

Junior Scientist's  
Lab Notebook

Activities for kids to learn about the lab



<http://www.soudan.umn.edu/>

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# Become a Jr. Scientist!

*Thank you for visiting the Soudan Underground Laboratory. This packet has fun activities just for kids. You can even do research projects just like the scientists you saw in our lab!*

As you learned on your tour, this lab is the site of physics experiments including MINOS (Main Injector Neutrino Oscillation Search), CDMSII (Cryogenic Dark Matter Search), and the Low Background Counting Facility. All of the equipment you saw underground had to be brought down there by the elevator shafts – the same way you came down! Physicists from all over the world work here.

The MINOS project is investigating fundamental particles called neutrinos. These particles have no charge and very little mass, so they are hard to catch! The detector underground in Soudan will try to see some neutrinos in a controlled environment so that we can learn more about them. The neutrinos that we are watching are produced at Fermi National Accelerator Laboratory near Chicago, IL. Neutrinos are produced naturally in stars and some neutrinos are still around from the origin of our universe! It is important for us to find out about neutrinos because they will tell us more about how our universe works.

Check the Lab website [www.sudan.umn.edu](http://www.sudan.umn.edu) for more information and to see a live picture of the neutrinos coming in!

*This packet is full of activities and games for you to try. You will check out new ideas and find exciting answers - This is what science is all about!*

*Have Fun!*

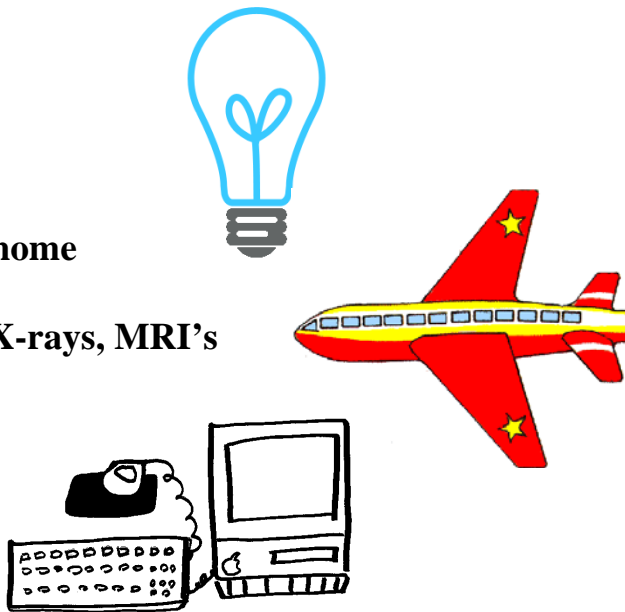
## What else do physicists do?

Research on tiny particles is not all that physicists do! A Physicist is a scientist with special knowledge in physical sciences. This has to do with just about everything that you can think of, from tiny particles that make up matter to huge planets in outer space! Physics covers it all.

Here are some cool things that physicists have done!

**Without research in physics, we would not have:**

- **Light bulbs**
- **Microwaves**
- **CDs**
- **Heating and Cooling for your home**
- **Some medical devices such as X-rays, MRI's**
- **Computers and the Internet**
- **Airplanes**
- **Space Exploration**
- **And more! See the American Institute of Physics website for details.**



