EXPERIMENT MANUAL

SCOPE CONSTRUCTOR

THAMES & KOSMOS

Safety Information

WARNING! Not appropriate for use by children under 3 years of age. There is a danger of suffocation due to the possibility of swallowing or inhaling small parts. Store this kit and built models out of reach of young children.

WARNING! Only suitable for children at least 8 years old. Instructions for parents or other responsible persons are attached and must be followed. Keep packaging and instructions as they contain important information.

Individual parts in this kit may have sharp edges or corners. Do not injure yourself!

Do not look directly at the sun through any of the lenses.

Do not look directly at the sun through any of the built models.

Do not store the kit in a place under direct sunlight.

Do not place parts in mouth.

Do not use broken parts.

Safety for Experiments with Batteries

››› Never experiment with wall outlets or the household power supply. Never insert wires, LED pins, or other parts into wall outlets! Household voltage can be deadly.
››› You will need two 1.5-volt AA batteries for the experiments. Due to their limited shelf life, these are not included in the kit.
››› Avoid short-circuiting the batteries while experimenting; they could explode!
››› Different types of batteries (e.g., rechargeable and standard batteries), or new and used batteries should not be used together.
››› Do not mix old and new batteries.
››› Do not mix alkaline, standard (carbon-zinc), or rechargeable (nickel-cadmium) batteries.
››› Only install batteries in the correct polarity direction. Press them gently into the battery compartment.
››› Never recharge non-rechargeable batteries. They could explode!
››› Rechargeable batteries must only be charged under adult supervision.
››› Rechargeable batteries are to be removed from the toy before being charged
››› Remove dead batteries from the kit.
››› Dispose of used batteries in accordance with environmental regulations.
››› Make absolutely sure that metallic objects such as coins or key chains are not left in contact with battery terminals.
››› Do not bend, warp, or otherwise deform batteries.
››› In all experiments with batteries, an adult should check the assembly to make sure it is set up correctly.
››› After experimenting, disconnect all circuits and remove the batteries from the battery compartment.

Notes on Environmental Protection

None of the electrical or electronic components in this kit should be disposed of in the regular household trash when you have finished using them. Instead, they must be delivered to a collection location for the recycling of electrical and electronic devices. The symbol on the product, instructions for use, or packaging indicates this.

The materials are reusable in accordance with their designation. By reusing or recycling used devices, you are making an important contribution to the protection of the environment. Please consult your local authorities for the appropriate disposal location.

Dear Parents!

This kit is appropriate for children ages 8 and up. Its main purpose is to explore optical science and its related applications through innovative and fun model building activities.

Please carefully read and follow the warnings listed in this manual. We recommend that you follow the steps in this manual to help your child assemble the models. By doing so, you will have a better understanding of all the assembly details and be able to successfully help your child build the models.

Prior to use, please read through the safety warnings, component functions, component quantities, and potential risks with your children. After each use, please count the components and store them in the box.

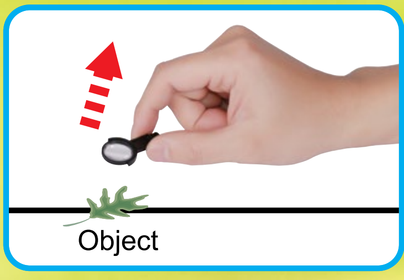
We hope you and your child have a lot of fun with this kit!

An experiment to help you hit the ground running

Try this simple experiment to get a feel for how lenses work.

1

2

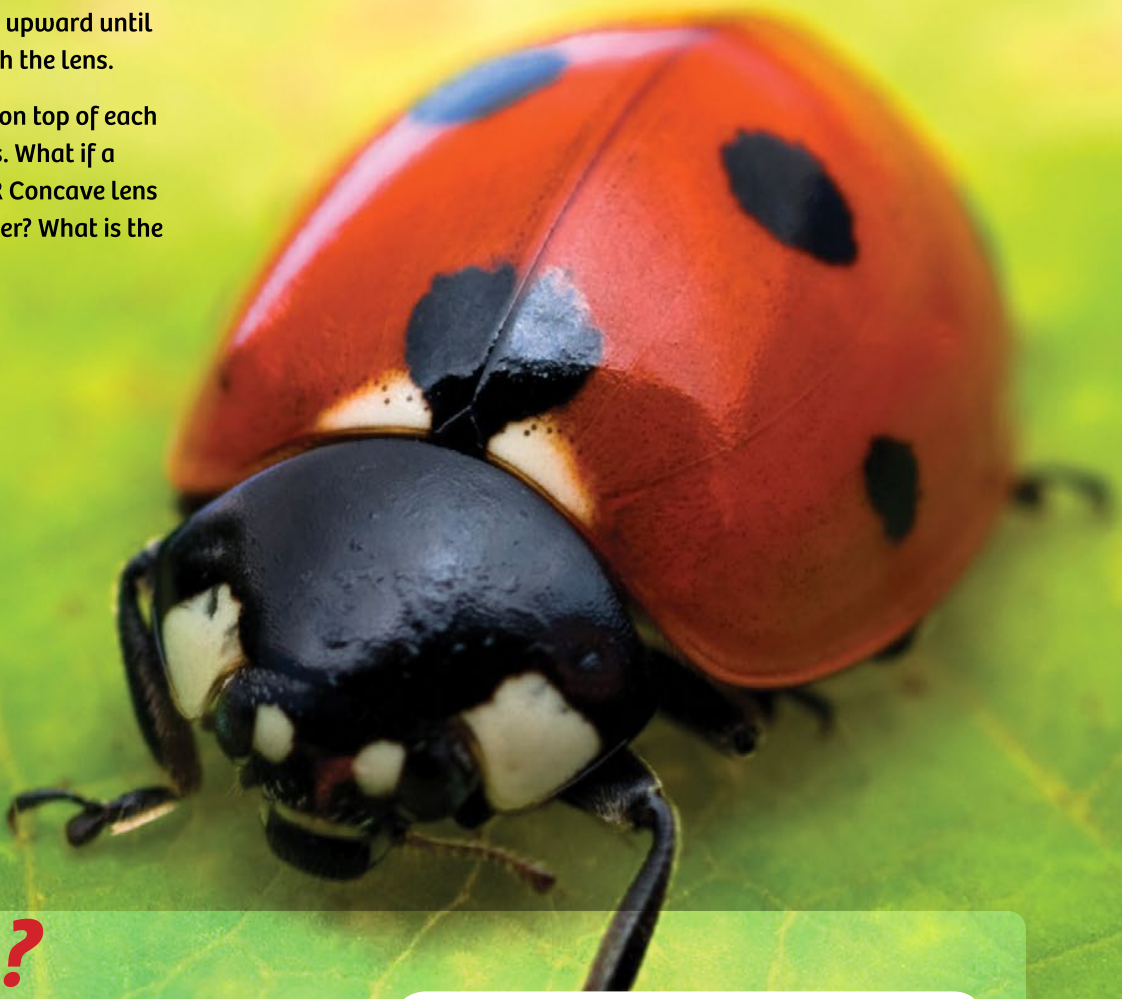


3

What is a lens?

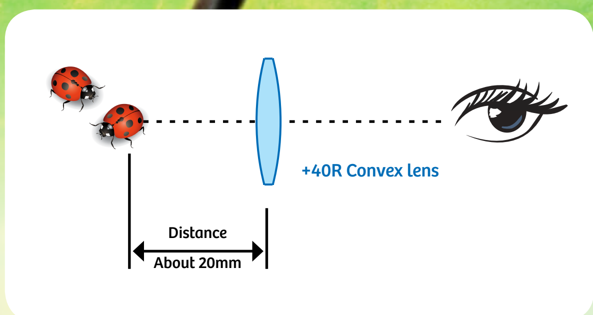
HERE'S HOW

1. Hold the +40R Convex lens in your right hand, positioned above an object like a leaf, a bug, or a small toy. (The name of each lens is molded into the plastic of the lens frame.)
2. Move your right hand slowly upward until you see a clear image through the lens.
3. Put two +40R Convex lenses on top of each other and observe the results. What if a +40R Convex lens and a -40R Concave lens are placed on top of each other? What is the result?



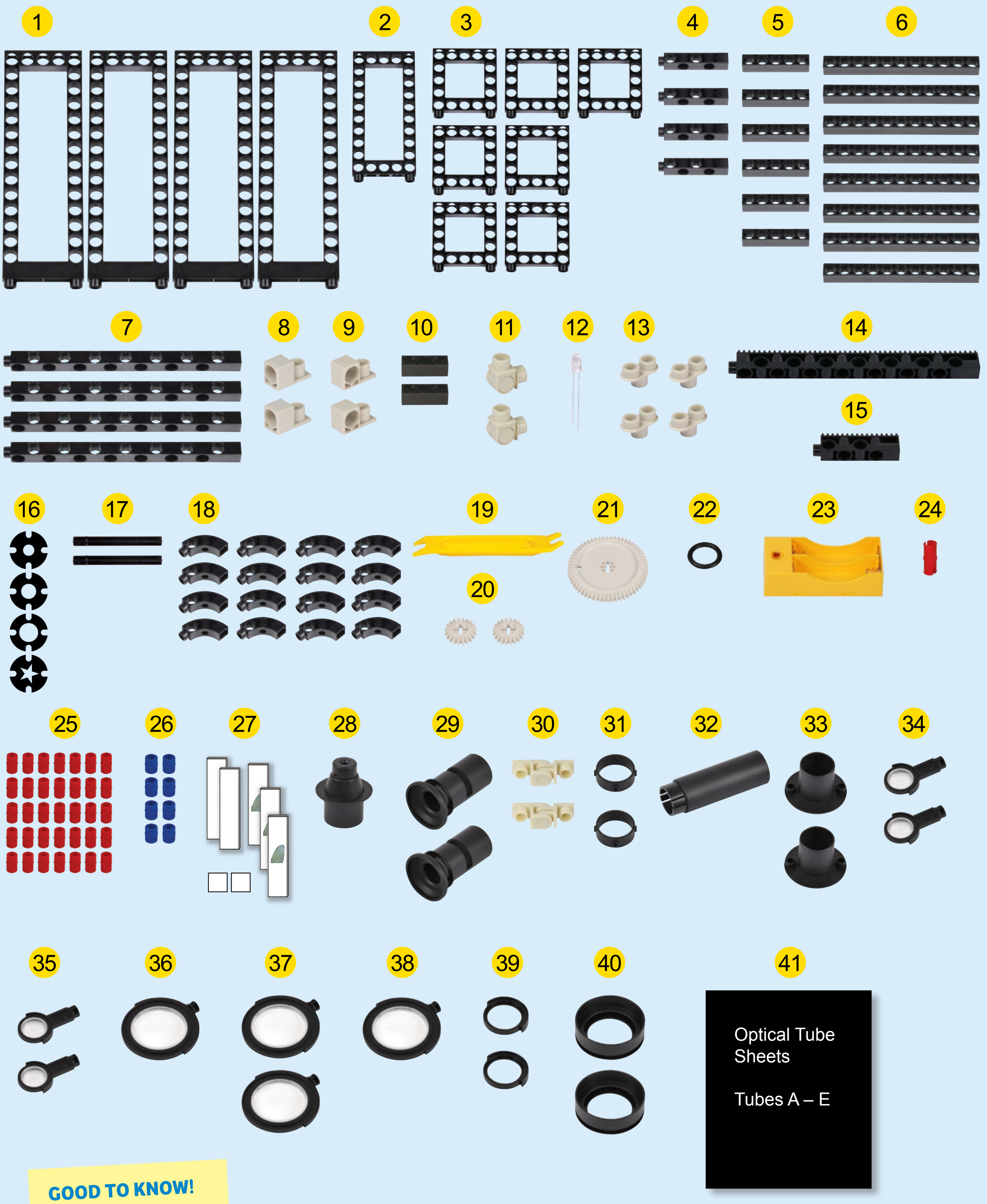
WHAT'S HAPPENING?

The lens magnifies the object. You will notice that the best distance between the object and the lens is about 20 mm. The lens material bends the light rays that are bouncing off of the object, traveling through the lens, and into your eye. Because of the shape of the lens, the light waves are bent in such a way that they make the image appear larger. If you move the lens forward or backward, you'll notice that the image goes out of focus.



››› KIT CONTENTS

What's Inside Your Experiment Kit:



GOOD TO KNOW!
If you are missing any parts, please contact Thames & Kosmos customer service.

You will also need: 2 x 1.5-volt batteries (type AA/LR6/penlight), paper, scissors, tape

›››CONTENTS

Checklist:

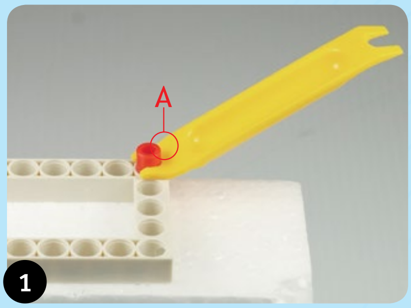
✔	No.	Description	Qty.
❍	1	Long Frame (Black)	4
❍	2	Medium Frame (Black)	1
❍	3	Square Frame (Black)	7
❍	4	5-Hole Dual Rod (Black)	4
❍	5	5-Hole Rod (Black)	6
❍	6	Rod (Black)	8
❍	7	Long Rod (Black)	4
❍	8	90 Degree Converter - Right	2
❍	9	90 Degree Converter - Left	2
❍	10	3-Hole Dual Rod (Black)	2
❍	11	Hinge	2
❍	12	LED	1
❍	13	Two-to-One Converter	4
❍	14	Rack 150 mm	1
❍	15	Rack 50 mm	1
❍	16	Aperture Cards (Set of 4)	1
❍	17	Drive Axle 7 cm	2
❍	18	Bent Rod	16
❍	19	Part Separator Tool	1
❍	20	Small Gear (Gray)	2
❍	21	Large Gear (Gray)	1
❍	22	O-Ring, Small	1
❍	23	Battery Holder, 3V, Single Outlet	1
❍	24	Joint Pin	1
❍	25	Anchor Pin (Red)	35
❍	26	Loose Anchor Pin (Blue)	8
❍	27	Specimens, Slides, Slips	7
❍	28	Objective Lens (+10R)	1
❍	29	Eyepiece Tube	2
❍	30	Sawtooth Joint	2
❍	31	Tube Ring	2
❍	32	Extension Tube	1
❍	33	Eyepiece Tube Holder	2
❍	34	+40R Convex Lens	2
❍	35	-40R Concave Lens	2
❍	36	+300R Convex Lens	1
❍	37	+170R Convex Lens	2
❍	38	Fog Filter	1
❍	39	Empty Lens Frame	2
❍	40	Objective Lens Frame	2
❍	41	Set of Optical Tube Sheets	1

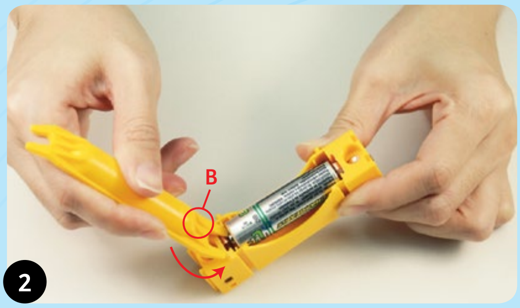
Total Amount: 148 Pieces

The part separator tool

In the box, you will find a small yellow tool called the part separator tool.

1. With end A of the tool, you can easily remove anchor pins.

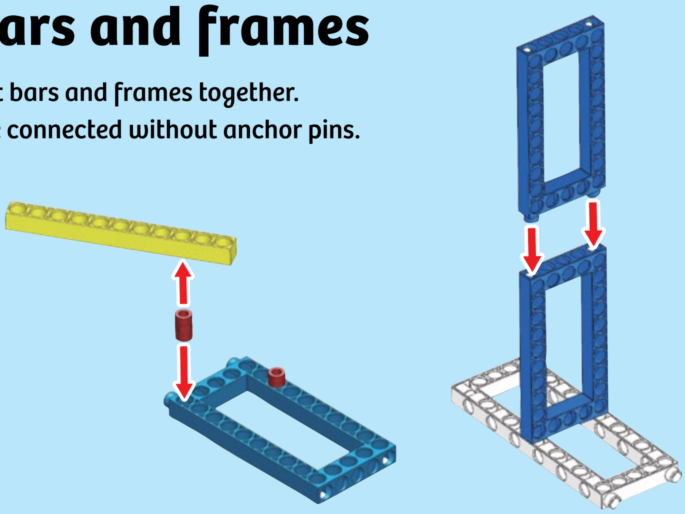




2. Use the B end of the tool to lift batteries out of the battery box.

Assembling bars and frames

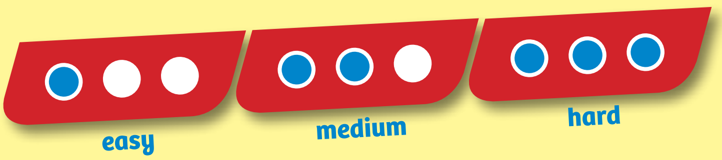
Use the anchor pins to connect bars and frames together.
Some components can also be connected without anchor pins.



TIP!

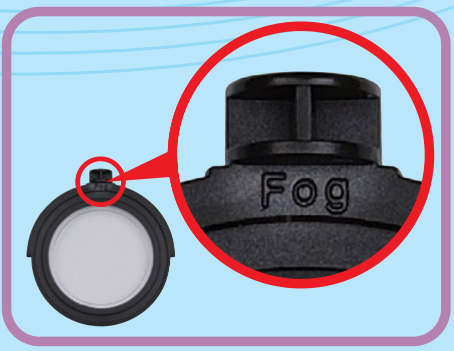
Above each model, you will find a red bar.

››› The bar shows you how hard the model is to assemble:

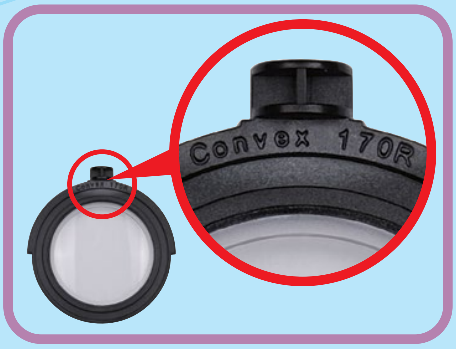


How to identify the lenses

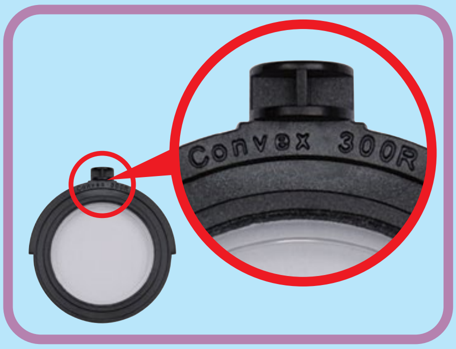
The names of the lenses are molded into the plastic frames of the lenses.



Fog filter



+170R Convex lens

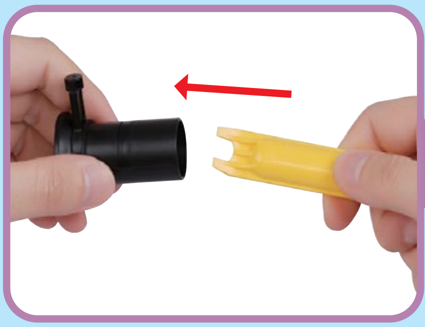


+300R Convex lens

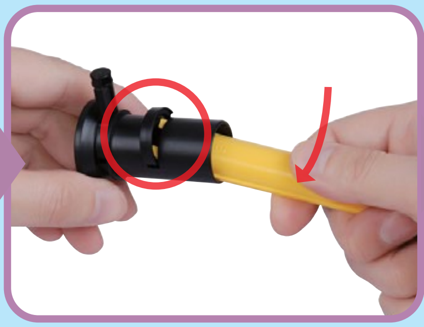
+40R Convex lens

-40R Concave lens

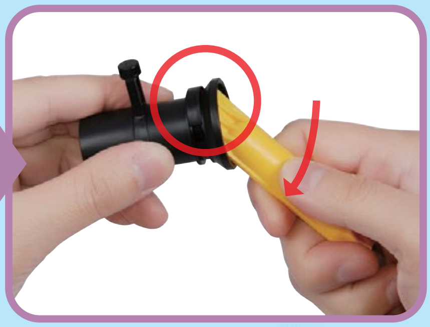
Removing the empty lens frame from the eyepiece tube



Insert the tool into the eyepiece tube.



Press the tool down. The empty lens frame will be pushed out. Remove it with your hand.



If the empty lens frame is at the other end, use the tool to remove the frame.

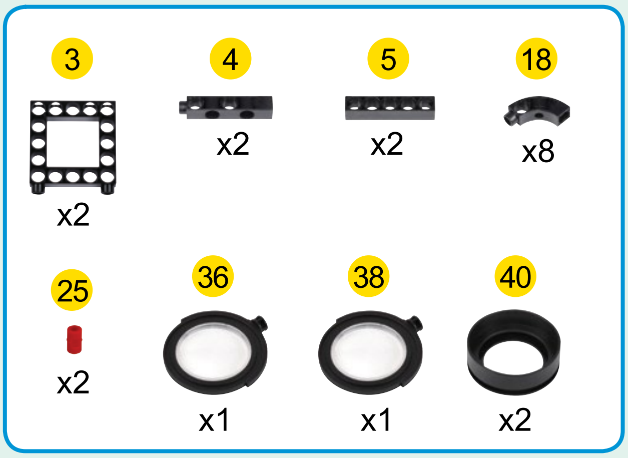
How to adjust the eyepiece tube

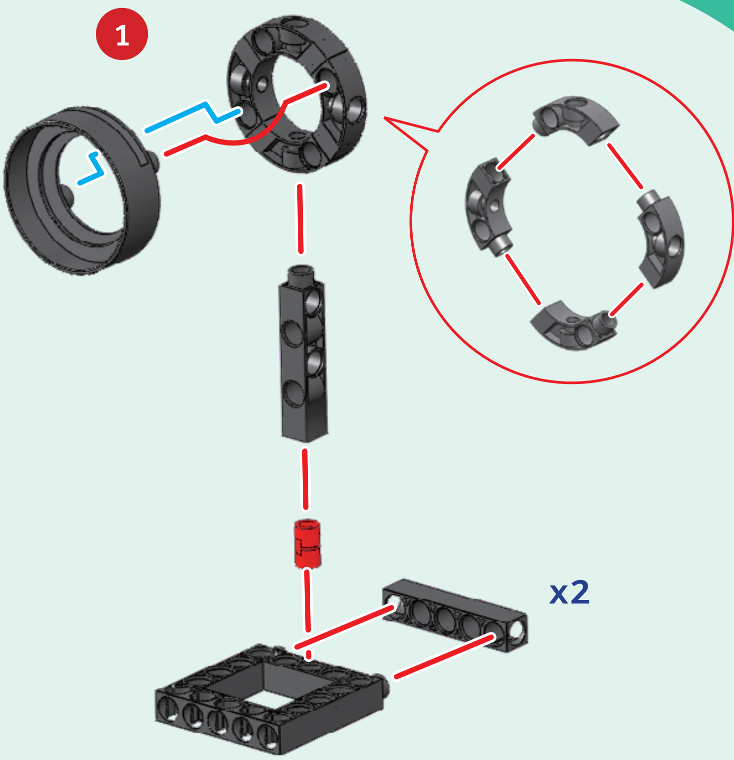
Slowly rotate the eyepiece tube to push it inward or slide it outward.

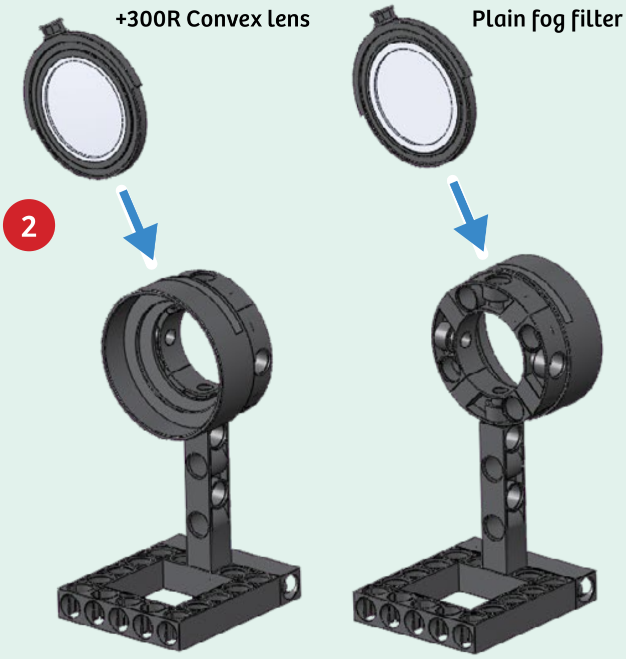
How Lenses Work

Lenses are optical devices that refract, or bend, light. Some lenses cause light rays to converge, or bend toward each other, and others cause light rays to diverge, or move away from each other. In this chapter, you will experiment with various lens configurations to learn how lenses work together to transform light and alter images.

EXPERIMENT 1



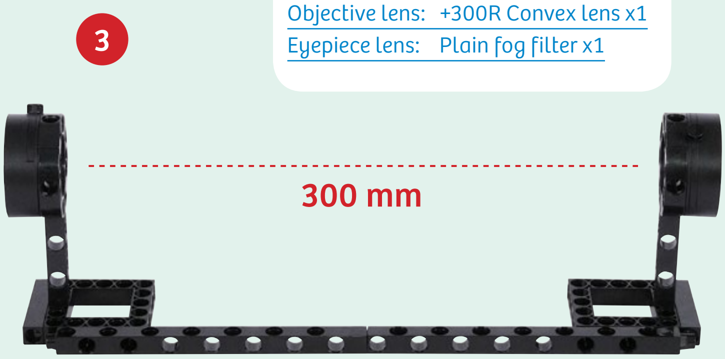




Lens system

Objective lens: +300R Convex lens x1

Eyepiece lens: Plain fog filter x1



Use a ruler or two rods to perfectly align your lenses.

Enlarging an image

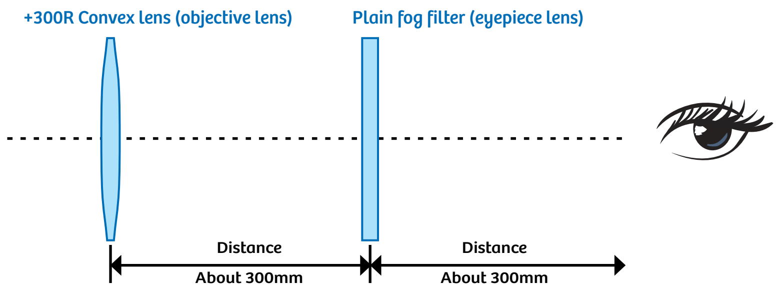
HERE'S HOW

1. Place the lenses 300 mm apart, facing towards a window as shown. Use a ruler or two rods to align the lenses perfectly.

3. Focus on an object outside the window. Move the fog lens slowly back and forth, and an image of the object will appear on the fog filter.

WHAT'S HAPPENING?

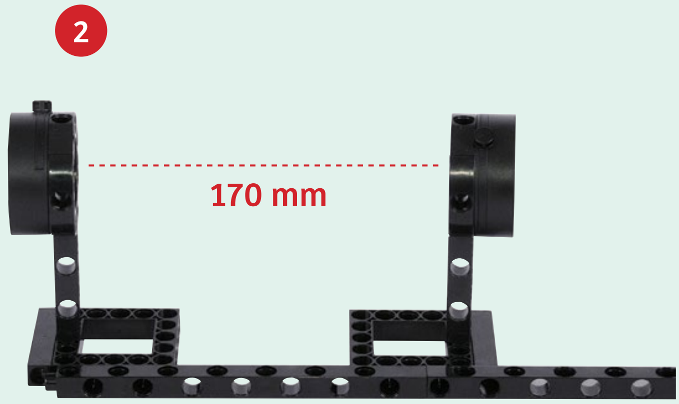
An image of the object you are viewing appears on the fog lens. The image appears inverted, or upside down. Changing the distance between the lenses will make the image more or less clear, or focused. Note the optimal distance between the lenses, and the size and brightness of the image. Now compare this to Experiment 2.



EXPERIMENT 2

Lens system

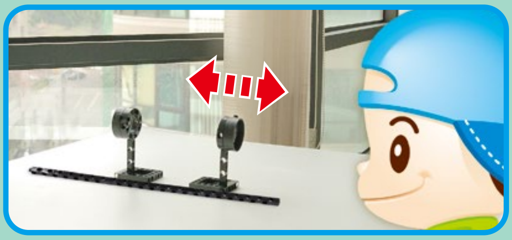
Objective lens: +170R Convex lens x1
Eyepiece lens: Plain fog filter x1



Smaller but crisper

HERE'S HOW

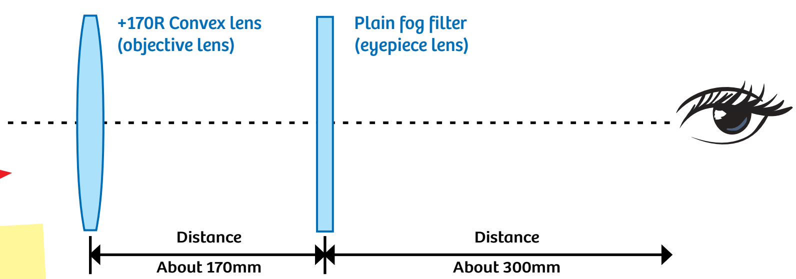
1. Starting with the setup from Experiment 1, replace the +300R Convex lens with the +170R Convex lens.
2. Position the lenses 170 mm apart and repeat the observation from Experiment 1, slowly moving the eyepiece lens back and forth until you see a clear image.



WHAT'S HAPPENING?

The image that appears on the fog lens is still inverted, but it is crisper and smaller than in Experiment 1. If you were to view an object that was closer to the objective lens than the first object you viewed, the distance between the objective lens and the eyepiece lens (fog lens) would need to be longer to keep the image of the object in focus. If you view an object that is further away, the distance between the objective and the eyepiece lenses needs to be shorter.

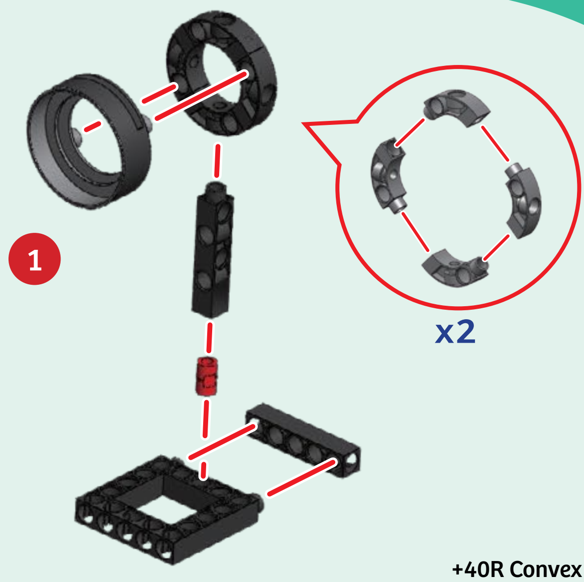
Note the differences between Experiment 1 and 2: the different distances between the lenses, and the difference in the size and brightness of the images on the fog filter.

