Putting the Genie Back in the Bottle: Nuclear Non-Proliferation in the New Millennium

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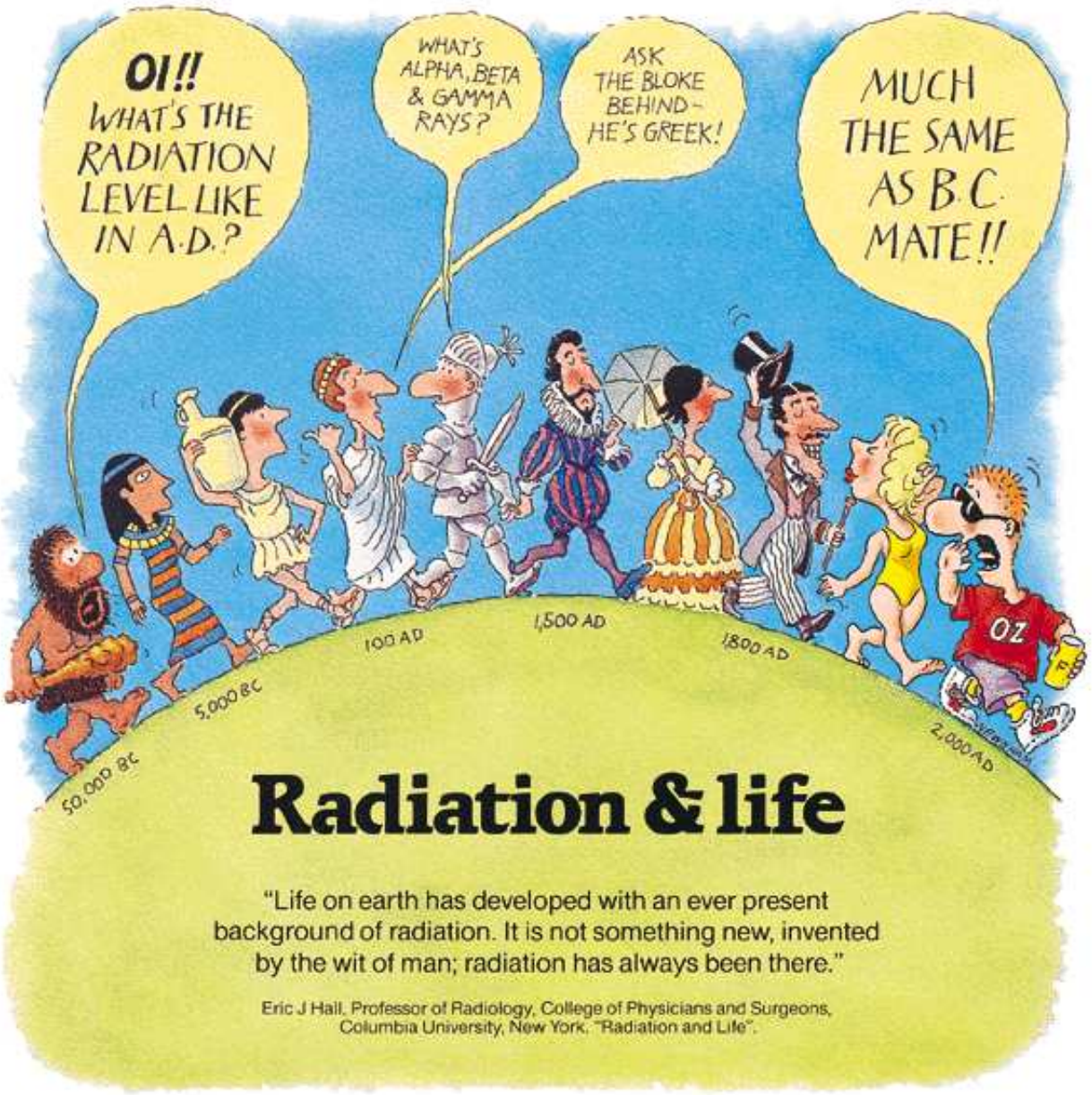
Outline:

1. How can nuclear materials hurt me?
2. Where do you get the stuff?
3. What can an opponent do with it?
4. What is being done about it?
5. What does it all mean?

What Is Radiation?

