The National WWII Museum

Science & Technology of WWII *Virtual Field Trip* videoconference

TEACHER GUIDE

Before your Virtual Field Trip

1. To better prepare your students for their National WWII Museum virtual field trip, share with them the enclosed Science & Technology of WWII Essay, Word Search, and Vocabulary List.

2. Distribute copies of the student worksheets on pages 10-11 before the videoconference begins.

3. You must make a **Test Call** to The National WWII Museum at least one day before your Virtual Field Trip. E-mail virtualclassroom@nationalww2museum.org to arrange your test call.

On the day of your Virtual Field Trip

1. With your students divided into four groups, dial The National WWII Museum's IP address: **72.158.213.42**

2. If there is a loss of connection during the videoconference, hang up and try to re-dial. The telephone number in the Museum's distance learning studio is 504-527-6012, x 351.

3. The Museum educator will greet your students and conduct the session. Students will be asked to participate by raising their hands. You will be asked to select students to answer certain questions or perform certain activities. You will be called upon to distribute hand-outs at the appropriate time. You are required to remain in the room during the entire video-conference.

After your Virtual Field Trip

1. A list of post-visit activities is attached.

2. The Museum will email you an evaluation form to fill out and return.

Program funds provided by

American Fidelity Foundation Entergy E.L. AND THELMA GAYLORD FOUNDATION

The National WWII Museum

Science & Technology of WWII *Virtual Field Trip* videoconference

LEARNING OUTCOMES

The National WWII Museum in New Orleans has created this Virtual Field Trip video-conference to introduce students to the science and technology advancements of World War II. By participating in this Virtual Field Trip, students will:

- **Learn the following vocabulary:**
  - Atomic bomb
  - Bakelite / new materials
  - Colossus
  - DDT
  - Encryption
  - Enigma
  - Eugenics
  - Penicillin
  - Plasma
  - Plutonium
  - Radar
  - Rocketry
  - Sonar
  - Technology

- **Explore WWII artifacts, gaining insight into history through object-based inquiry**

- **Analyze and debate decisions by politicians, military officials, and scientists during WWII**

- **Explore problem-solving and teamwork strategies by tackling a WWII design challenge**

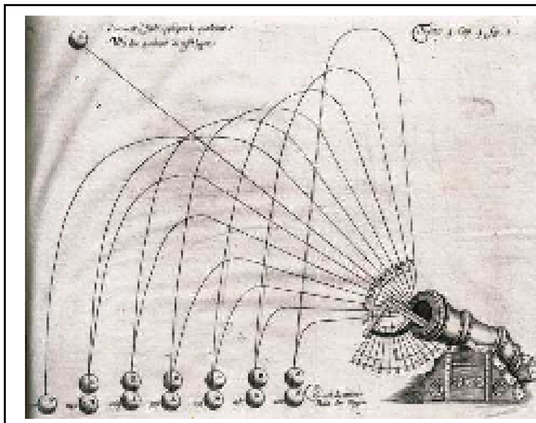
- **Gain an appreciation through examples for the value that science and technology plays in history**

- **Gain a knowledge of several career opportunities related to the study of history, including:**
  - Museum curator
  - Museum educator
  - Historical researcher

Science, Math, and War: A Strange Alliance

On the face of it, few human activities would seem to be more different than war and science. War aims to kill people and destroy things, to bring one country's military (or their whole society) under the control of another. War is primal, violent, chaotic. Science and mathematics, by contrast, seem the highest development of learning and civilization, creative and even noble activities. Science proceeds by slow, thoughtful activity, careful theory and experiment where every last detail or variable is controlled under precise conditions. Mathematics describes the world with a clean precision, in angles, lines, and equations. What could Science and Math on the one hand and War on the other possibly have to do with each other?

