PUSH AND PULL:
SIMPLE MACHINES AT WORK

1 videocassette ...................................... 23 minutes

Copyright MCMXC
Rainbow Educational Media
4540 Preslyn Drive
Raleigh, NC 27616-3177

Distributed by:
United Learning
1560 Sherman Ave., Suite 100
Evanston, IL. 60201
800-323-9084
www.unitedlearning.com | www.unitedstreaming.com
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Program Summary</td>
<td>1</td>
</tr>
<tr>
<td>Learning Objectives</td>
<td>4</td>
</tr>
<tr>
<td>Discussion Questions</td>
<td>5</td>
</tr>
<tr>
<td>Activities</td>
<td>8</td>
</tr>
<tr>
<td>Glossary</td>
<td>18</td>
</tr>
<tr>
<td>Bibliography</td>
<td>19</td>
</tr>
<tr>
<td>Script</td>
<td>9</td>
</tr>
</tbody>
</table>
INTRODUCTION

Many children are fascinated with machines. They are naturally curious about what machines do and how they work. It may seem to them that complicated machines such as bulldozers and derricks work in mysterious ways. But other machines, such as screws or crowbars seem so simple that children may not think of them as machines at all.

The video "Push and Pull: Simple Machines at Work" shows that all other machines, no matter how complex, are made up of combinations of six simple machines: the lever, the wheel and axle, the pulley, the inclined plane, the screw, and the wedge. The program examines each of these simple machines in turn. Using examples familiar to the children, along with computer graphics and animation, the program covers the basic principles of physics that govern simple machines. Students learn what work is, how force is necessary for work, and how machines help people do work. Children in the video demonstrate experiments that students can repeat at home or at school to clarify major points further.

After viewing the program, students will understand much more about all types of machines.

PROGRAM SUMMARY

The video opens with a visual collage of different types of machines. Some, such as a bulldozer and ski lift, may seem complicated; but others, like the wheel of a wagon, or a screw, may seem too ordinary to be machines. The narrator makes the point, however, that these, too, are machines and that by understanding simple machines students will know more about how even the most complicated machines work.

After the title, the video shows children on a playground and makes the point that some of the children are doing work and are using machines to help them do work. The video uses examples such as a seesaw and a wagon to define key concepts. It states that (a) work is moving something over a distance, (b) force is any push or pull, (c) whatever is being pushed or pulled is the resistance, and (d) machines help people do work. The video shows how a wagon and a seesaw are both examples of machines because they help people do work. It goes on to state that while these machines seem simple, all other machines, no
matter how complicated, are made up of combinations of simple machines.

The program next defines simple machines as machines that have few, if any, moving parts and states that there are six basic types of simple machines: the lever, the wheel and axle, the pulley, the inclined plane, the screw, and the wedge.

The video first looks at the lever. It shows how all levers are made up of three basic parts: the rod or beam that is also known as a lever stick, the fulcrum, and the load. The push or pull that moves the load is force.

The video then shows two children lifting a rock using a lever that consists of a board and a log that acts as a fulcrum. The video shows how it takes less force to lift the rock when the children are farther away from the fulcrum. In this way, it establishes a relationship between force and distance. The greater the distance the force is from the fulcrum, the less force it takes to lift a load.

The program then talks about different classes of levers. First class levers have the fulcrum in the middle, the force on one side, and the load on the other. In second class levers, such as a wheelbarrow and nutcracker, the fulcrum is not in the middle but on one side. The load is in the middle, and the force on the other side. In third class levers, the fulcrum is on one side, the force is in the middle, and the load is on the other side.

Next the video looks at another type of simple machine, the wheel and axle. Graphics show how a wheel and axle are actually a type of lever, with the axle acting as the fulcrum.

Children demonstrate an experiment with a stick that shows the relationship between force and distance in simple machines and how this relationship applies to a wheel and axle. The experiment shows how the farther force is from the axle, the less force it takes to turn the wheel.

Another kind of simple machine, the pulley, is related to the wheel and axle. There are different kinds of pulleys. One kind is called a fixed pulley because it remains anchored to one spot. Using examples such as a flag pole and a clothes line, the program shows how a fixed pulley doesn't decrease the amount of force needed to move something but does change the direction of the force. Because changing the direction of the force helps people do work, a fixed pulley still fits the definition of a machine.

