

EXPERIMENT MANUAL

SunBots

SOLAR-POWERED 8-IN-1 ROBOTS



THAMES & KOSMOS



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Thames & Kosmos, 89 Ship St., Providence, RI, 02903, USA | 1-800-587-2872 | www.thamesandkosmos.com

Dear Parents and Adults,

With this kit, you and your young engineers can build eight fun solar-powered models. Each model uses the same solar panel and motor, which are part of a module called the solar gearbox. Thus, the models can be built one at a time, and each model must be disassembled before the next is assembled.

By building the models, kids can learn about how the different mechanisms enable each model to move in a different way.

After a model is assembled, you can power it with direct sunlight or a lamp with a high-wattage incandescent or halogen light bulb held a few inches above the solar panel. Sunlight is far more powerful than any artificial light source. By experimenting with the solar panel, kids can learn a lot about this important source of renewable energy.

There is no battery, so energy is not stored in the device. It operates as long as it is exposed to a powerful enough light source.

Before building and experimenting, read the instructions together with your child and discuss the safety instructions. Please provide your child with the help and advice that he or she needs for tricky assembly steps and experiments, and accompany him or her every step of the way.

If your child is working on a table, provide a table mat to prevent damage to the furniture.

When cutting the plastic parts with a cutter, special care must be taken to avoid sharp edges, rough edges, and burrs. These can be removed using a cutter and a file. Provide your child with a cutter and supervise him or her until you are sure that he or she can use it without supervision.

We hope you and your child have fun building and experimenting with your SunBots!

 **CAUTION:**
Contains functional sharp edges or points.

Warning. Not suitable for children under 3 years. Choking hazard — small parts may be swallowed or inhaled.

Warning. Only for use by children aged 6 years and older, due to accessible electronic components. Instructions for parents or other supervising adults are included and have to be observed. Keep packaging and instructions as they contain important information.

NOTES ON ENVIRONMENTAL PROTECTION/NOTES ON DISPOSAL OF ELECTRICAL AND ELECTRONIC COMPONENTS:

The electronic components of this product are recyclable. For the sake of the environment, do not throw them into the household trash at the end of their lifespan. They must be delivered to a collection location for electronic waste, as indicated by the following symbol:



Please contact your local authorities for the appropriate disposal location.

>>> TABLE OF CONTENTS

Safety Information.....	Inside front cover
Table of Contents.....	1
Kit Contents.....	2
Tips for Assembly and Usage	3

Meet the SunBots!.....	4
Solar Panel and Motor Module Assembly Instructions	6
Solar Gearbox Module Assembly Instructions	7
Module A & B Assembly Instructions	8
Tips for Disassembly	9

Assembly Instructions for the Models

Zoomer: The Race-Car SunBot	10
Armie: The Armadillo SunBot	13
Bronto: The Dinosaur SunBot.....	17
Axel: The Big-Wheel SunBot	21
Tank: The Tank SunBot.....	25
Dizzy: The Spinning SunBot.....	29
Cricket: The Bug SunBot	33
Major: The Drumming SunBot.....	38

About Solar Energy	43
About Solar Cells	44

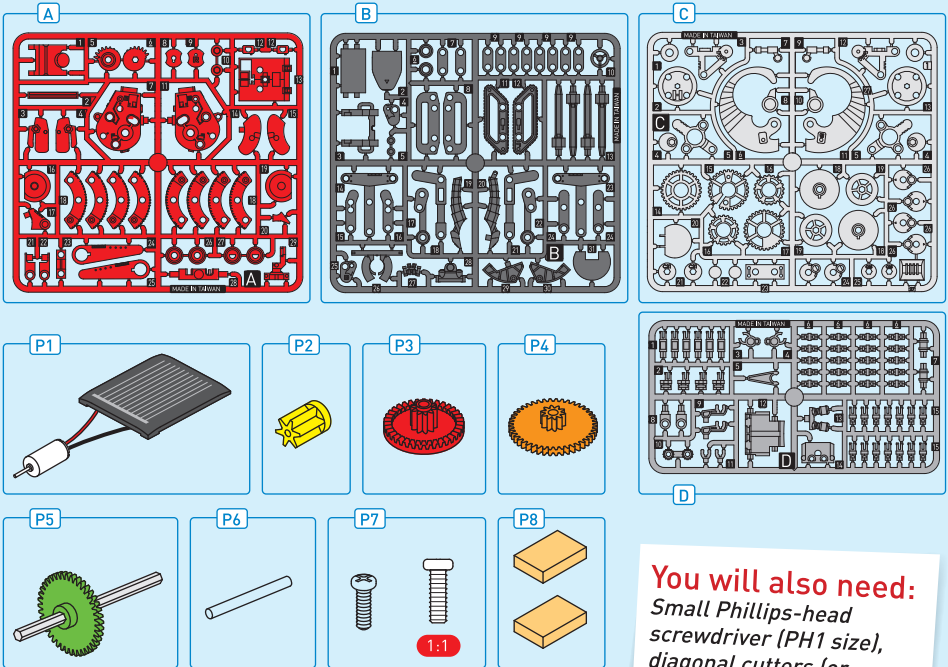
TIP!

Additional information can be found in the **Check It Out** sections on pages **43** and **44**.

GOOD TO KNOW!

If you are missing any parts, please contact Thames & Kosmos customer service: support@thamesandkosmos.com

What's inside your experiment kit:



You will also need:
 Small Phillips-head screwdriver (PH1 size), diagonal cutters (or scissors), nail file (optional)

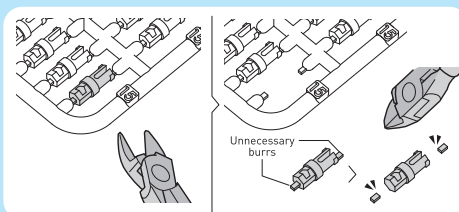
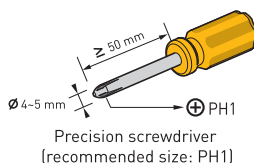
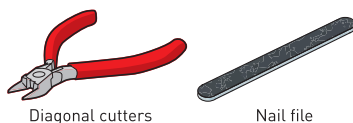
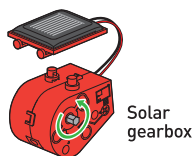
Checklist: Find — Inspect — Check Off

✓	No.	Description	Quantity
<input type="checkbox"/>	A	Plastic parts group A with parts A1 – A29	1
<input type="checkbox"/>	B	Plastic parts group B with parts B1 – B31	1
<input type="checkbox"/>	C	Plastic parts group C with parts C1 – C27	1
<input type="checkbox"/>	D	Plastic parts group D with parts D1 – D15	1
<input type="checkbox"/>	P1	Solar panel and motor	1
<input type="checkbox"/>	P2	Gear, yellow	1
<input type="checkbox"/>	P3	Gear, red	1
<input type="checkbox"/>	P4	Gear, orange	1
<input type="checkbox"/>	P5	Gear with metal shaft	1
<input type="checkbox"/>	P6	Round shaft	1
<input type="checkbox"/>	P7	Screw	1
<input type="checkbox"/>	P8	Double-sided adhesive mounting tape piece	2

>>> TIPS FOR ASSEMBLY AND USAGE

Please read through the tips below before starting and follow them during assembly and usage.

