltaics will also play a role in Sweden's future electricity generation, despite the country's northerly location and frequently cloudy skies.

The global market for photovoltaics is expanding at the rate of 30% per year. This development is driven by rising energy prices, subsidies to photovoltaics by governments, and the realization of the risks associated with global warming and consequent international commitments to reduce carbon emissions. The rapidly expanding markets have resulted in lowered photovoltaic production costs, and hence further expansion, still lower costs, etc. - a virtuous feedback loop.

Solar thermal power plants

Solar Parabolic Troughs can be used to heat a fluid, typically oil, in a pipe running along the focal axis. The heated fluid can then be used to generate electrical power. The liquid that is heated in this way need not be oil. In a solar thermal power plant in California, reflectors move in a manner that follows the sun's position and they concentrate solar energy onto a tower, where molten salt is heated to a temperature of 1050 degrees F (566 ^{o}C). The molten salt stores the heat, so that electricity can be generated even when the sun is not shining. The California plant generates 10 MW_e.

Solar designs in architecture

At present, the average global rate of use of primary energy is roughly 2 kW_t per person. In North America, the rate is 12 kW_t per capita, while in Europe, the figure is 6 kW_t. In Bangladesh, it is only 0.2 kW_t. This wide variation implies that considerable energy savings are possible, through changes in lifestyle, and through energy efficiency.

Figure 3.2: **A rooftop array of photovoltaic cells.**

Figure 3.3: **A solar thermal power plant. Arrays of heliostatic reflectors concentrate the sun's rays onto molten salt in the tower. The plant produces electricity at night because the salt remains hot..**

Figure 3.4: **A solar cooker.**

Figure 3.5: **A rooftop solar thermal array for domestic water heating.**

Important energy savings can be achieved through solar design in architecture. For example, insulation can be improved in walls, and insulating shutters can be closed at night.

In double envelope construction, a weatherproof shell surrounds the inner house. Between the outer shell and the house, sun-heated air circulates. A less extreme example of this principle is the construction of south-facing conservatories. The sun-heated air in the conservatories acts as a thermal buffer, and reduces heat loss from the house.

Solar design aims at making houses cool in the summer and warm in the winter. Awnings can be spread out in the summer to shade windows, and rolled together in the winter to allow sunshine to enter the house. Alternatively, deciduous trees can be planted in front of south-facing windows. During the summer, the leaves of the trees shade the windows, while in the winter, the leaves fall, allowing the sun to enter.

During daylight hours, houses can be illuminated by fiber optic light pipes, connected to a parabolic collector on the roof. The roof can also contain arrays of solar photovoltaic cells and solar water heaters.

Houses can be heated in the winter by heat pumps connected to a deeply buried network of pipes. Heat pumps function in much the same way as refrigerators or air conditioners. When they are used to warm houses in the winter, a volatile liquid such as ammonia is evaporated underground, where the temperature is relatively constant, not changing much between summer and winter. In the evaporation process, heat is absorbed from the ground. The gas is then compressed and re-liquefied within the house, and in this process, it releases the heat that was absorbed underground. Electricity is of course required to drive a heat pump, but far less electrical power is needed to do this than would be required to heat the house directly.

In general, solar design of houses and other buildings requires an initial investment, but over time, the investment is amply repaid through energy savings.

Solar systems for heating water and cooking

Solar heat collectors are are already in common use to supply hot water for families or to heat swimming pools. A common form of the solar heat collector consists of a flat, blackened heat-collecting plate to which tubes containing the fluid to be heated are connected. The plate is insulated from the atmosphere by a layer of air (in some cases a partial vacuum) above which there is a sheet of glass. Water flowing through the tubes is collected in a tank whenever it is hotter than the water already there. In cases where there is a danger of freezing, the heated fluid may contain antifreeze, and it may then exchange heat with water in the collection tank. Systems of this kind can function even in climates as unfavorable as that of Northern Europe, although during winter months they must be supplemented by conventional water-heaters.

In the developing countries, wood is often used for cooking, and the result is sometimes deforestation, soil erosion and desertification. In order to supply an alternative, many designs for solar cooking have been developed. Often the designs are very simple, and

many are both easy and inexpensive to build, the starting materials being aluminum foil and cardboard boxes.

3.8 Wind energy

Wind parks in favorable locations, using modern wind turbines, are able to generate 10 MW_e/km^2 or 10 W_e/m^2. Often wind farms are placed in offshore locations. When they are on land, the area between the turbines can be utilized for other purposes, for example for pasturage. For a country like Denmark, with good wind potential but cloudy skies, wind turbines can be expected to play a more important future role than photovoltaics. Denmark is already a world leader both in manufacturing and in using wind turbines. Today, on windy days, 100% of all electricity used in Denmark is generated by wind power, and the export of wind turbines makes a major contribution to the Danish economy. The use of wind power is currently growing at the rate of 38% per year. In the United States, it is the fastest-growing form of electricity generation.

The location of wind parks is important, since the energy obtainable from wind is proportional to the cube of the wind velocity. We can understand this cubic relationship by remembering that the kinetic energy of a moving object is proportional to the square of its velocity multiplied by the mass. Since the mass of air moving past a wind turbine is proportional to the wind velocity, the result is the cubic relationship just mentioned.

Before the decision is made to locate a wind park in a particular place, the wind velocity is usually carefully measured and recorded over an entire year. For locations on land, mountain passes are often very favorable locations, since wind velocities increase with altitude, and since the wind is concentrated in the passes by the mountain barrier. Other favorable locations include shorelines and offshore locations on sand bars. This is because onshore winds result when warm air rising from land heated by the sun is replaced by cool marine air. Depending on the season, the situation may be reversed at night, and an offshore wind may be produced if the water is warmer than the land.

The cost of wind-generated electrical power is currently lower than the cost of electricity generated by burning fossil fuels.

The "energy payback ratio" of a power installation is defined as the ratio of the energy produced by the installation over its lifetime, divided by the energy required to manufacture, construct, operate and decommission the installation. For wind turbines, this ratio is 17-39, compared with 11 for coal-burning plants. The construction energy of a wind turbine is usually paid back within three months.

Besides the propeller-like design for wind turbines there are also designs where the rotors turn about a vertical shaft. One such design was patented in 1927 by the French aeronautical engineer Georges Jean Marie Darrieus. The blades of a Darrieus wind turbine are airfoils similar to the wings of an aircraft. As the rotor turns in the wind, the stream of air striking the airfoils produces a force similar to the "lift" of an airplane wing. This force pushes the rotor in the direction that it is already moving. The Darrieus design has some advantages over conventional wind turbine design, since the generator can be placed

Figure 3.6: **Rows of wind turbines.**

Figure 3.7: **Vertical axis wind turbines.**

Figure 3.8: **Wind turbines on the Danish island of Samsø The island was the first in the world to achieve 100% renewable energy.**

at the bottom of the vertical shaft, where it may be more easily serviced. Furthermore, the vertical shaft can be lighter than the shaft needed to support a conventional wind turbine.

One problem with wind power is that it comes intermittently, and demand for electrical power does not necessarily come at times when the wind is blowing most strongly. To deal with the problem of intermittency, wind power can be combined with other electrical power sources in a grid. Alternatively, the energy generated can be stored, for example by pumped hydroelectric storage or by using hydrogen technology, as will be discussed below.

Bird lovers complain that birds are sometimes killed by rotor blades. This is true, but the number killed is small. For example, in the United States, about 70,000 birds per year are killed by turbines, but this must be compared with 57 million birds killed by automobiles and 97.5 million killed by collisions with plate glass.

The aesthetic aspects of wind turbines also come into the debate. Perhaps in the future, as wind power becomes more and more a necessity and less a matter of choice, this will be seen as a "luxury argument".

A Danish island reaches 100% renewable energy

The Danish island of Samsø is only 112 square kilometers in size, and its population numbers only 4,300. Nevertheless, it has a unique distinction. Samsø was the first closed land area to declare its intention of relying entirely on renewable energy, and it has now achieved this aim, provided that one stretches the definitions slightly.

In 1997, the Danish Ministry of Environment and Energy decided to sponsor a renewable-energy contest. In order to enter, communities had to submit plans for how they could make a transition from fossil fuels to renewable energy. An engineer (who didn't live

there) thought he knew how Samsø could do this, and together with the island's mayor he submitted a plan which won the contest. As a result, the islanders became interested in renewable energy. They switched from furnaces to heat pumps, and formed cooperatives for the construction of windmill parks in the sea near to the island. By 2005, Samsø was producing, from renewable sources, more energy than it was using. The islanders still had gasoline-driven automobiles, but they exported from their windmill parks an amount of electrical energy that balanced the fossil fuel energy that they imported. This is a story that can give us hope for the future, although a farming community like Samsø cannot serve as a model for the world.

3.9 Hydroelectric power

In 2015, hydroelectric power supplied 16.6% of all electrical power, and 70% of the electrical power generated from renewable energy. In the developed countries, the potential for increasing this percentage is small, because most of the suitable sites for dams are already in use. Mountainous regions of course have the greatest potential for hydroelectric power, and this correlates well with the fact that virtually all of the electricity generated in Norway comes from hydro, while in Iceland and Austria the figures are respectively 83% and 67%. Among the large hydroelectric power stations now in use are the La Grande complex in Canada (16 GW_e) and the Itapú station on the border between Brazil and Paraguay (14 GW_e). The Three Gorges Dam in China produces 18.2 GW_e.

Even in regions where the percentage of hydro in electricity generation is not so high, it plays an important role because hydropower can be used selectively at moments of peak demand. Pumping of water into reservoirs can also be used to store energy.

The creation of lakes behind new dams in developing countries often involves problems, for example relocation of people living on land that will be covered by water, and loss of the land for other purposes[7]. However the energy gain per unit area of lake can be very large - over 100 W_e/m^2. Fish ladders can be used to enable fish to reach their spawning grounds above dams. In addition to generating electrical power, dams often play useful roles in flood control and irrigation.

At present, hydroelectric power is used in energy-intensive industrial processes, such as the production of aluminum. However, as the global energy crisis becomes more severe, we can expect that metals derived from electrolysis, such as aluminum and magnesium, will be very largely replaced by other materials, because the world will no longer be able to afford the energy needed to produce them.

[7]Over a million people were displaced by the construction of the Three Gorges Dam in China, and many sites of cultural value were lost

Table 3.1: Technical potential and utilization of hydropower. (Data from World Energy Council, 2003.)

Region	Technical potential	Annual output	Percent used
Asia	0.5814 TW_e	0.0653 TW_e	11%
S. America	0.3187 TW_e	0.0579 TW_e	18%
Europe	0.3089 TW_e	0.0832 TW_e	27%
Africa	0.2155 TW_e	0.0091 TW_e	4%
N. America	0.1904 TW_e	0.0759 TW_e	40%
Oceania	0.0265 TW_e	0.0046 TW_e	17%
World	1.6414 TW_e	0.2960 TW_e	18%

Figure 3.9: **Hydroelectric power does not suffer from the problem of intermittency, but may sometimes produce undesirable social and ecological impacts.**

3.10 Energy from the ocean

Tidal power

The twice-daily flow of the tides can be harnessed to produce electrical power. Ultimately tidal energy comes from the rotation of the earth and its interaction with the moon's gravitational field. The earth's rotation is very gradually slowing because of tidal friction, and the moon is gradually receding from the earth, but this process will take such an extremely long time that tidal energy can be thought of as renewable.

There are two basic methods for harnessing tidal power. One can build barriers that create level differences between two bodies of water, and derive hydroelectric power from the head of water thus created. Alternatively it is possible to place the blades of turbines in a tidal stream. The blades are then turned by the tidal current in much the same way that the blades of a wind turbine are turned by currents of air.

There are plans for using the second method on an extremely large scale in Cook Strait, near New Zealand. A company founded by David Beach and Chris Bathurst plans to anchor 7,000 turbines to the sea floor of Cook Strait in such a way that they will float 40 meters below the surface. Beach and Bathurst say that in this position, the turbines will be safe from the effects of earthquakes and storms. The tidal flow through Cook Strait is so great that the scheme could supply all of New Zealand's electricity if the project is completed on the scale visualized by its founders.

Choosing the proper location for tidal power stations is important, since the height of tides depends on the configuration of the land. For example, tides of 17 meters occur in the Bay of Fundy, at the upper end of the Gulf of Maine, between New Brunswick and Nova

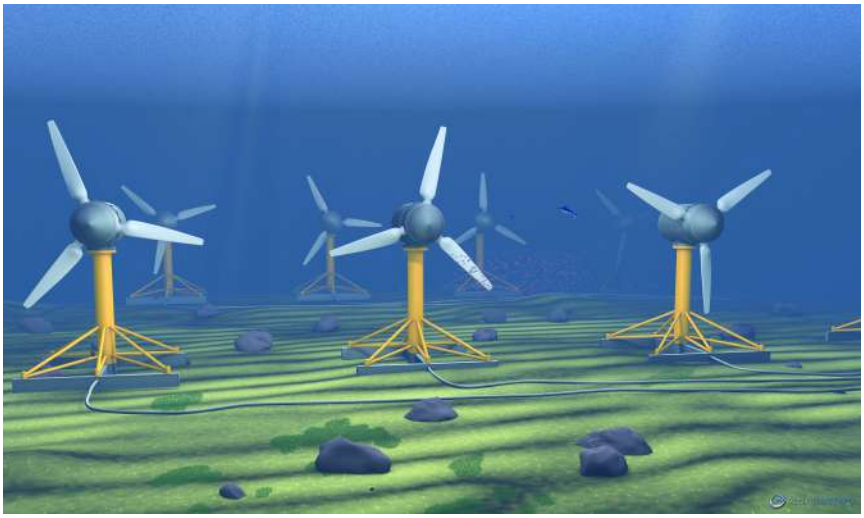

Figure 3.10: **Underwater turbines can make use of the energy of ocean currents.**

Scotia. Here tidal waves are funneled into the bay, creating a resonance that results in the world's greatest level difference between high an low tides. An 18 MW_e dam-type tidal power generation station already exists at Annapolis River, Nova Scotia, and there are proposals to increase the use of tidal power in the Bay of Fundy. Some proposals involve turbines in the tidal stream, similar to those proposed for use in the Cook Strait.

In the future, favorable locations for tidal power may be exploited to their full potentialities, even thought the output of electrical energy exceeds local needs. The excess energy can be stored in the form of hydrogen (see below) and exported to regions deficient in renewable energy resources.

Wave energy

At present, the utilization of wave energy is in an experimental stage. In Portugal, there are plans for a wave farm using the Pelamis Wave Energy Converter. The Pelamis is a long floating tube with two or more rigid sections joined by hinges. The tube is tethered with its axis in the direction of wave propagation. The bending between sections resulting from passing waves is utilized to drive high pressure oil through hydraulic motors coupled to electrical generators. Each wave farm in the Portuguese project is planned to use three Pelamis converters, each capable of producing 750 kW_e. Thus the total output of each wave farm will be 2.25 MW_e.

Another experimental wave energy converter is Salter's Duck, invented in the 1970's by Prof. Stephen Salter of the University of Edinburgh, but still being developed and improved. Like the Pelamis, the Duck is also cylindrical in shape, but the axis of the cylinder is parallel to the wave front, i.e. perpendicular to the direction of wave motion. A floating cam, attached to the cylinder, rises and falls as a wave passes, driving hydraulic motors within the cylinder. Salter's Duck is capable of using as much as 65% of the wave's

Figure 3.11: **The Pelamis wave energy transformer floats on the ocean like a giant sea snake. It consists of several segments which move against each other and build up hydraulic pressure. This in turn drives a turbine. A new Pelamis generation is currently under construction.**

energy.

The energy potentially available from waves is very large, amounting to as much as 100 kilowatts per meter of wave front in the best locations.

Ocean thermal energy conversion

In tropical regions, the temperature of water at the ocean floor is much colder than water at the surface. In ocean thermal energy conversion, cold water is brought to the surface from depths as great as 1 km, and a heat engine is run between deep sea water at a very low temperature and surface water at a much higher temperature.

According to thermodynamics, the maximum efficiency of a heat engine operating between a cold reservoir at the absolute temperature T_C and a hot reservoir at the absolute temperature T_H is given by 1-T_C/T_H. In order to convert temperature on the centigrade scale to absolute temperature (degrees Kelvin) one must add 273 degrees. Thus the maximum efficiency of a heat engine operating between water at the temperature of 25 ^{o}C and water at 5 ^{o}C is 1-(5+273)/(25+273)=0.067 = 6.7%. The efficiency of heat engines is always less than the theoretical maximum because of various losses, such as the loss due to friction. The actual overall efficiencies of existing ocean thermal energy conversion (OTEC) stations are typically 1-3%. On the other hand, the amount of energy potentially available from differences between surface and bottom ocean temperatures is extremely large.

Since 1974, OTEC research has been conducted by the United States at the Natural

Energy Laboratory of Hawaii. The Japanese government also supports OTEC research, and India has established a 1 MW_e OTEC power station floating in the ocean near to Tamil Nadu.

Renewable energy from evaporation

A September 26, 2017 article by Ahmet-Hamdi Cavusoglu et al. in *Nature Communications* points to evaporation as a future source of renewable energy. Here are some excerpts from the article:

"About 50% of the solar energy absorbed at the Earth's surface drives evaporation, fueling the water cycle that affects various renewable energy resources, such as wind and hydropower. Recent advances demonstrate our nascent ability to convert evaporation energy into work, yet there is little understanding about the potential of this resource.

"Here we study the energy available from natural evaporation to predict the potential of this ubiquitous resource. We find that natural evaporation from open water surfaces could provide power densities comparable to current wind and solar technologies while cutting evaporative water losses by nearly half. We estimate up to 325 GW of power is potentially available in the United States. Strikingly, water's large heat capacity is sufficient to control power output by storing excess energy when demand is low, thus reducing intermittency and improving reliability. Our findings motivate the improvement of materials and devices that convert energy from evaporation...

"Recent advances in water responsive materials and devices demonstrate the ability to convert energy from evaporation into work. These materials perform work through a cycle of absorbing and rejecting water via evaporation. These water-responsive materials can be incorporated into evaporation-driven engines that harness energy when placed above a body of evaporating water. With improvements in energy conversion efficiency, such devices could become an avenue to harvest energy via natural evaporation from water reservoirs."

Ozgur Sahin, a biophysicist at Columbia, has developed technology that uses spores from the harmless soil-dwelling bacterium *B. subtilis* to absorb and release water when the relative humidity of the surrounding air changes. At high humidity, the spores take in water and expand, and at low humidity they release water and contract, acting like a muscle.

3.11 Biomass

Biomass is defined as any energy source based on biological materials produced by photosynthesis - for example wood, sugar beets, rapeseed oil, crop wastes, dung, urban organic wastes, processed sewage, etc. Using biomass for energy does not result in the net emission of CO_2, since the CO_2 released by burning the material had previously been absorbed from the atmosphere during photosynthesis. If the biological material had decayed instead of being burned, it would released the same amount of CO_2 as in the burning process.

Figure 3.12: **Rapeseed is grown in several countries, including Denmark and the UK. Experimental Danish buses are already running on rapeseed oil.**

The solar constant has the value 1.4 kilowatts/m^2. It represents the amount of solar energy per unit area[8] that reaches the earth, before the sunlight has entered the atmosphere. Because the atmosphere reflects 6% and absorbs 16%, the peak power at sea level is reduced to 1.0 kW/m^2. Clouds also absorb and reflect sunlight. Average cloud cover reduces the energy of sunlight a further 36%. Also, we must take into account the fact that the sun's rays do not fall perpendicularly onto the earth's surface. The angle that they make with the surface depends on the time of day, the season and the latitude.

In Sweden, which lies at a northerly latitude, the solar energy per unit of horizontal area is less than for countries nearer the equator. Nevertheless, Göran Persson, during his term as Prime Minister of Sweden, announced that his government intends to make the country independent of imported oil by 2020 through a program that includes energy from biomass.

In his thesis, *Biomass in a Sustainable Energy System*, the Swedish researcher Pål Börjesson states that of various crops grown as biomass, the largest energy yields come from short-rotation forests (Salix viminalis, a species of willow) and sugar beet plantations. These have an energy yield of from 160 to 170 GJ$_t$ per hectare-year. (The subscript t means "thermal". Energy in the form of electricity is denoted by the subscript e). One can calculate that this is equivalent to about 0.5 MW$_t$/km^2, or 0.5 W$_t$/m^2. Thus, although 1.0 kW/m^2 of solar energy reaches the earth at noon at the equator, the trees growing in northerly Sweden can harvest a day-and-night and seasonal average of only 0.5 Watts of thermal energy per horizontal square meter[9]. Since Sweden's present primary energy use is approximately 0.04 TW$_t$, it follows that if no other sources of energy were used, a square area of Salix forest 290 kilometers on each side would supply Sweden's present energy

[8]The area is assumed to be perpendicular to the sun's rays.

[9]In tropical regions, the rate of biomass production can be more than double this amount.

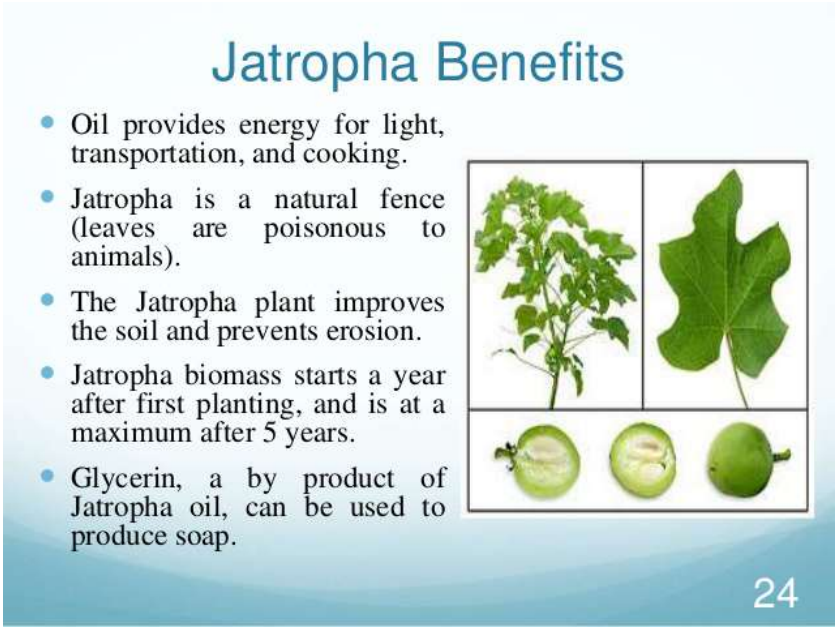

Figure 3.13: **In some countries, Jatropha is a promising source of biomass..**

needs. This corresponds to an area of 84,000 km^2, about 19% of Sweden's total area[10]. Of course, Sweden's renewable energy program will not rely exclusively on energy crops, but on a mixture of sources, including biomass from municipal and agricultural wastes, hydropower, wind energy and solar energy.

At present, both Sweden and Finland derive about 30% of their electricity from biomass, which is largely in the form of waste from the forestry and paper industries of these two countries.

Despite their northerly location, the countries of Scandinavia have good potentialities for developing biomass as an energy source, since they have small population densities and adequate rainfall. In Denmark, biodiesel oil derived from rapeseed has been used as fuel for experimental buses. Rapeseed fields produce oil at the rate of between 1,000 and 1,300 liters per hectare-crop. The energy yield is 3.2 units of fuel product energy for every unit of fuel energy used to plant the rapeseed, and to harvest and process the oil. After the oil has been pressed from rapeseed, two-thirds of the seed remains as a protein-rich residue which can be fed to cattle.

Miscanthus is a grassy plant found in Asia and Africa. Some forms will also grow in Northern Europe, and it is being considered as an energy crop in the United Kingdom. Miscanthus can produce up to 18 dry tonnes per hectare-year, and it has the great advantage that it can be cultivated using ordinary farm machinery. The woody stems are very suitable for burning, since their water content is low (20-30%).

For some southerly countries, honge oil, derived from the plant *Pongamia pinnata* may

[10]Additional land area would be needed to supply the energy required for planting, harvesting, transportation and utilization of the wood.

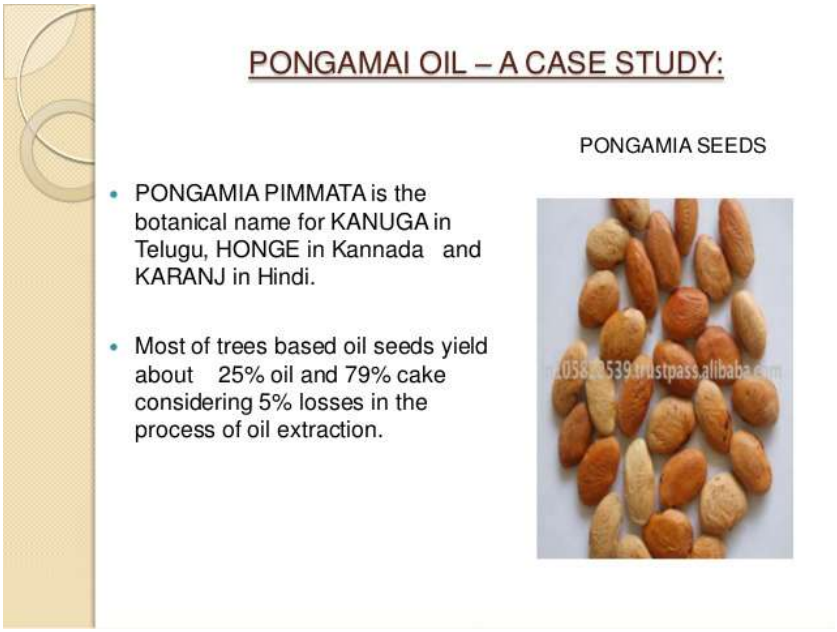

Figure 3.14: **The price of honge oil is quite competitive with other forms of oil.**

prove to be a promising source of biomass energy. Studies conducted by Dr. Udishi Shrinivasa at the Indian Institute of Sciences in Bangalore indicate that honge oil can be produced at the cost of $150 per ton. This price is quite competitive when compared with other potential fuel oils.

Recent studies have also focused on a species of algae that has an oil content of up to 50%. Algae can be grown in desert areas, where cloud cover is minimal. Farm waste and excess CO_2 from factories can be used to speed the growth of the algae.

It is possible that in the future, scientists will be able to create new species of algae that use the sun's energy to generate hydrogen gas. If this proves to be possible, the hydrogen gas may then be used to generate electricity in fuel cells, as will be discussed below in the section on hydrogen technology. Promising research along this line is already in progress at the University of California, Berkeley.

Biogas is defined as the mixture of gases produced by the anaerobic digestion of organic matter. This gas, which is rich in methane (CH_4), is produced in swamps and landfills, and in the treatment of organic wastes from farms and cities. The use of biogas as a fuel is important not only because it is a valuable energy source, but also because methane is a potent greenhouse gas, which should not be allowed to reach the atmosphere. Biogas produced from farm wastes can be used locally on the farm, for cooking and heating, etc. When biogas has been sufficiently cleaned so that it can be distributed in a pipeline, it is known as "renewable natural gas". It may then be distributed in the natural gas grid, or it can be compressed and used in internal combustion engines. Renewable natural gas can also be used in fuel cells, as will be discussed below in the section on Hydrogen Technology.

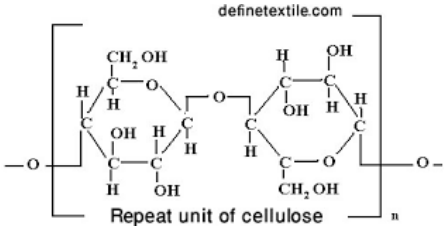

Figure 3.15: **Cellulose is a polysacheride. In other words, it is a long polymer whose subunits are sugars. The links between the sugar subunits in the chain can be broken, for example by the action of enzymes or acids. After this has been done, the resulting sugars can be fermented into alcohols, and these can be used to fuel motor vehicles or aircraft.**

Cellulostic ethanol

The fact that alcohols such as ethanol can be produced from cellulose has long been known.[11] In 1819, the French chemist Henri Braconnot demonstrated that cellulose could be broken down into sugars by treating it with sulfuric acid. The sugars thus produced could then be fermented into alcohols which could be used as liquid fuels.

In 1898, Germany built factories to commercialize this process, and shortly afterwards the same was done in the United States using a slightly different technique. These plants producing cellulostic ethanol operated during World War I, but the plants closed after the end of the war because of the cheapness and easy availability of fossil fuels. The production of cellulostic ethanol was revived during World War II.

During the last two decades, development of enzymatic techniques has supplied a better method of breaking the long cellulose polymer chain into sugars. In fact, it has recently become possible to use microbial enzymes both for this step and for the fermentation step.

In a September 9, 2008 article in the *MIT Technology Review*. Prachi Patal wrote: "New genetically modified bacteria could slash the costs of producing ethanol from cellulostic biomass, such as corn cobs and leaves, switchgrass, and paper pulp. The microbes produce ethanol at higher temperatures than are possible using yeast, which is currently employed to ferment sugar into the biofuel. The higher temperature more than halves the quantity of the costly enzymes needed to split cellulose into the sugars that the microbes can ferment. What's more, while yeast can only ferment glucose, 'this microorganism is good at using all the different sugars in biomass and can use them simultaneously and rapidly,' says Lee Lynd, an engineering professor at Dartmouth College, who led the microbe's development...

"Lynd wants to create microbes that would do it all: efficiently break down the cellulose and hemicellulose, and then ferment all the resulting sugars. Lynd, a cofounder of Mascoma, is working with colleagues at the startup, based in Cambridge, MA, to develop a simple one-step process for making cellulostic ethanol. In the combined process, a mixture of biomass and the microbes would go into a tank, and ethanol would come out."

Cellulostic ethanol has several advantages over alcohol derived from grain;

[11] See the Wikipedia article on *Cellulostic Ethanol*

- Cellulostic ethanol avoids the food-fuel competition.
- The net greenhouse-gas-reducing effect of ethanol derived from grain is questionable.
- Cellulostic ethanol can use cardboard and paper waste as starting substances, thus reducing the quantity of trash in waste dumps.

3.12 Geothermal energy

The ultimate source of geothermal energy is the decay of radioactive nuclei in the interior of the earth. Because of the heat produced by this radioactive decay, the temperature of the earth's core is 4300 ^{o}C. The inner core is composed of solid iron, while the outer core consists of molten iron and sulfur compounds. Above the core is the mantle, which consists of a viscous liquid containing compounds of magnesium, iron, aluminum, silicon and oxygen. The temperature of the mantle gradually decreases from 3700 ^{o}C near the core to 1000 ^{o}C near the crust. The crust of the earth consists of relatively light solid rocks and it varies in thickness from 5 to 70 km.

The outward flow of heat from radioactive decay produces convection currents in the interior of the earth. These convection currents, interacting with the earth's rotation, produce patterns of flow similar to the trade winds of the atmosphere. One result of the currents of molten conducting material in the interior of the earth is the earth's magnetic field. The crust is divided into large sections called "tectonic plates", and the currents of molten material in the interior of the earth also drag the plates into collision with each other. At the boundaries, where the plates collide or split apart, volcanic activity occurs. Volcanic regions near the tectonic plate boundaries are the best sites for collection of geothermal energy.

The entire Pacific Ocean is ringed by regions of volcanic and earthquake activity, the so-called Ring of Fire. This ring extends from Tierra del Fuego at the southernmost tip of South America, northward along the western coasts of both South America and North America to Alaska. The ring then crosses the Pacific at the line formed by the Aleutian Islands, and it reaches the Kamchatka Peninsula in Russia. From there it extends southward along the Kurile Island chain and across Japan to the Philippine Islands, Indonesia and New Zealand. Many of the islands of the Pacific are volcanic in nature. Another important region of volcanic activity extends northward along the Rift Valley of Africa to Turkey, Greece and Italy. In the Central Atlantic region, two tectonic plates are splitting apart, thus producing the volcanic activity of Iceland. All of these regions are very favorable for the collection of geothermal power.

The average rate at which the energy created by radioactive decay in the interior of the earth is transported to the surface is 0.06 W_t/m^2. However, in volcanic regions near the boundaries of tectonic plates, the rate at which the energy is conducted to the surface is much higher - typically 0.3 W_t/m^2. If we insert these figures into the thermal conductivity law

$$q = K_T \frac{\Delta T}{z}$$

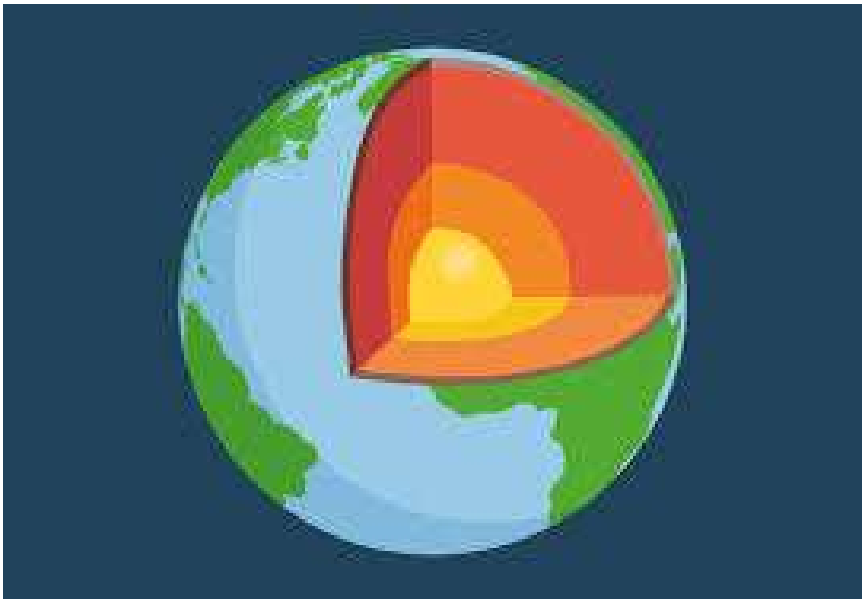

Figure 3.16: **The source of geothermal energy is the radioactive decay of elements deep within the earth.**

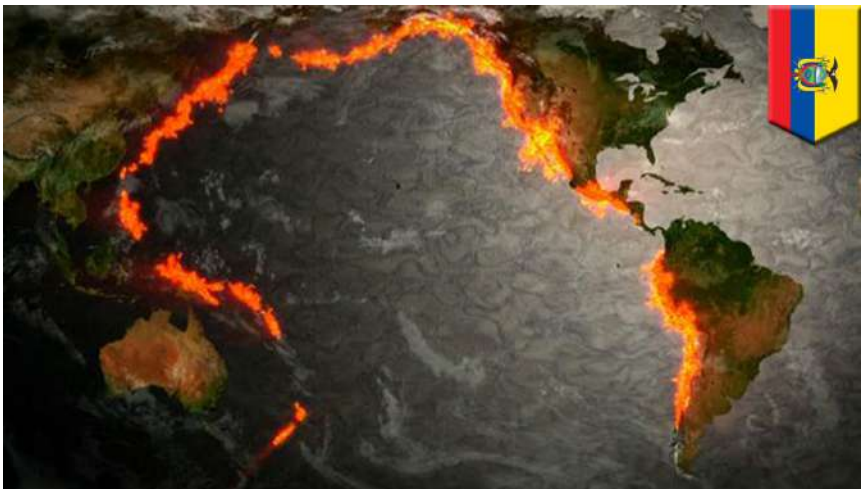

Figure 3.17: **The "ring of fire" is especially favorable for geothermal energy installations. The ring follows the western coasts of South America and North America to Alaska, After crossing the Bering Sea, it runs southward past Japan and Indonesia to New Zealand. Earthquakes and volcanic activity along this ring are produced by the collision of tectonic plates. Another strip-like region very favorable for geothermal installations follows Africa's Rift Valley northward through Turkey and Greece to Italy, while a third pass through Iceland.**

we can obtain an understanding of the types of geothermal resources available throughout the world. In the thermal conductivity equation, q is the power conducted per unit area, while K_T is the thermal conductivity of the material through the energy is passing. For sandstones, limestones and most crystalline rocks, thermal conductivities are in the range 2.5-3.5 $W_t/(m\ ^oC)$. Inserting these values into the thermal conductivity equation, we find that in regions near tectonic plate boundaries we can reach temperatures of 200 ^oC by drilling only 2 kilometers into rocks of the types named above. If the strata at that depth contain water, it will be in the form of highly-compressed steam. Such a geothermal resource is called a *high-enthalpy* resource[12].

In addition to high-enthalpy geothermal resources there are *low-enthalpy* resources in nonvolcanic regions of the world, especially in basins covered by sedimentary rocks. Clays and shales have a low thermal conductivity, typically 1-2 $W_t/(m\ ^oC)$. When we combine these figures with the global average geothermal power transmission, $q = 0.06\ W_t/m^2$, the thermal conduction equation tells us that $\Delta T/z = 0.04\ ^oC/m$. In such a region the geothermal resources may not be suitable for the generation of electrical power, but nevertheless adequate for heating buildings. The Creil district heating scheme north of Paris is an example of a project where geothermal energy from a low enthalpy resource is used for heating buildings.

The total quantity of geothermal electrical power produced in the world today is 8 GW_e, with an additional 16 GW_t used for heating houses and buildings. In the United States alone, 2.7 GW_e are derived from geothermal sources. In some countries, for example Iceland and Canada, geothermal energy is used both for electrical power generation and for heating houses.

There are three methods for obtaining geothermal power in common use today: Deep wells may yield dry steam, which can be used directly to drive turbines. Alternatively water so hot that it boils when brought to the surface may be pumped from deep wells in volcanic regions. The steam is then used to drive turbines. Finally, if the water from geothermal wells is less hot, it may be used in binary plants, where its heat is exchanged with an organic fluid which then boils. In this last method, the organic vapor drives the turbines. In all three methods, water is pumped back into the wells to be reheated. The largest dry steam field in the world is The Geysers, 145 kilometers north of San Francisco, which produces 1,000 MW_e.

There is a fourth method of obtaining geothermal energy, in which water is pumped down from the surface and is heated by hot dry rocks. In order to obtain a sufficiently large area for heat exchange the fissure systems in the rocks must be augmented, for example by pumping water down at high pressures several hundred meters away from the collection well. The European Union has established an experimental station at Soultz-sous-Forets in the Upper Rhine to explore this technique. The experiments performed at Soultz will determine whether the "hot dry rock" method can be made economically viable. If so, it can potentially offer the world a very important source of renewable energy.

[12]Enthalpy $\equiv H \equiv U + PV$ is a thermodynamic quantity that takes into account not only the internal energy U of a gas, but also energy PV that may be obtained by allowing it to expand.

The molten lava of volcanoes also offers a potential source of geothermal energy that may become available in the future, but at present, no technology has been developed that is capable of using it.

3.13 Hydrogen technologies

Electrolysis of water

When water containing a little acid is placed in a container with two electrodes and subjected to an external direct current voltage greater than 1.23 Volts, bubbles of hydrogen gas form at one electrode (the cathode), while bubbles of oxygen gas form at the other electrode (the anode). At the cathode, the half-reaction

$$2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^- \qquad E^0 = -1.23\ Volts$$

takes place, while at the anode, the half-reaction

$$4H^+(aq) + 4e^- \rightarrow 2H_2(g) \qquad E^0 = 0$$

occurs.

Half-reactions differ from ordinary chemical reactions in containing electrons either as reactants or as products. In electrochemical reactions, such as the electrolysis of water, these electrons are either supplied or removed by the external circuit. When the two half-reactions are added together, we obtain the total reaction:

$$2H_2O(l) \rightarrow O_2(g) + 2H_2(g) \qquad E^0 = -1.23\ Volts$$

Notice that $4H^+$ and $4e^-$ cancel out when the two half-reactions are added. The total reaction does not occur spontaneously, but it can be driven by an external potential E, provided that the magnitude of E is greater than 1.23 volts.

When this experiment is performed in the laboratory, platinum is often used for the electrodes, but electrolysis of water can also be performed using electrodes made of graphite.

Electrolysis of water to produce hydrogen gas has been proposed as a method for energy storage in a future renewable energy system. For example, it might be used to store energy generated by photovoltaics in desert areas of the world. Compressed hydrogen gas could then be transported to other regions and used in fuel cells. Electrolysis of water and storage of hydrogen could also be used to solve the problem of intermittency associated with wind energy or solar energy.

Half reactions

Chemical reactions in which one or more electrons are transferred are called *oxidation-reduction reactions*. Any reaction of this type can be used in a fuel cell. As an example,

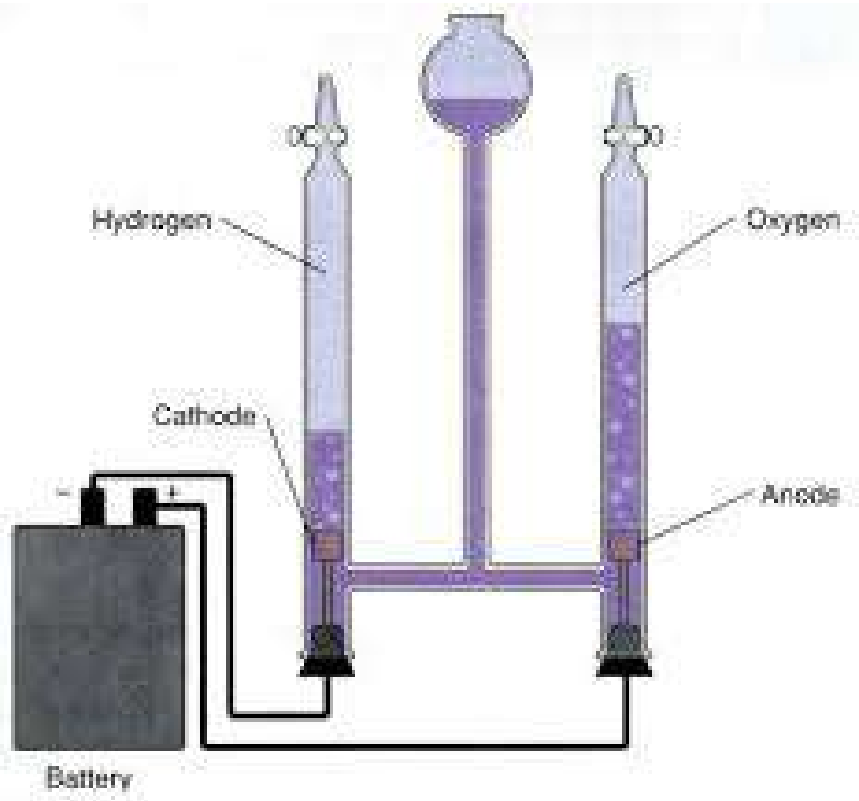

Figure 3.18: **Electrolysis of water.**

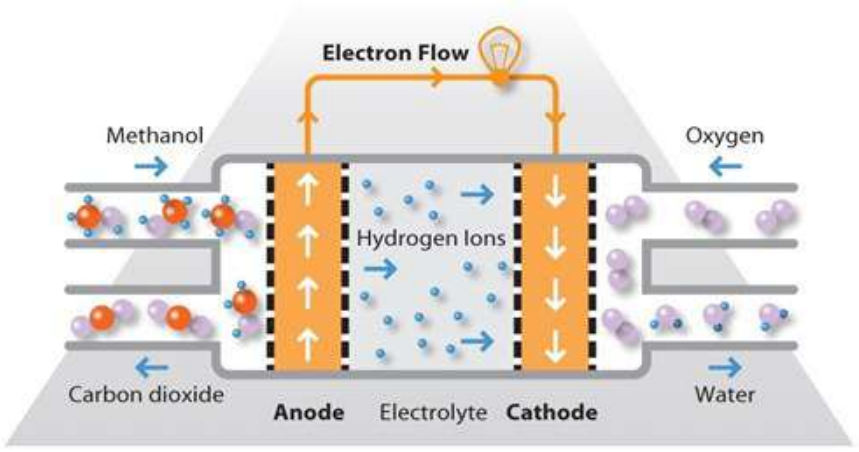

Figure 3.19: **A methanol fuel cell.**

we can consider the oxidation-reduction reaction in which solid lithium metal reacts with fluorine gas;

$$2Li_{(s)} + F_{2(g)} \rightarrow 2LiF_{(s)}$$

This reaction can be split into two half-reactions,

$$Li_{(s)} \rightarrow Li^{+} + e^{-} \qquad E_0 = -3.040\ V$$

and

$$F_{2(g)} \rightarrow 2F^{+} + 2e^{-} \qquad E_0 = 2.87\ V$$

The quantity E_0 which characterizes these half-reactions is called *standard potential* of the half-reaction, and it is measured in Volts. If the oxidation-reduction reaction is used as the basis of a fuel cell, the voltage of the cell is the difference between the two standard potentials. In the lithium fluoride example, it is

$$2.87\ V - (-3.040\ V) = 5.91\ V$$

Here are a few more half-reactions and their standard potentials:

$$\begin{aligned}
K^{+} + e^{-} &\rightarrow\ K_{(s)} & E_0 &= -2.924\ V \\
Na^{+} + e^{-} &\rightarrow Na_{(s)} & E_0 &= -2.7144\ V \\
2H_2O + 2e^{-} &\rightarrow H_20 + 2OH^{-} & E_0 &= -0.828\ V \\
Zn^{2+} + 2e^{-} &\rightarrow Zn_{(s)} & E_0 &= -0.7621\ V \\
Fe^{2+} + 2e^{-} &\rightarrow Fe_{(s)} & E_0 &= -0.440\ V \\
Pb^{2+} + 2e^{-} &\rightarrow Pb_{(s)} & E_0 &= -0.1266\ V \\
2H^{+} + 2e^{-} &\rightarrow H_{2(g)} & E_0 &\equiv 0.0000\ V \\
Cu^{2+} + 2e^{-} &\rightarrow Cu_{(s)} & E_0 &= +0.3394\ V \\
I_{2(s)} + 2e^{-} &\rightarrow 2I^{-} & E_0 &= +0.535\ V \\
Fe^{3+} + e^{-} &\rightarrow Fe^{2+} & E_0 &= +0.769\ V \\
Br_{2(l)} + 2e^{-} &\rightarrow 2Br^{-} & E_0 &= +1.0775\ V \\
O_{2(g)} + 4H^{+} + 4e^{-} &\rightarrow 2H_2O & E_0 &= +1.2288\ V \\
Cl_{2(g)} + 2e^{-} &\rightarrow 2Cl^{-} & E_0 &= +1.3601\ V
\end{aligned}$$

Fuel cells are closely related to storage batteries. Essentially, when we recharge a storage battery we are just running a fuel cell backwards, applying an electrical potential which is sufficient to make a chemical reaction run in a direction opposite to the way that it would run spontaneously. When the charged battery is afterwards used to drive a vehicle or to power an electronic device, the reaction runs in the spontaneous direction, but the energy of the reaction, instead of being dissipated as heat, drives electrons through an external circuit and performs useful work.

3.14 Reducing emissions from the cement industry

The cement industry currently account for 7% of all CO_2 emissions, that is to say, three times as much as air travel. If the cement industry were a country, it would be the third largest emitter, after China and the United States. The reason for this enormous and potentially fatal quantity of CO_2 is twofold. Firstly, in the manufacture of Portland cement, the following reaction occurs:

$$C_aCO_3 + \text{heat} \rightarrow CaO + CO_2$$

Thus CO_2 is released in the chemical reaction. Secondly, heat is required to heat the limestone (C_aCO_3) and this heat usually comes from the burning of fossil fuels. However there is hope that new experimental methods may be developed which can reduce or even eliminate the dangerous emissions from the global cement industry.[13]

Here are some excerpts from an article entitled *Why Cement Emissions Matter for Climate Change*[14]:

Some companies have been researching "novel" cements, which do away with the need for Portland clinker altogether. If these could rival the cost and performance of Portland cement, they would offer a way to significantly reduce emissions...

Geopolymer-based cements, for example, have been a focus of research since the 1970s. These do not use calcium carbonate as a key ingredient, harden at room temperature and release only water. Zeobond and banahUK are among firms producing these, with both claiming around 80-90% reduction in emissions compared to Portland cement.

There are also several firms developing "carbon-cured" cements, which absorb CO2, rather than water, as they harden. If this CO2 absorption can be made higher than CO2 released during their production, cements could potentially be used as a carbon sink.

US firm Solidia, for example, claims its concrete emits up to 70% less CO2 than Portland cement, including this sequestering step. The firm is now in a partnership with major cement producer LafargeHolcim.

Similarly, British start-up Novacem - a spin out from Imperial College London - claimed in 2008 that replacing Portland cement with its "carbon negative" product would allow the industry to become a net sink of CO2 emissions. However, the firm failed to raise sufficient funds to continue research and production.

Other firms are using completely different materials to make cement. North Carolina-based startup Biomason, for example, uses bacteria to grow cement bricks which it says are both similarly strong to traditional masonry and carbon-sequestering.