We can, of course, point to all kinds of new inventions that have had an impact on warfare. From bronze for weapons to giant warships, from catapults to crossbows to gunpowder, warfare has always been a primary motivator for technological creativity. The ancient Greek scientist Archimedes not only calculated the area under a parabola and estimated the value of Pi, he also built siege engines and methods for setting enemy ships on fire using sunlight. Bronze, one of the great new materials of human history, found one of its main uses in making sharp weapons. English scientist Isaac Newton's work focused on ballistics (helpful in calculating trajectories for cannonballs) and astronomy (helpful for navigating ships at sea). Firearms, electronics, computers, even the Internet were all developed originally for military purposes.



Yet the most profound impacts of science and mathematics on warfare may not have been any particular invention as much as ways of thinking, ways of being in the world. For centuries, warfare had been its own specialized skill, epitomized by professional officers – men of training, discipline, and high prestige in most societies (as they still are today). By contrast, scientists were often seen as esoteric conjurers, madmen, or at best isolated dabblers (think of the "mad scientist" figure that appears in so many old movies).

That all changed during the "Enlightenment," the period during the 16th and 17th centuries when philosophers celebrated the power of human reason. Their new techniques of mathematics, experiment, and natural philosophy found followers in the military as well. In France, for example, artillery officers became enthusiastic about Enlightenment principles, applying science and mathematics to everything from designing fortresses to measuring the sizes of cannonballs. One French artillery officer who took these ideas to heart was Napoleon Bonaparte, well schooled in mathematics and geography. When he became leader and then Emperor of France, he brought the "rationalizing" mission of the enlightenment to the French state, codifying laws according to rational principles. The "metric system" of measurement that most of the world uses today was one product of his efforts, a system that is supposedly completely "rational," in that all the measurements for weight, distance, volume, etc. are linked to each other (as opposed to the so-called "English" system of feet, inches, and pounds wherein the measurements were based on the anatomy of the king).

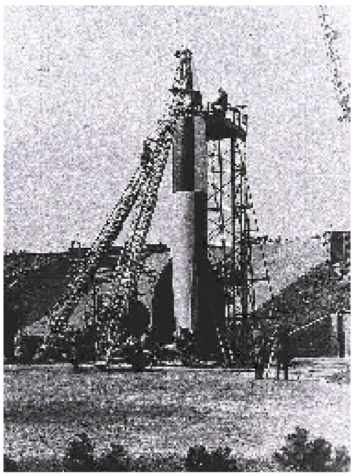
Enlightenment ideas had great impact on warfare in the United States as similar “rational” principles of measurement, uniformity, and standardization accompanied the period of industrialization that began around 1800. The first engineering school in the United States was not MIT or Stanford or Texas A&M, but West Point, the United States Army’s military academy, founded in 1804 based on French principles. In the early 1800s, these ideas were applied to the manufacture of guns, which had previously been made one at a time by an individual craftsman. Now, using ideas inherited from the French artillerists, guns were made in very large numbers by assembling smaller parts that were all identical or “interchangeable.” In the American Civil war (1861-1865), large numbers of these “mass-produced” guns equipped the Union Army (the Confederacy had few such factories and had to make do with purchasing large numbers of guns on European markets). The war also saw a revolution in naval technology, as steam power was applied to the very traditional endeavor of naval warfare. Railroads and telegraphs played key roles in moving men and materiel to a battlefield, and in sending news of battles won and lost back home in record times. Of course, these advances came at high cost – moving that many people, and that many guns resulted in ever larger battles in which people died in heretofore unheard of numbers. Fortunately, advances in medical science enabled some people to be saved, but many more died from disease than from actual battle wounds.

World War I (1914-1918) ended a century of wondrous industrial revolution. People believed that the inevitable progress and promise of science and technology would lead to the perfection of human society and war would be made obsolete. Instead, the “Great War” brought death and suffering on an industrial scale. Long-range artillery, giant battleships, submarines, gas warfare, telephones, and airplanes created a “high tech” battlefield. In order to synchronize their attacks, soldiers stopped using old fashioned pocket-watch timepieces and began wearing clocks on their wrists, the origins of today’s “wristwatch.” Despite the rationally-organized battle plans, armies ended up in stalemate for years and men fought from trenches in the most primitive conditions. Millions died, more than in all previous wars combined. The carnage led some to question the purpose and morality of modern warfare.