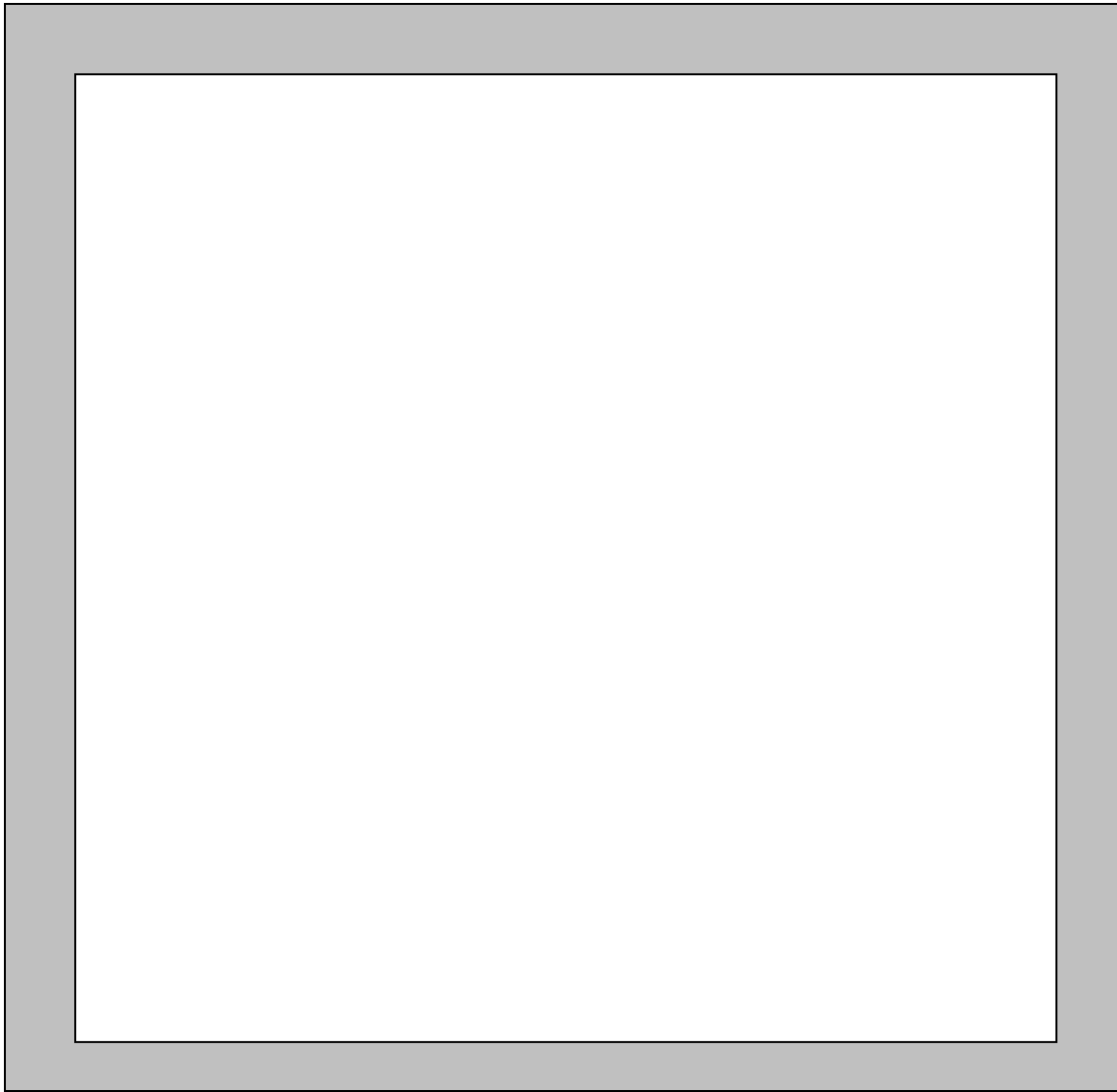
<http://www.aip.org/>

There are different branches of physics including astrophysics, acoustics, atomic physics, molecular physics, chemical physics, biological physics, condensed matter, mathematical physics, mechanics, optics, fluids ... and more!

