

Manhattan Project

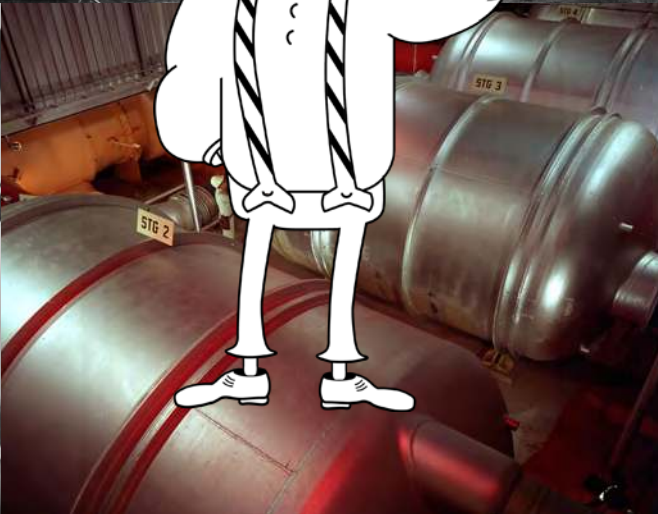
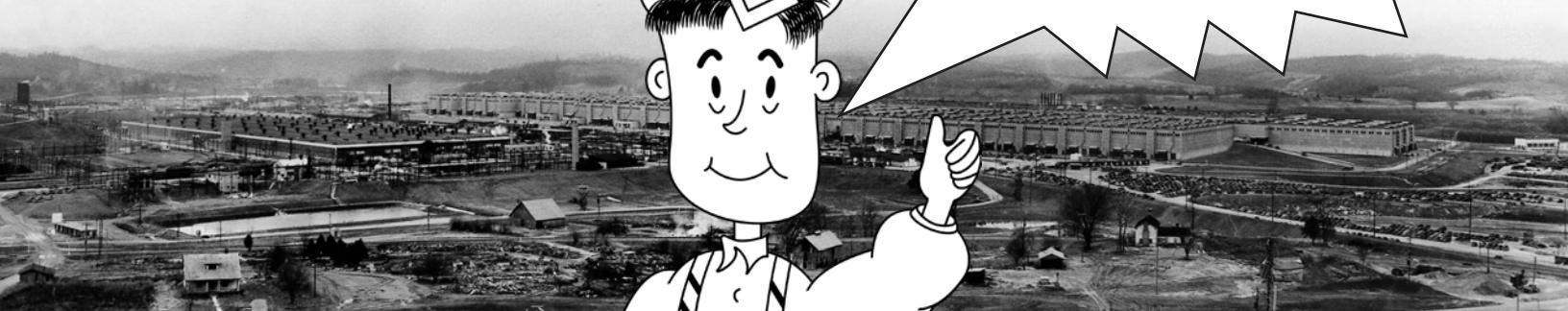
National Park Service
U.S. Department of the Interior

National Historical Park
NM, TN, WA



Junior Ranger Chemist Activity Book

Explore the
History and Science of
the Manhattan Project
at K-25!



Welcome to Manhattan Project National Historical Park

During World War II, Americans by the hundreds of thousands moved to factory towns across the country to build weapons and supplies for the troops fighting overseas.

Oak Ridge was one of those cities. But instead of airplanes, bullets, or tanks, the workers of the Manhattan Project's largest city had no idea what they were making in these giant factories. Only in the final days of the war would they find out their role in the top-secret military project to harness the atom and create the atomic bombs, Little Boy and Fat Man.

Keeping the project secret took hard work and everyone played a part. One part of working in Oak Ridge was wearing an Identification Badge. Your badge would allow guards and military police to identify **who** you were, **where** you lived, and if you were **allowed** to be in the area. Children were issued their first ID badges at the age of 12.



I'm Oakie
& I wear my
badge on
my hat.

Design Your Own

Before you explore the history and science of the Manhattan Project, create your own Identification badge. What important information will you include? At minimum, draw yourself and write your name in the badge to the right.