Warfare, it has been shown, has always spurred developments in science and math, just as science and math innovations have affected, and even revolutionized, warfare. Advances in transportation, communications, chemistry, material sciences, and other areas of science and technology have led to advances in labor-saving devices, life-saving procedures, and offered opportunities for greater longevity, comfort, creativity, and achievement. But many of those same scientific advances have been used to advance the field of war making. And once those advances come into existence, the quickly become available to all, whether friend or foe. It is said that science takes no side on the battlefield, rather it takes both sides. In World War II, that fact would quickly become evident with devastating results.

The Science & Technology of WWII

For all the role of science, mathematics, and new inventions in earlier wars, no war had as profound effect on the technologies of our current lives than World War II (1939-45). And no war was as profoundly affected by science, math, and technology as WWII.



We can point to numerous new inventions and scientific principles that emerged during the war. These include advances in rocketry, pioneered by Nazi Germany. The V-1 or "buzz bomb" was an automatic aircraft (today known as a "cruise missile") and the V-2 was a "ballistic missile" that flew into space before falling down on its target (both were rained on London during 1944-45, killing thousands of civilians). The "rocket team" that developed these weapons for the Germans came to the United States after World War II, settled in Huntsville, Alabama, under their leader Werner von Braun, and then built the rockets that sent American astronauts to the moon. Electronic computers were developed by the British for breaking the Nazi "Enigma" codes, and by the Americans for calculating ballistics and other battlefield equations. Numerous small "computers"—from hand-held calculating tables made out of cardboard, to mechanical trajectory calculators, to some of the earliest electronic digital computers, could be found in everything from soldiers' pockets to large command and control centers. Early control centers aboard ships and aircraft pioneered the networked, interactive computing that is so central to our lives today.

The entire technology of radar, which is the ability to use radio waves to detect objects at a distance, was barely invented at the start of the war but became highly developed in just a few years at the "Radiation Laboratory" at MIT. By allowing people to "see" remotely, at very long distances, radar made the idea of "surprise attack" virtually obsolete and vastly enlarged the arena of modern warfare (today's radars can see potential attackers from thousands of miles away). Radar allowed nations to track incoming air attacks, guided bombers to their targets, and directed anti-aircraft guns toward airplanes flying high above. Researchers not only constructed the radars themselves, but also devised countermeasures: during their bombing raids, Allied bombers dropped thousands of tiny strips of tinfoil, code-named "window" and "chaff" to jam enemy radar. By constructing complex pieces of electronic equipment that had to be small, rugged, and reliable, radar engineering also set the foundations for modern electronics, especially television. Radar signals could also be used for navigation, as a ship or airplane could measure its distance from several radar bacons to "triangulate" its position. A system for radar navigation, called LORAN (long-range navigation) was the precursor to today's satellite-based GPS technology.

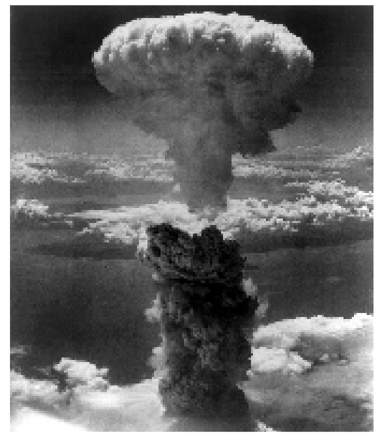
The military found other uses for radar. Meteorologists could track storms with this new technology. When weapons designers discovered a way to place tiny radar sets onto artillery shells, the proximity fuse was invented. These new fuses would explode when they neared their targets. By the end of the war, proximity fuses had became a critical component in many anti-aircraft shells.

World War II also saw advances in medical technology. Penicillin was not invented during the war, but it was first *mass produced* during the war, the key to making it available to millions of people (during World War II it was mostly used to treat the venereal diseases gonorrhea and syphilis, which had been the scourge of armies for thousands of years). While penicillin itself is still used today, it was also the precursor to the antibiotics that we take today to keep simple infections from becoming life-threatening illnesses. Medicines against tropical diseases like malaria also became critical for the United States to fight in tropical climates like the South Pacific. Pesticides like DDT played a critical role in killing mosquitoes (although the environmental impacts of DDT would last a long time; a famous book about DDT, Rachel Carson's *Silent Spring* (1962), would help found the modern environmental movement).