[13] https://www.ecowatch.com/scientists-create-living-concrete-2644831492.html
[14] https://www.carbonbrief.org/qa-why-cement-emissions-matter-for-climate-change

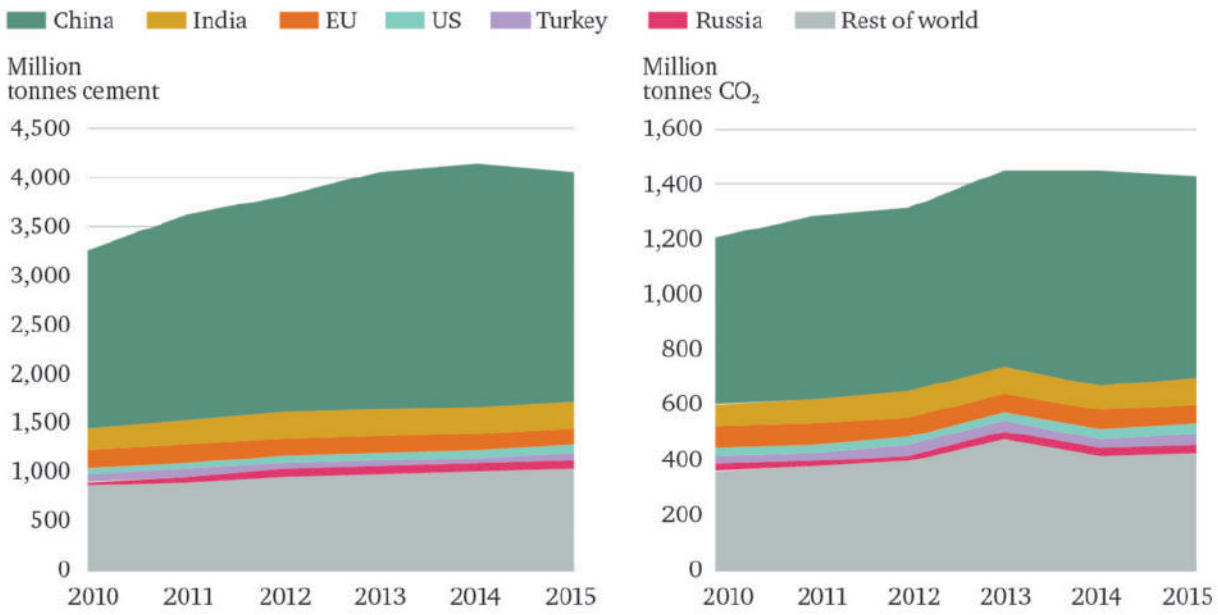

Figure 3.20: **China is the largest producer of cement and the associated CO_2 emissions.**

Figure 3.21: **BioMason uses bacteria to grow cement bricks which it says can sequester carbon. Credit: bioMASON, Inc..**

3.15 Reducing emissions from transportation sectors

We are in love with our automobiles, but it is not certain that they make our lives happier. We love our cars so much that we are willing to die (and kill) for them: Wikipedia states that "It is estimated that motor vehicle collisions caused the death of around 60 million people during the 20th century, around the same number of World War II casualties. Just in 2010 alone, 1.23 million people were killed due to traffic collisions."

Besides being dangerous, automobiles make our cities unpleasant. A pleasant city center is, almost by definition, a car-free one. Today, both tourists and Danish citizens enjoy Copenhagen's bicycle culture and car-free city center[15], and throughout the world, the pleasantness of cities is inversely proportional to the number of automobiles.

Some people visualize the transition from internal combustion engines to electric vehicles as the only change needed to make transportation environmentally friendly; but this ignores the enormous amount of energy, water (148,000 liters), and other resources needed to manufacture private automobiles. A truly sustainable future requites a transition, wherever possible, from private to public transport.

The government of Luxombourg recently announced that it intends to make all public transportation entirely free[16], thus saving on the collection of fares, and eliminating the massive traffic jams that have plagued the country's capital.Luxembourg City, the capital of the small Grand Duchy, suffers from some of the worst traffic congestion in the world. It is home to about 110,000 people, but a further 400,000 commute into the city to work. It will be interesting to follow the progress of this enlightened decision, due to take effect in 2020. Hopefully other countries will follow Luxombourg's example. Luxembourg has increasingly shown a progressive attitude to transport. This summer, the government brought in free transport for every child and young person under the age of 20. Secondary school students can use free shuttles between their institution and their home.

Top Gear is long-running BBC program celebrating the delights of car ownership and motor sport. It is an example of the fact that our mass media actively encourage harmful and unsustainable human behavior. The program appeals to car enthusiasts - people who are passionate about automobiles. How much better it would be if they were passionate about saving human civilization and the biosphere from irreversible feedback loops leading in the long run to catastrophic climate change, mass extinctions, and the collapse of human civilization!

In an article entitled *Why are people so in love with their cars?* [17], Tim Dugan explains why he loves his car:

"This car is bought and paid for by my own hand, it is the first major purchase I ever made as an adult. I worked off the loan and it wholly belongs to me. There is a sense of pride in this. Seeing the fruits of your labor and your saving and scrounging.

[15] https://www.theguardian.com/cities/2016/may/05/story-cities-copenhagen-denmark-modernist-utopia

[16] https://www.theguardian.com/world/2018/dec/05/luxembourg-to-become-first-country-to-make-all-public-transport-free

[17] https://www.quora.com/Why-are-people-so-in-love-with-their-cars

Figure 3.22: **Motor traffic in Manila.**

Figure 3.23: **We love our cars.**

"This car is a tribute to my mother, who has passed away a few years ago. I grew up in a 1981 Camaro, she loved her car like I love mine.

"This car goes FAST. I don't care much for racing but I do love driving fast and boy does her 700rwhp provide that!!

"I have personally seen her at her worst and best. I've had my hands covered in Camaro guts, elbow deep. I've felt the pain of seeing your brand new car with a blown motor out of it sitting in your garage with a hole where the engine is supposed to be and knowing your warranty ain't gonna cover that. These experiences made this vehicle mine through blood, sweat, tears, and vulgar language.

"This car is an extension of my personality. I am loud and noisy when I need to be but I prefer to stay subdued. This machine doesn't need to prove anything. She exudes confidence in herself and her ability to perform at 110% at a moments' notice - but she don't need to prove it, you can look at it, you can hear it and you'll know what's up. Just like her owner. I have nothing to prove - I've made my mark, I believe in myself and let the world make its decision.

"Lastly, this car changed my life. It gave me confidence and pride in myself. It helped me to get in touch with the man I would later grow up to become. It pushed me into a direction in life of working with my hands and being proud of doing well for myself without being stuck in a cubicle. It introduced and brought me into a huge group of amazing people I wouldn't have otherwise known. It gave my future wife a sense of my personality before she even met me. She knew I was a confident self sufficient red blooded American Male without me even saying a word - my Camaro did all the talking for me. She turns heads, she makes kids jump up and down screaming, 'THERE'S THE BAT-MOBILE!' She is a fantastic money sink, a pleasure to drive, and a fine automobile. Never will this vehicle leave my possession and never will it find decay in a junk heap while I walk this earth. It is my friend and compatriot, through thick and thin we have been together, even on the worst days I can hop in this thing and go for a spin and find solace, enjoyment, and testosterone producing speed."

Investment in electric vehicles

On July 5, 2017, the Volvo Car Group made the following announcement: [18]

"Volvo Cars, the premium car maker, has announced that every Volvo it launches from 2019 will have an electric motor, marking the historic end of cars that only have an internal combustion engine (ICE) and placing electrification at the core of its future business.

"The announcement represents one of the most significant moves by any car maker to embrace electrification and highlights how over a century after the invention of the internal combustion engine electrification is paving the way for a new chapter in automotive history.

"'This is about the customer,' said Håkan Samuelsson, president and chief executive.

[18] https://www.media.volvocars.com/global/en-gb/media/pressreleases/210058/volvo-cars-to-go-all-electric

'People increasingly demand electrified cars and we want to respond to our customers' current and future needs. You can now pick and choose whichever electrified Volvo you wish.'

"Volvo Cars will introduce a portfolio of electrified cars across its model range, embracing fully electric cars, plug in hybrid cars and mild hybrid cars.

"It will launch five fully electric cars between 2019 and 2021, three of which will be Volvo models and two of which will be high performance electrified cars from Polestar, Volvo Cars' performance car arm. Full details of these models will be announced at a later date."

The electric vehicle investment opportunity was also illustrated by the 2017 vote of Germany's Bundesrat to ban the manufacture of internal combustion engines after 2030 [19].

The article announcing the vote adds that "It's a strong statement in a nation where the auto industry is one of the largest sectors of the economy; Germany produces more automobiles than any other country in Europe and is the third largest in the world. The resolution passed by the Bundesrat calls on the European Commission (the executive arm of the European Union) to 'evaluate the recent tax and contribution practices of Member States on their effectiveness in promoting zero-emission mobility,' which many are taking to mean an end to the lower levels of tax currently levied on diesel fuel across Europe."

France plans to end the sale of vehicles powered by gasoline and diesel by 2040, environment minister Nicolas Hulot announced recently.

Hulot made the announcement on Thursday, June 13, 2017, in Paris as he launched the country's new Climate Plan to accelerate the transition to clean energy and to meet its targets under the Paris climate agreement.

To ease the transition, Hulot said the French government will offer tax incentives to replace fossil-fuel burning cars with clean alternatives.

Furthermore, the government of India has recently announced its intention to only nave electric vehicles by 2030[20]. This hugely ambitious plan was announced during the 2017 Confederation of Indian Industry Annual Session. Besides the avoidance of climate change, which might make many regions of India uninhabitable, the motive for replacing 28 million combustion engine vehicles by electric ones was the severe air pollution from which India suffers. Severe air pollution also motivates efforts by the government of China to promote the transition to electric vehicles.

The governments of Norway and the Netherlands have taken steps towards banning the internal combustion engine[21]. Both the upper and lower houses of the Netherlands' government voted to ban cars driven by internal combustion engines by 2025, the same year in which Norway plans to sell nothing but zero-emission vehicles.

[19]https://arstechnica.com/cars/2016/10/germanys-bundesrat-votes-to-ban-the-internal-combustion-engine-by-2030/

[20]https://www.greentechmedia.com/articles/read/what-country-will-become-the-first-to-ban-internal-combustion-cars

[21]http://www.prnewswire.com/news-releases/the-dutch-revolution-in-smart-charging-of-electric-vehicles-597268791.html

In a report commissioned by the investment bankers Cowan & Co, managing director and senior research analyst Jeffrey Osborne, predicted that electric vehicles will cost less than gasoline-powered cars by the early- to mid-2020s due to falling battery prices as well as the costs that traditional carmakers will incur as they comply to new fuel-efficiency standards. Osbourne pointed out that a number of major car brands are hopping onto the electric bandwagon to compete in a space carved out by industry disrupter, Tesla.

"We see the competitive tides shifting in 2019 and beyond as European [car makers] roiled by the diesel scandal and loss of share to Tesla in the high margin luxury segment step on the gas and accelerate the pace of EV introductions", he wrote.

Bloomberg New Energy Finance reported similar predictions: "Falling battery costs will mean electric vehicles will also be cheaper to buy in the U.S. and Europe as soon as 2025," the report said. "Batteries currently account for about half the cost of EVs, and their prices will fall by about 77 percent between 2016 and 2030."

In October, 2017, General Motors unveiled plans to roll out 20 new entirely electric car models by 2023, with two of the new EVs coming out in the next 18 months. Meanwhile, Ford announced the creation of "Team Edison," intended to accelerate the company's EV development and partnership work. The name, is "seemingly in direct response to Elon Musk's Tesla, which recently surpassed Ford's market capitalization."

Tesla's Chairman, highly successful inventor and entrepreneur Elon Musk, has made massive investments in factories manufacturing electric vehicles, improved lithium ion storage cells, and photovoltaic panels, as will be discussed in Chapter 2.

3.16 Renewables are now much cheaper than fossil fuels!

According to an article written by Megan Darby and published in *The Guardian* on 26 January, 2016, "Solar power costs are tumbling so fast the technology is likely to fast outstrip mainstream energy forecasts.

"That is the conclusion of Oxford University researchers, based on a new forecasting model published in Research Policy[22].

"Commercial prices have fallen by 58% since 2012 and by 16% in the last year

"Since the 1980s, panels to generate electricity from sunshine have got 10% cheaper each year. That is likely to continue, the study said, putting solar on course to meet 20% of global energy needs by 2027.' '

[22]http://www.sciencedirect.com/science/article/pii/S0048733315001699

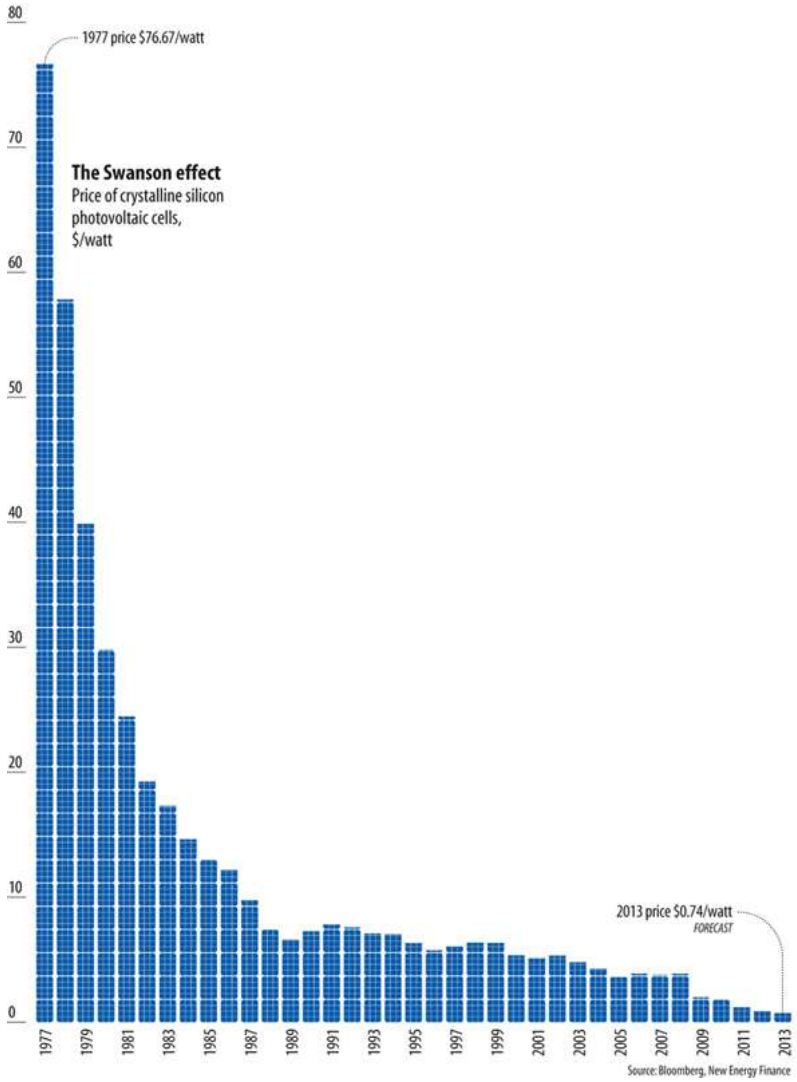

Figure 3.24: **The cost of photovoltaic cell panels is falling rapidly**

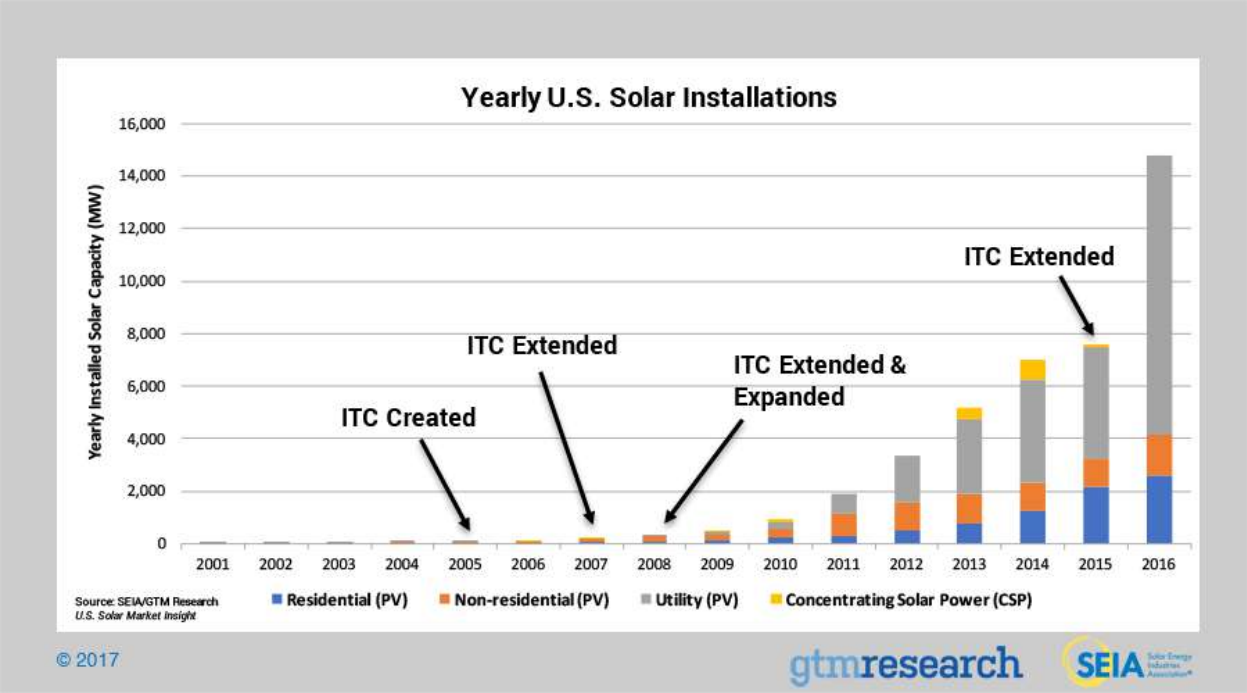

Figure 3.25: **Driven by falling prices, new solar installations in the United States are increasing rapidly. The acronym ITC stands for Solar Investment Tax Credit. Commercial prices have fallen by 58% since 2012 and by 16% in the last year**

3.17 Lester R. Brown

In December 2008, Lester R. Brown called attention to the following facts:

- The renewable energy industry - wind, solar, geothermal - are expanding by over 30 percent yearly;
- There are now, in the U.S., 24,000 megawatts of wind generating capacity online, but there is a staggering 225,000 megawatts of planned wind farms;
- What is needed is a World War II-type mobilization to produce electric-powered cars that will operate at an equivalent gas cost of $1 per gallon (Replacing each SUV with a plug-in hybrid could save $20,000 of oil imports over its lifetime);

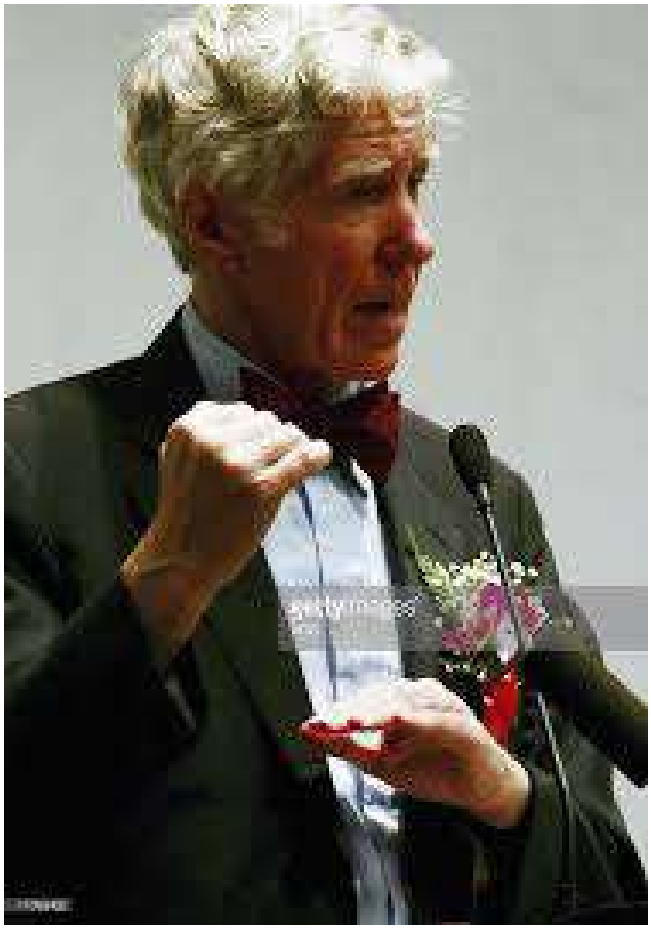

Figure 3.26: **Lester R. Brown, born in 1934, is the author of more than 50 books, and he has been called "...one of the world's most influential thinkers" (Washington Post). He is the founder of the Worldwatch Institute and the Earth Policy Institute. Books produced by Brown and his coworkers at the EPI can be freely downloaded and circulated. The 2015 book *The Great Transition: Shifting From Fossil Fuels to Solar and Wind Energy* can be freely downloaded from the following link: http://www.earth-policy.org/books/tgt**

3.18 We must create a livable future world

We give our children loving care, but it makes no sense to do so unless we do everything in our power to give them a future world in which they can survive. We also have a duty to our grandchildren, and to all future generations.

The amazingly rapid growth of science, technology, agriculture and industry has given the world many benefits, but indefinite growth on a finite planet is a logical impossibility, and we have now reached the point where the human success story has become a threat. Today we are faced with the threat of an environmental megacatastrophe, of which the danger of catastrophic climate change is a part. Human ingenuity also produced nuclear weapons, but the development of international law, governance and ethics has not kept pace, and we face the threat of an all-destroying nuclear war. Finally, because of population growth, the effect of climate change on agriculture, and the end of the fossil fuel era, there is a danger that by the middle of the present century a very large-scale famine could take the lives of as many as a billion people.

We owe it to future generations to take urgent action to prevent these threatened catastrophes. In the present chapter, we will focus on the climate emergency, while the dangers of nuclear war and famine will be discussed in chapters 3 and 5.

A United Nations report released Wednesday , 20 November, 2019, warned that worldwide projections for fossil fuel production over the next decade indicate that the international community is on track to fail to rein in planet-heating emissions and prevent climate catastrophe.

The Production Gap[23] is an 80 page report produced by a collaboration between the UN Environmental Programme and a number of academic institutions. It examines the discrepancy between countries' planned fossil fuel production and global production levels consistent with limiting warming to 1.5^oC or 2^oC, and concludes that the necessary policy changes are currently not being made.

The famous economist Nicholas Stern has stated that "This important report shows that governments' projected and planned levels of coal, oil, and gas production are dangerously out of step with the goals of the Paris agreement on climate change. It illustrates the many ways in which governments subsidize and otherwise support the expansion of such production. Instead, governments should implement policies that ensure existing production peaks soon and then falls very rapidly."

In an article published in *Common Dreams* on Wednesday, November 20, 2019, Hoda Baraka, the Chief Communications Officer for 350.org wrote: "The disconnect between Paris temperature goals and countries' plans and policies for coal, oil, and gas production is massive, worrying and unacceptable...

"The *production gap* is a term used to refer to the difference between a countries' planned levels of fossil fuel production, and what is needed to achieve international climate goals. This is the first time a UN report has looked directly and specifically at fossil fuel production as a key driver of climate breakdown. It shows that countries are planning to

[23]http://productiongap.org/wp-content/uploads/2019/11/Production-Gap-Report-2019.pdf

Figure 3.27: **"Ensuring a livable planet for future generations means getting serious about phasing out coal, oil, and gas," said Christiana Figueres, former executive secretary of the UNFCCC, "Countries such as Costa Rica, Spain, and New Zealand are already showing the way forward, with policies to constrain exploration and extraction and ensure a just transition away from fossil fuels. Others must now follow their lead."**

Figure 3.28: **Today the beautiful city of Venice is flooded. Tomorrow unless urgent climate action is taken, all coastal cities will be under water.**

produce fossil fuels far in excess of the levels needed to fulfil their climate pledges under the Paris Agreement, which themselves are far from adequate. This over investment in coal, oil, and gas supply locks in fossil fuel infrastructure that will make emissions reductions harder to achieve.

"The science is clear, to stay below 1.5 degrees we must stop the expansion of the fossil fuel industry immediately. That means that not a single new mine can be dug, not another pipeline built, not one more emitting powerplant fired up. And we have to get to work transitioning to sustainable renewable energy powered energy systems.

"Across the globe resistance to fossil fuels is rising, the climate strikes have shown the world that we are prepared to take action. Going forward our job is to keep up a steady drumbeat of actions, strikes and protests that gets louder and louder throughout 2020. Governments need to follow through, to act at the source of the flames that are engulfing our planet and phase out coal, oil, and gas production."

Figure 3.29: **On Friday, November 15, 2019, in a speech at the Vatican, Pope Francis railed against corporate crimes and announced consideration of adding "sins against ecology" to the church's official teachings. "The principle of profit maximization, isolated from any other consideration, leads to a model of exclusion which violently attacks those who now suffer its social and economic costs, while future generations are condemned to pay the environmental costs", he said. In his speech, Francis condemned global corporations that are responsible for "countries' over-indebtedness and the plunder of our planet's natural resources." He said that their activities have the "gravity of crimes against humanity," especially when they lead to hunger, poverty and the eradication of indigenous peoples.**

Figure 3.30: **A new report indicates that half of all insects may have been lost since 1970 as a result of the destruction of nature and heavy use of pesticides. The report said 40% of the 1million known species of insect are facing extinction. Unless steps are taken to correct the excessive use of pesticides and loss of habitat, there will be profound consequences for humans and all life on Earth. "We can't be sure, but in terms of numbers, we may have lost 50% or more of our insects since 1970 - it could be much more," said Prof Dave Goulson, at the University of Sussex, UK, who wrote the report for the Wildlife Trusts. Since most crops depend on insect pollination, the insect apocalypse will make it difficult to feed the Earth's growing population unless urgent corrective steps are taken.**

Figure 3.31: **Senator Bernie Sanders and Representative Alexandria Ocasio-Cortez field questions from audience members at the Climate Crisis Summit at Drake University on November 9, 2019, in Des Moines, Iowa. "Faced with the global crisis of climate change, the United States must lead the world in transforming our energy system away from fossil fuel to sustainable energy. The Green New Deal is not just about climate change," Sanders said, "It is an economic plan to create millions of good-paying jobs, strengthen our infrastructure, and invest in our country's frontline and vulnerable communities." The Green New Deal, which is strongly advocated by Sanders and Ocasio-Cortez in the United States, and also currently debated in many other countries, is inspired by the set of programs that Franklin D. Roosevelt used to end the Great Depression. It aims at maintaining full employment by substituting jobs in creating renewable energy infrastructure for jobs lost in the fossil fuel sector.**

Figure 3.32: **The *World Scientists' Warning of a Climate Emergency* was published in Bioscience on 5 November, 2019. The article states that "Scientists have a moral obligation to clearly warn humanity of any catastrophic threat and to 'tell it like it is.' On the basis of this obligation and the graphical indicators presented below, we declare, with more than 11,000 scientist signatories from around the world, clearly and unequivocally that planet Earth is facing a climate emergency...Despite 40 years of global climate negotiations... we have generally conducted business as usual and have largely failed to address this predicament."**

Figure 3.33: **Bush fires in Australia are threatening Sydney and have caused the Australian government to declare a state of emergency. But Australia's politicians continue the policies that have made their nation a climate change criminal, exporting vast quantities of coal and beef. The Deputy Prime Minister Michael McCormack said, of the fire victems: "They don't need the ravings of some pure enlightened and woke capital city greenies at this time when they are trying to save their homes." In other words, let's not talk about climate change. With costs approaching $100 billion, and a billion animals killed, the fires are the costliest natural disaster in Australian history. The link to climate change is obvious to anyone not profiting from the export of coal.**

Figure 3.34: **A Peoples' Climate March in Amsterdam, calling for an ambitious climate policy. The *World Scientists' Warning of a Climate Emergency* called attention to a number of indicators: "The basic scientific data of these changes is presented simply and with great clarity: a 5 percent rise every 10 years in carbon emissions; a 3.65 percent rise of another powerful greenhouse gas, methane, every 10 years; a global surface temperature rise of .183 degrees Celsius every 10 years; a decline of Arctic sea ice at a rate of 11.7 percent every 10 years; significant drops in the ice mass of Greenland, Antarctica and world glaciers; an increase in ocean acidity and temperatures; an increase of 44 percent in the amount of area burned by wildfires in the U.S. every 10 years; and an 88 percent rise in extreme weather events per 10 years."**

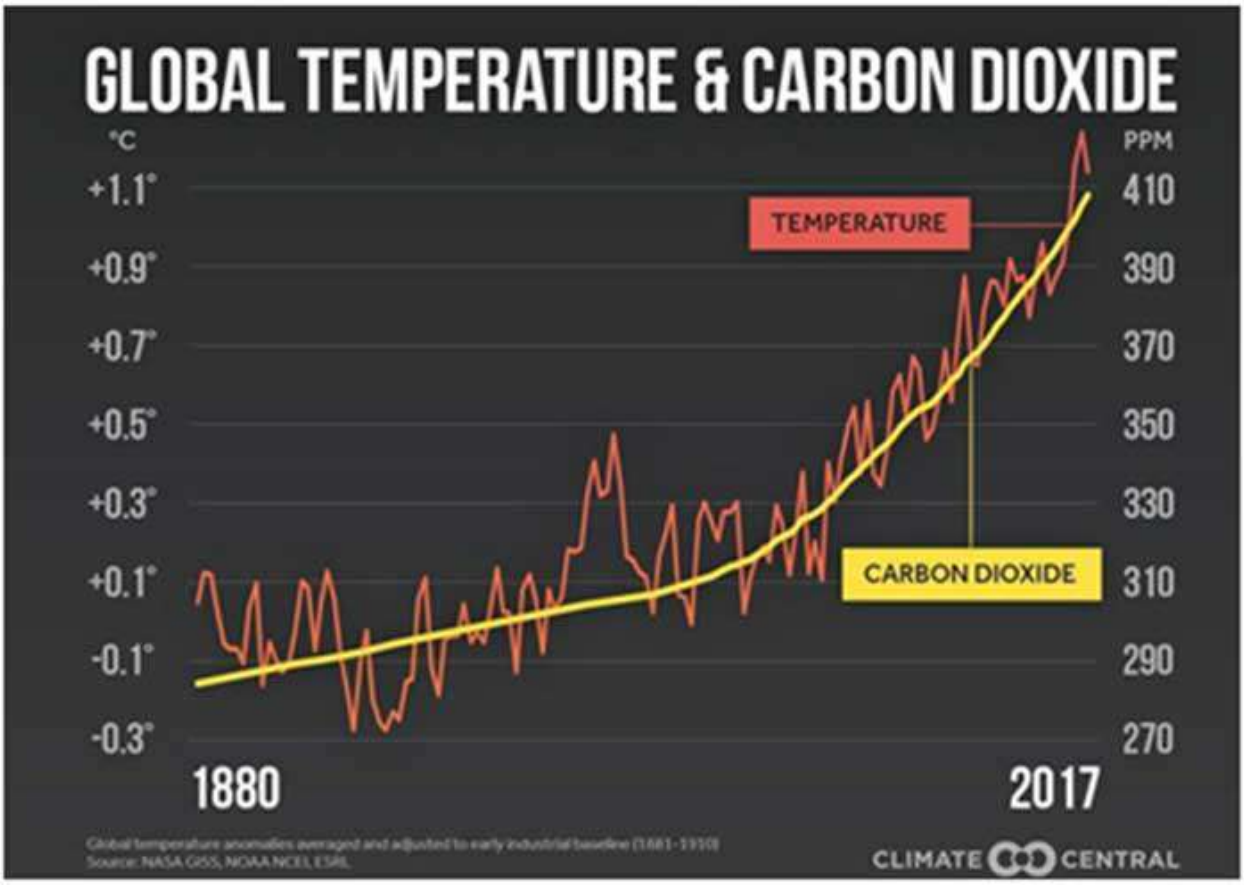

Figure 3.35: **The graphs showing increase in global temperatures and carbon dioxide follow each other closely. In an article published in Countercurrents on November 6, 2019, Dr. Andrew Glickson wrote: "As the concentration of atmospheric CO_2 has risen to 408 ppm and the total greenhouse gas level, including methane and nitrous oxide, combine to near 500 parts per million CO_2-equivalent, the stability threshold of the Greenland and Antarctic ice sheets, currently melting at an accelerated rate, has been exceeded. The consequent expansion of tropics and the shift of climate zones toward the shrinking poles lead to increasingly warm and dry conditions under which fire storms, currently engulfing large parts of South America, California, Alaska, Siberia, Sweden, Spain, Portugal, Greece, Angola, Australia and elsewhere have become a dominant factor in the destruction of terrestrial habitats."**

Figure 3.36: **The Royal Society of the United Kingdom documented ExxonMobil's funding of 39 organizations that promoted "inaccurate and misleading" views of climate science. In an article published by TomDispatch on November 11. 2019, Professor Naomi Oreskes of Harvard University wrote: "Much focus has been put on ExxonMobil's history of disseminating disinformation, partly because of the documented discrepancies between what that company said in public about climate change and what its officials said (and funded) in private. Recently, a trial began in New York City accusing the company of misleading its investors, while Massachusetts is prosecuting ExxonMobil for misleading consumers as well. If only it had just been that one company, but for more than 30 years, the fossil-fuel industry and its allies have denied the truth about anthropogenic global warming. They have systematically misled the American people and so purposely contributed to endless delays in dealing with the issue by, among other things, discounting and disparaging climate science, misrepresenting scientific findings, and attempting to discredit climate scientists. These activities are documented in great detail in *How Americans Were Deliberately Misled about Climate Change*, a report I recently co-authored, as well as in my 2010 book and 2014 film, *Merchants of Doubt*."**

Figure 3.37: **A fire burns a tract of the Amazon jungle in Agua Boa, Mato Grosso state, Brazil September 4, 2019. According to a report published by teleSUR on 7 November, 2019, "Deforestation in Brazil's Amazon region increased by 80 percent in September compared to the same month last year, according to a private study released on Wednesday stating that 802 square kilometers of forest was lost in the zone... Environmental and human rights organizations have confirmed that criminal networks are behind the indiscriminate cutting of trees in the region, and that after the illegal lumbering, those deforested zones are burned to make the land suitable for livestock raising and agriculture. In August, fires in the Brazilian Amazon were the worst in a decade, a situation that was denounced worldwide, especially the anti-ecological policies of President Jair Bolsonaro and his poor response to stop the fires."**

Figure 3.38: **In her testimony to the US Congress, Greta Thunberg did not prepare a statement for submission to the record. Instead, she submitted the most recent scientific report, issued by the IPCC three weeks earlier. She said simply, "I am submitting this report as my testimony because I don't want you to listen to me, I want you to listen to the scientists, and I want you to unite behind the science. And then I want you to take real action. Thank you." Here is what the scientists recommend: "Excessive extraction of materials and overexploitation of ecosystems, driven by economic growth, must be quickly curtailed to maintain the long-term sustainability of the biosphere. We need a carbon-free economy that explicitly addresses human dependence on the biosphere and policies that guide economic decisions accordingly. Our goals need to shift from GDP growth and the pursuit of affluence toward sustaining ecosystems and improving human well-being by prioritizing basic needs and reducing inequality."**

Figure 3.39: **Climate activist Greta Thunberg joined thousands of protesters in Lausanne, Switzerland Jan. 17, 2020. The youth activists were planning to attend the Davos summit to demand that "participants from all companies, banks, institutions, and governments immediately halt all investments in fossil fuel exploration and extraction, immediately end all fossil fuel subsidies, and immediately and completely divest from fossil fuels."**

3.19 The Evangelicals believe that there is no need to act

Here is an excerpt frp, an article by Bernard Daley Zaleha and Andrew Szasz entitled *Why conservative Christians don't believe in climate change*[24]:

American Christians have become increasingly polarized on issues of climate change and environmental regulation. In recent years, mainline Protestant denominations and the Roman Catholic Church have made explicit declarations of support for global climate action. Prominent Southern Baptists and other evangelical Protestants, on the other hand, have issued statements that are strikingly similar to the talking points of secular climate skeptics, and have attempted to stamp out "green" efforts within their own ranks. An analysis of resolutions and campaigns by evangelicals over the past 40 years shows that anti-environmentalism within conservative Christianity stems from fears that "stewardship" of God's creation is drifting toward neo-pagan nature worship, and from apocalyptic beliefs about "end times" that make it pointless to worry about global warming. As the climate crisis deepens, the moral authority of Christian leaders and organizations may play a decisive role in swaying public policy toward (or away from) action to mitigate global warming.

The highly dangerous beliefs of the Evangelicals are in strong contrast to the courageous and enlightened leadership of Pope Francis, who urges us to act resolutely to prevent catastrophic climate change.

3.20 Banks give fossil fuel giants $1.9 trillion since Paris

Banking on Climate Change 2019 - Fossil Fuel Report Card / : Alison Kirsch et al Rainforest Action Network (RAN) et al.. For the first time, this report adds up lending and underwriting from 33 global banks to the fossil fuel industry as a whole. The findings are stark: these Canadian, Chinese, European, Japanese, and U.S. banks have financed fossil fuels with $1.9 trillion since the Paris Agreement was adopted (2016-2018), with financing on the rise each year. This report finds that fossil fuel financing is dominated by the big U.S. banks, with JPMorgan Chase as the world's top funder of fossil fuels by a wide margin. In other regions, the top bankers of fossil fuels are Royal Bank of Canada in Canada, Barclays in Europe, MUFG in Japan, and Bank of China in China. Here are some quotations from the report:

[24]Bulletin of the Atomic Scientists 2015, Vol. 71(5) 19-30

In October 2018, the Intergovernmental Panel on Climate Change (IPCC) released a sobering report on the devastating impacts our world will face with 1.5^o Celsius of warming - let alone 2^{o}C - while setting out the emissions trajectory the nations of the world need to take if we are to have any shot at keeping to that 1.5^{o}C limit. This 10th edition of the annual fossil fuel finance report card, greatly expanded in scope, reveals the paths banks have taken in the past three years since the Paris Agreement was adopted, and finds that overall bank financing continues to be aligned with climate disaster.

For the first time, this report adds up lending and underwriting from 33 global banks to the fossil fuel industry as a whole. The findings are stark: these Canadian, Chinese, European, Japanese, and U.S. banks have financed fossil fuels with $1.9 trillion since the Paris Agreement was adopted (2016-2018), with financing on the rise each year. This report finds that fossil fuel financing is dominated by the big U.S. banks, with JPMorgan Chase as the world's top funder of fossil fuels by a wide margin. In other regions, the top bankers of fossil fuels are Royal Bank of Canada in Canada, Barclays in Europe, MUFG in Japan, and Bank of China in China.

This report also puts increased scrutiny on the banks' support for 100 top companies that are expanding fossil fuels, given that there is no room for new fossil fuels in the world's carbon budget. And yet banks supported these companies with $600 billion in the last three years. JPMorgan Chase is again on top, by an even wider margin, and North American banks emerge as the biggest bankers of expansion as well.

This report also grades banks' overall future-facing policies regarding fossil fuels, assessing them on restrictions on financing for fossil fuel expansion and commitments to phase out fossil fuel financing on a 1.5^{o}C-aligned trajectory. While some banks have taken important steps, overall major global banks have simply failed to set trajectories adequate for dealing with the climate crisis.

As in past editions, this fossil fuel finance report card also assesses bank policy and practice around financing in certain key fossil fuel subsectors, with league tables and policy grades on:

- **Tar sands oil: RBC, TD, and JPMorgan Chase are the biggest bankers of 30 top tar sands producers, plus four key tar sands pipeline companies. In particular, these banks and their peers support companies working to expand tar sands infrastructure, such as Enbridge and Teck Resources.**

- **Arctic oil and gas: JPMorgan Chase is the world's biggest banker of Arctic oil and gas by far, followed by Deutsche Bank and SMBC Group. Worryingly, financing for this subsector increased from 2017 to 2018.**

- **Ultra-deepwater oil and gas: JPMorgan Chase, Citi, and Bank of America are the top bankers here. Meanwhile, none of the 33 banks have policies to proactively restrict financing for ultra-deepwater extraction.**


UnionBank
MUFG UnionBank:
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COAL
KILLS
PROTECT
OUR
CLIMATE
WATER
AND
HEALTH
WATER
IS SACRED
NO PIPELINES
KEEP IT IN THE
GROUND
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LIFE
MNI WICHONI
NO TAR SANDS


NO DAPL
JP Morgan Chase
DON'T FUND
TRANS MOUNTAIN
RAINFOREST
#DEFUND TAR

- **Fracked oil and gas: For the first time, the report card looks at bank support for top fracked oil and gas producers and transporters - and finds financing is on the rise over the past three years. Wells Fargo and JPMorgan Chase are the biggest bankers of fracking overall - and, in particular, they support key companies active in the Permian Basin, the epicenter of the climate-threatening global surge of oil and gas production.**

- **Liquefied natural gas (LNG): Banks have financed top companies building LNG import and export terminals around the world with $46 billion since the Paris Agreement, led by JPMorgan Chase, Société Générale, and SMBC Group. Banks have an opportunity to avoid further damage by not financing Anadarko's Mozambique LNG project, in particular.**

- **Coal mining: Coal mining finance is dominated by the four major Chinese banks, led by China Construction Bank and Bank of China. Though many European and U.S. banks have policies in place restricting financing for coal mining, total financing has only fallen by three to five percentage points each year.**

- **Coal power: Coal power financing is also led by the Chinese banks - Bank of China and ICBC in particular - with Citi and MUFG as the top non-Chinese bankers of coal power. Policy grades for this subsector show some positive examples of European banks restricting financing for coal power companies.**

The human rights chapter of this report shows that as fossil fuel companies are increasingly held accountable for their contributions to climate change, finance for these companies also poses a growing liability risk for banks. The fossil fuel industry has been repeatedly linked to human rights abuses, including violations of the rights of Indigenous peoples and at-risk communities, and continues to face an ever-growing onslaught of lawsuits, resistance, delays, and political uncertainty.

The IPCC's 2018 report on the impacts of a 1.5^{o}C increase in global temperature showed clearly the direction the nations of the world need to take, and the emissions trajectory we need to get there. Banks must align with that trajectory by ending financing for expansion, as well as for these particular spotlight fossil fuels - while committing overall to phase out all financing for fossil fuels on a Paris Agreement-compliant timeline.

Figure 3.40: **Drilling for oil in the Arctic.**

Figure 3.41: **Indigenous protests against Arctic drilling.**


CHASE
CHASE: STOP
PROFITING OFF
DIRTY ENERGY
& RIGHTS ABUSES
JP Morgan Chase
DON'T FUND
TRANS MOUNTAIN

Figure 3.42: **A coal-fired power plant.**

3.21 Fossil fuel industry's disinformation campaign

The Wikipedia article on climate change denial describes it with the following words: "Although scientific opinion on climate change is that human activity is extremely likely to be the primary driver of climate change, the politics of global warming have been affected by climate change denial, hindering efforts to prevent climate change and adapt to the warming climate. Those promoting denial commonly use rhetorical tactics to give the appearance of a scientific controversy where there is none."

It is not surprising that the fossil fuel industry supports, on a vast scale, politicians and mass media that deny the reality of climate change. The amounts of money at stake are vast. If catastrophic climate change is to be avoided, coal, oil and natural gas "assets" worth trillions of dollars must be left in the ground. Giant fossil fuel corporations are desperately attempting to turn these "assets' into cash.

According to a recent article published in "The Daily Kos"[25], companies like Shell and Exxon, knew, as early as the 1970s, how their combustible products were contributing to irreversible warming of the planet, became public knowledge over the last few years.

A series of painstakingly researched articles[26] published in 2015 by the Pulitzer-prize winning Inside Climate News revealed an industry totally aware and informed for decades about the inevitable warming certain to occur as more and more carbon dioxide from the burning of fossil fuels was released into the atmosphere.

The article states that "In fact, the oil industry, and Exxon in particular, had the best climate models available, superior to those relied on by scientific community.[27] And armed with the foreknowledge developed through those models, Exxon and the other oil companies planned and executed an elaborate, cynical long term strategy: to invest hundreds of millions of dollars in a comprehensive propaganda effort designed to raise doubts about the existence and cause of climate change, a phenomenon they well knew was irrefutable, based on their own research. By 2016 the industry's lobbying to discredit the science of climate change had surpassed two billion dollars.

"Meanwhile, as newly discovered documents reported in The Guardian[28] attest, the same companies were preparing projections of what type of world they would be leaving for the rest of humanity. In the 1980s, oil companies like Exxon and Shell carried out internal assessments of the carbon dioxide released by fossil fuels, and forecast the planetary consequences of these emissions. In 1982, for example, Exxon predicted that by about 2060, CO_2 levels would reach around 560 parts per million - double the preindustrial level - and that this would push the planet's average temperatures up by about 2^oC over then-current

[25] ww.dailykos.com/stories/2018/9/23/1797888/-The-Oil-Companies-not-only-knew-fossil-fuels-caused-climate-change-they-knew-how-bad-it-would-get?detail=emaildkre

[26] https://insideclimatenews.org/news/15092015/Exxons-own-research-confirmed-fossil-fuels-role-in-global-warming

[27] https://insideclimatenews.org/news/18092015/exxon-confirmed-global-warming-consensus-in-1982-with-in-house-climate-models

[28] https://www.theguardian.com/environment/climate-consensus-97-per-cent/2018/sep/19/shell-and-exxons-secret-1980s-climate-change-warnings

levels (and even more compared to pre-industrial levels)."[29]

The Fossil Free MIT report, 2014

Here are some excerpts from a report entitled **"The Fossil Fuel Industry's Role in Hindering Climate Change Action: Lobbying and Disinformation Against Science and Scientists"**[30]:

In response to the unprecedented urgency of global climate change, Fossil Free MIT's petition, signed by more than 2,400 MIT members, is calling on MIT to divest its $11 billion endowment from the 200 fossil fuel companies with the world's largest publicly traded carbon reserves.

Fossil Free MIT believes that divestment from the fossil fuel industry presents MIT with a unique opportunity to lead the global effort to combat climate change. We wholeheartedly support our Institute's cutting-edge climate science and renewable energy technology research, as well as MIT's campus sustainability initiatives, and we propose divestment as a highly complementary strategy that will bring MIT's investments in line with the goals of its research and sustainability activities. There are three central reasons why we urge MIT to divest from the fossil fuel industry:

- **The fossil fuel industry's business practice is fundamentally inconsistent with the science of climate change mitigation. A 66% chance of limiting global warming to less than 2^oC above pre-industrial temperatures demands that no more than 35% of proven fossil fuel reserves can be burned prior to 2100. Yet in 2012, the fossil fuel industry spent $674 billion developing new reserves.**
- **The fossil fuel industry spends hundreds of millions of dollars lobbying and donating in Washington, D.C. against legislation for climate change action.**
- **Many fossil fuel companies are responsible for funding or orchestrating targeted anti-science disinformation campaigns that confuse the public,**

[29]See also https://truthout.org/articles/self-immolation-as-the-world-burns-an-earth-day-report/
https://countercurrents.org/2018/04/29/the-methane-time-bomb-and-the-future-of-the-biosphere/
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https://www.independent.co.uk/news/business/news/bp-shell-oil-global-warming-5-degree-paris-climate-agreement-fossil-fuels-temperature-rise-a8022511.html

[30]https://www.fossilfreemit.org/wp-content/uploads/2014/08/FossilFreeMIT-Lobbying-Disinformation.pdf

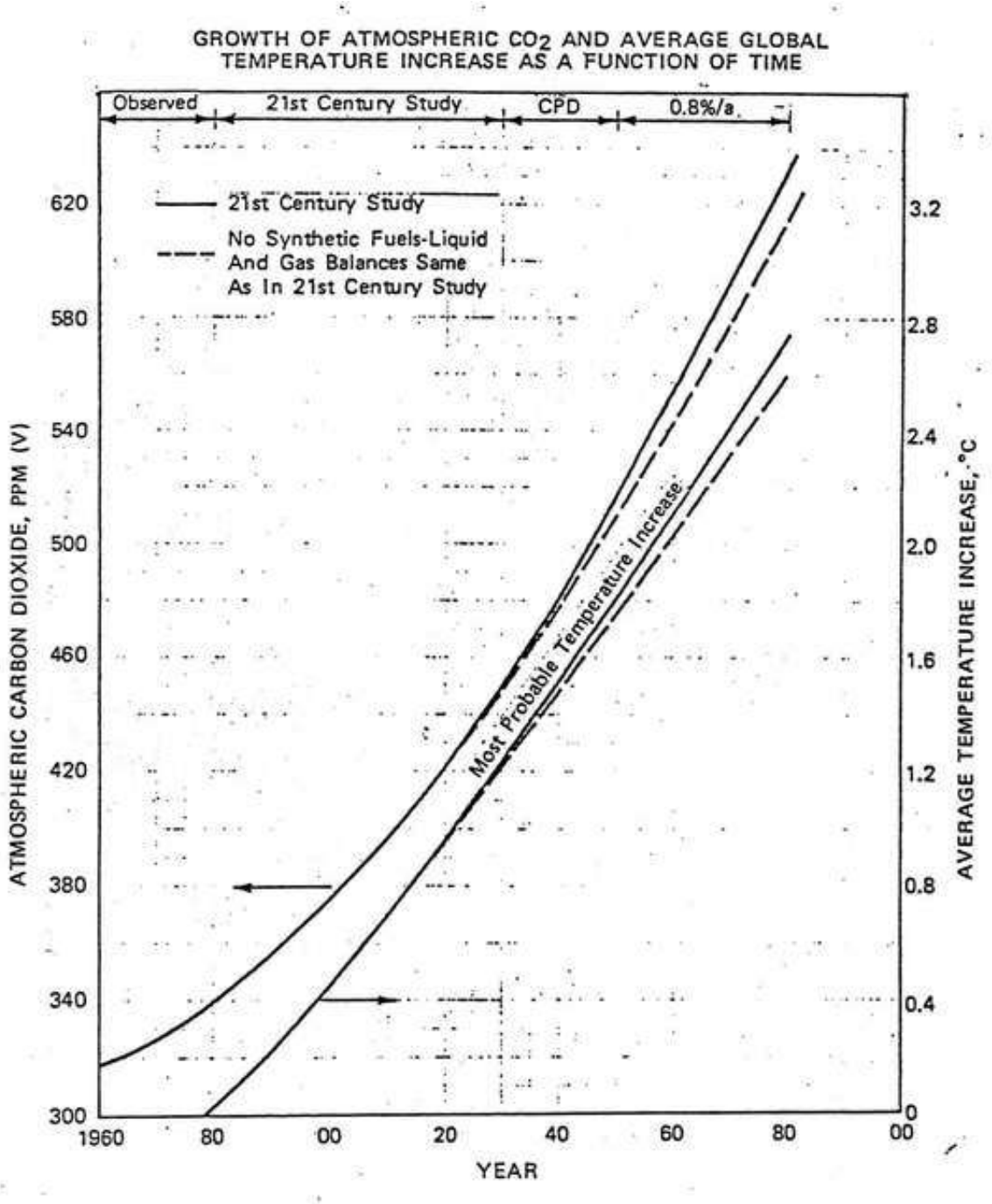

Figure 3.43: **Exxon's 1982 internal projections of the future increase in carbon dioxide levels shows CO_2 percentages increasing to 600 ppm and temperature increases of up to 3°C.**

sabotage science, and slander scientists.

