Be an Engineer!

When engineers design a tunnel, they make it very strong so that it will not collapse. Test the strength of a tunnel that you build. Make a small mountain—about the size of a softball—out of clay. Dig and build a tunnel through the mountain. Test your tunnel by placing heavy objects on top of your mountain. Measure how much weight the tunnel supported before collapsing. Record your observations.

Make a plan to build a stronger tunnel. Draw your new plan. Describe how you changed the tunnel. Make another mountain using the same amount of clay you used the first time. Build your new, stronger tunnel. Test your tunnel again and record your observations. Did your second tunnel hold more weight before collapsing? Why or why not?

Beyond the Book

Use the Internet or library to learn about The Big Dig, a tunnel project that took place in Boston, Massachusetts, from 1991 to 2006.

FOCUS Book

Science A–Z

The MOLE MACHINE

FOCUS Question

How do machines make tunnels?

Structure and Function

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The Mole: A Natural Digger

What are the best tools for digging a tunnel? Moles are animals that have strong paws for digging tunnels. Their paws are like shovels. They push dirt out of the way.

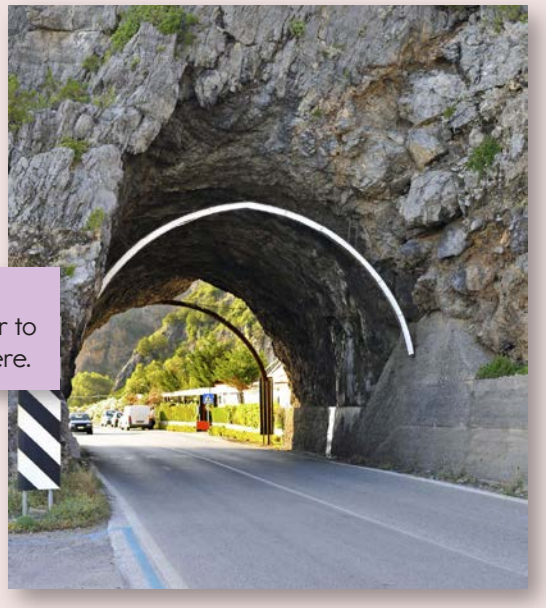
A molehill tells you that mole tunnels are under your feet. You do not see moles above ground very often. They live underground in the tunnels they dig.

Moles use their claws to break apart soil and their paws to move it out of the way.

Tunnel Time

People make tunnels, too. Tunnels help people get from place to place. Earth has many mountains and many bodies of water. How can we move past these things to get where we need to go? One way is to dig a tunnel.

We build tunnels under the water, through mountains, and even under cities! Train tunnels and sewer tunnels might run underneath your street.



Tunnels can make it easier to get somewhere.

wowser!

Switzerland has the longest railway tunnel in the world. It is 57 kilometers (35 mi.) long.

Building a tunnel starts above ground.

Digging a tunnel takes planning. This makes it easier and safer for the workers.

Pick Your Place

Some tunnels go through hard, dry rock. Others go through sandy or muddy places.

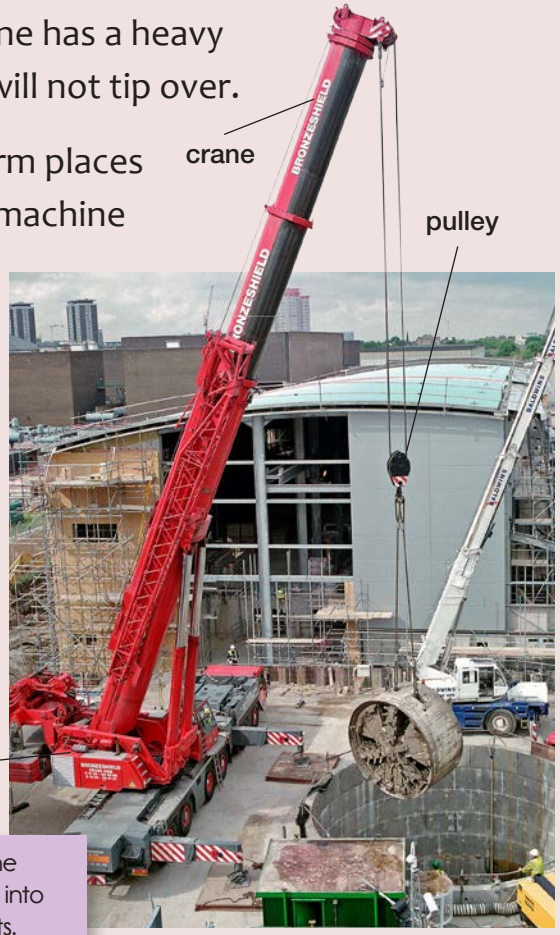
Engineers study where a tunnel should be built. They study the ground and make a plan for digging into it. Making a tunnel is not like building things in other places. If there is a problem, the digging must stop. The workers must be kept safe.

Dig This!

It is important to have the right machines when digging a tunnel. The first step is to dig a deep hole. Special machines carry the dirt out of the hole.