The science and technology of blood transfusions were also perfected during World War II, as was aviation medicine, which allowed people (including us) to fly safely at high altitudes for long periods. Studies of night vision, supplemental oxygen, even crash helmets and safety belts emerged from aviation medicine. Chemical labs cooked up a host of new technologies, from new types of explosives to incendiary bombs (including napalm, a form of jellied gasoline heavily used in Vietnam, but first used on the Pacific island of Tinian against the Japanese), flame throwers, and smoke screens. New materials and new uses for old materials appeared as well. Companies manufacturing consumer goods (such as silverware) converted to manufacture military goods (such as surgical instruments). Automobile factories re-tooled to make tanks and airplanes. These industrial modifications required rapid and creative engineering, transportation, and communications solutions. Because of the need to put most resources into the war effort, consumers at home experienced shortages and rationing of many basic items such as rubber, gasoline, paper, and coffee (the country imposed a national "Victory" speed limit of 35 miles per hour to save wear on tires—natural rubber being in short supply since the Japanese had occupied much of Southeast Asia). Consumers had to conserve, or just do without. Women's skirts were made shorter to save material and bathing suits were made out of two pieces (these later became known as "bikinis," named after an island in the Pacific where the army tested atomic weapons). The 3M Company felt compelled to run advertisements apologizing to homemakers for the scarcity of Scotch tape in stores across the country; available supplies of the product had been diverted to the front for the war effort. 3M promised "when victory comes "Scotch" cellulose tape will be back again in your home and office."

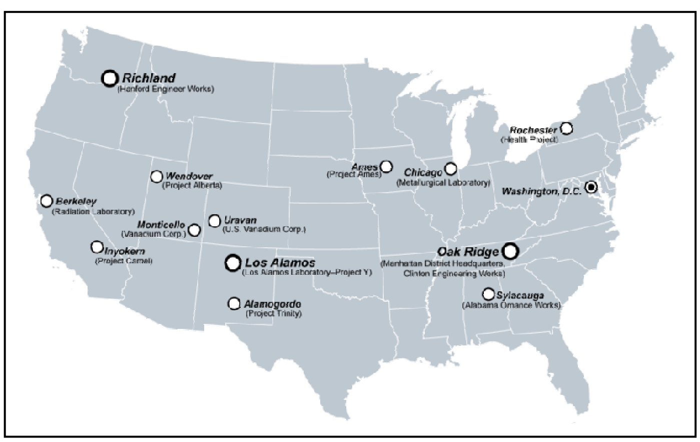
New materials emerged to fill these voids; many had been invented just before the war but found wide use during World War II: plastic wrap (trademarked as Saran wrap) became a substitute for aluminum foil for covering food (and was used for covering guns during shipping); cardboard milk and juice containers replaced glass bottles; acrylic sheets were molded into bomber noses and fighter-plane canopies; plywood emerged as a substitute for scarce metals, for everything from the hulls of PT boats to aircraft wings. The look and feel of 1950s America – a "modern" world of molded plywood furniture, fiberglass, plastics, and polyester – had its roots in the materials innovations of World War II.

The science of nutrition expanded greatly during WWII. In the United States, scientists worked to identify which vitamins and minerals were most essential to a healthy body and in what amounts. Studies were conducted to determine how many calories were burned doing various activities. Proper food preparation, storage and handling, and preservation became a top priority for the military. Soldiers' rations were carefully formulated to supply the maximum amount of nutrition and energy, while providing for variety and taste. Meeting these challenges meant working first in the laboratory before working in the kitchen. The development of the D-ration provides a great example. The "D" ration was a high-calorie emergency ration that came in the form of a fortified chocolate bar. A three-portion package of these bars would provide a soldier with 1,800 calories of energy. Once the military settled on a chocolate bar for their emergency ration, scientists set about creating it, with the following requirements: it had to weigh 4 ounces, it had to be high in calories, it had to be able to withstand high temperatures, and it had to taste "a little better than a boiled potato." This last requirement was imposed to keep soldiers from snacking on their emergency rations in non-emergency situations. By the end of the war, millions of these rations had been produced in the United States and delivered around the world, along with billions of other rations for the military.