**Do you have a question about the world in which you live?  
It can probably be answered through physics!**

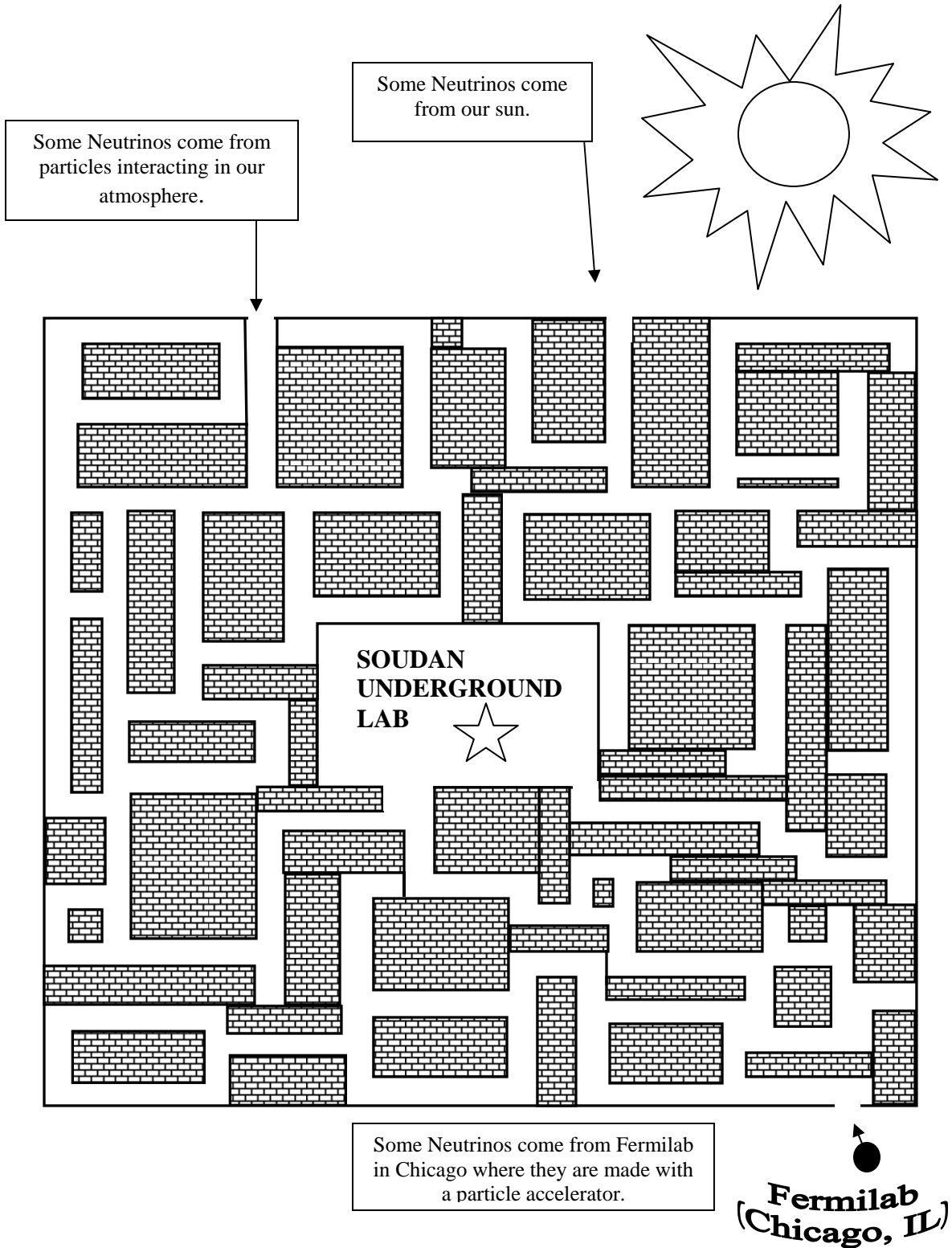
## Draw a Scientist

- Think about what you know about scientists. **Draw a scientist.** You can also include the place where a scientist works or equipment that a scientist uses.



- Now think of some examples of real scientists who you may have seen in the Soudan Underground Lab.
- How are real scientists different than the scientist that you pictured in your head?
- Search the internet for pictures of “scientists at work” to see the different types of people that do science!

Here in the Soudan Underground Lab, we get neutrinos coming through from a variety of different places. The detector can see neutrinos from the atmosphere, the sun, and from Fermilab. We can discover different things about neutrinos from looking at all of the neutrinos from different places. **Trace the Path of the neutrinos that come here to Soudan, Minnesota.** What is wrong with this puzzle? Check the bottom of the page for the answer.



Neutrinos can go through almost anything, so they would not need to follow the paths, they can go *straight* to Soudan!

# MAKE A BAT

Follow these easy instructions to make your own origami bat friend! Start with the square piece of paper provided in your packet.

1) **Fold Square in half.**

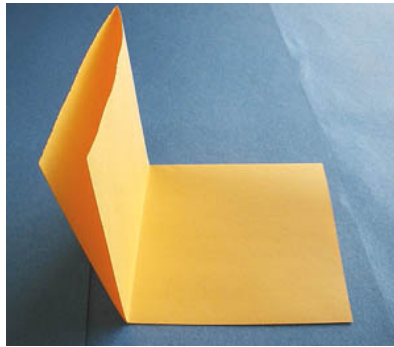
(Hold down the edges hard – they will move around if you don't!)

2) **Crease the new fold hard with your fingernail.**

3) **Fold it in half again. (It is now a square again!)**

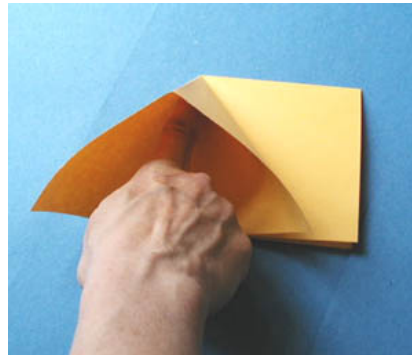
4) **Crease the newest fold well.**

5) **Stand up one side so it points straight up to the ceiling. (It looks like a wall.)**



6) **Push your finger in the top and all the way to the bottom (to the table) (It will begin to open up to the roof shape.) See the picture below.**

7) **Hold it while taking your finger out. Be sure the point looks flat.**



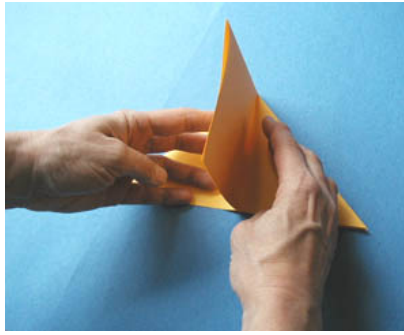
8) **Push it down into a triangle shape. The “roof” or triangle shape should be the same on both sides.**