Using a fixed pulley, children demonstrate an experiment in which they measure with a spring scale the amount of force it
takes to lift a weight. Then, they use a different kind of pulley, a **movable** pulley, to lift the same weight. A movable pulley moves along a rope as a weight is being lifted. Once again, a spring scale is used to measure the force required, and the video shows that the amount of force needed with a movable pulley is only half that needed with a fixed pulley.

The program shows how a movable pulley is often used with a fixed pulley in an arrangement called a "block and tackle."

The program next discusses another type of simple machine, the inclined plane. Graphics illustrate how pushing a weight up a long inclined plane requires less force than pushing it up a short inclined plane to the same height.

The program then poses a question to the viewers: How would they bicycle to the top of a mountain. Going straight up the mountain would be impossible, so one way might be to build an inclined plane. But the program also suggests another way; to wrap an inclined plane around the mountain. The viewer is then shown how this variation of the inclined plane is an example of another type of simple machine, a screw.

The screw is defined as an inclined plane wrapped around a post. The video shows how a screw's threads, its winding edges, increase the distance necessary to move a screw into a piece of wood but also decrease the force that is required. Using the example of a car jack, the program goes on to show how screws can help people lift a heavy weight.

The program shows another type of simple machine, the wedge. The wedge is also a variation of the inclined plane. Using examples such as a knife and an axe, the program shows how wedges can be used to push things apart.

The next segment of the video shows different things that students might see in the world around them and asks them to identify the types of simple machines they represent. Examples include the bow of a canoe (wedge), oars (lever), shade (pulley), and scissors (wedge and lever). The program describes how many things are made up of combinations of simple machines. Machines that include more than one simple machine are called compound machines.

Finally, the program summarizes the key points covered in the video.
LEARNING OBJECTIVES
After seeing this program, children should be able to:

— define force as any push or pull
— understand that work is done when a force moves an object over a distance
— understand that machines help people do work
— understand that simple machines are machines that have few or no moving parts
— identify the six types of simple machines:
  - lever
  - wheel and axle
  - pulley
  - inclined plane
  - screw wedge
— give examples of each type of simple machine
— understand how a lever can be used to move or lift objects
— understand how an inclined plane can be used to move objects
— understand that a wedge is a simple machine made of two inclined planes
— understand that wedges can be used to push things apart and cut things
— realize that a screw is an inclined plane that is twisted into a spiral and wrapped around a post
— realize that a wheel and axle is a simple machine where the wheel turns on a post
— understand that pulleys can be used to move things
— understand that complex machines are made up of simple machines
DISCUSSION QUESTIONS

1. **As described in the video, what is work?**
   (Work is moving something over a distance.)

2. **What is the definition of force?**
   (Force is any push or pull.)

3. **What is the name for whatever is being pushed or pulled when work occurs?**
   (Load or resistance.)

4. **In science, what is the definition of machine?**
   (A machine is anything that helps people do work.)

5. **How do machines help people do work?**
   (Often machines help do work by reducing the force it takes to move something over a distance. Machines may also help do work by changing the direction of a force.)

6. **Why is the wagon in the video a machine?**
   (The wagon reduces the amount of force it takes the boy to move his younger brother across the playground.)

7. **How are machines alike?**
   (All other machines, no matter how complex, are made up of combinations of simple machines.)

8. **What is a simple machine?**
   (A simple machine is a machine that has few, if any, moving parts.)

9. **Name the six types of simple machines described in the video.**
   (Lever, wheel and axle, pulley, inclined plane, screw, and wedge.)
10. What are the different parts of a lever?
   (The rod or beam, also known as a lever stick, the fulcrum, the load, and the force.)

11. What happens if you increase the distance of the force from the fulcrum when lifting something with a lever?
   (The greater the distance of the force from the fulcrum, the less force is required to lift the load.)

12. What is a first class lever?
   (A first class lever has the fulcrum in the middle, the load on one side, and the force on the other.)

13. What is a second class lever?
   (A second class lever has the fulcrum on one side, the load in the middle, and the force on the other side.)

14. What is a third class lever?
   (A third class lever has the load on one side, the fulcrum on the other side, and the force in the middle.)