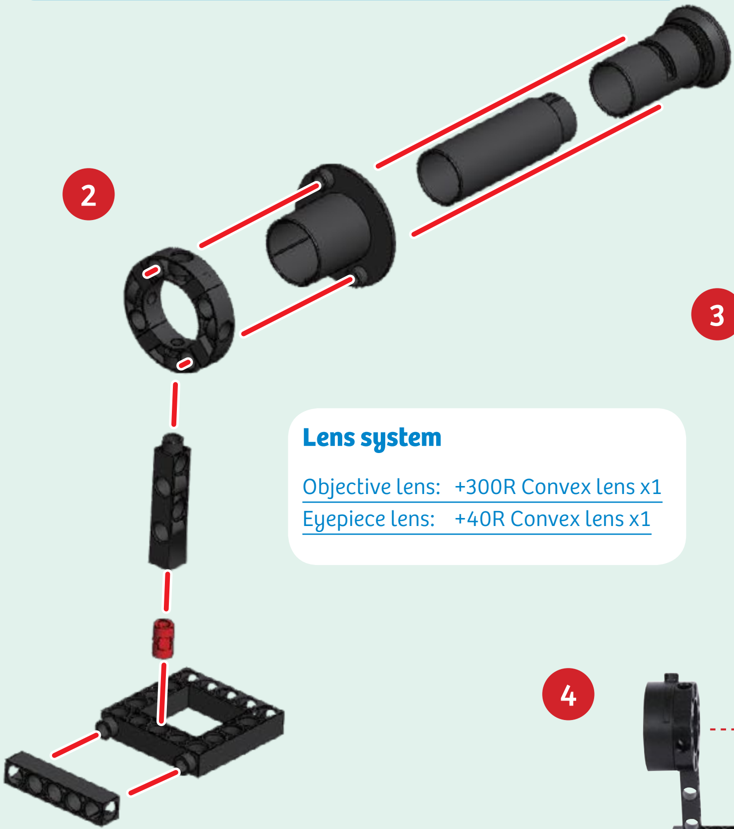


TIP!

These pictures after each experiment show a diagram of the lens setup or scope that was just constructed. They help you understand the path that light takes when it travels through the various lenses in a scope to your eye.

EXPERIMENT 3

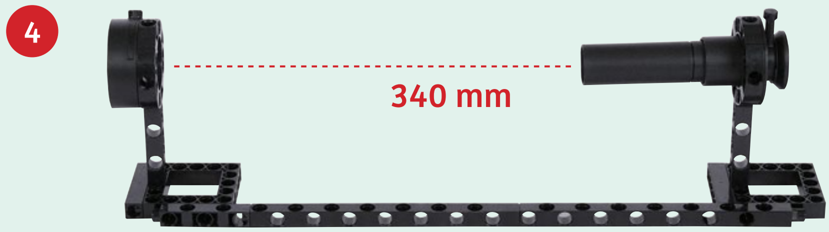




Lens system

Objective lens: +300R Convex lens x1

Eyepiece lens: +40R Convex lens x1



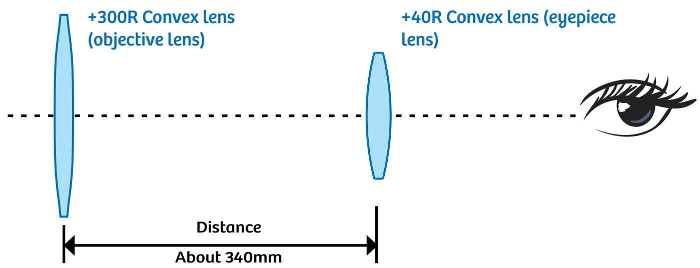
Inverted image

HERE'S HOW

1. Position the two lenses 340 mm apart and look through the eyepiece lens. Make small adjustments until you see a clear image.

WHAT'S HAPPENING?

This time, the image is upside down, or inverted. Note the distance between the two lenses, and the size and brightness of the image, and then try Experiment 4.



EXPERIMENT 4

1

Lens system

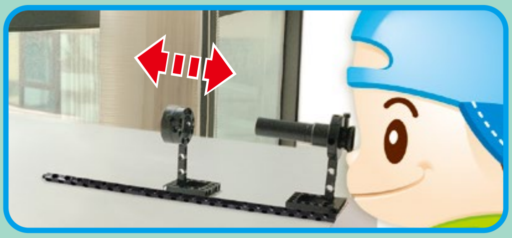
Objective lens: +170R Convex lens x1
Eyepiece lens: +40R Convex lens x1

2

Smaller but brighter

HERE'S HOW

1. Starting with the setup from Experiment 3, replace the +300R Convex lens with the +170R Convex lens.
2. Position the lenses 210 mm apart and repeat the observation from Experiment 3, slowly moving the eyepiece lens back and forth until you see a clear image.

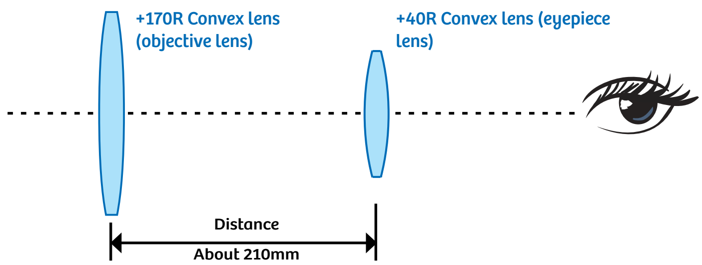


WHAT'S HAPPENING?

The image is still inverted, but it should appear smaller (less magnified) and brighter (easier to see).

When you change the distance between the lenses, the image will become more or less focused.

The farther away the object you are viewing, the closer the two lenses need to be relative to each other.



WHAT DO YOU SEE...

For each experiment in this chapter, ask yourself these questions:

1. What is the distance between the objective lens and the eyepiece lens for the clearest image?
2. What is the size of the image that can be seen clearly?
3. What is the brightness of the image that can be seen clearly?

EXPERIMENT 5

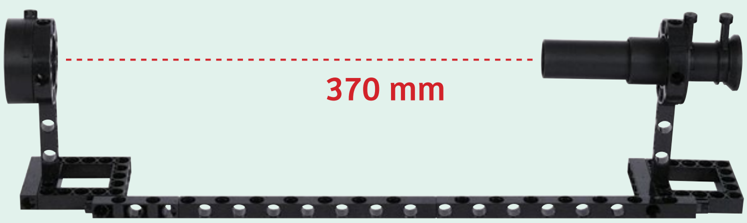
1

Lens system

Objective lens: +300R Convex lens x1

Eyepiece lens: +40R Convex lens x2

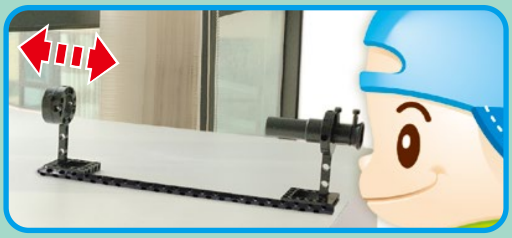
2



Adding another lens

HERE'S HOW

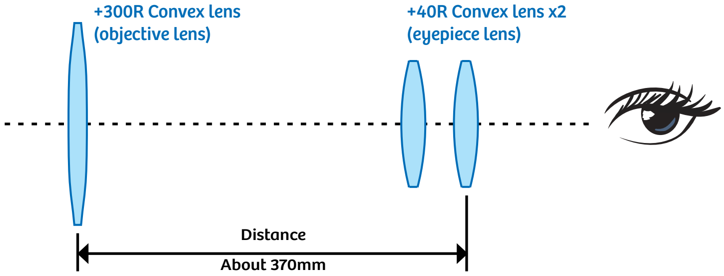
1. Starting with the setup from Experiment 4, replace the empty lens frame with a second +40R Convex lens, so that you have two +40R Convex lenses in the eyepiece tube. Also replace the +170R Convex lens with the +300R Convex lens.
2. Position the lenses 370 mm apart and repeat the observation from the previous experiments, slowly moving the eyepiece lens back and forth until you see a clear image.



WHAT'S HAPPENING?

It may take some time to adjust the lenses properly to see an image. The more lenses you add to your setup, the more you can magnify the image of the object you're looking at. However, the precision of the placement of each lens also becomes more critical.

Each lens must be in exactly the right place, or the image will be blurry or impossible to see. This is why it is important to build a frame for your scope, to hold your lenses perfectly in place and allow you to make slight adjustments to carefully refine the image.



EXPERIMENT 6

1

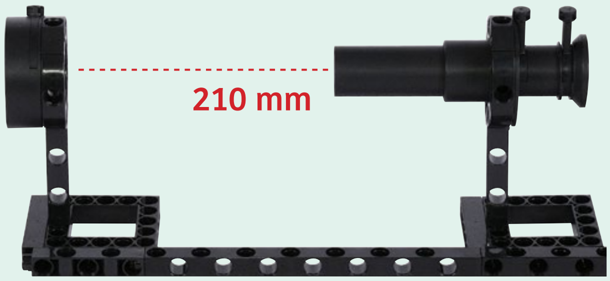
+170R Convex lens

+40R Convex lens x2

Lens system

Objective lens: +170R Convex lens x1
Eyepiece lens: +40R Convex lens x2

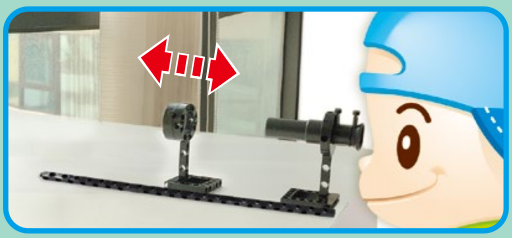
2



Smaller again

HERE'S HOW

1. Starting with the setup from Experiment 5, replace the +300R Convex lens with the +170R Convex lens. Keep the two +40R Convex lenses in place.
2. Position the lenses 210 mm apart and repeat the observation from the previous experiments, slowly moving the eyepiece lens back and forth until you see a clear image.

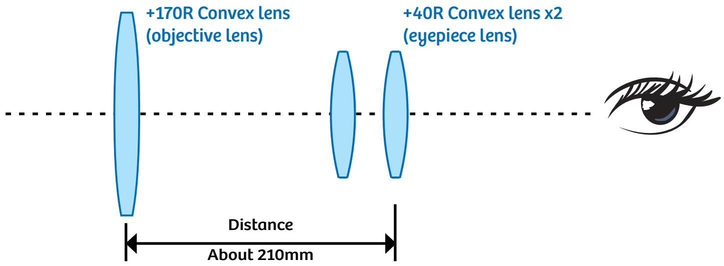


WHAT'S HAPPENING?

The image is still upside down, or inverted. The image is smaller (less magnified) than in Experiment 5, but the visual field is also wider. This means that you can see more of the object, but it is less magnified.

At this point, you should be starting to see how different combinations of lenses can be used to enlarge images in different ways for different purposes.

But what about the fact that the images have been upside down in each of the experiments so far? Is there a way to make them appear right-side up?



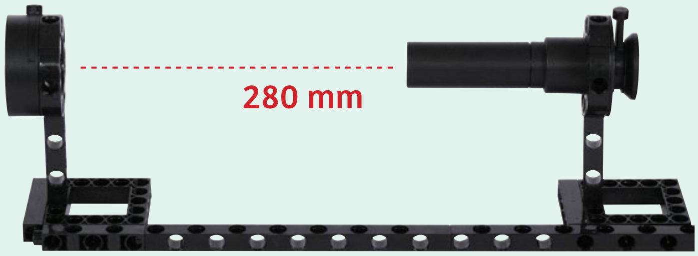
EXPERIMENT 7

1

Lens system

Objective lens: +300R Convex lens x1
Eyepiece lens: -40R Concave lens x1

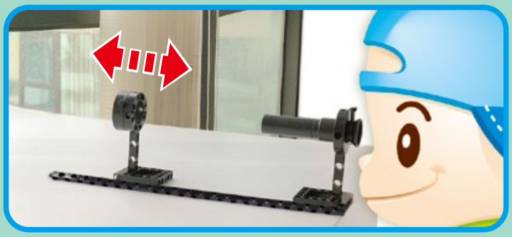
2



Flipping the image

HERE'S HOW

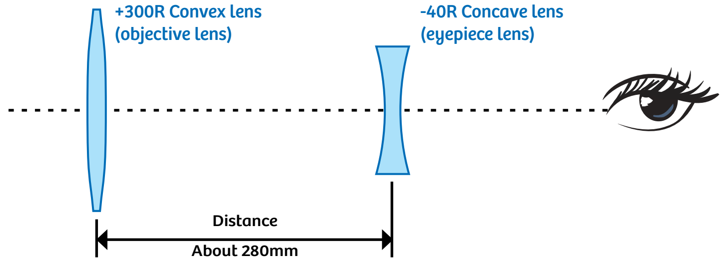
1. Starting with the setup from Experiment 6, replace the +170R Convex lens with the +300R Convex lens. Also replace the two +40R Convex lenses with a -40R Concave lens and an empty lens frame.
2. Position the lenses 280 mm apart and repeat the observation from the previous experiments, slowly moving the eyepiece lens back and forth until you see a clear image.



WHAT'S HAPPENING?

The image is right-side up! The concave lens works with the convex lens to make an upright image appear. However, you will also notice that the image is smaller (not as magnified) and also blurrier, especially around the edges of the visual field, than it was previously.

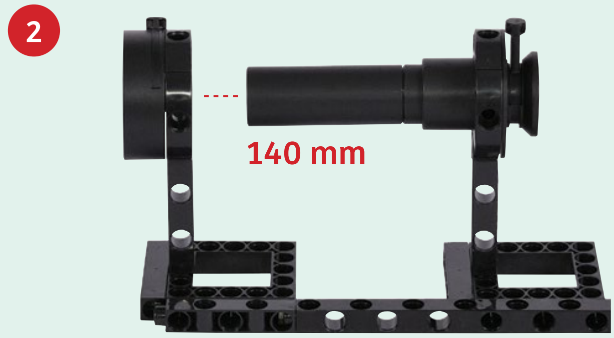
Telescopes using a combination of concave and convex lenses like this are therefore better suited for viewing objects on the surface of Earth, rather than in space. Spotting scopes and field telescopes often use lenses in this way.



EXPERIMENT 8

Lens system

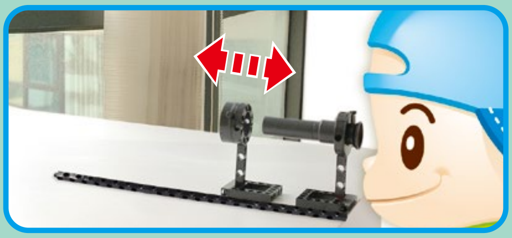
Objective lens: +170R Convex lens x1
Eyepiece lens: -40R Concave lens x1



Smaller upright image

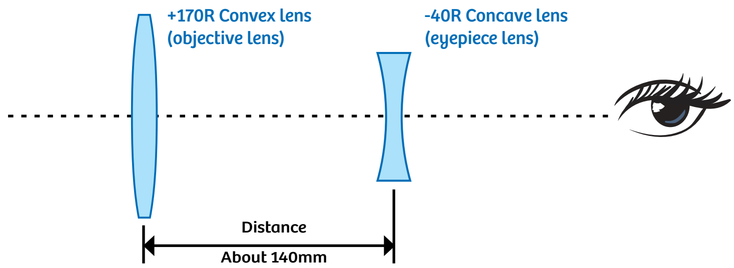
HERE'S HOW

1. Starting with the setup from Experiment 7, replace the +300R Convex lens with the +170R Convex lens.
2. Position the lenses 140 mm apart and repeat the observation from the previous experiments, slowly moving the eyepiece lens back and forth until you see a clear image.

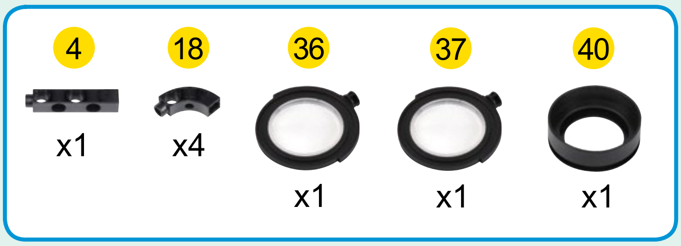


WHAT'S HAPPENING?

The image is still upright as in the previous experiment, but it is less magnified. Therefore, you can see more of the object in the visual field. You will probably notice the image is a little brighter and easier to focus than in the previous experiment.

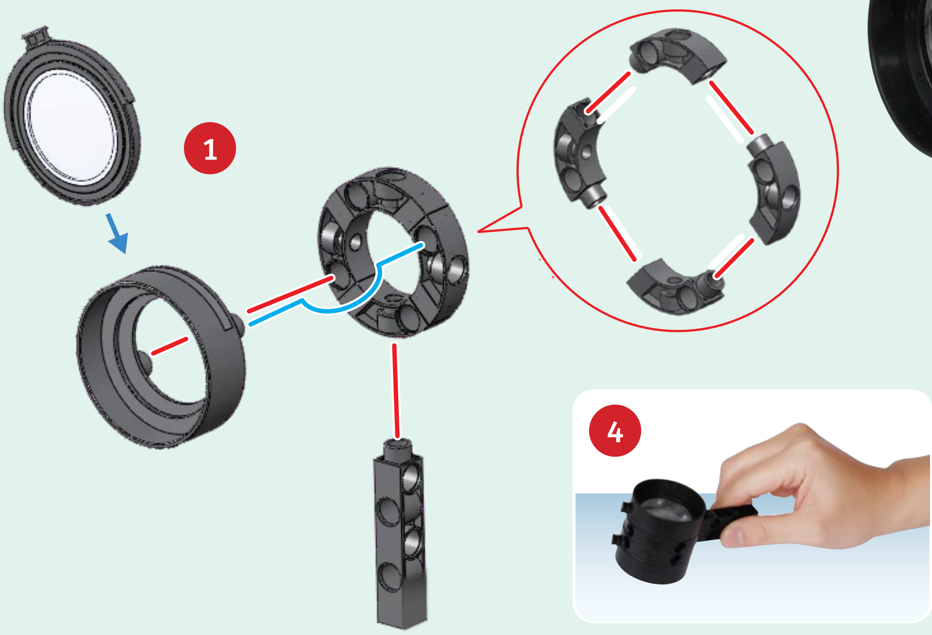


EXPERIMENTS 9 – 11



Lens system

Objective lens: +300R Convex lens x1



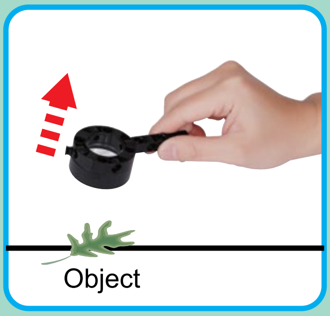
Lens system

Objective lens: +170R Convex lens x1

Magnifying glass

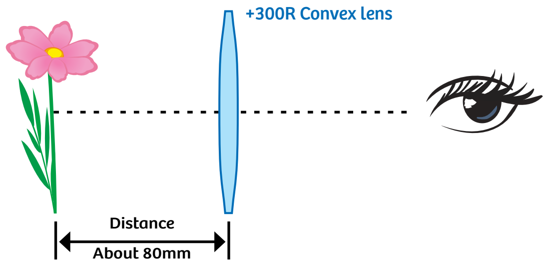
HERE'S HOW

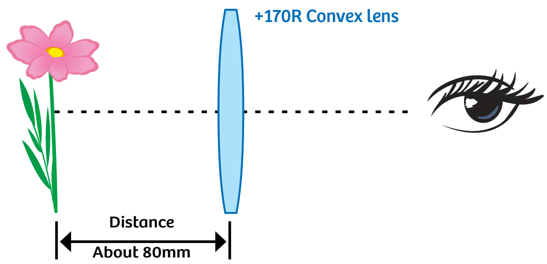
1. Start with the +300R Convex lens. Hold the magnifying glass in your hand, positioned about 80 mm above an object.
2. Slowly move the magnifying glass away from the object until the object becomes clear through the lens.
3. Replace the +300R Convex lens with the +170R Convex lens and repeat the observation for the second experiment.
4. Now try both lenses together for the third experiment.



WHAT'S HAPPENING?

The magnifying glass makes the object appear larger. The object appears right-side up. The image is bigger with the +170R Convex lens, and biggest with the two lenses on top of each other. So, you see how lenses can work together to magnify images more.

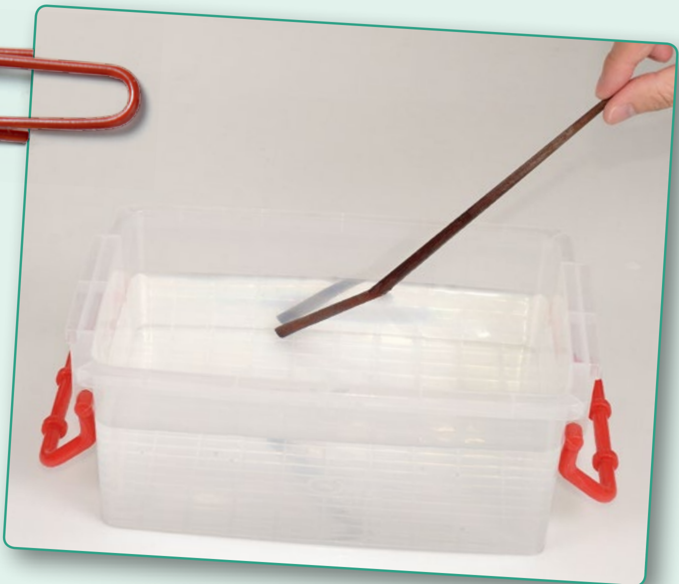




CHECK IT OUT

Light

Light rays travel in a straight line through empty space, and more or less in a straight line through the air. They can travel very long distances and reach remote places. Because of this principle, we can clearly see stars that are far away in outer space. Using objects such as a lens makes it possible to bend a ray of light. A straw appears to be bent in a glass of water because the water has bent the ray of light, not the straw. Technologies that use prismatic lenses and optical fibers to bend light for various purposes are invaluable in the modern world.



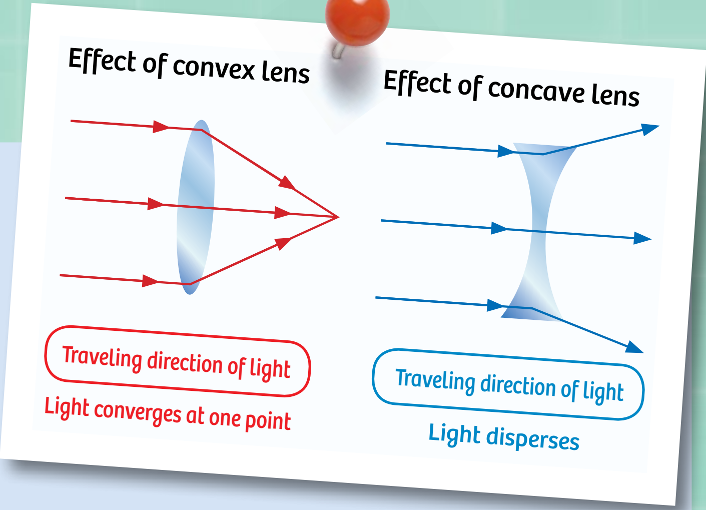
The part of the straw in the water appears to be bent.

HISTORY OF THE LENS

The existence of the lens for controlling light dates back thousands of years. Early lenses were made of crystal or other transparent minerals. One of the lens' early functions was to allow decorative ornaments to glow to enhance their beauty. Later on, glass lenses were invented and made into eyeglasses for people to wear. The type of material used for such lens nowadays is acrylic. Plastic lenses made of acrylic started being used less than 80 years ago. Since acrylic plastic is easy to make, lightweight, and convenient to use, it has replaced glass in the manufacturing of eyeglasses and camera lenses.

CHECK IT OUT

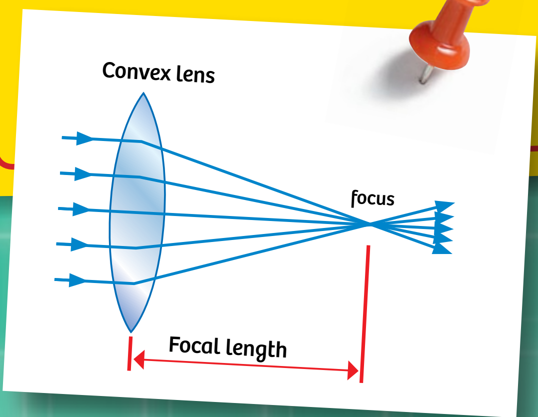
Lenses



Lenses bend rays of light. They can generally be divided into two types: convex lenses and concave lenses. A convex lens causes straight rays of light to converge, while a concave lens causes straight rays of light to diverge. By using these two types of lenses, it is possible to produce various optical devices and effects. Everyday applications for lenses include cameras, eyeglasses, telescopes, microscopes, CD players, photocopiers, and car headlights.

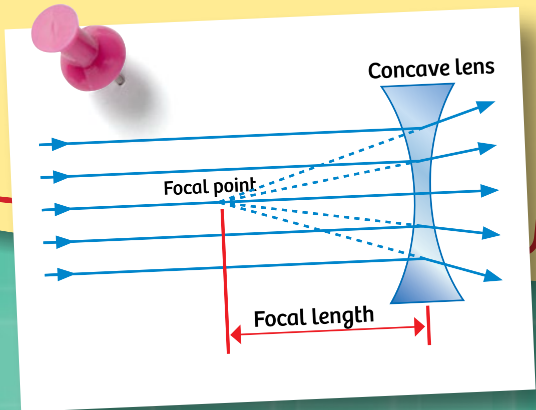
CONVEX LENS FOCUSING

Convex lenses are able to collect straight rays of light at a **focal point**. Collecting the rays of light is called focusing. The distance from the lens to the focal point is called the **focal length**. Placing a screen at the focal point allows you to project the image there. Placing film or an imaging sensor at the same place will make a camera.



CONCAVE LENS FOCUSING

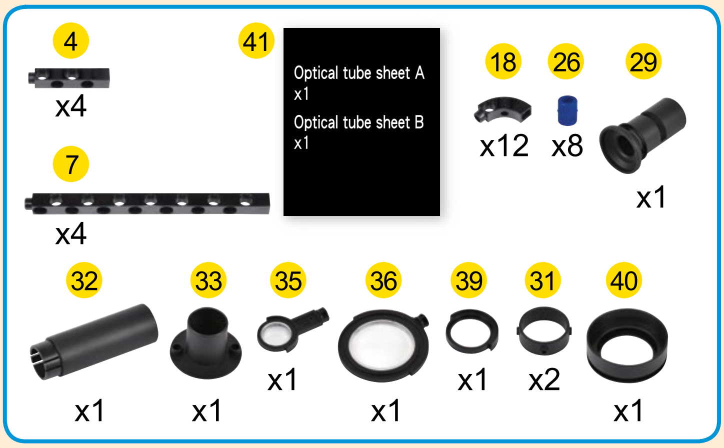
Concave lenses disperse straight rays of light. Therefore, they are used to make light rays more out of focus. As indicated by the illustration, the rays of light extend in the opposite direction to the focal point.



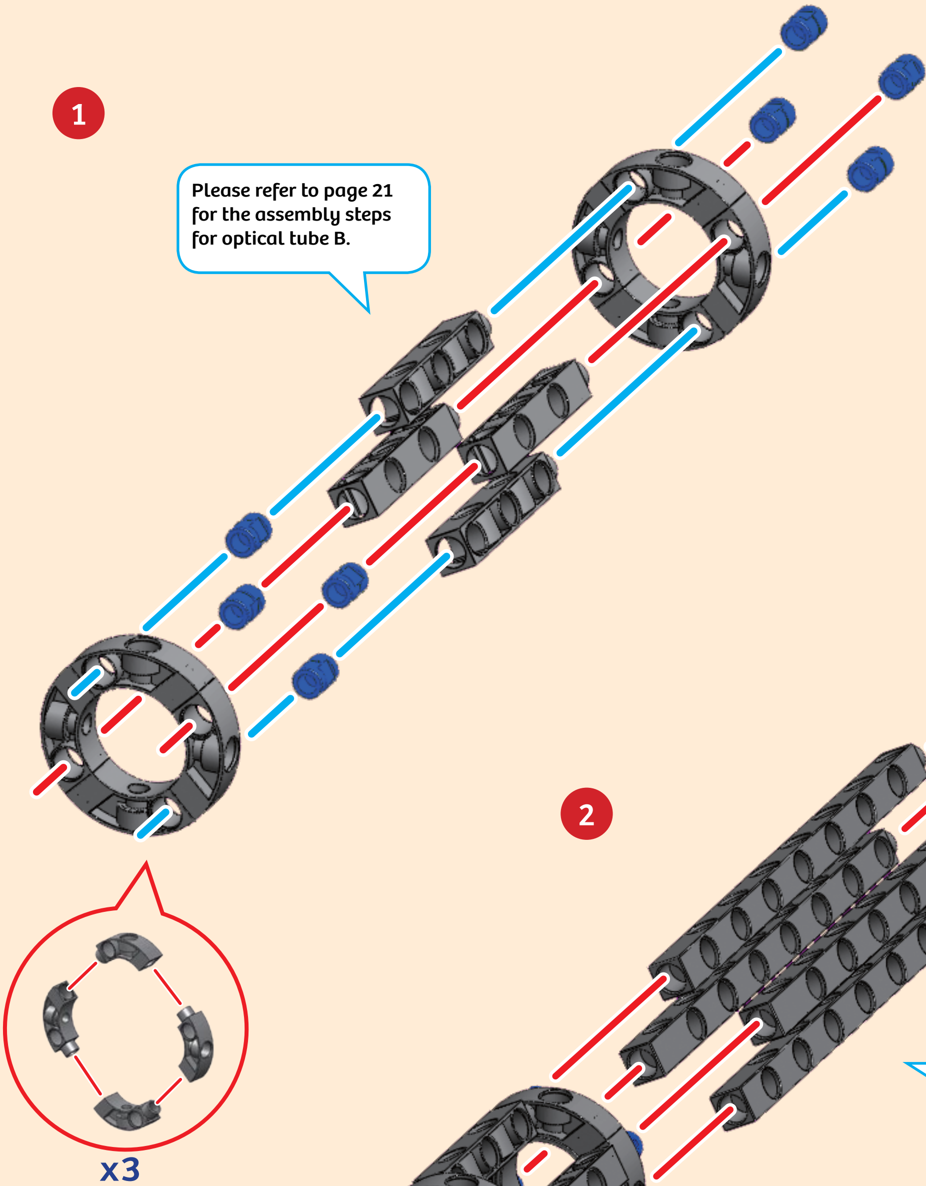
Spotting Scopes and Binoculars

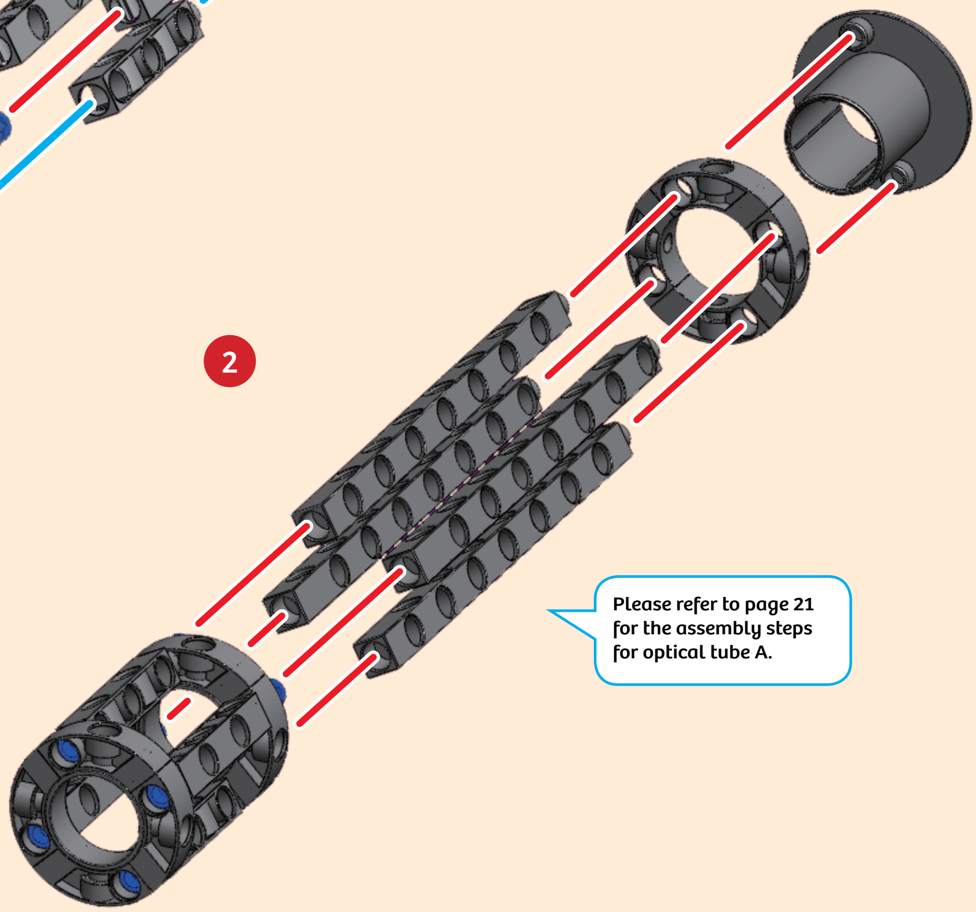
Spotting scopes, field telescopes, and binoculars are optical telescopes that are used mainly for viewing objects on Earth, such as ships on the ocean, animals on a safari, or birds on a bird-watching expedition. These scopes don't invert images like some astronomical telescopes, but they are also less powerful. Binoculars have two optical tubes instead of just one.