- The same solar panel and motor are used in each model. These are part of a module called the solar gearbox. First, assemble the solar gearbox following the steps on pages 6–8, and then use it to assemble each model, one at a time.
- You will need the tools shown to the right.
- Cut the plastic parts from their frames only when they are required. Do not cut them in advance.
- Use diagonal cutters or scissors to cut the plastic parts from the frames.
- Remove excess material and burrs using a cutter and a nail file before assembly. Look closely at the illustrations of the parts in this manual and be careful not to remove any portion of the actual parts themselves.
- Use a screwdriver of the correct size. Follow the steps to the right to fasten the screw perfectly.
- Tighten the screw all the way in. If it is not fastened tightly enough, the models may not function properly, may wear more quickly, and may fall apart.
- To power your model, put it in direct sunlight. You can also power it indoors using a lamp with a high-wattage (at least 50 watts) incandescent or halogen light bulb, held a few inches above the solar panel. Since there is no battery, energy is not stored in the device. It operates as long as it is exposed to a powerful enough light source.



Insert the tip of the screwdriver into the top of the screw, aligning it with the shaft of the screw.



Correct



(1) Turn the screwdriver to screw in the screw.

(2) Feel the tension increasing.

(3) Keep screwing until the screw is screwed all the way in.



Incorrect



Repeat until all the screws are tightly fastened.



MEET THE SUNBOTS!



NAME: ZOOMER (RACE-CAR SUNBOT)

HOME: SALT FLATS

SKILLS: RACING ALONG LONG, FLAT, STRAIGHTAWAYS

NOTES: LOVES SUPER SUNNY DAYS; CRUISING ON SANDY BEACHES; DRIVING REALLY, REALLY FAST!



NAME: ARMIE (ARMADILLO SUNBOT)

HOME: GRASSLANDS

SKILLS: SOMERSAULTS, TUMBLING, STRONG DEFENSIVE SKILLS

NOTES: AS LONG AS THE SUN IS SHINING, YOU CAN FIND ARMIE DOING SOMERSAULTS AND HAVING FUN!



NAME: TANK (TANK SUNBOT)

HOME: DESERT

SKILLS: ROVING OVER ROUGH DESERT TERRAIN; FINDING OASES

NOTES: TANK TREADS FOR FEET; LOVES TO EXPLORE DRY, LONELY DESERTS (WHERE THERE IS LOTS OF SUN!)



NAME: DIZZY (SPINNING SUNBOT)

HOME: ICE SHEETS

SKILLS: SPINNING AROUND IN CIRCLES; ICE SKATING; DANCING

NOTES: YOU CAN FIND DIZZY TWIRLING ENDLESSLY ON THE SUNNY, COLD ICE SHEETS AT THE NORTH POLE



NAME: BRONTØ (DINOSAUR SUNBOT)

HOME: JUNGLE

SKILLS: CAN GO WHERE BRONTOSAURUSES
COULD NEVER FIT BEFORE

NOTES: BRONTOSAURUSES ATE PLANTS FOR
ENERGY, BUT BRONTØ IS POWERED
DIRECTLY BY THE SUN!



NAME: AXEL (BIG-WHEEL SUNBOT)

HOME: CITY SIDEWALKS

SKILLS: MANEUVERING THROUGH THE CITY;
HOPPING CURBS; PATROLLING

NOTES: LOVES TO GIVE RIDES TO KIDS — AS
LONG AS THEY DON'T SIT ON THE
SOLAR PANEL AND BLOCK THE SUN!



NAME: CRICKET (BUG SUNBOT)

HOME: FOREST

SKILLS: CREEPING AND CRAWLING; ASPIRING
TAP DANCER

NOTES: CRICKET CRAWLS FROM BRANCH TO
BRANCH IN THE FOREST, LOOKING
FOR A SHADY PLACE TO REST



NAME: MAJOR (DRUMMING SUNBOT)

HOME: HIGH SCHOOL

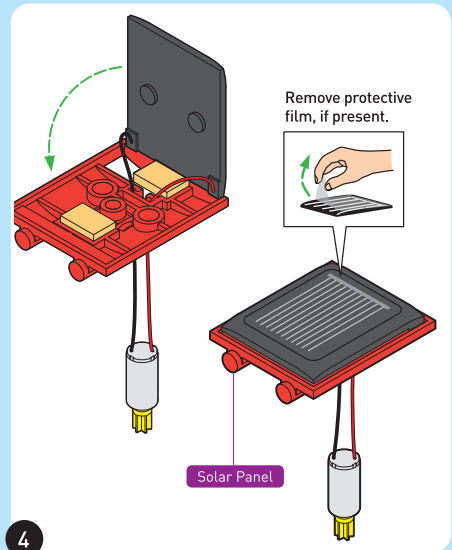
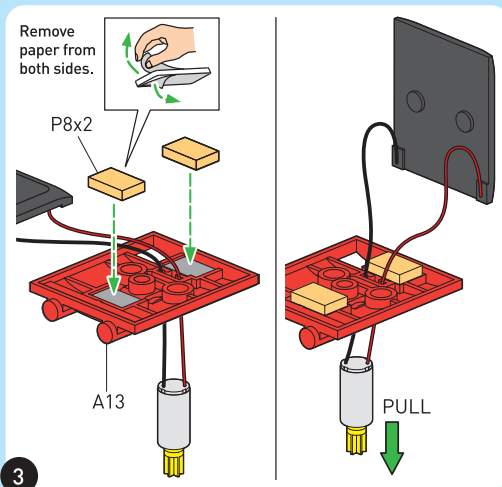
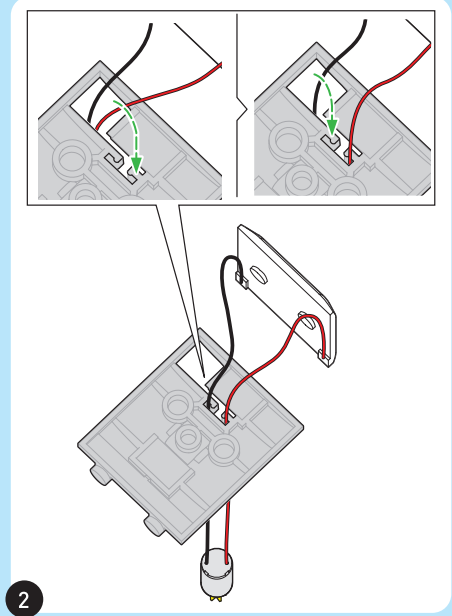
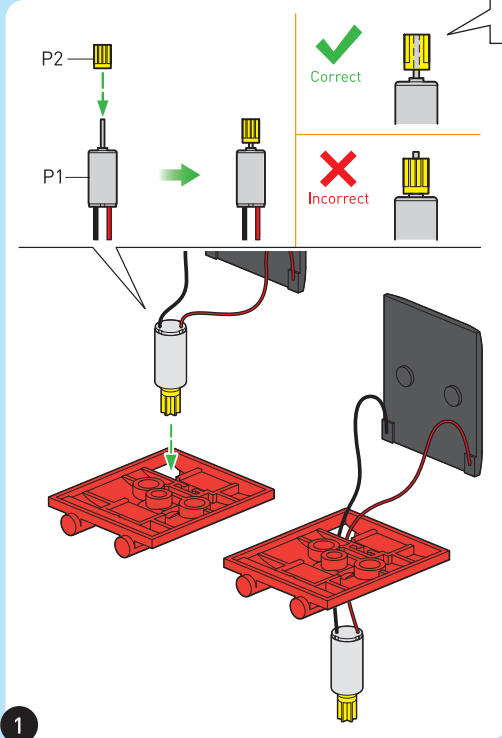
SKILLS: DRUMMING; MARCHING BAND;
KEEPING THE RHYTHM