And of course we're all familiar with the Atomic Bomb, two of which were dropped on Japan to end the Pacific war in 1945. In a pioneering effort, the United States mobilized a massive cadre of scientists, engineers, and industrial plants. The very names of these places have done, Oak Ridge, Tennessee, a city created from nothing around a factory to separate out uranium for the bomb, and Hanford, Washington, which created the new element plutonium. Atomic weapons are so complicated, in terms of the physics, and so difficult to build, in terms of the technology, that two different types of weapons were built, to increase the chances of getting at least one of them right. The bomb dropped on Hiroshima was a uranium-type bomb, and the one dropped on Nagasaki used plutonium. Scientists in Nazi Germany were working on an atomic bomb as well. But without the huge commitment of resources that the American government offered its scientists, they barely got out of the starting gate. The Atomic Bomb was like radar in that a small number of devices could make a major impact on military operations, so the new invention could have an effect before going into full scale mass production. By contrast, most conventional weapons took so long to mass produce that if they were not at least on the drawing board when the war started they often arrived too late to impact the war. It is notable, however, that the speed with which new weapons systems came on-line, from the drawing board to the factory floor to the battlefield had never before been seen.

Again, as in earlier eras, perhaps the most profound impacts of World War II were as much great ideas as they were pieces of hardware. Before the war, scientists were professors who ran small laboratories with students, with small amounts of money. Before the war scientists were looking into fundamental principles of the natural world, without much regard for practical applications, and they rarely attracted the attention of national governments. During World War II, science became mobilized on a grand scale; many of these professors and their students dropped everything to work on war-related challenges and initiative. The massive "research and development" (R&D) laboratory emerged in its modern form. The paradigm of these efforts was the "Manhattan Project" which put thousands of physicists together with



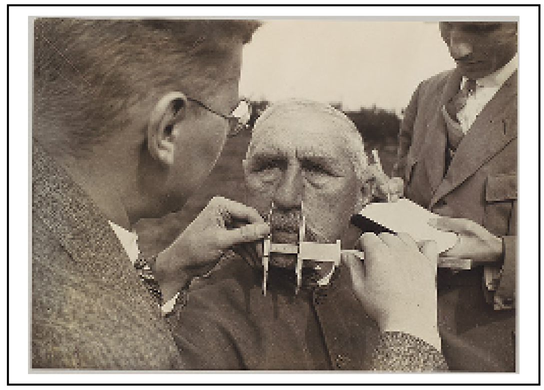
A selection of major United States sites in the Manhattan Project

Army-scaled logistics and designed, built, and manufactured the first atomic bombs. Other laboratories included the so-called "Radiation Laboratory" at MIT which developed radar. Numerous other laboratories focused on everything from electronics to medical research to psychological testing. By the end of the war, the atomic bomb made it clear that science had, in the words of one scientist, "lost its innocence" – that is it was now a critical tool of military power, and was given government money for research at many thousands of times the pre-war levels. Scientists became advisors to presidents on the most pressing issues of national and foreign policy. Ever since World War II, the American government has mobilized science, mathematics, and engineering on a vast scale, whether in large government laboratories, by funding research in universities, or by purchasing high-tech products from companies in industry.

Any discussion of the scientific and technological advancements during WWII must acknowledge the important developments in the field of training. It was one thing to design and build thousands of new, high-tech weapons and produce wondrous new medicines, but without people trained to use them, they would be worthless. New technologies – from moving pictures to new kinds of projectors and even simulators – allowed the military to train thousands of men and women quickly and efficiently (and formed the predecessors to modern technologies like PowerPoint presentations). At the end of the war, one frustrated Nazi general remarked that he and his fellow officers were not surprised that American industry could mobilize for war as quickly as it did. What was surprising and ultimately a major element of Germany's undoing was how quickly American industry and the American war machine could train its people.