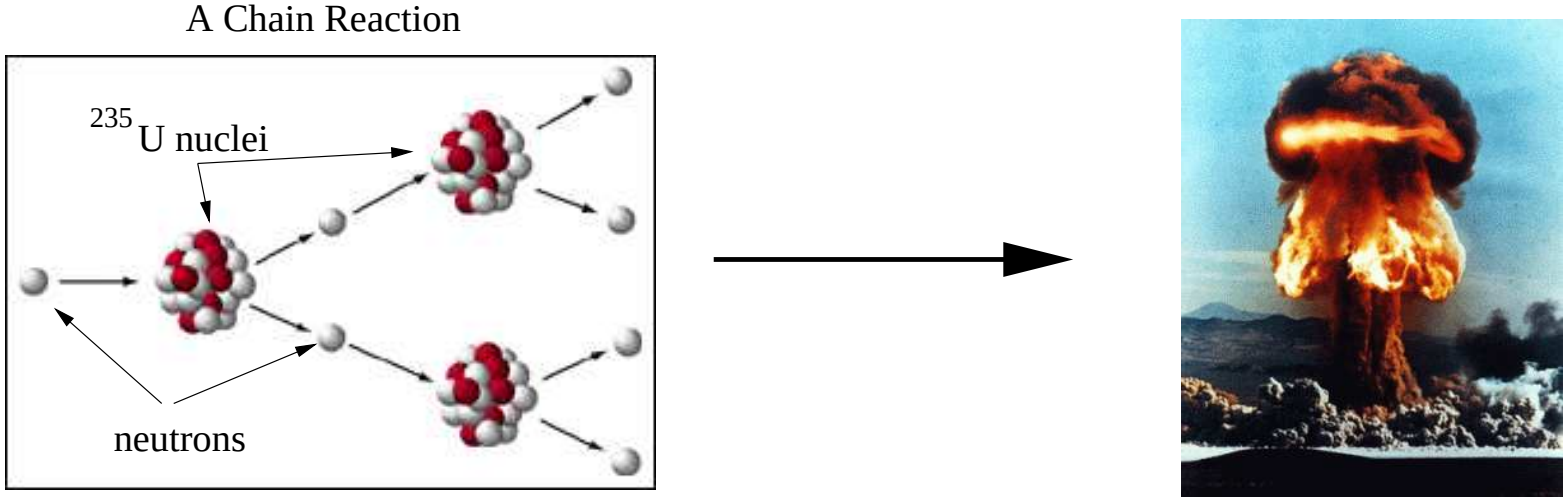


What Is Radiation?

- Emission or release of energy from atomic nuclei in the form of sub-atomic particles like photons, electrons, or other atomic nuclei.
- There is natural background radiation all around us that accounts for about 80% of the radiation on the Earth.
- Most of the man-made radiation is from X-ray machines and other medical procedures like cancer treatments.
- Wide range of industrial uses.
  - sterilize fully packaged and sealed medical supplies at room temperature (particularly important for plastic single use products).
  - cure rubbers and plastics with control unattainable with conventional chemical techniques.
  - cure solventless paints and coatings with unmatched speed.
  - food processing.
  - waste stream treatment.

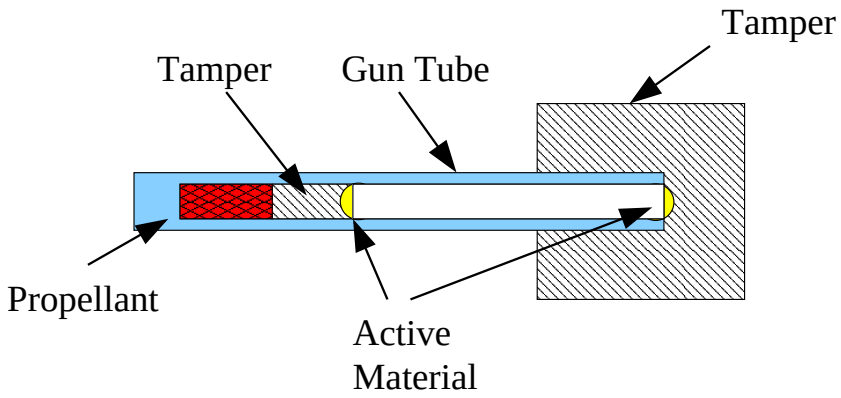
Nuclear Weapons 101

- Fissile materials (^{235}U, ^{233}U, ^{239}Pu) are used to make weapons of devastating power.
- Only about 8 kg of plutonium or 25 kg of highly-enriched uranium (HEU) is needed is needed to produce a weapon.
- As each nucleus splits, it emits 2 or so neutrons plus lots of energy. Most of the neutrons leave the material without striking any other nuclei under normal conditions.
- Increasing the density will create a ‘chain reaction’ where the emitted neutrons cause other fissions in a self-propagating process.