NOTES: MAJOR LOVES A PARADE AND
MARCHES TO THE BEAT OF HIS OWN
DRUM

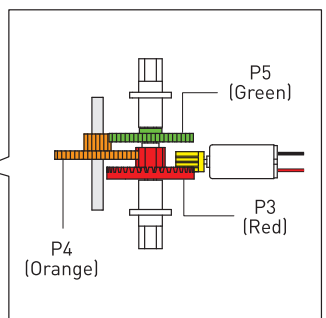
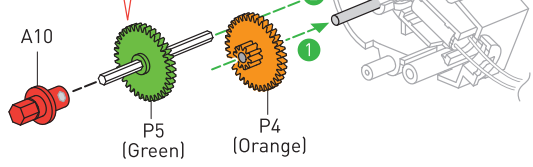
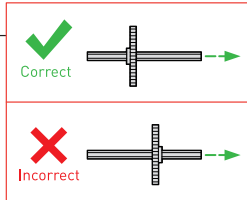
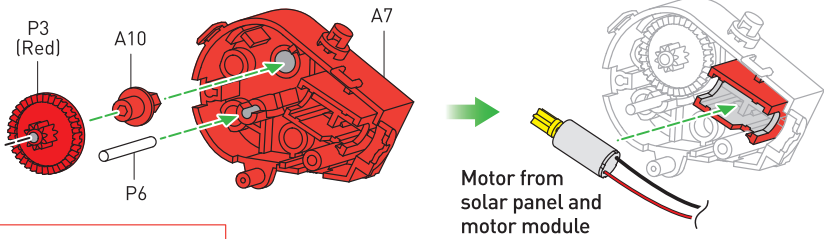
SOLAR PANEL AND MOTOR MODULE ASSEMBLY

First, follow the steps starting here to assemble the solar gearbox. Then use the solar gearbox to assemble each model, one at a time.

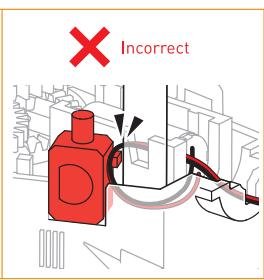
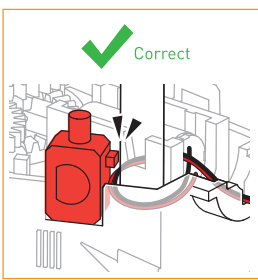
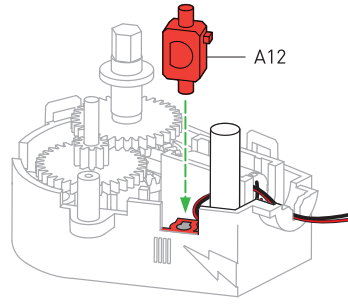
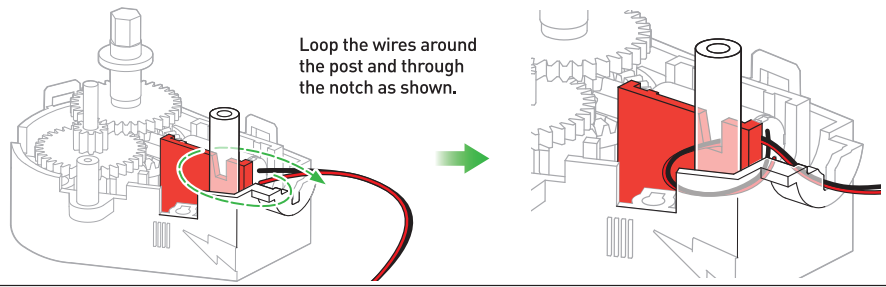
Note: You may need to adjust how much the motor axle sticks out of P2 when you get to step 1 on the next page, to get P2 and P3 to mesh properly.



SOLAR GEARBOX MODULE ASSEMBLY

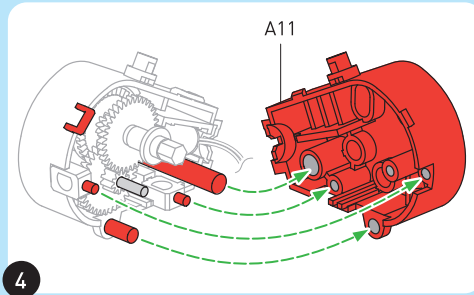
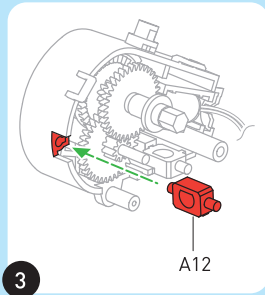


1

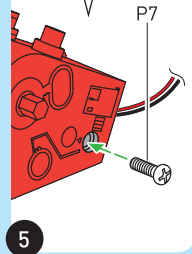


2

SOLAR GEARBOX MODULE ASSEMBLY



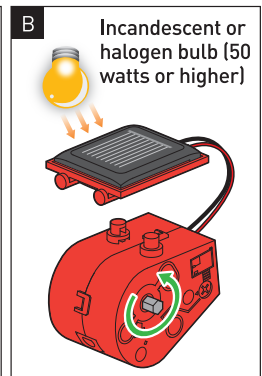
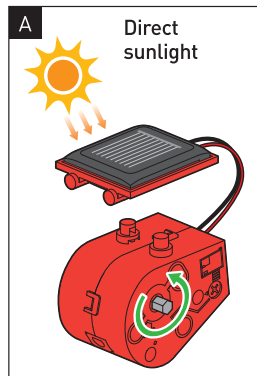
Follow the tips for tightening the screw on page 3.