Disinformation from fossil fuel and tobacco industries

Here are some excerpts from a February 19 2019 article by Mat Hope entitled **"Revealed: How the Tobacco and Fossil Fuel Industries Fund Disinformation Campaigns Around the World"**[31]:

Fossil fuel companies have a long history of adopting public relations strategies straight from the tobacco industry's playbook. But a new analysis shows the two industries' relationship goes much deeper - right down to funding the same organizations to do their dirty work.

MIT Associate Professor David Hsu analyzed organizations in DeSmog's disinformation database and the Guardian's tobacco database and found 35 thinktanks based in the US, UK, Australia, and New Zealand that promote both the tobacco and fossil fuel industries' interests.

Of these organizations, DeSmog can reveal that 32 have taken direct donations from the tobacco industry, 29 have taken donations from the fossil fuel industry, and 28 have received money from both. Two key networks, based around the Koch brothers and Atlas Network, are involved in coordinating or funding many of the thinktanks.

[31] https://www.desmogblog.com/2019/02/19/how-tobacco-and-fossil-fuel-companies-fund-disinformation-campaigns-around-world

Figure 3.44: **Smoke destroys human health, regardless of whether it is from cigarettes or coal-fired power plants. Fossil fuel corporations and tobacco companies have exhibited an astonishing degree of cynicism and lack of social responsibility.**

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Chapter 4

CATASTROPHIC NUCLEAR WAR

"The unleashed power of the atom has changed everything except our ways of thinking, and thus we drift towards unparalleled catastrophes."

"I don't know what will be used in the next world war, but the 4th will be fought with stones."

Albert Einstein

4.1 Introduction

Today, the greatest threats facing human civilization and the biosphere are catastrophic climate change and nuclear war. Each of these could potentially destroy our civilization, kill most humans, and make most of our planet uninhabitable for most species, including our own.

Figure 4.1: **Saint Paul's Cathedral during the London Blitz. Determined fire-fighting by citizens saved the cathedral from burning,** (Wikipedia)

The peoples of the world must unite and work with dedication to avoid these twin threats.

Figure 4.2: **A view of Dresden after the firebombing with a statue of "Goodness" in the foreground.** (Wikipedia)

4.2 Targeting civilians

4.3 The erosion of ethical principles during World War II

When Hitler invaded Poland in September, 1939, US President Franklin Delano Roosevelt appealed to Great Britain, France, and Germany to spare innocent civilians from terror bombing. "The ruthless bombing from the air of civilians in unfortified centers of population during the course of the hostilities", Roosevelt said (referring to the use of air bombardment during World War I) "...has sickened the hearts of every civilized man and woman, and has profoundly shocked the conscience of humanity." He urged "every Government which may be engaged in hostilities publicly to affirm its determination that its armed forces shall in no event, and under no circumstances, undertake the bombardment from the air of civilian populations or of unfortified cities."

Two weeks later, British Prime Minister Neville Chamberlain responded to Roosevelts appeal with the words: "Whatever the lengths to which others may go, His Majesty's Government will never resort to the deliberate attack on women and children and other civilians for purposes of mere terrorism."

Much was destroyed during World War II, and among the casualties of the war were the ethical principles that Roosevelt and Chamberlain announced at its outset. At the time of Roosevelt and Chamberlains declarations, terror bombing of civilians had already begun in the Far East. On 22 and 23 September, 1937, Japanese bombers attacked civilian populations in Nanjing and Canton. The attacks provoked widespread protests. The British Under Secretary of State for Foreign Affairs, Lord Cranborne, wrote: "Words cannot express the feelings of profound horror with which the news of these raids has been received by the whole civilized world. They are often directed against places far from the actual area of hostilities. The military objective, where it exists, seems to take a completely second place. The main object seems to be to inspire terror by the indiscriminate slaughter of civilians..."

On the 25th of September, 1939, Hitlers air force began a series of intense attacks on Warsaw. Civilian areas of the city, hospitals marked with the Red Cross symbol, and fleeing refugees all were targeted in a effort to force the surrender of the city through terror. On the 14th of May, 1940, Rotterdam was also devastated. Between the 7th of September 1940 and the 10th of May 1941, the German Luftwaffe carried out massive air attacks on targets in Britain. By May, 1941, 43,000 British civilians were killed and more than a million houses destroyed.

By the end of the war the United States and Great Britain were bombing of civilians on a far greater scale than Japan and Germany had ever done. For example, on July 24-28, 1943, British and American bombers attacked Hamburg with an enormous incendiary raid whose official intention was "the total destruction" of the city.

The result was a firestorm that did, if fact, lead to the total destruction of the city. One airman recalled, that "As far as I could see was one mass of fire. A sea of flame has been

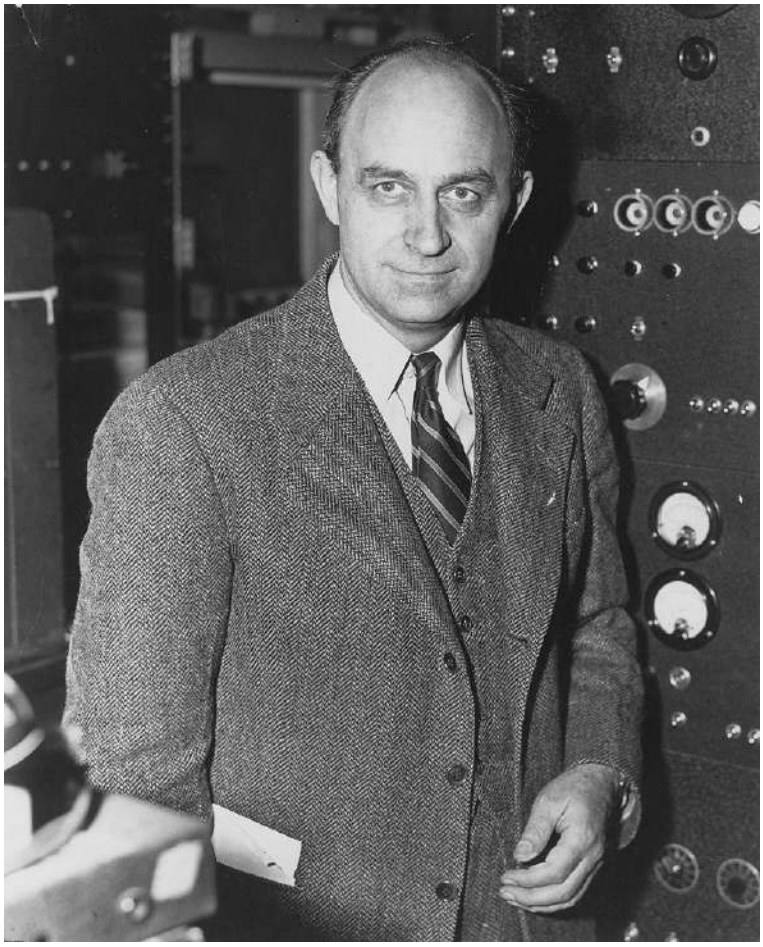

Figure 4.3: **Enrico Fermi (1901–1954). In 1934, he and his team of young Italian physicists split uranium atoms without realizing it.** (Public domain)

the description, and thats an understatement. It was so bright that I could read the target maps and adjust the bomb-sight." Another pilot was "...amazed at the awe-inspiring sight of the target area. It seemed as though the whole of Hamburg was on fire from one end to the other and a huge column of smoke was towering well above us - and we were on 20,000 feet! It all seemed almost incredible and, when I realized that I was looking at a city with a population of two millions, or about that, it became almost frightening to think of what must be going on down there in Hamburg."

Below, in the burning city, temperatures reached 1400 degrees Fahrenheit, a temperature at which lead and aluminum have long since liquefied. Powerful winds sucked new air into the firestorm. There were reports of babies being torn by the high winds from their mothers arms and sucked into the flames. Of the 45,000 people killed, it has been estimated that 50 percent were women and children and many of the men killed were elderly, above military age. For weeks after the raids, survivors were plagued by "...droves of vicious rats, grown strong by feeding on the corpses that were left unburied within the rubble as well

as the potatoes and other food supplies lost beneath the broken buildings."

The German cities Kassel, Pforzheim, Mainz, Dresden and Berlin were similarly destroyed, and in Japan, US bombing created firestorms in many cities, for example Tokyo, Kobe and Yokohama. In Tokyo alone, incendiary bombing caused more than 100,000 civilian casualties.

4.4 Hiroshima and Nagasaki

On August 6, 1945, at 8:15 in the morning, an atomic bomb was exploded in the air over Hiroshima. The force of the explosion was equivalent to twenty thousand tons of T.N.T.. Out of a city of two hundred and fifty thousand people, almost one hundred thousand were killed by the bomb; and another hundred thousand were hurt.

In some places, near the center of the city, people were completely vaporized, so that only their shadows on the pavement marked the places where they had been. Many people who were not killed by the blast or by burns from the explosion, were trapped under the wreckage of their houses. Unable to move, they were burned to death in the fire which followed.

Some accounts of the destruction of Hiroshima, written by children who survived it, have been collected by Professor Arata Osada. Among them is the following account, written by a boy named Hisato Ito. He was 11 years old when the atomic bomb was exploded over the city:

"On the morning of August 5th (we went) to Hiroshima to see my brother, who was at college there. My brother spent the night with us in a hotel... On the morning of the 6th, my mother was standing near the entrance, talking with the hotel proprietor before paying the bill, while I played with the cat. It was then that a violent flash of blue-white light swept in through the doorway."

"I regained consciousness after a little while, but everything was dark. I had been flung to the far end of the hall, and was lying under a pile of debris caused by the collapse of two floors of the hotel. Although I tried to crawl out of this, I could not move. The fine central pillar, of which the proprietor was so proud, lay flat in front of me. "

"I closed my eyes and was quite overcome, thinking that I was going to die, when I heard my mother calling my name. At the sound of her voice, I opened my eyes; and then I saw the flames creeping close to me. I called frantically to my mother, for I knew that I should be burnt alive if I did not escape at once. My mother pulled away some burning boards and saved me. I shall never forget how happy I felt at that moment - like a bird let out of a cage."

"Everything was so altered that I felt bewildered. As far as my eyes could see, almost all the houses were destroyed and on fire. People passed by, their bodies red, as if they had been peeled. Their cries were pitiful. Others were dead. It was impossible to go farther along the street on account of the bodies, the ruined houses, and the badly wounded who lay about moaning. I did not know what to do; and as I turned to the west, I saw that the flames were drawing nearer.."

Figure 4.4: **Hiroshima** (duniverso.com.br)

"At the waters edge, opposite the old Sentai gardens, I suddenly realized that I had become separated from my mother. The people who had been burned were plunging into the river Kobashi, and then were crying out: 'Its hot! Its hot! They were too weak to swim, and they drowned while crying for help."

In 1951, shortly after writing this account, Hisato Ito died of radiation sickness. His mother died soon afterward from the same cause.

Figure 4.5: **Hiroshima. The greater absorption of thermal energy by dark colors resulted in the clothes pattern, in the tight-fitting areas on this survivor, being burnt into the skin.**(Public domain)

Figure 4.6: **Nagasaki before the nuclear explosion and firestorm.** (Public domain)

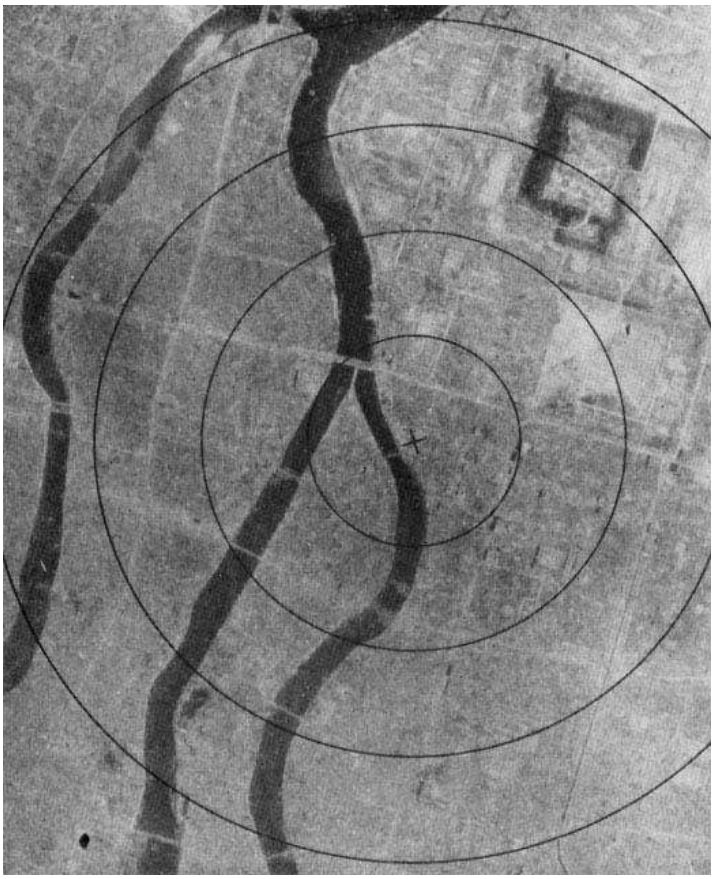

Figure 4.7: **Nagasaki afterwards.** (Public domain)

Figure 4.8: **The United States exploded a hydrogen bomb near the island of Enewetak in the South Pacific in 1952. The explosive force of the bomb was 500 times greater than the bombs that destroyed Hiroshima and Nagasaki. The Soviet Union tested its first hydrogen bomb in 1953. In March, 1954, the US tested another hydrogen bomb at the Bikini Atoll in the Pacific Ocean. It was 1000 times more powerful than the Hiroshima bomb. The Japanese fishing boat, Lucky Dragon, was 130 kilometers from the Bikini explosion, but radioactive fallout from the test killed one crew member and made all the others seriously ill.** (Public domain)

Figure 4.9: **After discussing the Bikini test and its radioactive fallout with Joseph Rotblat, Lord Russell became concerned for the future of the human gene pool if large numbers of such bombs should ever be used in a war. To warn humanity of the danger, he wrote what came to be known as the Russell-Einstein Manifesto. On July 9, 1955, with Rotblat in the chair, Russell read the Manifesto to a packed press conference. The document contains the words: "Here then is the problem that we present to you, stark and dreadful and inescapable: Shall we put an end to the human race, or shall mankind renounce war?... There lies before us, if we choose, continual progress in happiness, knowledge and wisdom. Shall we, instead, choose death because we cannot forget our quarrels? We appeal as human beings to human beings: Remember your humanity, and forget the rest." Lord Russell devoted much of the remainder of his life to working for the abolition of nuclear weapons. Here he is seen in 1962 in Trafalgar Square, London, addressing a meeting of the Campaign for Nuclear Disarmament.** (Public domain)

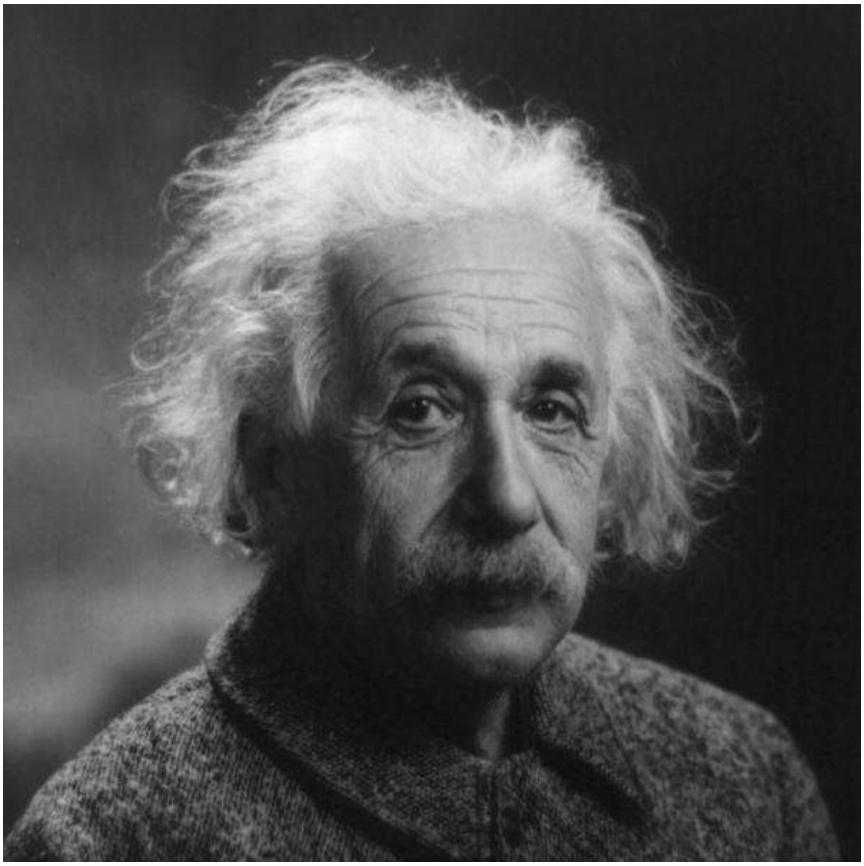

Figure 4.10: **Albert Einstein wrote: "The unleashed power of the atom has changed everything save our modes of thinking, and we thus drift toward unparalleled catastrophes." He also said, "I don't know what will be used in the next world war, but the 4th will be fought with stones."**(Wikimedia)

Figure 4.11: **Joseph Rotblat devoted the remainder of his life to working for peace and for the abolition of nuclear weapons. He became the president and guiding spirit of the Pugwash Conferences on Science and World Affairs, an organization of scientists and other scholars devoted to these goals. In his 1995 Nobel Peace Prize acceptance speech, Sir Joseph Rotblat (as he soon became) emphasized the same point that had been made in the Russell-Einstein Manifesto - that war itself must be eliminated in order to free civilization from the danger of nuclear destruction.** (Pugwash Conferences)

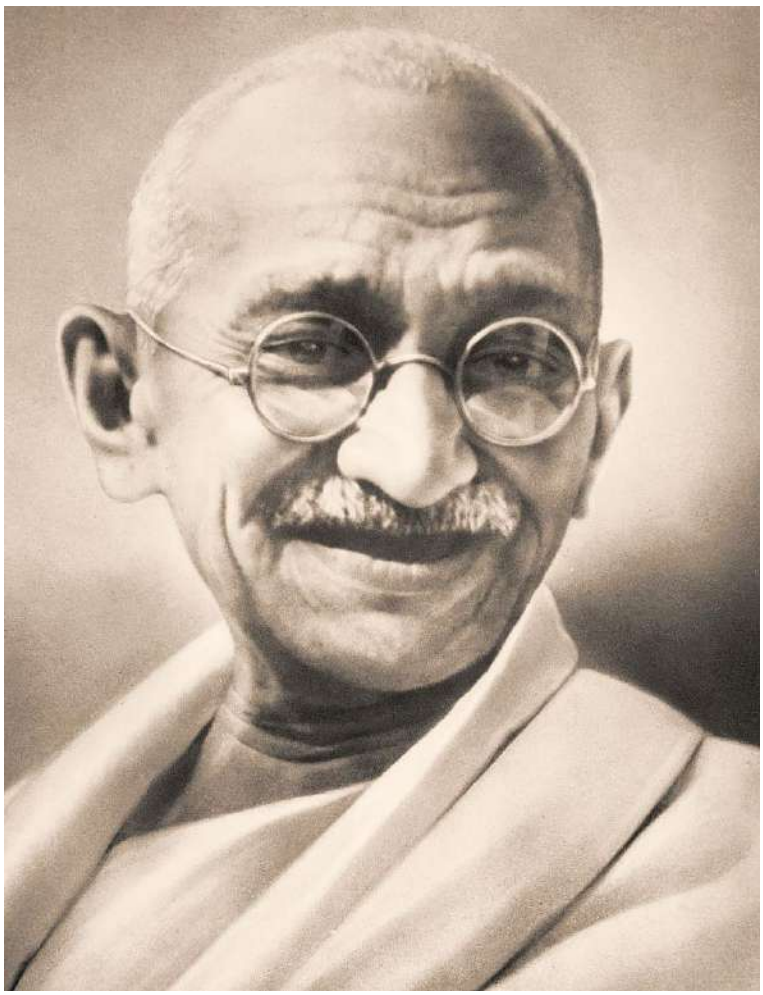

Figure 4.12: **To the insidious argument that "the end justifies the means", Mahatma Gandhi answered firmly: "They say 'means are after all means. I would say 'means are after all everything. As the means, so the end. Indeed the Creator has given us control (and that very limited) over means, none over end... The means may be likened to a seed, and the end to a tree; and there is the same inviolable connection between the means and the end as there is between the seed and the tree. Means and end are convertible terms in my philosophy of life." In other words, if evil means are used, the end achieved will be contaminated by the means used to achieve it. Gandhi's insight can be applied to the argument that the nuclear bombings that destroyed Hiroshima and Nagasaki helped to end World War II and were therefore justified. In fact, these terrible events lead to a nuclear arms race that still casts an extremely dark shadow over the future of human civilization.** (Public domain)

4.5 The postwar nuclear arms race

When the news of the atomic bombing of Hiroshima and Nagasaki reached Albert Einstein, his sorrow and remorse were extreme. During the remainder of his life, he did his utmost to promote the cause of peace and to warn humanity against the dangers of nuclear warfare. Together with Bertrand Russell and Joseph Rotblat he helped to found Pugwash Conferences on Science and World Affairs (Nobel Peace Prize 1995), an organization of scientists and other scholars devoted to world peace and to the abolition of nuclear weapons.

When Otto Hahn, the discoverer of fission, heard the news of the destruction of Hiroshima, he and nine other German atomic scientists were being held prisoner at an English country house near Cambridge. Hahn became so depressed that his colleagues feared that he would take his own life.

World public opinion was also greatly affected by the indiscriminate destruction of human life in Hiroshima and Nagasaki. Shortly after the bombings, the French existentialist author Albert Camus wrote: "Our technical civilization has just reached its greatest level of savagery. We will have to choose, in the more or less near future, between collective suicide and the intelligent use of our scientific conquests. Before the terrifying prospects now available to humanity, we see even more clearly that peace is the only battle worth waging. This is no longer a prayer, but a demand to be made by all peoples to their governments - a demand to choose definitively between hell and reason."

Among the scientists who had worked at Chicago and Los Alamos, there was relief that the war was over; but as descriptions of Hiroshima and Nagasaki became available there were also sharp feelings of guilt. Many scientists who had worked on the bomb project made great efforts to persuade the governments of the United States, England and the Soviet Union to agree to international control of atomic energy; but these efforts met with failure; and the nuclear arms race developed with increasing momentum.

In 1946, the United States proposed the Baruch Plan to internationalize atomic energy, but the plan was rejected by the Soviet Union, which had been conducting its own secret nuclear weapons program since 1943. On August 29, 1949, the USSR exploded its first nuclear bomb. It had a yield equivalent to 21,000 tons of TNT, and had been constructed from Pu-239 produced in a nuclear reactor. Meanwhile the United Kingdom had begun to build its own nuclear weapons.

The explosion of the Soviet nuclear bomb caused feelings of panic in the United States, and President Truman authorized an all-out effort to build superbombs using thermonuclear reactions - the reactions that heat the sun and stars. The idea of using a U-235 fission bomb to trigger a thermonuclear reaction in a mixture of light elements had first been proposed by Enrico Fermi in a 1941 conversation with his Chicago colleague Edward Teller. After this conversation, Teller (perhaps the model for Stanley Kubrick's character Dr. Strangelove) became a fanatical advocate of the superbomb.

After Truman's go-ahead, the American program to build thermonuclear weapons made rapid progress, and on October 31, 1952, the first US thermonuclear device was exploded at Eniwetok Atoll in the Pacific Ocean. It had a yield of 10.4 megatons, that is to say it had an explosive power equivalent to 10,400,000 tons of TNT. Thus the first thermonuclear

bomb was five hundred times as powerful as the bombs that had devastated Hiroshima and Nagasaki. Lighter versions of the device were soon developed, and these could be dropped from aircraft or delivered by rockets.

The Soviet Union and the United Kingdom were not far behind. In 1955 the Soviets exploded their first thermonuclear device, followed in 1957 by the UK. In 1961 the USSR exploded a thermonuclear bomb with a yield of 58 megatons. A bomb of this size, three thousand times the size of the Hiroshima bomb, would be able to totally destroy a city even if it missed it by 50 kilometers. Fall-out casualties would extend to a far greater distance.

In the late 1950s General Gavin, Chief of Army Research and Development in the United States, was asked by the Symington Committee, "If we got into a nuclear war and our strategic air force made an assault in force against Russia with nuclear weapons exploded in a way where the prevailing winds would carry them south-east over Russia, what would be the effect in the way of death?"

General Gavin replied: "Current planning estimates run on the order of several hundred million deaths. That would be either way depending on which way the wind blew. If the wind blew to the south-east they would be mostly in the USSR, although they would extend into the Japanese area and perhaps down into the Philippine area. If the wind blew the other way, they would extend well back into Western Europe."

Between October 16 and October 28, 1962, the Cuban Missile Crisis occurred, an incident in which the world came extremely close to a full-scale thermonuclear war. During the crisis, President Kennedy and his advisers estimated that the chance of an all-out nuclear war with Russia was 50%. Recently-released documents indicate that the probability of war was even higher than Kennedy's estimate. Robert McNamara, who was Secretary of Defense at the time, wrote later, "We came within a hairbreadth of nuclear war without realizing it... Its no credit to us that we missed nuclear war..."

In 1964 the first Chinese nuclear weapon was tested, and this was followed in 1967 by a Chinese thermonuclear bomb with a yield of 3.3 megatons. France quickly followed suit testing a fission bomb in 1966 and a thermonuclear bomb in 1968. In all about thirty nations contemplated building nuclear weapons, and many made active efforts to do so.

Because the concept of deterrence required an attacked nation to be able to retaliate massively even though many of its weapons might be destroyed by a preemptive strike, the production of nuclear warheads reached insane heights, driven by the collective paranoia of the Cold War. More than 50,000 nuclear warheads were produced worldwide, a large number of them thermonuclear. The collective explosive power of these warheads was equivalent to 20,000,000,000 tons of TNT, i.e. 4 tons for every man, woman and child on the planet, or, expressed differently, a million times the explosive power of the bomb that destroyed Hiroshima.

4.6 The end of the Cold War

In 1985, Michael Gorbachev (1931-) became the General Secretary of the Communist Party of the Soviet Union. Gorbachev had become convinced by his conversations with scientists

that the policy of nuclear confrontation between the United States and the USSR was far too dangerous to be continued over a long period of time. If continued, sooner or later, through accident of miscalculation, it would result in a disaster of unprecedented proportions. Gorbachev also believed that the USSR was in need of reform, and he introduced two words to characterize what he felt was needed: *glasnost* (openness) and *perestroika* (reconstruction).

In 1986, US President Ronald Reagan met Mikhail Gorbachev in Reykjavik, Iceland. The two leaders hoped that they might find ways of reducing the danger that a thermonuclear Third World War would be fought between their two countries. Donald Reagan, the White House Chief of Staff, was present at the meeting, and he records the following conversation: "At one point in time Gorbachev said 'I would like to do away with all nuclear weapons. And Reagan hit the table and said 'Well why didn't you say so in the first place! Thats exactly what I want to do! And if you want to do away with all the weapons, Ill agree to do away with all the weapons. Of course well do away with all the weapons. 'Good, [said Gorbachev] 'Thats great, but you must confine SDI to the laboratory. 'No I wont, said Reagan. 'No way. SDI continues. I told you that I am never going to give up SDI." The SDI program, which seemingly prevented Presidents Reagan and Gorbachev from reaching an agreement to completely eliminate their nuclear weapons was Reagan's "Star Wars" program which (in violation of the ABM Treaty) proposed to set up a system of of radar, satellites and missiles to shoot down attacking missiles.

Gorbachev s reforms effectively granted self-government to the various parts of the Soviet Union, and he himself soon resigned from his post as its leader, since the office was no longer meaningful. Most of the newly-independent parts of the old USSR began to introduce market economies, and an astonished world witnessed a series of unexpected and rapid changes: On September 10, 1989 Hungarian government opened its border for East German refugees; on November 9, 1989 Berlin Wall was reopened; on December 22, 1989 Brandenburg Gate was opened; and on October 3, 1990 Germany was reunited. The Cold War was over!

4.7 The Non-Proliferation Treaty

During the Cold War, a number of international treaties attempting to reduce the global nuclear peril had been achieved after much struggle. Among these, the 1968 Nuclear Non-Proliferation Treaty (NPT) has special importance. The NPT was designed to prevent the spread of nuclear weapons beyond the five nations that already had them; to provide assurance that "peaceful" nuclear activities of non-nuclear-weapon states would not be used to produce such weapons; to promote peaceful use of nuclear energy to the greatest extent consistent with non-proliferation of nuclear weapons; and finally, to ensure that definite steps towards complete nuclear disarmament would be taken by all states, as well steps towards comprehensive control of conventional armaments (Article VI).

The non-nuclear-weapon states insisted that Article VI be included in the treaty as a price for giving up their own ambitions. The full text of Article VI is as follows: "Each of the

Parties to the Treaty undertakes to pursue negotiations in good faith on effective measures relating cessation of the nuclear arms race at an early date and to nuclear disarmament, and on a Treaty on general and complete disarmament under strict international control."

The NPT has now been signed by 187 countries and has been in force as international law since 1970. However, Israel, India, Pakistan, and Cuba have refused to sign, and North Korea, after signing the treaty, withdrew from it in 1993. Israel began producing nuclear weapons in the late 1960s (with the help of a reactor provided by France) and the country is now believed to possess 100-150 of them, including neutron bombs. Israels policy is one of "nuclear opacity" - i.e., visibly possessing nuclear weapons while denying their existence.

South Africa, with the help of Israel and France, also produced nuclear weapons, which it tested in the Indian Ocean in 1979. In 1991 however, South Africa signed the NPT and destroyed its nuclear weapons.

India produced what it described as a "peaceful nuclear explosion" in 1974. By 1989 Indian scientists were making efforts to purify the lithium-6 isotope, a key component of the much more powerful thermonuclear bombs. In 1998, India conducted underground tests of nuclear weapons, and is now believed to have roughly 60 warheads, constructed from Pu-239 produced in "peaceful" reactors.

Pakistan's efforts to obtain nuclear weapons were spurred by India's 1974 "peaceful nuclear explosion". Zulfiquar Ali Bhutto, who initiated Pakistan's program, first as Minister of Fuel, Power and Natural Resources, and later as President and Prime Minister, declared: "There is a Christian Bomb, a Jewish Bomb and a Hindu Bomb. There must be an Islamic Bomb! We will get it even if we have to starve - even if we have to eat grass!" As early as 1970, the laboratory of Dr. Abdul Qadeer Khan, (a metallurgist who was to become Pakistan's leading nuclear bomb maker) had been able to obtain from a Dutch firm the high-speed ultracentrafuges needed for uranium enrichment. With unlimited financial support and freedom from auditing requirements, Dr. Khan purchased restricted items needed for nuclear weapon construction from companies in Europe and the United States. In the process, Dr. Khan became an extremely wealthy man. With additional help from China, Pakistan was ready to test five nuclear weapons in 1998. The Indian and Pakistani nuclear bomb tests, conducted in rapid succession, presented the world with the danger that these devastating bombs would be used in the conflict over Kashmir. Indeed, Pakistan announced that if a war broke out using conventional weapons, Pakistan's nuclear weapons would be used "at an early stage".

In Pakistan, Dr. A.Q. Khan became a great national hero. He was presented as the person who had saved Pakistan from attack by India by creating Pakistan's own nuclear weapons. In a Washington Post article[1] Pervez Hoodbhoy wrote: "Nuclear nationalism was the order of the day as governments vigorously promoted the bomb as the symbol of Pakistan's high scientific achievement and self-respect, and as the harbinger of a new Muslim era." Similar manifestations of nuclear nationalism could also be seen in India after India's 1998 bomb tests.

Early in 2004, it was revealed that Dr. Khan had for years been selling nuclear secrets

[1] 1 February, 2004

and equipment to Lybia, Iran and North Korea. However, observers considered that it was unlikely that Khan would be tried for these offenses, since a trial might implicate Pakistan's army as well as two of its former prime ministers. Furthermore, Dr. Khan has the strong support of Pakistan's Islamic fundamentalists. Recent assassinations emphasize the precariousness of Pakistan's government. There is a danger that it may be overthrown by Islamic fundamentalists, who would give Pakistan's nuclear weapons to terrorist organizations. This type of danger is a general one associated with nuclear proliferation. As more and more countries obtain nuclear weapons, it becomes increasingly likely that one of them will undergo a revolution, during the course of which nuclear weapons will fall into the hands of subnational organizations.

Article VIII of the Non-Proliferation Treaty provides for a conference to be held every five years to make sure that the NPT is operating as intended. In the 1995 NPT Review Conference, the lifetime of the treaty was extended indefinitely, despite the general dissatisfaction with the bad faith of the nuclear weapon states: They had dismantled some of their warheads but had taken no significant steps towards complete nuclear disarmament. The 2000 NPT Review Conference made it clear that the nuclear weapons states could not postpone indefinitely their commitment to nuclear disarmament by linking it to general and complete disarmament, since these are separate and independent goals of Article VI. The Final Document of the conference also contained 13 Practical Steps for Nuclear Disarmament, including ratification of a Comprehensive Test Ban Treaty (CTBT), negotiations on a Fissile Materials Cutoff Treaty, the preservation and strengthening of the Anti-Ballistic Missile (ABM) Treaty, greater transparency with regard to nuclear arsenals, and making irreversability a principle of nuclear reductions. Another review conference is scheduled for 2010, a year that marks the 55th anniversary of the destruction of Hiroshima and Nagasaki.

Something must be said about the concept of irreversability mentioned in the Final Document of the 2000 NPT Review Conference. Nuclear weapons can be destroyed in a completely irreversible way by getting rid of the special isotopes which they use. In the case of highly enriched uranium (HEU), this can be done by mixing it thoroughly with ordinary unenriched uranium. In natural uranium, the rare fissile isotope U-235 is only 0.7%. The remaining 99.3% consists of the common isotope, U-238, which under ordinary circumstances cannot undergo fission. If HEU is mixed with a sufficient quantity of natural uranium, so that the concentration of U-235 falls below 20%, it can no longer be used in nuclear weapons.

Getting rid of plutonium irreversibly is more difficult, but it could be cast into large concrete blocks and dumped into extremely deep parts of the ocean (e.g. the Japan Trench) where recovery would be almost impossible. Alternatively, it could be placed in the bottom of very deep mine shafts, which could afterwards be destroyed by means of conventional explosives. None of the strategic arms reduction treaties, neither the SALT treaties nor the 2002 Moscow Treaty, incorporate irreversability.

The recent recommendation by four distinguished German statesmen that all short-range nuclear weapons be destroyed is particularly interesting [13]. The strongest argument for the removal of US tactical nuclear weapons from Europe is the danger of collapse of

the NPT. The 2005 NPT Review Conference was a disaster, and there is a danger that at the 2010 Review Conference, the NPT will collapse entirely because of the discriminatory position of the nuclear weapon states (NWS) and their failure to honor their commitments under Article VI. NATOs present nuclear weapon policy also violates the NPT, and correcting this violation would help to save the 2010 Review Conference from failure.

At present, the air forces of the European countries in which the US nuclear weapons are stationed perform regular training exercises in which they learn how to deliver the weapons. This violates the spirit, and probably also the letter, of Article IV, which prohibits the transfer of nuclear weapons from an NWS to a non-NWS. The "nuclear sharing" proponents maintain that such transfers would only happen in an emergency; but there is nothing in the NPT saying that the treaty would not hold under all circumstances. Furthermore, NATO would be improved, rather than damaged, by giving up "nuclear sharing". If President Obama wishes to fulfill his campaign promises [14] - if he wishes to save the NPT - a logical first step would be to remove US tactical nuclear weapons from Europe.

4.8 Flaws in the concept of nuclear deterrence

Before discussing other defects in the concept of deterrence, it must be said very clearly that the idea of "massive nuclear retaliation" is completely unacceptable from an ethical point of view. The doctrine of retaliation, performed on a massive scale, violates not only the principles of common human decency and common sense, but also the ethical principles of every major religion. Retaliation is especially contrary to the central commandment of Christianity which tells us to love our neighbor, even if he or she is far away from us, belonging to a different ethnic or political group, and even if our distant neighbor has seriously injured us. This principle has a fundamental place not only in in Christianity but also in Buddhism. "Massive retaliation" completely violates these very central ethical principles, which are not only clearly stated and fundamental but also very practical, since they prevent escalatory cycles of revenge and counter-revenge.

Contrast Christian ethics with estimates of the number of deaths that would follow a US nuclear strike against Russia: Several hundred million deaths. These horrifying estimates shock us not only because of the enormous magnitude of the expected mortality, but also because the victims would include people of every kind: women, men, old people, children and infants, completely irrespective of any degree of guilt that they might have. As a result of such an attack, many millions of people in neutral countries would also die. This type of killing has to be classified as genocide.

When a suspected criminal is tried for a wrongdoing, great efforts are devoted to clarifying the question of guilt or innocence. Punishment only follows if guilt can be proved beyond any reasonable doubt. Contrast this with the totally indiscriminate mass slaughter that results from a nuclear attack!

It might be objected that disregard for the guilt or innocence of victims is a universal characteristic of modern war, since statistics show that, with time, a larger and larger percentage of the victims have been civilians, and especially children. For example, the

air attacks on Coventry during World War II, or the fire bombings of Dresden and Tokyo, produced massive casualties which involved all segments of the population with complete disregard for the question of guilt or innocence. The answer, I think, is that modern war has become generally unacceptable from an ethical point of view, and this unacceptability is epitomized in nuclear weapons.

The enormous and indiscriminate destruction produced by nuclear weapons formed the background for an historic 1996 decision by the International Court of Justice in the Hague. In response to questions put to it by WHO and the UN General Assembly, the Court ruled that "the threat and use of nuclear weapons would generally be contrary to the rules of international law applicable in armed conflict, and particularly the principles and rules of humanitarian law." The only *possible* exception to this general rule might be "an extreme circumstance of self-defense, in which the very survival of a state would be at stake". But the Court refused to say that even in this extreme circumstance the threat or use of nuclear weapons would be legal. It left the exceptional case undecided. In addition, the World Court added unanimously that "there exists an obligation to pursue in good faith *and bring to a conclusion* negotiations leading to nuclear disarmament in all its aspects under strict international control."

This landmark decision has been criticized by the nuclear weapon states as being decided "by a narrow margin", but the structuring of the vote made the margin seem more narrow than it actually was. Seven judges voted against Paragraph 2E of the decision (the paragraph which states that the threat or use of nuclear weapons would be generally illegal, but which mentions as a possible exception the case where a nation might be defending itself from an attack that threatened its very existence.) Seven judges voted for the paragraph, with the President of the Court, Muhammad Bedjaoui of Algeria casting the deciding vote. Thus the Court adopted it, seemingly by a narrow margin. But three of the judges who voted against 2E did so because they believed that no possible exception should be mentioned! Thus, if the vote had been slightly differently structured, the result would have be ten to four.

Of the remaining four judges who cast dissenting votes, three represented nuclear weapons states, while the fourth thought that the Court ought not to have accepted the questions from WHO and the UN. However Judge Schwebel from the United States, who voted against Paragraph 2E, nevertheless added, in a separate opinion, "It cannot be accepted that the use of nuclear weapons on a scale which would - or could - result in the deaths of many millions in indiscriminate inferno and by far-reaching fallout, have pernicious effects in space and time, and render uninhabitable much of the earth, could be lawful." Judge Higgins from the UK, the first woman judge in the history of the Court, had problems with the word "generally" in Paragraph 2E and therefore voted against it, but she thought that a more profound analysis might have led the Court to conclude in favor of illegality in all circumstances. Judge Fleischhauer of Germany said in his separate opinion, "The nuclear weapon is, in many ways, the negation of the humanitarian considerations underlying the law applicable in armed conflict and the principle of neutrality. The nuclear weapon cannot distinguish between civilian and military targets. It causes immeasurable suffering. The radiation released by it is unable to respect the territorial

integrity of neutral States."

President Bedjaoui, summarizing the majority opinion, called nuclear weapons "the ultimate evil", and said "By its nature, the nuclear weapon, this blind weapon, destabilizes humanitarian law, the law of discrimination in the use of weapons... The ultimate aim of every action in the field of nuclear arms will always be nuclear disarmament, an aim which is no longer utopian and which all have a duty to pursue more actively than ever."

Thus the concept of nuclear deterrence is not only unacceptable from the standpoint of ethics; it is also contrary to international law. The World Courts 1996 advisory Opinion unquestionably also represents the opinion of the majority of the worlds peoples. Although no formal plebiscite has been taken, the votes in numerous resolutions of the UN General Assembly speak very clearly on this question. For example the New Agenda Resolution (53/77Y) was adopted by the General Assembly on 4 December 1998 by a massively affirmative vote, in which only 18 out of the 170 member states voted against the resolution.[2] The New Agenda Resolution proposes numerous practical steps towards complete nuclear disarmament, and it calls on the Nuclear-Weapon States "to demonstrate an unequivocal commitment to the speedy and total elimination of their nuclear weapons and without delay to pursue in good faith and bring to a conclusion negotiations leading to the elimination of these weapons, thereby fulfilling their obligations under Article VI of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT)". Thus, in addition to being ethically unacceptable and contrary to international law, nuclear weapons also contrary to the principles of democracy.

Having said these important things, we can now turn to some of the other defects in the concept of nuclear deterrence. One important defect is that nuclear war may occur through accident or miscalculation - through technical defects or human failings. This possibility is made greater by the fact that despite the end of the Cold War, thousands of missiles carrying nuclear warheads are still kept on a "hair-trigger" state of alert with a quasi-automatic reaction time measured in minutes. There is a constant danger that a nuclear war will be triggered by error in evaluating the signal on a radar screen. For example, the BBC reported recently that a group of scientists and military leaders are worried that a small asteroid entering the earths atmosphere and exploding could trigger a nuclear war if mistaken for a missile strike.

A number of prominent political and military figures (many of whom have ample knowledge of the system of deterrence, having been part of it) have expressed concern about the danger of accidental nuclear war. Colin S. Grey[3] expressed this concern as follows: "The problem, indeed the enduring problem, is that we are resting our future upon a nuclear deterrence system concerning which we cannot tolerate even a single malfunction." General Curtis E. LeMay[4] has written, "In my opinion a general war will grow through a series of political miscalculations and accidents rather than through any deliberate attack by

[2]Of the 18 countries that voted against the New Agenda resolution, 10 were Eastern European countries hoping for acceptance into NATO, whose votes seem to have been traded for increased probability of acceptance.

[3]Chairman, National Institute for Public Policy

[4]Founder and former Commander in Chief of the United States Strategic Air Command

either side." Bruce G. Blair[5] has remarked that "It is obvious that the rushed nature of the process, from warning to decision to action, risks causing a catastrophic mistake."... "This system is an accident waiting to happen."

Today, the system that is supposed to give us security is called Mutually Assured Destruction, appropriately abbreviated as MAD. It is based on the idea of deterrence, which maintains that because of the threat of massive retaliation, no sane leader would start a nuclear war.

Before discussing other defects in the concept of deterrence, it must be said very clearly that the idea of "massive nuclear retaliation" is a form of genocide and is completely unacceptable from an ethical point of view. It violates not only the principles of common human decency and common sense, but also the ethical principles of every major religion.

Having said this, we can now turn to some of the other faults in the concept of nuclear deterrence. One important defect is that nuclear war may occur through accident or miscalculation, through technical defects or human failings, or by terrorism. This possibility is made greater by the fact that despite the end of the Cold War, thousands of missiles carrying nuclear warheads are still kept on "hair-trigger alert" with a quasi-automatic reaction time measured in minutes. There is a constant danger that a nuclear war will be triggered by error in evaluating the signal on a radar screen.

Incidents in which global disaster is avoided by a hair's breadth are constantly occurring. For example, on the night of 26 September, 1983, Lt. Col. Stanislav Petrov, a young software engineer, was on duty at a surveillance center near Moscow. Suddenly the screen in front of him turned bright red.

An alarm went off. It's enormous piercing sound filled the room. A second alarm followed, and then a third, fourth and fifth. "The computer showed that the Americans had launched a strike against us", Petrov remembered later. His orders were to pass the information up the chain of command to Secretary General Yuri Andropov. Within minutes, a nuclear counterattack would be launched. However, because of certain inconsistent features of the alarm, Petrov disobeyed orders and reported it as a computer error, which indeed it was.

Most of us probably owe our lives to his coolheaded decision and knowledge of software systems. The narrowness of this escape is compounded by the fact that Petrov was on duty only because of the illness of another officer with less knowledge of software, who would have accepted the alarm as real.

Narrow escapes such as this show us clearly that in the long run, the combination of space-age science and stone-age politics will destroy us. We urgently need new political structures and new ethics to match our advanced technology. Modern science has, for the first time in history, offered humankind the possibility of a life of comfort, free from hunger and cold, and free from the constant threat of death through infectious disease. At the same time, science has given humans the power to obliterate their civilization with nuclear weapons, or to make the earth uninhabitable through overpopulation and pollution. The question of which of these paths we choose is literally a matter of life or death for ourselves

[5]Brookings Institute

and our children.

Will we use the discoveries of modern science constructively, and thus choose the path leading towards life? Or will we use science to produce more and more lethal weapons, which sooner or later, through a technical or human failure, will result in a catastrophic nuclear war? Will we thoughtlessly destroy our beautiful planet through unlimited growth of population and industry? The choice among these alternatives is ours to make. We live at a critical moment of history, a moment of crisis for civilization.

No one alive today asked to be born at a time of crisis, but history has given each of us an enormous responsibility. Of course we have our ordinary jobs, which we need to do in order to stay alive; but besides that, each of us has a second job, the duty to devote both time and effort to solving the serious problems that face civilization during the 21st century. We cannot rely on our politicians to do this for us. Many politicians are under the influence of powerful lobbies. Others are waiting for a clear expression of popular will. It is the people of the world themselves who must choose their own future and work hard to build it.

No single person can achieve the changes that we need, but together we can do it. The problem of building a stable, just, and war-free world is difficult, but it is not impossible. The large regions of our present-day world within which war has been eliminated can serve as models. There are a number of large countries with heterogeneous populations within which it has been possible to achieve internal peace and social cohesion, and if this is possible within such extremely large regions, it must also be possible globally.

We must replace the old world of international anarchy, chronic war, and institutionalized injustice by a new world of law. The United Nations Charter, the Universal Declaration of Human Rights and the International Criminal Court are steps in the right direction. These institutions need to be greatly strengthened and reformed. We also need a new global ethic, where loyalty to one's family and nation will be supplemented by a higher loyalty to humanity as a whole. Tipping points in public opinion can occur suddenly. We can think, for example, of the Civil Rights Movement, or the rapid fall of the Berlin Wall, or the sudden change that turned public opinion against smoking, or the sudden movement for freedom and democracy in the Arab world. A similar sudden change can occur soon regarding war and nuclear weapons.

We know that war is madness. We know that it is responsible for much of the suffering that humans experience. We know that war pollutes our planet and that the almost unimaginable sums wasted on war prevent the happiness and prosperity of mankind. We know that nuclear weapons are insane, and that the precariously balanced deterrence system can break down at any time through human error or computer errors or through terrorist actions, and that it definitely will break down within our lifetimes unless we abolish it. We know that nuclear war threatens to destroy civilization and much of the biosphere.