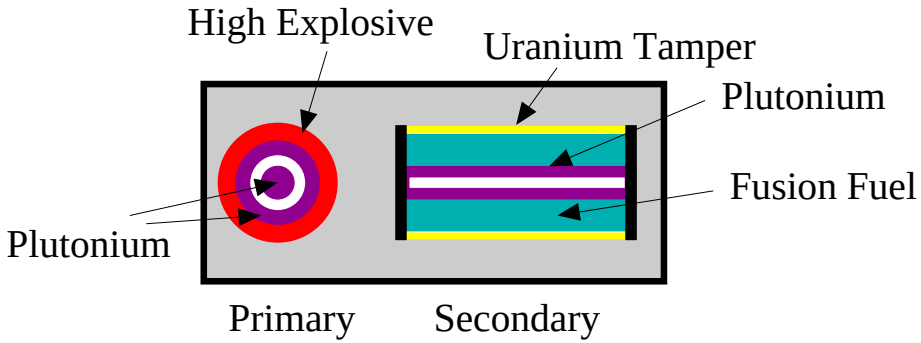


Nuclear Weapons 101

- A uranium, gun-type nuclear weapon.
- High explosive detonates pushing highly-enriched uranium at high speed down the gun tube and into the other piece of active material. The density increases enough to start the chain reaction.