Another critical idea that emerged during the war was "operations research," or OR. Early in the war, some British scientists recognized that a great deal of effort was being put into making new weapons (what they called "developmental research"), but not very much scientific thinking was going into how to use them in complex, real-world military operations (hence "operations research"). A classic problem was hunting Nazi submarines in the Atlantic Ocean that were sinking Allied ships. You only have so many airplanes, and they can only fly for so many miles before they need to refuel. What is the best way to organize the search patterns for these airplanes to have the most likelihood of finding these submarines? Mathematicians got hold of this problem and formulated in mathematical terms, using statistics and probability, which were then solvable for optimal solutions. The new "science" of operations research—applying mathematical principles to flows of materials—was then used on a whole variety of wartime problems, from dropping bombs on enemy cities to calculating the flow of goods through a factory production line. Similar techniques are used today in everything from scheduling airliners to running the "supply chain" at Wal-Mart.

It was not just scientists, mathematicians, and engineers that utilized math and science during WWII. Average soldiers, sailors, airmen, and Marines were regularly called upon to use math and science skills, often newly learned, to accomplish their missions. Taking measurements for firing artillery weapons, reading maps and compasses, determining air speeds and altitudes, setting timers on fuses, these tasks and countless others required a fundamental understanding of many math and science rules. More complicated operations, like navigating an airplane, ship, or submarine, interpreting radar signals, or even fixing a broken tank could require intense and sophisticated training. Even Army cooks used math. Cooking meals for thousands of men meant using math to formulate amounts of ingredients, determine cooking time, and appropriately plan an effective schedule for getting meals out on time. The average soldier may not have understood how an atom bomb worked—they didn't need to know that—but for day-to-day operations, using math and science skills wisely could make a big difference on the battlefield.



World War II also saw plenty of disturbing uses of math and science. The Nazi Holocaust, in which 6 million Jews and millions of other people "undesirable" to the German state were murdered, ranks as one of the foulest crimes in human history. Yet the perpetrators saw themselves as anything but primitive barbarians. Nazi race "science" purported to show "scientifically" the superiority of the white "Aryan" race over all other peoples, complete with measurements, classifications, men in white coats, and fancy-sounding scientific theories (later shown to be completely false). When the Nazis formally decided to systematically murder the entire Jewish population of Europe (at the Wannsee conference in 1942), they carried out their malevolent ideas by applying industrial methods borrowed from factories—everything from assembly-line-type organization of killing factories to IBM-punch-card machines keeping track of every last detail. "Mass destruction" instead of "mass production." Even the medical profession, usually the best example of science and compassion in any culture, got into the act by carrying out horrific "experiments" on prisoners as human subjects. Similarly, Nazi "high tech" weapons of new rockets and buzz bombs were used to attack civilians in a futile attempt to awe them into submission. Had these technologies and techniques and the vast resources put into the Nazi death camps been used to actually fight the war, rather than simply for malicious acts of terror, the Nazis might have stood up more strongly to the U.S. and its allies. The Nazis proved that a "scientific" mindset could well be applied to methods that were themselves mad, but their "rational" approach was undone by their murderous rage.

The fields of science and math and the technology that their study produces is not the restricted to any one country or side in a war. Scientific and technological progress served both sides in WWII. Both sides poured national resources into developing new and better weapons, materials, techniques for training and fighting, improvements in transportation, medicine, nutrition, and communications. Science and math also know no morality. Alone, they can exist in pure form, devoid of practical use for good or bad. It is only when people apply their actions, desires, intentions to that science and math that they have an opportunity to use them for positive or negative purposes. Each generation of humans can then examine those uses and decide for themselves as a society and as individuals if that science and math was used wisely or not.