The logic is there. We must translate into popular action which will put an end to the undemocratic, money-driven, power-lust-driven war machine. The peoples of the world must say very clearly that nuclear weapons are an absolute evil; that their possession does not increase anyone's security; that their continued existence is a threat to the life of every

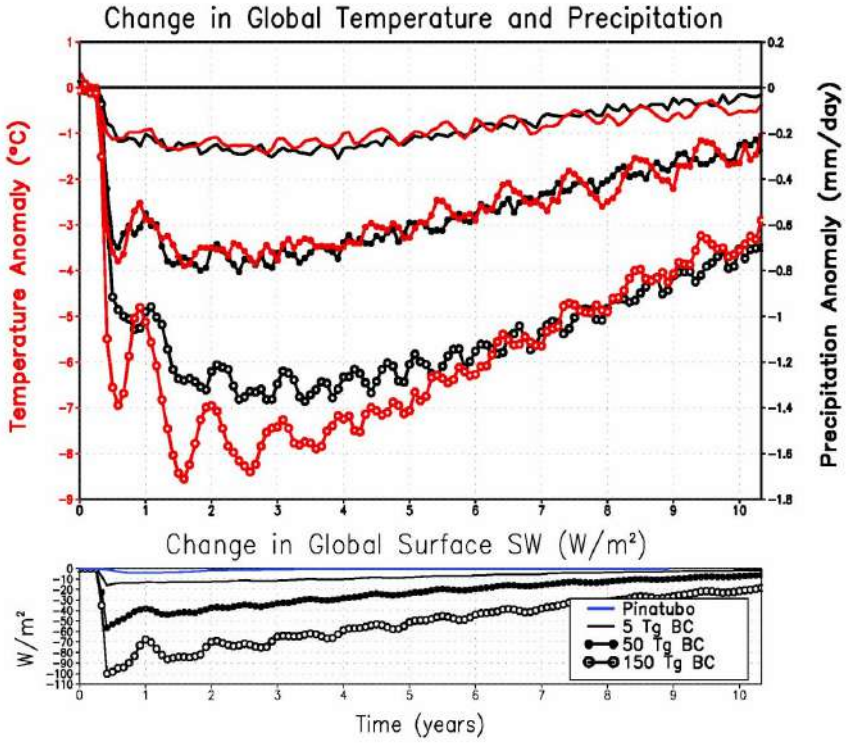

Figure 4.13: **Recent studies by atmospheric scientists have shown that the smoke from burning cities produced by even a limited nuclear war would have a devastating effect on global agriculture. The studies show that the smoke would rise to the stratosphere, where it would spread globally and remain for a decade, blocking sunlight and destroying the ozone layer. Because of the devastating effect on global agriculture, darkness from even a small nuclear war (e.g. between India and Pakistan) would result in an estimated billion deaths from famine.** (O. Toon, A. Robock and R. Turco, "The Environmental Consequences of Nuclear War", Physics Today, vol. 61, No. 12, 2008, p. 37-42)

person on the planet; and that these genocidal and potentially omnicidal weapons have no place in a civilized society.

Modern science has abolished time and distance as factors separating nations. On our shrunken globe today, there is room for one group only: the family of humankind. We must embrace all other humans as our brothers and sisters. More than that, we must feel that all of nature is part of the same sacred family; meadow flowers, blowing winds, rocks, trees, birds, animals, and other humans, all these are our brothers and sisters, deserving our care and protection. Only in this way can we survive together. Only in this way can we build a happy future.

"But nobody can predict that the fatal accident or unauthorized act will never happen", Fred Ikle of the Rand Corporation has written, "Given the huge and far-flung missile forces, ready to be launched from land and sea on on both sides, the scope for disaster by accident

is immense... In a matter of seconds - through technical accident or human failure - mutual deterrence might thus collapse."

Another serious failure of the concept of nuclear deterrence is that it does not take into account the possibility that atomic bombs may be used by terrorists. Indeed, the threat of nuclear terrorism has today become one of the most pressing dangers that the world faces, a danger that is particularly acute in the United States.

Since 1945, more than 3,000 metric tons (3,000,000 kilograms) of highly enriched uranium and plutonium have been produced - enough for several hundred thousand nuclear weapons. Of this, roughly a million kilograms are in Russia, inadequately guarded, in establishments where the technicians are poorly paid and vulnerable to the temptations of bribery. There is a continuing danger that these fissile materials will fall into the hands of terrorists, or organized criminals, or irresponsible governments. Also, an extensive black market for fissile materials, nuclear weapons components etc. has recently been revealed in connection with the confessions of Pakistan's bomb-maker, Dr. A.Q. Khan. Furthermore, if Pakistan's less-than-stable government should be overthrown, complete nuclear weapons could fall into the hands of terrorists.

On November 3, 2003, Mohamed ElBaradei, Director General of the International Atomic Energy Agency, made a speech to the United Nations in which he called for "limiting the processing of weapons-usable material (separated plutonium and high enriched uranium) in civilian nuclear programmes - as well as the production of new material through reprocessing and enrichment - by agreeing to restrict these operations to facilities exclusively under international control." It is almost incredible, considering the dangers of nuclear proliferation and nuclear terrorism, that such restrictions were not imposed long ago. Nuclear reactors used for "peaceful" purposes unfortunately also generate fissionable isotopes of plutonium, neptunium and americium. Thus all nuclear reactors must be regarded as ambiguous in function, and all must be put under strict international control. One might ask, in fact, whether globally widespread use of nuclear energy is worth the danger that it entails.

The Italian nuclear physicist Francesco Calogero, who has studied the matter closely, believes that terrorists could easily construct a simple gun-type nuclear bomb if they were in possession of a critical mass of highly enriched uranium. In such a simple atomic bomb, two grapefruit-sized subcritical portions of HEU are placed at opposite ends of the barrel of an artillery piece and are driven together by means of a conventional explosive. Prof. Calogero estimates that the fatalities produced by the explosion of such a device in the center of a large city could exceed 100,000.

We must remember the remark of U.N. Secretary General Kofi Annan after the 9/11/2001 attacks on the World Trade Center. He said, "*This time* it was not a nuclear explosion". The meaning of his remark is clear: If the world does not take strong steps to eliminate fissionable materials and nuclear weapons, it will only be a matter of time before they will be used in terrorist attacks on major cities. Neither terrorists nor organized criminals can be deterred by the threat of nuclear retaliation, since they have no territory against which such retaliation could be directed. They blend invisibly into the general population. Nor can a "missile defense system" prevent terrorists from using nuclear weapons, since the

weapons can be brought into a port in any one of the hundreds of thousands of containers that enter on ships each year, a number far too large to be checked exhaustively.

In this dangerous situation, the only logical thing for the world to do is to get rid of both fissile materials and nuclear weapons as rapidly as possible. We must acknowledge that the idea of nuclear deterrence is a dangerous fallacy, and acknowledge that the development of military systems based on nuclear weapons has been a terrible mistake, a false step that needs to be reversed. If the most prestigious of the nuclear weapons states can sincerely acknowledge their mistakes and begin to reverse them, nuclear weapons will seem less glamorous to countries like India, Pakistan, North Korea and Iran, where they now are symbols of national pride and modernism.

Civilians have for too long played the role of passive targets, hostages in the power struggles of politicians. It is time for civil society to make its will felt. If our leaders continue to enthusiastically support the institution of war, if they will not abolish nuclear weapons, then let us have new leaders.

Establishment opinion shifts towards nuclear abolition

Today there are indications that the establishment is moving towards the point of view that the peace movement has always held: - that nuclear weapons are essentially genocidal, illegal and unworthy of civilization; and that they must be completely abolished as quickly as possible. There is a rapidly-growing global consensus that a nuclear-weapon-free world can and must be achieved in the very near future.

One of the first indications of the change was the famous Wall Street Journal article by Schultz, Perry, Kissinger and Nunn advocating complete abolition of nuclear arms [1]. This was followed quickly by Mikhail Gorbachev's supporting article, published in the same journal [2], and a statement by distinguished Italian statesmen [3]. Meanwhile, in October 2007, the Hoover Institution had arranged a symposium entitled "Reykjavik Revisited; Steps Towards a World Free of Nuclear Weapons" [4].

In Britain, Sir Malcolm Rifkind, Lord Hurd and Lord Owen (all former Foreign Secretaries) joined the former NATO Secretary General Lord Robertson as authors of an article in The Times advocating complete abolition of nuclear weapons [5]. The UK's Secretary of State for Defense, Des Brown, speaking at a disarmament conference in Geneva, proposed that the UK "host a technical conference of P5 nuclear laboratories on the verification of nuclear disarmament before the next NPT Review Conference in 2010" to enable the nuclear weapon states to work together on technical issues.

In February, 2008, the Government of Norway hosted an international conference on "Achieving the Vision of a World Free of Nuclear Weapons" [7]. A week later, Norway's Foreign Minister, Jonas Gahr Støre, reported the results of the conference to a disarmament meeting in Geneva [8]. On July 11, 2008 , speaking at a Pugwash Conference in Canada, Norway's Defense Minister, Anne-Grete Strøm-Erichsen, reiterated her country's strong support for the complete abolition of nuclear weapons [9].

In July 2008, Barack Obama said in his Berlin speech, "It is time to secure all loose nuclear materials; to stop the spread of nuclear weapons; and to reduce the arsenals from

another era. This is the moment to begin the work of seeking the peace of a world without nuclear weapons."

Later that year, in September, Vladimir Putin said, "Had I been told just two or three years ago I wouldn't believe that it would be possible, but I believe that it is now quite possible to liberate humanity from nuclear weapons..."

Other highly-placed statesmen added their voices to the growing consensus: Australia's Prime Minister, Kevin Rudd, visited the Peace Museum at Hiroshima, where he made a strong speech advocating nuclear abolition. He later set up an International Commission on Nuclear Non-Proliferation and Disarmament co-chaired by Australia and Japan [10].

On January 9, 2009, four distinguished German statesmen (Richard von Weizäcker, Helmut Schmidt, Egon Bahr and Hans-Dietrich Genscher) published an article entitled "Towards a Nuclear-Free World: a German View" in the International Herald Tribune [12]. Among the immediate steps recommended in the article are the following:

- The vision of a nuclear-weapon-free world... must be rekindled.
- Negotiations aimed at drastically reducing the number of nuclear weapons must begin...
- The Nuclear Non-Proliferation Treaty (NPT) must be greatly reinforced.
- America should ratify the Comprehensive Nuclear Test-Ban Treaty.
- All short-range nuclear weapons must be destroyed.
- The Anti-Ballistic Missile (ABM) Treaty must be restored. Outer space may only be used for peaceful purposes.

4.9 Going to zero

On December 8-9, 2008, approximately 100 international leaders met in Paris to launch the Global Zero Campaign [11]. They included Her Majesty Queen Noor of Jordan, Norway's former Prime Minister Gro Harlem Brundtland, former UK Foreign Secretaries Sir Malcolm Rifkind, Margaret Beckett and David Owen, Ireland's former Prime Minister Mary Robinson, UK philanthropist Sir Richard Branson, former UN Under-Secretary-General Jayantha Dhanapala, and Nobel Peace Prize winners President Jimmy Carter, President Mikhail Gorbachev, Archbishop Desmond Tutu and Prof. Muhammad Yunus. The concrete steps advocated by Global Zero include:

- Deep reductions to Russian-US arsenals, which comprise 96% of the worlds 27,000 nuclear weapons.
- Russia and the United States, joined by other nuclear weapons states, cutting arsenals to zero in phased and verified reductions.

- Establishing verification systems and international management of the fuel cycle to prevent future development of nuclear weapons.

The Global Zero website [11] contains a report on a new public opinion poll covering 21 nations, including all of the nuclear weapons states.The poll showed that public opinion overwhelmingly favors an international agreement for eliminating all nuclear weapons according to a timetable. It was specified that the agreement would include monitoring. The average in all countries of the percent favoring such an agreement was 76%. A few results of special interest mentioned in the report are Russia 69%; the United States, 77%; China, 83%; France, 86%, and Great Britain, 81%.

In his April 5, 2009 speech in Prague the newly-elected U.S. President Barack Obama said: "To reduce our warheads and stockpiles, we will negotiate a new strategic arms reduction treaty with Russia this year. President Medvedev and I will begin this process in London, and we will seek an agreement by the end of the year that is sufficiently bold. This will set the stage for further cuts, and we will seek to involve all nuclear weapon states in this endeavor... To achieve a global ban on nuclear testing, my administration will immediately and aggressively pursue U.S. ratification of the Comprehensive Test Ban Treaty."

A few days later, on April 24, 2009, the European Parliament recommended complete nuclear disarmament by 2020. An amendment introducing the "Model Nuclear Weapons Convention" and the "Hiroshima-Nagasaki Protocol" as concrete tools to achieve a nuclear weapons free world by 2020 was approved with a majority of 177 votes against 130. The Nuclear Weapons Convention is analogous to the conventions that have successfully banned chemical and biological weapons.

4.10 The role of public opinion

Public opinion is extremely important for the actual achievement of complete nuclear abolition. In the first place, the fact that the public is overwhelmingly against the retention of nuclear weapons means that the continuation of nuclear arsenals violates democratic principles. Secondly, the weapons are small enough to be easily hidden. Therefore the help of "whistle-blowers" will be needed to help inspection teams to make sure that no country violates its agreement to irreversibly destroy every atomic bomb. What is needed is a universal recognition that nuclear weapons are an absolute evil, and that their continued existence is a threat to human civilization and to the life of every person on the planet.

Our aim must be to delegitimize nuclear weapons, in much the same way that unnecessary greenhouse gas emissions have recently been delegitimized, or cigarette smoking delegitimized, or racism delegitimized. This should be an easy task because of the essentially genocidal nature of nuclear weapons. For half a century, ordinary people have been held as hostages, never knowing from day to day whether their own lives and the lives of those they love would suddenly be sacrificed on the alter of thermonuclear nationalism and power politics. We must let the politicians know that we are no longer willing to

Figure 4.14: **Women Strike for Peace during the Cuban Missile Crisis in 1962.**(Public domain)

be hostages; and we must also accept individual responsibility for reporting violations of international treaties, although our own nation might be the violator.

Most of us grew up in schools where we were taught that duty to our nation was the highest duty; but the times we live in today demand a change of heart, a higher loyalty to humanity as a whole. If the mass media cooperate in delegitimizing nuclear weapons, if educational systems cooperate and if religions [6] cooperate, the change of heart that we need - the global ethic that we need - can quickly be achieved.

[6]As an example of the role that religions can play, we can consider the Buddhist organization Soka Gakkai International (SGI), which has 12 million members throughout the world. SGIs President Daisaku Ikeda has declared nuclear weapons to be an absolute evil and for more than 50 years the organization has worked for their abolition.

4.11 Complete abolition of nuclear weapons

Although the Cold War has ended, the danger of a nuclear catastrophe is greater today than ever before. There are almost 16,000 nuclear weapons in the world today, of which more than 90 percent are in the hands of Russia and the United States. About 2,000 of these weapons are on hair-trigger alert, meaning that whoever is in charge of them has only a few minutes to decide whether the signal indicating an attack is real, or an error. The most important single step in reducing the danger of a disaster would be to take all weapons off hair-trigger alert.

Bruce G. Blair, Brookings Institute, has remarked "It is obvious that the rushed nature of the process, from warning to decision to action, risks causing a catastrophic mistake... This system is an accident waiting to happen." Fred Ikle of the Rand Corporation has written,' 'But nobody can predict that the fatal accident or unauthorized act will never happen. Given the huge and far-flung missile forces, ready to be launched from land and sea on on both sides, the scope for disaster by accident is immense... In a matter of seconds, through technical accident or human failure, mutual deterrence might thus collapse."

Although their number has been substantially reduced from its Cold War maximum, the total explosive power of todays weapons is equivalent to roughly half a million Hiroshima bombs. To multiply the tragedy of Hiroshima and Nagasaki by a factor of half a million changes the danger qualitatively. What is threatened today is the complete breakdown of human society.

There is no defense against nuclear terrorism. We must remember the remark of U.N. Secretary General Kofi Annan after the 9/11/2001 attacks on the World Trade Center. He said, ' 'This time it was not a nuclear explosion". The meaning of his remark is clear: If the world does not take strong steps to eliminate fissionable materials and nuclear weapons, it will only be a matter of time before they will be used in terrorist attacks on major cities. Neither terrorists nor organized criminals can be deterred by the threat of nuclear retaliation, since they have no territory against which such retaliation could be directed. They blend invisibly into the general population. Nor can a "missile defense system" prevent terrorists from using nuclear weapons, since the weapons can be brought into a port in any one of the hundreds of thousands of containers that enter on ships each year, a number far too large to be checked exhaustively.

As the number of nuclear weapon states grows larger, there is an increasing chance that a revolution will occur in one of them, putting nuclear weapons into the hands of terrorist groups or organized criminals. Today, for example, Pakistans less-than-stable government might be overthrown, and Pakistans nuclear weapons might end in the hands of terrorists. The weapons might then be used to destroy one of the worlds large coastal cities, having been brought into the port by one of numerous container ships that dock every day. Such an event might trigger a large-scale nuclear conflagration.

Today, the world is facing a grave danger from the reckless behavior of the government of the United States, which recently arranged a coup that overthrew the elected government of Ukraine. Although Victoria Nulands December 13, 2013 speech talks much about democracy, the people who carried out the coup in Kiev can hardly be said to be democ-

racy's best representatives. Many belong to the Svoboda Party, which had its roots in the Social-National Party of Ukraine (SNPU). The name was an intentional reference to the Nazi Party in Germany.

It seems to be the intention of the US to establish NATO bases in Ukraine, no doubt armed with nuclear weapons. In trying to imagine how the Russians feel about this, we might think of the US reaction when a fleet of ships sailed to Cuba in 1962, bringing Soviet nuclear weapons. In the confrontation that followed, the world was bought very close indeed to an all-destroying nuclear war. Does not Russia feel similarly threatened by the thought of hostile nuclear weapons on its very doorstep? Can we not learn from the past, and avoid the extremely high risks associated with the similar confrontation in Ukraine today?

In general, aggressive interventions, in Iran, Syria, Ukraine, the Korean Peninsula and elsewhere, all present dangers for uncontrollable escalation into large and disastrous conflicts, which might potentially threaten the survival of human civilization.

Few politicians or military figures today have any imaginative understanding of what a war with thermonuclear weapons would be like. Recent studies have shown that in a nuclear war, the smoke from firestorms in burning cities would rise to the stratosphere where it would remain for a decade, spreading throughout the world, blocking sunlight, blocking the hydrological cycle and destroying the ozone layer. The effect on global agriculture would be devastating, and the billion people who are chronically undernourished today would be at risk. Furthermore, the tragedies of Chernobyl and Fukushima remind us that a nuclear war would make large areas of the world permanently uninhabitable because of radioactive contamination. A full-scale thermonuclear war would be the ultimate ecological catastrophe. It would destroy human civilization and much of the biosphere.

One can gain a small idea of the terrible ecological consequences of a nuclear war by thinking of the radioactive contamination that has made large areas near to Chernobyl and Fukushima uninhabitable, or the testing of hydrogen bombs in the Pacific, which continues to cause cancer, leukemia and birth defects in the Marshall Islands more than half a century later.

The United States tested a hydrogen bomb at Bikini in 1954. Fallout from the bomb contaminated the island of Rongelap, one of the Marshall Islands 120 kilometers from Bikini. The islanders experienced radiation illness, and many died from cancer. Even today, half a century later, both people and animals on Rongelap and other nearby islands suffer from birth defects. The most common defects have been ‘ ‘jelly fish babies", born with no bones and with transparent skin. Their brains and beating hearts can be seen. The babies usually live a day or two before they stop breathing.

A girl from Rongelap describes the situation in the following words: ‘ ‘I cannot have children. I have had miscarriages on seven occasions... Our culture and religion teach us that reproductive abnormalities are a sign that women have been unfaithful. For this reason, many of my friends keep quiet about the strange births that they have had. In privacy they give birth, not to children as we like to think of them, but to things we could only describe as octopuses, apples, turtles and other things in our experience. We do not have Marshallese words for these kinds of babies, because they were never born before the

radiation came."

The Republic of the Marshall Islands is suing the nine countries with nuclear weapons at the International Court of Justice at The Hague, arguing they have violated their legal obligation to disarm. The Guardian reports that ' 'In the unprecedented legal action, comprising nine separate cases brought before the ICJ on Thursday, the Republic of the Marshall Islands accuses the nuclear weapons states of a 'flagrant denial of human justice. It argues it is justified in taking the action because of the harm it suffered as a result of the nuclear arms race.

The Pacific chain of islands, including Bikini Atoll and Enewetak, was the site of 67 nuclear tests from 1946 to 1958, including the Bravo shot, a 15-megaton device equivalent to a thousand Hiroshima blasts, detonated in 1954. The Marshallese islanders say they have been suffering serious health and environmental effects ever since.

The island republic is suing the five 'established nuclear weapons states recognized in the 1968 nuclear non-proliferation treaty (NPT), the US, Russia (which inherited the Soviet arsenal), China, France and the UK, as well as the three countries outside the NPT who have declared nuclear arsenals: India, Pakistan and North Korea, and the one undeclared nuclear weapons state, Israel. The Republic of the Marshall Islands is not seeking monetary compensation, but instead it seeks to make the nuclear weapon states comply with their legal obligations under Article VI of the Nuclear Nonproliferation Treaty and the 1996 ruling of the International Court of Justice.

The Nuclear Age Peace Foundation (NAPF) is a consultant to the Marshall Islands on the legal and moral issues involved in bringing this case. David Krieger, President of NAPF, upon hearing of the motion to dismiss the case by the U.S. responded, ' 'The U.S. government is sending a terrible message to the world, that is, that U.S. courts are an improper venue for resolving disputes with other countries on U.S. treaty obligations. The U.S. is, in effect, saying that whatever breaches it commits are all right if it says so. That is bad for the law, bad for relations among nations, bad for nuclear non-proliferation and disarmament, and not only bad, but extremely dangerous for U.S. citizens and all humanity."

The RMI has appealed the U.S. attempt to reject its suit in the U.S, Federal Court, and it will continue to sue the nine nuclear nations in the International Court of Justice. Whether or not the suits succeed in making the nuclear nations comply with international law, attention will be called to the fact the nine countries are outlaws. In vote after vote in the United Nations General Assembly, the peoples of the world have shown how deeply they long to be free from the menace of nuclear weapons. Ultimately, the tiny group of power-hungry politicians must yield to the will of the citizens whom they are at present holding as hostages.

It is a life-or-death question. We can see this most clearly when we look far ahead. Suppose that each year there is a certain finite chance of a nuclear catastrophe, let us say 2 percent. Then in a century the chance of survival will be 13.5 percent, and in two centuries, 1.8 percent, in three centuries, 0.25 percent, in 4 centuries, there would only be a 0.034 percent chance of survival and so on. Over many centuries, the chance of survival would shrink almost to zero. Thus by looking at the long-term future, we can clearly see

that if nuclear weapons are not entirely eliminated, civilization will not survive.

Civil society must make its will felt. A thermonuclear war today would be not only genocidal but also omnicidal. It would kill people of all ages, babies, children, young people, mothers, fathers and grandparents, without any regard whatever for guilt or innocence. Such a war would be the ultimate ecological catastrophe, destroying not only human civilization but also much of the biosphere. Each of us has a duty to work with dedication to prevent it.

One important possibility for progress on the seemingly intractable issue of nuclear disarmament would be for a nation or group of nations to put forward a proposal for a Nuclear Weapons Convention for direct vote on the floor of the UN General Assembly. It would almost certainly be adopted by a massive majority. I believe that such a step would be a great achievement, even if bitterly opposed by some of the nuclear weapons states. When the will of the majority of the worlds peoples is clearly expressed in an international treaty, even if the treaty functions imperfectly, the question of legality is clear. Everyone can see which states are violating international law. In time, world public opinion will force the criminal states to conform with international law.

In the case of a Nuclear Weapons Convention, world public opinion would have especially great force. It is generally agreed that a full-scale nuclear war would have disastrous effects, not only on belligerent nations but also on neutral countries. Mr. Javier Pérez de Cuéllar , former Secretary-General of the United Nations, emphasized this point in one of his speeches: "I feel", he said, ' 'that the question may justifiably be put to the leading nuclear powers: by what right do they decide the fate of humanity? From Scandinavia to Latin America, from Europe and Africa to the Far East, the destiny of every man and woman is affected by their actions. No one can expect to escape from the catastrophic consequences of a nuclear war on the fragile structure of this planet. ..."

' 'No ideological confrontation can be allowed to jeopardize the future of humanity. Nothing less is at stake: todays decisions affect not only the present; they also put at risk succeeding generations. Like supreme arbiters, with our disputes of the moment, we threaten to cut off the future and to extinguish the lives of innocent millions yet unborn. There can be no greater arrogance. At the same time, the lives of all those who lived before us may be rendered meaningless; for we have the power to dissolve in a conflict of hours or minutes the entire work of civilization, with all the brilliant cultural heritage of humankind.

"...In a nuclear age, decisions affecting war and peace cannot be left to military strategists or even to governments. They are indeed the responsibility of every man and woman. And it is therefore the responsibility of all of us... to break the cycle of mistrust and insecurity and to respond to humanity's yearning for peace."

The eloquent words of Javier Pérez de Cuéllar express the situation in which we now find ourselves: Accidental nuclear war, nuclear terrorism, insanity of a person in a position of power, or unintended escalation of a conflict, could at any moment plunge our beautiful world into a catastrophic thermonuclear war which might destroy not only human civilization but also much of the biosphere.

A model Nuclear Weapons Convention already exists. It was drafted in 1996 and

updated in 2007 by three NGOs: International Association of Lawyers Against Nuclear Arms, International Network of Engineers and Scientists Against Nuclear Proliferation and International Physicians for the Prevention of Nuclear War. The Nuclear Weapons Convention (NWC) can be downloaded in many languages from the website of Unfold Zero. It could be put to a direct vote at the present session of the UN General Assembly. The mechanism for doing this could exactly parallel the method by which the Arms Trade Treaty was adopted in 2013. The UN Ambassador of Costa Rica could send a copy of the NWC to Secretary General Ban Ki-moon, asking him, on behalf of Costa Rica, Mexico and Austria to put it to a swift vote in the General Assembly.

There is strong evidence that the NWC would be passed by a large majority. For example, Humanitarian Initiative Joint Statement of 2015 was endorsed by 159 governments. Furthermore, the consensus document of the NPT Review Conference of 2010, endorsed by 188 state parties, contains the following sentence: ‘ ‘The Conference expresses its deep concern at the humanitarian consequences of any use of nuclear weapons and reaffirms the need for all States at all times to comply with applicable international law, including international humanitarian law”.

We can expect that the adoption of a Nuclear Weapons Convention will be opposed by the states that currently possess these weapons. One reason for this is the immense profits that suppliers make by ‘ ‘modernizing” nuclear arsenals. For example, the Arms Control Association states ‘ ‘The U.S. military is in the process of modernizing all of its existing strategic delivery systems and refurbishing the warheads they carry to last for the next 30-50 years.” It adds ‘ ‘Three independent estimates put the expected total cost over the next 30 years at as much as $1 trillion.” We should notice that these plans for long-term retention of nuclear weapons are blatant violations of Article VI of the NPT.

Money is often the motive for crimes, and in this case, a vast river of money is driving us in the direction of a catastrophic nuclear war. If we wait for the approval of the nuclear weapon states, we will have to wait forever, and the general public, whose active help we need in abolishing nuclear weapons, will feel more and more helpless and powerless. To prevent this, we need concrete progress rather than endless delay.

There are strong precedents for the adoption of the NWC against the opposition of powerful states. The Arms Trade Treaty is one precedent, the International Criminal Court is another and the Ottawa Treaty is a third.

The adoption of an Arms Trade Treaty is a great step forward; the adoption of the ICC, although its operation is imperfect, is also a great step forward, and likewise, the Antipersonnel Land-Mine Convention is a great step forward. In my opinion, the adoption of a Nuclear Weapons Convention, even in the face of powerful opposition, would also be a great step forward. When the will of the majority of the worlds peoples is clearly expressed in an international treaty, even if the treaty functions imperfectly, the question of legality is clear. Everyone can see which states are violating international law. In time, world public opinion will force the criminal states to conform to the law.

Figure 4.15: *Fireball of the Tsar Bomba (RDS-220), the largest weapon ever detonated (1961). Fission-fusion-fission bombs of almost unlimited power can be constructed by adding a layer of inexpensive ordinary uranium outside a core containing a fission-fusion bomb. Such a bomb would completely destroy a city even if it missed the target by 50 kilometers.* (Fair use: "Tsar Bomba", Wikipedia)

In the world as it is, the nuclear weapons now stockpiled are sufficient to kill everyone on earth several times over. Nuclear technology is spreading, and many politically unstable countries have recently acquired nuclear weapons or may acquire them soon. Even terrorist groups or organized criminals may acquire such weapons, and there is an increasing danger that they will be used.

In the world as it could be, both the manufacture and the possession of nuclear weapons would be prohibited. The same would hold for other weapons of mass destruction.

Suggestions for further reading

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Chapter 5

THE DANGER OF WIDESPREAD FAMINE

5.1 Several billion people might suffer

There is a danger that population growth, climate change and the end of the fossil fuel era could combine to produce an extremely large-scale global famine by the middle of the present century. Such a famine might involve several billion people, rather than millions.

5.2 Child mortality rates

Here are some quatitions from an article entitled *Child mortality rates drop but 15,000 children under 5 still die each day*, published in Agriculture at a Crossroads on September 18, 2018:[1]

Although the global number of child deaths remains high, the world has made tremendous progress in reducing child mortality over the past few decades. The total number of under-five deaths dropped to 5.3 million in 2018, down from 12.5 million in 1990. This is the main message of a report published today by UN organizations led by UNICEF and the World Health Organization (WHO). According to the "Levels and trends in child mortality: Report 2019", more women and their children are surviving today than ever before. Since 2000, child deaths have reduced by nearly half and maternal deaths by over one-third, mostly due to improved access to affordable, quality health services. However, in 2018 alone, 15,000 children died per day before reaching their fifth birthday. "It is especially unacceptable that these children and young adolescents died largely of preventable or treatable causes like infectious diseases and injuries when we have the means to prevent these deaths," the authors write

[1] https://www.globalagriculture.org/whats-new/news/en/33802.html

in the introduction to the report. The global under-five mortality rate fell to 39 deaths per 1,000 live births in 2018, down from 76 in 2000 - a 49% decline.

"Despite advances in fighting childhood illnesses, infectious diseases remain a leading cause of death for children under the age of 5, particularly in sub-Saharan Africa and Southern Asia," says the report. Pneumonia remains the leading cause of death globally among children under the age of 5, accounting for 15% of deaths. Diarrhoea (8%) and malaria (5%), together with pneumonia, accounted for almost a third of global under-five deaths in 2018. "Malnourished children, particularly those with severe acute malnutrition, have a higher risk of death from these common childhood illnesses. Nutrition-related factors contribute to about 45 per cent of deaths in children under 5 years of age," warns the report. The estimates also show vast inequalities worldwide, with women and children in sub-Saharan Africa facing a higher risk of death than in all other regions. Level of maternal deaths are nearly 50 times higher for women in sub-Saharan Africa compared to high-income countries. In 2018, 1 in 13 children in sub-Saharan Africa died before their fifth birthday - this is 15 times higher than the risk a child faces in Europe, where just 1 in 196 children aged less than 5 die.

5.3 The threat of large-scale famine

As glaciers melt in the Himalayas, depriving India and China of summer water supplies; as sea levels rise, drowning the fertile rice fields of Viet Nam and Bangladesh; as drought threatens the productivity of grain-producing regions of North America; and as the end of the fossil fuel era impacts modern high-yield agriculture, there is a threat of wide-spread famine. There is a danger that the 1.5 billion people who are undernourished today will not survive an even more food-scarce future.

People threatened with famine will become refugees, desperately seeking entry into countries where food shortages are less acute. Wars, such as those currently waged in the Middle East, will add to the problem.

What can we do to avoid this crisis, or at least to reduce its severity? We must urgently address the problem of climate change; and we must shift money from military expenditure to the support of birth control programs and agricultural research. We must also replace the institution of war by a system of effective global governance and enforcible international laws.

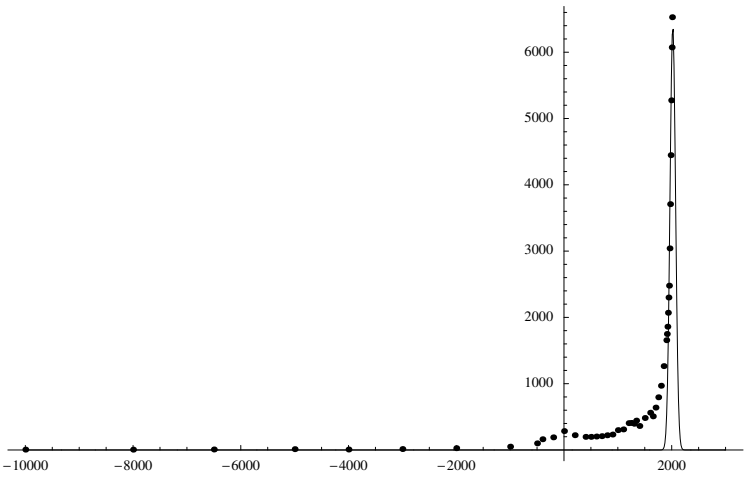

Figure 5.1: **Population growth and fossil fuel use, seen on a time-scale of several thousand years. The dots are population estimates in millions from the US Census Bureau. Fossil fuel use appears as a spike-like curve, rising from almost nothing to a high value, and then falling again to almost nothing in the space of a few centuries. When the two curves are plotted together, the explosive rise of global population is seen to be simultaneous with, and perhaps partially driven by, the rise of fossil fuel use. This raises the question of whether the world's population is headed for a crash when the fossil fuel era has ended.** (Author's own graph)

5.4 Optimum population in the distant future

What is the optimum population of the world? It is certainly not the maximum number that can be squeezed onto the globe by eradicating every species of plant and animal that cannot be eaten. The optimum global population is one that can be supported in comfort, equality and dignity - and with respect for the environment.

In 1848 (when there were just over one billion people in the world), John Stuart Mill described the optimal global population in the following words:

"The density of population necessary to enable mankind to obtain, in the greatest degree, all the advantages of cooperation and social intercourse, has, in the most populous countries, been attained. A population may be too crowded, although all be amply supplied with food and raiment."

"... Nor is there much satisfaction in contemplating the world with nothing left to the spontaneous activity of nature; with every rood of land brought into cultivation, which is capable of growing food for human beings; every flowery waste or natural pasture plowed up, all quadrupeds or birds which are not domesticated for man's use exterminated as his rivals for food, every hedgerow or superfluous tree rooted out, and scarcely a place left where a wild shrub or flower could grow without being eradicated as a weed in the name of improved agriculture. If the earth must lose that great portion of its pleasantness which it owes to things that the unlimited increase of wealth and population would extirpate from it, for the mere purpose of enabling it to support a larger, but not better or happier population, I sincerely hope, for the sake of posterity, that they will be content to be stationary, long before necessity compels them to it."[2]

Has the number of humans in the world already exceeded the earth's sustainable limits? Will the global population of humans crash catastrophically after having exceeded the carrying capacity of the environment? There is certainly a danger that this will happen - a danger that the 21st century will bring very large scale famines to vulnerable parts of the world, because modern energy-intensive agriculture will be dealt a severe blow by prohibitively high petroleum prices, and because climate change will reduce the world's agricultural output. When the major glaciers in the Himalayas have melted, they will no longer be able to give India and China summer water supplies; rising oceans will drown much agricultural land; and aridity will reduce the output of many regions that now produce much of the world's grain. Falling water tables in overdrawn aquifers, and loss of topsoil will add to the problem. We should be aware of the threat of a serious global food crisis in the 21st century if we are to have a chance of avoiding it.

The term *ecological footprint* was introduced by William Rees and Mathis Wackernagel in the early 1990's to compare demands on the environment with the earth's capacity to regenerate. In 2005, humanity used environmental resources at such a rate that it would take 1.3 earths to renew them. In other words, we have already exceeded the earth's carrying capacity. Since eliminating the poverty that characterizes much of the world

[2]John Stuart Mill, *Principles of Political Economy, With Some of Their Applications to Social Philosophy*, (1848).

today will require more resources per capita, rather than less. it seems likely that in the era beyond fossil fuels, the optimum global population will be considerably less than the present population of the world.

5.5 Population growth and the Green Revolution

Limitations on cropland

In 1944 the Norwegian-American plant geneticist Norman Borlaug was sent to Mexico by the Rockefeller Foundation to try to produce new wheat varieties that might increase Mexico's agricultural output. Borlaug's dedicated work on this project was spectacularly successful. He remained with the project for 16 years, and his group made 6,000 individual crossings of wheat varieties to produce high-yield disease-resistant strains.

In 1963, Borlaug visited India, bringing with him 100 kg. of seeds from each of his most promising wheat strains. After testing these strains in Asia, he imported 450 tons of the Lerma Rojo and Sonora 64 varieties - 250 tons for Pakistan and 200 for India. By 1968, the success of these varieties was so great that school buildings had to be commandeered to store the output. Borlaug's work began to be called a "Green Revolution". In India, the research on high-yield crops was continued and expanded by Prof. M.S. Swaminathan and his coworkers. The work of Green Revolution scientists, such Norman Borlaug and M.S. Swaminathan, has been credited with saving the lives of as many as a billion people.

Despite these successes, Borlaug believes that the problem of population growth is still a serious one. "Africa and the former Soviet republics", Borlaug states, "and the Cerrado[3], are the last frontiers. After they are in use, the world will have no additional sizable blocks of arable land left to put into production, unless you are willing to level whole forests, which you should not do. So, future food-production increases will have to come from higher yields. And though I have no doubt that yields will keep going up, whether they can go up enough to feed the population monster is another matter. Unless progress with agricultural yields remains very strong, the next century will experience human misery that, on a sheer numerical scale, will exceed the worst of everything that has come before."

With regard to the prospect of increasing the area of cropland, a report by the United Nations Food and Agricultural Organization (*Provisional Indicative World Plan for Agricultural Development*, FAO, Rome, 1970) states that "In Southern Asia,... in some countries of Eastern Asia, in the Near East and North Africa... there is almost no scope for expanding agricultural area... In the drier regions, it will even be necessary to return to permanent pasture the land that is marginal and submarginal for cultivation. In most of Latin America and Africa south of the Sahara, there are still considerable possibilities for expanding cultivated areas; but the costs of development are high, and it will often be more economical to intensify the utilization of areas already settled." Thus there is a possibility of increasing the area of cropland in Africa south of the Sahara and in Latin America, but

[3] The Cerrado is a large savanna region of Brazil.

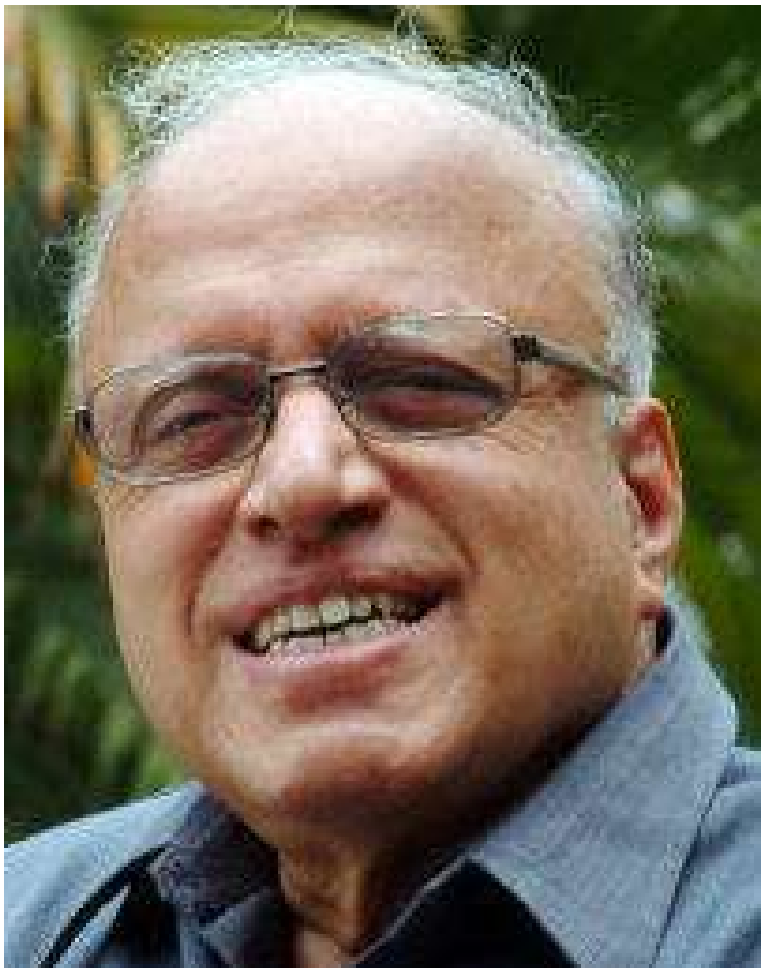

Figure 5.2: **Professor M.S. Swaminathan, father of the Green Revolution in India.** (Open and Shut7)

Figure 5.3: **Norman Borlaug and agronomist George Harrer in 1943.** (Human Wrongs Watch)

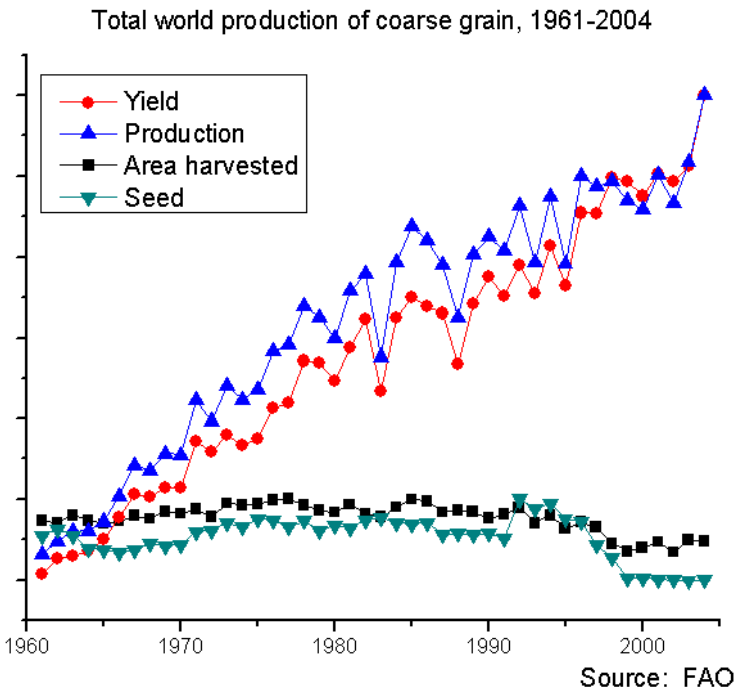

Figure 5.4: **This graph shows the total world production of coarse grain between 1960 and 2004. Because of high-yield varieties, the yield of grain increased greatly. Notice, however, that the land under cultivation remained almost constant. High-yield agriculture depends on large inputs of fossil fuel energy and irrigation, and may be difficult to maintain in the future.** (FAO)

only at the cost of heavy investment and at the additional cost of destruction of tropical rain forests.

Rather than an increase in the global area of cropland, we may encounter a future loss of cropland through soil erosion, salination, desertification, loss of topsoil, depletion of minerals in topsoil, urbanization and failure of water supplies. In China and in the southwestern part of the United States, water tables are falling at an alarming rate. The Ogallala aquifer (which supplies water to many of the plains states in the central and southern parts of the United States) has a yearly overdraft of 160%.

In the 1950's, both the U.S.S.R and Turkey attempted to convert arid grasslands into wheat farms. In both cases, the attempts were defeated by drought and wind erosion, just as the wheat farms of Oklahoma were overcome by drought and dust in the 1930's.

If irrigation of arid lands is not performed with care, salt may be deposited, so that the land is ruined for agriculture. This type of desertification can be seen, for example, in some parts of Pakistan. Another type of desertification can be seen in the Sahel region of Africa, south of the Sahara. Rapid population growth in the Sahel has led to overgrazing, destruction of trees, and wind erosion, so that the land has become unable to support even its original population.

Especially worrying is a prediction of the International Panel on Climate Change concerning the effect of global warming on the availability of water: According to Model A1 of the IPCC, global warming may, by the 2050's, have reduced by as much as 30% the water available in large areas of world that now a large producers of grain[4].

Added to the agricultural and environmental problems, are problems of finance and distribution. Famines can occur even when grain is available somewhere in the world, because those who are threatened with starvation may not be able to pay for the grain, or for its transportation. The economic laws of supply and demand are not able to solve this type of problem. One says that there is no "demand" for the food (meaning demand in the economic sense), even though people are in fact starving.

5.6 Energy-dependence of modern agriculture

Food prices and energy prices

A very serious problem with Green Revolution plant varieties is that they require heavy inputs of pesticides, fertilizers and irrigation. Because of this, the use of high-yield varieties contributes to social inequality, since only rich farmers can afford the necessary inputs. Monocultures, such as the Green Revolution varieties may also prove to be vulnerable to future epidemics of plant diseases, such as the epidemic that caused the Irish Potato Famine in 1845. Even more importantly, pesticides, fertilizers and irrigation all depend on the use of fossil fuels. One must therefore ask whether high agricultural yields can be maintained in the future, when fossil fuels are expected to become prohibitively scarce and expensive.

[4]See the discussion of the Stern Report in Chapter 7.

Modern agriculture has become highly dependent on fossil fuels, especially on petroleum and natural gas. This is especially true of production of the high-yield grain varieties introduced in the Green Revolution, since these require especially large inputs of fertilizers, pesticides and irrigation. Today, fertilizers are produced using oil and natural gas, while pesticides are synthesized from petroleum feedstocks, and irrigation is driven by fossil fuel energy. Thus agriculture in the developed countries has become a process where inputs of fossil fuel energy are converted into food calories. If one focuses only on the farming operations, the fossil fuel energy inputs are distributed as follows:

1. Manufacture of inorganic fertilizer, 31%
2. Operation of field machinery, 19%
3. Transportation, 16%
4. Irrigation, 13%
5. Raising livestock (not including livestock feed), 8%
6. Crop drying, 5%
7. Pesticide production, 5%
8. Miscellaneous, 8%

The ratio of the fossil fuel energy inputs to the food calorie outputs depends on how many energy-using elements of food production are included in the accounting. David Pimental and Mario Giampietro of Cornell University estimated in 1994 that U.S. agriculture required 0.7 kcal of fossil fuel energy inputs to produce 1.0 kcal of food energy. However, this figure was based on U.N. statistics that did not include fertilizer feedstocks, pesticide feedstocks, energy and machinery for drying crops, or electricity, construction and maintenance of farm buildings. A more accurate calculation, including these inputs, gives an input/output ratio of approximately 1.0. Finally, if the energy expended on transportation, packaging and retailing of food is included, Pimental and Giampietro found that the input/output ratio for the U.S. food system was approximately 10, and this figure did not include energy used for cooking.

The Brundtland Report's [5] estimate of the global potential for food production assumes "that the area under food production can be around 1.5 billion hectares (3.7 billion acres - close to the present level), and that the average yields could go up to 5 tons of grain equivalent per hectare (as against the present average of 2 tons of grain equivalent)." In other words, the Brundtland Report assumes an increase in yields by a factor of 2.5. This would perhaps be possible if traditional agriculture could everywhere be replaced by energy-intensive modern agriculture using Green Revolution plant varieties. However, Pimental

[5] World Commission on Environment and Development, *Our Common Future*, Oxford University Press, (1987). This book is often called "The Brundtland Report" after Gro Harlem Brundtland, the head of WCED, who was then Prime Minister of Norway.

and Giampietro's studies show that modern energy-intensive agricultural techniques cannot be maintained after fossil fuels have been exhausted.

At the time when the Brundtland Report was written (1987), the global average of 2 tons of grain equivalent per hectare included much higher yields from the sector using modern agricultural methods. Since energy-intensive petroleum-based agriculture cannot be continued in the post-fossil-fuel era, future average crop yields will probably be much less than 2 tons of grain equivalent per hectare.

The 1987 global population was approximately 5 billion. This population was supported by 3 billion tons of grain equivalent per year. After fossil fuels have been exhausted, the total world agricultural output is likely to be considerably less than that, and therefore the population that it will be possible to support will probably be considerably less than 5 billion, assuming that our average daily per capita use of food calories remains the same, and assuming that the amount of cropland and pasturage remains the same (1.5 billion hectares cropland, 3.0 billion hectares pasturage).

The Brundtland Report points out that "The present (1987) global average consumption of plant energy for food, seed and animal feed amounts to 6,000 calories daily, with a range among countries of 3,000-15,000 calories, depending on the level of meat consumption." Thus there is a certain flexibility in the global population that can survive on a given total agricultural output. If the rich countries were willing to eat less meat, more people could be supported.