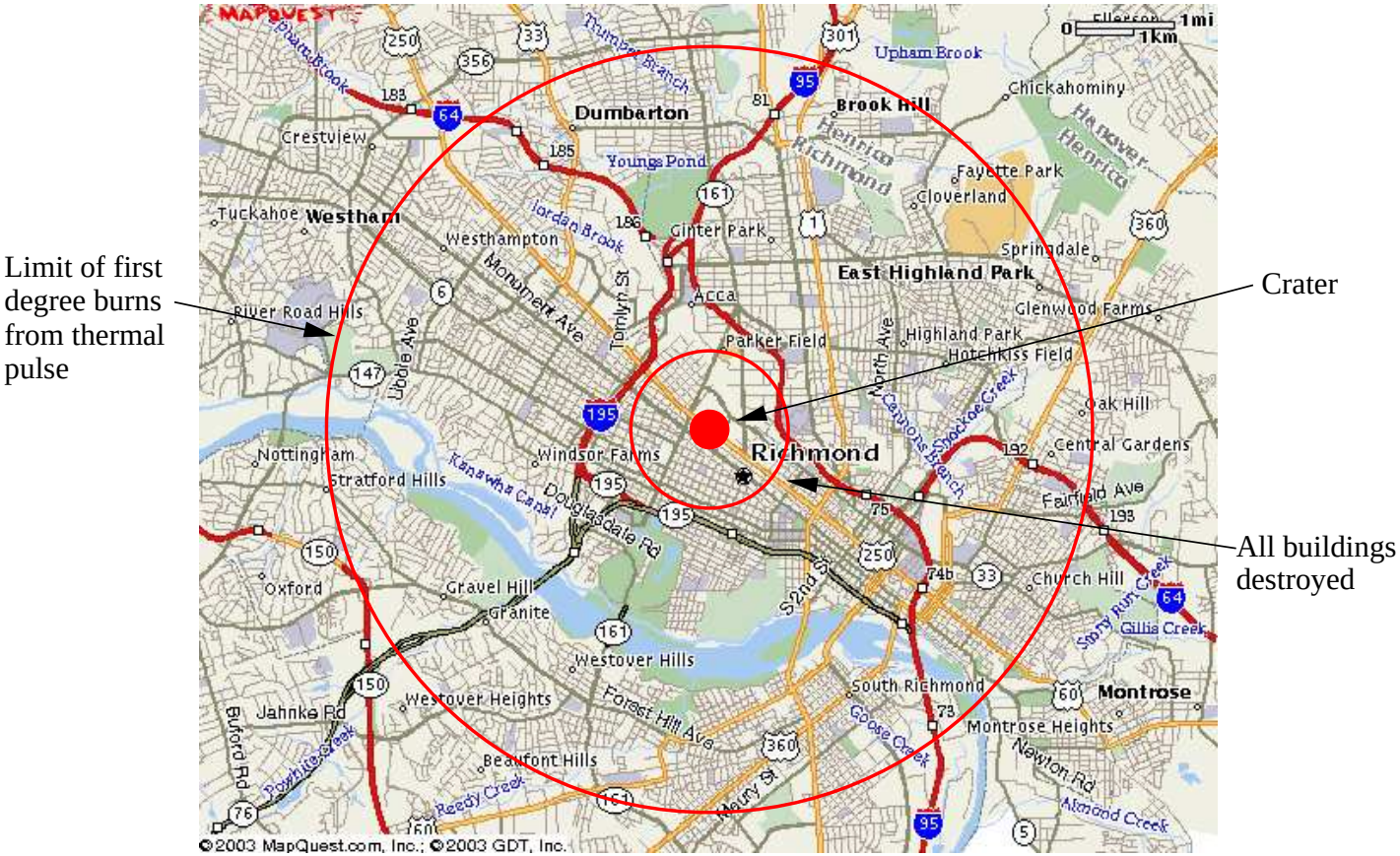


- A two-stage, thermonuclear weapon.
- High explosive detonates crushing the plutonium primary to a density where fission can occur.
- The uranium and plutonium in the secondary burn and increase the temperature until fusion starts. The energy released by the fusion reaction raises the temperature even higher and burns more of the fission fuel.



Nuclear Weapons 101

- The picture below illustrates the effect of a 20 kiloton blast (the size of the Nagasaki bomb) dropped on the Science Museum of Virginia.

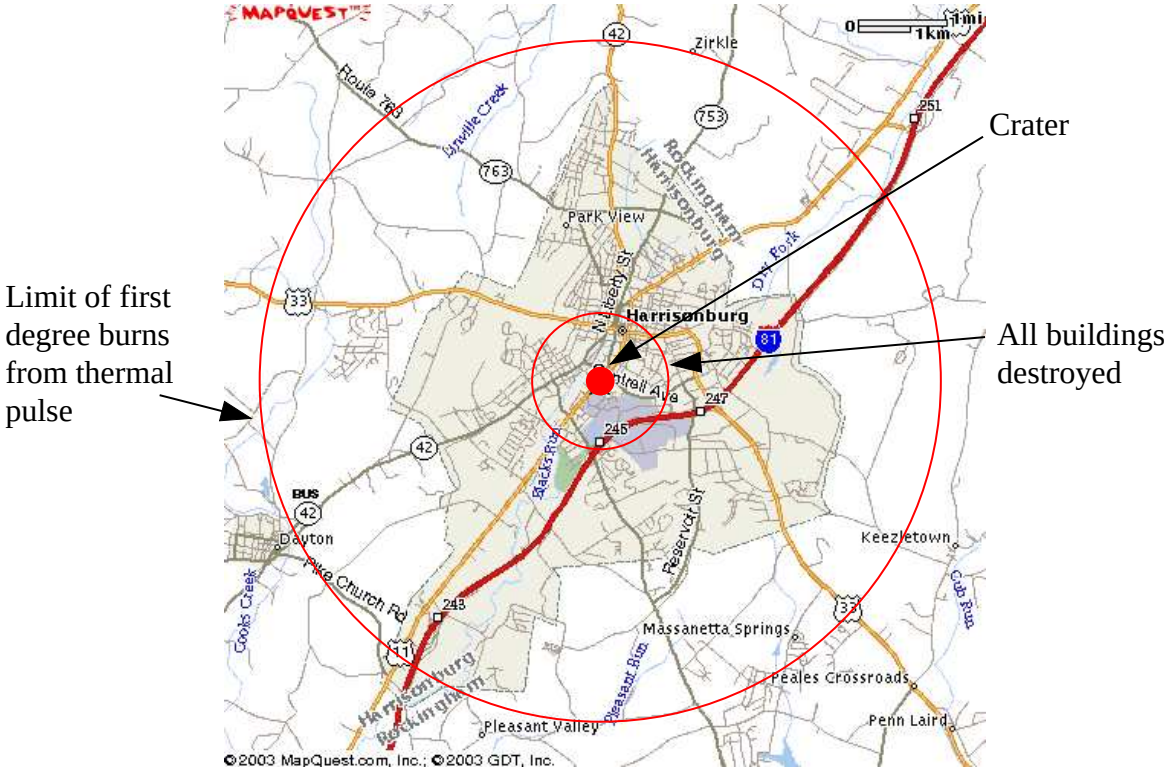


- The US and Russia have military stockpiles containing 1600 tons of highly-enriched uranium (HEU) and 200 tons of plutonium.