SOLAR GEARBOX TESTING

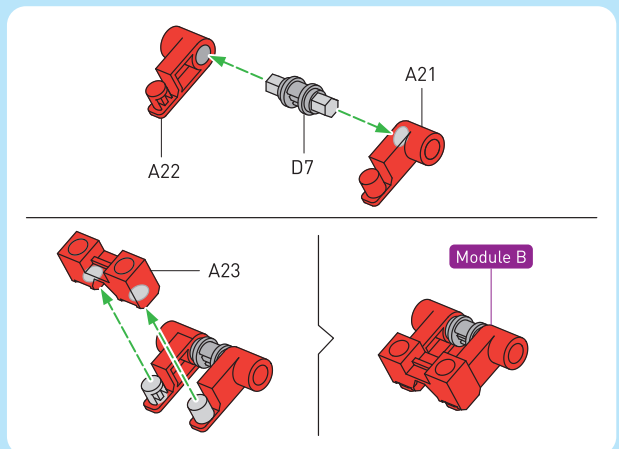
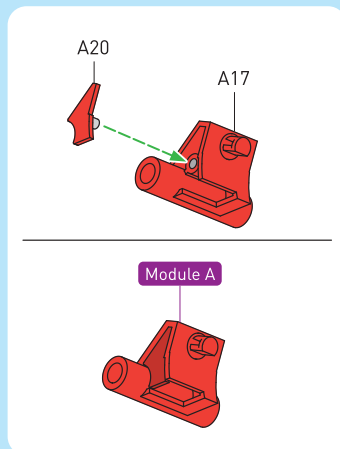
Place the solar gearbox in direct sunlight. As soon as enough light energy strikes the solar panel, the motor shaft should start spinning. If it doesn't work, carefully take it apart and reassemble it starting from the beginning.

The solar panel is a small photovoltaic system. These systems convert light energy — whether from the sun or from a powerful artificial light source — into electric current.



MODULES A & B ASSEMBLY

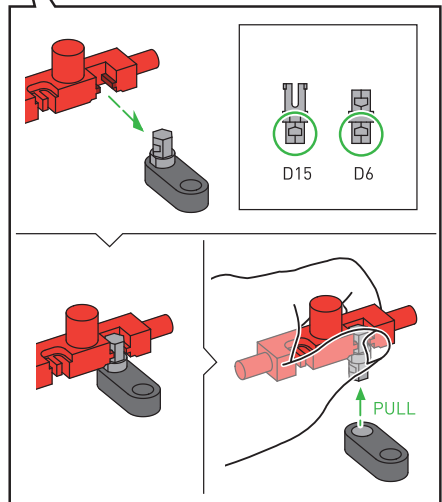
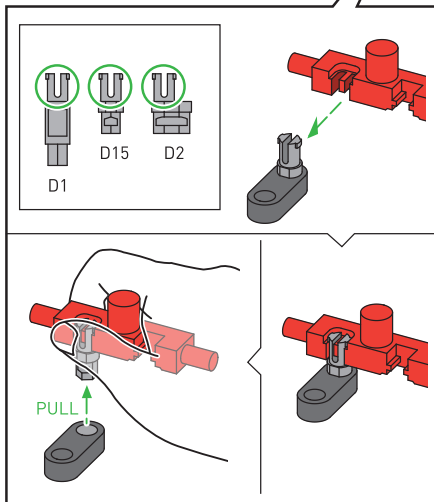
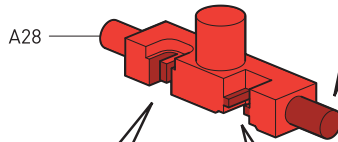
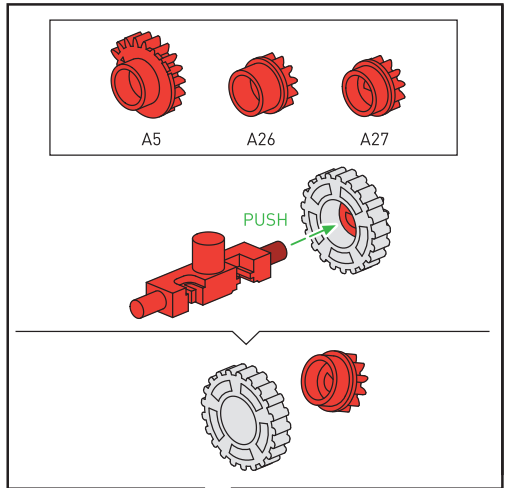
These modules are used in more than one model. Assemble them before building the models.



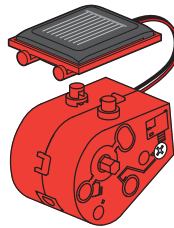
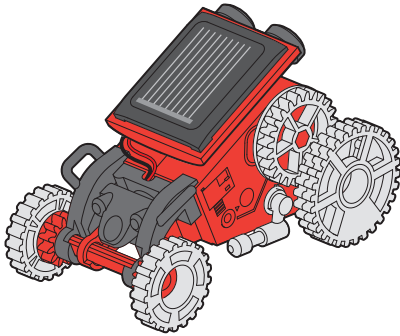
TIPS FOR DISASSEMBLY

USING THE PART SEPARATOR TOOL (PART A28)

Part A28 is a specially designed tool that can be used to help you disassemble various parts. These diagrams show you how each section of the tool can be used and for which parts.