15. What are some examples of each kind of lever?
   (Answers will vary. Examples in the program include a seesaw for a first class lever, a wheelbarrow and nutcracker for a second class lever, and a leaf rake for a third class lever.)

16. Why is a wheel and axle a variation of a lever?
   (The axle of a wheel is a kind of fulcrum and the spokes are like the bar of a lever.)

17. Does it take more or less force to turn a wheel the farther you are from the axle?
   (Less force.)

18. What is a fixed pulley?
   (A fixed pulley is anchored to one spot.)
19. What are some examples of fixed pulleys?
   (Answers may vary. Examples in the program include the pulley at the top of a flag pole and a pulley used as part of a clothesline.)

20. Does a fixed pulley decrease the amount of force it takes to move something?
   (No. A fixed pulley helps people do work by changing the direction of a force.)

21. What is a movable pulley?
   (A movable pulley moves along a rope. One end of the rope is fastened to a fixed point, such as a hook, while a person pulls on the other end.)

22. Compared to a fixed pulley, does a movable pulley decrease the amount of force necessary to lift something?
   (Yes. In fact, it takes only one half the force to lift something with a movable pulley as compared to a fixed pulley.)

23. Are movable pulleys often used with fixed pulleys? What is this arrangement called?
   (Yes. Cranes, for example, often use this arrangement, which is called a block and tackle.)

24. What is an inclined plane, and how does it help do work?
   (An inclined plane is a slanting surface. It makes it easier to move things to a higher place.)

25. How does changing the length of an inclined plane affect the amount of force it takes to push something up to a given height?
   (The greater the distance of the slanting surface, the less force it takes to push something up the plane.)

26. Why is a screw a variation of an incline plane?
   (A screw is an inclined plane wrapped around a post.)
27. How do screws help people do work?
   (It takes less force to turn the winding edges of a screw into a piece of wood than to push it straight into the wood. The winding edges move a greater distance, but less force is required.)

28. Why is a wedge a variation of the inclined plane?
   (A wedge is really two inclined planes put back to back.)

29. How do wedges work?
   (When you push on the wide part of a wedge, the force will push the narrow edge into something, pushing it apart.)

30. What are some examples of wedges?
   (Answers will vary. Examples in the video include knives, axes, nails, teeth.)

31. What are compound machines?
   (Compound machines are machines that are made up of two or more simple machines.)

SUGGESTED ACTIVITIES

1. Have students compose a list of examples of simple machines they may see or use in the course of a day. For example, levers that they may see or use include bottle openers and shovels. Wedges include many different tools with sharp edges such as chisels and saws. Inclined planes can often be found around a school. For example, a ramp is an inclined plane. Wheels are on many kinds of vehicles such as cars and bicycles. The gears on a bike are examples of wheels with teeth.

2. The program cites the examples of scissors and a drill as tools that are compound machines; that consist of more than one simple machine. Ask the students what other common tools are examples of compound machines. There are many possible answers. For example, a hammer includes a lever and a wedge. A wrench includes a screw and a lever.

3. The Greek scientist Archimedes long ago said that if he had a lever long enough he could move the earth. Ask the students
to comment on this statement. How does it relate to the relationship between force and distance in levers?

If the students have trouble, refer them to the example in the video of the girls lifting a rock with a lever. One of the girls moves a greater distance from the log fulcrum and is able to lift the rock by herself.

4. The video shows children doing experiments with pulleys using a spring scale to measure force. Students could try to duplicate these experiments or do others. For example, they could use a spring scale to measure the force it takes to move a weight up to a specific height using an inclined plane. Then they could repeat the experiment moving the weight up to the same height with a longer inclined plane.

Have the students keep records. How much force does it take to pull the weight when the inclined plane is twice as long? Three times as long? The students might also graph their data.

SCRIPT

NARRATOR:
Machines do many things.
They help move dirt,
and pump oil from the ground.
Machines help skiers to get to the top of a mountain
and travelers to fly.

There are also many machines that we may not think of as being machines.

These are machines that we may use every day.

They may seem too ordinary...too simple...to be machines.