K-25 Junior Ranger

Elements Make Up Everything

An element is a solid, liquid, or gas that cannot be broken down into smaller parts. From the water we drink — water is made up of two elements, oxygen and hydrogen — to what makes pennies shiny — they're covered in copper —, everything around us is made from elements.

A single piece of an element is called an atom. Atoms are very, very, very small, trillions could fit in the period at the end of this sentence. But which element was so important for the Manhattan Project?

Uranium!

The uranium takes a big trip to get to Oak Ridge for the Manhattan Project.

Use the clues below to trace the route the uranium takes on its global journey.*

ST. LOUIS, MISSOURI

After the US Army purchased the raw uranium ore, it needed to be processed into other uranium compounds for later enrichment.

STATEN ISLAND, NEW YORK

Far away from the battles of World War II, this busy city seemed like a safe place to store the uranium ore until a buyer could be found.

OAK RIDGE, TENNESSEE

You are here!
K-25 was one step in making the fuel for the Little Boy atomic bomb. The other factories in Oak Ridge were Y-12 and S-50.

BELGIAN CONGO

Uranium ore, or pitchblende, was mined here along with another element, radium. In 1942, when the Manhattan Project began, 1,400 tons of ore had already been shipped abroad. Another 3,000 tons had been mined but were awaiting shipment from Africa. Much more uranium was still in the ground.

That's a long journey!
Did I bring enough socks?

More than 30 other sites globally contributed to the Manhattan Project and many of those worked with uranium.

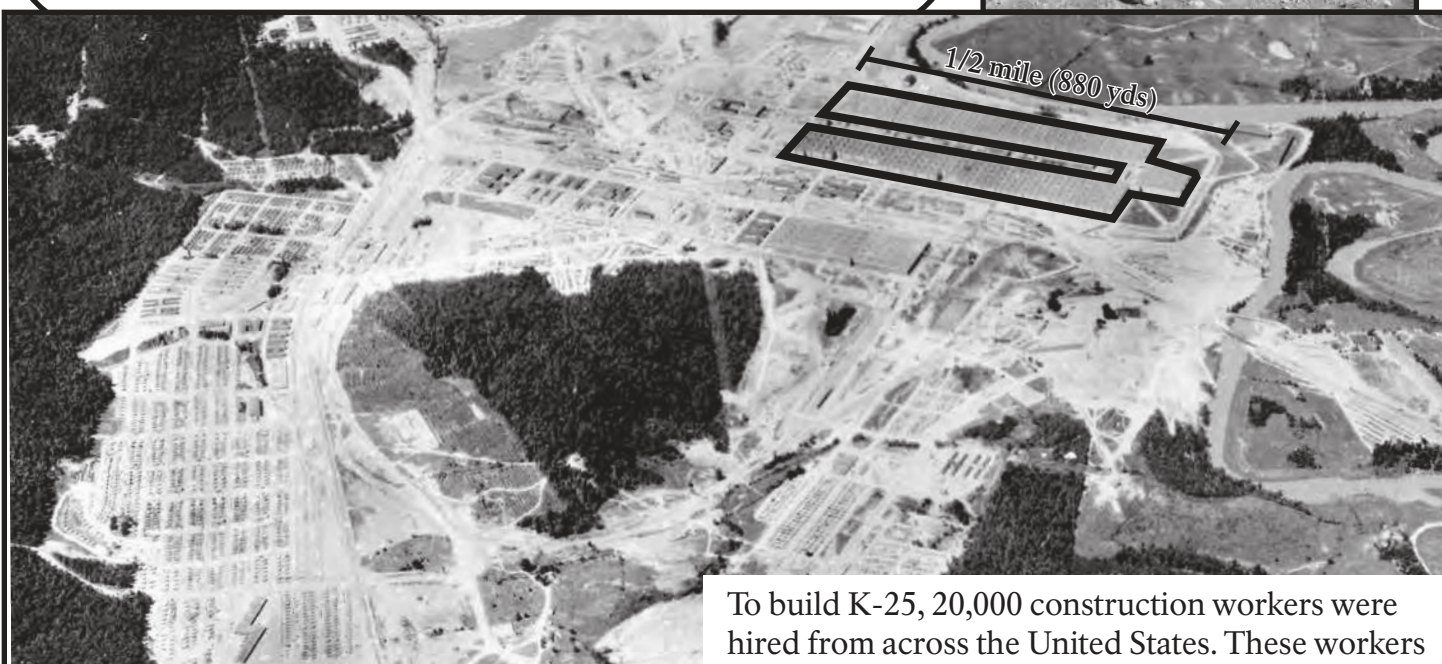
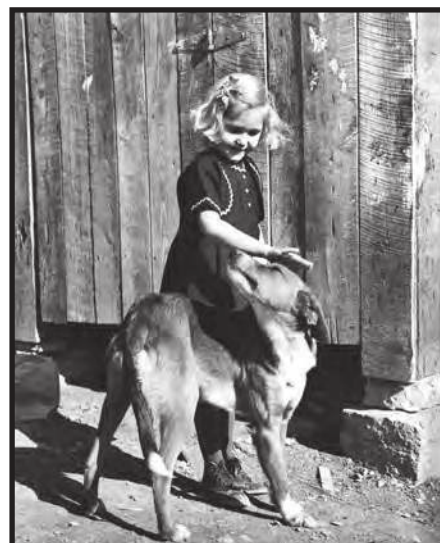
*Important Note: These maps are not to scale and leave a lot of important places out. Africa is more than three times the size of the US.