A *crane* is used to move heavy things. A crane has pulleys to make the work easier. It has wheels and axles, too. The crane has a heavy bottom so that it will not tip over.

The crane's long arm places the tunnel-boring machine into the hole. (The word *bore* means to make a hole.) The tunnel-boring machine is also called a *mole machine*.



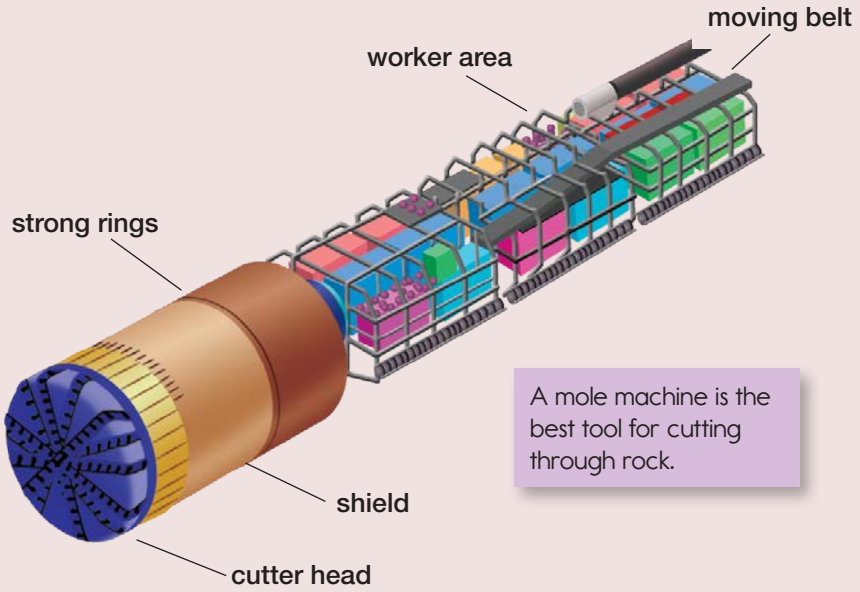
The mole machine must be lowered into the tunnel in parts.

Mole Machine

A mole machine is much stronger than a real mole. The mole machine can cut through rock!

The front part is the *cutter head.* Have you ever seen a cheese grater cut cheese? The cutter head cuts through rock as if it were cheese. Behind the cutter head is the *shield.* It protects the workers from flying rocks. The rocks are moved out of the tunnel after they are cut.

As the mole machine digs, workers put up strong rings in the tunnel. The rings keep the walls of the tunnel from falling in.

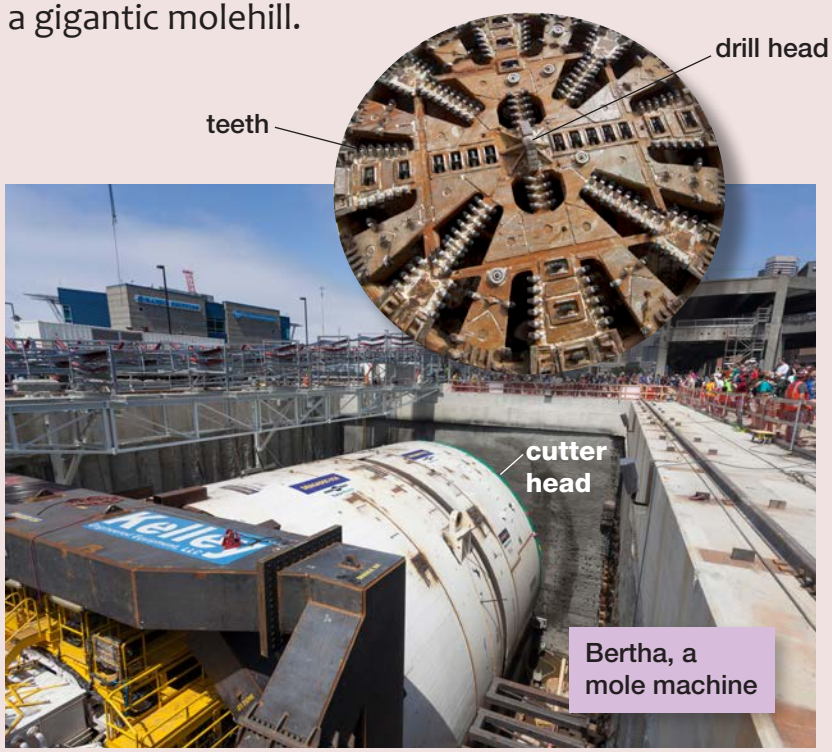


A mole machine is the best tool for cutting through rock.

The Right Tool for the Job

Each part of the mole machine is right for its job. The cutter head has hard teeth that rocks cannot scratch. A strong motor spins the teeth. They can cut almost any rock.

One of the largest mole machines in the world is nicknamed Bertha. It has a screw-shaped part behind its cutter head. As the screw turns, it pushes rocks away from the machine. Bertha turns rock into a gigantic molehill.