But by understanding simple machines, you can understand much more about even the most complicated machines.
NARRATOR:
We don't usually think of a playground as a place where work goes on.
A playground is a place to have fun.
But, despite appearances, while these children are playing, many of them are also doing work.
This kind of work is different than schoolwork which involves thinking.
In science, the definition of work is moving something over a distance.
So, this boy is doing work by moving his brother across the playground.
Work like this requires force.
The definition of force is any push or pull.
Pulling a wagon involves force.
Here's still another definition.
Whatever is being pushed or pulled is called the resistance, or load.
Here, the boy being pulled in the wagon is the load.
And here the little girl being pushed on the swing by her mother is the load.
Not only is there a lot of work going on, but this playground also is full of machines that help people do work.
Machines on a playground? Well, in science a machine is anything that helps people do work. Machines often help by reducing the force it takes to move something over a distance.
So this seesaw is a machine because it helps these two boys lift each other up in the air.
And this wagon is a machine because it reduces the amount of force it takes to move a younger brother across the playground.
Machines like the seesaw and wagon may seem pretty far removed from complex machines like the ones shown here helping repair a road.
But all machines are alike in that they help people do work. All machines are alike in another way too. No matter how complicated some machines may look—all machines are made up of combinations of simple machines.

Simple machines are machines that have few if any moving parts. There are six types of simple machines. These are the lever, the wheel and axle, the pulley, the inclined plane, the screw, and the wedge.

Let's look first at the lever. Remember that the definition of a simple machine is one that has few, if any, moving parts. All levers are made up of the same few parts. First, there is a beam or a rod, also known as a lever stick.

The lever stick rests on a point called a fulcrum. The lever stick can rock back and forth on the fulcrum.

Levers help us lift things. The weight that a lever lifts is the load, or resistance.

And the push or pull that moves the lever is the force. And that's all there is to this simple machine.

You can see levers in many places. Can you think of any levers? Well, you've already seen one in this program. A seesaw is a lever.

Can you tell where the fulcrum is? It's where the seesaw rocks back and forth.

As the children lift each other up, they take turns providing the force and being the load.

Suppose you had to lift a very heavy rock. To help, you could use a board and a log as a lever.

Put the log, which acts as the fulcrum, under the middle area of the board,

and then push on the board to lift the rock.

First try pushing on the board close to the fulcrum.

You might need help from a friend.

Then try pushing on the board farther away from the fulcrum.

You would find that it takes much less force to lift the rock. In fact, you might be able to do it by yourself.

So, what does this teach us about the relationship between force and distance in levers?
Well, one thing it tells us is that the farther away the force is from the fulcrum, the less force it takes to lift a load.

In fact, if we double the distance of the force from the fulcrum, it takes only one half the force to lift the load.

The levers that we've looked at so far have all been of one type. They've had the load on one side, the fulcrum in the middle, and the force on the other side. Such levers are called first class levers.

But there are other kinds of levers. In some levers the fulcrum is not in the middle, but on one side, the load is in the middle, and the force is on the other side. Such levers are called second class levers.

A wheelbarrow is an example of a second class lever. The fulcrum of the wheelbarrow is where the wheel is. The load is what is in the wheelbarrow. And you provide the force by lifting the handles.

Here’s another example of a second class lever, a nutcracker. The fulcrum is at the end of the nutcracker. The load, the nut, is in the middle, and you provide the force by squeezing the handles.

There is also another type of lever. With this type of lever the fulcrum is on one side, the force is in the middle, and the load is on the other side. This type of lever is called a third class lever.

Raking leaves is an example of a third class lever in operation. The fulcrum is the hand at the end of the rake, the other hand provides the force, and the leaves are the load.

Now let’s look at another kind of simple machine. People depend on this simple machine all the time.

Without this simple machine there would be no cars...or bicycles.

You couldn't roller skate or skate board. What is this simple machine?

This simple machine is a wheel that is attached to a post called an axle. The wheel and axle turn together.

We are all familiar with wheels and axles on cars, and toys, and roller skates, but there are some wheels and axles that you might not recognize right away.

For example, a doorknob is a wheel, if you took the doorknob off, you'd see that it is attached to an axle.

A wheel and axle actually is a kind of lever. How can this be?
Well, it may seem clearer if you think of the bar of a lever as a spoke in a wheel, and the fulcrum as the axle. Add some more spokes all the way around, and a rim, and you have a wheel. Remember how, with a lever, when you increase the distance of the force from the fulcrum, less force is required to lift the load? Something similar happens with a wheel and axle. Here's an experiment you can do that will demonstrate what we mean.