Building K-25

Wheat Community

People lived in this area long before Oak Ridge was built. One community that was directly affected by the Manhattan Project and the building of K-25 was Wheat. Named for their first postmaster, rather than the crop, this rural community was home to 1,000 people and included schools, churches, stores, and abundant farmland.

In late 1942, the Manhattan Project removed the residents from their land, offering between \$35-\$45 dollars per acre. Many residents were only given a few weeks to move, making way for the building of K-25.



To build K-25, 20,000 construction workers were hired from across the United States. These workers lived in two main camps at the construction site, Happy Valley and Wheat Colony.

Their construction camps were built on a grid of streets and trailers. Look closely at this photo from 1945. Can you find their many homes? Circle or color in the housing camps.

During the Manhattan Project, K-25 was the largest building in the world. At one half miles (880 yards) long, 1,000 feet (333 yards) wide, and four stories tall, the building was so big that many of its 12,000 employees used bicycles to navigate the cavernous rooms. How many football field lengths (100 yards) would you need to travel around K-25?



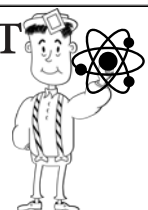
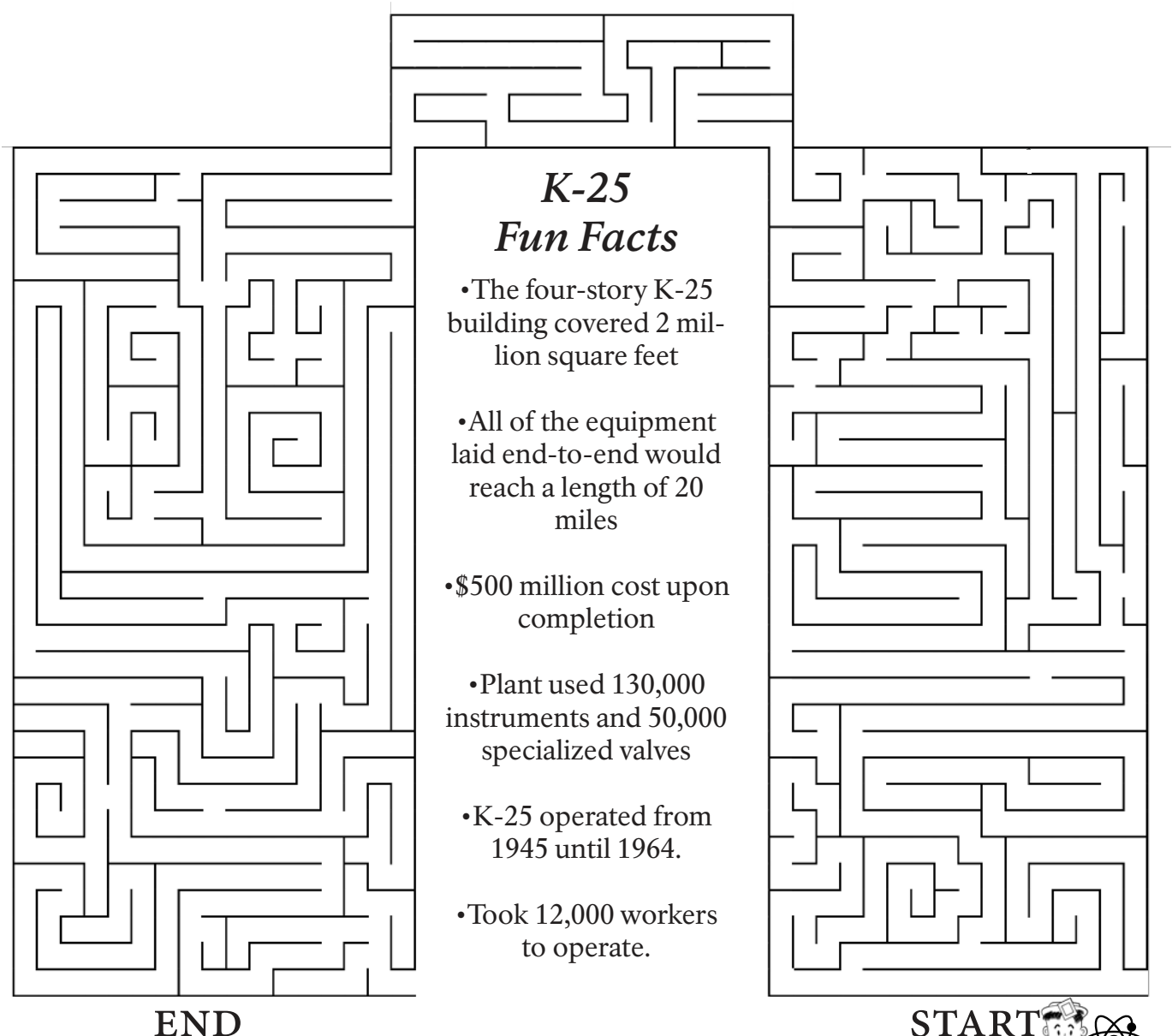
Workers pour and smooth the concrete floors inside K-25.

Help Oakie Process The Uranium

To create weapons-grade uranium, the uranium needs to be processed in factories like K-25. What makes weapons-grade uranium powerful is a certain uranium atom. Not all uranium atoms have the same properties or behave the same ways. Scientists call these different types of an element an **Isotope**. Uranium has two common isotopes, uranium 235 (U-235) and uranium 238 (U-238). The numbers tell us how much the atom weighs.

U-235 is very rare, less than one out of a hundred atoms, but holds the key to the atomic bomb. The factories in Oak Ridge concentrated U-235. Inside the K-25 plant, uranium gas passed through 2,892 chambers. As the gas passed through each stage, more of the U-235 and less of the U-238 remained. This separation process was called **gaseous diffusion**.

Help Oakie guide the U-235 atom through the maze of pipes inside K-25.



Separating the Uranium Isotopes

Gaseous Diffusion

Why couldn't the scientists and technicians use chemistry to separate out the uranium isotopes?

The process used in K-25, gaseous diffusion, involved uranium gas pumped through large tanks through a barrier.

This barrier did not sort the atoms like a filter. The lighter isotope, U-235, passed through the barrier faster than the heavier isotope, U-238. The atoms are the same shape and size, even though they weigh different amounts.