5.7 Effects of climate change on agriculture

Effects of temperature increase on crops

There is a danger that when climate change causes both temperature increases and increased aridity in regions like the US grain belt, yields will be very much lowered. Of the three main grain types (corn, wheat and rice) corn is the most vulnerable to the direct effect of increases in temperature. One reason for this is the mechanism of pollination of corn: A pollen grain lands on one end of a corn-silk strand, and the germ cell must travel the length of the strand in order to fertilize the kernel. At high temperatures, the corn silk becomes dried out and withered, and is unable to fulfill its biological function. Furthermore, heat can cause the pores on the underside of the corn leaf to close, so that photosynthesis stops.

According to a study made by Mohan Wali and coworkers at Ohio State University, the photosynthetic activity of corn increases until the temperature reaches 20 degrees Celsius. It then remains constant until the temperature reaches 35 degrees, after which it declines. At 40 degrees and above, photosynthesis stops altogether.

Scientists in the Philippines report that the pollination of rice fails entirely at 40 degrees Celsius, leading to crop failures. Wheat yields are also markedly reduced by temperatures in this range.

Predicted effects on rainfall

According to the Stern Report, some of the major grain-producing areas of the world might loose up to 30% of their rainfall by 2050. These regions include much of the United States, Brazil, the Mediterranean region, Eastern Russia and Belarus, the Middle East, Southern Africa and Australia. Of course possibilities for agriculture may simultaneously increase in other regions, but the net effect of climate change on the world's food supply is predicted to be markedly negative.

Unsustainable use of groundwater

It may seem surprising that fresh water can be regarded as a non-renewable resource. However, groundwater in deep aquifers is often renewed very slowly. Sometimes renewal requires several thousand years. When the rate of withdrawal of groundwater exceeds the rate of renewal, the carrying capacity of the resource has been exceeded, and withdrawal of water becomes analogous to mining a mineral. However, it is more serious than ordinary mining because water is such a necessary support for life.

In many regions of the world today, groundwater is being withdrawn faster than it can be replenished, and important aquifers are being depleted. In China, for example, groundwater levels are falling at an alarming rate. Considerations of water supply in relation to population form the background for China's stringent population policy.

At a recent lecture, Lester Brown of the Worldwatch Institute was asked by a member of the audience to name the resource for which shortages would most quickly become acute. Most of the audience expected him to name oil, but instead he replied "water". Lester Brown then cited China's falling water table. He predicted that within decades, China would be unable to feed itself. He said that this would not cause hunger in China itself: Because of the strength of China's economy, the country would be able to purchase grain on the world market. However Chinese purchases of grain would raise the price, and put world grain out of reach of poor countries in Africa. Thus water shortages in China will produce famine in parts of Africa, Brown predicted.

Under many desert areas of the world are deeply buried water tables formed during glacial periods when the climate of these regions was wetter. These regions include the Middle East and large parts of Africa. Water can be withdrawn from such ancient reservoirs by deep wells and pumping, but only for a limited amount of time.

In oil-rich Saudi Arabia, petroenergy is used to drill wells for ancient water and to bring it to the surface. Much of this water is used to irrigate wheat fields, and this is done to such an extent that Saudi Arabia exports wheat. The country is, in effect, exporting its ancient heritage of water, a policy that it may, in time, regret. A similarly short-sighted project is Muammar Qaddafi's enormous pipeline, which will bring water from ancient sub-desert reservoirs to coastal cities of Libya.

In the United States, the great Ogallala aquifer is being overdrawn. This aquifer is an enormous stratum of water-saturated sand and gravel underlying parts of northern Texas, Oklahoma, New Mexico, Kansas, Colorado, Nebraska, Wyoming and South Dakota. The

average thickness of the aquifer is about 70 meters. The rate of water withdrawal from the aquifer exceeds the rate of recharge by a factor of eight.

Thus we can see that in many regions, the earth's present population is living on its inheritance of water, rather than its income. This fact, coupled with rapidly increasing populations and climate change, may contribute to a food crisis partway through the 21st century.

Glacial melting and summer water supplies

The summer water supplies of both China and India are threatened by the melting of glaciers. The Gangotri glacier, which is the principle glacier feeding India's great Ganges River, is reported to be melting at an accelerating rate, and it could disappear within a few decades. If this happens,the Ganges could become seasonal, flowing only during the monsoon season.

Chinese agriculture is also threatened by disappearing Himalayan glaciers, in this case those on the Tibet-Quinghai Plateau. The respected Chinese glaciologist Yao Tandong estimates that the glaciers feeding the Yangtze and Yellow Rivers are disappearing at the rate of 7% per year.

The Indus and Mekong Rivers will be similarly affected by the melting of glaciers. Lack of water during the summer season could have a serious impact on the irrigation of rice and wheat fields.

Forest loss and climate change

Mature forests contain vast amounts of sequestered carbon, not only in their trees, but also in the carbon-rich soil of the forest floor. When a forest is logged or burned to make way for agriculture, this carbon is released into the atmosphere. One fifth of the global carbon emissions are at present due to destruction of forests. This amount is greater than the CO_2 emissions for the world's transportation systems.

An intact forest pumps water back into the atmosphere, increasing inland rainfall and benefiting agriculture. By contrast, deforestation, for example in the Amazonian rainforest, accelerates the flow of water back into the ocean, thus reducing inland rainfall. There is a danger that the Amazonian rainforest may be destroyed to such an extent that the region will become much more dry. If this happens, the forest may become vulnerable to fires produced by lightning strikes. This is one of the feedback loops against which the Stern Report warns - the drying and burning of the Amazonian rainforest may become irreversible, greatly accelerating climate change, if destruction of the forest proceeds beyond a certain point.

Erosion of topsoil

Besides depending on an adequate supply of water, food production also depends on the condition of the thin layer of topsoil that covers the world's croplands. This topsoil is being

degraded and eroded at an alarming rate: According to the World Resources Institute and the United Nations Environment Programme, "It is estimated that since World War II, 1.2 billion hectares... has suffered at least moderate degradation as a result of human activity. This is a vast area, roughly the size of China and India combined." This area is 27% of the total area currently devoted to agriculture [6]. The report goes on to say that the degradation is greatest in Africa.

The risk of topsoil erosion is greatest when marginal land is brought into cultivation, since marginal land is usually on steep hillsides which are vulnerable to water erosion when wild vegetation is removed.

David Pimental and his associates at Cornell University pointed out in 1995 that "Because of erosion-associated loss of productivity and population growth, the per capita food supply has been reduced over the past 10 years and continues to fall. The Food and Agricultural Organization reports that the per capita production of grains which make up 80% of the world's food supply, has been declining since 1984."

Pimental et al. add that "Not only is the availability of cropland per capita decreasing as the world population grows, but arable land is being lost due to excessive pressure on the environment. For instance, during the past 40 years nearly one-third of the world's cropland (1.5 billion hectares) has been abandoned because of soil erosion and degradation. Most of the replacement has come from marginal land made available by removing forests. Agriculture accounts for 80% of the annual deforestation."

Topsoil can also be degraded by the accumulation of salt when irrigation water evaporates. The worldwide area of irrigated land has increased from 8 million hectares in 1800 to more than 100 million hectares today. This land is especially important to the world food supply because it is carefully tended and yields are large in proportion to the area. To protect this land from salination, it should be irrigated in such a way that evaporation is minimized.

Finally cropland with valuable topsoil is being be lost to urban growth and highway development, a problem that is made more severe by growing populations and by economic growth.

Laterization

Every year, more than 100,000 square kilometers of rain forest are cleared and burned, an area which corresponds to that of Switzerland and the Netherlands combined. Almost half of the world's tropical forests have already been destroyed. Ironically, the land thus cleared often becomes unsuitable for agriculture within a few years.

Tropical soils may seem to be fertile when covered with luxuriant vegetation, but they are usually very poor in nutrients because of leeching by heavy rains. The nutrients which remain are contained in the vegetation itself; and when the forest cover is cut and burned, the nutrients are rapidly lost.

[6] The total area devoted to agriculture throughout the world is 1.5 billion hectares of cropland and 3.0 billion hectares of pasturage.

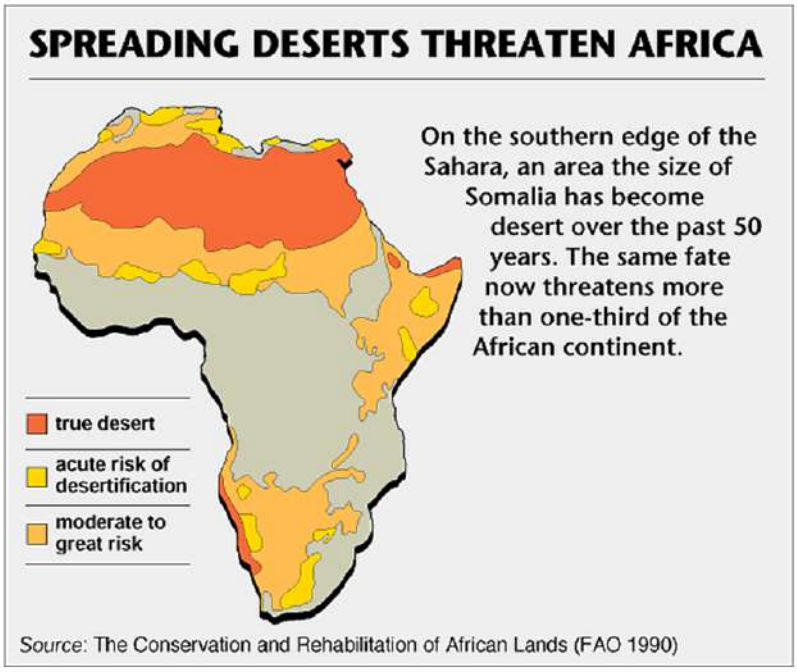

Figure 5.5: **Desert regions of the Africa that are in danger of spreading.** (FAO)

Often the remaining soil is rich in aluminum oxide and iron oxide. When such soils are exposed to oxygen and sun-baking, a rocklike substance called Laterite is formed. The temples of Angkor Wat in Cambodia are built of Laterite; and it is thought that laterization of the soil contributed to the disappearance of the Khmer civilization, which built these temples.

5.8 Harmful effects of industrialized farming

A major global public health crisis may soon be produced by the wholesale use of antibiotics in the food of healthy farm animals. The resistance factors produced by shovelling antibiotics into animal food produces resistance factors (plasmids) which can easily be transferred to human pathogens. A related problem is the excessive use of pesticides and artificial fossil-fuel-derived fertilizers in agriculture. Pharming is not a joke. It is a serious threat.[7]

[7]http://ecowatch.com/2014/03/06/misuse-antibiotics-fatal-superbug-crisis/
http://ecowatch.com/2013/12/06/8-scary-facts-about-antibiotic-resistance/
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Plasmids

Bacteria belong to a class of organisms (prokaryotes) whose cells do not have a nucleus. Instead, the DNA of the bacterial chromosome is arranged in a large loop. In the early 1950's, Joshua Lederberg discovered that bacteria can exchange genetic information. He found that a frequently-exchanged gene, the F-factor (which conferred fertility), was not linked to other bacterial genes; and he deduced that the DNA of the F-factor was not physically a part of the main bacterial chromosome. In 1952, Lederberg coined the word "plasmid" to denote any extrachromosomal genetic system.

In 1959, it was discovered in Japan that genes for resistance to antibiotics can be exchanged between bacteria; and the name "R-factors" was given to these genes. Like the F-factors, the R-factors did not seem to be part of the main loop of bacterial DNA.

Because of the medical implications of this discovery, much attention was focused on the R-factors. It was found that they were plasmids, small loops of DNA existing inside the bacterial cell, but not attached to the bacterial chromosome. Further study showed that, in general, between one percent and three percent of bacterial genetic information is carried by plasmids, which can be exchanged freely even between different species of bacteria.

In the words of the microbiologist, Richard Novick, "Appreciation of the role of plasmids has produced a rather dramatic shift in biologists' thinking about genetics. The traditional view was that the genetic makeup of a species was about the same from one cell to another, and was constant over long periods of time. Now a significant proportion of genetic traits are known to be variable (present in some individual cells or strains, absent in others), labile (subject to frequent loss or gain) and mobile, all because those traits are associated with plasmids or other atypical genetic systems."

Because of the ease with which plasmids conferring resistance to antibiotics can be transferred from animal bacteria to the bacteria carrying human disease, the practice of feeding antibiotics to healthy farm animals is becoming a major human health hazard. The World Health Organization has warned that if we lose effective antibiotics through this mechanism, "Many common infections will no longer have a cure, and could kill unabated". The US Center for Disease Control has pointed to the emergence of "nightmare bacteria", and the chief medical officer for England Prof Dame Sally Davies has evoked parallels with the "apocalypse".

Pesticides, artificial fertilizers and topsoil

A closely analogous danger results from the overuse of pesticides and petroleum-derived fertilizers in agriculture. A very serious problem with Green Revolution plant varieties is that they require heavy inputs of pesticides, fertilizers and irrigation. Because of this, the use of high-yield varieties contributes to social inequality, since only rich farmers can afford the necessary inputs. Monocultures, such as the Green Revolution varieties may also prove

http://sustainableagriculture.net/about-us/
https://pwccc.wordpress.com/programa/

to be vulnerable to future plant diseases, such as the epidemic that caused the Irish Potato Famine in 1845. Even more importantly, pesticides, fertilizers and irrigation all depend on the use of fossil fuels. One must ask, therefore, whether high-yield agriculture can be maintained in the post-fossil-fuel era.

Topsoil is degraded by excessive use of pesticides and artificial fertilizers. Natural topsoil is rich in organic material, which contains sequestered carbon that would otherwise be present in our atmosphere in the form of greenhouse gases. In addition, natural topsoil contains an extraordinarily rich diversity of bacteria and worms that act to convert agricultural wastes from one year's harvest into nutrients for the growth of next year's crop. Pesticides kill these vital organisms, and make the use of artificial fertilizers necessary.

Finally, many small individual farmers, whose methods are sustainable, are being eliminated by secret land-grabs or put out of business because they cannot compete with unsustainable high-yield agriculture. Traditional agriculture contains a wealth of knowledge and biodiversity, which it would be wise for the world to preserve.

5.9 The demographic transition

The phrase "developing countries" is more than a euphemism; it expresses the hope that with the help of a transfer of technology from the industrialized nations, all parts of the world can achieve prosperity. Some of the forces that block this hope have just been mentioned. Another factor that prevents the achievement of worldwide prosperity is population growth.

In the words of Dr. Halfdan Mahler, former Director General of the World Health Organization, "Country after country has seen painfully achieved increases in total output, food production, health and educational facilities and employment opportunities reduced or nullified by excessive population growth."

The growth of population is linked to excessive urbanization, infrastructure failures and unemployment. In rural districts in the developing countries, family farms are often divided among a growing number of heirs until they can no longer be subdivided. Those family members who are no longer needed on the land have no alternative except migration to overcrowded cities, where the infrastructure is unable to cope so many new arrivals. Often the new migrants are forced to live in excrement-filled makeshift slums, where dysentery, hepatitis and typhoid are endemic, and where the conditions for human life sink to the lowest imaginable level. In Brazil, such shanty towns are called "favelas".

If modern farming methods are introduced in rural areas while population growth continues, the exodus to cities is aggravated, since modern techniques are less labor-intensive and favor large farms. In cities, the development of adequate infrastructure requires time, and it becomes a hopeless task if populations are growing rapidly. Thus, population stabilization is a necessary first step for development.

It can be observed that birth rates fall as countries develop. However, development is sometimes blocked by the same high birth rates that economic progress might have prevented. In this situation (known as the "demographic trap"), economic gains disappear

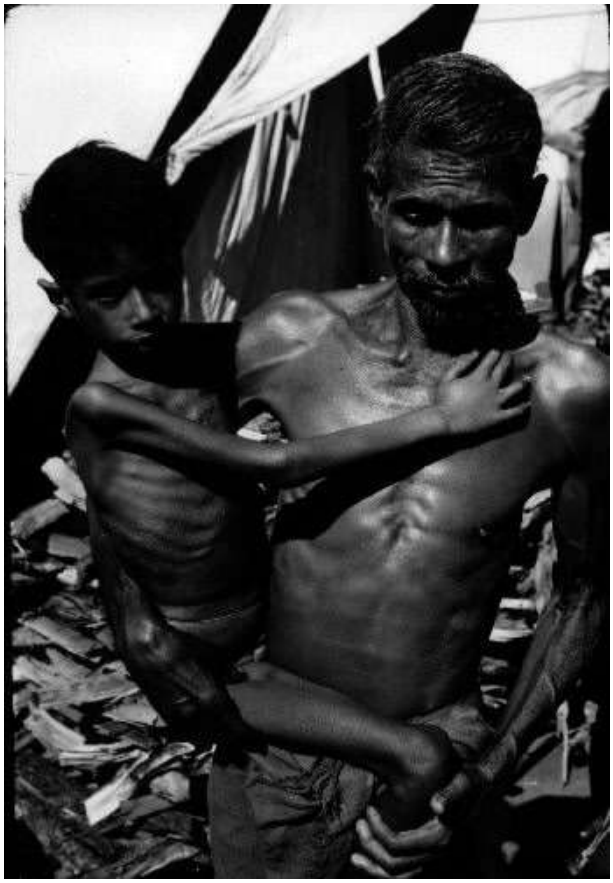

Figure 5.6: **Child suffering with the deficiency disease Marasmus in India.** (Public domain)

immediately because of the demands of an exploding population.

For countries caught in the demographic trap, government birth control programs are especially important, because one cannot rely on improved social conditions to slow birth rates. Since health and lowered birth rates should be linked, it is appropriate that family-planning should be an important part of programs for public health and economic development.

A recent study conducted by Robert F. Lapham of Demographic Health Surveys and W. Parker Maudlin of the Rockefeller Foundation has shown that the use of birth control is correlated both with socio-economic setting and with the existence of strong family-planning programs. The implication of this study is that even in the absence of increased living standards, family-planning programs can be successful, provided they have strong government support.

China, the world's most populous nation, has adopted the somewhat draconian policy of allowing only one child for families in living in towns and cities (35.9% of the population). Chinese leaders obtained popular support for their one-child policy by means of an educational program which emphasized future projections of diminishing water resources and diminishing cropland per person if population increased unchecked. Like other developing countries, China has a very young population, which will continue to grow even when fertility has fallen below the replacement level because so many of its members are contributing to the birth rate rather than to the death rate. China's present population is 1.3 billion. Its projected population for the year 2025 is 1.5 billion. China's one-child policy is supported by 75% of the country's people, but the methods of enforcement are sometimes criticized, and it has led to a M/F sex ratio of 1.17/1.00. The natural baseline for the sex ratio ranges between 1.03/1.00 and 1.07/1.00.

Education of women and higher status for women are vitally important measures, not only for their own sake, but also because in many countries these social reforms have proved to be the key to lower birth rates. Religious leaders who oppose programs for the education of women and for family planning on "ethical" grounds should think carefully about the scope and consequences of the catastrophic global famine which will undoubtedly occur within the next 50 years if population is allowed to increase unchecked. Do these leaders really wish to be responsible for the suffering and death from starvation of hundreds of millions of people?

At the United Nations Conference on Population and Development, held in Cairo in September, 1994, a theme which emerged very clearly was that one of the most important keys to controlling the global population explosion is giving women better education and equal rights. These goals are desirable for the sake of increased human happiness, and for the sake of the uniquely life-oriented point of view which women can give us; but in addition, education and improved status for women have shown themselves to be closely connected with lowered birth rates. When women lack education and independent careers outside the home, they can be forced into the role of baby-producing machines by men who do not share in the drudgery of cooking, washing and cleaning; but when women have educational, legal, economic, social and political equality with men, experience has shown that they choose to limit their families to a moderate size.

Figure 5.7: **Education of women and higher status for women are vitally important measures, not only for their own sake, but also because these social reforms have proved to be the key to lower birth rates.** (Kundan Srivastava)

Sir Partha Dasgupta of Cambridge University has pointed out that the changes needed to break the cycle of overpopulation and poverty are all desirable in themselves. Besides education and higher status for women, they include state-provided social security for old people, provision of water supplies near to dwellings, provision of health services to all, abolition of child labor and general economic development.

The UN Summit on Addressing Large Movements of Refugees and Migrants

On September 19, 2016, the United Nations General Assembly held a 1-day summit meeting to address the pressing problem of refugees. It is a problem that has been made acute by armed conflicts in the Middle East and Africa, and by climate change.

One of the outcomes of the summit was the a Declaration for Refugees and Migrants. Here is a statement of the severity of the problem from paragraph 3 of the Declaration:

"We are witnessing in today's world an unprecedented level of human mobility. More people than ever before live in a country other than the one in which they were born. Migrants are present in all countries of the world. Most of them move without incident. In 2015, their number surpassed 244 million, growing at a rate faster than the world's population. However, there are 65 million forcibly displaced persons, including over 21 million refugees, 3 million asylum seekers and over 40 million internally displaced persons."

Sadly, the world's response to the tragic plight of refugees fleeing from zones of armed conflict has been less than generous. Men, women and many children, trying to escape from almost certain death in the war-torn Middle East, have been met, not with sympathy and kindness, but with barbed wire and tear gas.

Germany's Chancellor, Angela Merkel, courageously made arrangements for her country to accept a large number of refugees, but as a consequence her party has suffered political setbacks. On the whole, European governments have moved to the right, as anti-refugee parties gained strength. The United States, Canada Australia and Russia, countries that could potentially save the lives of many refugees, have accepted almost none. In contrast, tiny Lebanon, despite all its problems, has become the home of so many refugees that they are a very large fraction of the country's total population.

As the effects of climate change become more pronounced, we can expect the suffering and hopelessness of refugees to become even more severe. This is a challenge which the world must meet with humanity and solidarity.

The World Cities Report, 2016

According to the World Cities Report[8], by 2030, two thirds of the world's population will be living in cities. As the urban population increases, the land area occupied by cities is increasing at a higher rate. It is projected that by 2030, the urban population of developing countries will double, while the area covered by cites could triple.

Commenting on this, the UN-Habitat Executive Director, Joan Clos, said: "In the twenty years since the Habitat II conference, the world has seen a gathering of its population in urban areas. This has been accompanied by socioeconomic growth in many instances. But the urban landscape is changing and with it, the pressing need for a cohesive and realistic approach to urbanization".

"Such urban expansion is wasteful in terms of land and energy consumption and increases greenhouse gas emissions. The urban centre of gravity, at least for megacities, has shifted to the developing regions."

One can foresee that in the future, as fossil fuels become increasingly scarce, the problem of feeding urban populations will become acute.

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Chapter 6

ALBERT EINSTEIN, SCIENTIST AND PACIFIST

"The unleashed power of the atom has changed everything except our ways of thinking, and thus we drift towards unparalleled catastrophes."

"I don't know what will be used in the next world war, but the 4th will be fought with stones."

Albert Einstein (1879-1955)

Besides being one of the greatest physicists of all time, Albert Einstein was a lifelong pacifist, and his thoughts on peace can speak eloquently to us today. We need his wisdom today, when the search for peace has become vital to our survival as a species.

6.1 Family background

Albert Einstein was born in Ulm, Germany, in 1879. He was the son of middle-class, irreligious Jewish parents, who sent him to a Catholic school. Einstein was slow in learning to speak, and at first his parents feared that he might be retarded; but by the time he was eight, his grandfather could say in a letter: "Dear Albert has been back in school for a week. I just love that boy, because you cannot imagine how good and intelligent he has become."

Remembering his boyhood, Einstein himself later wrote: "When I was 12, a little book dealing with Euclidean plane geometry came into my hands at the beginning of the school year. Here were assertions, as for example the intersection of the altitudes of a triangle in one point, which, though by no means self-evident, could nevertheless be proved with such certainty that any doubt appeared to be out of the question. The lucidity and certainty made an indescribable impression on me."

When Albert Einstein was in his teens, the factory owned by his father and uncle began

to encounter hard times. The two Einstein families moved to Italy, leaving Albert alone and miserable in Munich, where he was supposed to finish his course at the gymnasium. Einstein's classmates had given him the nickname "Beidermeier", which means something like "Honest John"; and his tactlessness in criticizing authority soon got him into trouble. In Einstein's words, what happened next was the following: "When I was in the seventh grade at the Lutpold Gymnasium, I was summoned by my home-room teacher, who expressed the wish that I leave the school. To my remark that I had done nothing wrong, he replied only, 'Your mere presence spoils the respect of the class for me'."

Einstein left gymnasium without graduating, and followed his parents to Italy, where he spent a joyous and carefree year. He also decided to change his citizenship. "The over-emphasized military mentality of the German State was alien to me, even as a boy", Einstein wrote later. "When my father moved to Italy, he took steps, at my request, to have me released from German citizenship, because I wanted to be a Swiss citizen."

6.2 Special and general relativity theory

The financial circumstances of the Einstein family were now precarious, and it was clear that Albert would have to think seriously about a practical career. In 1896, he entered the famous Zürich Polytechnic Institute with the intention of becoming a teacher of mathematics and physics. However, his undisciplined and nonconformist attitudes again got him into trouble. His mathematics professor, Hermann Minkowski (1864-1909), considered Einstein to be a "lazy dog"; and his physics professor, Heinrich Weber, who originally had gone out of his way to help Einstein, said to him in anger and exasperation: "You're a clever fellow, but you have one fault: You won't let anyone tell you a thing! You won't let anyone tell you a thing!"

Einstein missed most of his classes, and read only the subjects which interested him. He was interested most of all in Maxwell's theory of electro-magnetism, a subject which was too "modern" for Weber. There were two major examinations at the Zürich Polytechnic Institute, and Einstein would certainly have failed them had it not been for the help of his loyal friend, the mathematician Marcel Grossman.

Grossman was an excellent and conscientious student, who attended every class and took meticulous notes. With the help of these notes, Einstein managed to pass his examinations; but because he had alienated Weber and the other professors who could have helped him, he found himself completely unable to get a job. In a letter to Professor F. Ostwald on behalf of his son, Einstein's father wrote: "My son is profoundly unhappy because of his present joblessness; and every day the idea becomes more firmly implanted in his mind that he is a failure, and will not be able to find the way back again."

From this painful situation, Einstein was rescued (again!) by his friend Marcel Grossman, whose influential father obtained for Einstein a position at the Swiss Patent Office: Technical Expert (Third Class). Anchored at last in a safe, though humble, position, Einstein married one of his classmates. He learned to do his work at the Patent Office very

efficiently; and he used the remainder of his time on his own calculations, hiding them guiltily in a drawer when footsteps approached.

In 1905, this Technical Expert (Third Class) astonished the world of science with five papers, written within a few weeks of each other, and published in the Annalen der Physik. Of these five papers, three were classics: One of these was the paper in which Einstein applied Planck's quantum hypothesis to the photoelectric effect. The second paper discussed "Brownian motion", the zig-zag motion of small particles suspended in a liquid and hit randomly by the molecules of the liquid. This paper supplied a direct proof of the validity of atomic ideas and of Boltzmann's kinetic theory. The third paper was destined to establish Einstein's reputation as one of the greatest physicists of all time. It was entitled "On the Electrodynamics of Moving Bodies", and in this paper, Albert Einstein formulated his special theory of relativity. Essentially, this theory maintained that all of the fundamental laws of nature exhibit a symmetry with respect to rotations in a 4-dimensional space-time continuum.

Gradually, the importance of Einstein's work began to be realized, and he was much sought after. He was first made Assistant Professor at the University of Zürich, then full Professor in Prague, then Professor at the Zürich Polytechnic Institute; and finally, in 1913, Planck and Nernst persuaded Einstein to become Director of Scientific Research at the Kaiser Wilhelm Institute in Berlin. He was at this post when the First World War broke out

While many other German intellectuals produced manifestos justifying Germany's invasion of Belgium, Einstein dared to write and sign an anti-war manifesto. Einstein's manifesto appealed for cooperation and understanding among the scholars of Europe for the sake of the future; and it proposed the eventual establishment of a League of Europeans. During the war, Einstein remained in Berlin, doing whatever he could for the cause of peace, burying himself unhappily in his work, and trying to forget the agony of Europe, whose civilization was dying in a rain of shells, machine-gun bullets, and poison gas.

The work into which Einstein threw himself during this period was an extension of his theory of relativity. He already had modified Newton's equations of motion so that they exhibited the space-time symmetry required by his Principle of Special Relativity. However, Newton's law of gravitation. remained a problem.

Obviously it had to be modified, since it disagreed with his Special Theory of Relativity; but how should it be changed? What principles could Einstein use in his search for a more correct law of gravitation? Certainly whatever new law he found would have to give results very close to Newton's law, since Newton's theory could predict the motions of the planets with almost perfect accuracy. This was the deep problem with which he struggled.

In 1907, Einstein had found one of the principles which was to guide him, the Principle of Equivalence of inertial and gravitational mass. After turning Newton's theory over and over in his mind, Einstein realized that Newton had used mass in two distinct ways: His laws of motion stated that the force acting on a body is equal to the mass of the body multiplied by its acceleration; but according to Newton, the gravitational force on a body is also proportional to its mass. In Newton's theory, gravitational mass, by a coincidence, is equal to inertial mass; and this holds for all bodies. Einstein decided to construct a

theory in which gravitational and inertial mass necessarily have to be the same.

He then imagined an experimenter inside a box, unable to see anything outside it. If the box is on the surface of the earth, the person inside it will feel the pull of the earth's gravitational field. If the experimenter drops an object, it will fall to the floor with an acceleration of 32 feet per second per second. Now suppose that the box is taken out into empty space, far away from strong gravitational fields, and accelerated by exactly 32 feet per second per second. Will the enclosed experimenter be able to tell the difference between these two situations? Certainly no difference can be detected by dropping an object, since in the accelerated box, the object will fall to the floor in exactly the same way as before.

With this "thought experiment" in mind, Einstein formulated a general Principle of Equivalence: He asserted that no experiment whatever can tell an observer enclosed in a small box whether the box is being accelerated, or whether it is in a gravitational field. According to this principle, gravitation and acceleration are locally equivalent, or, to say the same thing in different words, gravitational mass and inertial mass are equivalent.

Einstein soon realized that his Principle of Equivalence implied that a ray of light must be bent by a gravitational field. This conclusion followed because, to an observer in an accelerated frame, a light beam which would appear straight to a stationary observer, must necessarily appear very slightly curved. If the Principle of Equivalence held, then the same slight bending of the light ray would be observed by an experimenter in a stationary frame in a gravitational field.

Another consequence of the Principle of Equivalence was that a light wave propagating upwards in a gravitational field should be very slightly shifted to the red. This followed because in an accelerated frame, the wave crests would be slightly farther apart than they normally would be, and the same must then be true for a stationary frame in a gravitational field. It seemed to Einstein that it ought to be possible to test experimentally both the gravitational bending of a light ray and the gravitational red shift.

This seemed promising; but how was Einstein to proceed from the Principle of Equivalence to a formulation of the law of gravitation? Perhaps the theory ought to be modeled after Maxwell's electromagnetic theory, which was a field theory, rather than an "action at a distance" theory. Part of the trouble with Newton's law of gravitation was that it allowed a signal to be propagated instantaneously, contrary to the Principle of Special Relativity. A field theory of gravitation might cure this defect, but how was Einstein to find such a theory? There seemed to be no way.

From these troubles Albert Einstein was rescued (a third time!) by his staunch friend Marcel Grossman. By this time, Grossman had become a professor of mathematics in Zürich, after having written a doctoral dissertation on tensor analysis and non-Euclidean geometry, the very things that Einstein needed. The year was then 1912, and Einstein had just returned to Zürich as Professor of Physics at the Polytechnic Institute. For two years, Einstein and Grossman worked together; and by the time Einstein left for Berlin in 1914, the way was clear. With Grossman's help, Einstein saw that the gravitational field could be expressed as a curvature of the 4-dimensional space-time continuum.

In 1919, a British expedition, headed by Sir Arthur Eddington, sailed to a small island off the coast of West Africa. Their purpose was to test Einstein's prediction of the bending

of light in a gravitational field by observing stars close to the sun during a total eclipse. The observed bending agreed exactly with Einstein's predictions; and as a result he became world-famous. The general public was fascinated by relativity, in spite of the abstruseness of the theory (or perhaps because of it). Einstein, the absent-minded professor, with long, uncombed hair, became a symbol of science. The world was tired of war, and wanted something else to think about.

Einstein met President Harding, Winston Churchill and Charlie Chaplin; and he was invited to lunch by the Archbishop of Canterbury. Although adulated elsewhere, he was soon attacked in Germany. Many Germans, looking for an excuse for the defeat of their nation, blamed it on the pacifists and Jews; and Einstein was both these things.

6.3 Einstein's letter to Freud: Why war?

Because of his fame, Einstein was asked to make several speeches at the Reichstag. and in all these speeches he condemned violence and nationalism, urging that these be replaced by and international cooperation and law under an effective international authority. He also wrote many letters and articles pleading for peace and for the renunciation of militarism and violence.

Einstein believed that the production of armaments is damaging, not only economically, but also spiritually. In 1930 he signed a manifesto for world disarmament sponsored by the Womens International League for Peace and Freedom. In December of the same year, he made his famous statement in New York that if two percent of those called for military service were to refuse to fight, governments would become powerless, since they could not imprison that many people. He also argued strongly against compulsory military service and urged that conscientious objectors should be protected by the international community. He argued that peace, freedom of individuals, and security of societies could only be achieved through disarmament, the alternative being "slavery of the individual and annihilation of civilization".

In letters, and articles, Einstein wrote that the welfare of humanity as a whole must take precedence over the goals of individual nations, and that we cannot wait until leaders give up their preparations for war. Civil society, and especially public figures, must take the lead. He asked how decent and self-respecting people can wage war, knowing how many innocent people will be killed.

In 1931, the International Institute for Intellectual Cooperation invited Albert Einstein to enter correspondence with a prominent person of his own choosing on a subject of importance to society. The Institute planned to publish a collection of such dialogues. Einstein accepted at once, and decided to write to Sigmund Freud to ask his opinion about how humanity could free itself from the curse of war. A translation from German of part of the long letter that he wrote to Freud is as follows:

"Dear Professor Freud, The proposal of the League of Nations and its International Institute of Intellectual Cooperation at Paris that I should invite a person to be chosen by myself to a frank exchange of views on any problem that I might select affords me a very

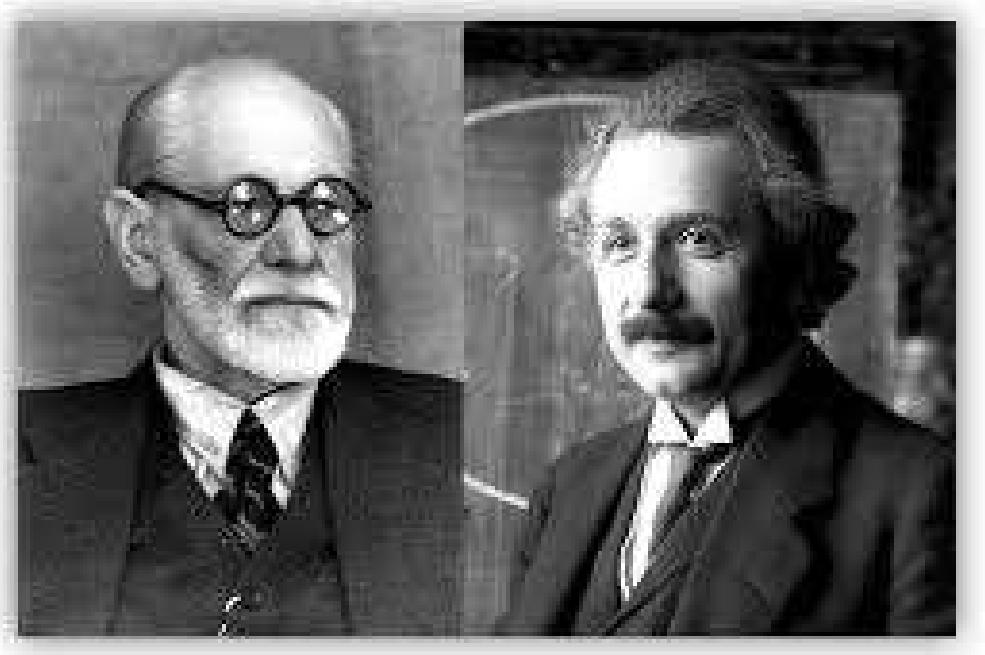

Figure 6.1: **Sigmund Freud and Albert Einstein (public domain). Their exchange of letters entitled "Why War?" deserves to be read by everyone concerned with the human future.**

welcome opportunity of conferring with you upon a question which, as things are now, seems the most important and insistent of all problems civilization has to face. This is the problem: Is there any way of delivering mankind from the menace of war? It is common knowledge that, with the advance of modern science, this issue has come to mean a matter of life or death to civilization as we know it; nevertheless, for all the zeal displayed, every attempt at its solution has ended in a lamentable breakdown."

"I believe, moreover, that those whose duty it is to tackle the problem professionally and practically are growing only too aware of their impotence to deal with it, and have now a very lively desire to learn the views of men who, absorbed in the pursuit of science, can see world-problems in the perspective distance lends. As for me, the normal objective of my thoughts affords no insight into the dark places of human will and feeling. Thus in the enquiry now proposed, I can do little more than seek to clarify the question at issue and, clearing the ground of the more obvious solutions, enable you to bring the light of your far-reaching knowledge of man's instinctive life upon the problem.."

"As one immune from nationalist bias, I personally see a simple way of dealing with the superficial (i.e. administrative) aspect of the problem: the setting up, by international consent, of a legislative and judicial body to settle every conflict arising between nations... But here, at the outset, I come up against a difficulty; a tribunal is a human institution which, in proportion as the power at its disposal is... prone to suffer these to be deflected by extrajudicial pressure..."

Freud replied with a long and thoughtful letter in which he said that a tendency towards conflict is an intrinsic part of human emotional nature, but that emotions can be overridden by rationality, and that rational behavior is the only hope for humankind.

6.4 The fateful letter to Roosevelt

Albert Einstein's famous relativistic formula, relating energy to mass, soon yielded an understanding of the enormous amounts of energy released in radioactive decay. Marie and Pierre Curie had noticed that radium maintains itself at a temperature higher than its surroundings. Their measurements and calculations showed that a gram of radium produces roughly 100 gram-calories of heat per hour. This did not seem like much energy until Rutherford found that radium has a half-life of about 1,000 years. In other words, after a thousand years, a gram of radium will still be producing heat, its radioactivity only reduced to one-half its original value. During a thousand years, a gram of radium produces about a million kilocalories, an enormous amount of energy in relation to the tiny size of its source! Where did this huge amount of energy come from? Conservation of energy was one of the most basic principles of physics. Would it have to be abandoned?

The source of the almost-unbelievable amounts of energy released in radioactive decay could be understood through Einstein's formula equating the energy of a system to its mass multiplied by the square of the velocity of light, and through accurate measurements of atomic weights. Einstein's formula asserted that mass and energy are equivalent. It was realized that in radioactive decay, neither mass nor energy is conserved, but only a

quantity more general than both, of which mass and energy are particular forms. Scientists in several parts of the world realized that Einstein's discovery of the relationship between mass and energy, together with the discovery of fission of the heavy element uranium meant that it might be possible to construct a uranium-fission bomb of immense power.

Meanwhile night was falling on Europe. In 1929, an economic depression had begun in the United States and had spread to Europe. Without the influx of American capital, the postwar reconstruction of the German economy collapsed. The German middle class, which had been dealt a severe blow by the great inflation of 1923, now received a second heavy blow. The desperate economic chaos drove German voters into the hands of political extremists.

On January 30, 1933, Adolf Hitler was appointed Chancellor and leader of a coalition cabinet by President Hindenburg. Although Hitler was appointed legally to this post, he quickly consolidated his power by unconstitutional means: On May 2, Hitler's police seized the headquarters of all trade unions, and arrested labor leaders. The Communist and Socialist parties were also banned, their assets seized and their leaders arrested. Other political parties were also smashed. Acts were passed eliminating Jews from public service; and innocent Jewish citizens were boycotted, beaten and arrested. On March 11, 1938, Nazi troops entered Austria.

On March 16, 1939, the Italian physicist Enrico Fermi (who by then was a refugee in America) went to Washington to inform the Office of Naval Operations that it might be possible to construct an atomic bomb; and on the same day, German troops poured into Czechoslovakia.

A few days later, a meeting of six German atomic physicists was held in Berlin to discuss the applications of uranium fission. Otto Hahn, the discoverer of fission, was not present, since it was known that he was opposed to the Nazi regime. He was even said to have exclaimed: "I only hope that you physicists will never construct a uranium bomb! If Hitler ever gets a weapon like that, I'll commit suicide."

The meeting of German atomic physicists was supposed to be secret; but one of the participants reported what had been said to Dr. S. Flügge, who wrote an article about uranium fission and about the possibility of a chain reaction. Flügge's article appeared in the July issue of Naturwissenschaften, and a popular version in the Deutsche Allgemeine Zeitung. These articles greatly increased the alarm of American atomic scientists, who reasoned that if the Nazis permitted so much to be printed, they must be far advanced on the road to building an atomic bomb.

In the summer of 1939, while Hitler was preparing to invade Poland, alarming news reached the physicists in the United States: A second meeting of German atomic scientists had been held in Berlin, this time under the auspices of the Research Division of the German Army Weapons Department. Furthermore, Germany had stopped the sale of uranium from mines in Czechoslovakia.

The world's most abundant supply of uranium, however, was not in Czechoslovakia, but in Belgian Congo. Leo Szilard, a refugee Hungarian physicist who had worked with Fermi to measure the number of neutrons produced in uranium fission, was deeply worried that the Nazis were about to construct atomic bombs; and it occurred to him that uranium

from Belgian Congo should not be allowed to fall into their hands.

Szilard knew that his former teacher, Albert Einstein, was a personal friend of Elizabeth, the Belgian Queen Mother. Einstein had met Queen Elizabeth and King Albert of Belgium at the Solvay Conferences, and mutual love of music had cemented a friendship between them. When Hitler came to power in 1933, Einstein had moved to the Institute of Advanced Studies at Princeton; and Szilard decided to visit him there. Szilard reasoned that because of Einstein's great prestige, and because of his long-standing friendship with the Belgian Royal Family, he would be the proper person to warn the Belgians not to let their uranium fall into the hands of the Nazis. Einstein agreed to write to the Belgian king and queen.

On August 2, 1939, Szilard again visited Einstein, accompanied by Edward Teller and Eugene Wigner, who (like Szilard) were refugee Hungarian physicists. By this time, Szilard's plans had grown more ambitious; and he carried with him the draft of another letter, this time to the American President, Franklin D. Roosevelt. Einstein made a few corrections, and then signed the fateful letter, which reads (in part) as follows:

"Some recent work of E. Fermi and L. Szilard, which has been communicated to me in manuscript, leads me to expect that the element uranium may be turned into an important source of energy in the immediate future. Certain aspects of the situation seem to call for watchfulness and, if necessary, quick action on the part of the Administration. I believe, therefore, that it is my duty to bring to your attention the following.."

"It is conceivable that extremely powerful bombs of a new type may be constructed. A single bomb of this type, carried by boat and exploded a port, might very well destroy the whole port, together with some of the surrounding territory.."

The letter also called Roosevelt's attention to the fact that Germany had already stopped the export of uranium from the Czech mines under German control. After making a few corrections, Einstein signed it. On October 11, 1939, three weeks after the defeat of Poland, Roosevelt's economic adviser, Alexander Sachs, personally delivered the letter to the President. After discussing it with Sachs, the President commented,"This calls for action." Later, when atomic bombs were dropped on civilian populations in an already virtually-defeated Japan, Einstein bitterly regretted having signed Szilard's letter to Roosevelt. He said repeatedly that signing the letter was the greatest mistake of his life, and his remorse was extreme.

Throughout the remainder of his life, in addition to his scientific work, Einstein worked tirelessly for peace, international understanding and nuclear disarmament. His last public act, only a few days before his death in 1955, was to sign the Russell-Einstein Manifesto, warning humankind of the catastrophic consequences that would follow from a war with nuclear weapons.

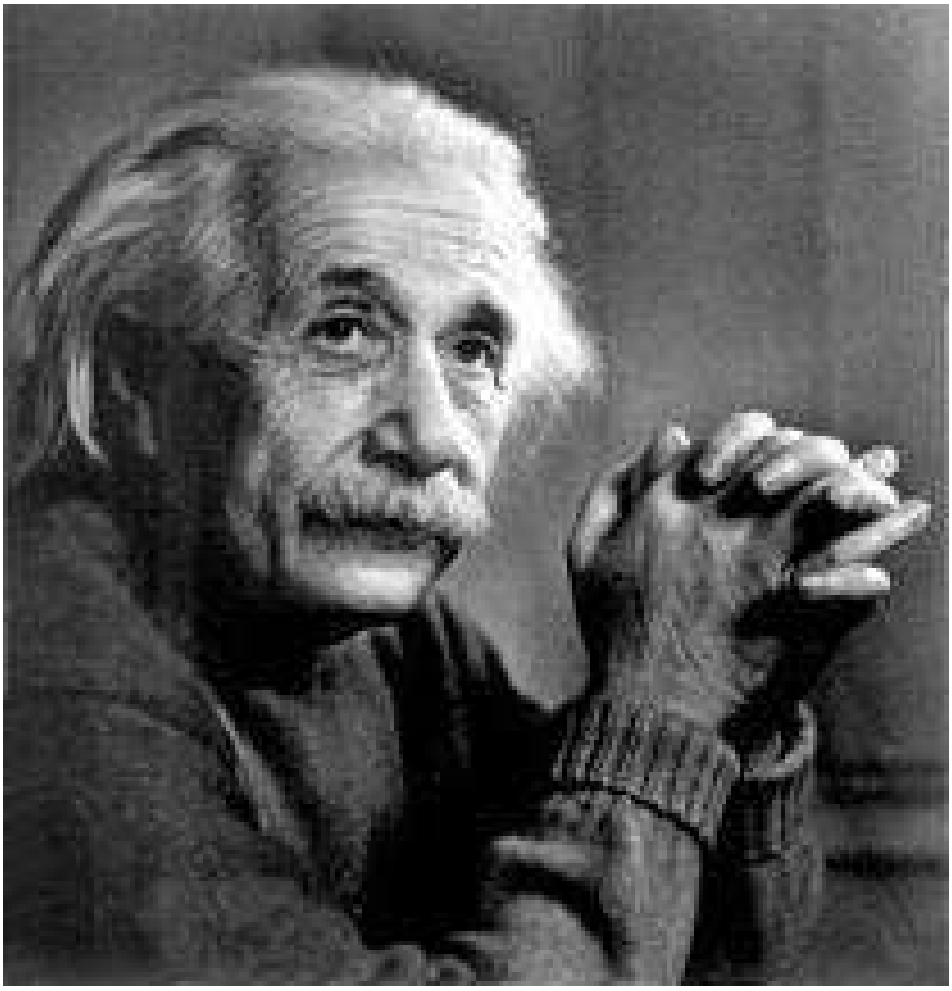

Figure 6.2: **Signing the Russell-Einstein declaration was the last public act of Einstein's life.**

6.5 A few more things that Einstein said about peace:

We cannot solve our problems with the same thinking that we used when we created them.

It has become appallingly obvious that our technology has exceeded our humanity.

Peace cannot be kept by force; it can only be achieved by understanding.

The world is a dangerous place to live; not because of the people who are evil, but because of the people who don't do anything about it.

Insanity: doing the same thing over and over again and expecting to get different results.

Nothing will end war unless the people themselves refuse to go to war.

Past thinking and methods did not prevent world wars. Future thinking must prevent war.

You cannot simultaneously prevent and prepare for war.

Never do anything against conscience, even if the state demands it.

Taken as a whole, I would believe that Gandhi's views were the most enlightened of all political men of our time.

Without ethical culture, there is no salvation for humanity.

War seems to me to be a mean, contemptible thing: I would rather be hacked in pieces than take part in such an abominable business. And yet so high, in spite of everything, is my opinion of the human race that I believe this bogey would have disappeared long ago, had the sound sense of the nations not been systematically corrupted by commercial and political interests acting through the schools and the Press.

Suggestions for further reading

1. Paul Arthur Schlipp (editor), *Albert Einstein: Philosopher-Scientist*, Open Court Publishing Co., Lasalle Illinois (1970).

2. Banesh Hoffmann, *Albert Einstein, Creator and Rebel*, The Viking Press, New York (1972).
3. Albert Einstein and Leopold Infeld, *The Evolution of Physics*, Cambridge University Press (1971).

Chapter 7

NIELS BOHR ANTICIPATES THE NUCLEAR ARMS RACE

7.1 Christian Bohr's household

Christian Bohr (1855-1911) was appointed professor of physiology at the University of Copenhagen in 1886. In this position, he made a number of important discoveries connected with respiration in mammals, including what is now known as the "Bohr effect", i.e. the tendency of high concentrations of CO_2 and of H^+ ions to increase the efficiency of hemoglobin in releasing oxygen. Christian Bohr was also the teacher of August Krogh, who later won a Nobel Prize in Medicine and Physiology.