9) **Crease everything well.**

10) **Turn over. It will look like this:**



**11) Stand up the square flap.  
You may have to push it around and  
rub the fold to make it willing to stand up.**

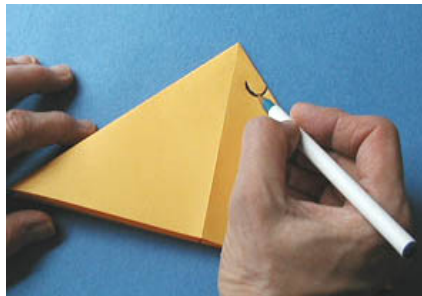


**12) Collapse the roof shape.  
Be sure it looks the same on  
both sides before you crease the fold.**



**13) Crease the fold.**

**14) Draw a smile shape that does not touch the center crease.  
See how it is away from the crease:**



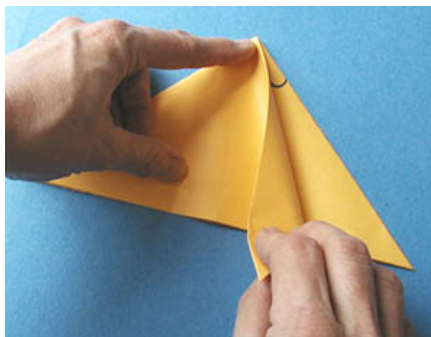
**15) Cut (or tear) on the line.**

**16) Flip one cut layer over to left.**

**17) Flip one of the back un-cut layers to the right.**

**18) Now turn it over. (You will see the plain side.)**

**19) Fold in both edges  
to sit along the center crease.**





**20) Crease the new folds well!  
You are almost done!**

**21) Grab the bat's nose and fold down the head over the tummy**

**22) Draw on a face!  
Here is your Bat!**



**Thanks to The Manchester CT Elementary School for the use of their instructions and pictures for this project – they can be found on the web at**

**<http://art-smart.ci.manchester.ct.us/easy-bat/easy-bat.html>**

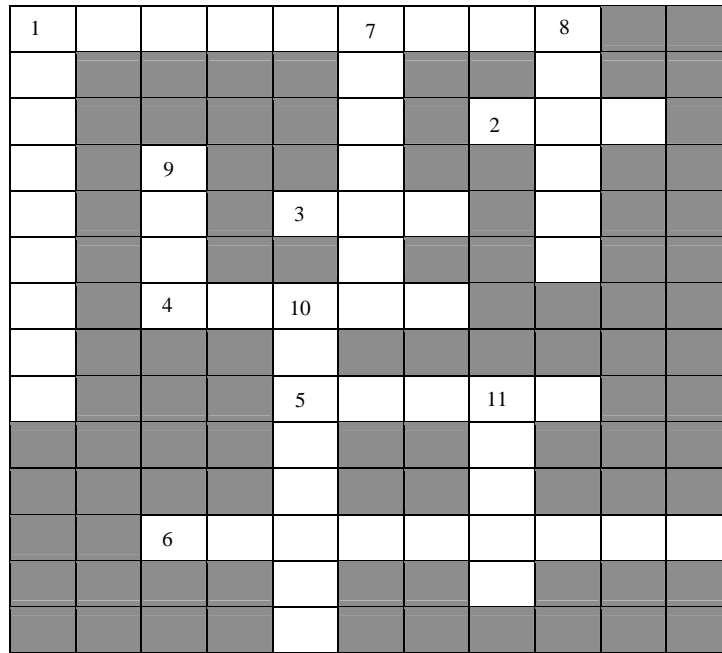
## Soudan Underground Laboratory BINGO

Before the tour, fill in the blank spaces with questions of your own.  
 Fill in the answers to the questions during the tour.  
 Try to get as many BINGOs (five in a row) as you can.

<b>M</b>	<b>I</b>	<b>N</b>	<b>O</b>	<b>S</b>
What is the name of a physicist?	How thick is one steel plate MINOS detector?	What does CDMS stand for?	How big is this cavern?	How many tons does the MINOS detector weigh?
How do they "see" the light from the muon?	Name 3 Universities or institutions that helped build MINOS or CDMS.	How many muons go through this paper underground?	How many stacks of detectors are in the CDMS experiment?	How did they get the detector down here?
What classes did a physicist like in school?	Give the name of one of the people who built the MINOS detector.	Free Space	How many neutrinos are detected each day?	How cold is absolute zero in Fahrenheit?
Ask a physicist what they like about their job.	How many muons go through this paper above ground?	Why is the experiment down here?	Where is the neutrino beam created?	What is another job that people do down here?
Who painted the mural?	What is one hobby of a physicist?	How often does FermiLab in Chicago send neutrinos up here?	Where do people who work here eat lunch?	What is the name of the stuff that detects the light?

## Soudan Lab Crossword Puzzle

**Read the clues and write the answers in the puzzle spaces.**  
 (If you get stuck, check the definitions in the back of the packet.)



### **ACROSS**

- 1) The very small parts of matter. (examples are neutrinos and electrons)
- 2) Large Star, source of some neutrinos.
- 3) An animal found down in the mine.
- 4) The short name, or abbreviation, for the Main Injector Neutrino Oscillation Search.
- 5) Opposite of 'above', as in \_\_\_\_\_ground.
- 6) A person with expert knowledge of science. Some of these people work down in the underground lab.