- The dangerous radioactivity is produced only during the blast.

Nuclear Weapons 101

- The picture below illustrates the effect of a 20 kiloton blast (about the size of the Nagasaki bomb) dropped on Miller Hall.



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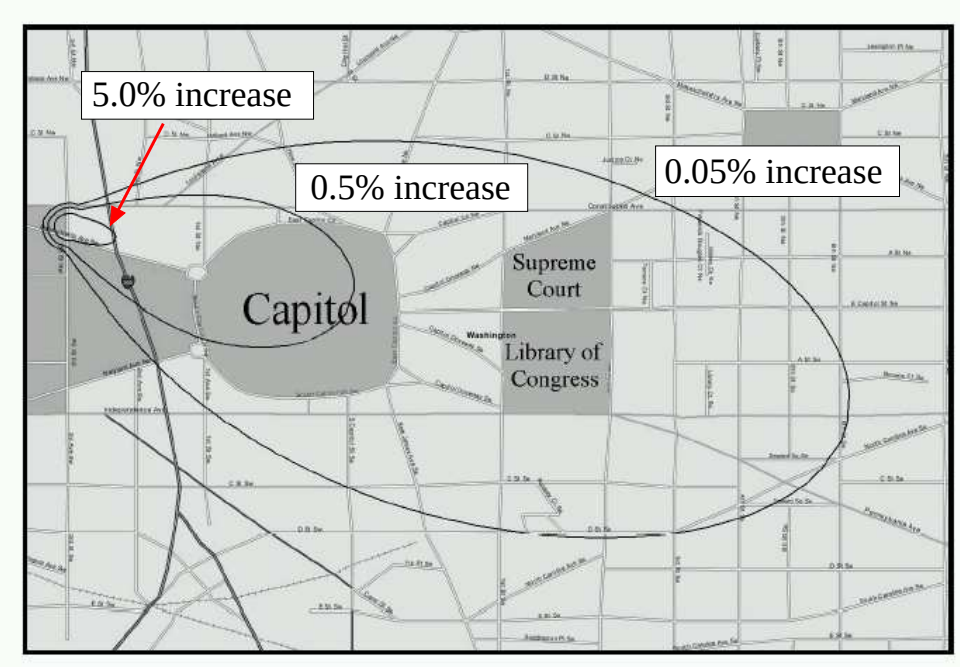
The Radiation Dispersal Device ('dirty bomb')

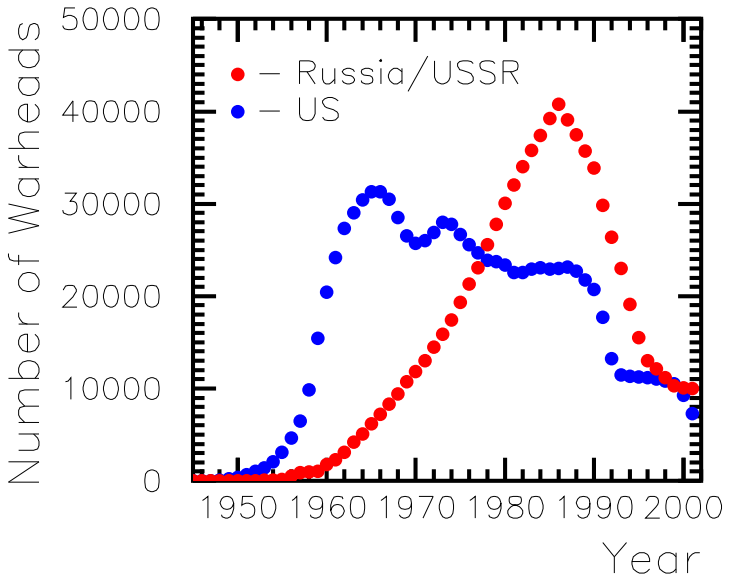
- The dirty bomb combines conventional explosives with highly radioactive materials. The explosion vaporizes the radioactive materials (the atomic nuclei are unaffected) and disperses them into the air.
- Almost all of the immediate damage is due to blast NOT due to radiation.
- Studies of the range of possible attacks have shown that the biggest impacts will be an increase in the cancer rate and the economic cost of the cleanup.