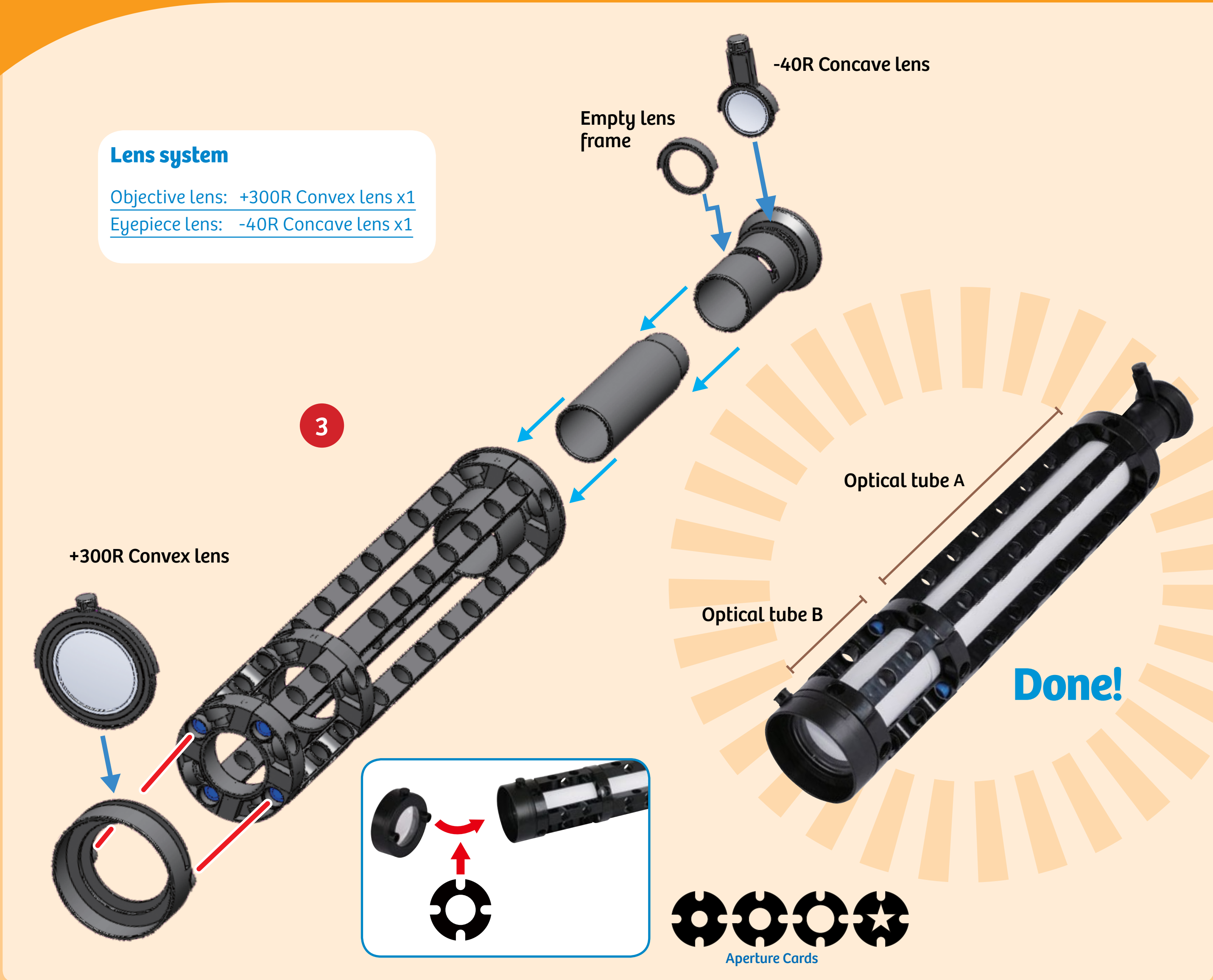
EXPERIMENT 12



Handheld 8x Long Field Telescope



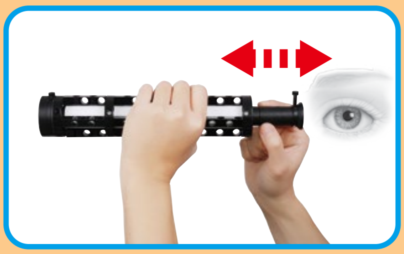




Experiment 12

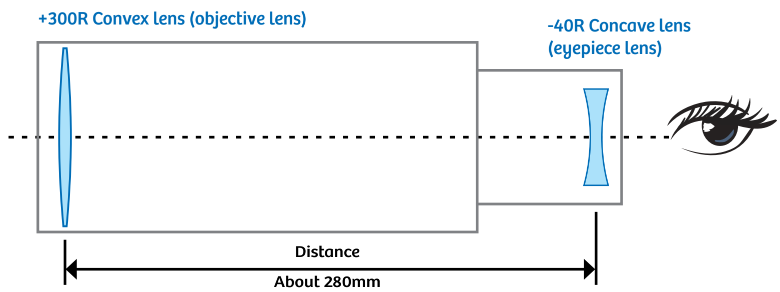
HERE'S HOW

1. Hold the -40R Concave lens tube close to your eye. Hold the eyepiece tube with your right hand.
2. Slowly move the tube back and forth with your left hand. A clear image will appear.
3. Now insert one of the aperture cards into the telescope and observe its effect.



WHAT'S HAPPENING?

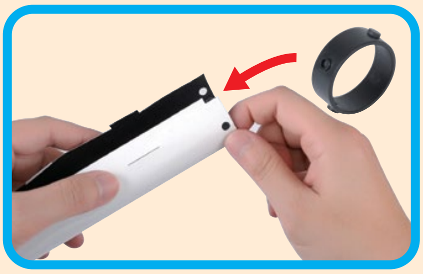
This is a Galilean telescope. This means a convex lens is used as an objective lens and a concave lens is used as an eyepiece. It was invented in 1609 by Galileo Galilei. Its main advantage is that it produces an upright image, but its main disadvantage is that its field of vision gets smaller with increased power. The lens tube is used for the first time in this experiment. It blocks out light and makes it easier to keep the lenses in the right places. The closer the object being viewed, the longer the tube needs to be. When the aperture is added, it does not reduce the visual field. Although it becomes darker, only the center of the lens is used, so it creates a very clear image.



ASSEMBLY TIPS

Optical Tube A

You will need this optical tube for Experiments 12 and 13.

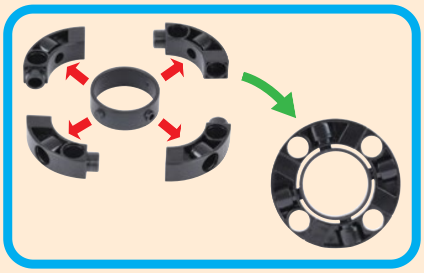


1. Roll the optical sheet A into a tube with the tube ring (Part 31) at the end of the tube.

2. Insert the four pegs on the tube ring into the holes in the optical tube.

3. Fix the optical tube in place starting with two bent rods (Part 18).

4. Use two more bent rods (Part 18) to finish fixing the tube in place.



5. Make sure the four pegs on the tube ring are completely inserted into the four holes in the bent rods.

6. Insert the tube into the model you are building and complete it.

Optical Tube B

You will need this optical tube for Experiments 12, 13, 14, 15, 23, and 24.

1. Roll the optical sheet B into a tube with the tube ring (Part 31) at the end of the tube.

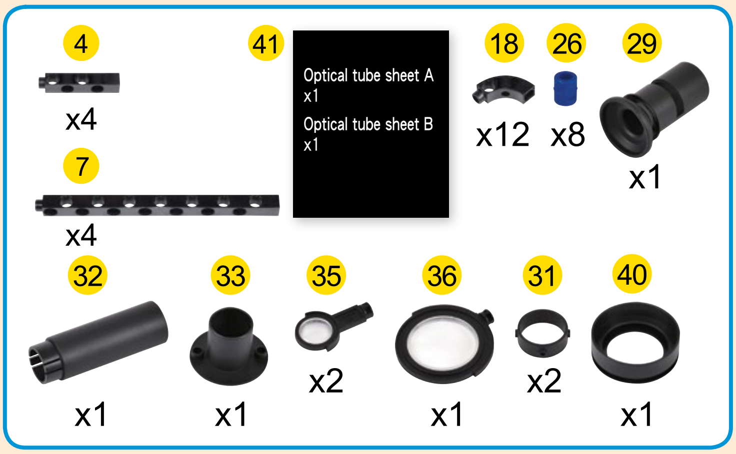
2. Insert the four pegs on the tube ring into the holes in the optical tube.

3. Fix the optical tube in place starting with two bent rods (Part 18).

4. Use two more bent rods (Part 18) to finish fixing the tube in place.

5. Insert the tube into the model you are building.

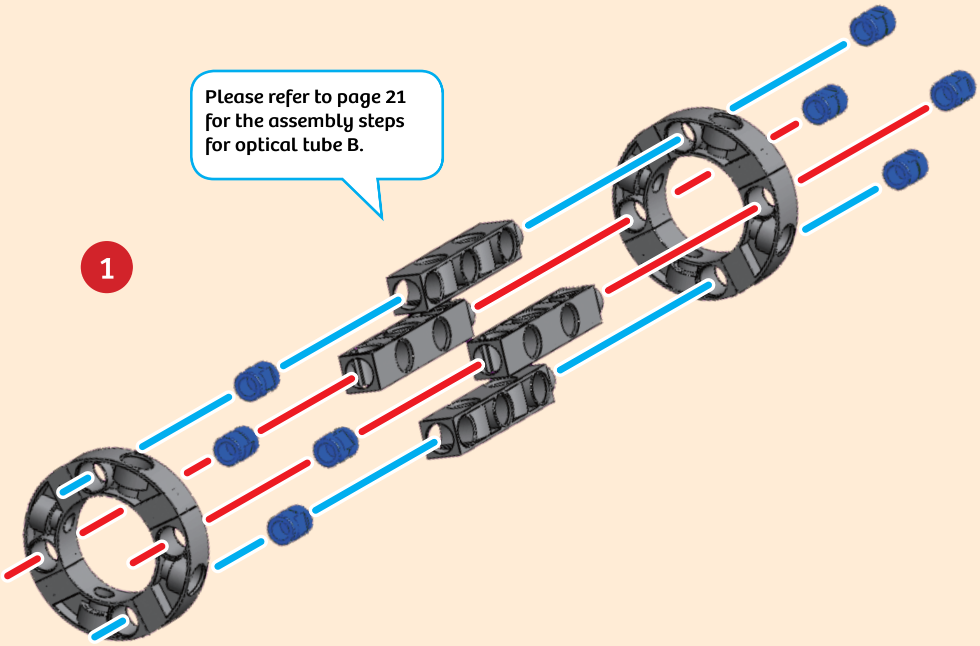
6. Complete the assembly.

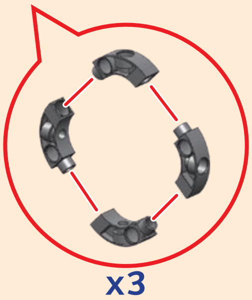


Handheld 15x Field Telescope

Please refer to page 21 for the assembly steps for optical tube B.

1





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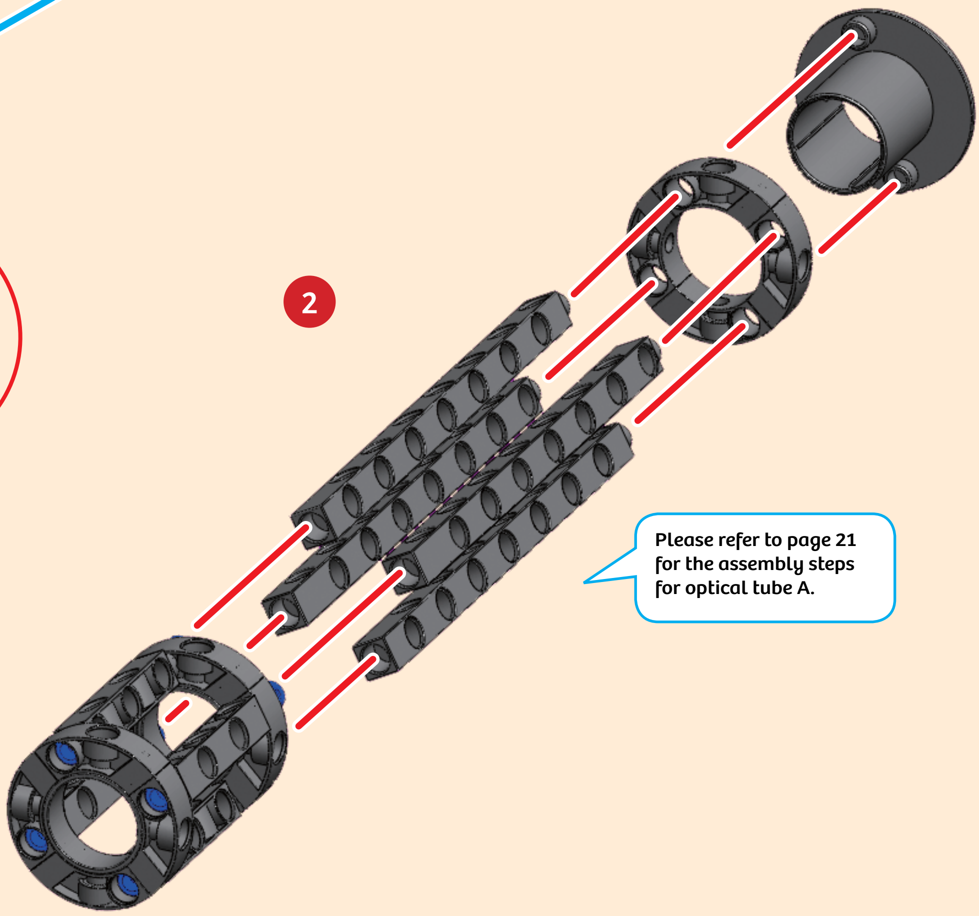
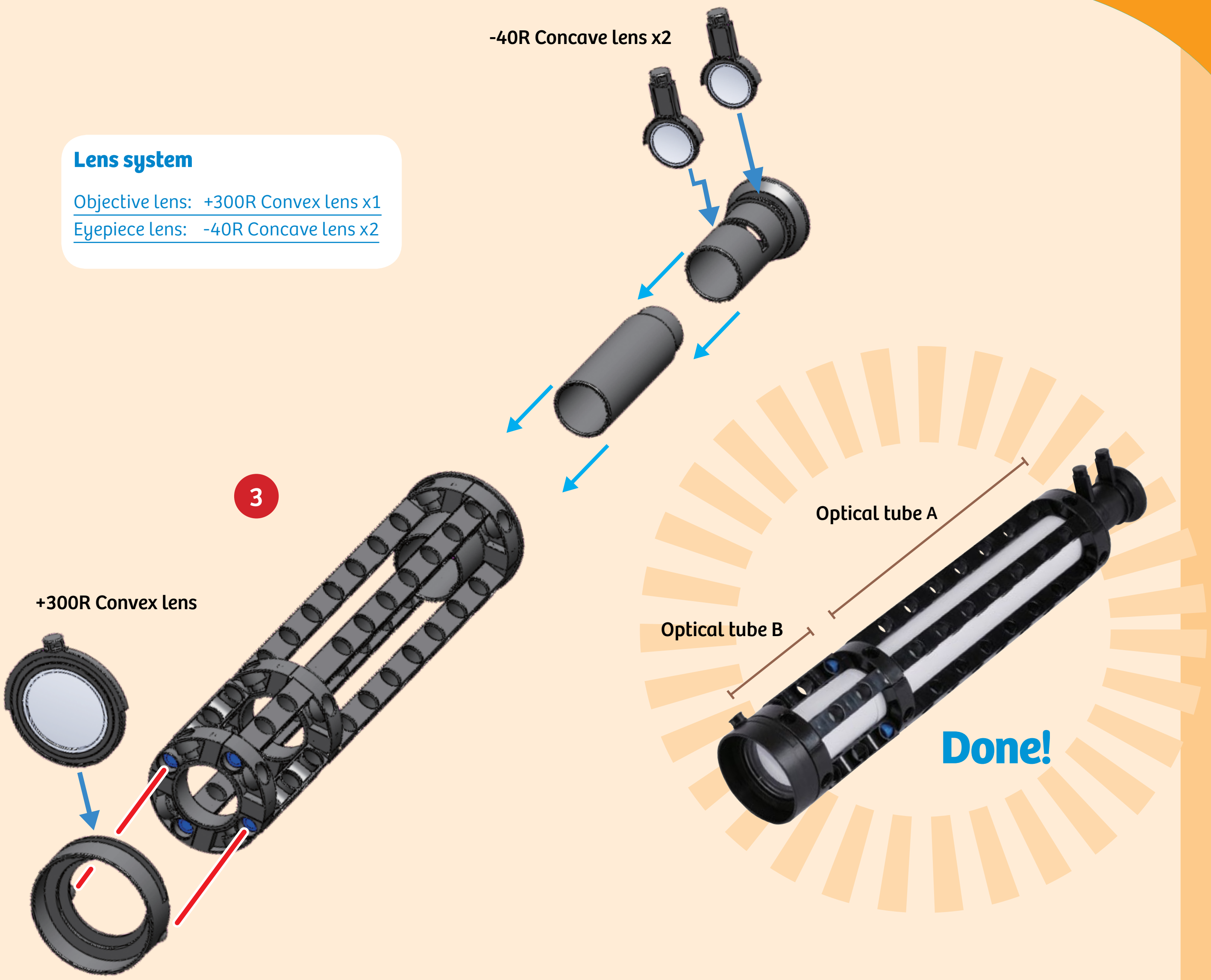


Please refer to page 21 for the assembly steps for optical tube A.

Lens system

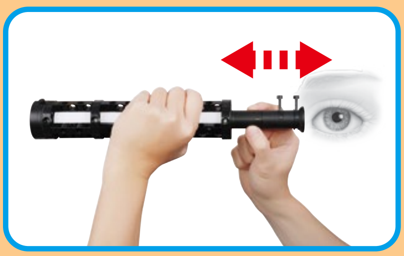
Objective lens: +300R Convex lens x1
Eyepiece lens: -40R Concave lens x2



Experiment 13

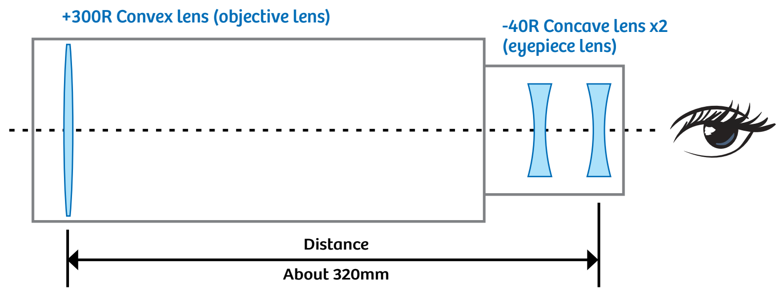
HERE'S HOW

1. Hold the -40R Concave lens tube close to your eye. Hold the eyepiece tube with your right hand.
2. Slowly move the tube back and forth with your left hand. A clear image will appear.
3. Now insert one of the aperture cards into the telescope and observe its effect.



WHAT'S HAPPENING?

Adding a second -40R Concave lens in the eyepiece tube increases the magnifying power of the scope by almost two times. The image viewed with this scope is magnified more than the one in Experiment 12, but the size of the visual field is smaller. Because of its smaller visual field, it is more difficult to hold the scope steady enough to focus on an object.

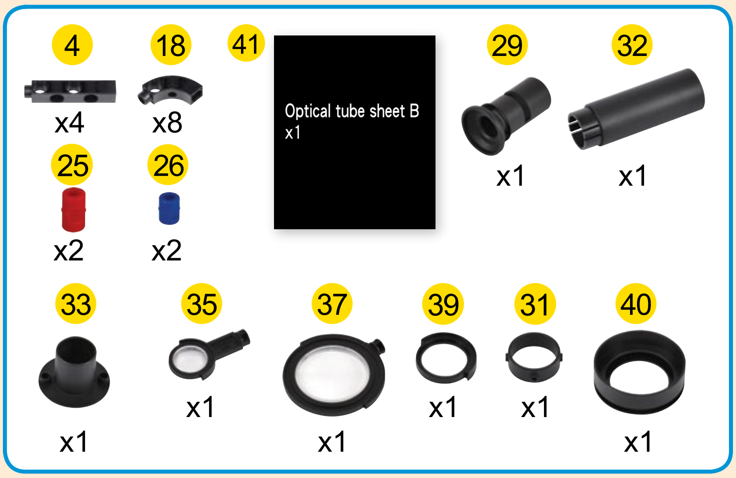


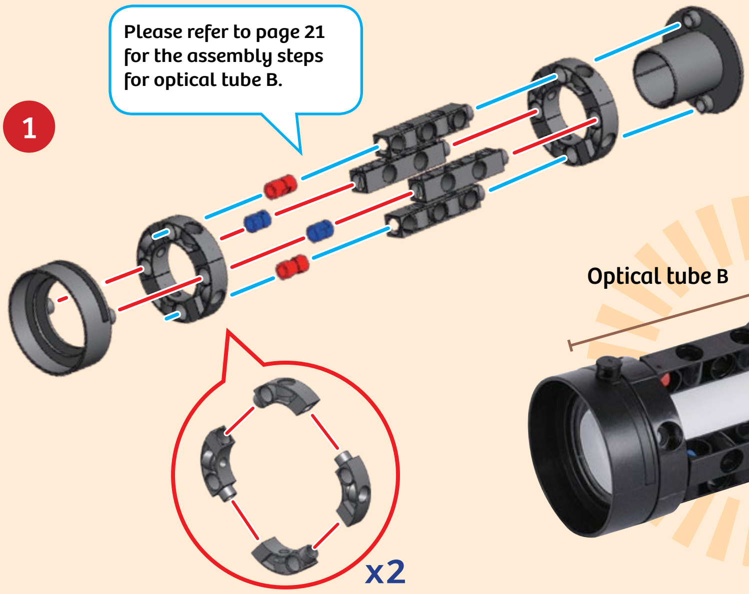
EXPERIMENT 14

Handheld 4x Field Telescope

Lens system

Objective lens: +170R Convex lens x1
Eyepiece lens: -40R Concave lens x1

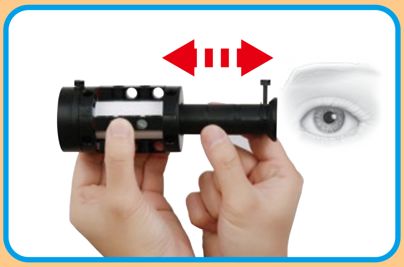




Experiment 14

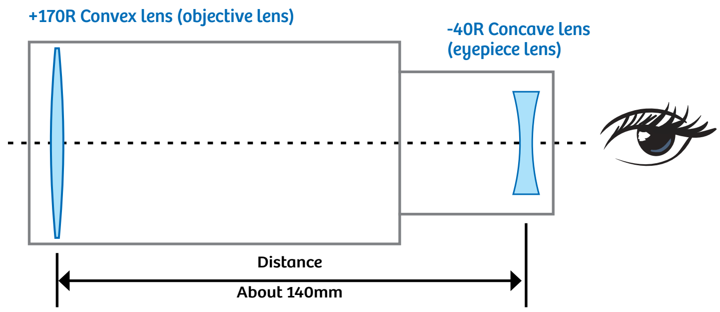
HERE'S HOW

1. Hold the -40R Concave lens tube close to your eye. Hold the eyepiece tube with your right hand.
2. Slowly move the tube back and forth with your left hand. A clear image will appear.
3. Now insert one of the aperture cards into the telescope and observe its effect.

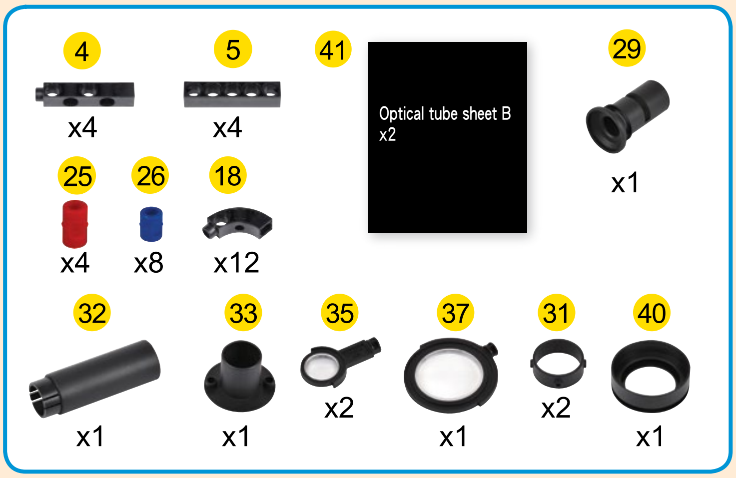


WHAT'S HAPPENING?

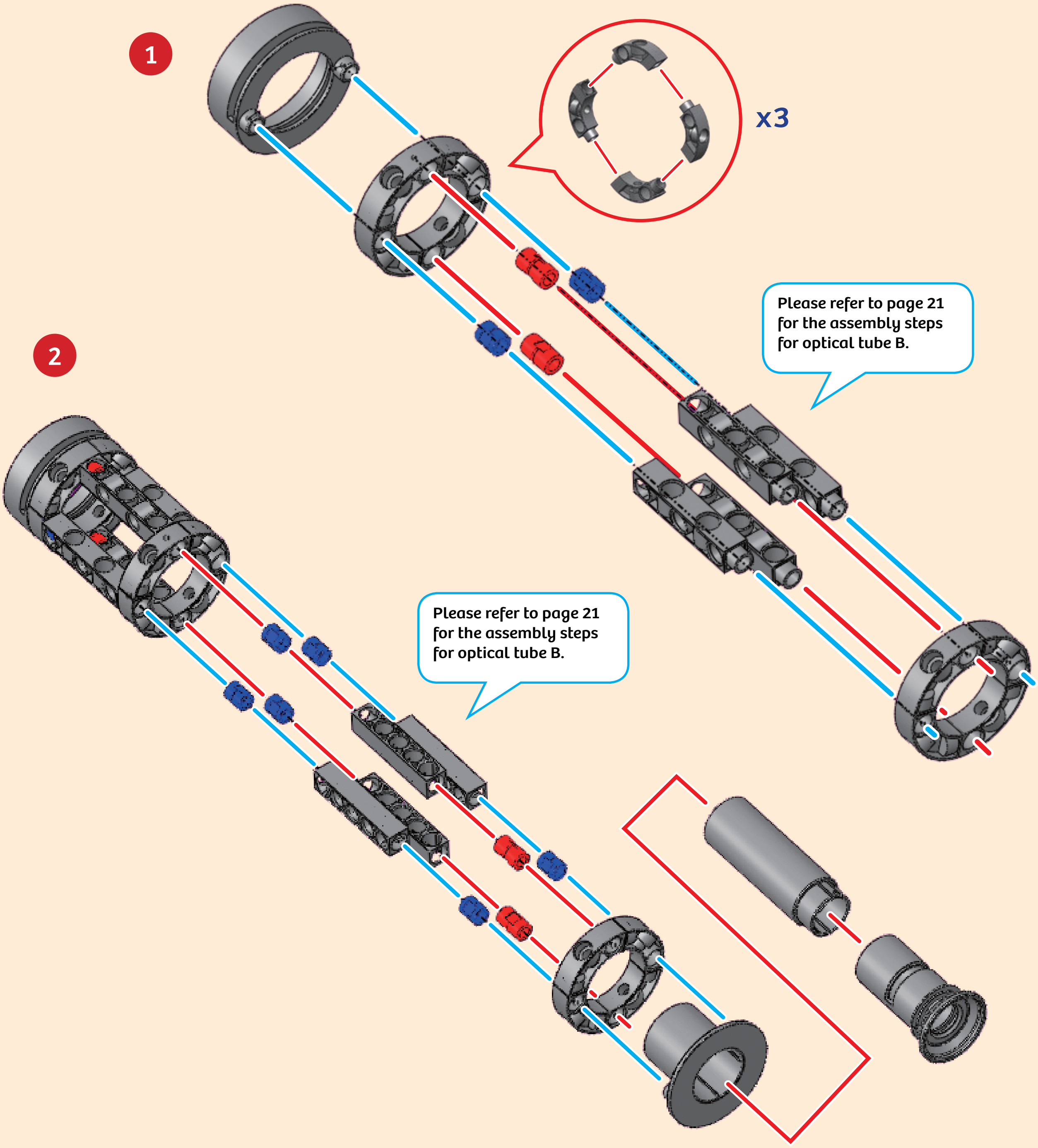
Because of its lower power and larger visual field, it's easier to keep objects in this scope's visual field. Plus, it has a shorter lens tube, making it more portable.