### **DOWN**

- 1) A person with expert knowledge of physical science. This is a particular type of Scientist.
- 7) Fermilab, where the neutrinos are shot from, is near this big city in Illinois.
- 8) \_\_\_\_\_, MN is where the historical iron mine and Underground Lab are located.
- 9) A concentrated stream of particles, as in *The \_\_\_\_\_ of neutrinos is sent underground from Fermilab to Soudan.*
- 10) The MINOS project is researching this fundamental particle.
- 11) The planet that we live on.

## New Words or phrases:

Atmosphere-the whole mass of air surrounding the earth

Bat- night-flying mammals with forelimbs forming wings

Experiment – a test or a trial, a procedure carried out under controlled conditions to discover something, to test a hypothesis, or to serve as an example

Fermilab- Fermi National Accelerator Laboratory. A national particle physics lab in Batavia, IL (near Chicago, IL). The MINOS beam starts here.

Gram - A unit of mass. One dollar bill is about 1 gram.

Hypothesis – Something not proved but assumed to be true for purposes of argument or further study or investigation

MINOS- The Main Injector Neutrino Oscillation Search. This is an experiment starting at Fermilab near Chicago, IL, and ending in the Soudan mine in Soudan, MN. The near detector and particle accelerator (beginning of beam) are in Fermilab, while the far detector is in Soudan.

Scientist- a person skilled in science.

Neutrino- fundamental particle with very little mass and no charge. The MINOS project is investigating neutrinos.

Particles – one of the very small parts of matter (like an electron). Everything in the whole universe is made up of particles.

Particle accelerator (beam)- a device that is used to give high velocities to charged particles (like electrons and protons).

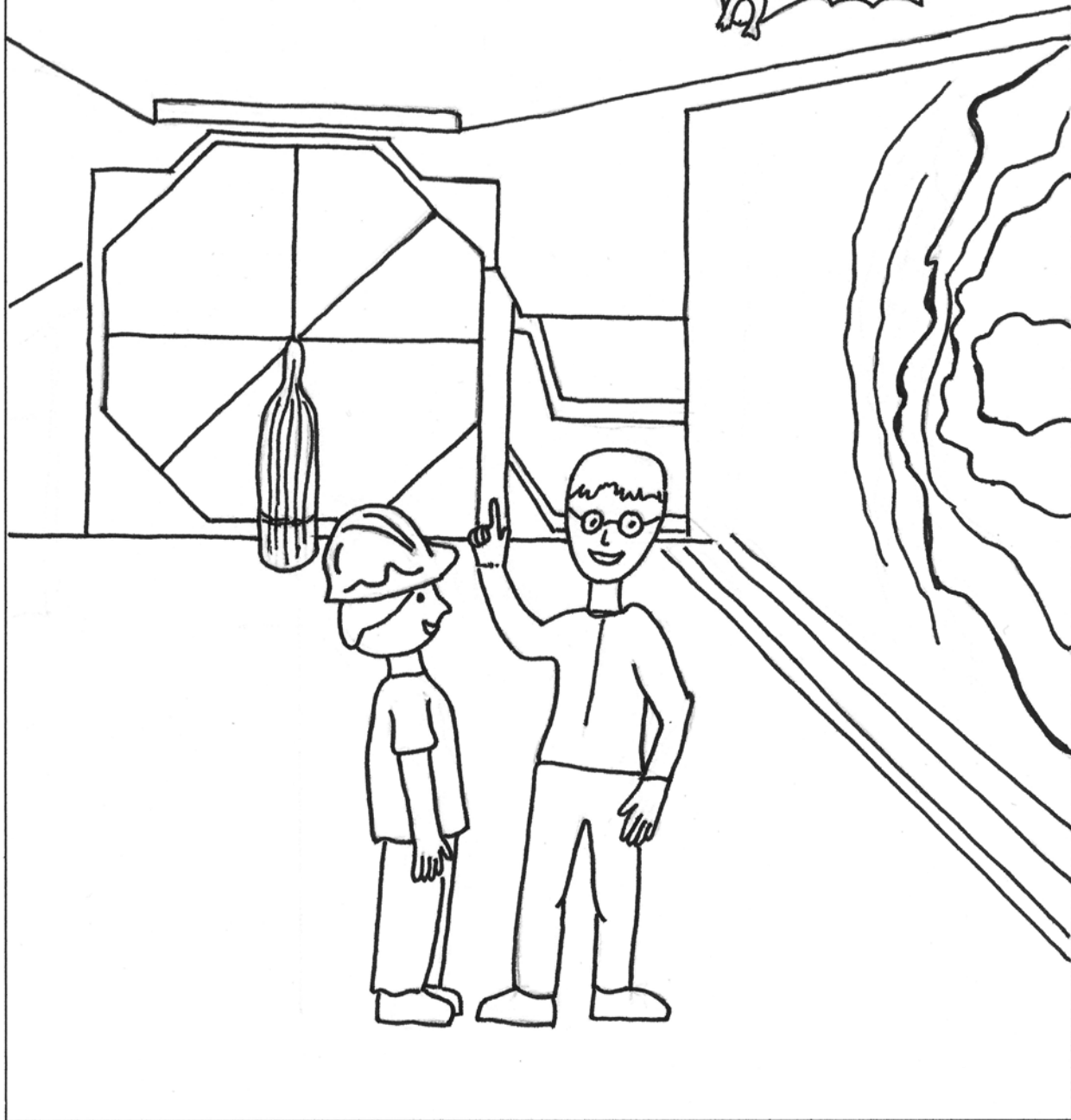
Physicist- A certain type of scientist who specializes in knowledge of physical science (physics).