'Dirty Bombs: Response to a Threat', Federation of American Scientists Public Interest Report, Vol. 55, no. 2, 2002.

The Soviet and US Nuclear Arsenals

- By the end of the Cold War the US and USSR had nuclear arsenals containing about 64,000 warheads on various delivery vehicles.
- US and Soviet military stockpiles contained about 1600 tons of highly-enriched uranium (HEU) and about 200 tons of plutonium.



- An unforeseen consequence of the end of the Cold War was the disposition of nuclear weapons materials.

Non-military Sources of Radioactive Materials

- The amounts and types of materials are less well known than in the nuclear weapons case.
- Especially in the former Soviet Union many radioactive materials have been orphaned, *i.e.* they are outside official regulatory control, according to the International Atomic Energy Agency.
- Fuel for nuclear reactors is not considered a nuclear weapons proliferation risk and is not subject to the tight security of weapons-grade materials. World demand for reactor fuel is at about 60,000 tons per year.
- The US nuclear power industry produces about 30,000 tons of spent fuel each year.

Fissile Material Security Declines in Russia (loose nukes)

- The economic situation in Russia left few funds for maintaining the security of now-unused nuclear materials.
- Weapons-grade material is dispersed in hundreds of buildings many with poor security and accounting.

Building at the Kurchatov Institute housing HEU with no motion sensors, detectors, or portal monitors.

- Since 1991 there have been numerous instances of nuclear smuggling, but there is no hard evidence that any weapons-grade material from the Russian nuclear weapons complex has been stolen.

Why should you care?

- The US and most other nations have a long-standing policy of nuclear nonproliferation.
- A nuclear blast would have horrific consequences; loss of life, property, and security.
- Even acquisition of a nuclear weapon by an adversary could have a devastating influence on US security and non-proliferation.
- **One of the highest hurdles to obtaining a nuclear weapon is acquiring enough weapons-grade fissile material to produce a bomb**. Iraq spent $5-$10 billion in the 1980's to produce a few grams of plutonium.
- Smuggling fissile material is a 'short-cut' to acquiring nuclear weapons; it lowers the acquisition hurdle.
- Prevention (*i.e.*, security) is critical especially against an 'insider' threat.

Is the threat real?

- Vulnerability of fissile material to insider theft.
  - The USSR relied on ‘guards, guns, and gulag’ for security. Morale in the defense complex was high and there was less concern about smuggling by the staff.
  - Financial and economic problems in the Russian nuclear cities during the 1990’s made the staff susceptible to the temptation of nuclear smuggling (the insider threat).
- Are there buyers?
  - Likely! There is abundant anecdotal evidence.
  - Iraq spent $5-$10 billion in the 1980’s to produce a few grams of plutonium. They continue this effort.
  - Aum Shinrikyo and Osama bin Laden’s group (two terrorist organizations) supposedly tried to obtain fissile material.

Can An Opponent Build a Nuclear Bomb?

- What can a nation-state do?
  - The technology to enrich uranium or plutonium is within the reach of many countries.
  - A simple, low-yield, uranium weapon could probably be assembled with a reasonable chance of going off without testing. Low yield here means about the size of the Hiroshima bomb.
  - It is much more difficult to produce a small, thermonuclear weapon that could be mounted on a ballistic missile.
- What can a terrorist organization do?
  - Producing enriched uranium or plutonium is beyond the capabilities of most terrorists, but stealing it is NOT!
  - A gun-type, uranium weapon of low yield is still a difficult endeavor, but could be done.
  - There are other alternatives for terrorists like a ‘dirty bomb’ or the traditional guns and bombs.

The US Response

- In 1991 the US Congress passes the Nunn-Lugar Act. The US pays to improve security of fissile materials and to dismantle the Russian nuclear complex (cooperative threat reduction).

Fissile Material Storage Facility under construction at Mayak, financed by the US Cooperative Threat Reduction program.