How would you separate something that has different weights but the same shape and size?

Other Separation Methods In Oak Ridge

K-25 wasn't the only factory in Oak Ridge during the Manhattan Project. Two others, S-50 and Y-12, helped create the fuel for the Little Boy atomic bomb. Use the images below to puzzle out the methods used at the other factories.



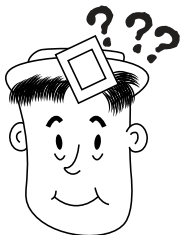
How
politicians
are chosen



How you'd
move a boat



Y-12's method was



S-50's method was



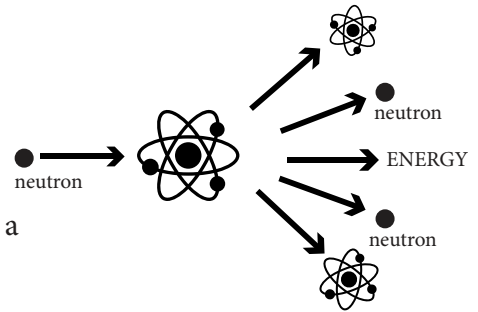
A type of
cold weather
underwear or
Long Johns



The wet phase
of matter

The Chain Reaction

The power of atomic bombs comes from the energy released in splitting atoms, what scientists call nuclear fission. Atoms don't split easily, you can't just break one with a hammer. Scientists discovered that if an atom of uranium was hit with a smaller particle - a neutron - the U-235 would split. In the splitting, two smaller atoms are created, two neutrons shoot away and a little bit even turns into energy!



Even though they're very small, those extra neutrons have a big role to play. Every atom split releases more neutrons to split even more atoms. Let's help Oakie figure out how quickly the number of atoms split grows.

1 atom releases enough neutrons to split 2 more atoms.

2 can split 4 more. Those 4 can split 8 more.

How many times would this chain need to repeat before Oakie could split over 500 atoms? _____

The bomb had more than 170 septillion U-235 atoms!



How quickly the chain reaction grows is called exponential growth.

Each new link in the chain is double the one before it and half of the next.

Take your work from calculating the chain reaction and draw a graph in the space below.



Bombings of Hiroshima and Nagasaki, Japan

On August 6, 1945, the Enola Gay dropped the Little Boy atomic bomb on Hiroshima, Japan. The bomb was fueled by enriched uranium from Oak Ridge. Three days later, on August 9, 1945, a second atomic bomb, Fat Man, was dropped on Nagasaki, Japan. This bomb was fueled by plutonium, an element created in another Manhattan Project city — Hanford, Washington.

Both Nagasaki and Hiroshima were destroyed as a result of the bombings.



The Manhattan Project's secret mission was revealed to the workers in Oak Ridge and the world on the same day, August 6, 1945.

One final step to complete this book and become a Junior Ranger!
Find a park ranger or VIP (a park volunteer in the green shirts) and
recite the Junior Ranger Pledge.

Manhattan Project National Historical Park Junior Ranger Pledge

As a Junior Ranger Chemist, I will...

Tell others about the history and science I've learned here today,

Explore other parks and historic sites, and

Protect the national parks so people can learn and
enjoy them,

Forever!



This is to Certify that

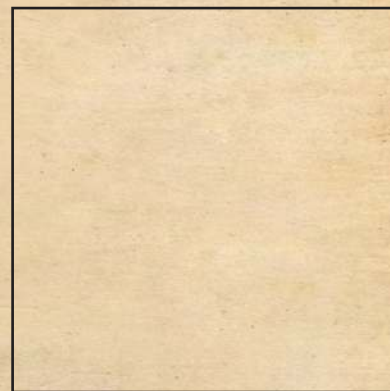
Name of Junior Ranger

has successfully completed all requirements to become
a Junior Ranger Chemist through learning about the
Chemistry and History of the Manhattan Project in
America's Secret City, Oak Ridge, Tennessee.



Junior Ranger Stamp

Signature of Park Ranger/VIP



Park Cancellation Stamp