Sun – The large star at the center of our solar system. It gives off neutrinos from the interactions deep inside that provide its power.

# Color in the Scene

Bats can't see colors. Below, you can see basically what a bat sees underground at the Soudan Lab.

**Please help to color the scene in the way you see it – in lots of color!**

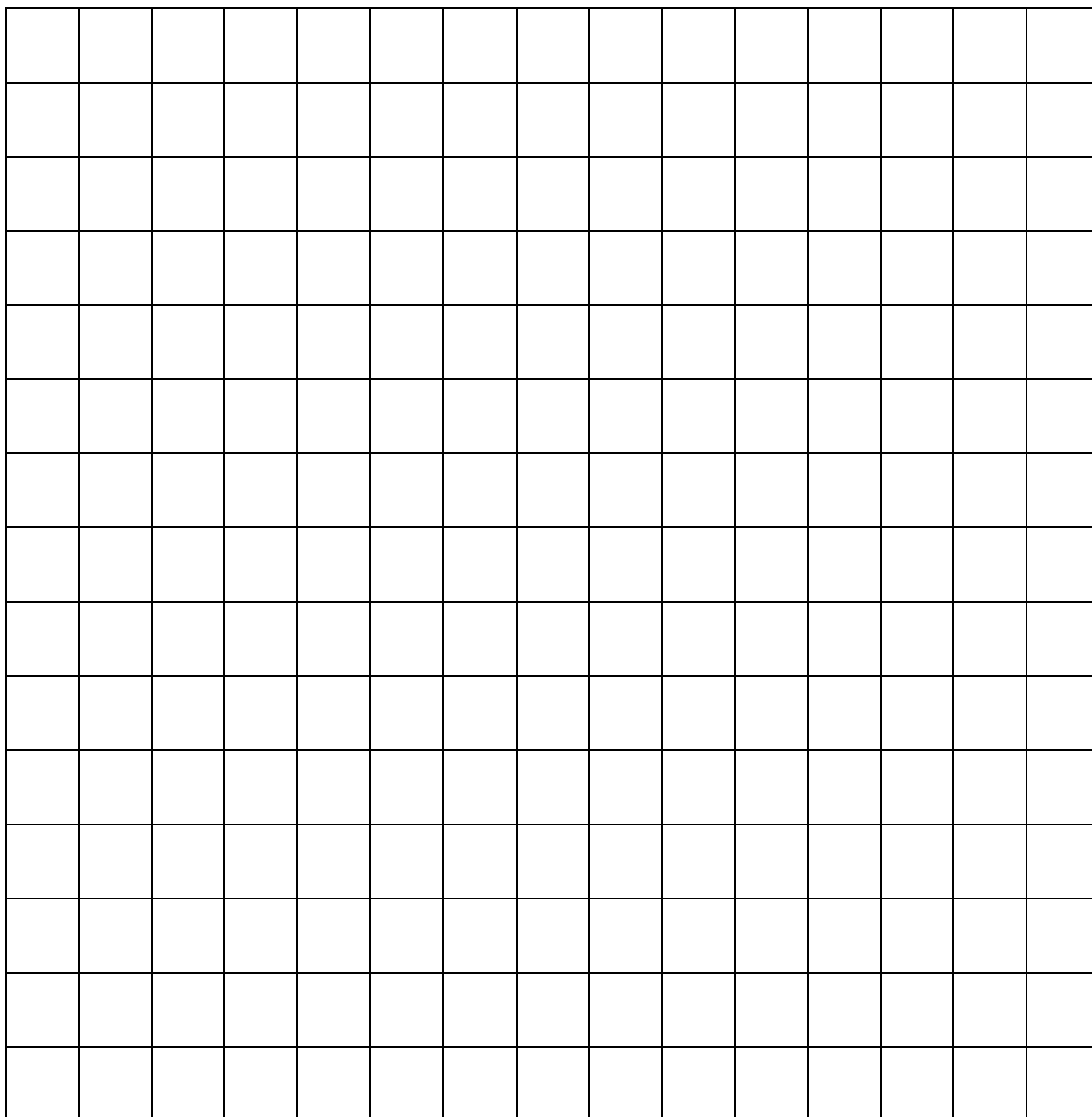


# RESEARCH PROJECT #1

## How Many Neutrinos?

Hold up your hand and count “1 Mississippi”. In that time, trillions of neutrinos flew right through your hand! In fact, 3 trillion neutrinos pass through a square centimeter in a second! You can figure out how many neutrinos go through YOUR very own hand every second by doing this project.