Christian Bohr's wife, Ellen Adler Bohr, belonged to a wealthy Jewish banking family, and Niels Bohr was born in the impressive multi-story Adler mansion that still stands today near one of Copenhagen's canals opposite the Danish Parliament. During the time that Niels and Harold Bohr were growing up, this house was the meeting place for many of Copenhagen's leading intellectuals, and the boys were allowed to attend meetings where scientific and philosophical questions were debated. This upbringing contributed to the fact that both Niels and Harold later became famous in their respective fields, physics and mathematics.

The Bohr family has produced outstanding scientists for four generations. Besides Christian, Niels and Harold Bohr, there is also Niels' son Aage, who shared a Nobel Prize in Physics for his work on the excited states of nuclei. Aage's sons, Vilhelm and Thomas, are also outstanding scientists.

Having been brought up in a highly intellectual household, Niels Bohr's scientific abilities developed early. In 1905, when Niels was 20, a gold medal competition was announced by the Royal Danish Society of Sciences and Letters. The challenge was to investigate a method for determining the surface tension of liquids. The method had been proposed earlier by Lord Raleigh, and it involved measuring the frequency of oscillations on the surface of a water jet. After working in his father's laboratory, making his own glassware to produce elliptical water jets, and presenting his results together with a mathematical

Figure 7.1: **Christian Bohr (1855-1911), the father of Niels and Harold Bohr. He was Professor of Physiology at the University of Copenhagen.**

analysis, Niels Bohr won the gold medal.

Figure 7.2: **Niels Bohr (1885-1952) as a young man.**

Figure 7.3: **Niels Bohr and his wife, Margrethe.**

7.2 Planck, Einstein and Bohr

According to the model proposed by Rutherford in 1911, every atom has an extremely tiny nucleus, which contains almost all of the mass of the atom. Around this tiny but massive nucleus, Rutherford visualized light, negatively-charged electrons circulating in orbits, like planets moving around the sun. Rutherford calculated that the diameter of the whole atom had to be several thousand times as large as the diameter of the nucleus.

Rutherford's model of the atom explained beautifully the scattering experiments of Geiger and Marsden, but at the same time it presented a serious difficulty: According to Maxwell's equations, the electrons circulating in their orbits around the nucleus ought to produce electromagnetic waves. It could easily be calculated that the electrons in Rutherford's atom ought to lose all their energy of motion to this radiation, and spiral in towards the nucleus. Thus, according to classical physics, Rutherford's atom could not be stable. It had to collapse.

Niels Bohr became aware of this paradox when he worked at Rutherford's Manchester laboratory during the years 1911-1913. Bohr was not at all surprised by the failure of classical concepts when applied to Rutherford's nuclear atom. Since he had been educated in Denmark, he was more familiar with the work of German physicists than were his English colleagues at Manchester. In particular, Bohr had studied the work of Max Planck (1858-1947) and Albert Einstein (1879-1955).

Just before the turn of the century, the German physicist, Max Planck, had been studying theoretically the electromagnetic radiation coming from a small hole in an oven. The hole radiated as though it were an ideally black body. This "black body radiation" was very puzzling to the physicists of the time, since classical physics failed to explain the frequency distribution of the radiation and its dependence on the temperature of the oven.

In 1901, Max Planck had discovered a formula which fitted beautifully with the experimental measurements of the frequency distribution of black body radiation; but in order to derive his formula, he had been forced to make a radical assumption which broke away completely from the concepts of classical physics.

Planck had been forced to assume that light (or, more generally, electromagnetic radiation of any kind) can only be emitted or absorbed in amounts of energy which Planck called "quanta". The amount of energy in each of these "quanta" was equal to the frequency of the light multiplied by a constant, h, which came to be known as "Planck's constant".

This was indeed a strange assumption! It seemed to have been pulled out of thin air; and it had no relation whatever to anything that had been discovered previously in physics. The only possible justification for Planck's quantum hypothesis was the brilliant success of his formula in explaining the puzzling frequency distribution of the black body radiation. Planck himself was greatly worried by his own radical break with classical concepts, and he spent many years trying unsuccessfully to relate his quantum hypothesis to classical physics.

In 1905, Albert Einstein published a paper in the *Annalen der Physik* in which he applied Planck's quantum hypothesis to the photoelectric effect. (At that time, Einstein was 25 years old, completely unknown, and working as a clerk at the Swiss Patent Office.)

Figure 7.4: **Niels Bohr and Albert Einstein in a photo by Paul Ehrenfest. Public domain, Wikimedia Commons**

The photoelectric effect was another puzzling phenomenon which could not in any way be explained by classical physics. The German physicist Lenard had discovered in 1903 that light with a frequency above a certain threshold could knock electrons out of the surface of a metal; but below the threshold frequency, nothing at all happened, no matter how long the light was allowed to shine.

Using Planck's quantum hypothesis, Einstein offered the following explanation for the photoelectric effect: A certain minimum energy was needed to overcome the attractive forces which bound the electron to the metal surface. This energy was equal to the threshold frequency multiplied by Planck's constant. Light with a frequency equal to or higher than the threshold frequency could tear an electron out of the metal; but the quantum of energy supplied by light of a lower frequency was insufficient to overcome the attractive forces.

Einstein later used Planck's quantum formula to explain the low-temperature behavior of the specific heats of crystals, another puzzling phenomenon which defied explanation by classical physics. These contributions by Einstein were important, since without this supporting evidence it could be maintained that Planck's quantum hypothesis was an *ad hoc* assumption, introduced for the sole purpose of explaining black body radiation.

As a student, Niels Bohr had been profoundly impressed by the radical ideas of Planck and Einstein. In 1912, as he worked with Rutherford at Manchester, Bohr became convinced that the problem of saving Rutherford's atom from collapse could only be solved by means of Planck's quantum hypothesis.

Returning to Copenhagen, Bohr continued to struggle with the problem. In 1913, he found the solution: The electrons orbiting around the nucleus of an atom had "angular momentum". Assuming circular orbits, the angular momentum was given by the product

of the mass and velocity of the electron, multiplied by the radius of the orbit. Bohr introduced a quantum hypothesis similar to that of Planck: He assumed that the angular momentum of an electron in an allowed orbit, (multiplied by 2 pi), had to be equal to an integral multiple of Planck's constant. The lowest value of the integer, n=1, corresponded to the lowest allowed orbit. Thus, in Bohr's model, the collapse of Rutherford's atom was avoided.

Bohr calculated that the binding energies of the various allowed electron orbits in a hydrogen atom should be a constant divided by the square of the integer n; and he calculated the value of the constant to be 13.5 electron-Volts. This value fit exactly the observed ionization energy of hydrogen. After talking with the Danish spectroscopist, H.M. Hansen, Bohr realized with joy that by combining his formula for the allowed orbital energies with the Planck-Einstein formula relating energy to frequency, he could explain the mysterious line spectrum of hydrogen.

When Niels Bohr published all this in 1913, his paper produced agonized cries of "foul!" from the older generation of physicists. When Lord Rayleigh's son asked him if he had seen Bohr's paper, Rayleigh replied: "Yes, I have looked at it; but I saw that it was of no use to me. I do not say that discoveries may not be made in that sort of way. I think very likely they may be. But it does not suit me." However, as more and more atomic spectra and properties were explained by extensions of Niels Bohr's theories, it became clear that Planck, Einstein and Bohr had uncovered a whole new stratum of phenomena, previously unsuspected, but of deep and fundamental importance.

Figure 7.5: **Another photo of Bohr and Einstein by Ehrenfest. Public domain, Wikimedia Commons**

7.3 Atomic numbers

Bohr's atomic theory soon received strong support from the experiments of one of the brightest of Rutherford's bright young men - Henry Moseley (1887-1915). Moseley came from a distinguished scientific family. Not only his father, but also both his grandfathers, had been elected to the Royal Society. After studying at Oxford, where his father had once been a professor, Moseley found it difficult to decide where to do his postgraduate work. Two laboratories attracted him: the great J.J. Thomson's Cavendish Laboratory at Cambridge, and Rutherford's laboratory at Manchester. Finally, he decided on Manchester, because of the revolutionary discoveries of Rutherford, who two years earlier had won the 1908 Nobel Prize for Chemistry.

Rutherford's laboratory was like no other in the world, except J.J. Thomson's. In fact, Rutherford had learned much about how to run a laboratory from his old teacher, Thomson. Rutherford continued Thomson's tradition of democratic informality and cheerfulness. Like Thomson, he had a gift for infecting his students with his own powerful scientific curiosity, and his enthusiastic enjoyment of research.

Thomson had also initiated a tradition for speed and ingenuity in the improvisation of experimental apparatus - the so-called "sealing-wax and string" tradition - and Rutherford continued it. Niels Bohr, after working with Rutherford, was later to continue the tradition of informality and enthusiasm at the Institute for Theoretical Physics which Bohr founded in Copenhagen in 1920.

Niels Bohr had shown that the binding energies of the allowed orbits in a hydrogen atom are equal to Rydberg's constant , R (named after the distinguished Swedish spectroscopist, Johannes Robert Rydberg), divided by the square of an integral "quantum number", n. He had also shown that for heavier elements, the constant, R, is equal to the square of the nuclear charge, Z, multiplied by a factor which is the same for all elements. The constant, R, could be observed in Moseley's studies of X-ray spectra: Since X-rays are produced when electrons are knocked out of inner orbits and outer electrons fall in to replace them, Moseley could use the Planck-Einstein relationship between frequency and energy to find the energy difference between the orbits, and Bohr's theory to relate this to R.

Moseley found complete agreement with Bohr's theory. He also found that the nuclear charge, Z, increased regularly in integral steps as he went along the rows of the periodic table: Hydrogen had Z=1, helium Z=2, lithium Z=3, and so on up to uranium with Z=92. The 92 electrons of a uranium atom made it electrically neutral, exactly balancing the charge of the nucleus. The number of electrons of an element, and hence its chemical properties, Moseley found, were determined uniquely by its nuclear charge, which Moseley called the "atomic number".

Moseley's studies of the nuclear charges of the elements revealed that a few elements were missing. In 1922, Niels Bohr received the Nobel Prize for his quantum theory of the atom; and he was able to announce at the presentation ceremony that one of Moseley's missing elements had been found at his institute. Moseley, however, was dead. He was one of the ten million young men whose lives were needlessly thrown away in Europe's most tragic blunder - the First World War.

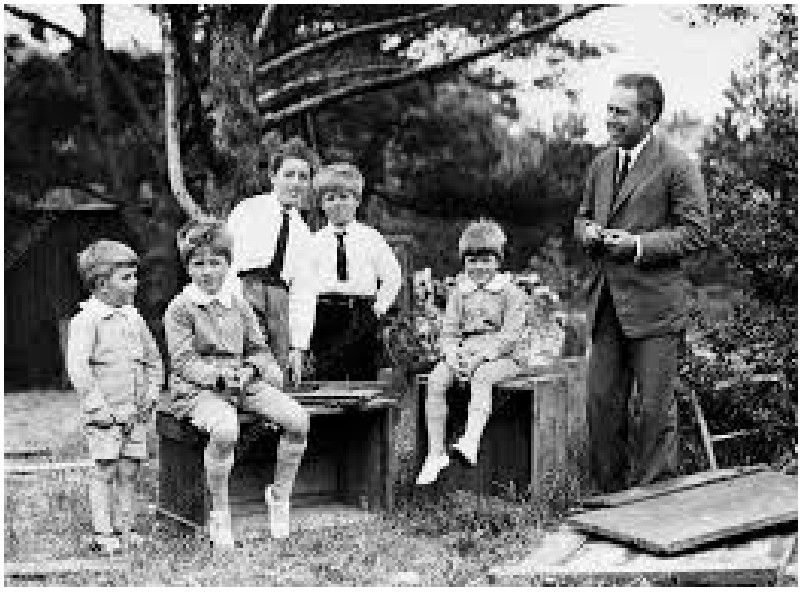

Figure 7.6: **Niels Bohr with his sons at their summer house in Tisvilde.**

7.4 Bohr's Institute of Theoretical Physics

In 1916, Niels Bohr was appointed professor of theoretical physics at the University of Copenhagen, a post that had been created especially for him. The following year, in 1917, he started to raise money for the construction of a new institute in which his new department could be housed. The project received large contributions from the Danish government and the Carlsberg Foundation, and from wealthy Danish businessmen. Bohr himself designed the building, which opened in 1920.

During the period when Hitler's Nazi party was coming to power in Germany, Bohr was able to offer a refuge at his Institute of Theoretical Physics to many important physicists who could no longer remain in Germany. Those to whom Bohr gave refuge included Guido Beck, Felix Bloch, James Franck, George de Hevesy, Otto Frisch, Hilde Levi, Lise Meitner, George Placzek, Eugene Rabinowitch, Stefan Rozental, Erich Ernst Schneider, Edward Teller, Arthur von Hippel and Victor Weisskopf. Because of this, because of Bohr's dynamic and inspiring presence, and because he was able to continue the tradition of informality, enthusiasm and speed which characterized J.J. Thomson's Cavendish and Rutherford's Manchester laboratories, Bohr's institute became the world's most important center for theoretucl physics, especially during the 1930's.

Bohr was tirelessly energetic. He liked to discuss his ideas in dialogue with one of the bright young men at his institute, putting forward an idea, and expecting a counter-argument to be thrown back. It was like a game of ping-pong. In this way, a new idea could be tested by exploring all of its consequences.

When a new scientist arrived at his institute, Bohr liked to invite the newcomer to accompany him on a two-day walking tour to his summer house in Tisvilde, about 50

kilometers north of Copenhagen. In his autobiographical book "Physics and Beyond", Werner Heisenberg describes such a two-man tour together with Bohr. This custom allowed Bohr to get to know both the personality and the potential scientific contributions of the new arrival. It also allowed Bohr to get some exercise and to keep himself in good physical condition.

The Nazi occupation of Denmark

On 9 April, 1940, Nazi Germany invaded and quickly occupied Denmark. The Germans explained that their purpose was "to protect Denmark from a British invasion". During the first three years of occupation the Germans allowed the Danish government, police force and army to exist. However, in 1943, after extensive sabotage actions by the Danish resistance movement, the German policy changed and became much harsher.

Shortly after this sudden change, the Danes became aware that their Jewish population was in danger of being arrested and sent to concentration camps. Luckily it was possible for Danish citizens to organize a secret rescue operation, in which almost all members of Denmark's Jewish community escaped to Sweden in small boats. Among them were Niels Bohr and his son Aage.

Niels and Aage Bohr fly to England

After some time in Sweden, where he helped to organize aid for Jewish refugees from Denmark, Niels Bohr and his son Aage flew to England in a small aircraft. It flew at a high altitude in order to avoid observation. Niels Bohr's oxygen mask did not fit properly because of his unusually large head, and he became unconscious. Luckily this was noticed before anything very serious happened.

Figure 7.7: **The Institute of Theoretical Physics, established by Niels Bohr at the University of Copenhagen. Today it is known as the Niels Bohr Institute**

Figure 7.8: **Another view of the Niels Bohr Institute.**

Figure 7.9: **Aage Bohr (1922-2008), one of Niels and Margrethe Bohr's sons. Together with Ben Mottelson, he was awarded the 1975 Nobel Prize in Physics for developing a successful theory of the excited states of nuclei.**

Figure 7.10: **Ben Roy Mottelson (born in 1926), who shared the 1975 Nobel Prize in Physics with Aage Bohr. Although now very old, he still comes in to work at the Niels Bohr Institute.**

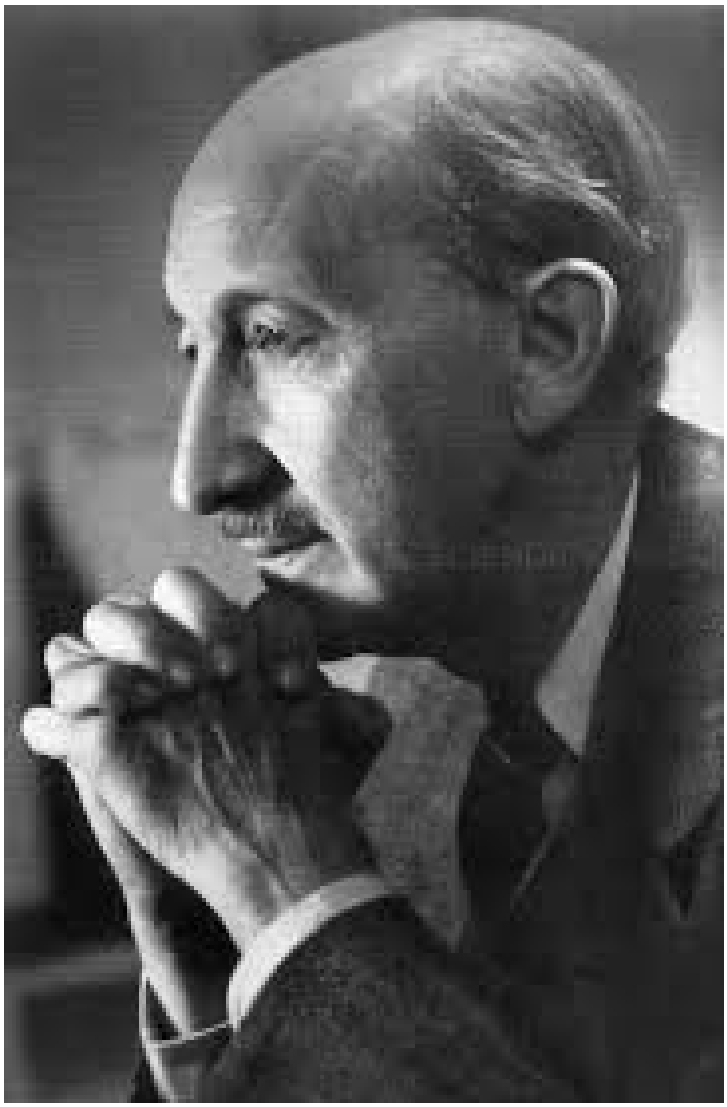

Figure 7.11: **George de Hevesy (1885-1966), co-discoverer of the element Haffnium, and pioneer of the use of radioactive tracer elements in biochemistry. He received the Nobel Prize in Chemistry in 1943 for work which he performed at the Niels Bohr Institute. The name "Haffnium" is derived from the Latin name for Copenhagen.**

7.5 Bohr anticipates the nuclear arms race

After escaping from Denmark to Sweden in a fishing boat in 1943, Niels Bohr and his son Aage flew to England, and then to Los Alamos in the United States, where work on a nuclear bomb was in progress. In 1943, a special intelligence unit called "Aslos" had been set up to determine how far German work on a nuclear bomb had progressed. Advanced units, entering mainland Europe after D-Day, intervied captured German scientists and found that the German program had never come near to producing a nuclear bomb.

The news that the Germans would not produce atomic bombs was classified as a secret. Nevertheless, it passed through the grapevine to the scientists working on the atomic bomb project in America; and it reversed their attitude to the project. Until then, they had been worried that Hitler would be the first to produce nuclear weapons. In 1944, they began to worry instead about what the American government might do if it came to possess such weapons.

At Los Alamos, Niels Bohr became the center of discussion and worry about the ethics of continued work on the bomb project. He was then 59 years old; and he was universally respected both for his pioneering work in atomic physics, and for his outstandingly good character.

Bohr was extremely worried because he foresaw a postwar nuclear arms race unless international control of atomic energy could be established. Consequently, as a spokesman for the younger atomic scientists, he approached both Roosevelt and Churchill to urge them to consider means by which international control might be established.

Roosevelt, too, was worried about the prospect of a postwar nuclear armaments race; and he was very sympathetic towards Bohr's proposals for international control. He suggested that Bohr travel to England and contact Churchill, to obtain his point of view.

Churchill was desperately busy, and basically unsympathetic towards Bohr's proposals; but on May 16, 1944, he agreed to a half-hour interview with the scientist. The meeting was a complete failure. Churchill and his scientific advisor, Lord Cherwell, spent most of the time talking with each other, so that Bohr had almost no time to present his ideas.

Although he could be very persuasive in long conversations, Bohr was unable to present his thoughts briefly. He wrote and spoke in a discursive style, similar to that of Henry James. Each of his long, convoluted sentences was heavily weighted with qualifications and dependent clauses. At one point in the conversation, Churchill turned to Lord Cherwell and asked: "What's he talking about, physics or politics?"

Bohr's low, almost whispering, way of speaking irritated Churchill. Furthermore, the two men were completely opposed in their views: Bohr was urging openness in approaching the Russians, with a view to establishing international control of nuclear weapons. Churchill, a defender of the old imperial order, was concerned mainly with maintaining British and American military supremacy.

After the interview, Churchill became worried that Bohr would give away "atomic secrets" to the Russians; and he even suggested that Bohr be arrested. However, Lord Cherwell explained to the Prime Minister that the possibility of making atomic bombs, as well as the basic means of doing so, had been common knowledge in the international

scientific community ever since 1939.

After his disastrous interview with Churchill, Niels Bohr carefully prepared a memorandum to be presented to President Roosevelt. Realizing how much depended on its success or failure, Bohr wrote and rewrote the memorandum, sweating in the heat of Washington's summer weather. Aage Bohr, who acted as his father's secretary, typed the memorandum over and over, following his father's many changes of mind.

Finally, in July, 1944, Bohr's memorandum was presented to Roosevelt. It contains the following passages:

"...Quite apart from the question of how soon the weapon will be ready for use, and what role it will play in the present war, this situation raises a number of problems which call for urgent attention. Unless, indeed, some agreement about the control of the new and active materials can be obtained in due time, any temporary advantage, however great, may be outweighed by a perpetual menace to human society."

"Ever since the possibilities of releasing atomic energy on a vast scale came into sight, much thought has naturally been given to the question of control; but the further the exploration of the scientific problems is proceeding, the clearer it becomes that no kind of customary measures will suffice for this purpose, and that the terrifying prospect of a future competition between nations about a weapon of such formidable character can only be avoided by a universal agreement in true confidence..."

Roosevelt was sympathetic with the ideas expressed in this memorandum. In an interview with Bohr, he expressed his broad agreement with the idea of international control of atomic energy. Unfortunately, the President had only a few months left to live.

Roosevelt's successor, Harry Truman, had not known about the existence of nuclear weapons before taking office, and he was cautiously feeling his way. Meanwhile, General Leslie Groves, the military commander of the Los Alamos project, was very anxious to get credit for ending World War II, rather than being blamed for wasting billions of dollars of the taxpayers' money. It was easy for Groves to convince Truman to give the order to drop bombs on Hiroshima and Nagasaki. Thus Bohr's efforts to prevent this tragedy failed, and the postwar nuclear arms race which he anticipated still casts a dark shadow over the future of human civilization and the biosphere.

Suggestions for further reading

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Chapter 8

LINUS PAULING, CHEMISTRY AND PEACE

8.1 Pauling's contributions to science

Linus Pauling's contributions to science are too numerous to be listed in detail here. We will only discuss his work as the principal founder of a new discipline: quantum chemistry.

Lewis structures

In 1916, G.N. Lewis of the University of California, Berkeley, proposed a theory of chemical bonding in which a pair of electrons, one donated by each of the bonding atoms, together form a covalent bond. For example, in the hydrogen molecule, H_2, one electron is contributed by each of the two hydrogen atoms. Another example of a Lewis structure is the NO_2^- ion shown in Figure 15.2. The outer-shell electrons that do not contribute to bonding are represented by pairs of dots and are called *lone pairs*.

Heitler-London theory

The next step in valence bond theory was taken in 1927 by Walter Heitler and Fritz London, who used Erwin Schrödinger's wave equation and Wolfgang Pauli's exclusion principle to study the covalent bonding of the hydrogen molecule.

Linus Pauling's contributions

Linus Pauling developed these ideas further by introducing the key concepts of resonance and orbital hybredization. Pauling's two famous books, *Introduction to Quantum Mechanics, With Applications to Chemistry* (with E. Bright Wilson, 1935), and *The Nature of the Chemical Bond* (1939) were extremely important and influential, as was Charles Coulson's *Valence* (1952).

Figure 8.1: **Gilbert N. Lewis (1875-1946). He was nominated for the Nobel Prize in Chemistry 41 times, but never won it.**

Figure 8.2: **The NO_2^- ion, an example of a Lewis structure.**

8.2 Molecular orbital theory

In molecular orbital theory, atomic orbitals shown in in Figure 11.6 are used to build up a representation of the orbital of an electron moving in a molecule. For example, Figure 15.3 shows a schematic diagram of the LCAO (Linear Combination of Atomic Orbitals) model of bonding in the H_2 molecule. When two hydrogen atoms approach each other, the two electrons move in an attractive potential produced by both nuclei. Thus the range of their motion is enlarged. According to the Pauli exclusion principle, both electrons are allowed to move in this enlarged region, if they have opposite spins. The electronic wave function in the enlarged region of motion is called a a *molecular orbital*.

In the LCAO approximation, molecular orbitals are built up from atomic orbitals centered on the individual atoms of a molecule. For example, suppose that in the H_2 molecule we denote the positions of the two nuclei by $\mathbf{X}_1$ and $\mathbf{X}_2$. Then we can approximate the molecular orbitals $\phi_\sigma(\mathbf{x})$ and $\phi_{\sigma^*}(\mathbf{x})$ by symmetric and antisymmetric combinations of the two atomic orbitals, $\chi_{1s}(\mathbf{x}-\mathbf{X}_1)$ and $\chi_{1s}(\mathbf{x}-\mathbf{X}_2)$:

$$\begin{aligned} \phi_\sigma(\mathbf{x}) &= N\left[\chi_{1s}(\mathbf{x}-\mathbf{X}_1)+\chi_{1s}(\mathbf{x}-\mathbf{X}_2)\right] \\ \phi_{\sigma^*}(\mathbf{x}) &= N'\left[\chi_{1s}(\mathbf{x}-\mathbf{X}_1)-\chi_{1s}(\mathbf{x}-\mathbf{X}_2)\right] \end{aligned} \tag{8.1}$$

where N and N' are normalizing constants. The symmetric combination is called a *bonding orbital*, and in the hydrogen molecule ground state it is doubly occupied, the two electrons having opposite spin quantum numbers. In the ground state of H_2, the antibomding orbital, $\phi_{\sigma^*}(\mathbf{x})$, is unoccupied, as is illustrated schematically in Figure 15.3.

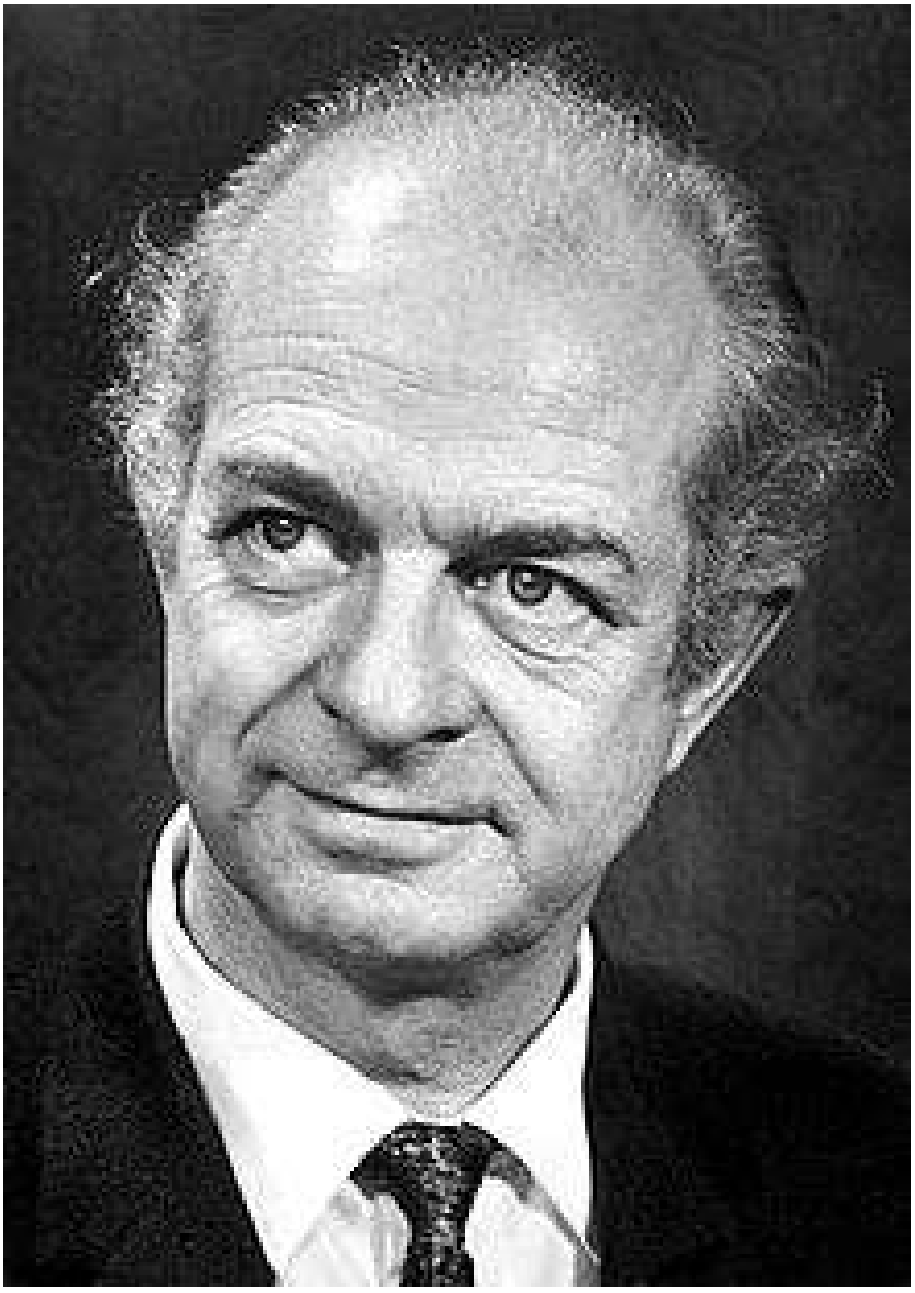

Figure 8.3: **Linus Pauling (1901-1994). The New Scientist called him one of the 20 most important scientists in history. He was awarded the Nobel Prize in Chemistry in 1954 and the Nobel Peace Prize in 1962.**

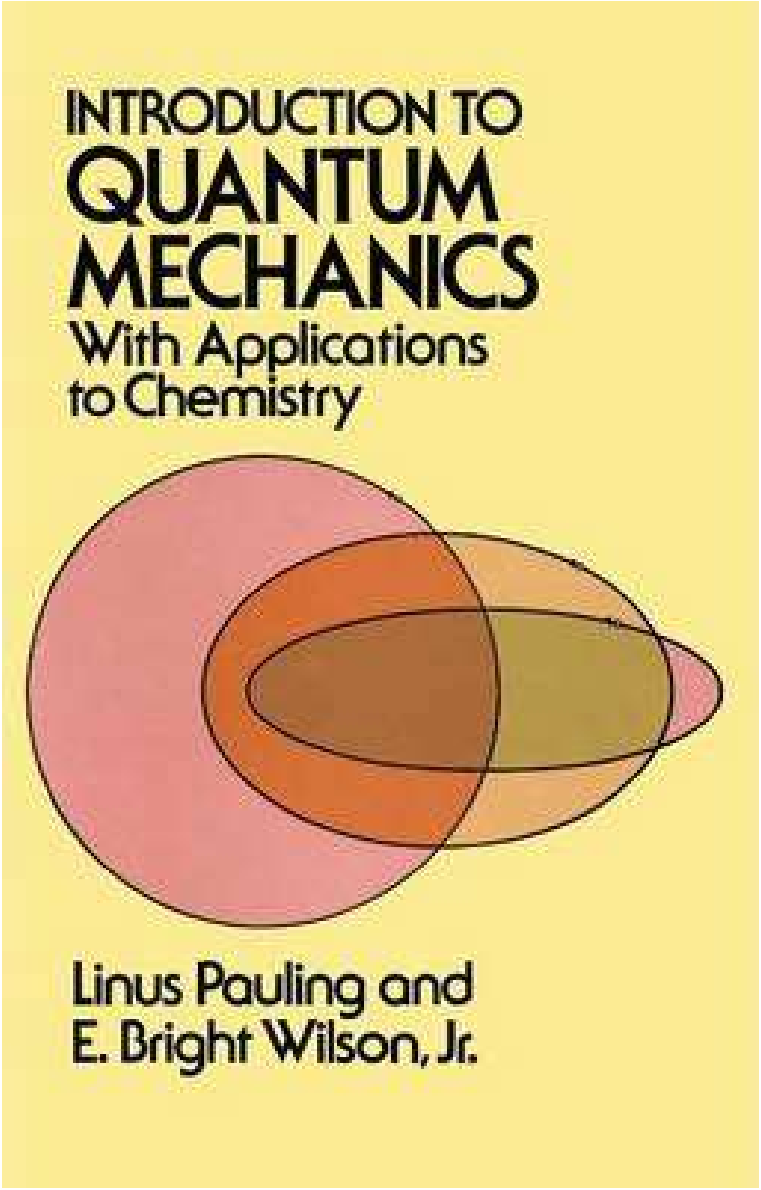

Figure 8.4: **Two-time Nobel Prize winner Linus Pauling, Research Professor at the Linus Pauling Institute of Science and Medicine, Palo Alto, California, and E. Bright Wilson, Jr., Professor Emeritus of Chemistry at Harvard University, provide a readily understandable study of "wave mechanics," discussing the Schrödinger wave equation and the problems which can be solved with it. The book was first published in 1935, and it is still in use today.**

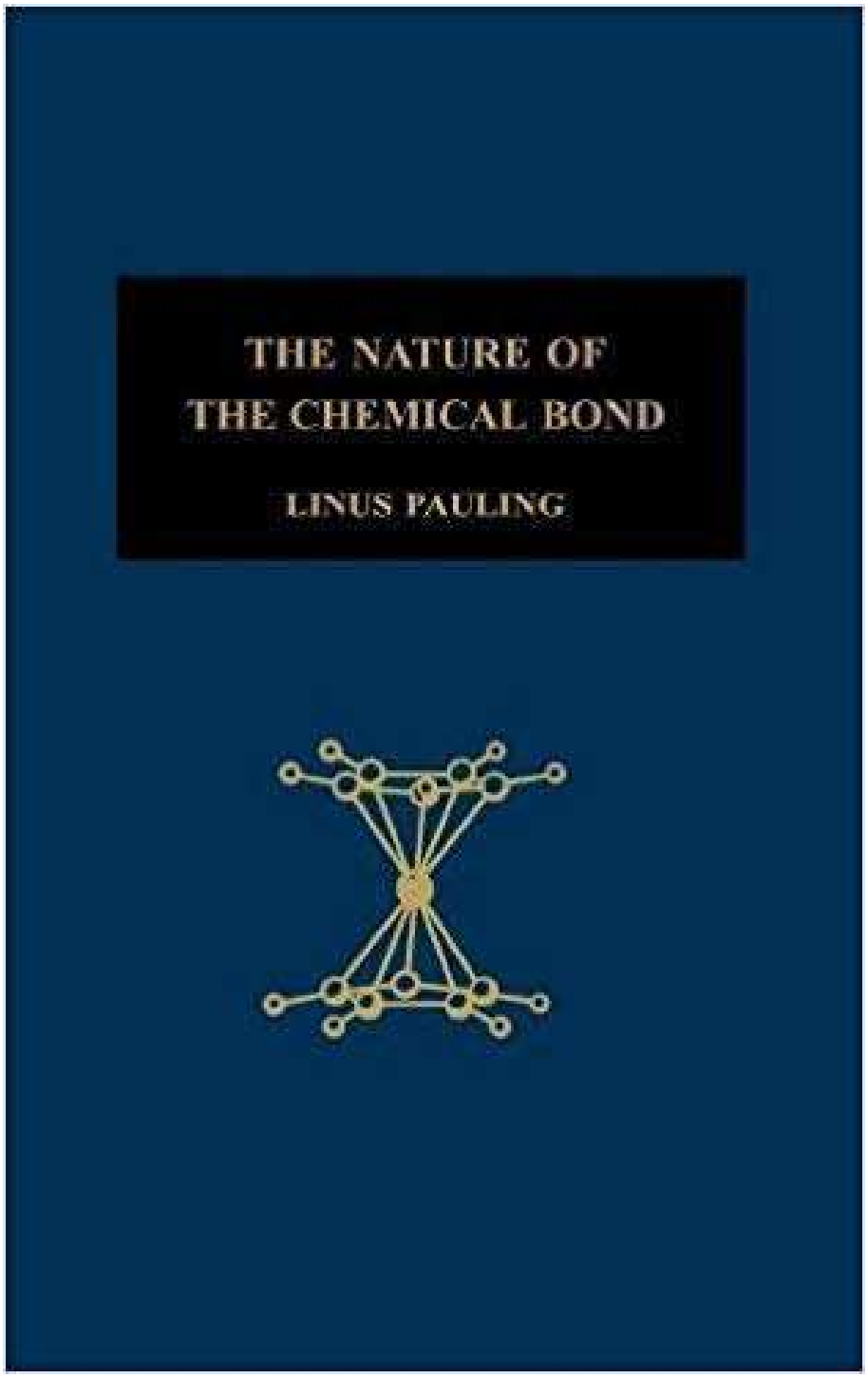

Figure 8.5: **Linus Pauling's famous book, *The Nature of the Chemical Bond and the Structure of Molecules and Crystals*. Cornell University Press, 1939.**

8.3 Pauling's Nobel Lecture, 1962: *Science and Peace*

Here are some excerpts from the lecture:

I believe that there will never again be a great world war - a war in which the terrible weapons involving nuclear fission and nuclear fusion would be used. And I believe that it is the discoveries of scientists upon which the development of these terrible weapons was based that is now forcing us to move into a new period in the history of the world, a period of peace and reason, when world problems are not solved by war or by force, but are solved in accordance with world law, in a way that does justice to all nations and that benefits all people.

Let me again remind you, as I did yesterday in my address of acceptance of the Nobel Peace Prize for 1962, that Alfred Nobel wanted to invent "a substance or a machine with such terrible power of mass destruction that war would thereby be made impossible forever". Two thirds of a century later scientists discovered the explosive substances that Nobel wanted to invent the fissionable substances uranium and plutonium, with explosive energy ten million times that of Nobel's favorite explosive, nitroglycerine, and the fusionable substance lithium deuteride, with explosive energy fifty million times that of nitroglycerine. The first of the terrible machines incorporating these substances, the uranium-235 and plutonium-239 fission bombs, were exploded in 1945, at Alamogordo, Hiroshima, and Nagasaki2. Then in 1954, nine years later, the first of the fission-fusion-fission superbombs was exploded, the 20-megaton Bikini bomb, with energy of explosion one thousand times greater than that of a 1945 fission bomb.

This one bomb, the 1954 superbomb, contained less than one ton of nuclear explosive. The energy released in the explosion of this bomb was greater than that of all of the explosives used in all of the wars that have taken place during the entire history of the world, including the First World War and the Second World War.

Thousands of these superbombs have now been fabricated; and today, eighteen years after the construction of the first atomic bomb, the nuclear powers have stockpiles of these weapons so great that if they were to be used in a war hundreds of millions of people would be killed, and our civilization itself might not survive the catastrophe.

Thus the machines envisaged by Nobel have come into existence, and war has been made impossible forever.

The world has now begun its metamorphosis from its primitive period of history, when disputes between nations were settled by war, to its period of maturity, in which war will be abolished and world law will take its place. The first great stage of this metamorphosis took place only a few months ago - the formulation by the governments of the United States, Great Britain, and the Soviet Union, after years of discussion and negotiation, of a Treaty banning the

testing of nuclear weapons on the surface of the earth, in the oceans, and in space, and the ratification and signing of this treaty by nearly all of the nations in the world.

I believe that the historians of the future may well describe the making of this treaty as the most important action ever taken by the governments of nations, in that it is the first of a series of treaties that will lead to the new world from which war has been abolished forever.

We see that science and peace are related. The world has been greatly changed, especially during the last century, by the discoveries of scientists. Our increased knowledge now provides the possibility of eliminating poverty and starvation, of decreasing significantly the suffering caused by disease, of using the resources of the world effectively for the benefit of humanity. But the greatest of all the changes has been in the nature of war the several million fold increase in the power of explosives and corresponding changes in methods of delivery of bombs.

These changes have resulted from the discoveries of scientists, and during the last two decades scientists have taken a leading part in bringing them to the attention of their fellow human beings and in urging that vigorous action be taken to prevent the use of the new weapons and to abolish war from the world.

The first scientists to take actions of this sort were those involved in the development of the atomic bomb. In March, 1945, before the first nuclear explosion had been carried out, Leo Szilard prepared a memorandum4 to President Franklin Delano Roosevelt5 in which he pointed out that a system of international control of nuclear weapons might give civilization a chance to survive. A committee of atomic scientists, with James Franck as chairman, on June 11, 1945, transmitted to the U.S. Secretary of War a report urging that nuclear bombs not be used in an unannounced attack against Japan, as this action would prejudice the possibility of reaching an international agreement on control of these weapons.

In 1946 Albert Einstein, Harold Urey, and seven other scientists8 formed an organization to educate the American people about the nature of nuclear weapons and nuclear war. This organization, the Emergency Committee of Atomic Scientists (usually called the Einstein Committee), carried out an effective educational campaign over a five-year period. The nature of the campaign is indicated by the following sentences from the 1946 statement by Einstein:

"Today the atomic bomb has altered profoundly the nature of the world as we know it, and the human race consequently finds itself in a new habitat to which it must adapt its thinking... Never before was it possible for one nation to make war on another without sending armies across borders. Now with rockets and atomic bombs no center of population on the earth's surface is secure from surprise destruction in a single attack... Few men have ever seen the bomb. But all men if told a few facts can understand that this bomb and the danger

of war is a very real thing, and not something far away. It directly concerns every person in the civilized world. We cannot leave it to generals, senators, and diplomats to work out a solution over a period of generations... There is no defense in science against the weapon which can destroy civilization. Our defense is not in armaments, nor in science, nor in going underground. Our defense is in law and order... Future thinking must prevent wars."

During the same period and later years, many other organizations of scientists were active in the work of educating people about nuclear weapons and nuclear war; among them I may mention especially the Federation of American Scientists (in the United States)10, the Atomic Scientists' Association (Great Britain), and the World Federation of Scientific Workers (with membership covering many countries).

On July 15, 1955, a powerful statement, called the Mainau Declaration, was issued by fifty-two Nobel laureates. This statement warned that a great war in the nuclear age would imperil the whole world, and ended with the sentences: "All nations must come to the decision to renounce force as a final resort of policy. If they are not prepared to do this, they will cease to exist."

A document of great consequence, the Russell-Einstein Appeal, was made public by Bertrand Russell on July 9, 1955. Russell, who for years remained one of the world's most active and effective workers for peace, had drafted this document some months earlier, and it had been signed by Einstein two days before his death, and also by nine other scientists. The Appeal began with the sentence: "In the tragic situation which confronts humanity, we feel that scientists should assemble in conference to appraise the perils that have arisen as a result of the development of weapons of mass destruction..." And it ended with the exhortation: "There lies before us, if we choose, continual progress in happiness, knowledge, and wisdom. Shall we, instead, choose death, because we cannot forget our quarrels? We appeal, as human beings, to human beings: Remember your humanity, and forget the rest. If you can do so, the way lies open to a new Paradise; if you cannot, there lies before you the risk of universal death."

This Appeal led to the formation of the Pugwash Continuing Committee, with Bertrand Russell as chairman, and to the holding of a series of Pugwash Conferences (eleven during the years 1957 to 1963). Financial support for the first few conferences was provided by Mr. Cyrus Eaton, and the first conference was held in his birthplace, the village of Pugwash, Nova Scotia.

Among the participants in some of the Pugwash Conferences have been scientists with a close connection with the governments of their countries, as well as scientists without government connection. The Conferences have permitted the scientific and practical aspects of disarmament to be discussed informally in a thorough, penetrating, and productive way and have led to some valuable proposals. It is my opinion that the Pugwash Conferences were significantly helpful in the formulation and ratification of the 1963 Bomb Test Ban Treaty.

Concern about the damage done to human beings and the human race by the radioactive substances produced in nuclear weapons tests was expressed with increasing vigor in the period following the first fission-fusion-fission bomb test at Bikini on March 1, 1954. Mention was made of radioactive fallout in the Russell-Einstein Appeal and also in the statement of the First Pugwash Conference. In his Declaration of Conscience issued in Oslo on April 24, 1957, Dr. Albert Schweitzer described the damage done by fallout and asked that the great nations cease their tests of nuclear weapons. Then on May 15, 1957, with the help of some of the scientists in Washington University, St. Louis, I wrote the Scientists' Bomb Test Appeal, which within two weeks was signed by over two thousand American scientists and within a few months by 11,021 scientists, of forty-nine countries. On January 15, 1958, as I presented the Appeal to Dag Hammarskjöld as a petition to the United Nations, I said to him that in my opinion it represented the feelings of the great majority of the scientists of the world. The Bomb Test Appeal consists of five paragraphs. The first two are the following:

"We, the scientists whose names are signed below, urge that an international agreement to stop the testing of nuclear bombs be made now.

"Each nuclear bomb test spreads an added burden of radioactive elements over every part of the world. Each added amount of radiation causes damage to the health of human beings all over the world and causes damage to the pool of human germ plasm such as to lead to an increase in the number of seriously defective children that will be born in future generations."

Let me now say a few words to amplify the last statement, about which there has been controversy. Each year, of the nearly 100 million children born in the world, about 4,000,000 have gross physical or mental defects, such as to cause great suffering to themselves and their parents and to constitute a major burden on society. Geneticists estimate that about five percent, 200,000 per year, of these children are grossly defective because of gene mutations caused by natural high-energy radiation - cosmic rays and natural radioactivity, from which our reproductive organs cannot be protected. This numerical estimate is rather uncertain, but geneticists agree that it is of the right order of magnitude.

Moreover, geneticists agree that any additional exposure of the human reproductive cells to high-energy radiation produces an increase in the number of mutations and an increase in the number of defective children born in future years, and that this increase is approximately proportional to the amount of the exposure.

The explosion of nuclear weapons in the atmosphere liberates radioactive fission products - cesium 137, strontium go, iodine 131, and many others. In addition, the neutrons that result from the explosion combine with nitrogen nuclei in the atmosphere to form large amounts of a radioactive isotope of carbon, carbon 14, which then is incorporated into the organic molecules of every human being. These radioactive fission products are now damaging the

pool of human germ plasma and increasing the number of defective children born.

Carbon 14 deserves our special concern. It was pointed out by the Soviet scientist O.I. Leipunsky in 1957 that this radioactive product of nuclear tests would cause more genetic damage to the human race than the radioactive fallout (cesium 137 and other fission products), if the human race survives over the 8,000-year mean life of carbon 14. Closely agreeing numerical estimates of the genetic effects of bomb-test carbon 14 were then made independently by me and by Drs. Totter, Zelle, and Hollister of the United States Atomic Energy Commission. Especially pertinent is the fact that the so-called "clean" bombs, involving mainly nuclear fusion, produce when they are tested more carbon 14 per megaton than the ordinary fission bombs or fission-fusion-fission bombs...

Many estimates have been made by scientists of the probable effects of hypothetical nuclear attacks. One estimate, reported in the 1957 Hearings before the Special Subcommittee on Radiation of the Joint Committee on Atomic Energy of the Congress of the United States, was for an attack on population and industrial centers and military installations in the United States with 250 bombs totaling 2,500 megatons. The estimate of casualties presented in the testimony, corrected for the increase in population since 1957, is that sixty days after the day on which the attack took place ninety-eight million of the 190 million American people would be dead, and twenty-eight million would be seriously injured but still alive; many of the remaining seventy million survivors would be suffering from minor injuries and radiation effects.

This is a small nuclear attack made with use of about one percent of the existing weapons. A major nuclear war might well see a total of 30,000 megatons, one-tenth of the estimated stockpiles, delivered and exploded over the populated regions of the United States, the Soviet Union, and the other major European countries. The studies of Hugh Everett and George E. Pugh, of the Weapons Systems Evaluation Division, Institute of Defense Analysis, Washington, D.C., reported in the 1959 Hearings before the Special Subcommittee on Radiation, permit us to make an estimate of the casualties of such a war. This estimate is that sixty days after the day on which the war was waged, 720 million of the 800 million people in these countries would be dead, sixty million would be alive but severely injured, and there would be twenty million other survivors. The fate of the living is suggested by the following statement by Everett and Pugh: "Finally, it must be pointed out that the total casualties at sixty days may not be indicative of the ultimate casualties. Such delayed effects as the disorganization of society, disruption of communications, extinction of livestock, genetic damage, and the slow development of radiation poisoning from the ingestion of radioactive materials may significantly increase the ultimate toll."

No dispute between nations can justify nuclear war. There is no defense against nuclear weapons that could not be overcome by increasing the scale of the attack. It would be contrary to the nature of war for nations to adhere to agreements to fight "limited" wars, using only "small" nuclear weapons - even little wars today are perilous, because of the likelihood that a little war would grow into a world catastrophe.

The only sane policy for the world is that of abolishing war...

The great importance of the 1963 Test Ban Treaty lies in its significance as the first step toward disarmament. To indicate what other steps need to be taken, I shall now quote some of the statements made by President Kennedy in his address to the United Nations General Assembly on the 26th of September, 1961.

"The goal (of disarmament) is no longer a dream. It is a practical matter of life or death. The risks inherent in disarmament pale in comparison to the risks inherent in an unlimited arms race...