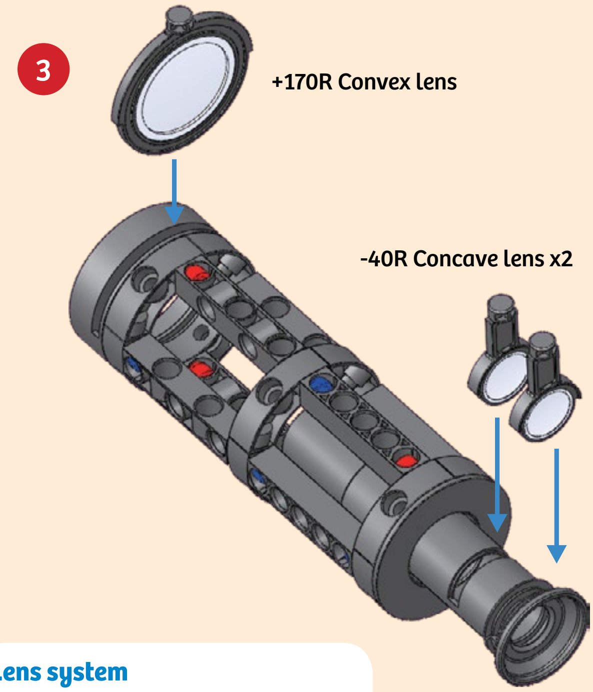


EXPERIMENT 15



Handheld 8x Short Field Telescope





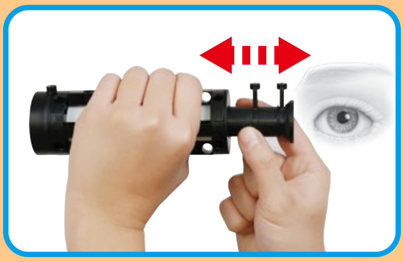
Lens system

Objective lens:	+170R Convex lens x1
Eyepiece lens:	-40R Concave lens x2

Experiment 15

HERE'S HOW

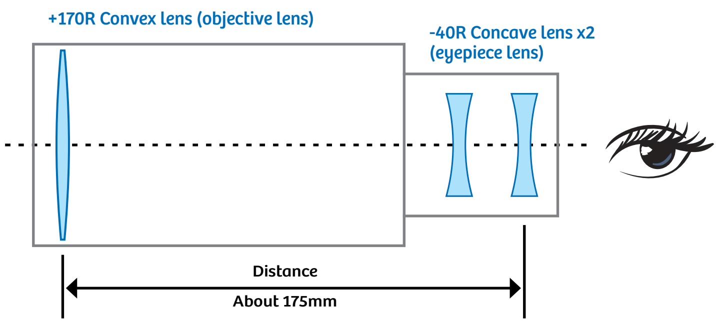
1. Hold the -40R Concave lens tube close to your eye. Hold the eyepiece tube with your right hand.
2. Slowly move the tube back and forth with your left hand. A clear image will appear.
3. Now insert one of the aperture cards into the telescope and observe its effect.



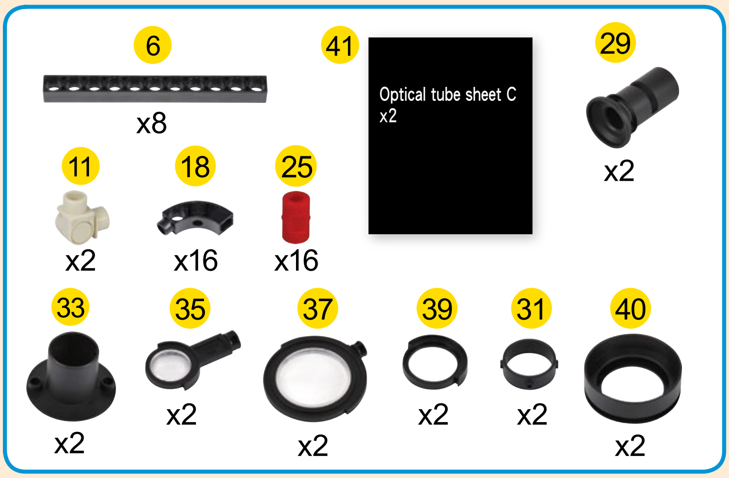
WHAT'S HAPPENING?

Adding a second -40R Concave lens in the eyepiece tube increases the magnifying power of the scope by almost two times. The image viewed with this scope is magnified more than the one in Experiment 14, but the size of the visual field is smaller. Because of its smaller visual field, it is more difficult to hold the scope steady enough to focus on an object.

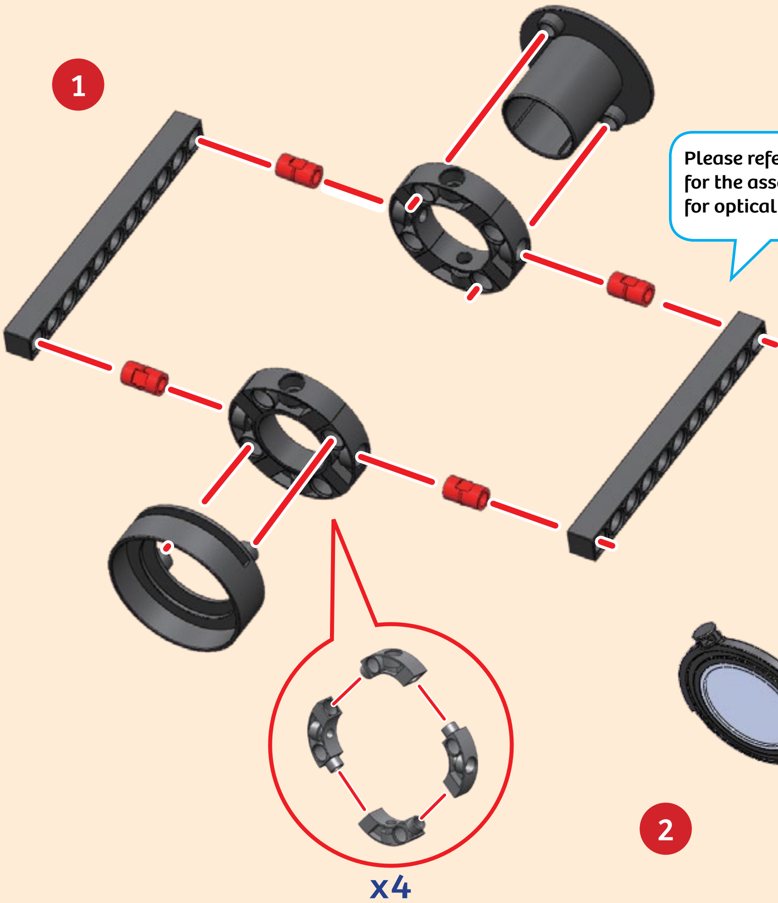
How does this scope compare to the scope in Experiment 13?



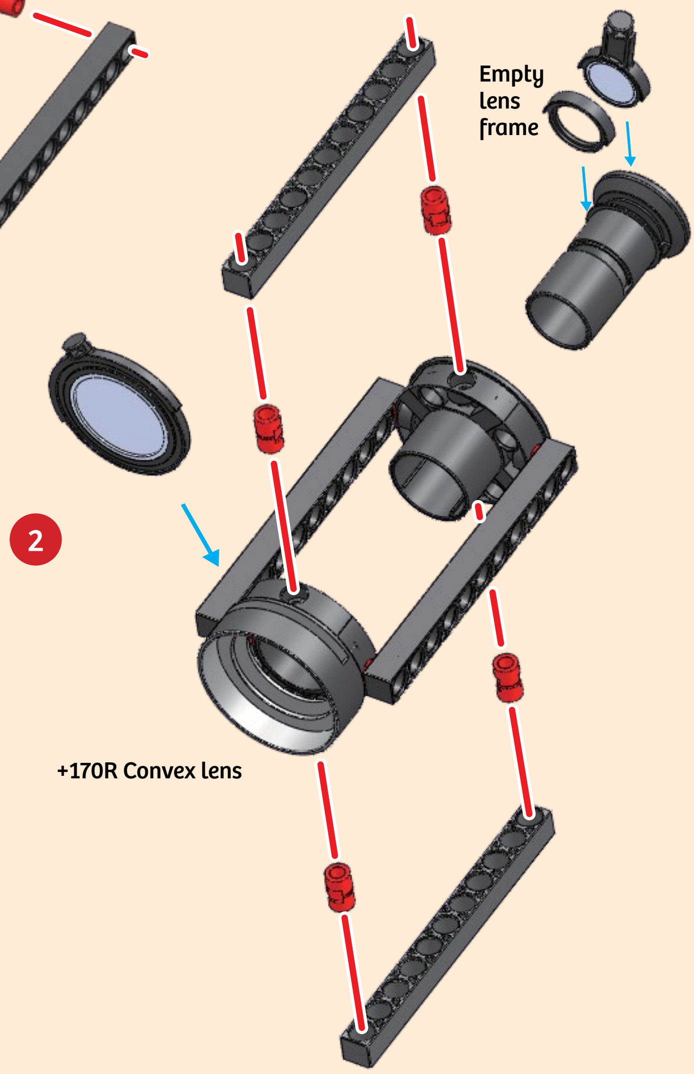
EXPERIMENT 16

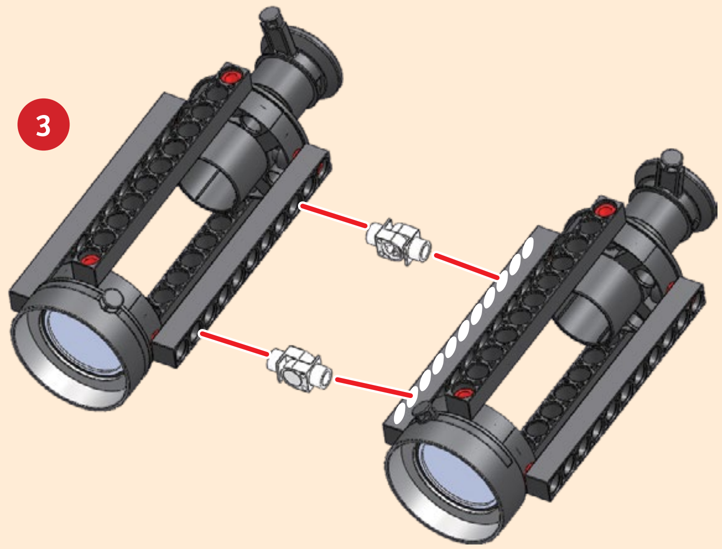


Binoculars 4x



Please refer to page 29 for the assembly steps for optical tube C.





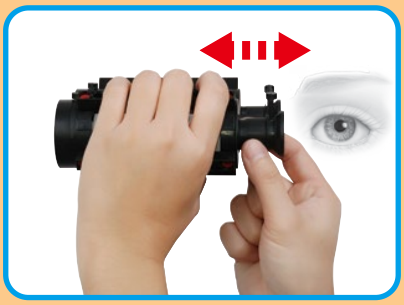
Lens system

Objective lens: +170R Convex lens x2
Eyepiece lens: -40R Concave lens x2

Experiment 16

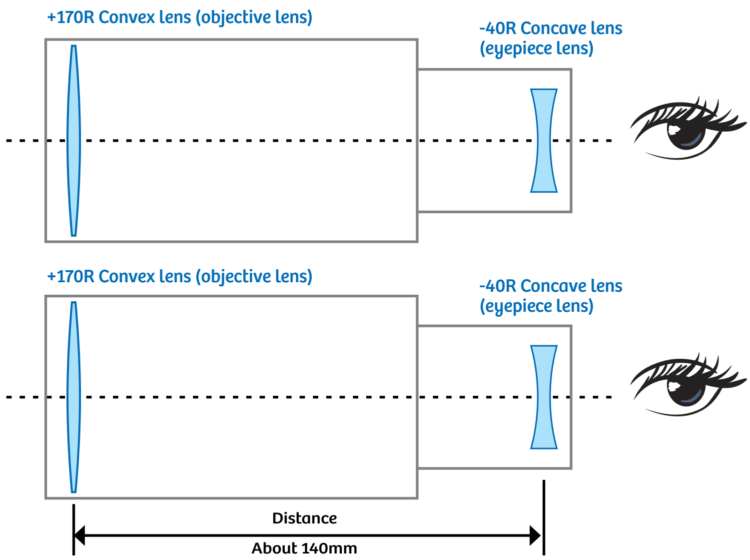
HERE'S HOW

1. Hold the -40R Concave lens tubes close to your eyes.
2. Slowly move the tubes back and forth with your hand, one at a time. A clear image will appear.
3. To properly adjust the focus of the left and right sides, it is necessary to adjust one eye at a time. Block off one lens, adjust the other side so you see a clear image, and then follow the same procedure for the other side.



WHAT'S HAPPENING?

A pair of binoculars is made of two telescopes — one for each eye. It shows an upright image, and because both eyes are used, it also gives the image a sense of depth. Because of the large amount of light it takes in, it is also useful in astronomical observations. Proper adjustment will reduce fatigue to the eyes while observing. Therefore binoculars are good for observing over long periods of time. It is necessary to make proper adjustments to the distance between both eyes and the focus for both sides.



●●○ ASSEMBLY TIPS

Optical Tube C

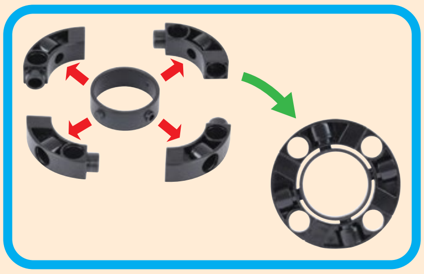
You will need this optical tube for Experiments 16–22 and 25–28.

1. Roll the optical sheet C into a tube with the tube ring (Part 31) at the end of the tube.

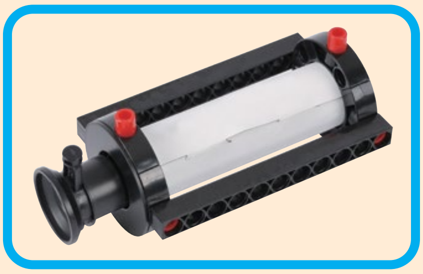
2. Insert the four pegs on the tube ring into the holes in the optical tube.

3. Fix the optical tube in place starting with two bent rods (Part 18).

4. Use two more bent rods (Part 18) to finish fixing the tube in place.



5. Make sure the four pegs on the tube ring are completely inserted into the four holes in the bent rods.

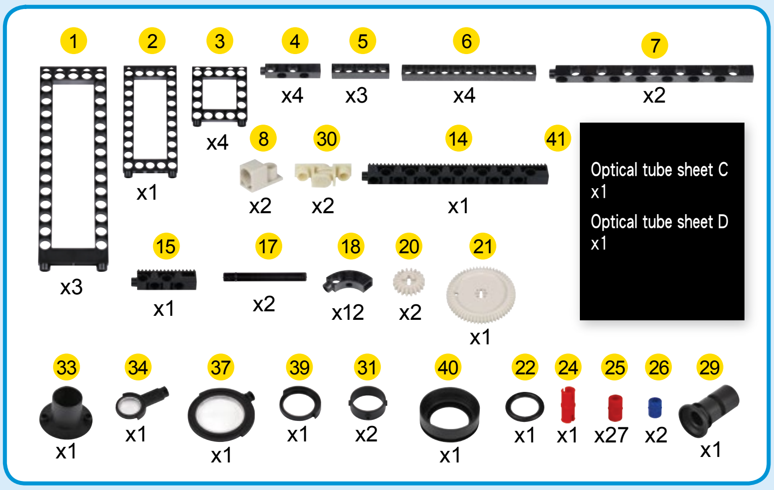


6. Insert the tube into the model you are building and complete it.

Telescopes

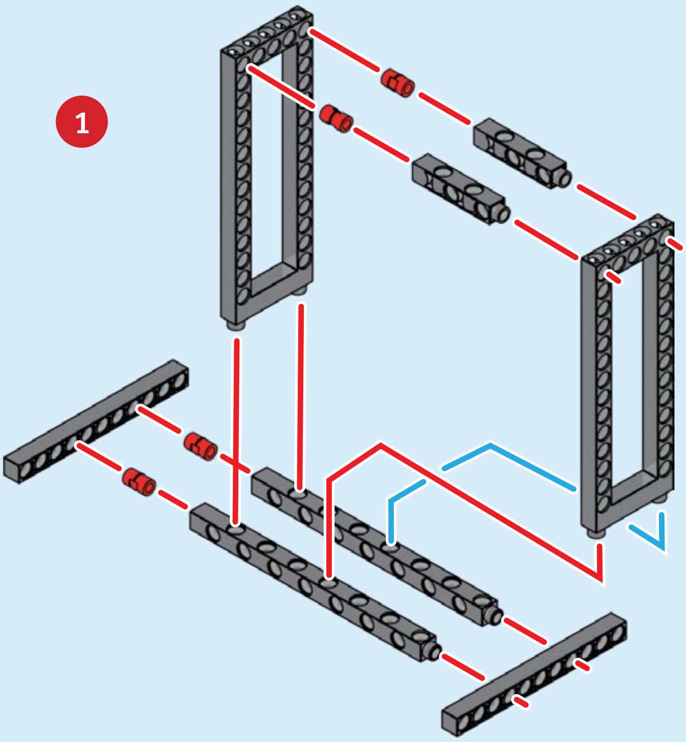
There are many different types of telescopes. All telescopes are instruments that collect electromagnetic radiation from far away places, but the electromagnetic radiation can be collected in different forms: visible light, radio waves, x-rays, microwaves, and more. The telescopes in this kit use optical lenses to bend visible light waves to magnify images.

EXPERIMENT 17



Telescope 4x with Short Optical Tube

1



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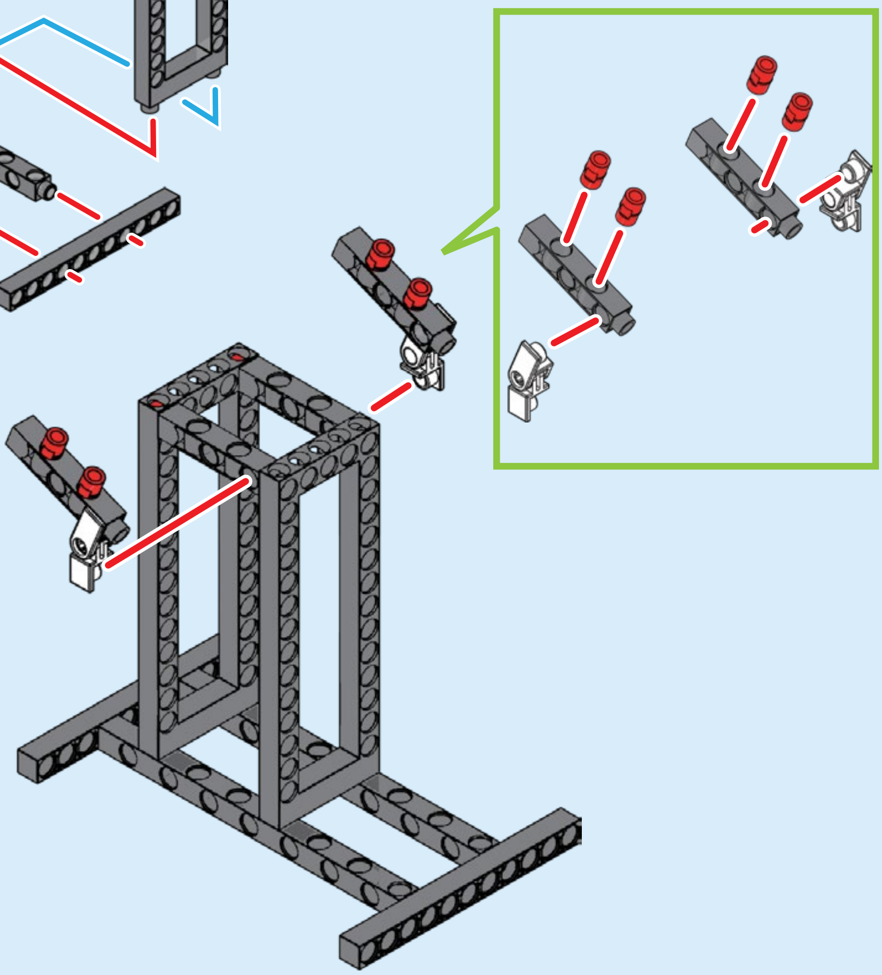

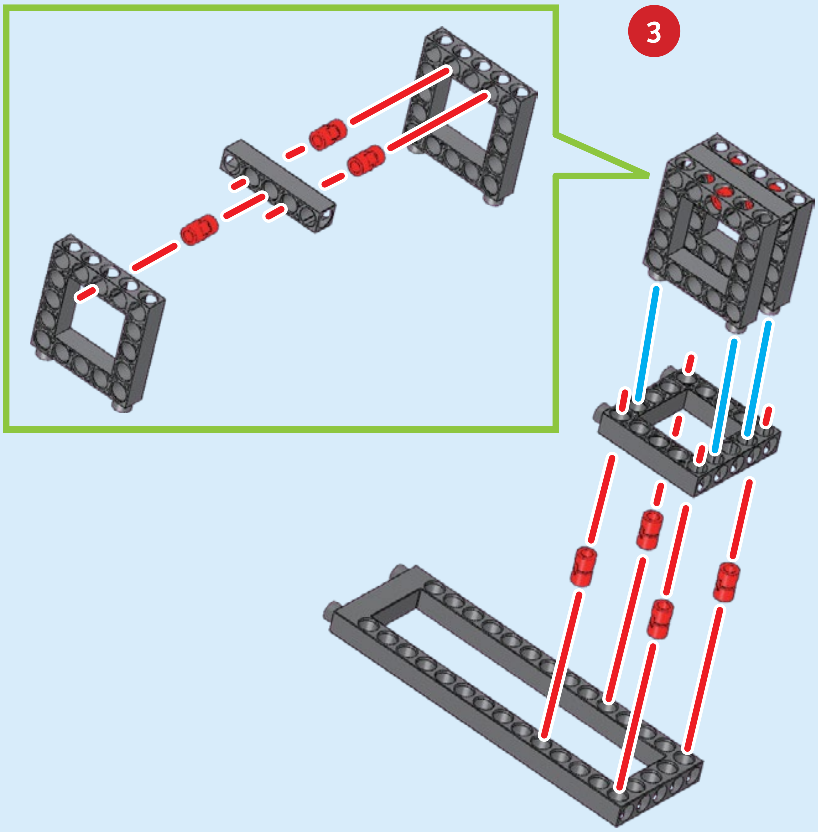
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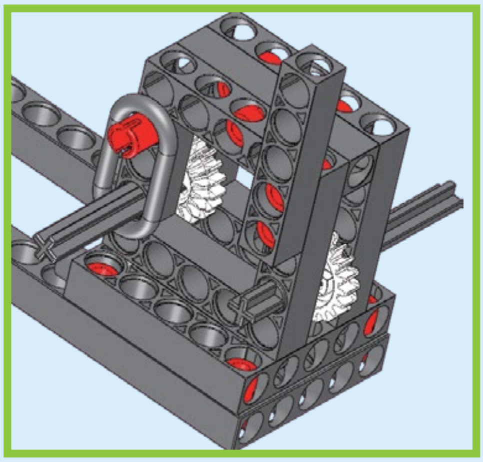
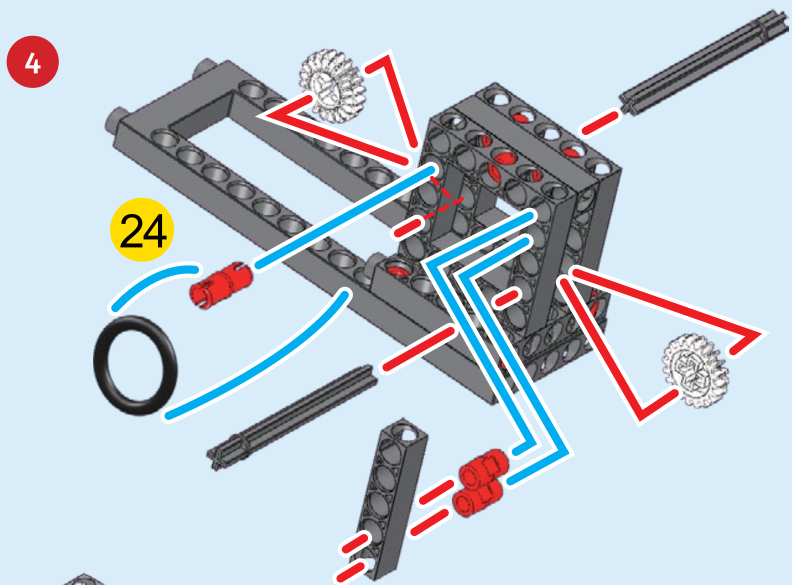
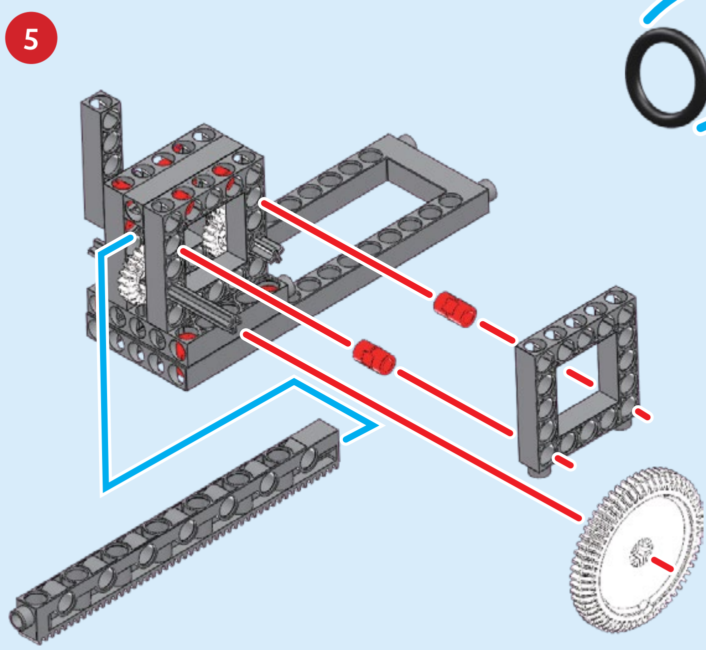
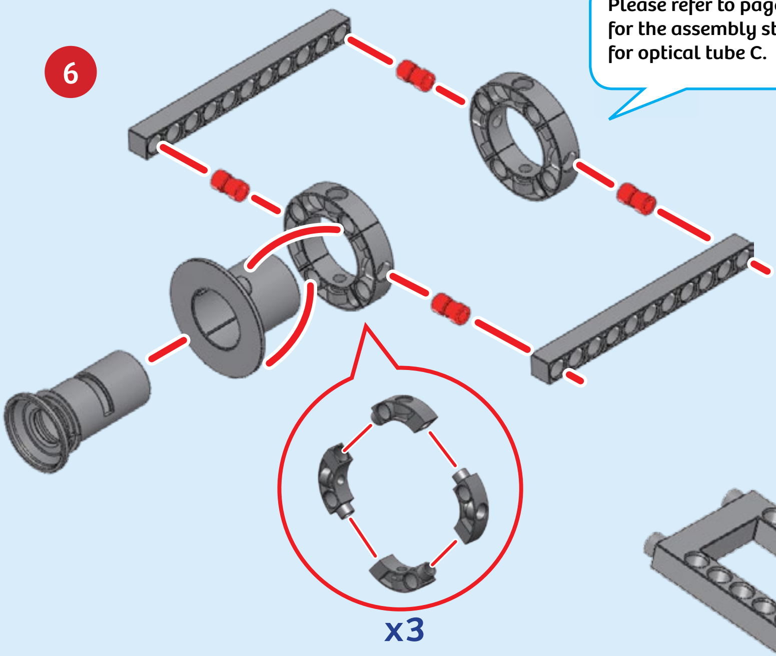



4
24

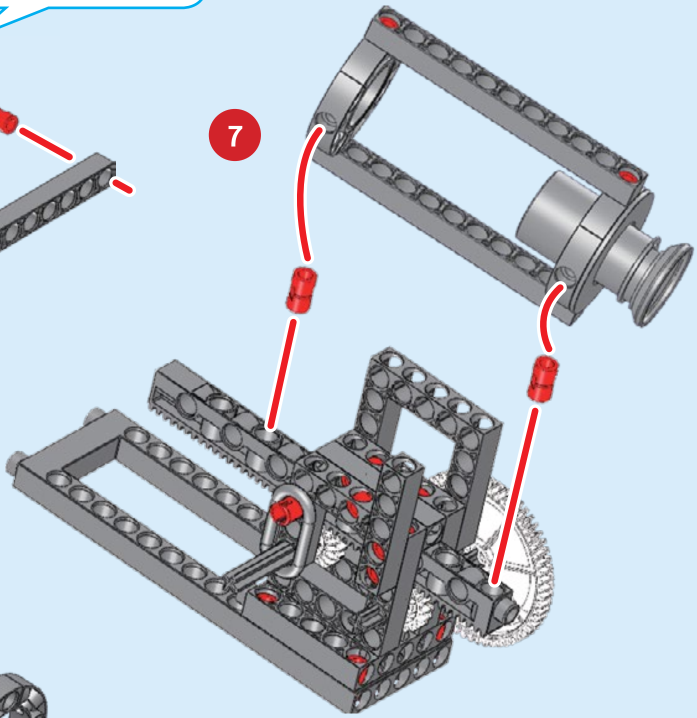

5

6



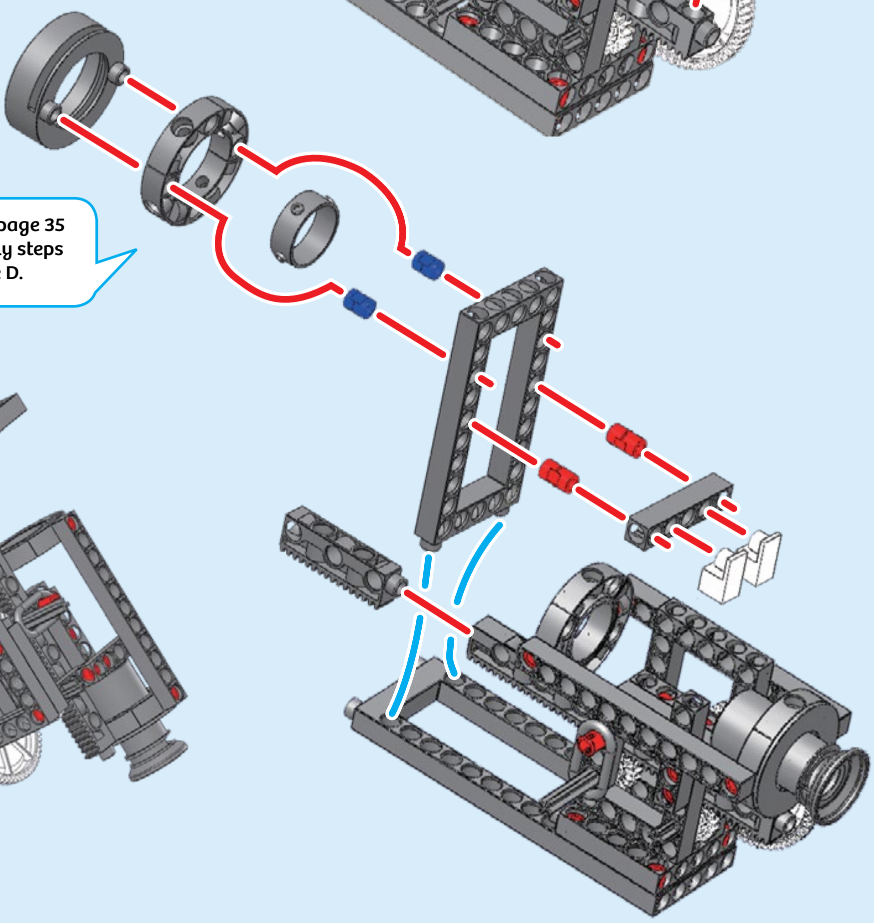
Please refer to page 29 for the assembly steps for optical tube C.