In conclusion, World War II was the first "high tech war," if we define that modern phrase to mean a war fought with new technologies that were specifically invented for that particular war. The atomic bombs were but the most visible of thousands of small inventions, from materials in the home to training films to new ways of seeing the enemy that contributed to the war effort. The organization of this great war of invention had lasting effects, setting the stage for our "national innovation system" to this day – where the country employs the talents of scientists and engineers to help solve national problems. Moreover, the inventions of World War II can be found in so much of our daily lives, from Saran wrap to computers and large-scale production and shipping of industrial products. Even our education system, the very way we train people to use new technologies, finds some of its origins in World War II. Sometimes it might seem lamentable that so much of our noblest energy – scientific and engineering creativity – goes into humanity's most destructive activities. But like it or not, technology and war continue to be intertwined.

The Science & Technology of My Lifetime

Write down the three greatest scientific or technological advancements or inventions that have occurred during your lifetime.

I was born in ______________

1. ____

2. ____

3. ____

THE SCIENCE AND TECHNOLOGY OF MY FUTURE

Write down three predictions for scientific or technological advancements or inventions you will see in your lifetime.

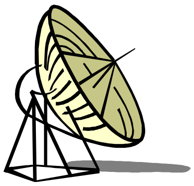
1. ____ Year? ____________

2. ____ Year? ____________

3. ____ Year? ____________

The Science & Technology of WWII

TOP SEVEN LIST



DURING WWII / NOW

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WWII Science & Technology

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L	S	N	I	M	A	T	I	V	T	P	I	E	H	E
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Bakelite
Colossus
DDT
D-Ration
Enigma
Eugenics
Jet Fighter
Organization
Penicillin
Plasma
Plutonium
Proximity Fuse
Radar
Rocketry
Sonar
Training
Trinitite
Trinity Test
Vitamins
Xyklon-B

Science & Technology of WWII Vocabulary

Bakelite One of many types of new, synthetic materials developed and mass produced during WWII. These new materials became the popular plastics and building materials used ever since.

Colossus The first programmable, digital computer. Created by the British to crack the German Lorenz code, Colossus used more than 1,500 vacuum tube switches to quickly and efficiently run through possible letter sequences looking for recognizable patterns.

DDT Short for Dichloro-Diphenyl-Trichloroethane; an insecticide. First synthesized in 1874, DDT's insecticidal properties were not discovered until 1939. In WWII, it was used with great effect among both military and civilian populations to control mosquitoes spreading malaria and lice transmitting typhus, resulting in dramatic reductions in both diseases. Its overuse after the war led to concerns about environmental impact, spawning the modern environmental movement.

D-Ration A high-calorie chocolate bar created by the U.S. Army during WWII to serve as an emergency ration for soldiers who did not have access to any other food. The Army purposely made the D-ration taste bad, so that soldiers would not be tempted to eat it unless they had to.

Enigma The German field encoding machine. Thought to create an unbreakable code, the Germans had no idea that the British had broken the Enigma code using a mechanical machine called the Bombe. The Enigma could create a code whose solution had 100^{134}.

Eugenics A pseudo-science that purported to show, through various types of measurements, classifications, and statistics, that certain types (“races”) of people had certain characteristics, that some were more valuable than others, and that some were unworthy of human life. Nazi ideology took these ideas to their extremes. After World War II the revelation of their atrocities discredited the “science” behind them, which most now see as ideology masquerading as scientific data.

Jet Fighter A military fighter airplane that is powered by turbines, rather than propellers. Turbines compress air, which is then sprayed with fuel and ignited. The explosion is sent out the back of the turbine creating thrust and moving the plane forward with great speed.

Organization WWII saw great advances in the way complex problems, such as transportation, supply, and planning for military campaigns, are carried out. The science of operations research is an interdisciplinary branch of applied mathematics and formal science that uses methods such as mathematical modeling, statistics, and algorithms to arrive at optimal solutions to very complex problems. In other words, Operations Research helps armies, businesses, and governments achieve their goals using scientific methods.

Penicillin A bacteria-killing substance derived from certain mold spores. Penicillin was first discovered in 1928, but was not successfully mass-produced until 1942. It saved countless lives of soldiers and civilians by preventing bacterial infections that could easily turn deadly.