Our new disarmament program includes:

First, signing the test-ban treaty by all nations;

Second, stopping production of fissionable materials and preventing their transfer to (other) nations;

Third, prohibiting the transfer of control over nuclear weapons to other nations;

Fourth, keeping nuclear weapons from outer space;

Fifth, gradually destroying existing nuclear weapons;

And Sixth, halting... the production of strategic nuclear delivery vehicles, and gradually destroying them."...

I am glad to take this opportunity to express my gratitude to the Norwegian Storting (Parliament) for its outstanding work for international arbitration and peace during the last seventy-five years. In this activity the Storting has been the leader among the parliaments of nations. I remember the action of the Storting in 1890 of urging that permanent treaties for arbitration of disputes between nations be made, and the statement that "the Storting is convinced that this idea has the support of an overwhelming proportion of our people. Just as law and justice have long ago replaced the rule of the fist in disputes between man and man, so the idea of settling disputes among peoples and nations is making its way with irresistible strength. More and more, war appears to the general consciousness as a vestige of prehistoric barbarism and a curse to the human race."

Now we are forced to eliminate from the world forever this vestige of prehistoric barbarism, this curse to the human race. We, you and I, are privileged to be alive during this extraordinary age, this unique epoch in the history of the world, the epoch of demarcation between the past millennia of war and suf-

fering, and the future, the great future of peace, justice, morality, and human well-being. We are privileged to have the opportunity of contributing to the achievement of the goal of the abolition of war and its replacement by world law. I am confident that we shall succeed in this great task; that the world community will thereby be freed not only from the suffering caused by war but also, through the better use of the earth's resources, of the discoveries of scientists, and of the efforts of mankind, from hunger, disease, illiteracy, and fear; and that we shall in the course of time be enabled to build a world characterized by economic, political, and social justice for all human beings and a culture worthy of man's intelligence.

8.4 War still persists

More than half a century after Linus Pauling made this optimistic lecture in Stockholm, war still persists, although everyone realizes that it causes much of the suffering that afflicts human society and that it also causes immense economic damage.

Pauling was right in pointing out that modern weapoms make war so prohibitively dangerous that the abolition of war is the only way to assure the long-term survival of human civilization. However, his expectation that the abolition of war as an institution would happen soon seems to have been wrong.

Linus Pauling was an example of a scientist with a conscience - a sense of social responsibility. But there are many scientists and engineers who lack any social conscience whatever, and who have accepted jobs in the weapons industries. There are also many politicians, who are equally lacking in conscience, who accept enormous contributions from the weapons manufacturers in exchange for their votes, assuring that obscenely bloated military budgets will be voted into place. According to the Stockholm International Peace Research Institute (SIPEI), the world spent roughly 2 trillion US dollars on armaments in 2020. Other costs of war are even more appalling.

Voters must be aware of this flow of money from military-industrial complexes to politicians, to overfunding of the weapons industries, if it ever is to be stopped.

Do our "Defense Departments" really defend us? Absolutely not! Their very title is a lie. A military-industrial complex sells itself by claiming to defend civilians. It justifies vast and crippling budgets by this claim; but it is a fraud. For the military-industrial complex, the only goal is money and power. Civilians like ourselves are just hostages. We are expendable. We are pawns in the power game, the money game. This is most clearly seen in nuclear war, where a large percentage of the civilian populations of both belegerant and neutral countries would die.

Military-industrial complexes need enemies. Without them, they would wither. Why is the Cold War being revived? Why is war with Iran threatened? It is to justify gigantic spending on weapons

As the Indian writer Arundhati Roy said, "Once weapons were manufactured to fight wars. Today wars are manufactured to sell weapons."

Appendix A

THE TWO MAINAU DECLARATIONS

A.1 Meetings of Nobel laureates at Lindau

Ever since 1951, meetings of Nobel laureates have been held at the town of Lindau, on the shores of Lake Constance in Bavaria. The meetings have been hosted by Count Lennart Bernadotte, a grandson of King Gustav V of Sweden, and his family. After the meetings, the participants, including students who have been listening to the lectures of the Nobel laureates, always take a boat trip to the beautiful island of Mainau, which is owned by the Bernadotte family.

A.2 The Mainau Declaration of 1955 on nuclear weapons

The first Mainau Declaration was drafted by Otto Hahn and Max Born. Here is the full text:

We, the undersigned, are scientists of different countries, different creeds, different political persuasions. Outwardly, we are bound together only by the Nobel Prize, which we have been favored to receive. With pleasure we have devoted our lives to the service of science. It is, we believe, a path to a happier life for people. We see with horror that this very science is giving mankind the means to destroy itself. By total military use of weapons feasible today, the earth can be contaminated with radioactivity to such an extent that whole peoples can be annihilated. Neutrals may die thus as well as belligerents.

If war broke out among the great powers, who could guarantee that it would not develop into a deadly conflict? A nation that engages in a total war thus signals its own destruction and imperils the whole world.

We do not deny that perhaps peace is being preserved precisely by the fear of these weapons. Nevertheless, we think it is a delusion if governments believe

that they can avoid war for a long time through the fear of these weapons. Fear and tension have often engendered wars. Similarly it seems to us a delusion to believe that small conflicts could in the future always be decided by traditional weapons. In extreme danger no nation will deny itself the use of any weapon that scientific technology can produce.

All nations must come to the decision to renounce force as a final resort. If they are not prepared to do this, they will cease to exist.

The original 18 signatories

Kurt Alder
Max Born
Adolf Butenandt
Arthur H. Compton
Gerhard Domagk
Hans von Euler-Chelpin
Otto Hahn
Werner Heisenberg
George Hevesy
Richard Kuhn
Fritz Lipmann
Hermann Joseph Muller
Paul Hermann Müller
Leopold Ruzicka
Frederick Soddy
Wendell M. Stanley
Hermann Staudinger
Hideki Yukawa

Within a year, the number of supporters rose to 52 Nobel laureates.

A.3 The Mainau Declaration of 2015 on climate change

Here is the full text of the declaration:

We undersigned scientists, who have been awarded Nobel Prizes, have come to the shores of Lake Constance in southern Germany, to share insights with promising young researchers, who like us come from around the world. Nearly 60 years ago, here on Mainau, a similar gathering of Nobel Laureates in science issued a declaration of the dangers inherent in the newly found technology of nuclear weapons - a technology derived from advances in basic science. So far

we have avoided nuclear war though the threat remains. We believe that our world today faces another threat of comparable magnitude.

Successive generations of scientists have helped create a more and more prosperous world. This prosperity has come at the cost of a rapid rise in the consumption of the world's resources. If left unchecked, our ever-increasing demand for food, water, and energy will eventually overwhelm the Earth's ability to satisfy humanity's needs, and will lead to wholesale human tragedy. Already, scientists who study Earth's climate are observing the impact of human activity.

In response to the possibility of human-induced climate change, the United Nations established the Intergovernmental Panel on Climate Change (IPCC) to provide the world's leaders a summary of the current state of relevant scientific knowledge. While by no means perfect, we believe that the efforts that have led to the current IPCC Fifth Assessment Report represent the best source of information regarding the present state of knowledge on climate change. We say this not as experts in the field of climate change, but rather as a diverse group of scientists who have a deep respect for and understanding of the integrity of the scientific process.

Although there remains uncertainty as to the precise extent of climate change, the conclusions of the scientific community contained in the latest IPCC report are alarming, especially in the context of the identified risks of maintaining human prosperity in the face of greater than a 2^oC rise in average global temperature. The report concludes that anthropogenic emissions of greenhouse gases are the likely cause of the current global warming of the Earth. Predictions from the range of climate models indicate that this warming will very likely increase the Earth's temperature over the coming century by more than 2^oC above its pre-industrial level unless dramatic reductions are made in anthropogenic emissions of greenhouse gases over the coming decades.

Based on the IPCC assessment, the world must make rapid progress towards lowering current and future greenhouse gas emissions to minimize the substantial risks of climate change. We believe that the nations of the world must take the opportunity at the United Nations Climate Change Conference in Paris in December 2015 to take decisive action to limit future global emissions. This endeavor will require the cooperation of all nations, whether developed or developing, and must be sustained into the future in accord with updated scientific assessments. Failure to act will subject future generations of humanity to unconscionable and unacceptable risk.

The original signatories

Peter Agre
J.M. Bishop
Elizabeth Blackburn

Martin Chalfie
Steven Chu
Claude Cohen-Tannoudji
James W. Cronin
Peter Doherty
Gerhard Ertl
Edmond Fischer
Walter Gilbert
Roy Glauber
David Gross
John L. Hall
Serge Haroche
Stefan Hell
Jules H. Hoffmann
Klaus von Klitzing
Harold Kroto
William Moerner
Ferid Murad
Ei-ichi Negishi
Saul Perlmutter
William Phillips
Richard Roberts
Kailash Satyarthi
Brian Schmidt
Hamilton O. Smith
George Smoot
Jack Szostak
Roger Y. Tsien
Harold Varmus
J. Robin Warren
Arieh Warshel
Torsten Wiesel
Robert Wilson

These were soon joined by an almost equal number of other Nobel laureates-

Figure A.1: **Mainau Castle on Mainau Island, property of the Bernadotte family and the traditional venue of the last day of every Lindau Nobel Laureate Meeting.**

Figure A.2: **Nobel laureate Brian Schmidt reading the Mainau Declaration 2015 on Climate Change.**

Figure A.3: **The Spring path at the island of Mainau during the tulip blooming.**

Figure A.4: **The Italian water steps at the island of Mainau during the tulip blooming 2010.**

Appendix B

THE LOFOTEN DECLARATION (SEPTEMBER, 2017)

B.1 Text of the Declaration

Climate Leadership Requires a Managed Decline of Fossil Fuel Production

Global climate change is a crisis of unprecedented scale, and it will take unprecedented action to avoid the worst consequences of our dependence on oil, coal, and gas. Equally as critical as reducing demand and emissions is the need for immediate and ambitious action to stop exploration and expansion of fossil fuel projects and manage the decline of existing production in line with what is necessary to achieve the Paris climate goals.

Clean, safe, and renewable fuels are already redefining how we see energy and it is time for nations to fully embrace 21st century energy and phase out fossil fuels.

The Lofoten Declaration affirms that it is the urgent responsibility and moral obligation of wealthy fossil fuel producers to lead in putting an end to fossil fuel development and to manage the decline of existing production.

We stand in solidarity with, and offer our full support for, the growing wave of impacted communities around the world who are taking action to defend and protect their lives and livelihoods in the face of fossil fuel extraction and climate change. It is a priority to elevate these efforts. Frontline communities are the leaders we must look to as we all work together for a safer future.

A global transition to a low carbon future is already well underway. Continued expansion of oil, coal, and gas is only serving to hinder the inevitable transition while at the same time exacerbating conflicts, fuelling corruption, threatening biodiversity, clean water and air, and infringing on the rights of Indigenous Peoples and vulnerable communities.

Energy access and demand are and must now be met fully through the clean energies of the 21st century. Assertions that new fossil fuels are needed for this transformation are not only inaccurate; they also undermine the speed and penetration of clean energy.

We recognize that a full transition away from fossil fuels will take decades, but also, that this shift is an opportunity more than a burden. We are in a deep hole with climate. We must begin by not digging ourselves any deeper.

Research shows that the carbon embedded in existing fossil fuel production will take us far beyond safe climate limits. Thus, not only are new exploration and new production incompatible with limiting global warming to well below 2Â°C (and as close to 1.5Â°C as possible), but many existing projects will need to be phased-out faster than their natural decline.

This task should be first addressed by countries, regions, and corporate actors who are best positioned in terms of wealth and capacity to undergo an ambitious just transition away from fossil fuel production. In particular, leadership must come from countries that are high-income, have benefitted from fossil fuel extraction, and that are historically responsible for significant emissions.

We call on these governments and companies to recognize that continued fossil fuel exploration and production without a managed decline and a just transition is irreconcilable with meaningful climate action. We also note that there are tremendous leadership opportunities for these countries to demonstrate that moving beyond oil, coal, and gas, both demand and production, is not only possible, but can be done while protecting workers, communities, and economies.

B.2 Signatories

1. ACT Alliance EU, Europe
2. Action Paysanne Contre la Faim, Democratic Republic of the Congo
3. African Coalition For Sustainable Energy and Access, Cameroon
4. Alliance Sud, Switzerland
5. Alofa Tuvalu, France / Tuvalu
6. Alternative Information and Development Centre, South Africa
7. Alternative Technology Association, Australia
8. Amazon Watch, United States
9. Arab Youth Climate Muster , Lebanon
10. As You Sow, United States
11. Ashden, United Kingdom
12. The Ashden Trust, United Kingdom
13. Asia Pacific Forum on Women, Law and Development, Asia-Pacific
14. Asian Peoples Movement on Debt and Development, Asia

15. Association NigÃ©rienne des Scouts de l'Environnement, Niger
16. Athens County Fracking Action Network, United States
17. The Australia Institute, Australia
18. Australian Marine Conservation Society, Australia
19. The Bellona Foundation, Norway
20. Bicitekas, Mexico
21. Bioroot Energy, Inc., United States
22. Bold Alliance, United States
23. Both ENDS, The Netherlands
24. BSF, Canada
25. Bund für Umwelt und Naturschutz Deutschlands (Friends of the Earth Germany), Germany
26. Campaign for a Just Energy Future, South Africa
27. Canadian Interfaith Fast for the Climate, Canada
28. Caravan of Non-violence, CÃ´te d'Ivoire
29. Catholic Earthcare Australia, Australia
30. CatholicNetwork.us, United States
31. Centar za zivotnu sredinu (Friends of the Earth Bosnia and Herzegovina), Bosnia and Herzegovina
32. Center for Biological Diversity, United States
33. Center for International Environmental Law, United States
34. Center for Justice, Governance, and Environmental Action, Kenya
35. Centre for Environmental Justice, Zambia
36. Centre for Environmental Rights, South Africa
37. Centre for Human Rights and Climate Change Research, Nigeria
38. Change Partnership, International
39. Changemaker, Norway
40. Citizens' Climate Lobby Australia, Australia
41. Clean Air Action Group, Hungary
42. Climate Action Hobart, Australia
43. Climate Action Network International, International
44. Climate and Health Alliance, Australia
45. Climate Change Coalition of Door County, Wisconsin, United States
46. Climate Change Network Nigeria, Nigeria
47. Climate Hawks Vote, United States
48. Climate Justice Programme, Australia
49. Climate Justice Project, United States
50. ClimÃ¡ximo, Portugal
51. CoalSwarm, United States
52. Coletivo Clima, Portugal
53. Collectif Causse Méjean , Gaz de Schiste NON!, France
54. Columbus Community Bill of Rights, United States
55. Community Action for Nature Conservation, Kenya

56. Conseil Régional des Organisations Non Gouvernementales de Développement, Democratic Republic of the Congo
57. Corporate Europe Observatory, Europe
58. Creative Roustabouts, United States Developpement sans Frontieres, Cameroon
59. DC Divest, United States
60. DeCOALinize, Kenya
61. DivestInvest Individual, United States
62. Earth Action, Inc., United States
63. Earthlife Africa Johannesburg, South Africa
64. Earthworks, United States
65. EcoEquity, United States
66. Ecological Society of the Philippines, Philippines
67. Ecologistas en Acción, Spain
68. ECOMUNIDADES, Red Ecologista de la Cuenca de México, Mexico
69. EKOenergy, Finland
70. Empowered African Youths Foundation, Nigeria
71. Energiewende ER(H)langen e.V., Germany
72. Environics Trust, India
73. Environment Centre NT, Australia
74. Environmental Defence, Canada
75. Environmental Justice Foundation, United Kingdom
76. Environmental Rights Action (Friends of the Earth Nigeria), Nigeria
77. European Climate Foundation, Europe
78. Faculty and Staff Divestment Network, United States
79. Fastenopfer, Switzerland
80. Fiji Medical and Dental Secretariat , Fiji
81. Finance and Trade Watch, Austria
82. FOCSIV, Volontari nel Mondo, Italy
83. Food and Water Europe, Europe
84. Food and Water Watch, United States
85. Fossielvrij NL, The Netherlands
86. Fossil Free Berlin, Germany
87. Fossil Free California, United States
88. Fossil Free South Africa, South Africa
89. Foundation for Environment and Agriculture, Bulgaria
90. Frack Free Lancashire, United Kingdom
91. FracTracker Alliance, United States
92. Framtiden i våre hender, Norway
93. Franciscan Action Network, United States
94. Frederick Mulder Foundation, United Kingdom
95. FreshWater Accountability Project, United States
96. Friends For Environmental Justice, United States
97. Friends of the Century, Liberia

98. Friends of the Earth Australia, Australia
99. Friends of the Earth Canada, Canada
100. Friends of the Earth England, Wales and Northern Ireland, United Kingdom
101. Friends of the Earth Ghana, Ghana
102. Friends of the Earth Ireland, Ireland
103. Friends of the Earth Malaysia, Malaysia
104. Friends of the Earth Malta, Malta
105. Friends of the Earth Scotland, Scotland
106. Friends with Environment in Development, Uganda
107. Futerra, United Kingdom
108. Futurepump, United Kingdom
109. George Mason University Center for Climate Change Communication, United States
110. Geotourism Stewardship Council, Dominica
111. GLOBAL 2000 (Friends of the Earth Austria), Austria
112. Global Catholic Climate Movement, International
113. Global Climate Finance Campaign, South Africa
114. Global Greengrants Fund, United States
115. Global Witness, International
116. Green Development Advocates, Cameroon
117. The Green Institute, Australia
118. Greenpeace
119. groundWork (Friends of the Earth South Africa), South Africa
120. Groupe d'Action et de Recherche en Environnement et Développement, Togo
121. Guernsey County Citizens Support on Drilling Issues, United States
122. Hands Off Schwedeneck, Germany
123. Health and Environment Alliance, Europe
124. Health of Mother Earth Foundation, Nigeria
125. Healthy Futures, Australia
126. HEDA Resource Centre, Nigeria
127. Heinrich Böll Foundation, Germany
128. Honor the Earth, United States
129. Iceland Nature Conservation Association, Iceland
130. IDF Line, Guinea
131. Idle No More SF Bay, United States
132. Innoventi, Norway
133. Institute for Climate and Sustainable Cities, Philippines
134. International Institute for Sustainable Development, International
135. INTLawyers, Switzerland
136. Jeunes Volontaires pour l'Environnement, Togo
137. Joseph Rowntree Charitable Trust, United Kingdom
138. Justica Ambiental, Mozambique
139. Justice amd Witness Ministries, United Church of Christ, United States
140. Kulima, Mozambique

141. Landscape Studio and Tropical Nursery CC, South Africa
142. Les Amis de la Terre Togo (Friends of the Earth Togo), Togo
143. Leave It in the Ground Initiative, Germany
144. Lund University Fossil Free, Sweden
145. The Mark Leonard Trust, United Kingdom
146. Medical Society Consortium on Climate and Health, United States
147. Milieudefensie (Friends of the Earth Netherlands), The Netherlands
148. Mom Loves Taiwan Association , Taiwan
149. Mountain Lakes Preservation Alliance, United States
150. NativesRule Australia
151. Natur og Ungdom (Young Friends of the Earth Norway), Norway
152. Natural Resources Alliance of Kenya, Kenya
153. Naturvernforbundet (Friends of the Earth Norway), Norway
154. NGO Ecoclub, Ukraine
155. North Country Veterans for Peace, United States
156. The Norwegian Grandparents Climate Campaign, Norway
157. A Nossa Terra, AssociaÃ§Ã£o Ambiental Portugal, Portugal
158. NYU Divest, United States
159. Observatorio Petrolero Sur, Argentina
160. Oil Change International, International
161. Oilwatch Ghana, Ghana
162. Pakistan Fisherfolk Forum, Pakistan
163. Pan African Climate Justice Alliance, Africa
164. Philippine Movement for Climate Justice, Philippines
165. Plataforma Algarve Livre de Petróleo, Portugal
166. Poolden-Puckham Charitable Foundation, United Kingdom
167. Power Shift Network, United States
168. Prosperity For RI, United States
169. Radical Independence Campaign East Kilbride, Scotland
170. Rainforest Action Network, United States
171. Réseau Associatif de Khnifiss, Morocco
172. Residents Action on Fylde Fracking, England
173. ReSource, The Netherlands
174. Russian Social-Ecological Union (Friends of the Earth Russia), Russia
175. Sano Sansar Initiative, Nepal
176. Save Lamu Kenya
177. Seeds for the Sol, United States
178. Serve All Trust, United Kingdom
179. ShareAction, United Kingdom
180. Sierra Club, United States
181. Sierra Leone Consortium for Climate Change and Sustainable Development, Sierra Leone
182. Sierra Leone School Green Club, Sierra Leone

183. Socio-Ecological Union International, Russia
184. Solar Workers Union 1, United States
185. South Durban Community Environmental Alliance, South Africa
186. Southern Oregon Climate Action Now, United States
187. Spire Org, Norway
188. Stand.earth, Canada / United States
189. Stop Petróleo Vila do Bispo, Portugal
190. Students for a Just and Stable Future, United States
191. Sungenix Energy Solutions, United States
192. Sustainable Population Australia, Australia
193. SustainUS, United States
194. Tedhelte, Niger
195. Third World Network, Malaysia
196. TierrActiva, Colombia
197. UK Nanas, United Kingdom
198. UK Youth Climate Coalition, United Kingdom
199. Unitarian Universalist Association, United States
200. Unitarian Universalist Ministry for Earth, United States
201. Upper Valley Affinity Group, United States
202. urgewald Germany
203. Walkin'Sagres, Portugal
204. We Women Lanka, Sri Lanka
205. West Coast Environmental Law Association, Canada
206. The West Virginia Mountain Party, United States
207. The Wilderness Society, Australia
208. Tongu Youth Agenda for Development, Ghana
209. Women's International League for Peace and Freedom Norway, Norway
210. Women Natural Resource Governance Institute, Uganda
211. WoMin (African Women Unite against Destructive Resource Extraction, South Africa
212. WWF-Norway, Norway
213. Yes to Life No to Mining Global Solidarity Network, International
214. Young Christian in Action for Development, Togo
215. Young Friends of the Earth Ireland, Ireland
216. Young Voices on Climate Change, United States
217. YUVA Association, Turkey
218. ZERO, Associacáo Sistema Terrestre SustentÃ¡vel, Portugal
219. 350 Climate Movement of Denmark, Denmark
220. 350 DC, United States
221. 350 Montgomery County, United States
222. 350 PDX, United States
223. 350 Silicon Valley, United States
224. 350.org, International

Appendix C

THE CASE AGAINST NUCLEAR POWER GENERATION

C.1 The Chernobyl disaster

The dangers of nuclear power generation are exemplified by the Chernobyl disaster: On the 26th of April, 1986, during the small hours of the morning, the staff of the Chernobyl nuclear reactor in Ukraine turned off several safety systems in order to perform a test. The result was a core meltdown in Reactor 4, causing a chemical explosion that blew off the reactor's 1,000-ton steel and concrete lid. 190 tons of highly radioactive uranium and graphite were hurled into the atmosphere. The resulting radioactive fallout was 200 times greater than that caused by the nuclear bombs that destroyed Hiroshima and Nagasaki. The radioactive cloud spread over Belarus, Ukraine, Russia, Finland, Sweden and Eastern Europe, exposing the populations of these regions to levels of radiation 100 times the normal background. Ultimately, the radioactive cloud reached as far as Greenland and parts of Asia.

The exact number of casualties resulting from the Chernobyl meltdown is a matter of controversy, but according to a United Nations report, as many as 9 million people have been adversely affected by the disaster. Since 1986, the rate of thyroid cancer in affected areas has increased ten-fold. An area of 155,000 square kilometers (almost half the size of Italy) in Belarus, Ukraine and Russia is still severely contaminated. Even as far away as Wales, hundreds of farms are still under restrictions because of sheep eating radioactive grass.

Public opinion turned against nuclear power generation as a result of the Chernobyl disaster. Had the disaster taken place in Western Europe or North America, its effect on public opinion would have been still greater. Nevertheless, because of the current energy crisis, and because of worries about global warming, a number of people are arguing that nuclear energy should be given a second chance. The counter-argument is that a large increase in the share of nuclear power in the total spectrum of energy production would have little effect on climate change but it would involve unacceptable dangers, not only

dangers of accidents and dangers associated with radioactive waste disposal, but above all, dangers of proliferation of nuclear weapons.

Of the two bombs that destroyed Hiroshima and Nagasaki, one made use of the rare isotope of uranium, U-235, while the other used plutonium. Both of these materials can be made by a nation with a nuclear power generation program.

C.2 Reactors and nuclear weapons

Uranium has atomic number 92, i.e., a neutral uranium atom has a nucleus containing 92 positively-charged protons, around which 92 negatively-charged electrons circle. All of the isotopes of uranium have the same number of protons and electrons, and hence the same chemical properties, but they differ in the number of neutrons in their nuclei. For example, the nucleus of U-235 has 143 neutrons, while that of U-238 has 146. Notice that 92+143=235, while 92+146=238. The number written after the name of an element to specify a particular isotope is the number of neutrons plus the number of protons. This is called the "nucleon number", and the weight of an isotope is roughly proportional to it. This means that U-238 is slightly heavier than U-235. If the two isotopes are to be separated, difficult physical methods dependent on mass must be used, since their chemical properties are identical. In natural uranium, the amount of the rare isotope U-235 is only 0.7 percent.

A paper published in 1939 by Niels Bohr and John A. Wheeler indicated that it was the rare isotope of uranium, U-235, that undergoes fission. A bomb could be constructed, they pointed out, if enough highly enriched U-235 could be isolated from the more common isotope, U-238 Calculations later performed in England by Otto Frisch and Rudolf Peierls showed that the "critical mass" of highly enriched uranium needed is quite small: only a few kilograms.

The Bohr-Wheeler theory also predicted that an isotope of plutonium, Pu-239, should be just as fissionable as U-235[1]. Instead of trying to separate the rare isotope, U-235, from the common isotope, U-238, physicists could just operate a nuclear reactor until a sufficient amount of Pu-239 accumulated, and then separate it out by ordinary chemical means.

Thus in 1942, when Enrico Fermi and his coworkers at the University of Chicago produced the world's first controlled chain reaction within a pile of cans containing ordinary (nonenriched) uranium powder, separated by blocks of very pure graphite, the chain-reacting pile had a double significance: It represented a new source of energy for mankind, but it also had a sinister meaning. It represented an easy path to nuclear weapons, since one of the by-products of the reaction was a fissionable isotope of plutonium, Pu-239. The

[1]Both U-235 and Pu-239 have odd nucleon numbers. When U-235 absorbs a neutron, it becomes U-236, while when Pu-239 absorbs a neutron it becomes Pu-240. In other words, absorption of a neutron converts both these species to nuclei with even nucleon numbers. According to the Bohr-Wheeler theory, nuclei with even nucleon numbers are especially tightly-bound. Thus absorption of a neutron converts U-235 to a highly-excited state of U-236, while Pu-239 is similarly converted to a highly excited state of Pu-240. The excitation energy distorts the nuclei to such an extent that fission becomes possible.

bomb dropped on Hiroshima in 1945 used U-235, while the Nagasaki bomb used Pu-239.

By reprocessing spent nuclear fuel rods, using ordinary chemical means, a nation with a power reactor can obtain weapons-usable Pu-239. Even when such reprocessing is performed under international control, the uncertainty as to the amount of Pu-239 obtained is large enough so that the operation might superficially seem to conform to regulations while still supplying enough Pu-239 to make many bombs.

The enrichment of uranium[2] is also linked to reactor use. Many reactors of modern design make use of low enriched uranium (LEU) as a fuel. Nations operating such a reactor may claim that they need a program for uranium enrichment in order to produce LEU for fuel rods. However, by operating their ultracentrifuges a little longer, they can easily produce highly enriched uranium (HEU), i.e., uranium containing a high percentage of the rare isotope U-235, and therefore usable in weapons.

Known reserves of uranium are only sufficient for the generation of 8×10^{20} joules of electrical energy [3], i.e., about 25 TWy. It is sometimes argued that a larger amount of electricity could be obtained from the same amount of uranium through the use of fast breeder reactors, but this would involve totally unacceptable proliferation risks. In fast breeder reactors, the fuel rods consist of highly enriched uranium. Around the core, is an envelope of natural uranium. The flux of fast neutrons from the core is sufficient to convert a part of the U-238 in the envelope into Pu-239, a fissionable isotope of plutonium.

Fast breeder reactors are prohibitively dangerous from the standpoint of nuclear proliferation because both the highly enriched uranium from the fuel rods and the Pu-239 from the envelope are directly weapons-usable. It would be impossible, from the standpoint of equity, to maintain that some nations have the right to use fast breeder reactors, while others do not. If all nations used fast breeder reactors, the number of nuclear weapons states would increase drastically.

It is interesting to review the way in which Israel, South Africa, Pakistan, India and North Korea[4] obtained their nuclear weapons, since in all these cases the weapons were constructed under the guise of "atoms for peace", a phrase that future generations may someday regard as being tragically self-contradictory.

Israel began producing nuclear weapons in the late 1960's (with the help of a "peaceful" nuclear reactor provided by France, and with the tacit approval of the United States) and the country is now believed to possess 100-150 of them, including neutron bombs. Israel's policy is one of visibly possessing nuclear weapons while denying their existence.

South Africa, with the help of Israel and France, also weaponized its civil nuclear program, and it tested nuclear weapons in the Indian Ocean in 1979. In 1991 however, South Africa destroyed its nuclear weapons and signed the NPT.

India produced what it described as a "peaceful nuclear explosion" in 1974. By 1989 Indian scientists were making efforts to purify the lithium-6 isotope, a key component of

[2]i.e. production of uranium with a higher percentage of U-235 than is found in natural uranium

[3]Craig, J.R., Vaugn, D.J. and Skinner, B.J., *Resources of the Earth: Origin, Use and Environmental Impact, Third Edition*, page 210.

[4]Israel, India and Pakistan have refused to sign the Nuclear Non-Proliferation Treaty, and North Korea, after signing the NPT, withdrew from it in 2003.

the much more powerful thermonuclear bombs. In 1998, India conducted underground tests of nuclear weapons, and is now believed to have roughly 60 warheads, constructed from Pu-239 produced in "peaceful" reactors.

Pakistan's efforts to obtain nuclear weapons were spurred by India's 1974 "peaceful nuclear explosion". As early as 1970, the laboratory of Dr. Abdul Qadeer Khan, (a metallurgist who was to become Pakistan's leading nuclear bomb maker) had been able to obtain from a Dutch firm the high-speed ultracentrifuges needed for uranium enrichment. With unlimited financial support and freedom from auditing requirements, Dr. Khan purchased restricted items needed for nuclear weapon construction from companies in Europe and the United States. In the process, Dr. Khan became an extremely wealthy man. With additional help from China, Pakistan was ready to test five nuclear weapons in 1998. The Indian and Pakistani nuclear bomb tests, conducted in rapid succession, presented the world with the danger that these devastating weapons would be used in the conflict over Kashmir. Indeed, Pakistan announced that if a war broke out using conventional weapons, Pakistan's nuclear weapons would be used "at an early stage".

In Pakistan, Dr. A.Q. Khan became a great national hero. He was presented as the person who had saved Pakistan from attack by India by creating Pakistan's own nuclear weapons. In a Washington Post article[5] Pervez Hoodbhoy wrote: "Nuclear nationalism was the order of the day as governments vigorously promoted the bomb as the symbol of Pakistan's high scientific achievement and self-respect..." Similar manifestations of nuclear nationalism could also be seen in India after India's 1998 bomb tests.

Early in 2004, it was revealed that Dr. Khan had for years been selling nuclear secrets and equipment to Libya, Iran and North Korea, and that he had contacts with Al-Qaeda. However, observers considered that it was unlikely that Khan would be tried, since a trial might implicate Pakistan's army as well as two of its former prime ministers.

Recent assassination attempts directed at Pakistan's President, Pervez Musharraf, emphasize the precariousness of Pakistan's government. There a danger that it may be overthrown, and that the revolutionists would give Pakistan's nuclear weapons to a subnational organization. This type of danger is a general one associated with nuclear proliferation. As more and more countries obtain nuclear weapons, it becomes increasingly likely that one of them will undergo a revolution, during the course of which nuclear weapons will fall into the hands of criminals or terrorists.

If nuclear reactors become the standard means for electricity generation as the result of a future energy crisis, the number of nations possessing nuclear weapons might ultimately be as high as 40. If this should happen, then over a long period of time the chance that one or another of these nations would undergo a revolution during which the weapons would fall into the hands of a subnational group would gradually grow into a certainty.

There is also a possibility that poorly-guarded fissionable material could fall into the hands of subnational groups, who would then succeed in constructing their own nuclear weapons. Given a critical mass of highly-enriched uranium, a terrorist group, or an organized criminal (Mafia) group, could easily construct a crude gun-type nuclear explosive

[5] 1 February, 2004

device. Pu-239 is more difficult to use since it is highly radioactive, but the physicist Frank Barnaby believes that a subnational group could nevertheless construct a crude nuclear bomb (of the Nagasaki type) from this material.

We must remember the remark of U.N. Secretary General Kofi Annan after the 9/11/2001 attacks on the World Trade Center. He said, "*This time* it was not a nuclear explosion". The meaning of his remark is clear: If the world does not take strong steps to eliminate fissionable materials and nuclear weapons, it will only be a matter of time before they will be used in terrorist attacks on major cities, or by organized criminals for the purpose of extortion. Neither terrorists nor organized criminals can be deterred by the threat of nuclear retaliation, since they have no territory against which such retaliation could be directed. They blend invisibly into the general population. Nor can a "missile defense system" prevent criminals or terrorists from using nuclear weapons, since the weapons can be brought into a port in any one of the hundreds of thousands of containers that enter on ships each year, a number far too large to be checked exhaustively.

Finally we must remember that if the number of nations possessing nuclear weapons becomes very large, there will be a greatly increased chance that these weapons will be used in conflicts between nations, either by accident or through irresponsible political decisions.

On November 3, 2003, Mohamed ElBaradei, Director General of the International Atomic Energy Agency, made a speech to the United Nations in which he called for "limiting the processing of weapons-usable material (separated plutonium and high enriched uranium) in civilian nuclear programs - as well as the production of new material through reprocessing and enrichment - by agreeing to restrict these operations to facilities exclusively under international control." It is almost incredible, considering the dangers of nuclear proliferation and nuclear terrorism, that such restrictions were not imposed long ago.

From the facts that we have been reviewing, we can conclude that if nuclear power generation becomes widespread during a future energy crisis, and if equally widespread proliferation of nuclear weapons is to be avoided, the powers and budget of the IAEA will have to be greatly increased. All enrichment of uranium and reprocessing of fuel rods throughout the world will have to be placed be under direct international control, as has been emphasized by Mohamed ElBaradei. Because this will need to be done with fairness, such regulations will have to hold both in countries that at present have nuclear weapons and in countries that do not. It has been proposed that there should be an international fuel rod bank, to supply new fuel rods and reprocess spent ones. In addition to this excellent proposal, one might also consider a system where all power generation reactors and all research reactors would be staffed by the IAEA.

Nuclear reactors used for "peaceful" purposes unfortunately also generate fissionable isotopes of not only of plutonium, but also of neptunium and americium. Thus all nuclear reactors must be regarded as ambiguous in function, and all must be put under strict international control. One must ask whether globally widespread use of nuclear energy is worth the danger that it entails.

Let us now examine the question of whether nuclear power generation would appreciably help to prevent global warming. The fraction of nuclear power in the present energy

generation spectrum is at present approximately 1/16. Nuclear energy is used primarily for electricity generation. Thus increasing the nuclear fraction would not affect the consumption of fossil fuels used directly in industry, transportation, in commerce, and in the residential sector. Coal is still a very inexpensive fuel, and an increase in nuclear power generation would do little to prevent it from being burned. Thus besides being prohibitively dangerous, and besides being unsustainable in the long run (because of finite stocks of uranium and thorium), the large-scale use of nuclear power cannot be considered to be a solution to the problem of anthropogenic climate change.

Optimists point to the possibility of using fusion of light elements, such as hydrogen, to generate power. However, although this can be done on a very small scale (and at great expense) in laboratory experiments, the practical generation of energy by means of thermonuclear reactions remains a mirage rather than a realistic prospect on which planners can rely. The reason for this is the enormous temperature required to produce thermonuclear reactions. This temperature is comparable to that existing in the interior of the sun, and it is sufficient to melt any ordinary container. Elaborate "magnetic bottles" have been constructed to contain thermonuclear reactions, and these have been used in successful very small scale experiments. However, despite 50 years of heavily-financed research, there has been absolutely no success in producing thermonuclear energy on a large scale, or at anything remotely approaching commercially competitive prices.

Appendix D

ICAN AWARDED THE 2017 NOBEL PEACE PRIZE

D.1 What is ICAN?

The International Campaign to Abolish Nuclear Weapons, abbreviated ICAN, is a coalition of 468 NGO's in 101 countries. The purpose of ICAN is to change the focus in the disarmament debate to "the the humanitarian threat posed by nuclear weapons, drawing attention to their unique destructive capacity, their catastrophic health and environmental consequences, their indiscriminate targeting, the debilitating impact of a detonation on medical infrastructure and relief measures, and the long-lasting effects of radiation on the surrounding area." Nobel Peace Prize

ICAN was founded in 2007 by the International Physicians for the Prevention of Nuclear War, an organization which itself received a Nobel Peace Prize in 1985. IPPNW was inspired by the success of the campaign that achieved the Ottawa Treaty in 1997, a treaty which banned antipersonnel land-mines against bitter opposition from the worst offenders. Thus, from the start. ICAN envisioned a treaty passed and without the participation or signatures of the nuclear weapons states. ICAN believed that such a treaty would have the great value of unambiguously underlining the illegality, immorality and omnicidal nature of nuclear weapons. Nuclear weapons states would eventually be forced to yield to the will of the vast majority of humankind.

On July 7, 2017, the Treaty on the Prohibition of Nuclear Weapons was adopted by an overwhelming majority, 122 to 1, by the United Nations General Assembly. The adoption of the treaty, a milestone in humanity's efforts to rid itself of nuclear insanity, was to a large extent due to the efforts of ICAN's participating organizations.

On December 10, 2017 ICAN's efforts were recognized by the award of the Nobel Peace Prize. Part of the motivation for the award was the fact that the threat of a thermonuclear global catastrophe is higher today than it has been at any time since the Cuban Missile Crisis. Because of the belligerent attitudes and mental instability of Donald Trump and Kim Jong Un, the end of human civilization and much of the biosphere is, in the words of

Figure D.1: **From left to right: Berit Reiss-Andersen, Chairman of the Norwegian Nobel Committee, Setsuko Thurlow, an 85-year-old survivor of the 1945 atomic bombing of Hiroshima, and ICAN Executive Director Beatrice Fihn.**

Beatrice Finn, "only a tantrum away".

Figure D.2: **Celebrating the award.**

D.2 The ICAN Nobel Lecture by Beatrice Fihn

Your Majesties, Members of the Norwegian Nobel Committee, Esteemed guests,

Today, it is a great honour to accept the 2017 Nobel Peace Prize on behalf of thousands of inspirational people who make up the International Campaign to Abolish Nuclear Weapons.

Together we have brought democracy to disarmament and are reshaping international law.

We most humbly thank the Norwegian Nobel Committee for recognizing our work and giving momentum to our crucial cause.

We want to recognize those who have so generously donated their time and energy to this campaign.

We thank the courageous foreign ministers, diplomats, Red Cross and Red Crescent staff, UN officials, academics and experts with whom we have worked in partnership to advance our common goal.

And we thank all who are committed to ridding the world of this terrible threat.

At dozens of locations around the world - in missile silos buried in our earth, on submarines navigating through our oceans, and aboard planes flying high in our sky - lie 15,000 objects of humankind's destruction.

Perhaps it is the enormity of this fact, perhaps it is the unimaginable scale of the consequences, that leads many to simply accept this grim reality. To go about our daily lives with no thought to the instruments of insanity all around us.

For it is insanity to allow ourselves to be ruled by these weapons. Many critics of this movement suggest that we are the irrational ones, the idealists with no grounding in reality. That nuclear-armed states will never give up

their weapons.

But we represent the only rational choice. We represent those who refuse to accept nuclear weapons as a fixture in our world, those who refuse to have their fates bound up in a few lines of launch code.

Ours is the only reality that is possible. The alternative is unthinkable.

The story of nuclear weapons will have an ending, and it is up to us what that ending will be.

Will it be the end of nuclear weapons, or will it be the end of us?

One of these things will happen.

The only rational course of action is to cease living under the conditions where our mutual destruction is only one impulsive tantrum away.

Today I want to talk of three things: fear, freedom, and the future.

By the very admission of those who possess them, the real utility of nuclear weapons is in their ability to provoke fear. When they refer to their "deterrent" effect, proponents of nuclear weapons are celebrating fear as a weapon of war.

They are puffing their chests by declaring their preparedness to exterminate, in a flash, countless thousands of human lives.

Nobel Laureate William Faulkner said when accepting his prize in 1950, that "There is only the question of 'when will I be blown up?'" But since then, this universal fear has given way to something even more dangerous: denial.

Gone is the fear of Armageddon in an instant, gone is the equilibrium between two blocs that was used as the justification for deterrence, gone are the fallout shelters.

But one thing remains: the thousands upon thousands of nuclear warheads that filled us up with that fear.

The risk for nuclear weapons use is even greater today than at the end of the Cold War. But unlike the Cold War, today we face many more nuclear armed states, terrorists, and cyber warfare. All of this makes us less safe.

Learning to live with these weapons in blind acceptance has been our next great mistake.

Fear is rational. The threat is real. We have avoided nuclear war not through prudent leadership but good fortune. Sooner or later, if we fail to act, our luck will run out.

A moment of panic or carelessness, a misconstrued comment or bruised ego, could easily lead us unavoidably to the destruction of entire cities. A calculated military escalation could lead to the indiscriminate mass murder of civilians.

If only a small fraction of today's nuclear weapons were used, soot and smoke from the firestorms would loft high into the atmosphere - cooling, darkening and drying the Earth's surface for more than a decade.

It would obliterate food crops, putting billions at risk of starvation.

Yet we continue to live in denial of this existential threat.

But Faulkner in his Nobel speech also issued a challenge to those who came after him. Only by being the voice of humanity, he said, can we defeat fear;

can we help humanity endure.

ICAN's duty is to be that voice. The voice of humanity and humanitarian law; to speak up on behalf of civilians. Giving voice to that humanitarian perspective is how we will create the end of fear, the end of denial. And ultimately, the end of nuclear weapons.

That brings me to my second point: freedom.

As the International Physicians for the Prevention of Nuclear War, the first ever anti-nuclear weapons organization to win this prize, said on this stage in 1985:

"We physicians protest the outrage of holding the entire world hostage. We protest the moral obscenity that each of us is being continuously targeted for extinction."

Those words still ring true in 2017.

We must reclaim the freedom to not live our lives as hostages to imminent annihilation.

Man - not woman! - made nuclear weapons to control others, but instead we are controlled by them.

They made us false promises. That by making the consequences of using these weapons so unthinkable it would make any conflict unpalatable. That it would keep us free from war.

But far from preventing war, these weapons brought us to the brink multiple times throughout the Cold War. And in this century, these weapons continue to escalate us towards war and conflict.

In Iraq, in Iran, in Kashmir, in North Korea. Their existence propels others to join the nuclear race. They don't keep us safe, they cause conflict.

As fellow Nobel Peace Laureate, Martin Luther King Jr, called them from this very stage in 1964, these weapons are "both genocidal and suicidal".

They are the madman's gun held permanently to our temple. These weapons were supposed to keep us free, but they deny us our freedoms.

It's an affront to democracy to be ruled by these weapons. But they are just weapons. They are just tools. And just as they were created by geopolitical context, they can just as easily be destroyed by placing them in a humanitarian context.

That is the task ICAN has set itself - and my third point I wish to talk about, the future.

I have the honour of sharing this stage today with Setsuko Thurlow, who has made it her life's purpose to bear witness to the horror of nuclear war.

She and the hibakusha were at the beginning of the story, and it is our collective challenge to ensure they will also witness the end of it.

They relive the painful past, over and over again, so that we may create a better future.

There are hundreds of organizations that together as ICAN are making great strides towards that future.

There are thousands of tireless campaigners around the world who work each day to rise to that challenge.

There are millions of people across the globe who have stood shoulder to shoulder with those campaigners to show hundreds of millions more that a different future is truly possible.

Those who say that future is not possible need to get out of the way of those making it a reality.

As the culmination of this grassroots effort, through the action of ordinary people, this year the hypothetical marched forward towards the actual as 122 nations negotiated and concluded a UN treaty to outlaw these weapons of mass destruction.

The Treaty on the Prohibition of Nuclear Weapons provides the pathway forward at a moment of great global crisis. It is a light in a dark time.

And more than that, it provides a choice.

A choice between the two endings: the end of nuclear weapons or the end of us.

It is not naive to believe in the first choice. It is not irrational to think nuclear states can disarm. It is not idealistic to believe in life over fear and destruction; it is a necessity.

All of us face that choice. And I call on every nation to join the Treaty on the Prohibition of Nuclear Weapons.

The United States, choose freedom over fear. Russia, choose disarmament over destruction. Britain, choose the rule of law over oppression. France, choose human rights over terror. China, choose reason over irrationality. India, choose sense over senselessness. Pakistan, choose logic over Armageddon. Israel, choose common sense over obliteration. North Korea, choose wisdom over ruin.

To the nations who believe they are sheltered under the umbrella of nuclear weapons, will you be complicit in your own destruction and the destruction of others in your name?

To all nations: choose the end of nuclear weapons over the end of us!

This is the choice that the Treaty on the Prohibition of Nuclear Weapons represents. Join this Treaty.

We citizens are living under the umbrella of falsehoods. These weapons are not keeping us safe, they are contaminating our land and water, poisoning our bodies and holding hostage our right to life.

To all citizens of the world: Stand with us and demand your government side with humanity and sign this treaty. We will not rest until all States have joined, on the side of reason.

No nation today boasts of being a chemical weapon state. No nation argues that it is acceptable, in extreme circumstances, to use sarin nerve agent. No nation proclaims the right to unleash on its enemy the plague or polio.

That is because international norms have been set, perceptions have been changed.

And now, at last, we have an unequivocal norm against nuclear weapons.

Monumental strides forward never begin with universal agreement.

With every new signatory and every passing year, this new reality will take hold.

This is the way forward. There is only one way to prevent the use of nuclear weapons: prohibit and eliminate them.

Nuclear weapons, like chemical weapons, biological weapons, cluster munitions and land mines before them, are now illegal. Their existence is immoral. Their abolishment is in our hands.

The end is inevitable. But will that end be the end of nuclear weapons or the end of us? We must choose one.

We are a movement for rationality. For democracy. For freedom from fear.

We are campaigners from 468 organizations who are working to safeguard the future, and we are representative of the moral majority: the billions of people who choose life over death, who together will see the end of nuclear weapons.

Thank you.

D.3 The Nobel Lecture continued by Setsuko Thurlow

Your Majesties, Distinguished members of the Norwegian Nobel Committee, My fellow campaigners, here and throughout the world, Ladies and gentlemen,

It is a great privilege to accept this award, together with Beatrice, on behalf of all the remarkable human beings who form the ICAN movement. You each give me such tremendous hope that we can - and will - bring the era of nuclear weapons to an end.

I speak as a member of the family of hibakusha - those of us who, by some miraculous chance, survived the atomic bombings of Hiroshima and Nagasaki. For more than seven decades, we have worked for the total abolition of nuclear weapons.

We have stood in solidarity with those harmed by the production and testing of these horrific weapons around the world. People from places with long-forgotten names, like Moruroa, Ekker, Semipalatinsk, Maralinga, Bikini. People whose lands and seas were irradiated, whose bodies were experimented upon, whose cultures were forever disrupted.

We were not content to be victims. We refused to wait for an immediate fiery end or the slow poisoning of our world. We refused to sit idly in terror as the so-called great powers took us past nuclear dusk and brought us recklessly

close to nuclear midnight. We rose up. We shared our stories of survival. We said: humanity and nuclear weapons cannot coexist.

Today, I want you to feel in this hall the presence of all those who perished in Hiroshima and Nagasaki. I want you to feel, above and around us, a great cloud of a quarter million souls. Each person had a name. Each person was loved by someone. Let us ensure that their deaths were not in vain.

I was just 13 years old when the United States dropped the first atomic bomb, on my city Hiroshima. I still vividly remember that morning. At 8:15, I saw a blinding bluish-white flash from the window. I remember having the sensation of floating in the air.

As I regained consciousness in the silence and darkness, I found myself pinned by the collapsed building. I began to hear my classmates' faint cries: "Mother, help me. God, help me."

Then, suddenly, I felt hands touching my left shoulder, and heard a man saying: "Don't give up! Keep pushing! I am trying to free you. See the light coming through that opening? Crawl towards it as quickly as you can." As I crawled out, the ruins were on fire. Most of my classmates in that building were burned to death alive. I saw all around me utter, unimaginable devastation.