With one hand, hold a stick at the middle. Imagine your arm is an axle, and the stick is the spoke of a wheel. Now have a friend grab the stick with both hands as close to your hand as possible. Have her try to turn the stick while you try to keep it still. Think of this as trying to turn a small wheel. Now have your friend make the wheel bigger by grabbing the stick farther away. Notice how much easier it is to turn the stick.

So what does this tell us? It means the greater the distance from the axle, the easier it is to turn the wheel. In other words, it takes less force to turn a large wheel on an axle than a small one.

Another kind of simple machine is related to the wheel. This simple machine is called a pulley. A pulley is made with a wheel that has a groove in it to hold a rope. By pulling on the rope, you can lift a weight or load. There are different kinds of pulleys. One kind can be found on top of a flag pole. It is called a fixed pulley because it remains anchored to one spot.

A fixed pulley doesn't decrease the amount of force you need to move something. But it does change the direction of a force. You pull down on the rope...and the flag goes up.

The pulley doesn't make the flag seem any lighter, but without the pulley you'd have to climb to the top of the flag pole. A clothesline provides another example of a fixed pulley. Pulling the rope one way will move the clothes in the opposite direction.
Even though a fixed pulley doesn't reduce the amount of force necessary to move something, it still fits the definition of a machine because it helps us do work. In this case it helps us do work by changing the direction of a force.

Here's an experiment you can do with a fixed pulley. Attach one end of a rope to a weight such as some books, and the other end to a spring scale, which measures force.

Then measure the amount of force needed to lift the weight using a fixed pulley.

Here we've frozen or stopped the video picture of the scale as the weight is being lifted. The scale shows it takes about 38 newtons of force to lift the books. "Newtons" are units of measurement that are used to measure force.

What if we were to use a different kind of pulley, a movable pulley? A movable pulley moves along a rope. One end of the rope is fastened to a fixed point, such as a hook, while you pull on the other end.

Using a movable pulley, try lifting the same weight that you lifted with a fixed pulley.

Using the spring scale, we see here that it takes 19 newtons of force. With a fixed pulley it took 38 newtons.

So, a movable pulley cuts the amount of force needed to lift something in half.

Because movable pulleys decrease the amount of force necessary to lift something, they often are used with fixed pulleys, like this. This type of set-up is called a block and tackle.

Movable pulleys are commonly used along with fixed pulleys to lift heavy loads, like this bucket of cement. This movable pulley is being used by a crane.

To see another kind of simple machine, let's return to the playground...This slide is a type of simple machine called an inclined plane.

An inclined plane is a slanting surface. This slanting surface makes it easier to move things to a higher place.
As with other simple machines, an inclined plane helps people do work. For example, it takes a lot of force to lift this box up to the back of this truck. Is there a better way?

Using a ramp gives you an inclined plane. It allows you to use less force to move the box into the truck than by simply lifting it. Here are two inclined planes. They both have the same height, but one is much longer than the other. If you pushed a weight up both planes, which inclined plane would require less force?

Well, let's look at the short inclined plane first. Let's say the sloping surface of the inclined plane is 10 meters long. Let's say also that it takes 100 newtons of force to push the weight up this ten meter inclined plane.

Now let's look at the other inclined plane. This time, suppose the sloping surface of the inclined plane is twice as long, 20 meters. To push a load up this plane would take only half as much force, 50 newtons. The longer the distance, the less force it takes to move something up an inclined plane.

Here's a problem for you. Suppose you had to bicycle to the top of a mountain.

Obviously, going straight up the mountain would be impractical. No bike could go straight up the side of a mountain, so what could you do?

Well, you could build an inclined plane but it would have to be very long. And it would have to start a long way from the base of the mountain. This might be a very expensive and impractical solution.

But there is another way. There is no reason why an inclined plane has to be straight. What if you wrapped an inclined plane around the mountain? This is, in fact, how most mountain roads are built. They wind around the mountain rather than going straight up the mountain's side.

Does the way the inclined plane winds around the mountain remind you of anything?

Look at this common screw.

A screw, in fact, is really an inclined plane wrapped around a post. The screw is another type of simple machine.
Some screws, like wood screws, have sharp points. The winding edges are called threads. When you twist the screw into a piece of wood, the threads grip the wood very tightly.