ZOOMER



Solar Gearbox



D15x2

1:1



A2



A26x2



A27x2



A29



B3



B6x2



B10



B28



C7



C9



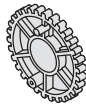
C14



C15



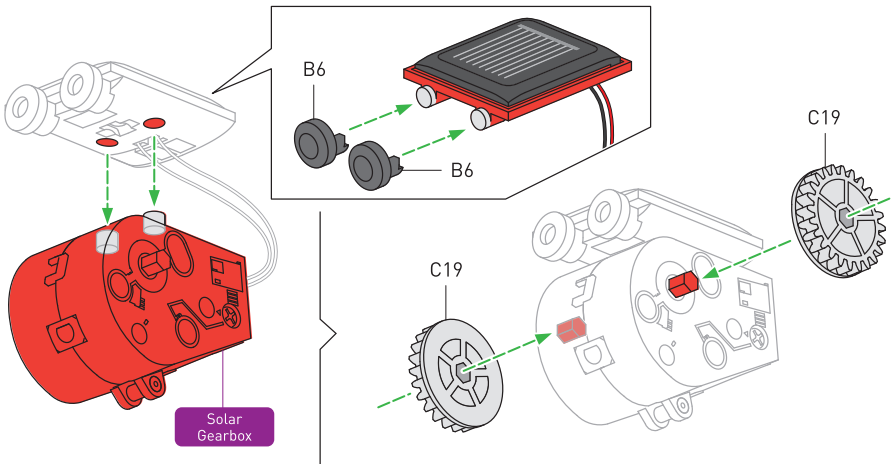
C16x2



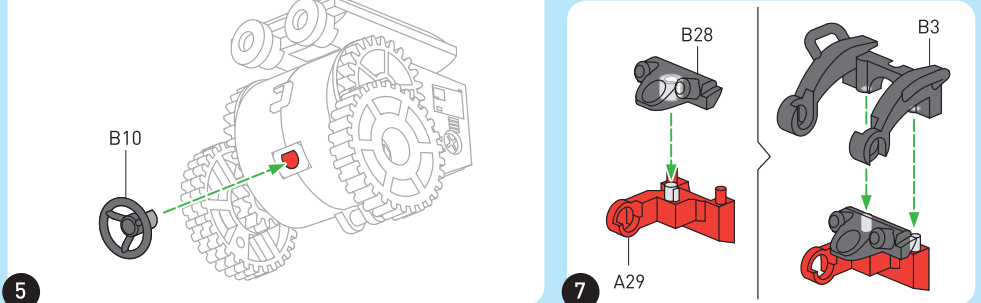
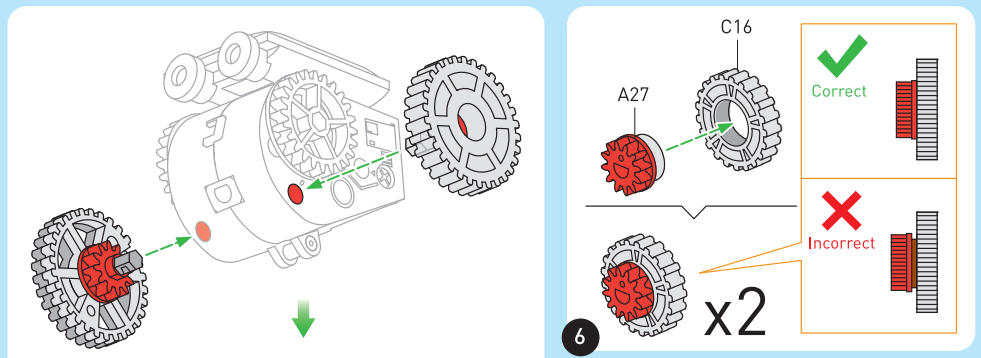
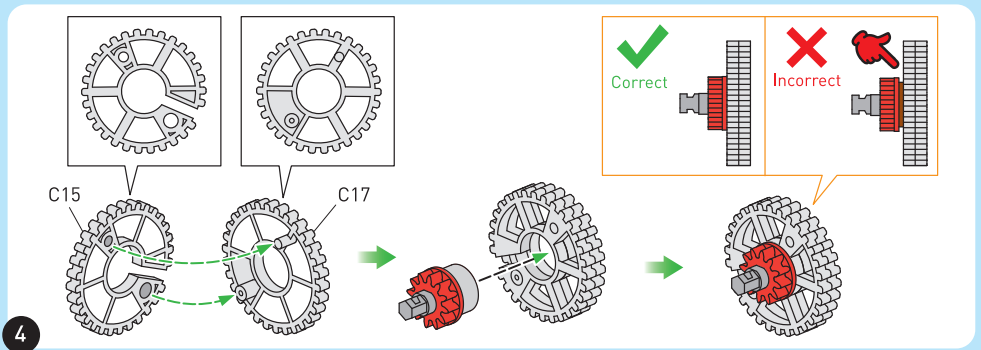
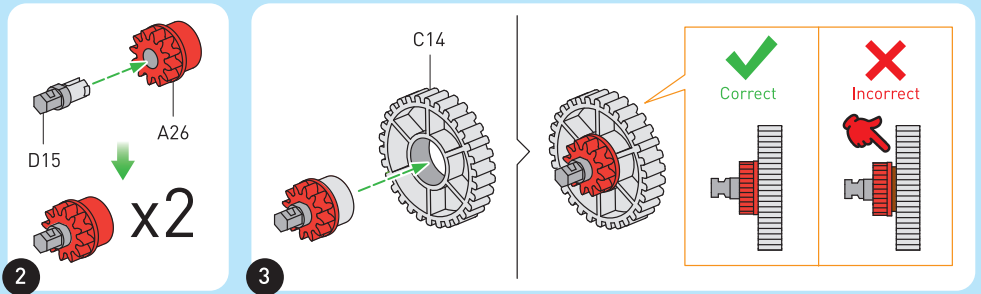
C17



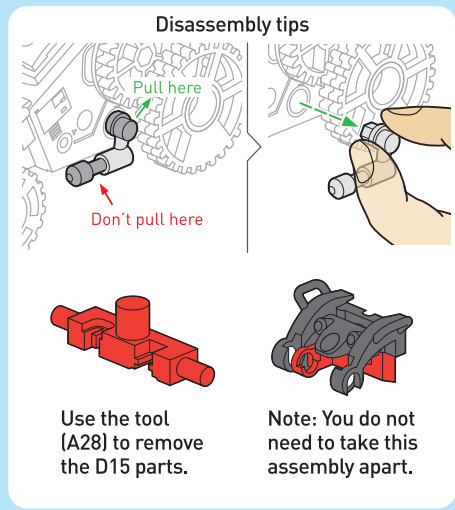
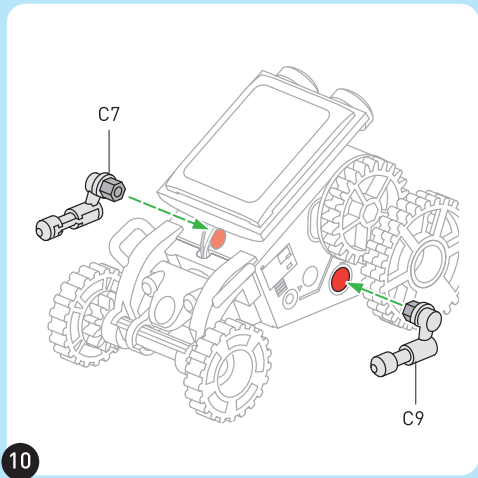
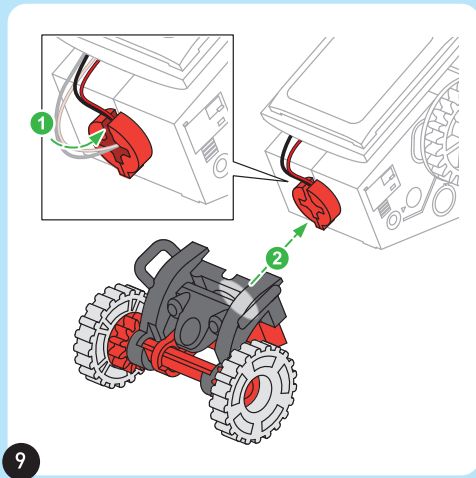
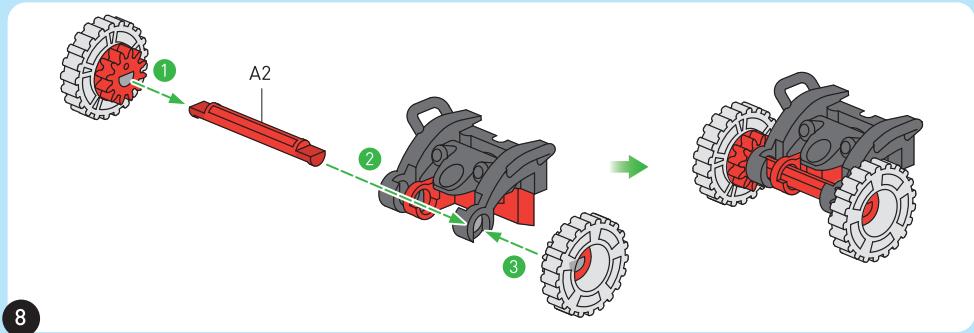
C19x2