Processions of ghostly figures shuffled by. Grotesquely wounded people, they were bleeding, burnt, blackened and swollen. Parts of their bodies were missing. Flesh and skin hung from their bones. Some with their eyeballs hanging in their hands. Some with their bellies burst open, their intestines hanging out. The foul stench of burnt human flesh filled the air.

Thus, with one bomb my beloved city was obliterated. Most of its residents were civilians who were incinerated, vaporized, carbonized - among them, members of my own family and 351 of my schoolmates.

In the weeks, months and years that followed, many thousands more would die, often in random and mysterious ways, from the delayed effects of radiation. Still to this day, radiation is killing survivors.

Whenever I remember Hiroshima, the first image that comes to mind is of my four-year-old nephew, Eiji - his little body transformed into an unrecognizable melted chunk of flesh. He kept begging for water in a faint voice until his death released him from agony.

To me, he came to represent all the innocent children of the world, threatened as they are at this very moment by nuclear weapons. Every second of every day, nuclear weapons endanger everyone we love and everything we hold dear. We must not tolerate this insanity any longer.

Through our agony and the sheer struggle to survive - and to rebuild our lives from the ashes - we hibakusha became convinced that we must warn the world about these apocalyptic weapons. Time and again, we shared our testimonies.

But still some refused to see Hiroshima and Nagasaki as atrocities - as war crimes. They accepted the propaganda that these were "good bombs" that

had ended a "just war". It was this myth that led to the disastrous nuclear arms race - a race that continues to this day.

Nine nations still threaten to incinerate entire cities, to destroy life on earth, to make our beautiful world uninhabitable for future generations. The development of nuclear weapons signifies not a country's elevation to greatness, but its descent to the darkest depths of depravity. These weapons are not a necessary evil; they are the ultimate evil.

On the seventh of July this year, I was overwhelmed with joy when a great majority of the world's nations voted to adopt the Treaty on the Prohibition of Nuclear Weapons. Having witnessed humanity at its worst, I witnessed, that day, humanity at its best. We hibakusha had been waiting for the ban for seventy-two years. Let this be the beginning of the end of nuclear weapons.

All responsible leaders will sign this treaty. And history will judge harshly those who reject it. No longer shall their abstract theories mask the genocidal reality of their practices. No longer shall "deterrence" be viewed as anything but a deterrent to disarmament. No longer shall we live under a mushroom cloud of fear.

To the officials of nuclear-armed nations - and to their accomplices under the so-called "nuclear umbrella" - I say this: Listen to our testimony. Heed our warning. And know that your actions are consequential. You are each an integral part of a system of violence that is endangering humankind. Let us all be alert to the banality of evil.

To every president and prime minister of every nation of the world, I beseech you: Join this treaty; forever eradicate the threat of nuclear annihilation.

When I was a 13-year-old girl, trapped in the smouldering rubble, I kept pushing. I kept moving toward the light. And I survived. Our light now is the ban treaty. To all in this hall and all listening around the world, I repeat those words that I heard called to me in the ruins of Hiroshima: "Don't give up! Keep pushing! See the light? Crawl towards it."

Tonight, as we march through the streets of Oslo with torches aflame, let us follow each other out of the dark night of nuclear terror. No matter what obstacles we face, we will keep moving and keep pushing and keep sharing this light with others. This is our passion and commitment for our one precious world to survive.

D.4 The Treaty on the Prohibition of Nuclear Weapons (TPNW)

The Treaty on the Prohibition of Nuclear Weapons (TPNW) was adopted by a massive majority of nations at the United Nations General Assembly on 20 September, 2017, and it entered into force on 22 January, 2021.

122 nations voted in favour of the treaty, 1 against (Netherlands), and 1 official abstention (Singapore). 69 nations did not vote, among them all of the nuclear weapon states and all NATO members except the Netherlands. Although the nuclear weapons states and their allies continue to oppose the TPNW, one hopes that by making the position of the great majority of the nations of the world very clear, the treaty will ultimately make its opponents conform to the force of world public opinion and common sense.

Some of the provisions of the treaty

- **Article 1 contains prohibitions against the development, testing, production, stockpiling, stationing, transfer, use and threat of use of nuclear weapons, as well as against assistance and encouragement to the prohibited activities. Finally, any direct or indirect "control over nuclear weapons or other nuclear explosive devices" is forbidden.**

- **Article 2 requires each party to declare whether it had nuclear weapons of their own or deployed on its territory, including the elimination or conversion of related facilities.**

- **Article 3 requires parties that do not possess nuclear weapons to maintain their existing IAEA safeguards and, if they have not already done so, to accept safeguards based on the model for non-nuclear-weapon states under the NPT.**

- **Article 4 sets out general procedures for negotiations with an individual nuclear armed state becoming party to the treaty, including time limits and responsibilities. If that state has eliminated its nuclear weapons before becoming a party to the treaty, an unspecified "competent international authority" will verify that elimination, and the state must also conclude a safeguards agreement with the IAEA to provide credible assurance that it has not diverted nuclear material and has no undeclared nuclear material or activities. If that state has not yet destroyed its arsenal, it must negotiate with that "competent international authority" a time-bound plan for the verified and irreversible elimination of its nuclear weapons programme, which will submit it to the next meeting of signing states or to the next review conference, whichever comes first.**

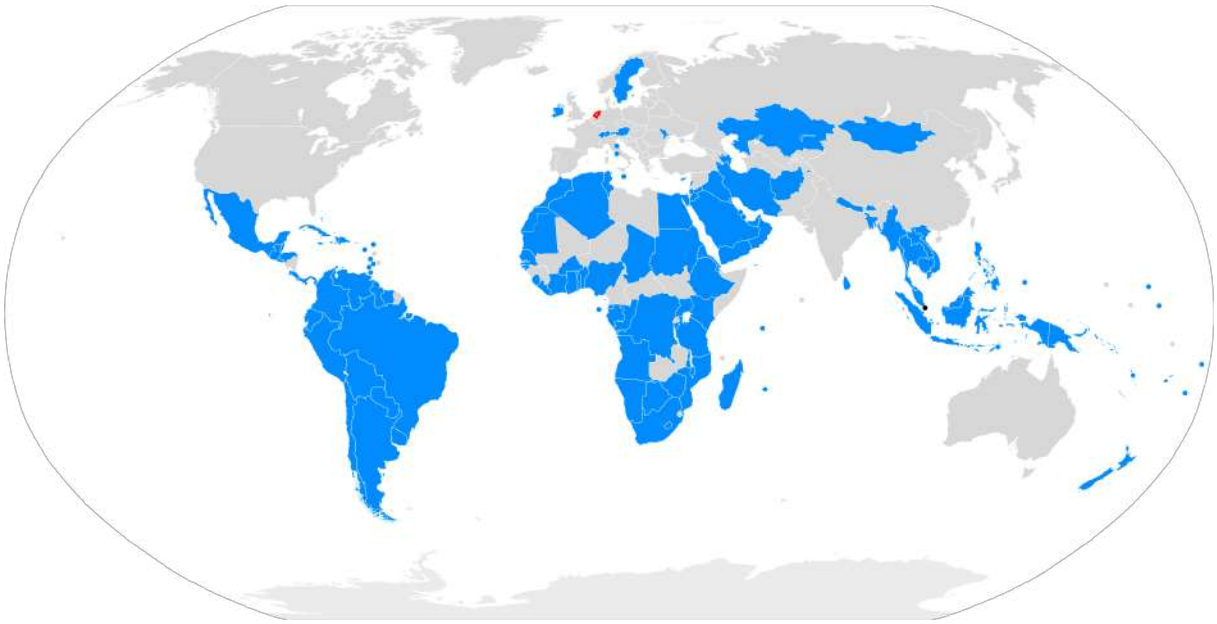

Figure D.3: **UN vote on adoption of the treaty on 7 July 2017 Blue=Yes; Red=No; Black=Abstention; Grey=Did not vote.**

Figure D.4: **Ambassador Thani Thongphakdi of Thailand, the chair of a UN working group on nuclear disarmament, accepts a global parliamentary appeal from Beatrice Fihn, executive director of the International Campaign to Abolish Nuclear Weapons, in Geneva on May 3, 2016. It was signed by 838 parliamentarians in 42 countries.**

Appendix E

HIROSHIMA: A SILENCE BROKEN

E.1 Book review: "Hiroshima, August 6, 1945, a Silence Broken"

Why the book is important

The nuclear destruction of Hiroshima was a tragedy in itself, but its larger significance is that it started a nuclear arms race which today threatens to destroy human society and much of the biosphere.

E.2 Soka Gakkai

Soka Gakkai is a large Nichiren Buddhist religious group. Its 12 million members are centered primarily in Japan, but Soka Gakkai International (SGI) has groups in 192 countries. In Japanese, the words "Soka Gakkai" mean "Value-Creating Education". The organization was started by two Japanese educators, Tsunisaburo Makiguchi and Josei Toda, both of whom were imprisoned by their government during World War II because of their opposition to militarism. Makaguchi died as a result of his imprisonment, but Josei Toda went on to found a large and vigorous educational organization dedicated to culture, humanism, world peace and nuclear abolition.

E.3 The Toda Declaration and Daisaku Ikeda's Proposals

In 1957, before a cheering audience of 50,000 young Soka Gakkai members, Josei Toda declared nuclear weapons to be an absolute evil. He said that their possession is criminal

Figure E.1: **In 1957, before a cheering audience of 50,000 young Soka Gakkai members, Josei Toda declared nuclear weapons to be an absolute evil. He said that their possession is criminal under all circumstances, and he called on the young people present to work untiringly to rid the world of all nuclear weapons. Source: SGI International**

under all circumstances, and he called the young people present to work untiringly to rid the world of all nuclear weapons.

Toda was the mentor of Daisaku Ikeda, the first president SGI. Every year, President Ikeda issues a Peace Proposal, calling for international understanding and dialogue, as well as nuclear abolition, and outlining practical steps by which he believes these goals may be achieved. In his 2013 Peace Proposal, Ikeda, noted that 2015 will be the 70th anniversary of the destruction of Hiroshima, and he proposed that the NPT review conference should take place in Hiroshima, rather that in New York. He proposed that this should be followed by "an expanded global summit for a nuclear-weapon-free world"

E.4 The Hiroshima Peace Committee and the last remaining hibakushas

In Japanese the survivors of injuries from the nuclear bombing of Hiroshima and Nagasaki are called "hibakushas". Over the years, the Soka Gakkai Hiroshima Peace Committee has published many books containing their testimonies. The most recent of these books, "A Silence Broken", contains the testimonies of 14 men, now all in their late 70's or in their 80's, who are among the last few remaining hibakushas. All 14 of these men have kept silent until now because of the prejudices against hibakushas in Japan, where they and their children are thought to be unsuitable as marriage partners because of the effects

Figure E.2: **It was like a scene from hell. Source: SGI International.**

of radiation. But now, for various reasons, they have chosen to break their silence. Many have chosen to speak now because of the Fukushima disaster.

The testimonies of the hibakushas give a vivid picture of the hell-like horrors of the nuclear attack on the civilian population of Hiroshima, both in the short term and in the long term. For example, Shigeru Nonoyama, who was 15 at the time of the attack, says: "People crawling out from crumbled houses started to flee. We decided to escape to a safe place on the hill. We saw people with melted ears stuck to their cheeks, chins glued to their shoulders, heads facing in awkward positions, arms stuck to bodies, five fingers joined together and grab nothing. Those were the people fleeing. Not merely a hundred or two, The whole town was in chaos."

"I saw the noodle shop's wife leg was caught under a fallen pole, and a fire was approaching. She was screaming, 'Help me! Help me!' There were no soldiers, no firefighters. I later heard that her husband had cut off his wife's leg with a hatchet to save her."

"Each and every scene was hell itself. I couldn't tell the difference between the men and the women. Everybody had scorched hair, burned hair, and terrible burns. I thought I saw a doll floating in a fire cistern, but it was a baby. A wife trapped under her fallen house was crying, 'Dear, please help me, help me!' Her husband had no choice but to leave her in tears."

"...I hovered between life and death for three months, from August to October. When a fly landed on a festering wound, it would bleed white maggots in a few days. My mother shooed away the flies through the night with a fan through the night. She must have been desperately determined not to lose any more sons or daughters. My dangling skin dried and turned hard, like paper. My mother picked off the dried skin. She made a cream of straw ash and cooking oil, and applied it to my burnt head, face and fingertips, turning me black..."

The testimonies of the other hibakushas are equally horrifying.

Figure E.3: **Burned beyond recognition. Source: SGI International.**

Figure E.4: **Memories of August 6. Source: SGI International.**

Figure E.5: **The effects lasted a lifetime. Source: SGI International.**

Figure E.6: **After the bombing. Source: SGI International.**

The postwar nuclear arms race

On August 29, 1949, the USSR exploded its first nuclear bomb. It had a yield equivalent to 21,000 tons of TNT, and had been constructed from Pu-239 produced in a nuclear reactor. Meanwhile the United Kingdom had begun to build its own nuclear weapons.

The explosion of the Soviet nuclear bomb caused feelings of panic in the United States, and President Truman authorized an all-out effort to build superbombs using thermonuclear reactions - the reactions that heat the sun and stars. On October 31, 1952, the first US thermonuclear device was exploded at Eniwetok Atoll in the Pacific Ocean. It had a yield of 10.4 megatons, that is to say it had an explosive power equivalent to 10,400,000 tons of TNT. Thus the first thermonuclear bomb was five hundred times as powerful as the bombs that had devastated Hiroshima and Nagasaki. The Soviet Union and the United Kingdom were not far behind.

In 1955 the Soviets exploded their first thermonuclear device, followed in 1957 by the UK. In 1961 the USSR exploded a thermonuclear bomb with a yield of 58 megatons. A bomb of this size, two thousand times the size of the Hiroshima bomb, would destroy a city completely even if it missed it by 50 kilometers. France tested a fission bomb in 1966 and a thermonuclear bomb in 1968. In all about thirty nations contemplated building nuclear weapons, and many made active efforts to do so.

Because the concept of deterrence required an attacked nation to be able to retaliate massively even though many of its weapons might be destroyed by a preemptive strike, the production of nuclear warheads reached insane heights, driven by the collective paranoia of the Cold War. More than 50,000 nuclear warheads were produced worldwide, a large number of them thermonuclear. The collective explosive power of these warheads was equivalent to 20,000,000,000 tons of TNT, i.e., 4 tons for every man, woman and child on the planet, or, expressed differently, a million times the explosive power of the bomb that destroyed Hiroshima. Today, the collective explosive power of all the nuclear weapons in

the world is about half that much, but still enough to destroy human society.

There are very many cases on record in which the world has come very close to a catastrophic nuclear war. One such case was the Cuban Missile Crisis. Robert McNamara, who was the US Secretary of Defense at the time of the crisis, had this to say about how close the world came to a catastrophic nuclear war: "I want to say, and this is very important: at the end we lucked out. It was luck that prevented nuclear war. We came that close to nuclear war at the end. Rational individuals: Kennedy was rational; Khrushchev was rational; Castro was rational. Rational individuals came that close to total destruction of their societies. And that danger exists today."

A number of prominent political and military figures (many of whom have ample knowledge of the system of deterrence, having been part of it) have expressed concern about the danger of accidental nuclear war. Colin S. Gray, Chairman, National Institute for Public Policy, expressed this concern as follows: "The problem, indeed the enduring problem, is that we are resting our future upon a nuclear deterrence system concerning which we cannot tolerate even a single malfunction". Bruce G. Blair (Brookings Institute) has remarked that "It is obvious that the rushed nature of the process, from warning to decision to action, risks causing a catastrophic mistake"... "This system is an accident waiting to happen."

As the number of nuclear weapon states grows larger, there is an increasing chance that a revolution will occur in one of them, putting nuclear weapons into the hands of terrorist groups or organized criminals. Today, for example, Pakistan's less-than-stable government might be overthrown, and Pakistan's nuclear weapons might end in the hands of terrorists. The weapons might then be used to destroy one of the world's large coastal cities, having been brought into the port by one of numerous container ships that dock every day, a number far too large to monitored exhaustively. Such an event might trigger a large-scale nuclear conflagration.

Recent research has shown that a large-scale nuclear war would be an ecological catastrophe of enormous proportions, producing very large-scale famine through its impact on global agriculture, and making large areas of the world permanently uninhabitable through long-lived radioactive contamination.

How do these dangers look in the long-term perspective? Suppose that each year there is a certain finite chance of a nuclear catastrophe, let us say 1 percent. Then in a century the chance of a disaster will be 100 percent, and in two centuries, 200 percent, in three centuries, 300 percent, and so on. Over many centuries, the chance that a disaster will take place will become so large as to be a certainty. Thus by looking at the long-term future, we can see that if nuclear weapons are not entirely eliminated, civilization will not survive.

We will do well to remember Josei Toda's words: "Nuclear weapons are an absolute evil. Their possession is criminal under all circumstances"

Appendix F

BOOK REVIEW: THE PATH TO ZERO

The Path to Zero, by Richard Falk and David Krieger

This book ought to be required reading for college students everywhere in the world, and also for decision-makers. It shakes us out of our complacency and makes us realize that widespread, immediate and dedicated public action is urgently needed if we are to save human civilization and the biosphere from a thermonuclear catastrophe. The book is published by Paradigm Publishers, 2845 Wilderness Place, Boulder, CO 80301, USA. (www.paradigmpublishers.com) On the back cover there are endorsements, with which I entirely agree, by Archbishop Desmond Tutu and David Ellsberg.

" We are greatly privileged, like flies on the wall, to join this conversation between two remarkable stalwarts. Richard Falk and David Krieger, in the campaign for a nuclear-free world. It is unconscionable that so many of us seem to accept the prospect of our 'mutually assured destruction', the immoral massacre of millions of civilians, and to view with equanimity such a gross violation of international law. Falk and Krieger discuss persuasively and cogently the folly of reliance on nuclear weapons that can cause apocalyptic devastation. If we want to survive in a habitable world, then we have no choice: we must heed, and do so urgently, these lovers of mankind." Archbishop Desmond Tutu, Nobel Peace Laureate

" In 'The Path to Zero', Falk and Krieger engage in a stunningly eloquent dialogue on a range of nuclear dangers, and our common responsibility to put an end to them. This is urgent reading for citizens, scientists, policy-makers and political leaders, actually for anyone who cares about the future of civilization and life on earth", Daniel Ellsberg, Whistleblower

Other enthusiastic endorsements come from Jonathan Schell, Commander Robert Green and Maude Barlow.

The book has ten chapters: 1 The Nuclear Age; 2 Nuclear Deterrence; 3 Nuclear

Proliferation; 4 Nuclear Arms Control and Nuclear Disarmament; 5 Nuclear Weapons and Militarism; 6 Nuclear Weapons and Nuclear Energy; 7 Nuclear Weapons and International Law; 8 Nuclear Weapons, Culture and Morality; 9 Nuclear Weapons and Democracy; 10 The Path to Zero.

F.1 The two authors

Richard Falk is Albert G. Milbank Professor of International Law and Practice Emeritus at Princeton, where he was a member of the faculty for 40 years. Since 2002 he has been a research professor at the University of California-Santa Barbara. He has been Special Rapporteur on Occupied Palestine for the UN Human Rights Council since 2008, and served on a panel of experts appointed by the President of the UN General Assembly, 2008-2009. He is the author or editor of numerous books, including " Legality and Legitimacy in Global Affairs" (Oxford 2012).

David Krieger is a Founder of the Nuclear Age Peace Foundation, and has served as President of the Foundation since 1982. Under his leadership, the Foundation has initiated many innovative projects for building peace, strengthening international law, abolishing nuclear weapons, and empowering peace leaders. Among other leadership positions, he is one of 50 Councilors from around the world on the World Future Council. He is the author and editor of numerous books and articles related to achieving peace in the Nuclear Age. A graduate of Occidental College, he holds MA and PhD degrees in political science from the University of Hawaii.

F.2 Flaws in the concept of nuclear deterrence

In discussing the concept of nuclear deterrence, the two authors emphasize the fact that it violates the fundamental ethical principles of every major religion. Dr. Krieger comments:

Krieger: " Who are we? What kind of culture would be content to base its security on threatening to murder hundreds of millions of innocent people?"

The two authors also point out that the idea of deterrence is an unproved theory, based on the assumption that accidents will not happen, and that leaders are always rational. In fact, we know historically that the world has come extremely near to accidental nuclear war on very numerous occasions, and there are also many historical instances of irrational behavior by leaders. This cannot continue indefinitely without a catastrophe.[1]

[1]See: http://www.cadmusjournal.org/article/issue-4/flaws-concept-nuclear-deterrance

Figure F.1: **Richard Falk**

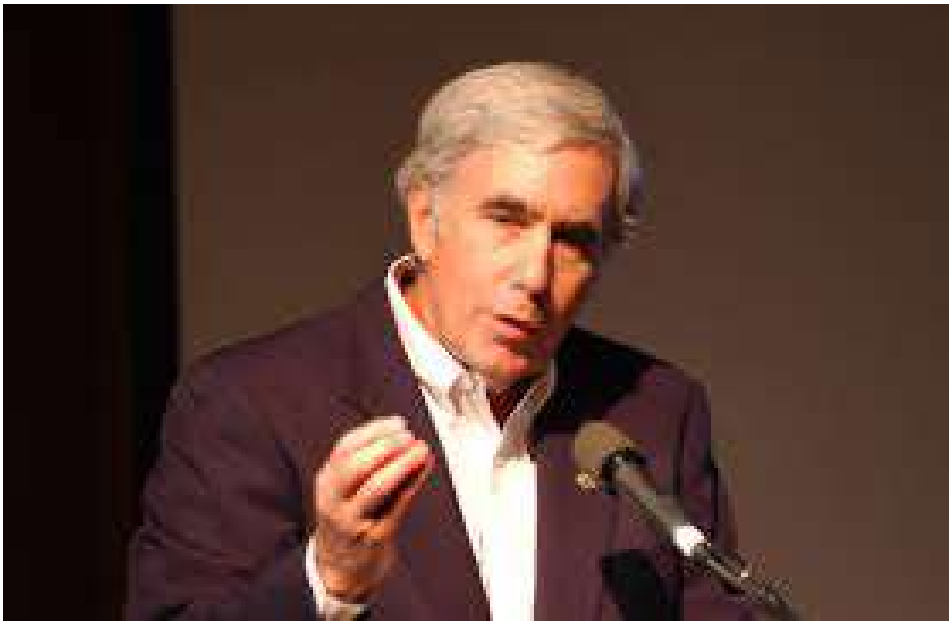

Figure F.2: **David Krieger**

F.3 The illegality of nuclear weapons

As Dr. Krieger and Prof. Falk point out, the threat or use of nuclear weapons violates international law. The fact that planning an aggressive war or conducting one is a crime according to the Nuremberg Principles is discussed. The two authors also review in detail the 1996 Advisory Opinion of the International Court of Justice, which was asked by the UN General Assembly and the World Health Organization to rule on the legality of the threat or use of nuclear weapons. The ICJ ruled that under almost all circumstances, the threat or use of nuclear weapons would be illegal. The only possible exception was the case where a country might be under attack and its very survival threatened. The Court gave no ruling on this extreme case. Finally, the ICJ ruled unanimously that states possessing nuclear weapons have an obligation to get rid of them within a short time-frame.

Falk: " It may be time for the General Assembly to put this question to the ICJ: What legal consequences arise from the persistent failure of the nuclear weapon states to fulfill their obligations under Article VI of the NPT? In my view, the nonnuclear states have also been irresponsible in not insisting on on mutuality of respect in the nonproliferation setting. It may be up to civil society actors to bring wider attention to this disrespect for the vital norms of international law..." [2]

F.4 Colonialism and exceptionalism

Falk: " We need to remember that the expansion of Europe at the expense of the non-Western world rested on violence and the superiority of European weaponry and strategic logistics, including naval power. This link between Western militarism and historical ascendancy is, in my view, one of the deep reasons why there is such an irrational attachment to nuclear weaponry, making it very difficult to renounce as the supreme expression of political violence."

Krieger: " I would like to add that there is a general orientation in much of Western society to subordinate international law to geopolitical desire, in other words, not to allow international law to be a limiting factor in seeking geopolitical advantage. International law is thus applied when useful and ignored when self-interest and convenience dictate. This is a striking manifestation of the double standards that have served the interests of the powerful in both the colonial and postcolonial worlds."

[2] http://www.icj-cij.org/docket/files/93/7407.pdf
http://www.currentconcerns.ch/index.php?id=711
https://www.wagingpeace.org/author/john-avery/
http://human-wrongs-watch.net/2015/03/27/tactical-nuclear-weapons-in-europe-the-dangers-are-very-great-today/
http://www.countercurrents.org/avery250514.htm

F.5 The Nuclear Non-Proliferation Treaty

In discussing the Nuclear Non-Proliferation Treaty, Prof. Falk and Dr. Krieger point out that that it has several serious flaws: It is unsymmetrical, giving a special status to the nuclear weapons states, and forbidding all others to possess these weapons. The treaty encourages the " peaceful" use of nuclear energy, which in practice opens the door to acquisition of nuclear weapons by many nations and which exposes the world to radioactive fallout from accidents like Chernobyl and Fukushima, and very long-term dangers from radioactive wastes. Finally, membership in the NPT is not universal. Here are some comments by the two authors:

Falk: " In my view, the failure of the nuclear weapon states to pursue nuclear disarmament over a period of more than forty years, despite the injunction to do so by the International Court of Justice, is a material breach of the NPT that would give any party the option of pronouncing the treaty void."

Krieger: " It would be wonderful to see a strong and concerted effort by non-nuclear-weapon states to challenge the nuclear weapons club. I think that the most effective thing that such states could do would be to start the process of negotiating a nuclear weapons convention and, if necessary, to do it without the nuclear weapon states."

Falk: " My proposal is a two-year ultimatum by as many nonnuclear states as possible, threatening to withdraw from the NPT unless serious nuclear disarmament negotiations get underway."

Dr. Krieger is not in complete agreement with Prof. Falk regarding such an ultimatum. He feels that even though it is flawed in many ways, the NPT is still so valuable that its continuation ought not to be threatened.

Krieger: " One of the great problems with the NPT is that it encourages the peaceful use of nuclear energy, which actually opens the door to nuclear weapons proliferation. It ends up making the treaty work against itself. Of course, Israel is not a party to the treaty, nor are India and Pakistan. This demonstrates a fundamental weakness of international law, that is, the exemption of nations that do not sign a treaty from the law. This would be unworkable in domestic law, and it is equally so in international law."

Krieger: " The nuclear plant operators are willing to downplay for short-term gain the catastrophic risks that are involved in the use of nuclear reactors to boil water. They are wiling to generate wastes that will adversely affect the health and well-being of untold generations to follow us on the planet. The tragedy is that governments embrace and support this industry, demonstrating that they also do not place the interests of their people and the future at the forefront of their planning and decision making."

http://www.baselpeaceoffice.org/article/global-wave-2015-and-peace-planet-un-nuclear-non-proliferation-conference

F.6 No first use; no hair-trigger alerted missiles

In their concluding chapter, the two authors agree that a No First Use declaration could be a useful first step. Prof. Falk comments:

Falk: " What conceivable justification, consistent with a deterrence rationale for the retention of nuclear weapons, is there for not assuring other governments that the United States will only use such weaponry in retaliation a prior attack with nuclear weaponry? It is rather clear that such a declaration, especially if backed up by non-nuclear deployments, would both give the United States some new claim to leadership with respect to the weaponry and exert enormous psychological pressure on other nuclear weapon states to follow the American lead."

This, of course, could be linked to taking all nuclear weapons systems off hair-trigger alert, which is probably the most important first step towards avoiding the catastrophe of an accidental nuclear war. Dr Krieger comments:

Krieger: " Those responsible for maintaining nuclear arsenals on hair-trigger alert are delusional if they think that it can be maintained indefinitely without dire consequences."

Some conclusions

When the Cold War ended in 1991, many people heaved a sigh of relief and concluded that they no longer had to worry about the threat of a nuclear Armageddon. Prof. Falk and Dr. Krieger show us that this comforting belief is entirely false, that the dangers are greater than ever before, and that it is vital to bring this fact to the urgent attention of today's young people, who were born long after the tragic nuclear destruction of Hiroshima and Nagasaki, or perhaps even born after the end of the Cold War.

Ultimately, the complete abolition of nuclear weapons is linked with a change of heart, the replacement of narrow nationalism by loyalty to humanity as a whole, and the replacement of militarism by a just and enforcible system of international law.

Suggestions for further reading:

Ban Ki-moon. " The United Nations and security in a nuclear-weapon-free world." Address to the East-West Institute, October 24, 2008.

Green, Robert, " Breaking Free from Nuclear Deterrence." Santa Barbara: Nuclear Age Peace Foundation, 10th Annual Frank K. Kelly Lecture on Humanity's Future, 2011,

" Legality of the Threat or Use of Nuclear Weapons." Advisory Opinion of the International Court of Justice, The Hague, July 8, 1996. http://www.icj-cij.org/docket/files/93/7407.pdf

McCloy-Zorin Accords. " Joint Statement of Agreed Principles for Disarmament Negotiations," signed on September 20, 1961, unanimously adopted by the United Nations General Assembly on December 20, 1961.

Model Nuclear Weapons Convention. " Convention on the Prohibition of the Development, Testing, Production, Stockpiling, Transfer, Use and Threat of Use of Nuclear Weapons and their Elimination, April 2007."
http://www.inesap.org/publications/nuclear-weapons-convention

Obama, Barak, Remarks of President Barak Obama, Hradcany Square, Prague, Czech Republic, April 5, 2009.
http://prague.usembassy.gov/obama.html

Rotblat, Joseph, " Remember Your Humanity", Nobel Lecture, Oslo, Norway, December 10, 1995,

Russell-Einstein Manifesto, issued in London, July 9, 1955,
http://www.pugwash.org/about/manifesto.htm

Santa Barbara Declaration, " Reject Nuclear Deterrence: An Urgent Call to Action,"
http://www.wagingpeace.org/santa-barbara-declaration-reject-nuclear-deterrence-an-urgent-call-to-action/

Treaty on the Non-Proliferation of Nuclear Weapons, entered into force on March 5, 1970.
http://www.state.gov/www/global/arms/treaties/npt1.html

Vancouver Declaration. " Law's Imperative for the Urgent Achievement of a Nuclear-Weapon-Free World," Vancouver, Canada, March 21, 2011.
http://www.lcnp.org/wcourt/Feb2011VancouverConference/vancouverdeclaration.pdf

Appendix G

SOME PEACE EDUCATION INITIATIVES IN DENMARK

G.1 The Danish Peace Academy

The Danish Peace Academy and its enormous website are interesting because they were founded and developed almost single-handedly by one person: Holger Terp, who has for many years been nearly blind as a result of a stroke. A few years ago he also suffered a severe heart attack which required a 5-fold bypass operation. Despite these seemingly insurmountable health problems, Holger works from early morning to late at night in the cause of world peace and international understanding.

Holger Terp completed his education as a librarian in 1992. In 1996, he participated in a course on "Internet and Presentation Technique" at the Academy of Fine Arts in Copenhagen. However, in 1999 he suffered a stroke, which made him blind in one eye and almost blind in the other. The stroke also affected Holger's speech, so that it was difficult to understand him when he talked. Instead of giving up, as many people would have done, Holger resolved to devote the remainder his life to the cause of world peace. Despite his severe handicap, he has achieved almost incredible results, a full account of which can be found on the link www.fredsakademiet.dk/ht.htm .

Holger's greatest achievement has been to found the Danish Peace Academy and to single-handedly create its enormous website. The website contains more than 79,000 images and files related to peace, in Danish, English and German, and it is currently visited by between 2,000 and 4,000 different people each day. Many of the visitors are from schools and universities in various parts of the world, who use the information on the website as a part of their studies.

In creating his website, Holger has used both his training as a librarian and the knowledge that he gained from the 1996 course at Copenhagen's Academy of Fine Arts. As a result, many parts of the website have great visual beauty because of the liberal use of images. For example, one can enjoy Holger's "Greenham Common Songbook", which is an account of the successful efforts of the woman's peace movement in England to prevent

Figure G.1: **Holger Terp**

common land at Greenham from being used as a base for nuclear weapons. The songbook is a piece of history, illustrated not only by the songs, which the visitor to the website can hear performed by such artists as Peggy Seeger, but also by countless beautiful posters and photos from the era. Other special features of the website are numerous books, articles, poetry and song collections, a peace-related encyclopedia, and a timeline showing the history of the peace movement, from the middle ages up to the present. For example, one can find on the website the interesting fact that war was once completely unknown to the inhabitants of Greenland. When Danish teachers in the 19th century explained European history to the Greenlanders, they had to teach them what war is, since the people of Greenland had never heard of it!

Holger himself is the author or editor of numerous books, and he has translated Gandhi's autobiography into Danish. The example of Gandhi's life has always been a guide for Holger, and perhaps Holger's life can be a guide for our own efforts, as we strive to work for peace. If he could achieve so much with such a severe handicap, then the rest of us ought to be able to do something too.

G.2 The Danish National Group of Pugwash Conferences

Many countries have local Pugwash groups, and the Danish National Pugwash Group is one of these. Our activities include conferences at the Danish Parliament, aimed at influencing decision-makers, but other activities are aimed influencing public opinion. Peace education activities include the award of student peace prizes on United Nations Day.

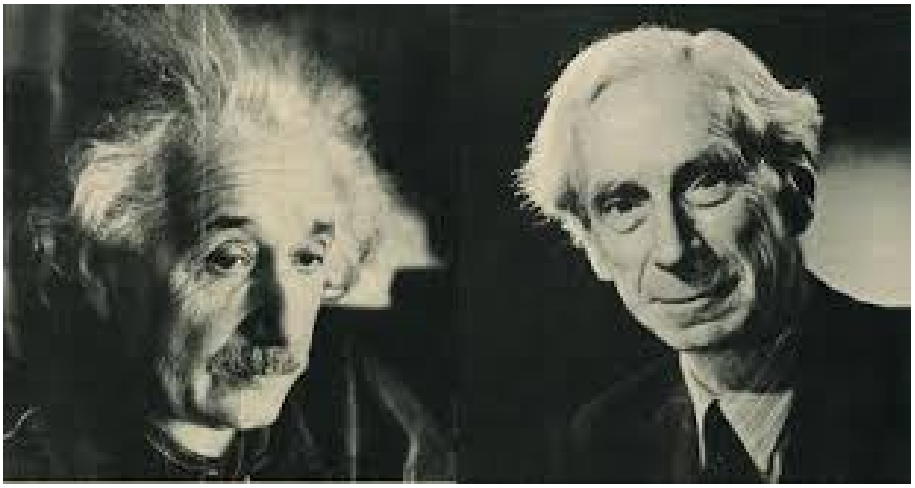

Figure G.2: **The Russell-Einstein Manifesto: "Shall we put an end to the human race, or shall mankind renounce war?"**

United Nations Day Student Peace Prizes

In collaboration with the Danish Peace Academy, and with the help of the Hermod Lannung Foundation the Danish National Group of Pugwash Conferences on Science and World Affairs has offered prizes each year to students at 10 Danish gymnasiums for projects related to global problems and their solutions and to the United Nations.

These projects are essays, dramatic sketches, videos, websites, posters, etc., and they were judged on UN Day, before large audiences of students. The background for this project is as follows: In 2007, in collaboration with several other NGO's, we arranged a visit to Copenhagen by Dr. Tadatoshi Akiba, the Mayor of Hiroshima. In connection with his visit, we arranged a Peace Education Conference at the University of Copenhagen.

In connection with Dr. Akiba's visit, we also arranged a day of peace education at Copenhagen's Open Gymnasium. About 15 people from various branches of Denmark's peace movement arrived at the gymnasium at 7.00 a.m., and between 8.00 and 10.00 they talked to 15 groups of about 25-50 students about topics related to peace. At 10.30, all 500 students assembled in a large hall, where Dr. Akiba gave an address on abolition of nuclear weapons. A chorus from the gymnasium sang, and finally there was a panel discussion.

The students were extremely enthusiastic about the whole program. The success of our 2007 effort made us want to do something similar in 2008, and perhaps to broaden the scope. Therefore we wrote to the Minister of Education, and proposed that October 24, United Nations Day, should be a theme day in all Danish schools and gymnasiums, a day devoted to the discussion of global problems and their solutions. We received the very kind reply. The Minister said that he thought our idea was a good one, but that he did not have the power to dictate the curricula to schools. We needed to contact the individual schools, gymnasiums and municipalities.

In the autumn of 2008 we arranged a United Nations Day program on October 24 at

Figure G.3: **A painting representing the work of the United Nations. It won first prize at a UN Day Student Peace Prize competition**

Sankt Annæ Gymnasium with the cooperation of Nørre Gymnasium. We offered prizes to drama students at the two gymnasiums for the best peace-related dramatic sketch, a condition being that the sketches should be performed and judged before a large audience. Our judges were the famous actress Mia Luhne, Johan Olsen, the lead singer of a popular rock group, and the dramatist Steen Haakon Hansen. The students' sketches and the judges speeches about the meaning of peace were very strong and moving. Everyone was very enthusiastic about the day. The judges have said that they would be willing to work with us again on peace-related cultural events.

Our successes in 2007 and 2008 have made us wish to continue and possibly expand the idea of making United Nations Day a theme day in Danish schools and gymnasiums, a day for discussion of global problems and their solutions, with special emphasis on the role of the United Nations. The Hermod Lannung Foundation supported our project for extending this idea to 10 Danish gymnasiums in 2010, 2011 and 2012.

The Hermod Lannung Foundation has generously awarded us funds to continue the project in 2013. The Danish United Nations Association worked with us on this project in 2011, and we hope that they will help us to expand it in the future, with additional funding from the Ministry of Education.

Figure G.4: **Bishop N.F.S. Grundtvig (1738-1872) established Peoples' Colleges in Denmark**

G.3 The Gruntvigian Peoples' Colleges

A unique feature of the Danish educational system is the adult education that is available at about a hundred FolkehÃ¸jskole (Peoples' Colleges). This tradition of adult education dates back to the Danish poet-bishop N.F.S. Grundtvig (1783-1872). Besides writing more than half of the hymns presently used in Danish churches, Grundtvig also introduced farmers' cooperatives into Denmark and founded a system of adult education.

At the time when Grundtvig lived, the Industrial Revolution had already transformed England into a country that exported manufactured goods but was unable to feed itself because of its large population. In this situation, Denmark began a prosperous trade, exporting high quality agricultural produce to England (for example dairy products, bacon, and so on). Grundtvig realized that it would be to the advantage of small-scale Danish farmers to process and export these products themselves, thus avoiding losing a part of their profits to large land-owners or other middlemen who might do the processing and exporting for them. He organized the small farmers into cooperatives, and in order to give the farmers enough knowledge and confidence to run the cooperatives, Grundtvig created a system of adult education: the Peoples' Colleges. The cooperatives and the adult education system contributed strongly to making Denmark a prosperous and democratic country.

Of the hundred or so Grundtvigian Peoples' Colleges exiting today, about forty offer peace education as a subject. An example of such a peace education course was the two-week summer school "Towards a Non-violent Society", held at the International College in Elsinore during the summer of 1985. Since it was supported not only by the students' fees but also by a government subsidy, the summer school was able to pay the travel and living expenses for lecturers who came from many parts of the world.

Among the stars of the summer school were former US Governor Harold Stassen, the only living person who had signed the UN Charter; the famous Cambridge University ethologist, Professor Robert Hinde; Professor Suman Khana from India, an expert on non-violence and Gandhi; Sister George, a Catholic nun from Jerusalem, who spoke 12

Figure G.5: **At the time of our summer school, former US Governor Harold Stassen was the only living person who had signed the UN Charter.**

languages during the course of her daily work and who was an expert on the conflicts of the Middle East; and Meta Ditzel, a member of the Danish Parliament who advocated legislation to make excessively violent videos less easily available to children. Other lectures were given by representatives of Amnesty International and the Center for Rehabilitation of Torture Victims.

Since the summer school took place outside the regular term, all of the rooms at the International College were available, and students came not only from Denmark, but also from other parts of Scandinavia and Europe. Part of the summer tradition of the Grundvigian High Schools is that students of all ages pay the modest fees in order to have an intellectually stimulating vacation, during the course of which they will form new friendships. Thus the summer school had a social function as well as a pedagogical one. Accordingly, Suman Khana taught a yoga class as well as a class on the Gandhian tradition of non-violence.

In order to illustrate how horrible excessively violent videos can be, the Danish parliamentarian Meta Ditzel was scheduled to show one of the worst videos of this type to the group. She went to a video shop and asked for the worst one available, saying that it was needed as part of her campaign to make violent videos illegal. The owner of the shop, realizing that his livelihood was being threatened, gave her the most innocent film that he could find, and the horrible example later that evening turned out to be less than horrifying. (Meta Ditzel had not previewed it.)

G.4 Ethics for Science and Engineering Students

The summer school "Towards a Nonviolent Society", which I helped to plan, had an interesting consequence, which affected my activities in the peace movement: One of the other people involved in organizing the summer school urged me to enter an essay contest sponsored by the Nuclear Age Peace Foundation. The contest called for essays on how to give scientists and engineers a sense of social responsibility. Following my friend's suggestion, I wrote an essay saying that universities ought to offer courses on the history and social impact of science. As the course reached modern times, it would be natural to introduce a discussion of the ethical , social and political problems created by the extremely rapid development of science and technology.

My essay did not win the contest, but the friend who had asked me to write it was so pleased with what I had written that he translated it into Danish and submitted it to "Politiken", one of the major Danish newspapers. When it was published, students from the University of Copenhagen, where I was teaching, came to me and said, "Well, if you really believe what you have written, you have to make such a course!" As the result of their urging I planned a course entitled "Science, Ethics and Politics", but I had great difficulties in getting the studies committee to accept it as part of the curriculum. They apparently thought that science, ethics and politics were three entirely separate things, which ought not to have anything to do with each other.

Finally the course was accepted under the condition that neither I nor any of the students who attended the course should get any credit for it. However, it was a great success. Later, the name was changed to "Science and Society", and the students were finally given credit for attending the course. Meanwhile, the President of the University of Copenhagen heard about the course, and he kept sending me encouraging notes. One day he called me on the telephone, and said that since he knew that I was interested in global problems related to the rapid development of science and technology, he wondered whether I would like to be the Contact Person for Denmark for the Pugwash Conferences on Science and World Affairs. They had asked him to do this job, but he was too busy with his work as President. Since he was my boss, I had to say yes.

I continued to give the "Science and Society" course until my retirement in 2003. Meanwhile, at the Niels Bohr Institute and at the Royal Agricultural College, similar courses were started. Finally, all of us who were involved in these courses wrote to the Minister of Education and proposed that such courses ought to be compulsory for all science and engineering students in Denmark. The Minister called together the heads of the Danish institutions of higher education and put the question to them. They accepted the idea, but it could not be put into practice immediately because there were not enough people qualified to give the courses.

A program was started by Prof. Claus Emmeche of the Niels Bohr Institute to train people to teach the new courses. Finally, everything was ready, and starting in the autumn of 2004, all Danish science and engineering students at the university level have been required to take a course on the philosophy of science and its ethical aspects. The curriculum covers the history of science and technology, emphasizing cases where technology has

Figure G.6: **A program was started by Prof. Claus Emmeche of the Niels Bohr Institute to train people to teach the new courses.**

produced socially harmful results as well as cases where the results have been beneficial. Global problems related to science are also be a part of the curriculum.

G.5 Peace Education in Danish Elementary Schools

A book entitled "Et barn har brug for fred!" ("A Child Needs Peace!") by Nils Hartmann of the Danish UNICEF Committee provides a good example of peace education at the elementary level. Here are rough translations of a few of the paragraphs of Nils Hartmann's book:

"Peace and solidarity: A more just division of the resources of the world requires that we, in our part of the world, feel more solidarity with people in the less developed countries. In other words we must feel that we have much in common with them. People who feel solidarity with each other don't fight. They are friends. Solidarity means more than just making sacrifices for each other. If we only give others things we have too much of, something is missing. True solidarity also means that we must have respect for each other - respect for each other's culture, actions, religion and life. When we respect each other, we are also open towards each other. We need each other and learn from each other."

"Peace and fundamental needs: When people's fundamental needs are satisfied, they are able to feel secure, and the reasons for war and conflicts disappear. But it is important that every person satisfies these fundamental needs in a way that doesn't harm or exploit

others.

- If I buy a weapon in order to feel more safe, there will be others who feel threatened.
- If I exploit others in order to satisfy my own needs, there will be dissatisfaction and conflicts.
- If I use more food than I need, others will go hungry.
- If I dig a well and claim all the water for myself, others will go thirsty.
- If I buy unnecessary things, others will go without necessities"

"What can we get for the money that is wasted on armaments? In 1985 the world used about 8,000 billion (8,000,000,000,000) kroner4 for military purposes. In other words, half a billion kroner are being wasted while this lesson is going on. Here are a few examples of things we could have bought for a fraction of that amount of money:"

"Health: Almost everywhere in the world there is a lack of doctors, nurses and hospitals. This is especially true in the poorest country districts and slums of developing countries. A large number of children in these countries need to be vaccinated against some of the illnesses that are already eliminated from our part of the world. Measels, whooping cough, diphtheria, polio, tuberculosis and lockjaw cost the lives of millions of children each year. Also, many children need to come to a health clinic to get medicine and vitamins. Building up even a very basic health system would do wonders. The cost of a basic health system for the whole world is estimated to be 17 billion kroner per year."

"Safe drinking water: More than 2 billion people have no way of getting safe water. Impure water and lack of water lead to many diseases. Today, diarrohea is the most common cause of death for small children in the developing countries. The United Nations has declared the period 1981-1990 to be the International Water Decade. The United Nations has calculated that by using a total of 50 billion kroner, it would be possible to give pure drinking water to all the people of the world."

"Education: In developing countries, less than half of the adults have more than a year of schooling. Education is the best investment that we can make if we want to modernize a society and to create positive development. Building schools for all of the developing countries, educating teachers, and producing teaching materials would cost 55 billion kroner. (Eight Danish kroner = one US dollar.)"

These paragraphs from Nils Hartmann's book are illustrated with photographs of children from the developing countries. The paragraphs are written in simple language, and the examples used are related to the needs of children.

Denmark has for many years had an educational policy that aims at teaching children cooperative attitudes and habits rather than purely competitive ones. This system makes use of projects in which several children cooperate rather than individual projects. The use of cooperative projects in the Danish educational system can be thought of as an indirect form of peace education. Even at the university level, the Danish educational system makes much more use of cooperative projects than is the case in most other countries.

G.6 Alternative media in Denmark.

Modern powerholders are acutely aware of the importance of propaganda. Thus the media are a battleground where reformers struggle for attention, but are defeated with great regularity by the wealth and power of the establishment. This is a tragedy because today there is an urgent need to make public opinion aware of the serious problems facing civilization, and the steps that are needed to solve these problems. The mass media could potentially be a great force for public education, but in general their role is not only unhelpful; it is often negative. War and conflict are blatantly approved of by television and newspapers.

Today we are faced with the task of creating a new global ethic in which loyalty to family, religion and nation will be supplemented by a higher loyalty to humanity as a whole. In case of conflicts, loyalty to humanity as a whole must take precedence. In addition, our present culture of violence must be replaced by a culture of peace.

How do the media fulfill this life-or-death responsibility? Do they give us insight? No, they give us pop music. Do they give us an understanding of the sweep of evolution and history? No, they give us sport. Do they give us an understanding of need for strengthening the United Nations, and the ways that it could be strengthened? No, they give us soap operas. Do they give us unbiased news? No, they give us news that has been edited to conform with the interests of the military-industrial complex and other powerful lobbies. Do they present us with the need for a just system of international law that acts on individuals? On the whole, the subject is neglected. Do they tell of the essentially genocidal nature of nuclear weapons, and the need for their complete abolition? No, they give us programs about gardening and making food.

In general, the mass media behave as though their role is to prevent the peoples of the world from joining hands and working to change the world and to save it from thermonuclear and environmental catastrophes. The television viewer sits slumped in a chair, passive, isolated, disempowered and stupefied. The future of the world hangs in the balance, the fate of children and grandchildren hang in the balance, but the television viewer feels no impulse to work actively to change the world or to save it. The Roman emperors gave their people bread and circuses to numb them into political inactivity. The modern mass media seem to be playing a similar role.

Since today's powerholders completely control the mass media, workers for peace must create alternative media. In Denmark, several people have been active in this field. Holger Terp's Danish Peace Academy website can be thought of as an important alternative medium for peace education Holger has also produced a series of radio programs devoted to the history of peace songs.

Another important worker for peace education via alternative radio programs is Arne Hansen. He also maintains a website, where recordings of his radio programs can be accessed. In addition, Arne has an Internet newsletter with a large readership, which calls attention to his radio broadcasts, and to other matters of interest to the peace movement.

Troels Peter Schmidt and his wife Nina Larsen produce an extremely valuable alternative television station called "TV Gaderummet" (TV Streetspace). Although they are only able to broadcast their programs at times when not many viewers can see them, the

Figure G.7: **Arne Hansen's radio broadcasts and Internet newsletter contribute importantly to peace education in Denmark.**

broadcasts have a large impact because they are available on YouTube. Troels uses his Internet mailing list to call his programs to the attention of people who might be interested in them.

These are a few examples of peace education initiatives in Denmark. It is my great hope that some of the techniques described above will be useful for peace education in other countries

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Index