Because of the winding threads, you have to turn the screw a greater distance than if you were to push it straight into the wood, but turning it this way takes less force.

Screws are useful in many ways. They can be used to move or lift things...This man is using a jack to lift his car.

If you look closely, you can see that the jack includes a kind of screw that makes it possible to lift the car with less force.

Like the screw, the wedge is another variation of the inclined plane. In fact, you could think of a wedge as being two inclined planes put back to back.

Wedges are used to push things apart. When you push on the wide part of the wedge, the force will push the narrow edge into something, pushing it apart.

Wedges have many uses. They can help split a log.

Whenever you cut something, you're using a wedge. Knives are wedges with thin sharp edges.

The tip of a nail is a wedge. The wedge shape makes it easier to drive the nail into a piece of wood.

We even have wedges inside our mouths. Your teeth are wedges that make it possible to chew an apple.

Levers, wheels and axles, pulleys, inclined planes, screws, and wedges. These are the six types of simple machines. You see these simple machines all around you, but sometimes you might not recognize them right away.

Look at the sharp, pointed bow of the canoes. They help the canoes cut through the water. Can you tell what kind of simple machine a canoe's bow is?

The wedge shape makes it easier for the canoes to cut through the water.

Here's another boat. It is an example not only of a wedge but also of another kind of simple machine. Look at the oars. Do you know what kind of simple machine the oars are?

The oars are levers.

What kind of simple machine helps raise this shade?
Do you see how a pulley is used to raise the shade?
What about these scissors? Are there simple machines in these scissors that make it easier to cut paper?
If you answered wedges you would be right. Each blade of the scissors is a wedge.
But you might also have answered levers. The scissors are two levers joined in a single fulcrum.
Many things we see around us are made up of several types of simple machines. Take a look at this drill.
One part of the drill is in the form of a screw. But the drill also has gears that are a type of wheel.
Machines that consist of two or more simple machines are called compound machines.
This bulldozer has parts that include wedges, levers, wheels and screws.
Compound machines can have many parts that work together in ways that may not be immediately clear.
But no matter how complicated different machines may appear, every machine is made up of combinations of the six simple machines that we have looked at in this program.
(summary)
In this program we've seen that work means moving something over a distance.
And that in order to do work you need force; any push or pull.
We've seen that machines help people do work.
And that simple machines are machines that have few, if any, moving parts.
Simple machines help people do work by reducing the amount of force needed to move or lift something.
Or simple machines may help us do work by changing the direction of a force.
And finally, we've seen that all machines, no matter how complex, are made up of simple machines.
END
GLOSSARY

AXLE: The shaft on which a wheel turns.

FIXED PULLEY: A type of pulley that is anchored to one place.

FORCE: The push or pull that makes it possible to move something over a distance.

FULCRUM: The part of a lever on which a lever stick moves or pivots.

INCLINED PLANE: A type of simple machine. An inclined plane is a sloping surface that can be used to help people move loads to a higher height.

JACK: A device that helps people lift heavy objects.

LEVER: A type of simple machine. Levers help move things. Parts of a lever include the lever stick, the fulcrum, and the load.

LOAD: Whatever is being pushed or pulled when work occurs.
MACHINE: As defined in the program, a machine is something that helps people do work. Machines help do work by reducing the amount of force necessary to move something or by changing the direction of a force.

MOVABLE PULLEY: A type of pulley that moves along a rope as a load is moved.

NEWTON: A unit of measurement used to measure force.

PULLEY: A type of simple machine that consists of a wheel over which a rope or chain passes.

RESISTANCE: Whatever is being pushed or pulled when work occurs.

SCREW: A type of simple machine. A screw is an inclined plane wrapped around a post.

SIMPLE MACHINE: A machine that has few, if any, moving parts. The six types of simple machines identified in the program are the lever, the wheel and the axle, the pulley, the inclined plane, the screw, and the wedge.

WEDGE: A type of simple machine. A wedge is a variation of the inclined plane and helps push things apart.

WHEEL and AXLE: A type of simple machine.

WORK: As defined in the video, work consists of moving something over a distance.

BIBLIOGRAPHY


Aylesworth, Thomas S. (editor). **It Works Like This.** Natural History Press; Garden City, New York; 1968.

Catherall, Ed. **Levers and Ramps.** Wayland; London; 1982.