**First, trace your hand on this grid.**



Each box is about one square centimeter. **Lightly shade in the boxes that your hand has covered.** Now **count up the boxes** that you have shaded in. (Every two half-boxes make one more whole one).

Write the number of colored boxes here:

Your hand is \_\_\_\_\_ boxes (or square centimeters) big.

Now here is where you need to do some math. You can use a calculator or ask a parent to help you. Take your number and multiply it by 3:

\_\_\_\_\_ (square centimeters) x 3 = \_\_\_\_\_

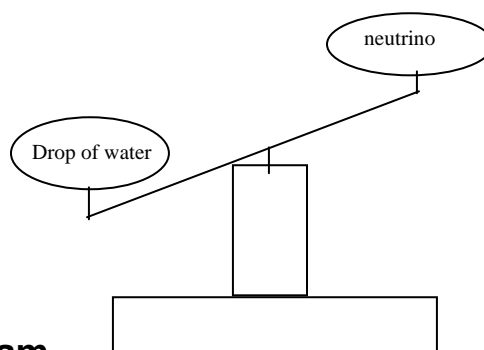
This is how many trillion neutrinos go through your hand every second!

## RESEARCH PROJECT #2

### How little are neutrinos?

Feel how heavy these objects are.  
How do they compare to how heavy a neutrino is?

<b>Kid Brother (6 year old kid) .....</b>	<b>25,000 grams</b>
<b>Paperback Book .....</b>	<b>200 grams</b>
<b>Spoon .....</b>	<b>35 grams</b>
<b>CD .....</b>	<b>15 grams</b>
<b>Key .....</b>	<b>8 grams</b>
<b>Pen or Pencil.....</b>	<b>5 grams</b>
<b>Piece of Paper .....</b>	<b>4½ grams</b>
<b>Penny.....</b>	<b>2½ grams</b>
<b>Napkin .....</b>	<b>2 grams</b>
<b>Kleenex® Facial tissue .....</b>	<b>1½ grams</b>
<b>Paper Clip .....</b>	<b>½ or 0.5 gram</b>
<b>Tic Tac® .....</b>	<b>½ or 0.5 gram</b>
<b>Cotton Ball .....</b>	<b>1/3 or 0.3 gram</b>
<b>Piece of Grass .....</b>	<b>1/10 or 0.1 gram</b>
<b>Pinch of Salt .....</b>	<b>1/13 or 0.08 gram</b>
<b>Drop of water .....</b>	<b>1/20 or 0.05 gram</b>



**A neutrino weighs less than  
0.00000000000000000000000000000000000002 grams!**

This means that you would need about:

1 billion x 1 billion x 1 billion x 1 million neutrinos

(1,000,000,000,000,000,000,000,000,000,000,000) to be as heavy as a Kleenex®.

***That is more neutrinos then there are drops of water in the oceans!!!***

## RESEARCH PROJECT #3

### How fast is a neutrino?

(Warning: this activity includes advanced math like division and decimals so you may need help from a parent and a calculator.)

### How long would it take you to walk from Chicago to Soudan?

- Count the number of seconds it takes you to walk from the front end of your car to the back end. \_\_\_\_\_ seconds
- Divide the length of your car by this time in seconds to figure out how fast you can walk. Take 5 meters (this is a guess at the length of your car) and divide it by the number of seconds it took you to walk it:

$$5 \div \frac{\text{_____}}{\text{(number of seconds to walk length of car)}} = \frac{\text{_____}}{\text{(your speed)}}$$

- You can walk at a speed of \_\_\_\_\_ meters per second.  
(your speed)
- Soudan is about 700,000 meters from Chicago IL (If you could walk straight there). Take this distance and divide it by your speed to get how long it will take to walk to Soudan. This will be a big number!

$$700,000 \div \frac{\text{_____}}{\text{(your speed)}} = \boxed{\frac{\text{_____}}{\text{(seconds to walk to Soudan)}}}$$

- It would take you this many seconds to walk to Soudan.  
(Bonus: with 3600 seconds in an hour, can you figure out the time in hours?)

### How long does it take a neutrino to get from Chicago to Soudan?

- Neutrinos travel almost as fast as light (300,000,000 meters per second)! Just as you did before, divide 700,000 meters by this speed to figure out how quickly it takes a neutrino to get to Soudan.

$$700,000 \div 300,000,000 = \boxed{\frac{\text{_____}}{\text{(seconds for neutrino to get to Soudan)}}}$$

It's too bad you can't fly on the back of a neutrino... you would get there much faster!!



# Science Word Search

**Find** and **circle** the science words below. They may be written from left to right, right to left, top to bottom, bottom to top, or diagonal.

Good Luck!