Plasma — The liquid component of blood composed of 90% water. During WWII scientists discovered that wounded soldiers could be given plasma as a temporary substitute for whole blood. Plasma was easier to transport and did not decompose as easily as blood.

Proximity Fuse — An electronic fuse that allowed a bomb to explode at a specific distance from its target. Proximity fuses used tiny electronic radar components first developed during WWII. These fuses made anti-aircraft shells and other bombs much more effective.

Radar — Radio detection and ranging; a means of detecting and tracking distant objects by transmitting radio waves and then measuring the reflections. Radar in World War II was used to track attacking bombers, for airplane-to-airplane combat, to guide bombers to their targets, to direct gunfire, even to follow mortar shells back to their sources.

Rocketry — The German rocket team at Peenemunde developed liquid-fueled rocket weapons that were used to attack civilians in London and throughout southeast England. Hitler believed that these new weapons would turn the tide of war in the Nazis' favor. American engineers developed smaller, but tactically more effective, solid fuel rockets. These technologies, along with engineers German, American, and Russian, made the period after WWII into "the Space Age" that continues to this day.

Sonar — Sound navigation and ranging; a technology that uses sound waves (usually underwater) for navigation, communication with or detection of other vessels, by bouncing sound waves off objects and measuring the time it takes them to return.

Training — The development of great numbers of new weapons, vehicles, and fighting techniques during WWII necessitated the development of new training methods. The military hired film makers and cartoonists to create movies and training manuals that could be understood by 18, 19, and 20-year old draftees. Engineers created different kinds of "simulators" to recreate combat conditions in a laboratory setting to aid in training.

Trinitite — The name given to the radioactive glass substance formed from super-heated sand in the blast crater during the Trinity Test.

Trinity Test — The code name for the first atomic bomb test, July 16, 1945, outside Alamogordo, NM. Dr. Robert Oppenheimer and General Leslie Groves oversaw the successful test.

Vitamins — Organic compounds required in tiny amounts by organisms; during WWII scientists made great advances in their understanding of how the human body uses vitamins, enabling them to make recommendations for daily nutrition and create military rations with appropriate amounts of nutrients.

Zyklon-B — Cyanide-based insecticide infamous for its use by Nazi Germany against humans in the gas chambers of extermination camps during the Holocaust. The Nazis employed many of the latest techniques in industrial organization, transportation, manufacturing, and accounting to carry out their attempted genocide.

The National WWII Museum

Science & Technology of WWII *Virtual Field Trip* videoconference

POST-VIDEOCONFERENCE ACTIVITIES

To re-enforce the lessons learned during your Virtual Field Trip, do one or more of the following activities with your class:

1. Assign students to research one scientific or technological advancement of WWII and write a short essay about what they find. Potential subjects: radar, the atomic bomb, penicillin, early computers, jet engines, operations research, and rocketry.

2. If it is age appropriate, hold a class discussion using one or more of the following questions as starters:

    - What kinds of technological weapons are morally acceptable and what kinds are not?
    - Under what circumstances is it morally acceptable to bomb civilians during a war?
    - Was it the right decision for the US Government to bring Nazi rocket scientists to the U.S. to help develop the American space program?
    - If the Nazi medical experiments on prisoners produced medical data that would be useful for today's researchers, would it be ethical to use that data?
    - Should a doctor use his or her medical knowledge to assist the military or government design physical or mental techniques for interrogating prisoners of war?
    - Is it heroic to use new weapons technologies that allow people to kill from a distance, without ever seeing their enemies?

3. Assign students to design the following inventions, including drawings and written descriptions for each (the more imaginative, the better):

    - A device for a single soldier to carry a wounded comrade off the battlefield
    - A vehicle that can climb a five-foot wall and cross a ten-foot ditch
    - A suit of clothes that a soldier can eat
    - A device for teachers to better control their students' classroom behavior

For Further Information:

The National World War II Museum has an excellent website with an abundance of information and activities available to teachers and students. Please let your students know about our website and provide them with the web address:

www.nationalww2museum.org