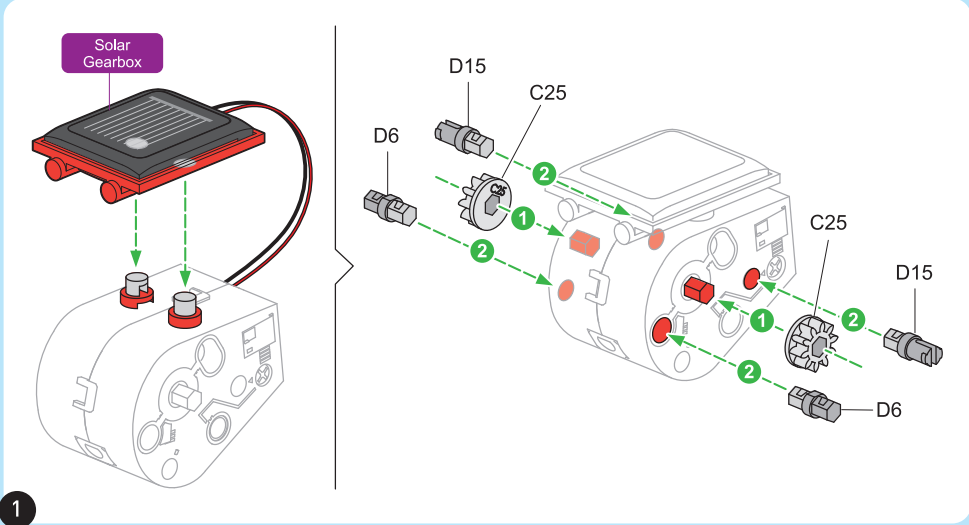
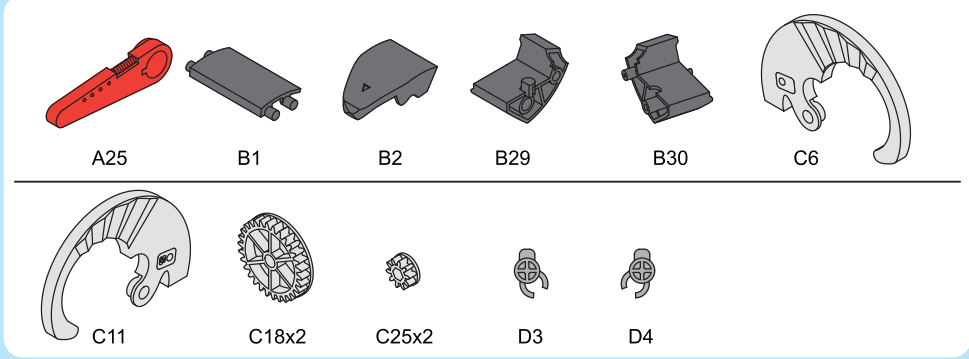
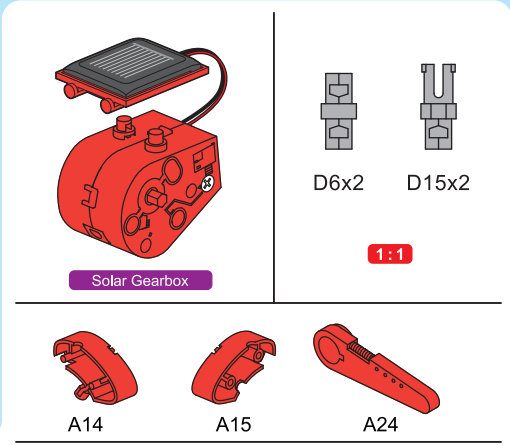
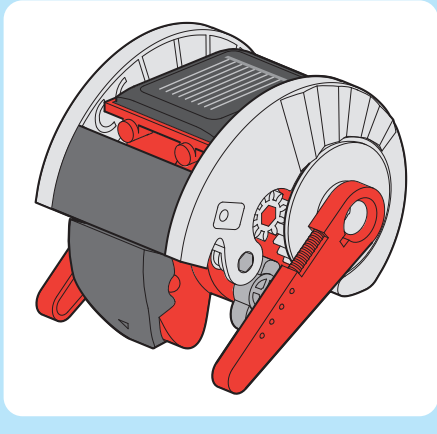
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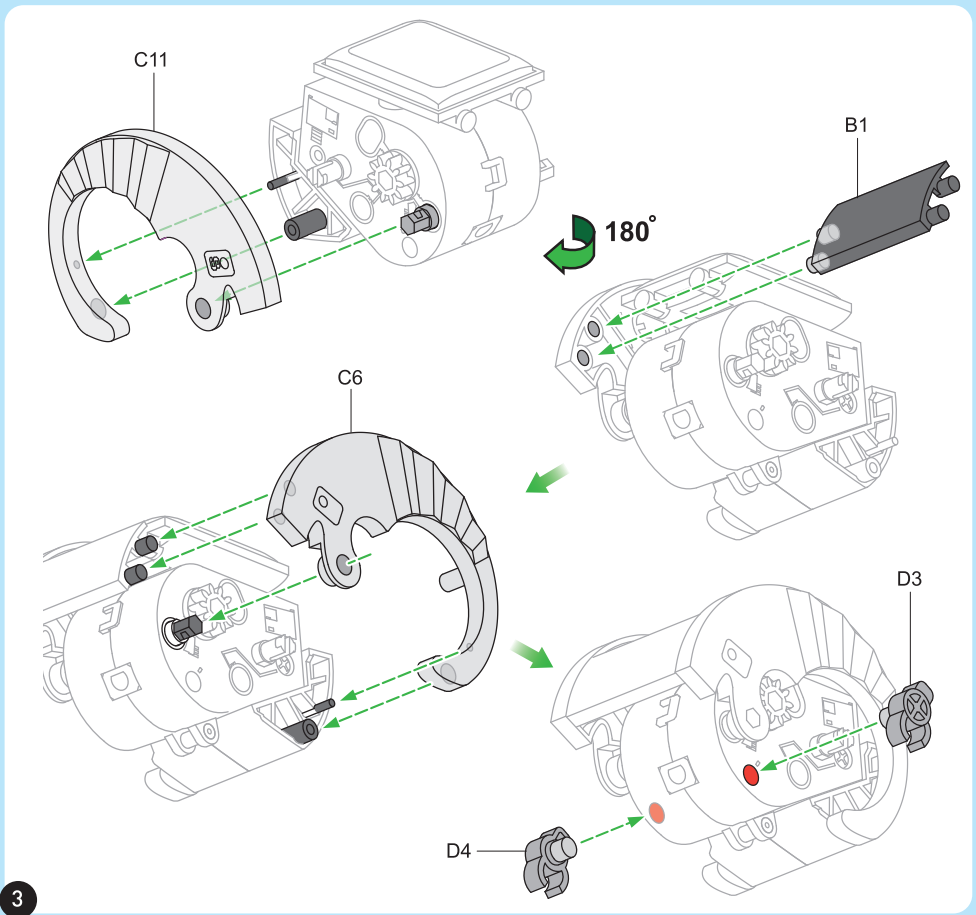
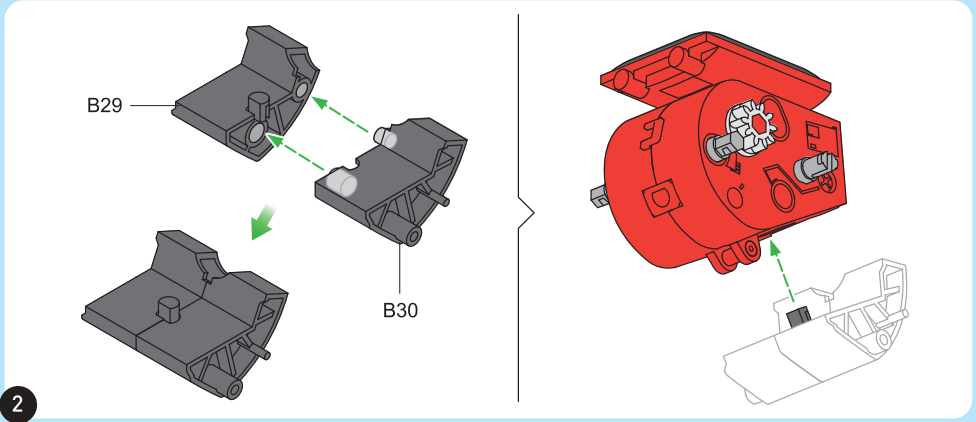