7

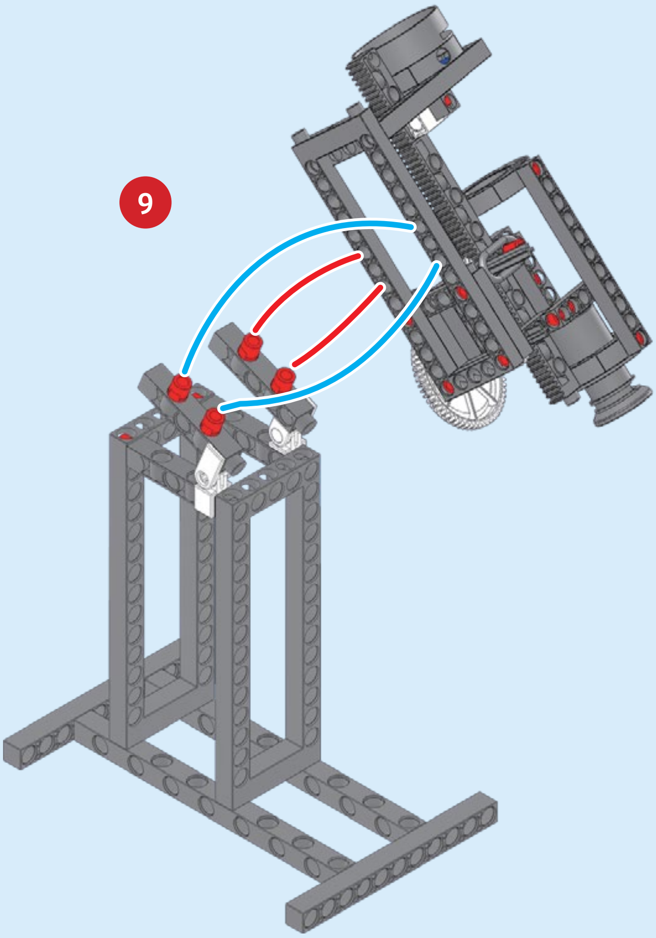


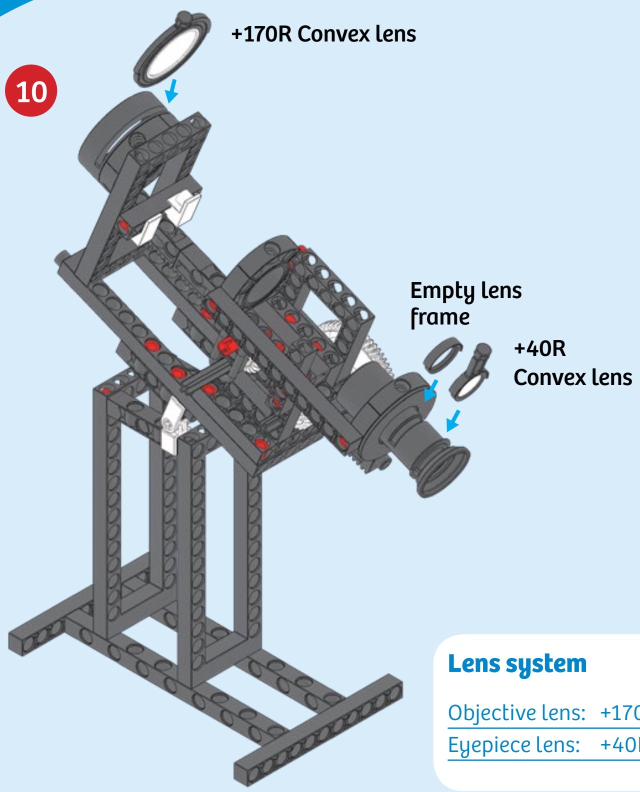
8

Please refer to page 35 for the assembly steps for optical tube D.



9





Lens system

Objective lens: +170R Convex lens x1
Eyepiece lens: +40R Convex lens x1

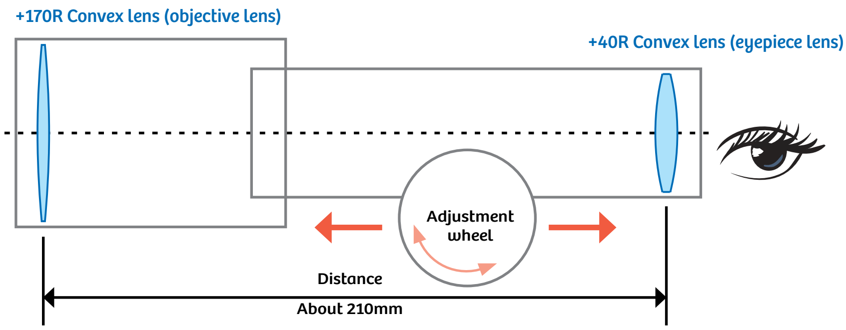
Experiment 17

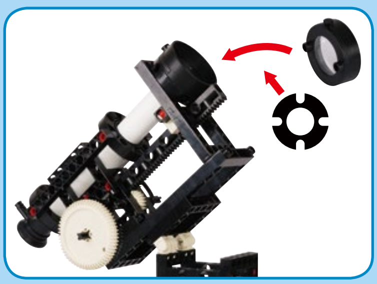
HERE'S HOW

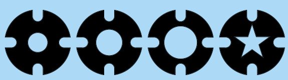
1. Turn the big grey gear on the side of the telescope, and a clear image will appear.
2. The sawtooth joint can be adjusted to different angles to view different objects in the sky.
3. Now insert one of the aperture cards into the telescope and observe its effect.

WHAT'S HAPPENING?

The adjustment knob is used to move the lens tube to adjust the focus. The scope uses a combination of two lens tubes to block out the light. Light will not come in from the sides even when you adjust the focus. The image appears inverted, which is acceptable for astronomical observations.





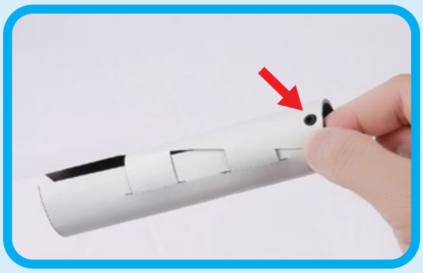

Aperture Cards

ASSEMBLY TIPS

Optical Tubes D & E

You will need these optical tubes for Experiments 17–22.

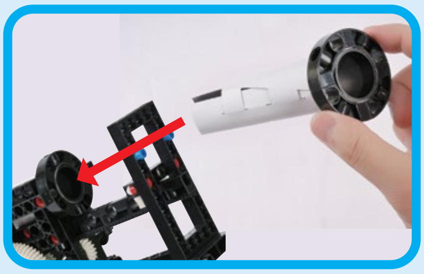
1. Roll the optical sheet D or E into a tube with the tube ring (Part 31) at the end of the tube.



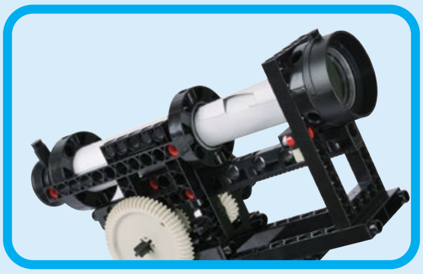
2. Insert the four pegs on the tube ring into the holes in the optical tube.

3. Fix the optical tube in place starting with two bent rods (Part 18).

4. Use two more bent rods (Part 18) to finish fixing the tube in place.



5. Insert the tube through the frame and partially into optical tube C.

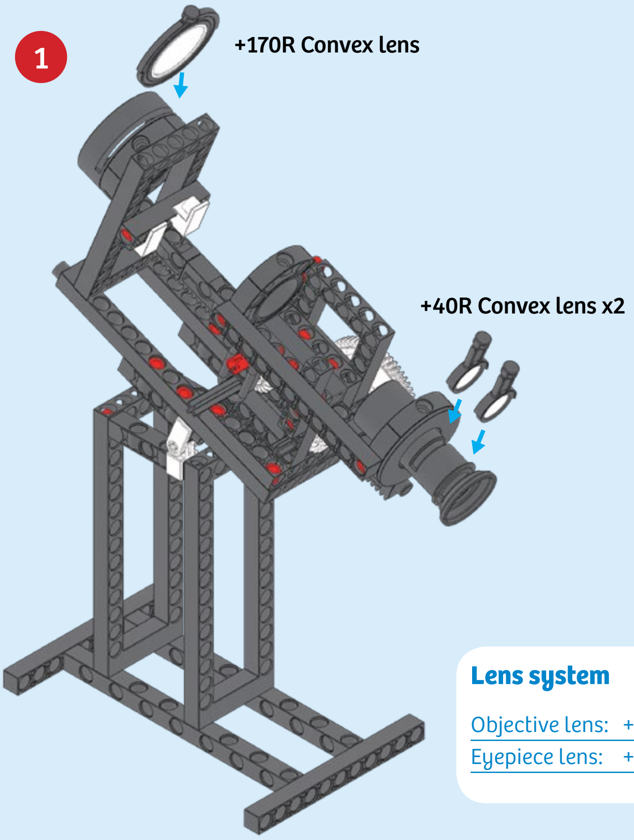


6. Complete the assembly.

EXPERIMENT 18

Telescope 10x with Short Optical Tube

1



Lens system

Objective lens: +170R Convex lens x1
Eyepiece lens: +40R Convex lens x2

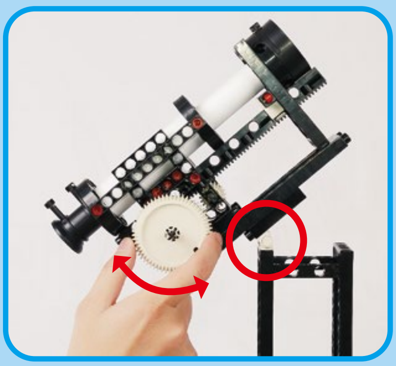
Experiment 18

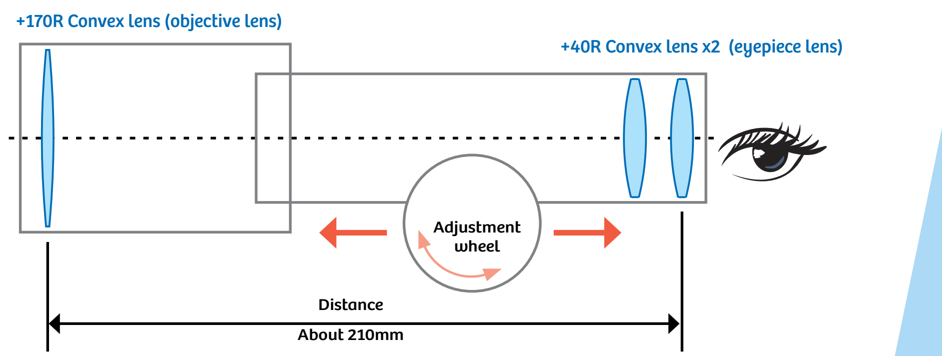
HERE'S HOW

1. Replace the empty lens frame in the model from the previous experiment with a second +40R Convex lens.
2. Turn the big grey gear on the side of the telescope, and a clear image will appear.
3. The sawtooth joint can be adjusted to different angles to view different objects in the sky.
4. Now insert one of the aperture cards into the telescope and observe its effect.

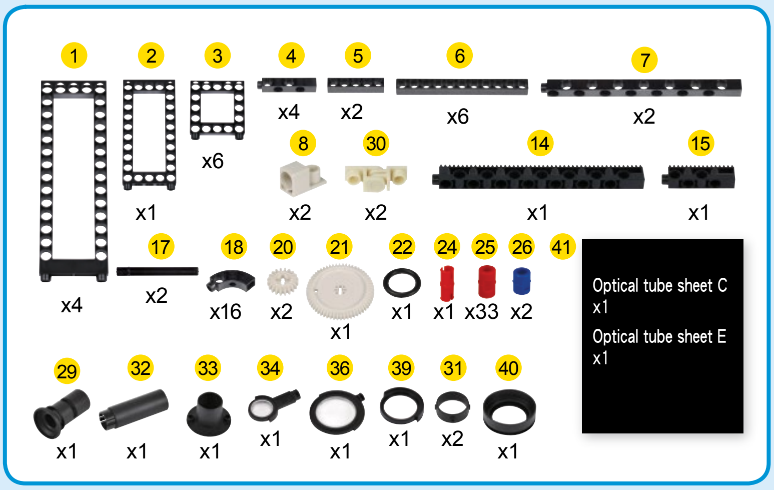
WHAT'S HAPPENING?

Compare this telescope to the one from Experiment 17. You'll see that this telescope is more powerful.



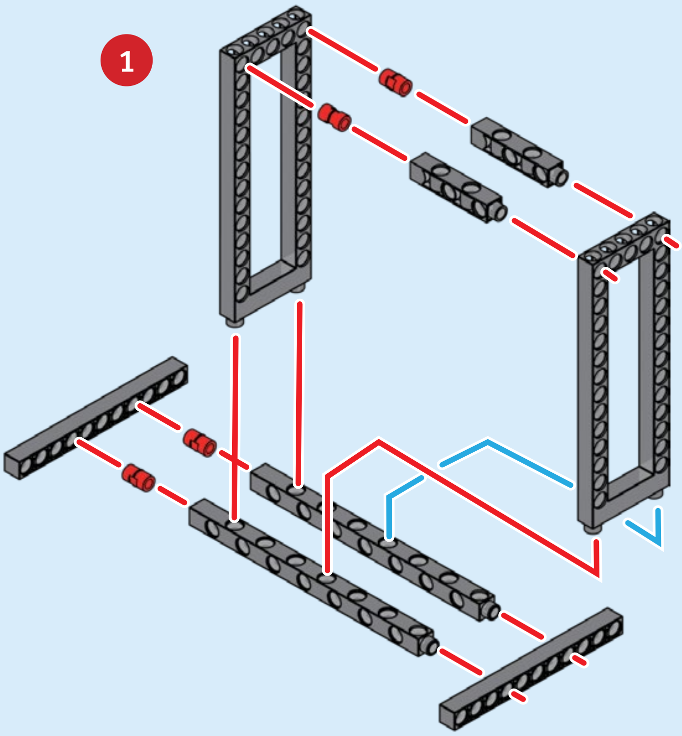


EXPERIMENT 19



Telescope 10x with Long Optical Tube

1



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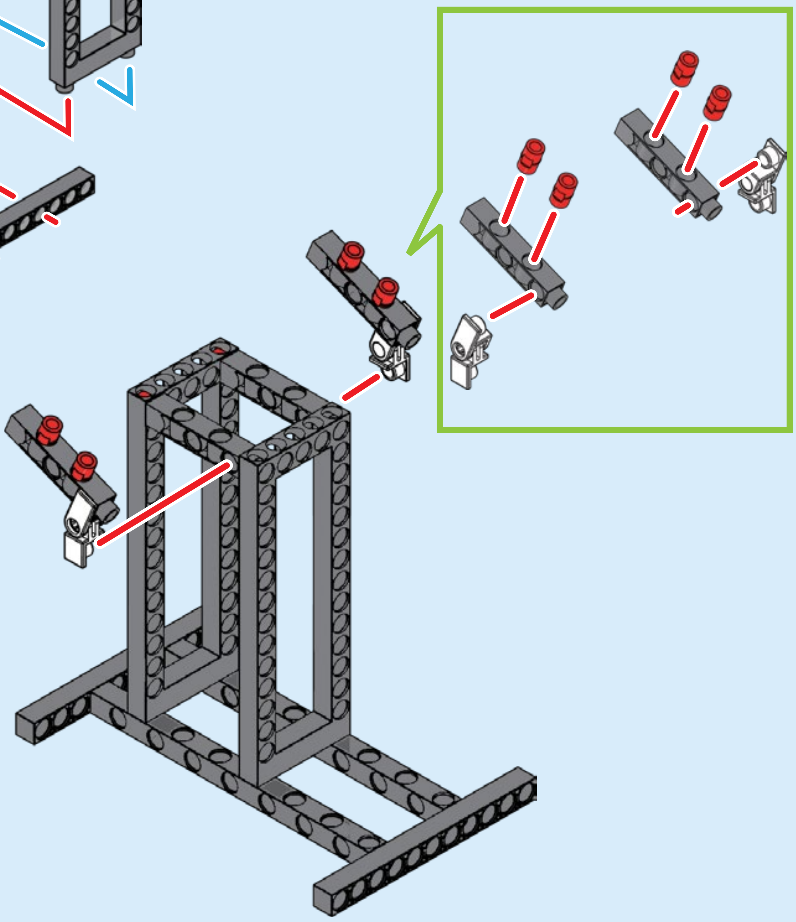

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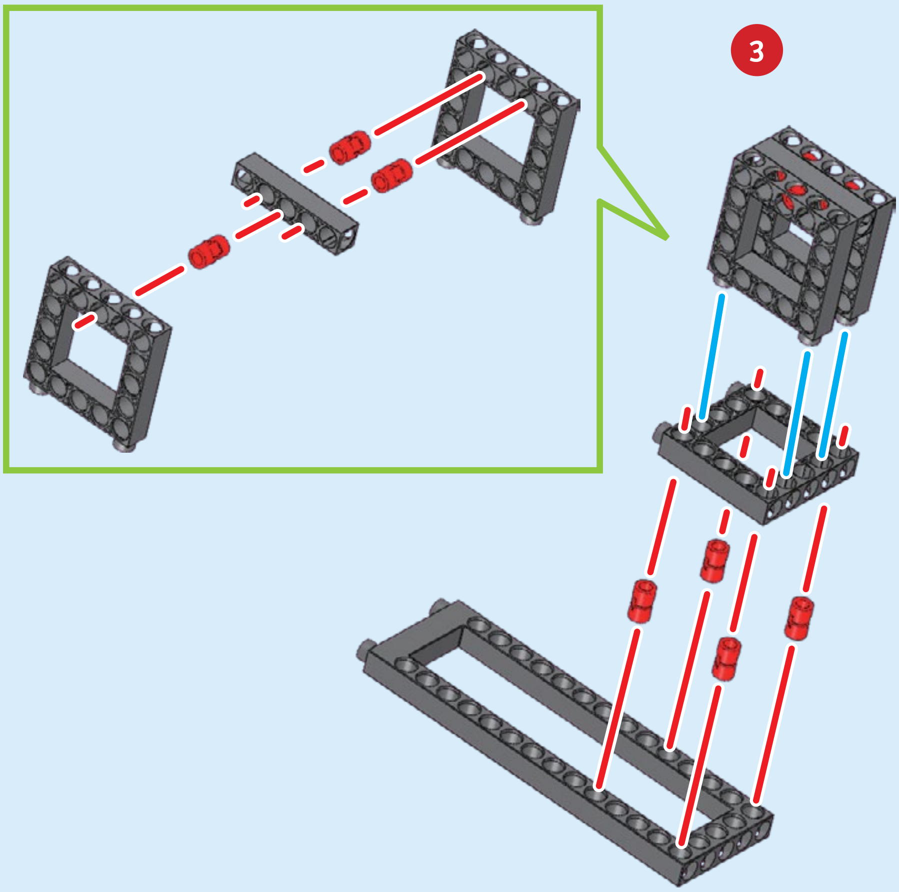

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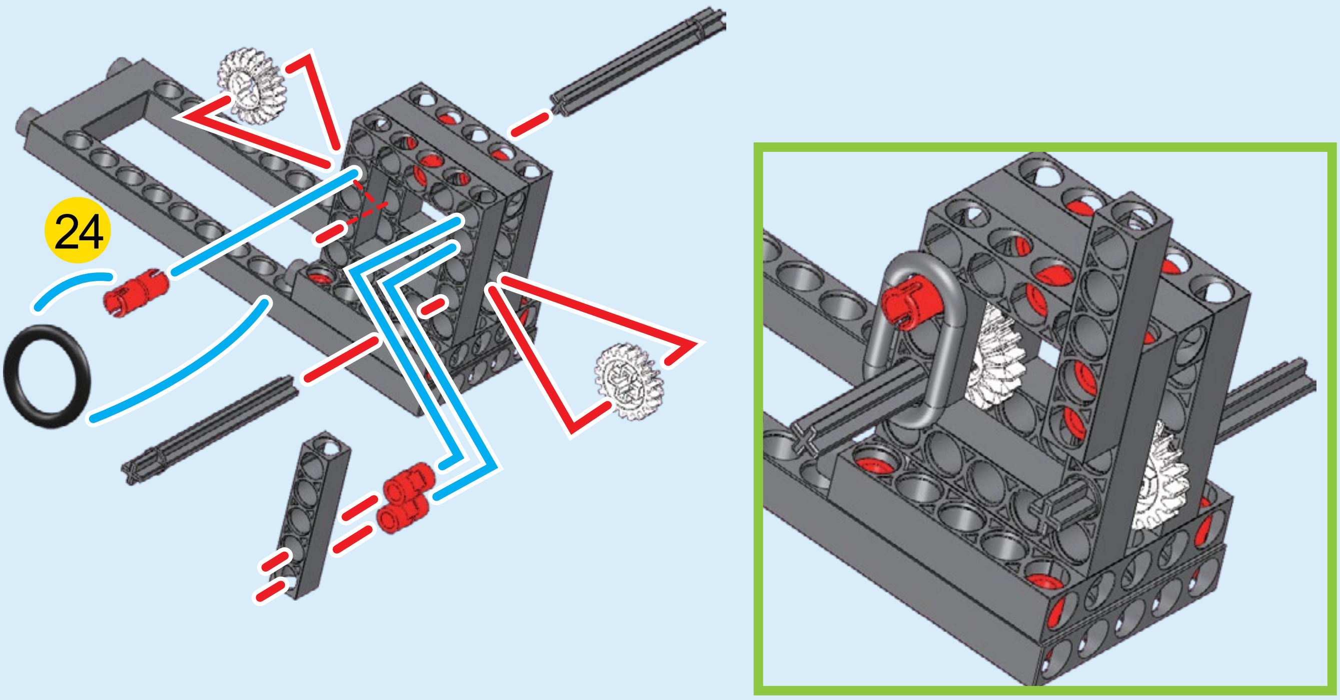
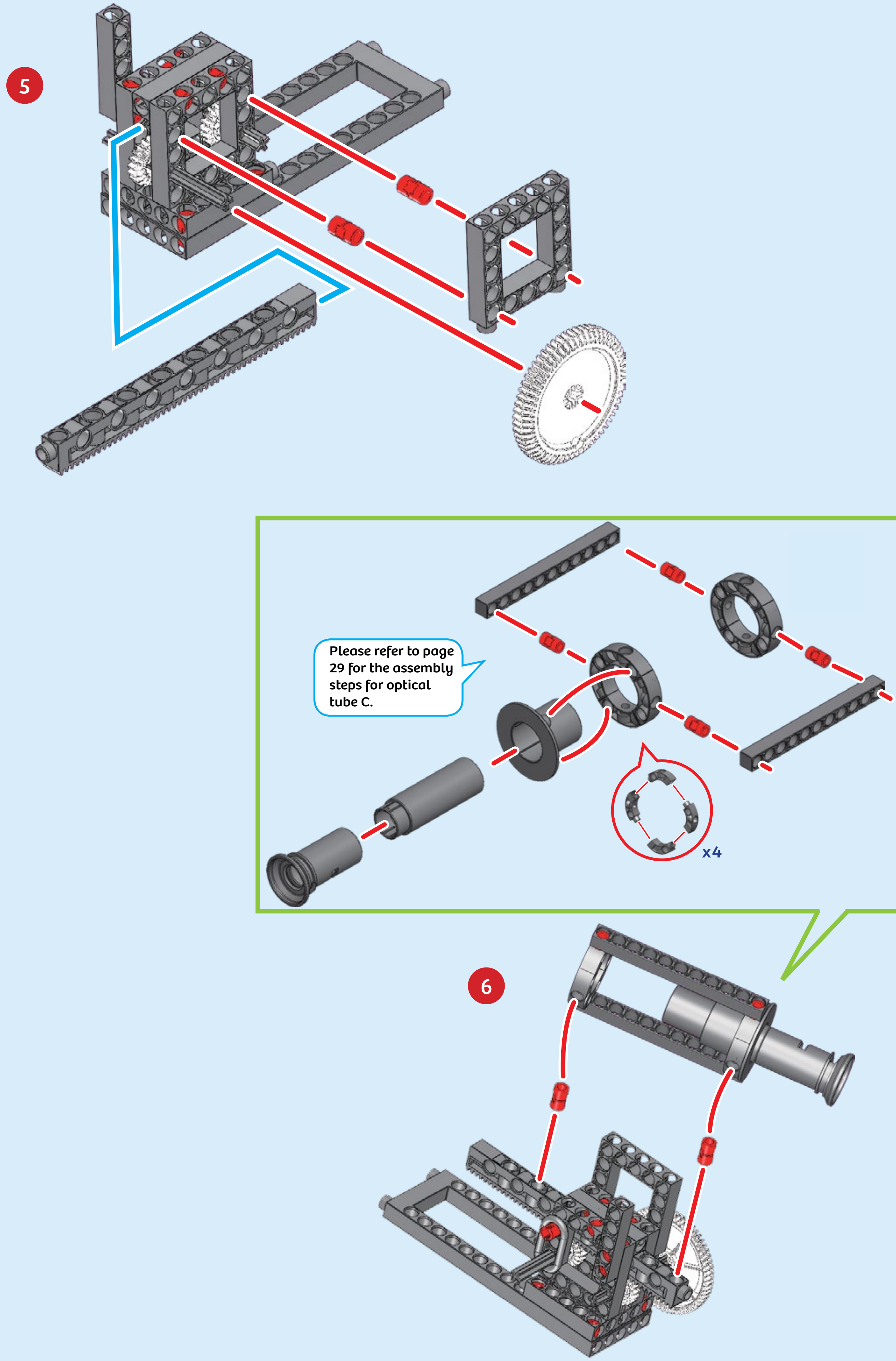
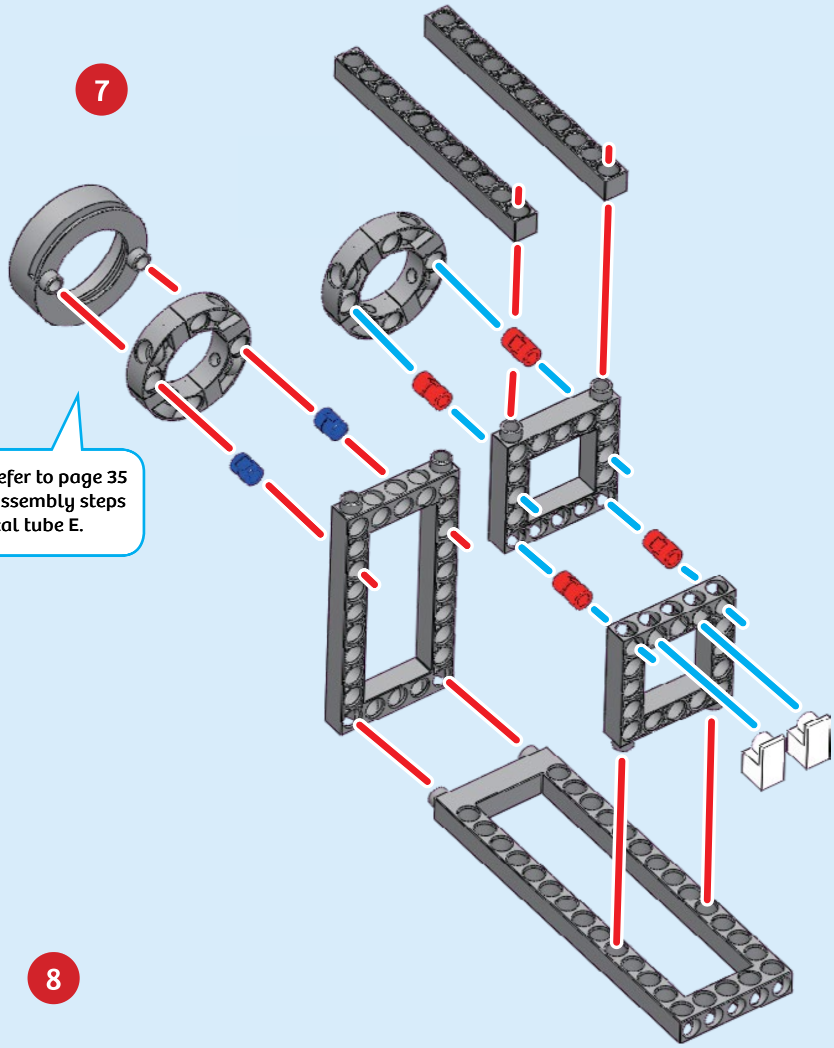


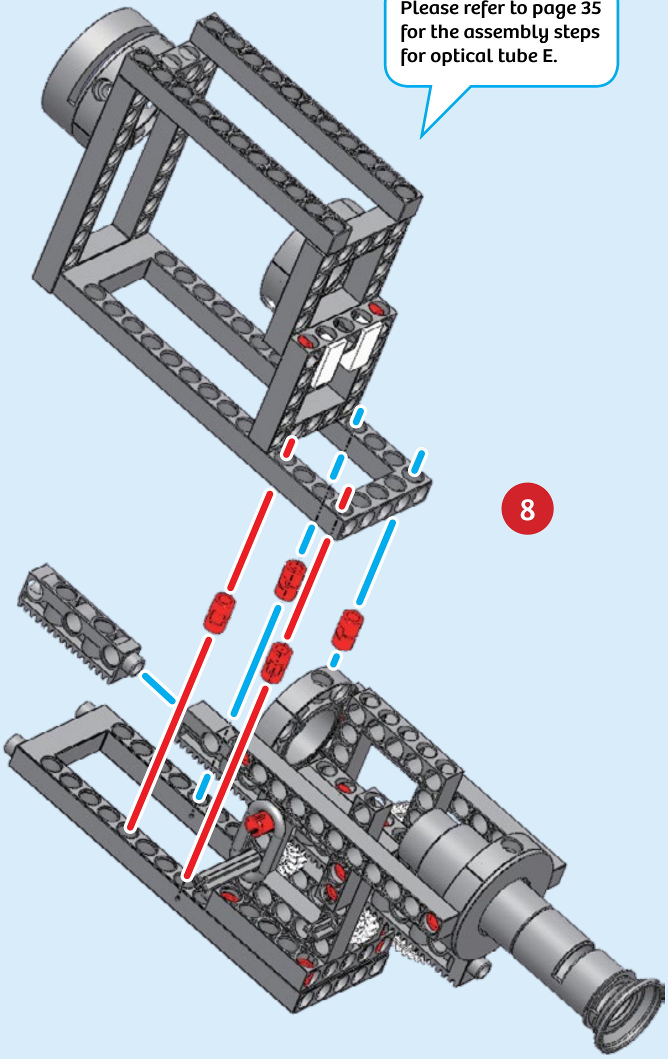

5
Please refer to page 29 for the assembly steps for optical tube C.
x4
6

7

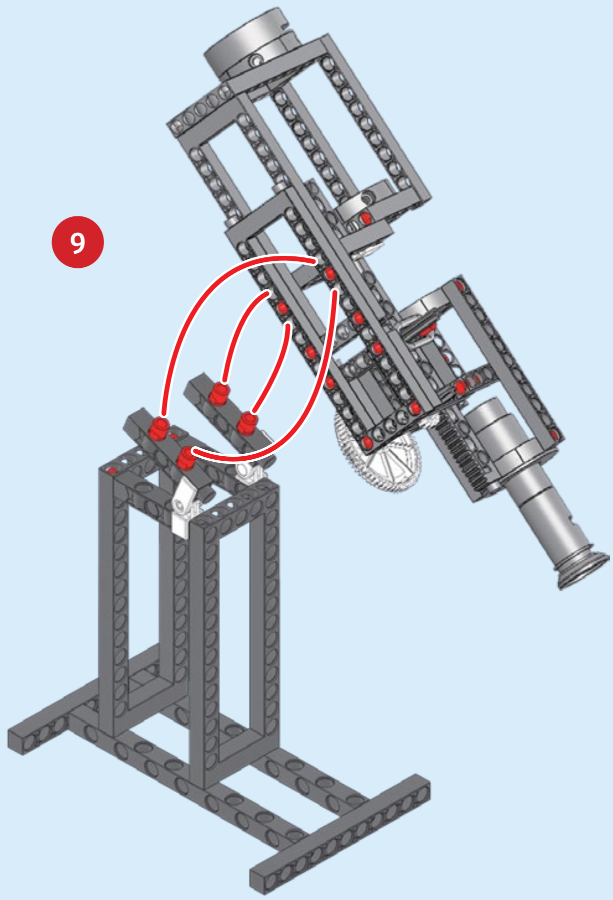


Please refer to page 35 for the assembly steps for optical tube E.