Scientist

Physics

Theory

Experiment

Fact

Universe

Research

Particles

Detector

Equation

Find

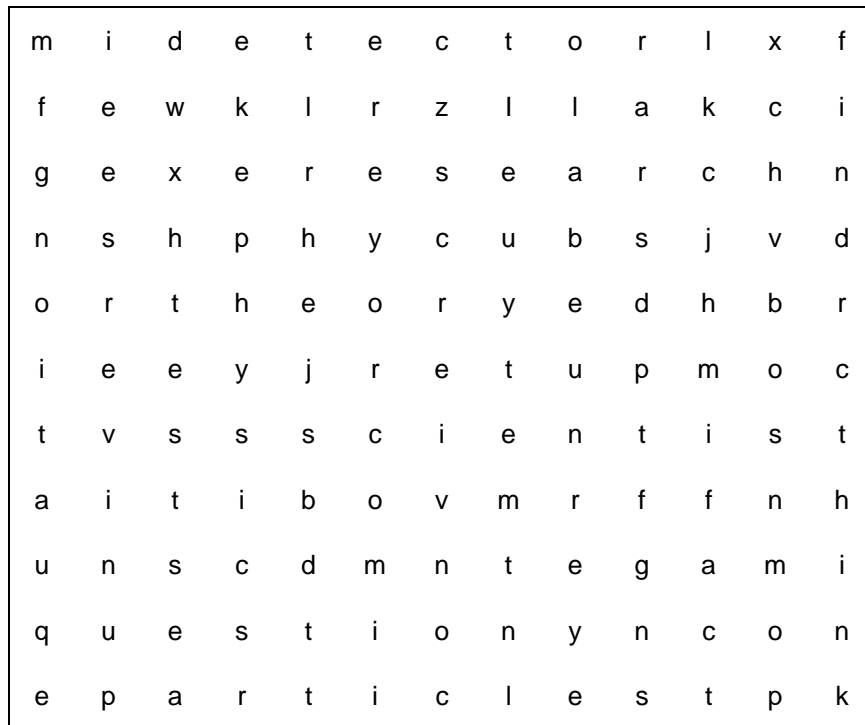
Test

Question

Computer

Lab

Think

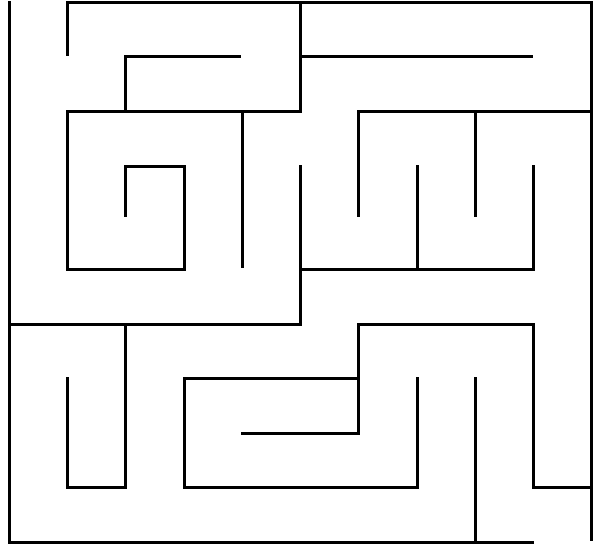


**Help the bat find its way out of the Lab**

**Soudan Underground Lab Word Search**

T	L	A	T	O	M	K	B
P	M	U	P	A	U	H	A
M	I	N	E	H	R	A	B
N	N	C	O	B	A	T	A
C	O	L	D	Y	L	M	L
I	S	A	D	M	H	I	H
L	S	N	A	N	S	N	A
A	P	H	Y	S	I	C	S

**Finish**



**Words To Find**

ART	LAB	CDMS	ATOM	MURAL
BAT	MINOS	MINE	COLD	PHYSICS

**Fun Bat Fact Quiz**

See how much you know about bats! Answers below.

1. T/F. Bats are blind.
2. T/F. Bats are the only mammal that can fly.
3. T/F. Bats are actually flying mice.
4. T/F. A baby bat is called a pup.
5. T/F. No species of bat ever helps pollinate flowers.
6. T/F. About 70% of all bats eat insects like mosquitoes.
7. T/F. Bats can have more than one baby per year.
8. T/F. The scientific name for bats is Chiroptera, which means "hand-wing".
9. T/F. A group of bats living together is called a swarm.
10. T/F. Many bats use sound to find food and navigate.
11. T/F. No species of bat lives on fruit.
12. T/F. The smallest bat in the world is about the size of a bumblebee.
13. T/F. Bats often get tangled in people's hair.
14. T/F. The biggest bat in the world has a wingspan of almost 6 feet.

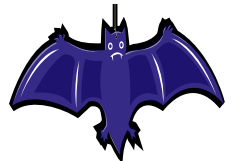
1.F 2.T 3.F 4.T 5.F 6.T 7.F 8.T 9.F 10.T 11.F 12.T 13.F 14.T

**Match the Words to the Pictures**

**Bat**



**Computer**



**Miner**



**Scientist**