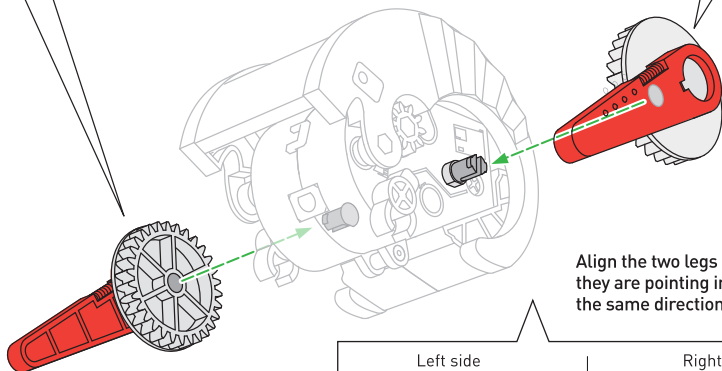
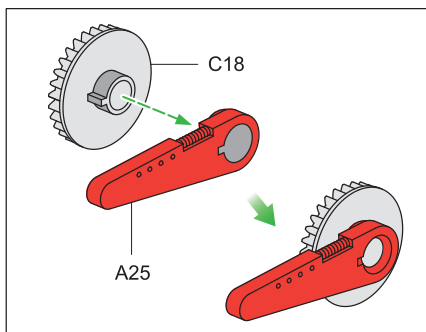
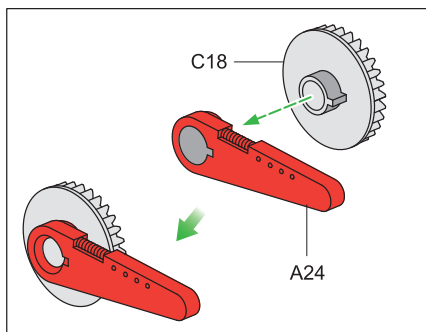
ZOOMER



ARMIE

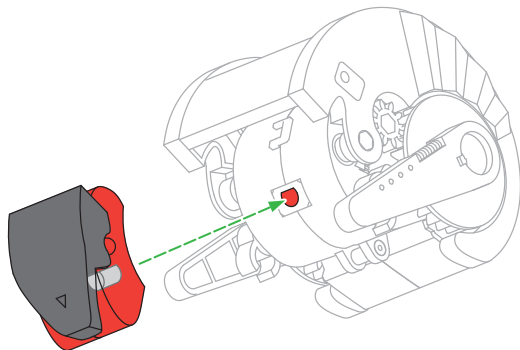
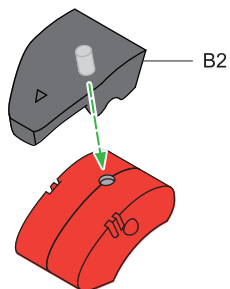
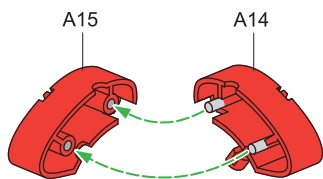
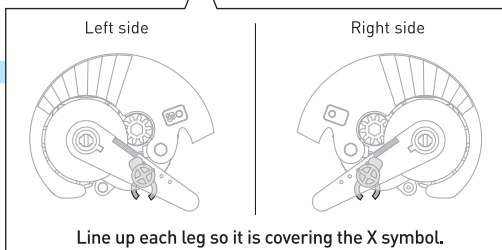




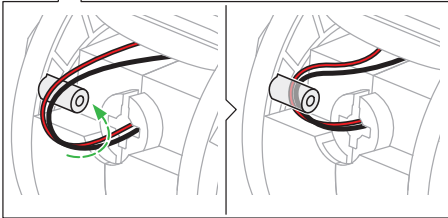
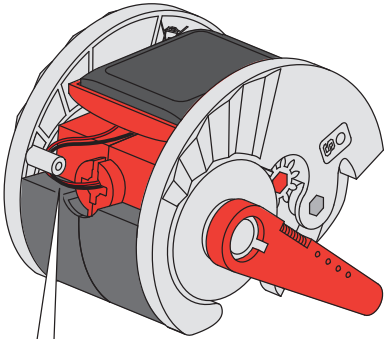


Align the two legs so that they are pointing in exactly the same direction.