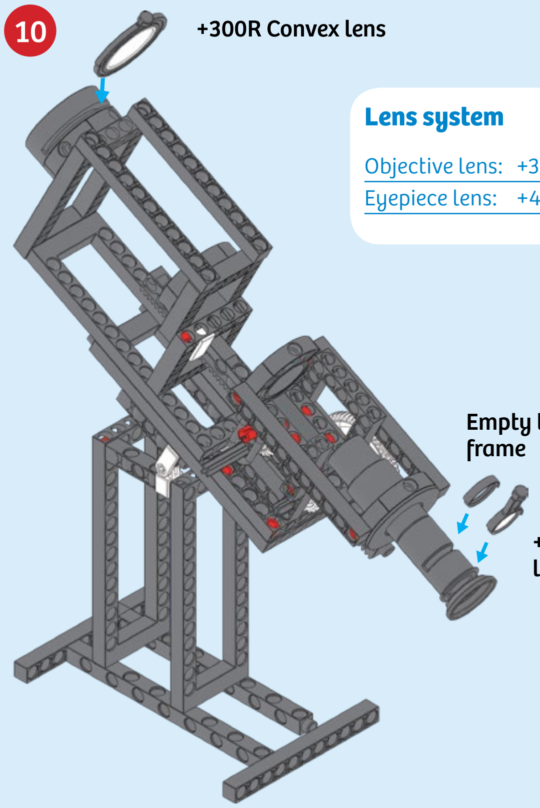
8



9



10



Lens system

Objective lens: +300R Convex lens x1
Eyepiece lens: +40R Convex lens x1

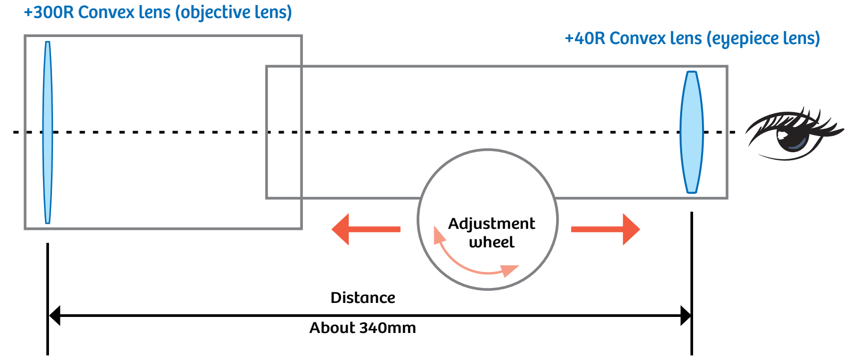
Experiment 19

HERE'S HOW

1. Turn the big grey gear on the side of the telescope, and a clear image will appear.
2. The sawtooth joint can be adjusted to different angles to view different objects in the sky.
3. Now insert one of the aperture cards into the telescope and observe its effect.

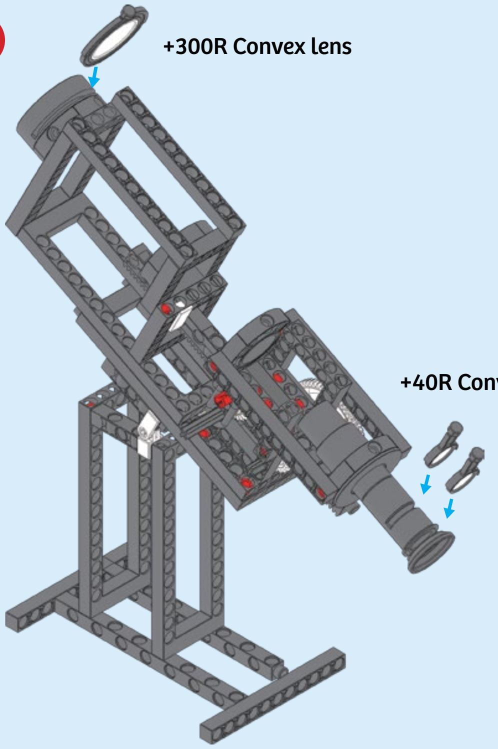
WHAT'S HAPPENING?

Compare this telescope with the telescope in Experiment 18. This one is just as powerful, but uses a different lens system and a longer tube. For what types of observations would each scope be better suited?



Telescope 15x with Long Optical Tube

1



Lens system

Objective lens: +300R Convex lens x1
Eyepiece lens: +40R Convex lens x2

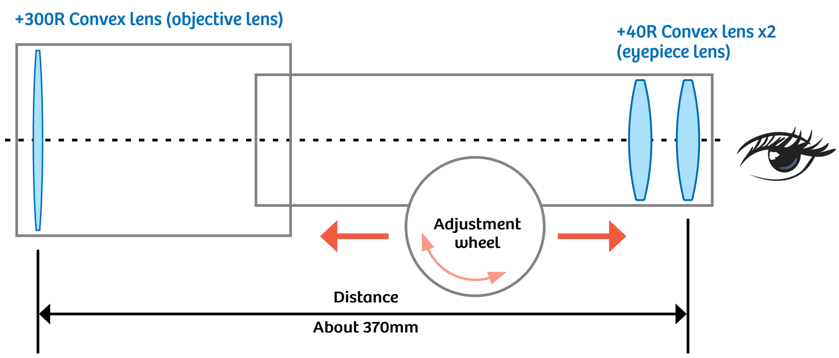
Experiment 20

HERE'S HOW

1. Replace the empty lens frame in the model from the previous experiment with a second +40R Convex lens.
2. Turn the big grey gear on the side of the telescope, and a clear image will appear.
3. The sawtooth joint can be adjusted to different angles to view different objects in the sky.

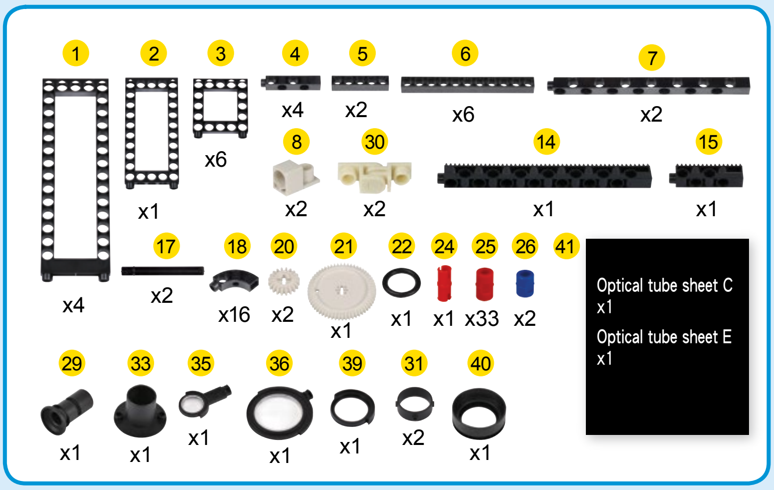
WHAT'S HAPPENING?

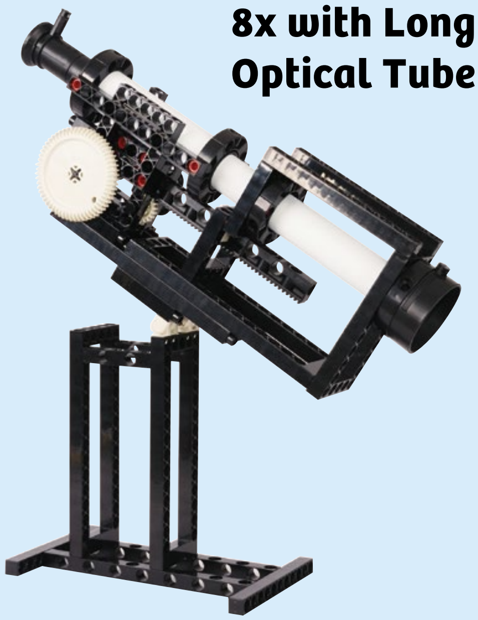
This telescope is the most powerful astronomical telescope you can build with this kit. The combination of the +300R Convex lens, the two +40R Convex lenses, and the long tube makes this scope the most powerful.



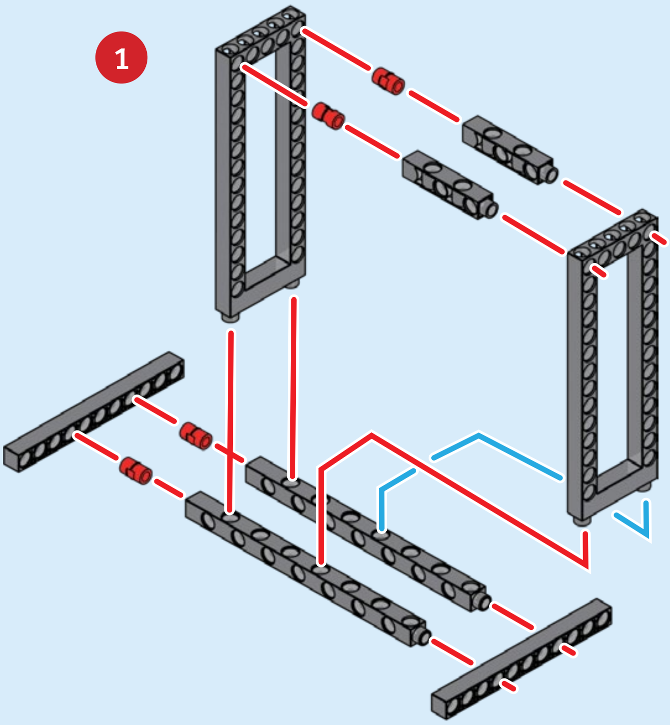
EXPERIMENT 21

Field Telescope 8x with Long Optical Tube

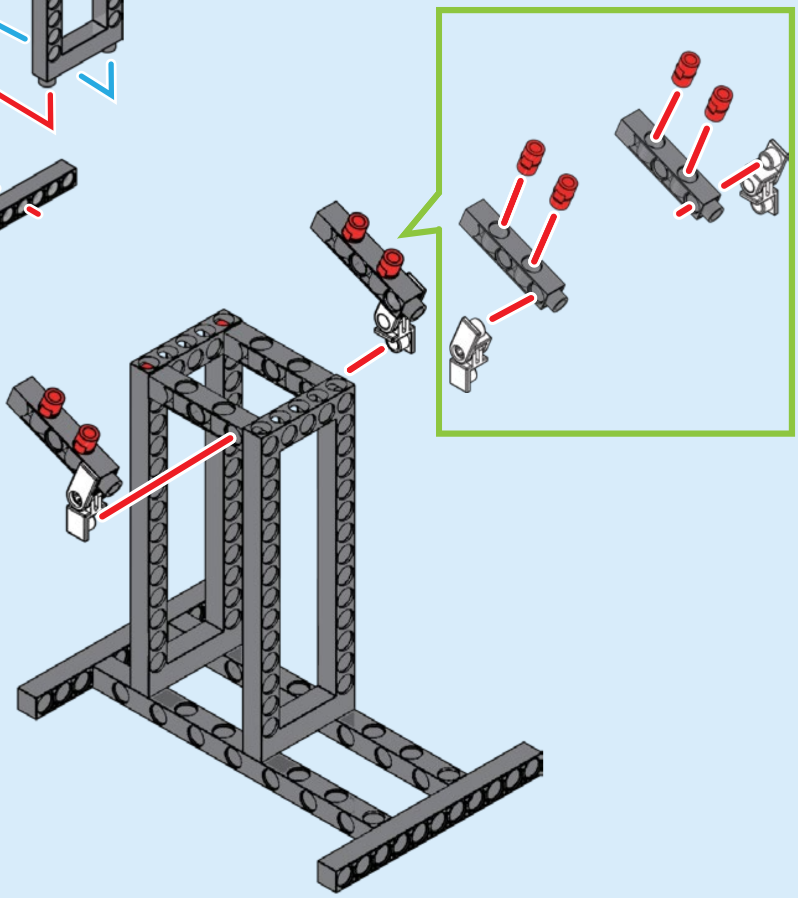




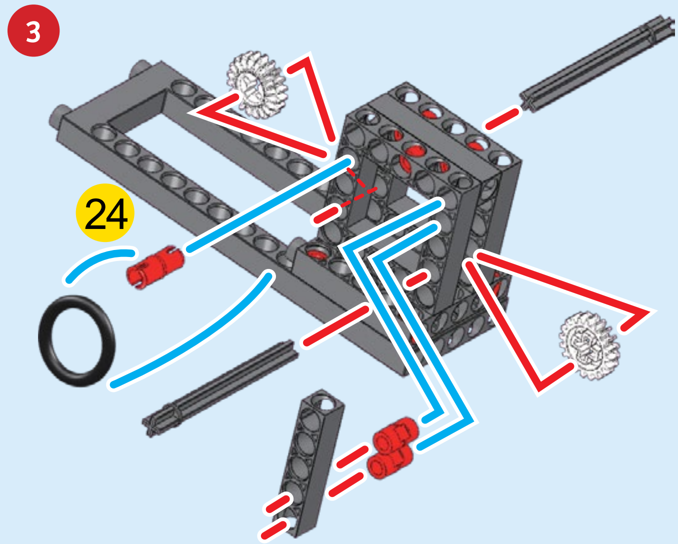
1

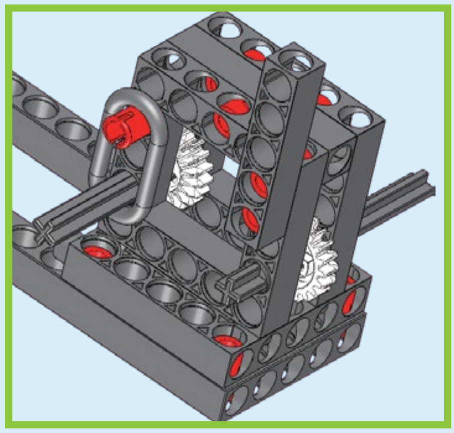


2

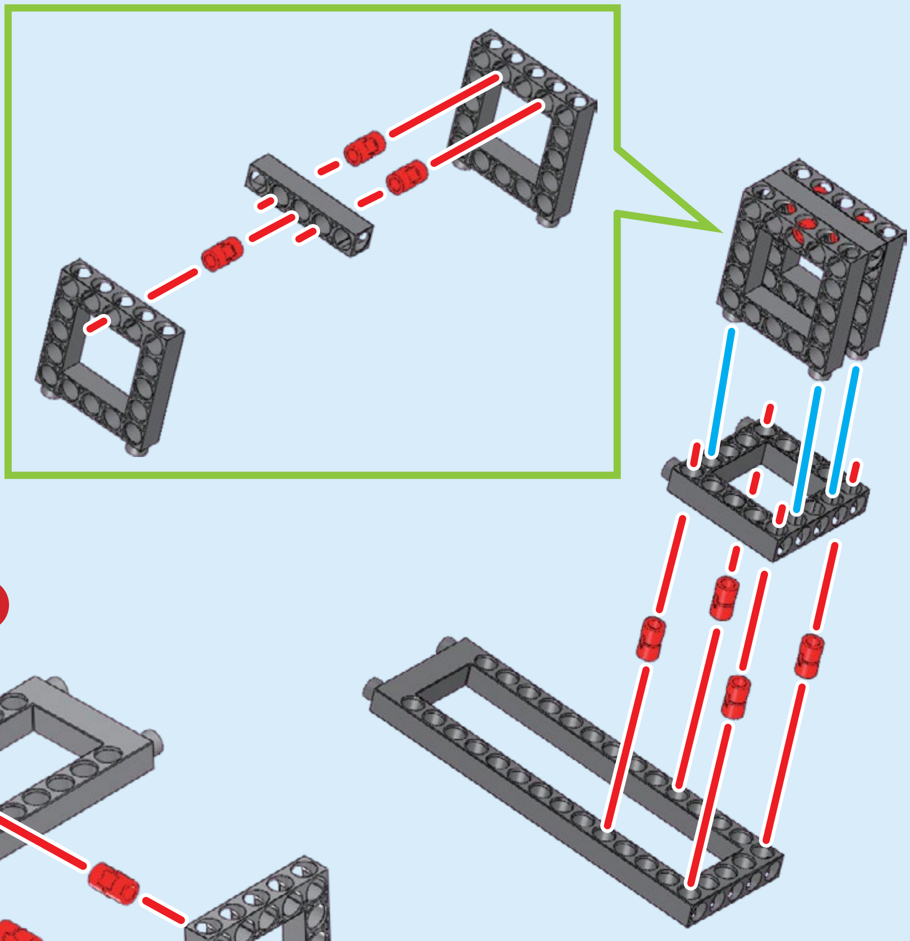


3

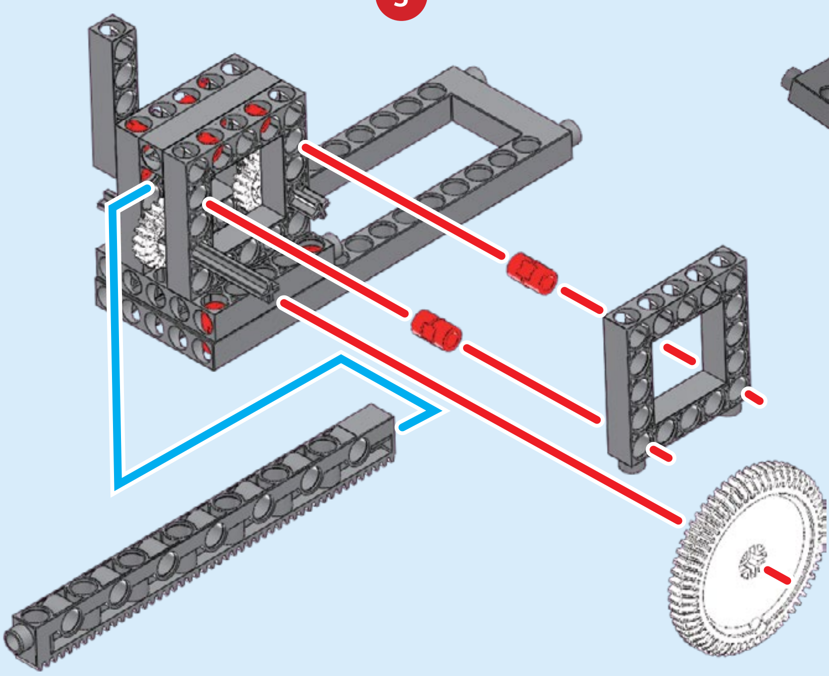


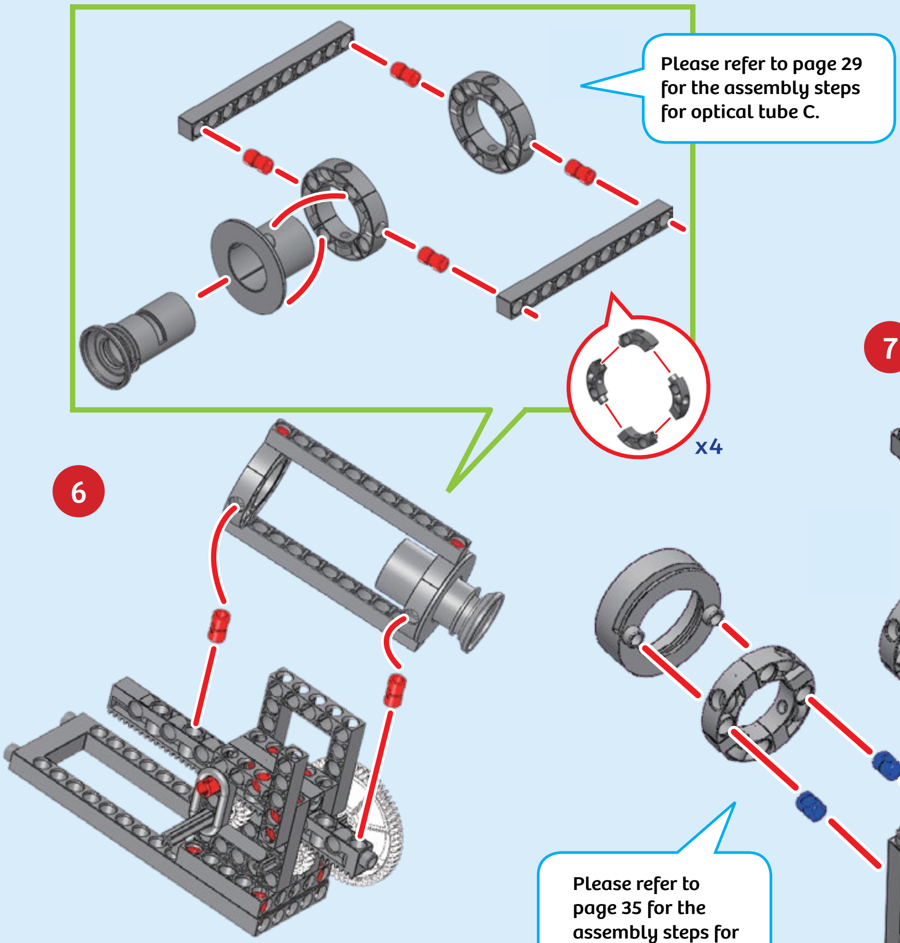


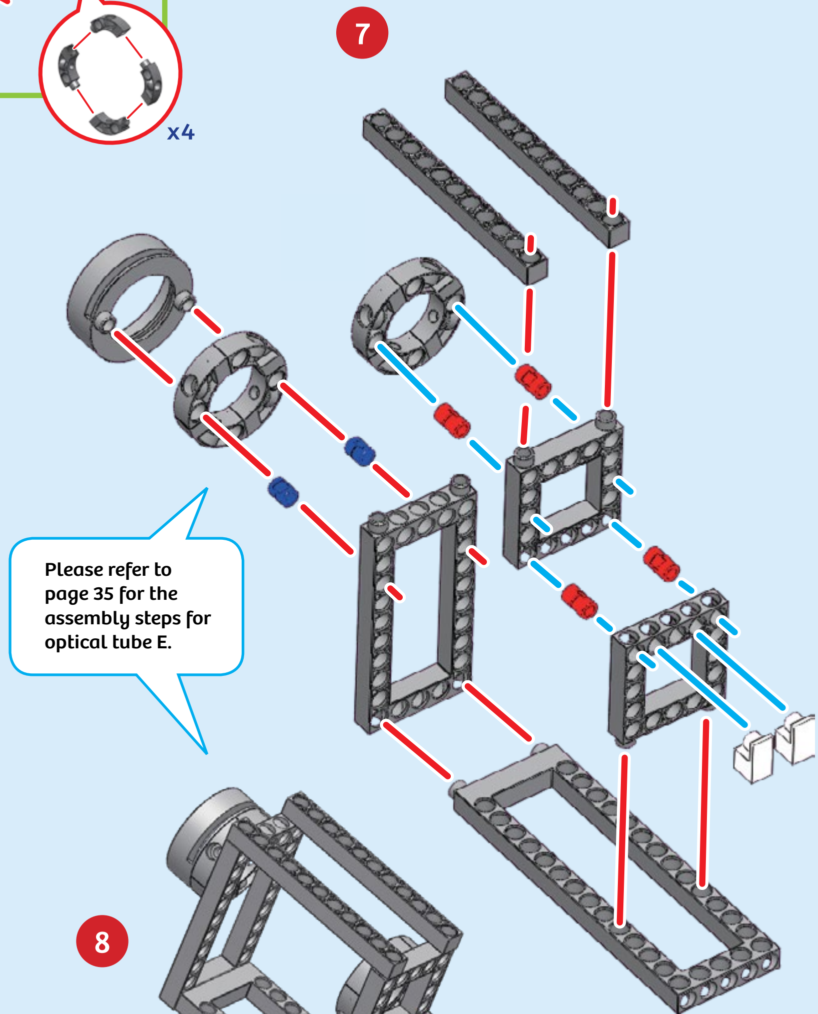
4

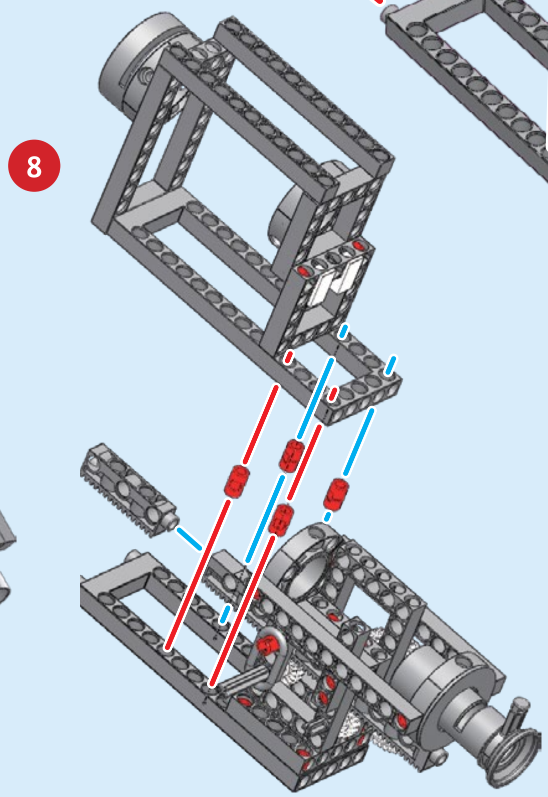


5




Please refer to page 29 for the assembly steps for optical tube C.
x4
6


7
Please refer to page 35 for the assembly steps for optical tube E.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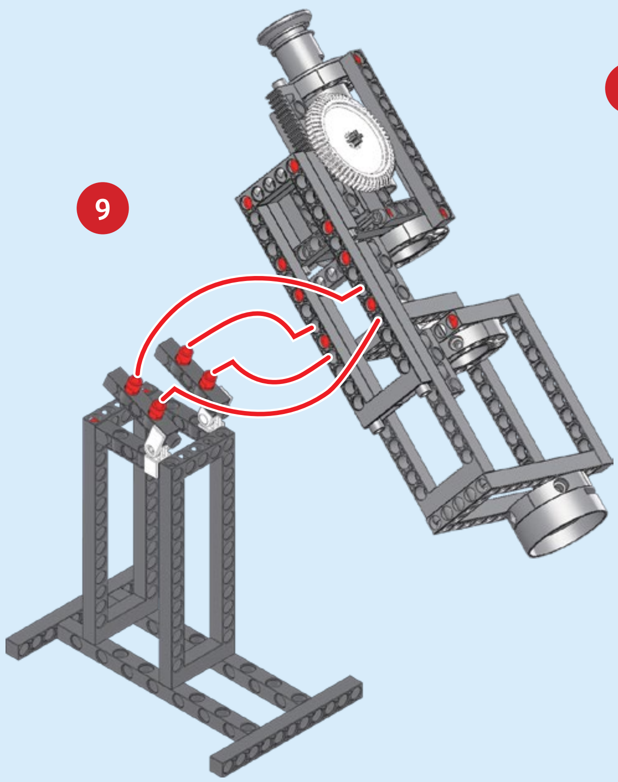
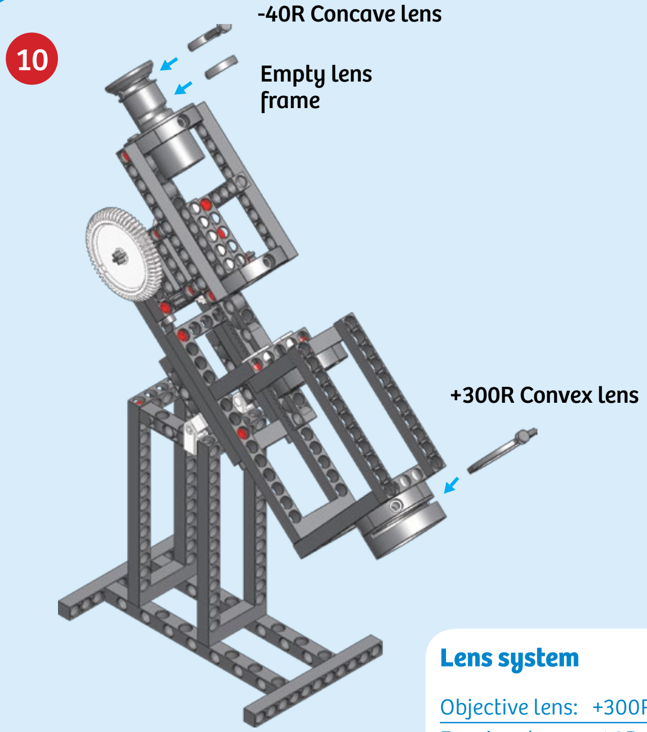

9



Lens system

Objective lens: +300R Convex lens x1
Eyepiece lens: -40R Concave lens x1

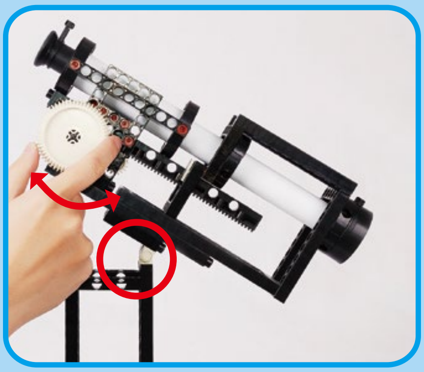
Experiment 21

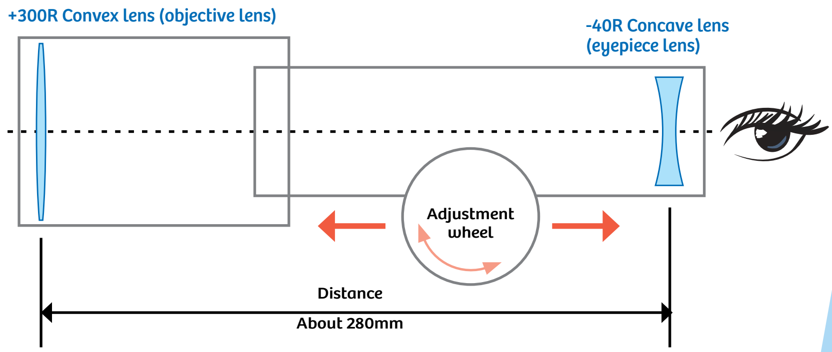
HERE'S HOW

1. Turn the big grey gear on the side of the telescope, and a clear image will appear.
2. The sawtooth joint can be adjusted to different angles to view different objects in the sky.
3. Now insert one of the aperture cards into the telescope and observe its effect.