- The US spends about $700 million a year to reduce this threat.
- The Fissile Material Storage Facility (FMSF) will securely store plutonium and uranium from dismantled weapons.
- The HEU Purchase Agreement requires 500 metric tons of HEU to be downblended to reactor fuel (a form not usable in a nuclear weapon) by 2013 at a cost of $20 billion.

Can an opponent make a ‘dirty bomb’?

- The radioactive material is MUCH easier to obtain.
- The material is widely used in medicine, industry, and academia.
- The scenario mentioned above was based on the amount of cesium found in a medical gauge in North Carolina last spring.
- The International Atomic Energy Agency (IAEA) has found more than 100 countries around the world that lack adequate controls on radioactive materials.
- The answer is yes, but the effects are far less grave than a nuclear bomb.

The US Response

- Educate ourselves (go to talks like this one)! Panic may be the most damaging consequence.
- The US government is tightening licensing procedures and raising security standards for radioactive material.
- Research is being funded for replacement technologies (*e.g.*, ion beams to sterilize food instead of radioactive sources).

- Develop new mitigation technologies, *i.e.*, better cleanup methods.
- Improve detection in sensitive areas.
- Develop response plans coordinating state, local, and federal government agencies.

Is it Working?

- Considerable progress has been made.
- The US Department of Energy has installed complete or partial security systems to protect about 32% of 603 metric tons of insecure, weapons-grade material.[2]
- Opps! The previous statement means there are about 410 metric tons vulnerable to theft.
- Much remains to be done.

Example of enhanced security systems at Russian Minstry of Defense nuclear storage sites that are provided by the US.

2. Government Accounting Office, *Security of Russia's Nuclear Material*, GAO-01-312, February 2001.

Layers of Defense

- The first line of defense.
  - Consolidate, eliminate, and secure Russian nuclear materials and delivery systems.
- The second line of defense.
  - Provide equipment and training for export controls in Russia and the central Asian states like Uzbekistan, Turkmenistan, *etc*.

- The third line of defense problem.
  - The US has extensive, porous borders. In 2000, 645 metric tons of cocaine were shipped into the US.[1]

1. National Drug Intelligence Center, *National Drug Threat Assessment 2002*, 2002-Q0317-001, December, 2001.

Assessing Risk

What should you stay awake worrying about at night?

Number of Deaths in 2000	Cause
2,400,000	All causes
46,000	Car and truck accidents
29,000	Suicide
20,000	Poisoning
17,000	Homicide
14,000	Falling
4,000	Drowning
3,000	Fire
2,000	Environment

Source: U.S. National Center for Health Statistics, National Vital Statistics Report, Vol. 50, no. 15, Sept. 16, 2002. Web: www.cdc.gov/nchs .

Conclusions

- Do we live in a safer world than during the Cold War? Yes, sort of.
- Is nuclear terrorism likely? Maybe.
  - Nuclear bombs are still difficult; dirty bombs are not. Nuclear terrorism could have a large psychological effect.
  - The weapons of choice will still be guns, knives, and explosives.
- Has the threat of a nuclear conflict increased? Yes, sort of.
  - The threat of a large-scale nuclear war between Russia and the US is smaller.
  - The proliferation of nuclear weapons technology has increased the risk of nuclear weapons being used.
- What can be done? Lots, but it will take time, money and leadership from the US.
- What can I do?
  - Learn! Panic is one of the chief enemies.
  - Engage! Discuss these issues with others.
  - Vote! Write to Congress.

What are all those abbreviations?

Abbreviation	Full title	Status before 9/11	Status after 9/11
CTBT	Comprehensive Test Ban Treaty	Not supported by administration.	No change.
NPT	Non-Proliferation Treaty	See CTBT.	No change.
ABM	Anti-Ballistic Missile Treaty	US is scheduled to withdraw.	No change.
BWC	Biological Weapons Convention	US withdraws.	No change.
CTR	Cooperative Threat Reduction	Faced significant budget cuts.	Budget restored.

Science and Security in an Age of Terrorism

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February 5, 2003, 7:30 pm, Science Museum of Virginia

President Bush has called on our nation's scientists and engineers to harness the vast capabilities of science and technology to provide greater security in the war on terrorism. This talk focuses on some of the problems we face in that war, the ideas that may win it, and at what price.

Some new technologies (and their implications)

- New ways to detect chemical and biological agents.
- New databases and new paths to find information.
- Total Information Awareness.
- Swarm intelligence - 'Minority Report' in the making.