Bertha, a mole machine

Dangers of Digging

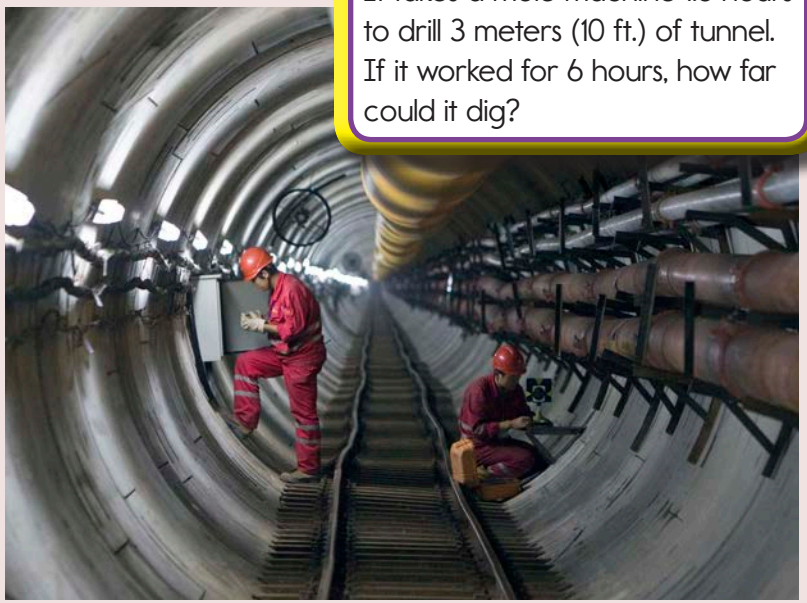
Digging a tunnel through soft ground might seem easy, but hard ground holds together. Soft ground, such as sand, can collapse. Workers must be careful when digging.

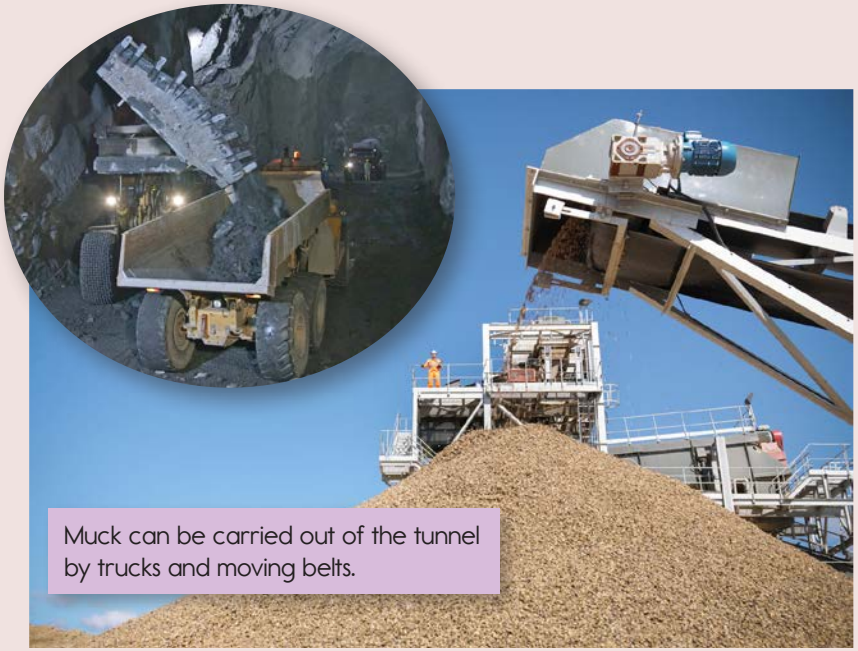
People in the tunnel need fresh air. Think of a very long tunnel with only one opening. Where does the air come from? It must be brought in from outside.

If it rains, water can get into the tunnel. The tunnel can become flooded.

Math Moment

It takes a mole machine 1.5 hours to drill 3 meters (10 ft.) of tunnel. If it worked for 6 hours, how far could it dig?





Muck can be carried out of the tunnel by trucks and moving belts.

Another problem is *muck*. Muck is the leftover dirt and water from the dig. There is a lot of muck, and all of it has to go! Sometimes moving belts are used to take the muck out of the tunnel, but other times the muck is too wet and it must be pumped out. Other times, there is so much rock that trucks carry it away.

Where does all that muck go? Some of it is used to make new land somewhere else. For example, muck can be used to make islands larger.

There are many problems to solve when digging tunnels. Machines can help solve many of them.

Read-Think-Write

Write your answers on separate paper. Use details from the text as evidence.

1. Imagine a tunnel that connects two cities on opposite sides of a mountain. How does it help make life easier?
2. Why do workers put strong rings inside the tunnel as they dig?
3. Look at the image on page 7. How do the features of the cutter head help it do its job?
4. Building tunnels can be dangerous to workers. How do workers stay safe?
5. Which of the following describes *muck*?
   - Ⓐ a valuable resource in a mine
   - Ⓑ a waste product from a dig project
   - Ⓒ an important tool for making tunnels

FOCUS Question

How do machines make tunnels? Choose one of the machines shown on pages 5–7. Describe why it is the best tool for the job it needs to do.