WHAT'S HAPPENING?

With the -40R Concave lens, this telescope shows an upright image. This makes it good for viewing objects on the surface of Earth, rather than in the sky.

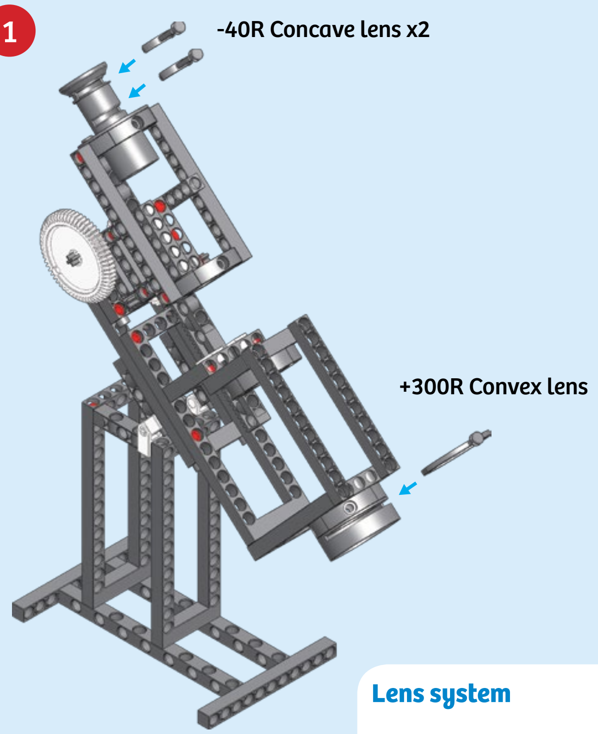




EXPERIMENT 22

Field Telescope 15x with Long Optical Tube

1



Lens system

Objective lens: +300R Convex lens x1
Eyepiece lens: -40R Concave lens x2

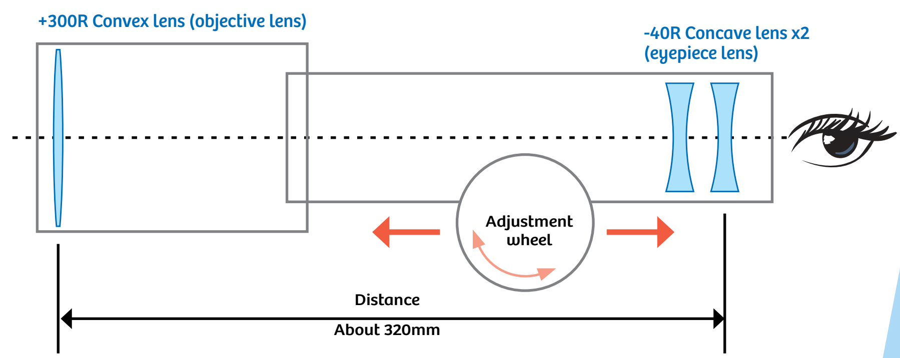
Experiment 22

HERE'S HOW

1. Replace the empty lens frame in the model from the previous experiment with a second -40R Concave lens.
2. Turn the big grey gear on the side of the telescope, and a clear image will appear.
3. The sawtooth joint can be adjusted to different angles to view different objects in the sky.

WHAT'S HAPPENING?

This is another field telescope with an upright image in the visual field, but because there are now two -40R Concave lenses, it is more powerful than the model in Experiment 21.

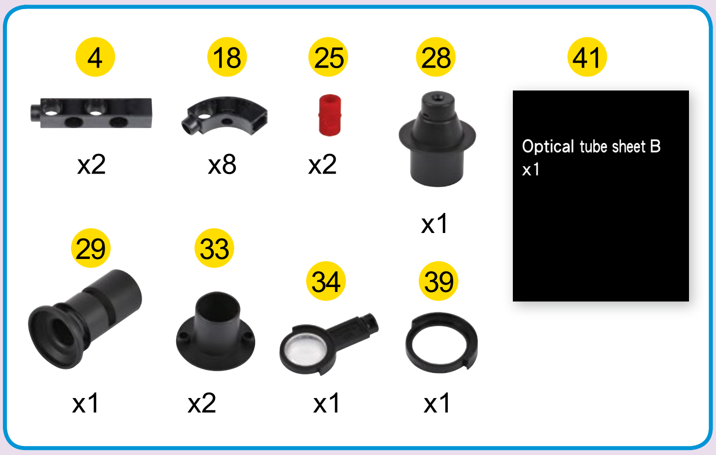


Microscopes

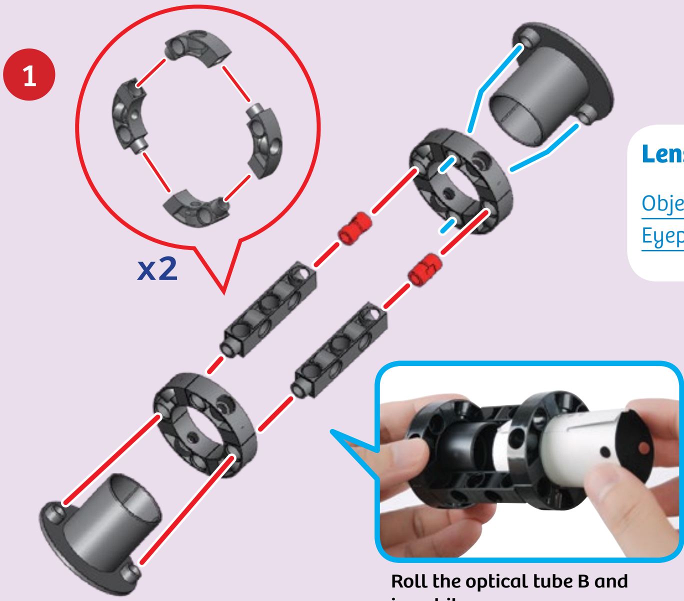
A microscope is an instrument that is used to magnify images of objects that are too small to see with the naked eye. Traditional microscopes use optical lenses to bend light rays that bounce off of microscopic objects, resulting in enlarged images. Electron microscopes bounce electrons off of extremely small objects and use sensors to read the electrons and create images.

Scanning probe microscopes use various physical "probes" — like heat, voltage, magnetism, atomic force — to make images of microscopic specimens.

EXPERIMENT 23



Low Power Handheld Microscope

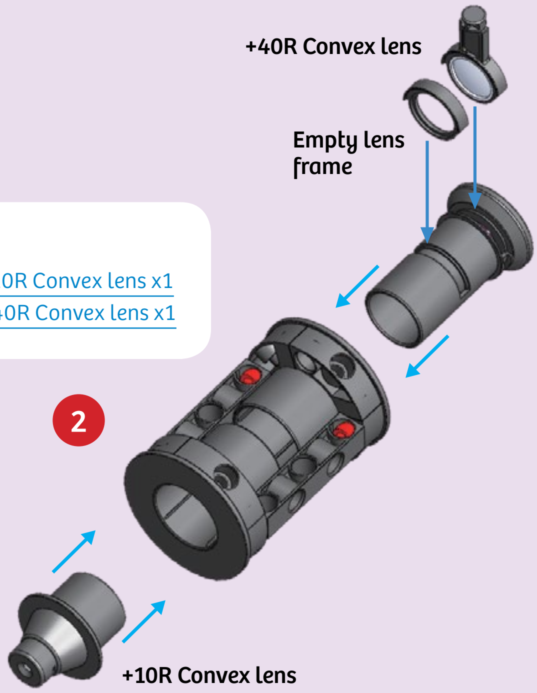


Roll the optical tube B and insert it.

Lens system

Objective lens: +10R Convex lens x1

Eyepiece lens: +40R Convex lens x1



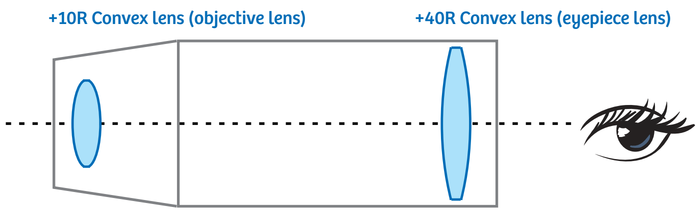
Experiment 23

HERE'S HOW

1. Put the +10R Convex lens close to the target object in good light with your hand holding the tube.
2. Move the scope upward slowly.
3. You can see a clear image when there is about 1 cm between the target object and the +10R Convex lens.

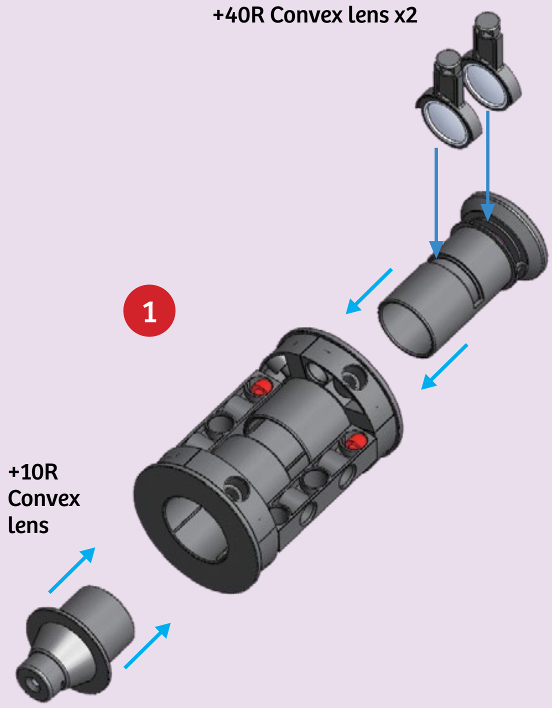
WHAT'S HAPPENING?

It is difficult to use a handheld microscope for high-power observations, but it is good for low-power observations. Slight unsteadiness of the hand does not hinder low-power observation. Because the image appears inverted, it may take some practice to be able to accurately adjust the position of the scope.



Add an extension tube to try a longer microscope! What is the size and brightness of the image viewed by the longer microscope?

EXPERIMENT 24



Medium Power Handheld Microscope

Lens system

Objective lens: +10R Convex lens x1
Eyepiece lens: +40R Convex lens x2

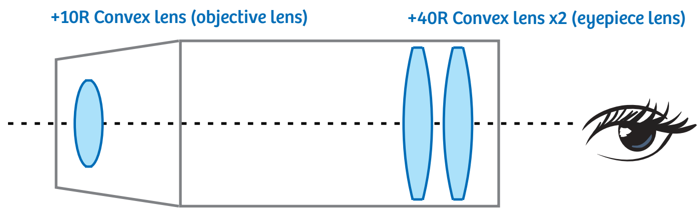
Experiment 24

HERE'S HOW

1. Replace the empty lens frame with a second +40R Convex lens.
2. Put the +10R Convex lens close to the target object in good light with your hand holding the tube.
3. Move the scope upward slowly.
4. You can see a clear image when there is about 1 cm between the target object and the +10R Convex lens.

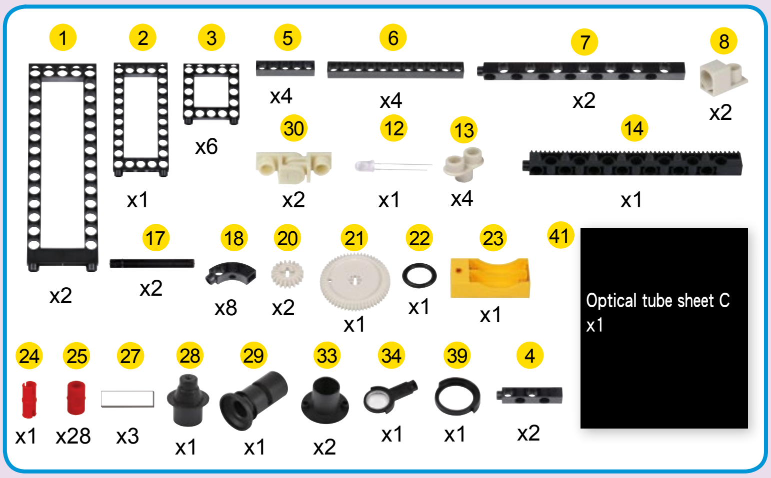
WHAT'S HAPPENING?

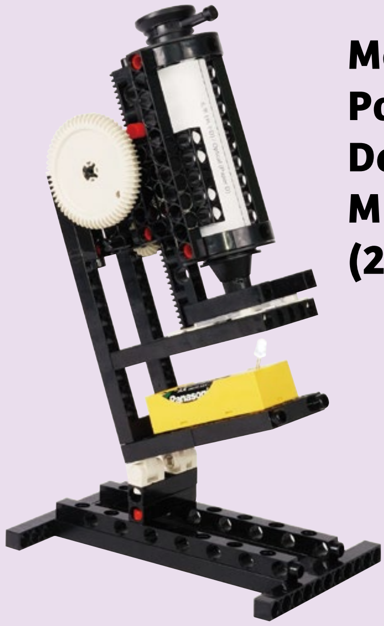
This is a more powerful version of the scope in Experiment 23 because it has two +40R Convex lenses instead of one.



Add an extension tube to try a longer microscope! What is the size and brightness of the image viewed by the longer microscope?

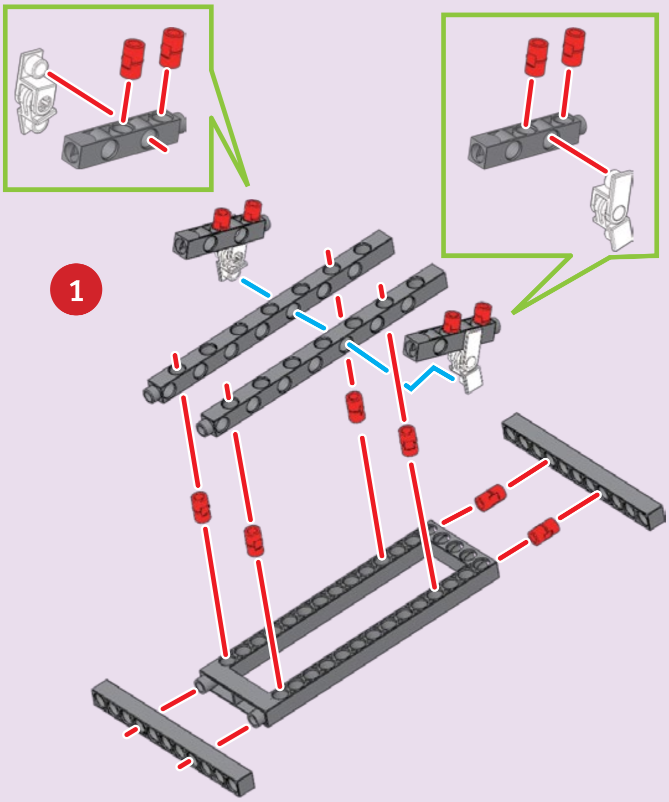
EXPERIMENT 25





Medium Power Desktop Microscope (25x)

1



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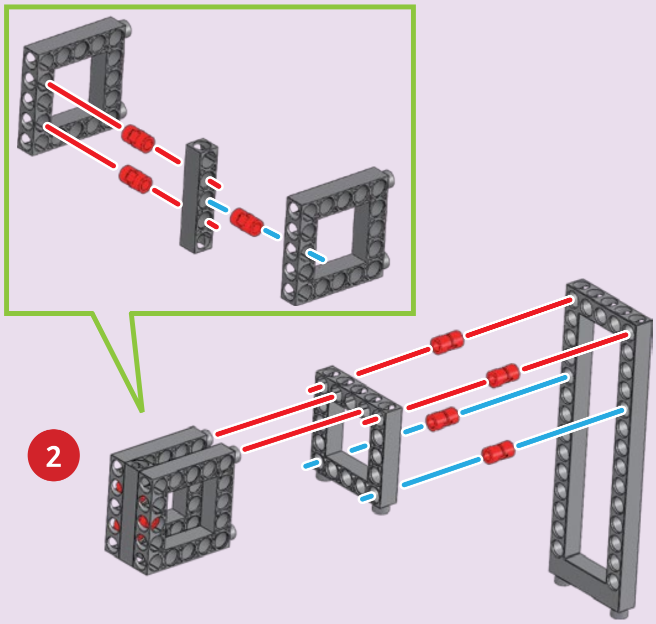
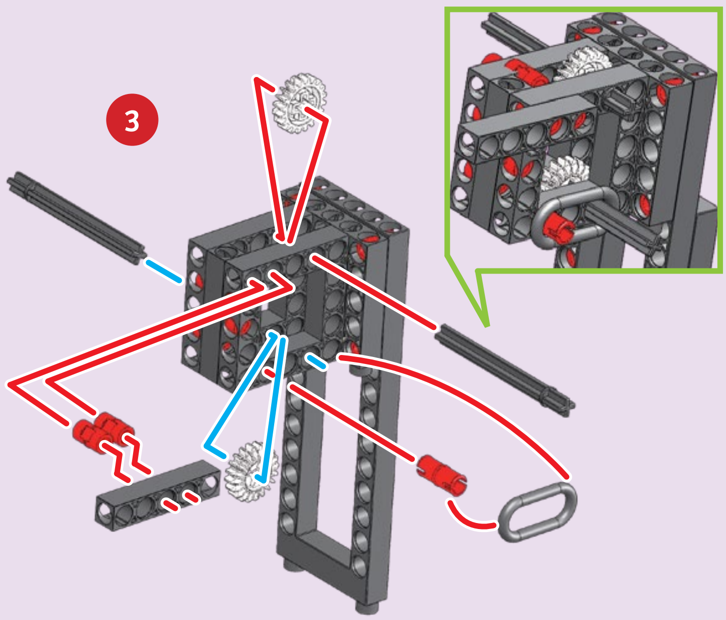
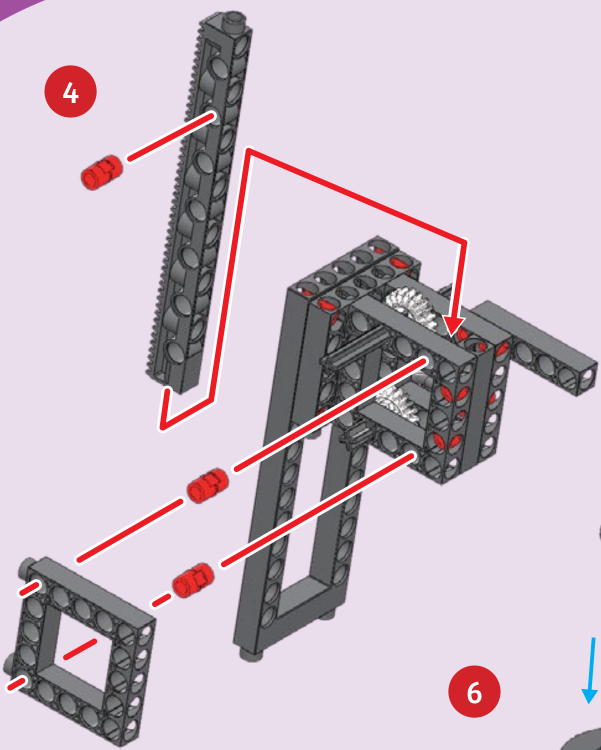


3



4



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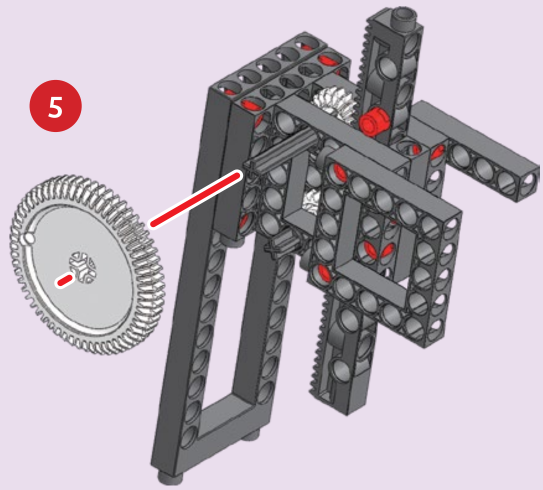
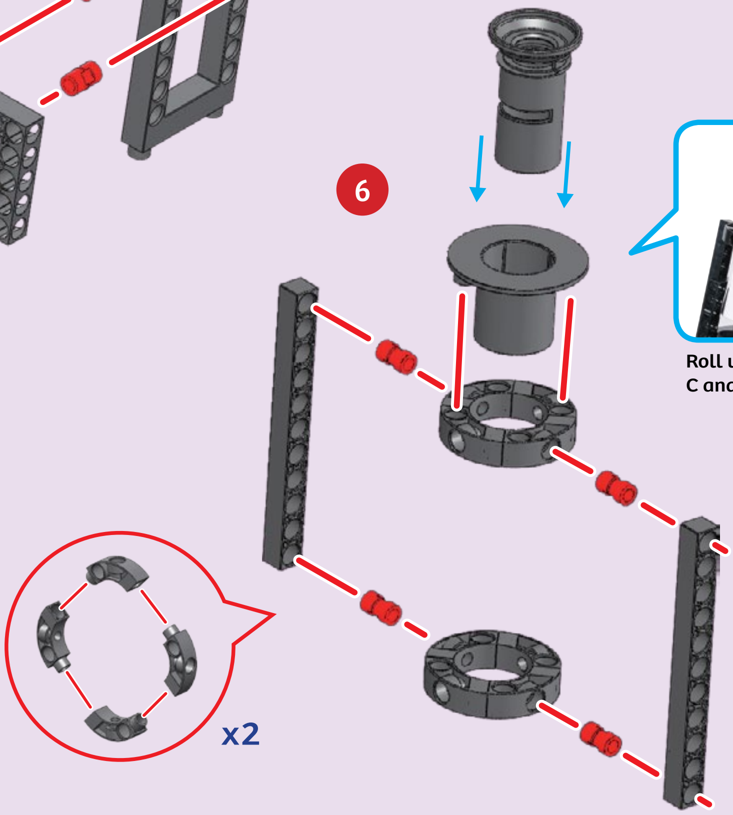
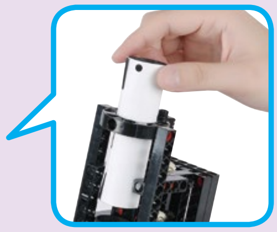


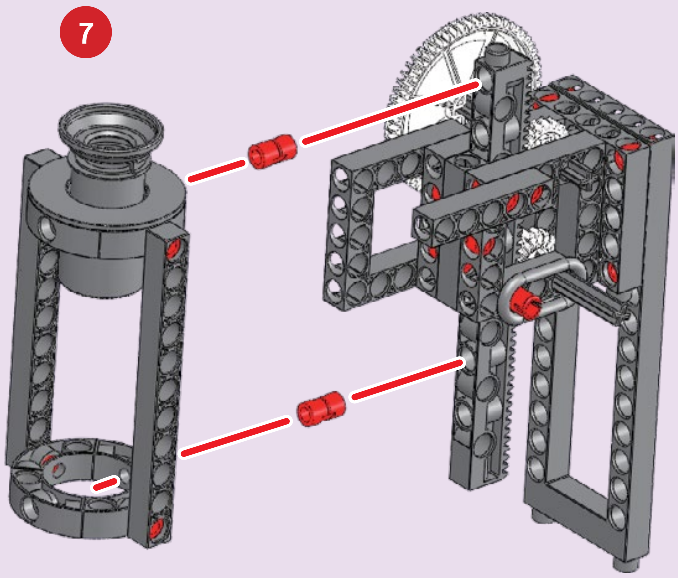
6





Roll up the optical tube C and insert it.

7



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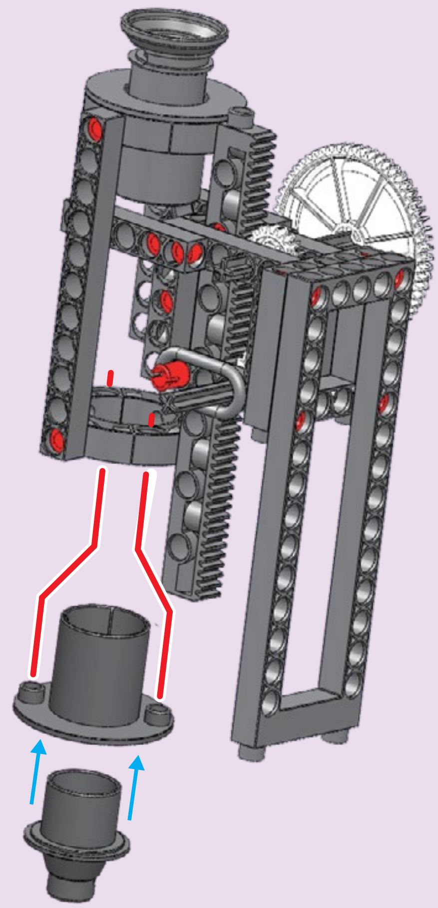

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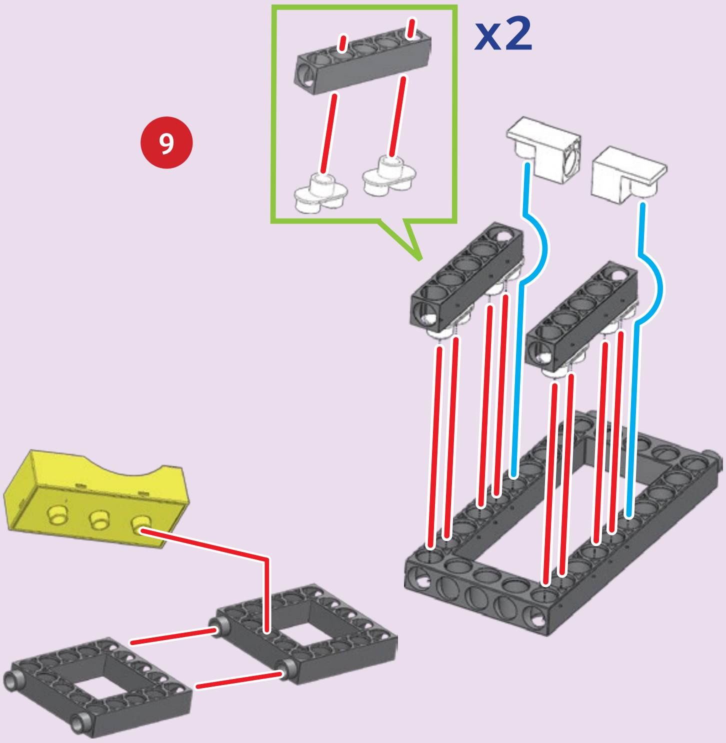

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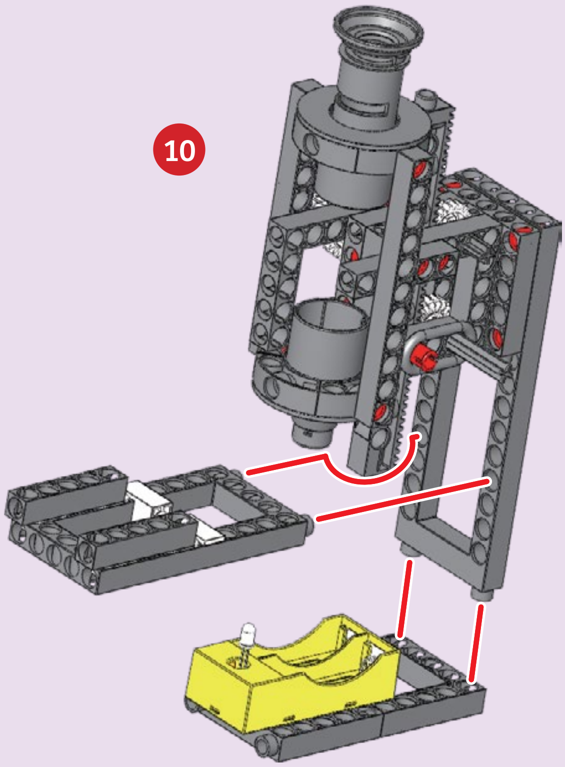

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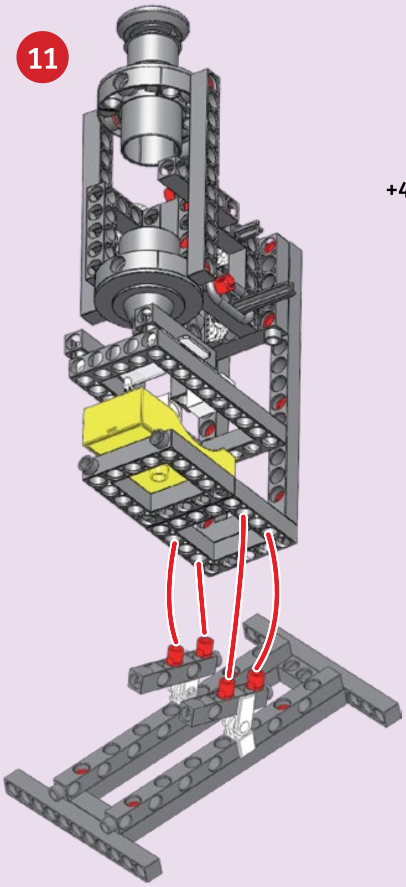

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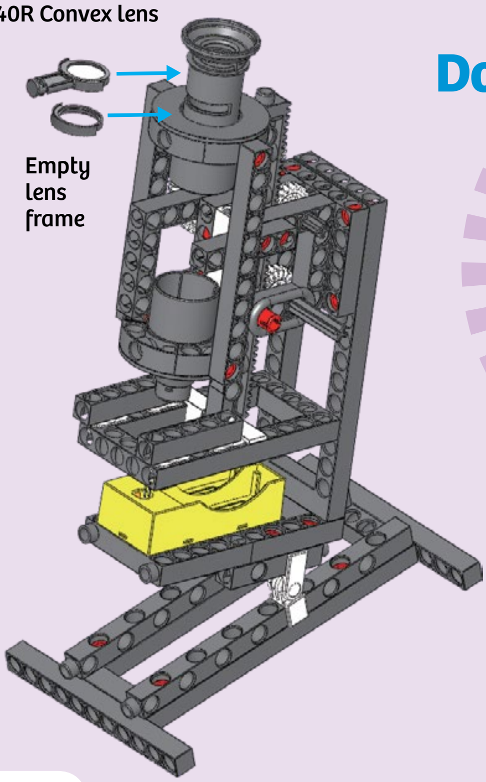


Done!

TIP !

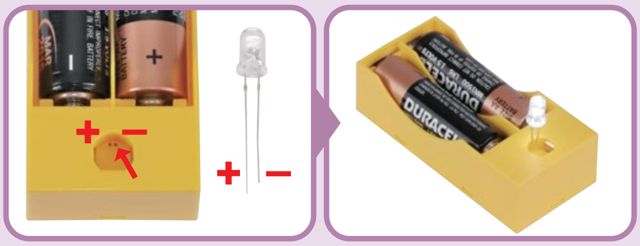
Please refer to page 54 for instructions for installing the LED light bulb and slide.

Lens system

Objective lens: +10R Convex lens x1

Eyepiece lens: +40R Convex lens x1

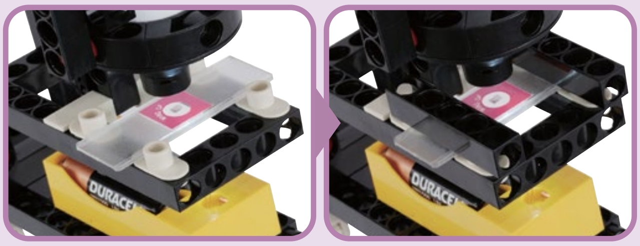
Installing the LED Light



1. Look closely and you will see two small holes in the battery holder. The LED has two wire legs: the long one is positive and the short one is negative.

2. Insert the LED into the small holes with the positive leg in the positive hole and the negative leg in the negative hole. The LED will light up. If the legs are reversed, the LED will not light up.

Positioning the Slides



1. Remove the 5-hole rod from both sides of the microscope stage. Place the slide on the stage.

2. Install 5-hole rod to secure the slide in position.

Experiment 25

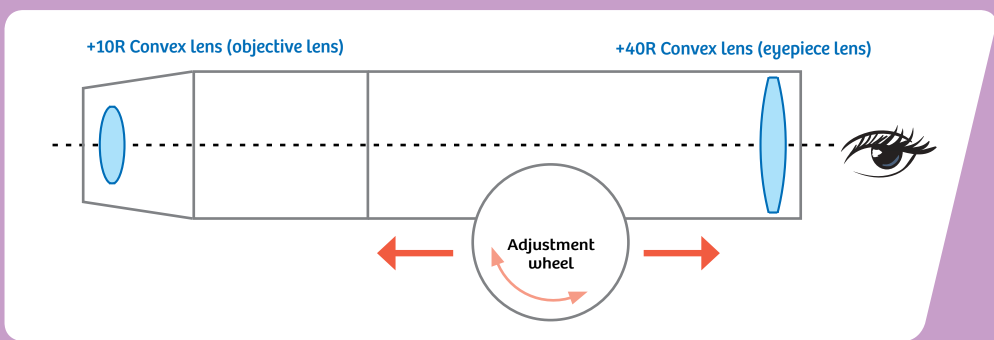
HERE'S HOW

1. Turn the big grey gear on the side of the microscope, and a clear image will appear. Start close to the slide and slowly turn the adjustment wheel while looking through the eyepiece until the image on the slide comes into focus. Turn the wheel slowly. Turn it slightly past the position for a clear image, then turn the wheel back a little to refine the focus. You may need to move the slide as well to ensure that there is a specimen under the objective lens.

2. The sawtooth joint can be adjusted to different angles so the scope can be positioned at the best angle for viewing.

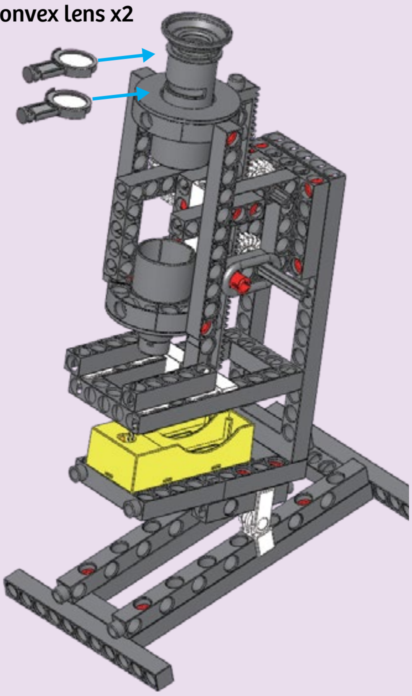
WHAT'S HAPPENING?

This desktop microscope has a relatively low power for desktop microscopes. Before using a higher-power microscope, you should start with this microscope to get the hang of it. A desktop microscope is effective in preventing the shaking caused by an unsteady hand. Because the image appears inverted, when adjusting the position, the object on the stage will move in the opposite direction.



EXPERIMENT 26

1 +40R Convex lens x2



High Power Desktop Microscope (50x)

Lens system

Objective lens: +10R Convex lens x1
Eyepiece lens: +40R Convex lens x2

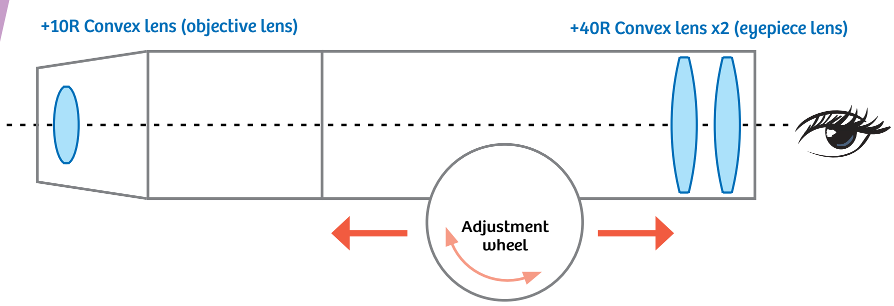
Experiment 26

HERE'S HOW

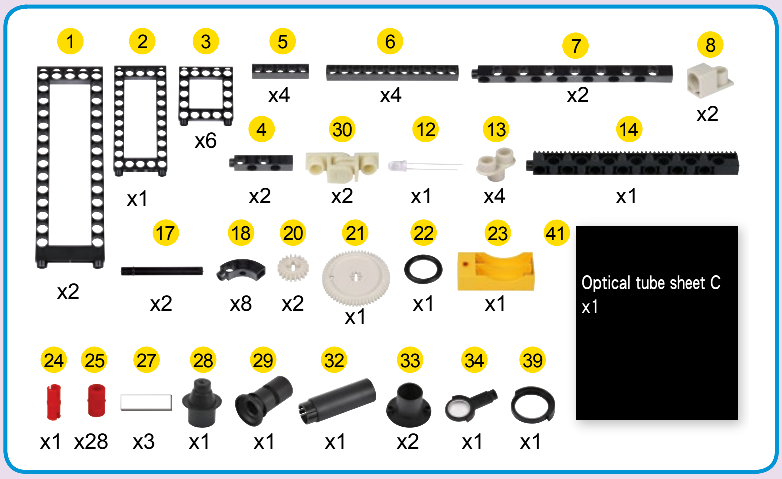
1. Replace the empty lens frame with a second +40R Convex lens. Repeat the observation from the previous experiment.

WHAT'S HAPPENING?

What do you notice about the image in this version of the microscope? The image should be larger (magnified more) than in the previous experiment.

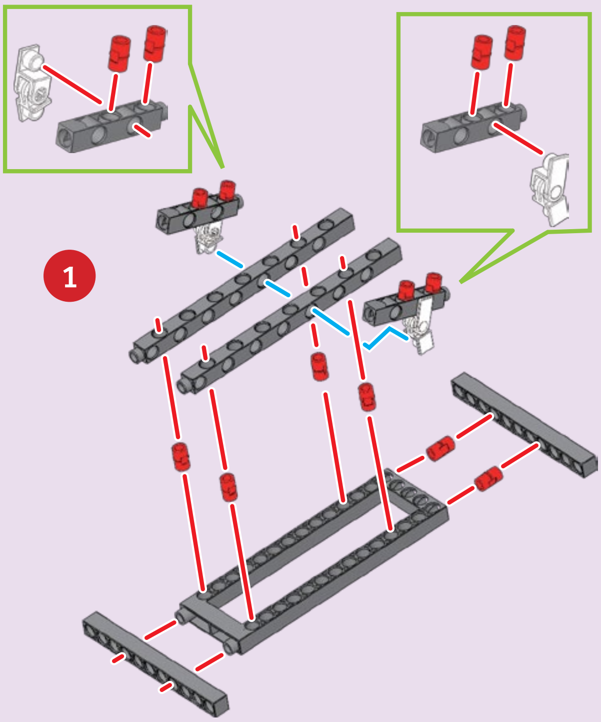


EXPERIMENT 27



Medium Power Desktop Microscope (40x)

1



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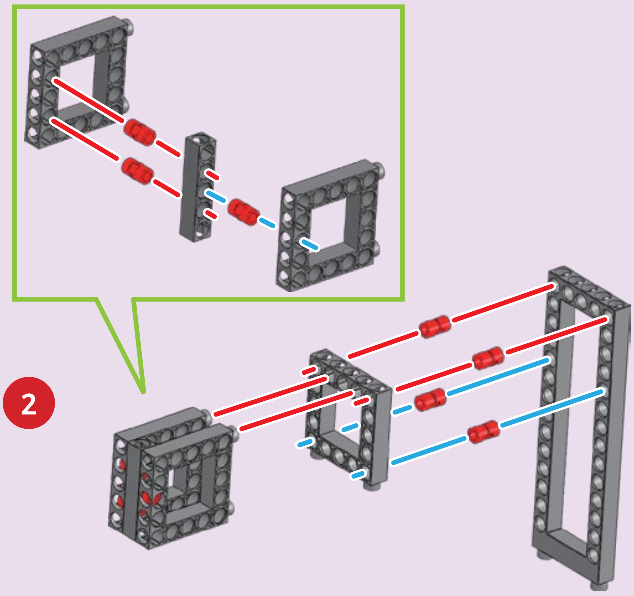

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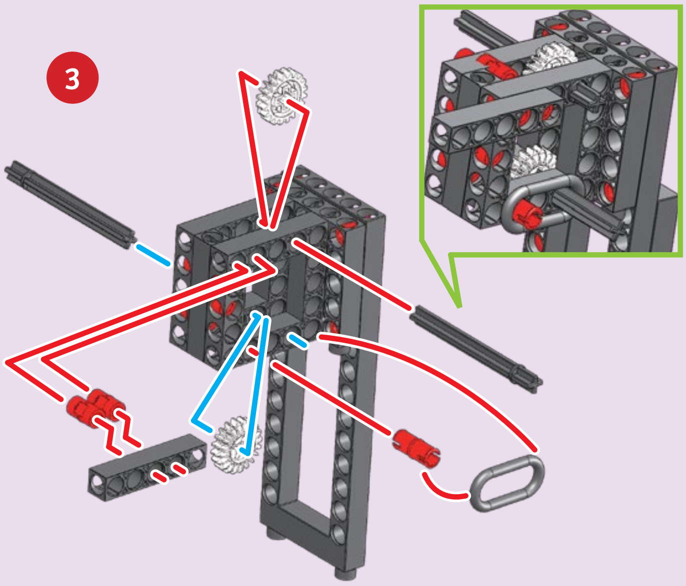

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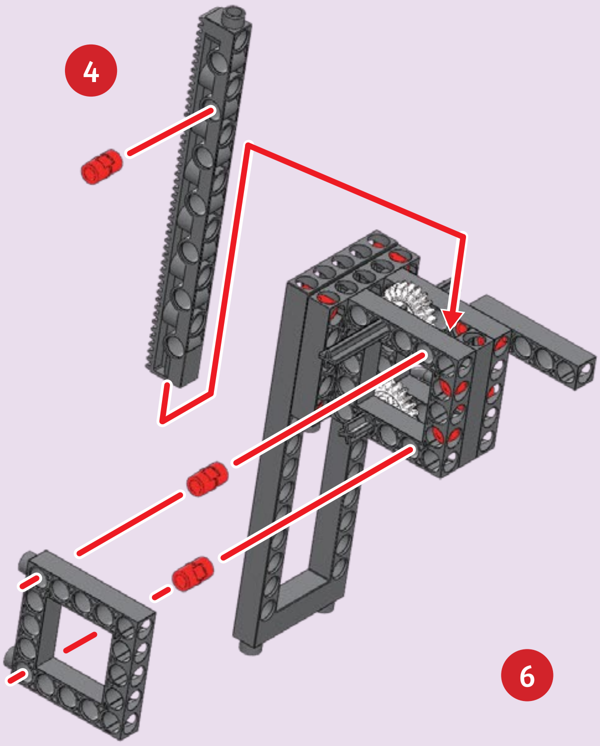

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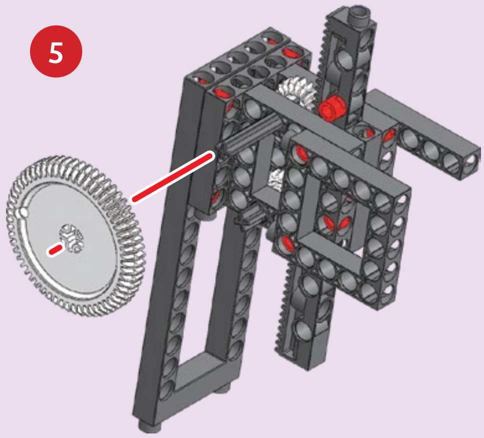

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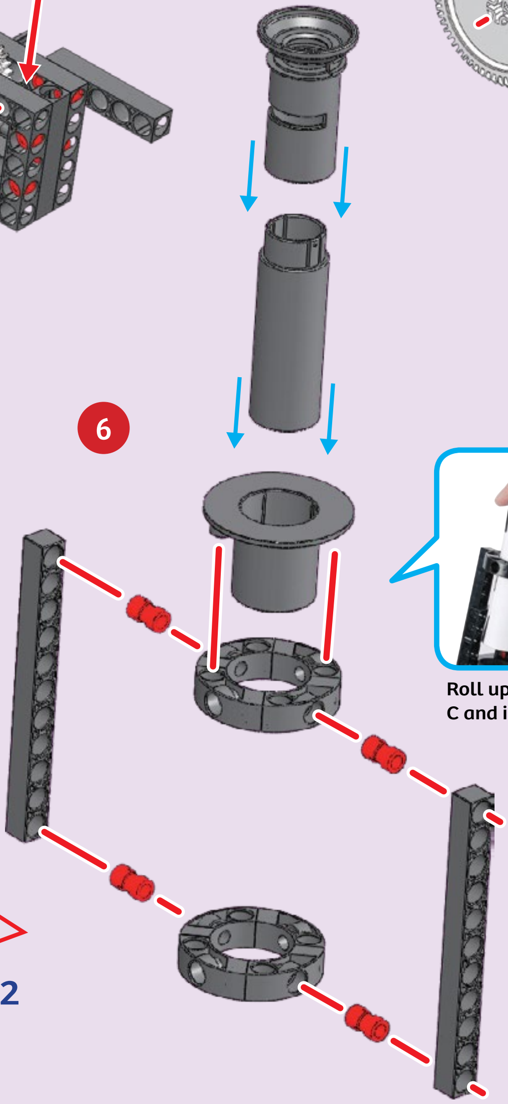
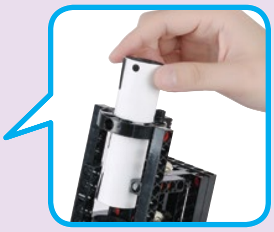
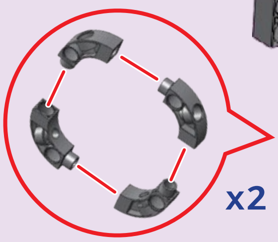




Roll up the optical tube C and insert it.



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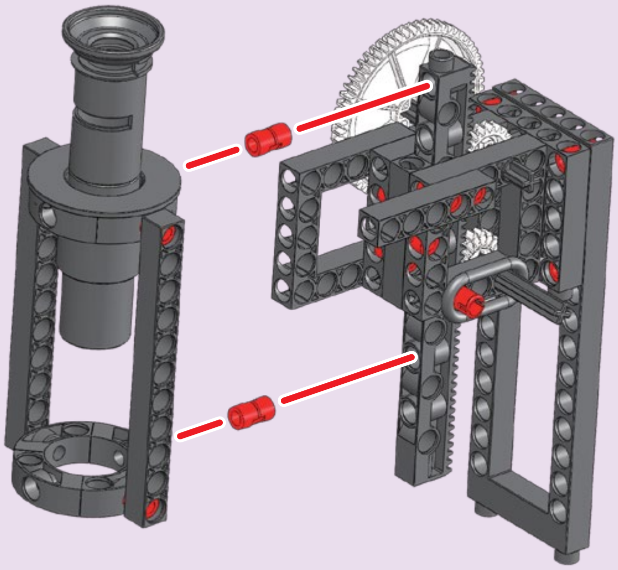

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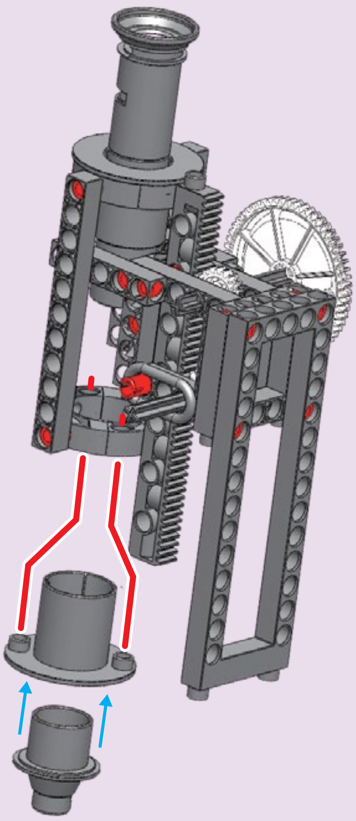

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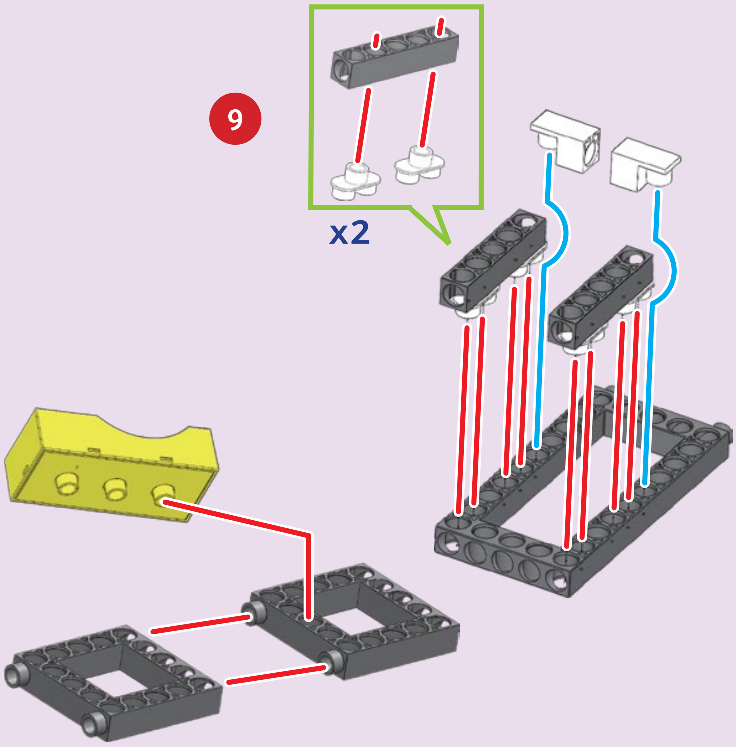

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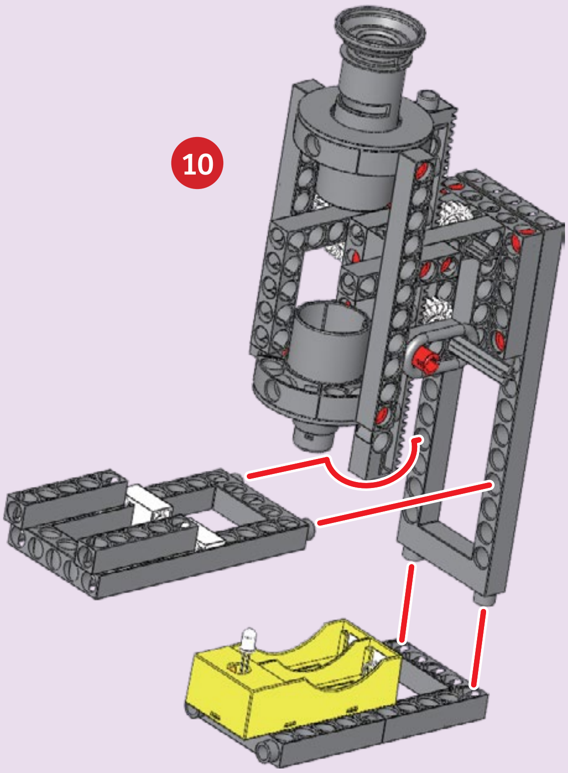

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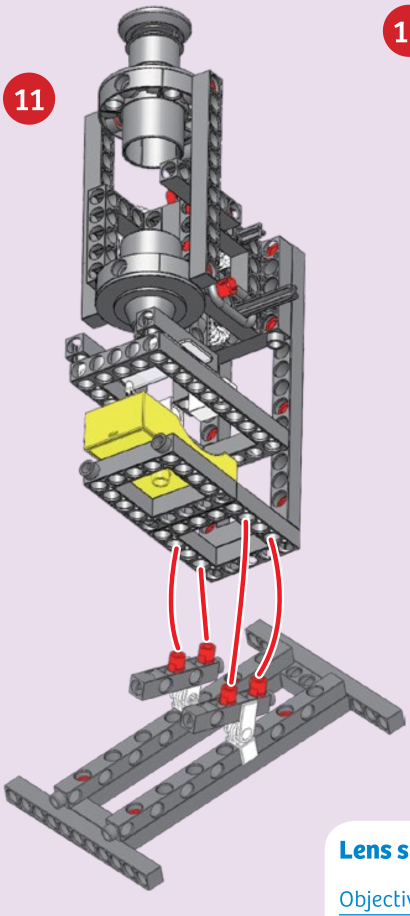

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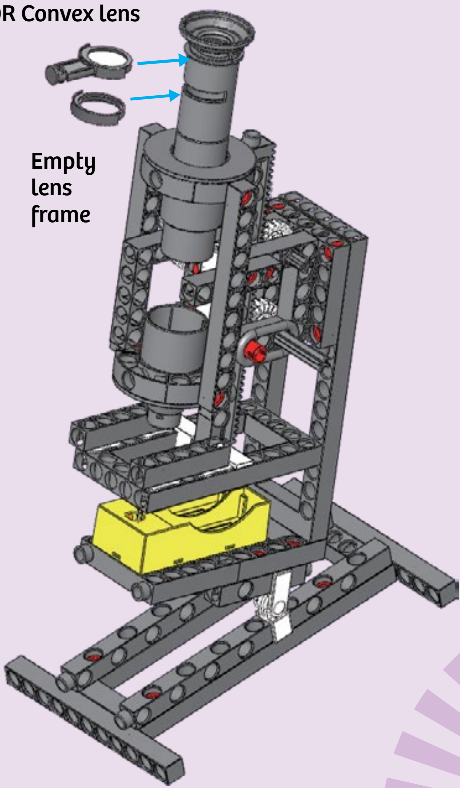
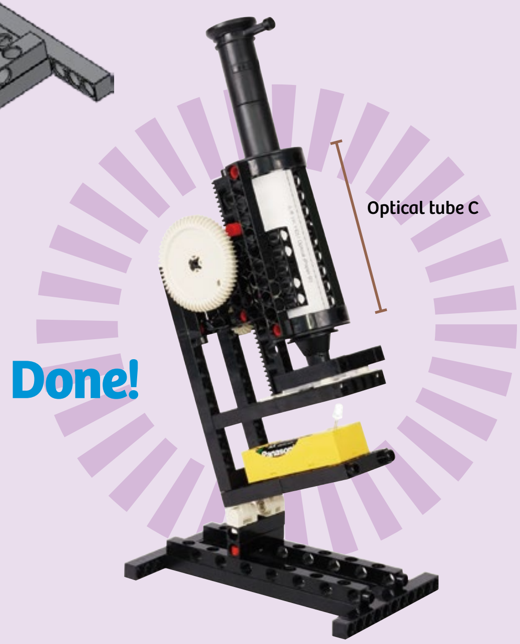


Lens system

Objective lens: +10R Convex lens x1

Eyepiece lens: +40R Convex lens x1



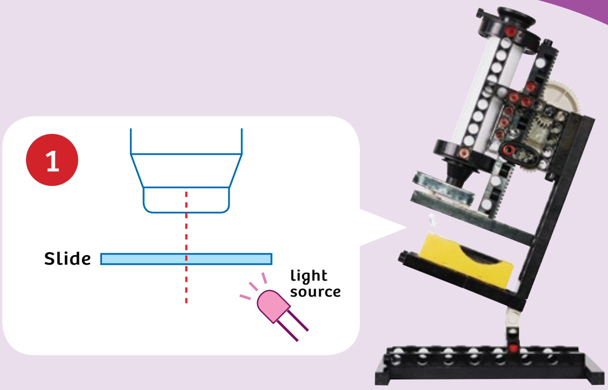
Lighting the Microscope

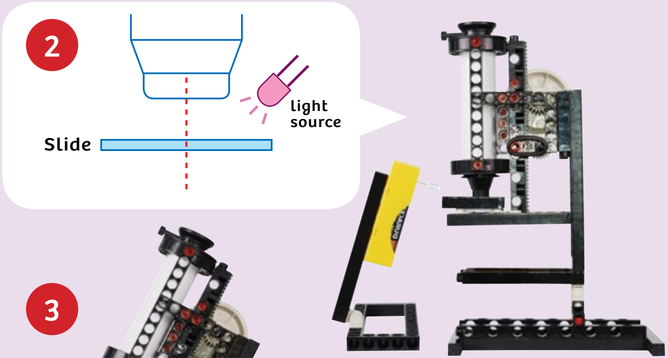
Microscopes need a lot of light to work properly. Use the methods here to control the light level to provide the right amount of brightness for different viewing situations.

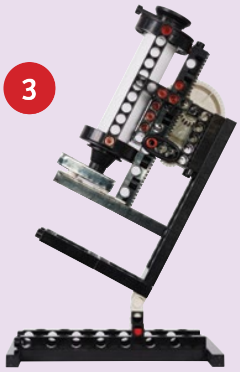
1. **LED Lighting from Below:** Good for observing objects that allow light to penetrate through them. For example: plankton, microorganisms, or plant cross sections.

2. **LED Lighting from Above:** Good for observing coins, insects, printed material, or other objects that allow no penetration of light. Try shining the light on the objects from many different angles.

3. **Natural Lighting:** Make use of sunlight or an indoor light source. Point the microscope toward the direction of the light source.







Experiment 27

HERE'S HOW

1. Turn the big grey gear on the side of the microscope, and a clear image will appear. Follow the detailed instructions in Experiment 25.

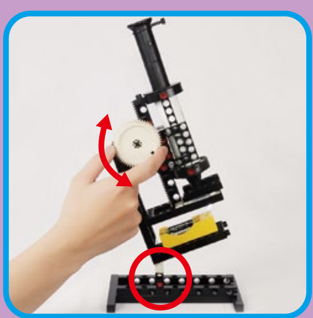
2. The sawtooth joint can be adjusted to different angles so the scope can be positioned at the best angle for viewing.

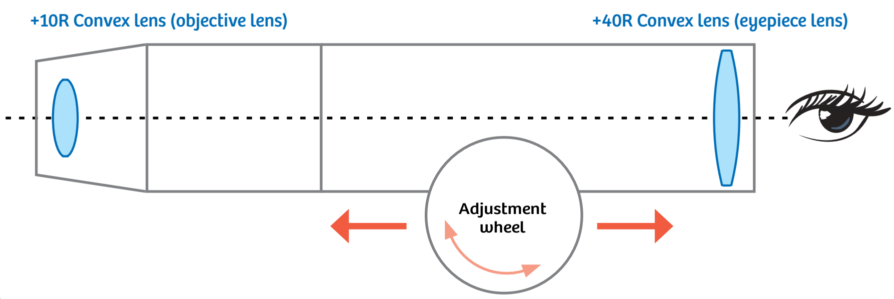
WHAT'S HAPPENING?

How big is the image you can see with the microscope? How brightness is the image?

How could you adjust the scope setup to more easily observe opaque objects that don't allow light to pass through them?

How could you adjust the scope setup to more easily observe objects that do allow light to pass through them?

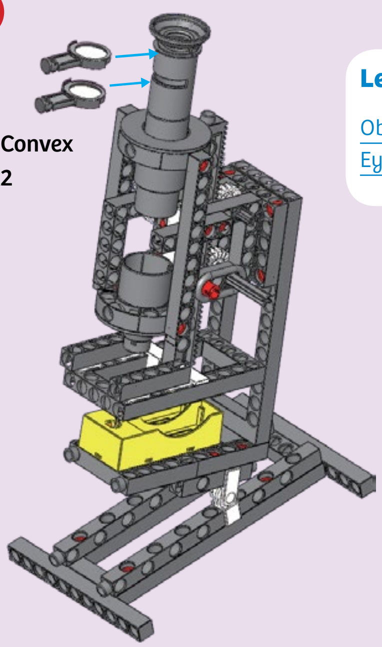




EXPERIMENT 28

High Power Desktop Microscope (80x)

1



Lens system

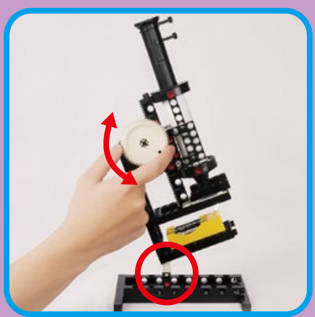
Objective lens: +10R Convex lens x1

Eyepiece lens: +40R Convex lens x2

Experiment 28

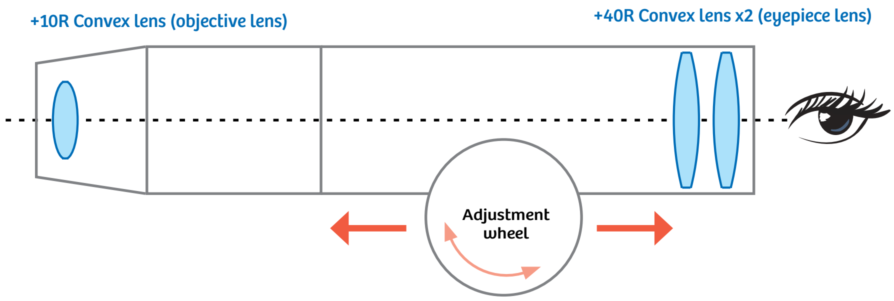
HERE'S HOW

1. Replace the empty lens frame with a second +40R Convex lens. Repeat the observation from the previous experiment.



WHAT'S HAPPENING?

What are the differences between this High Power Desktop Microscope (80x) and the Medium Power Desktop Microscope (40x) from the previous experiment? Which microscope gives you the best image of each of the prepared slides?



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