4

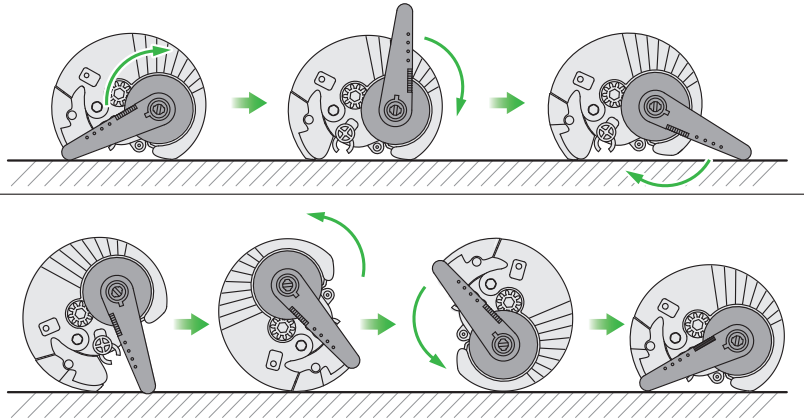


5



6

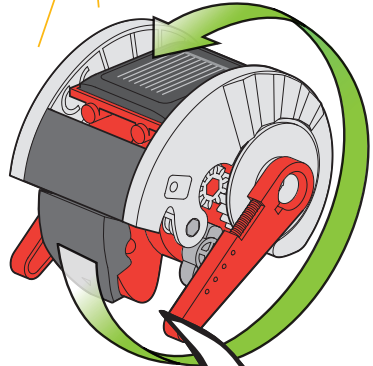
This diagram shows how the rotating leg causes the model to roll over.



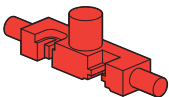
7



Done!

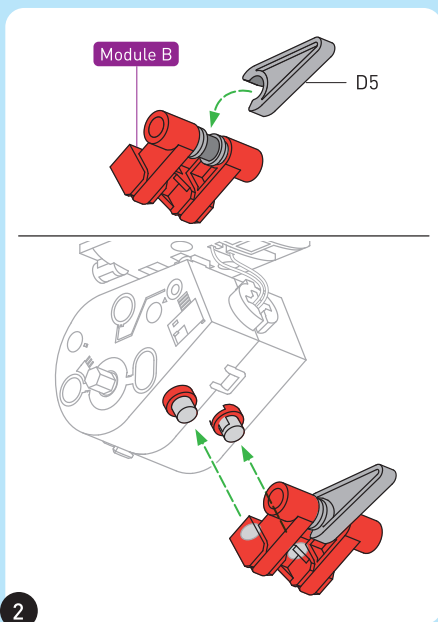
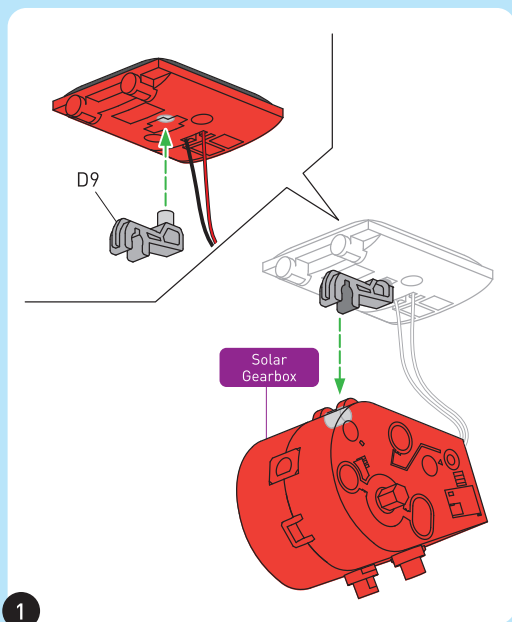
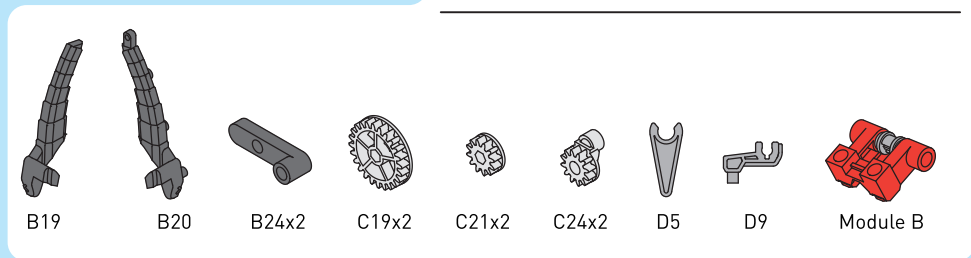
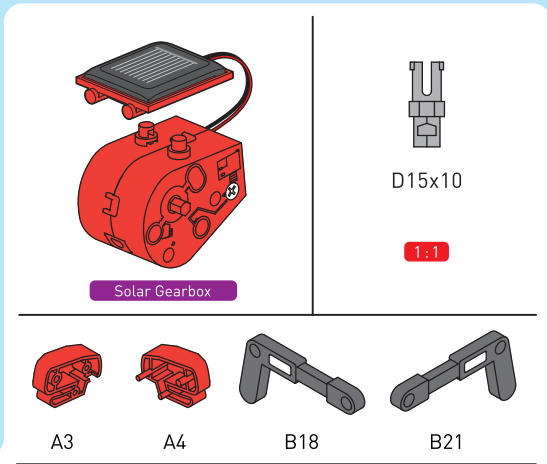
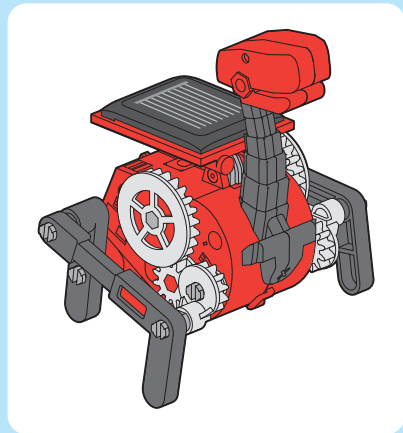


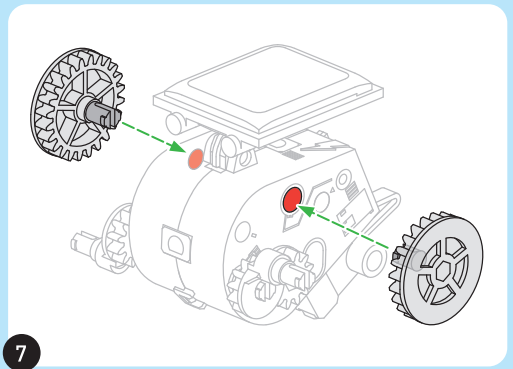
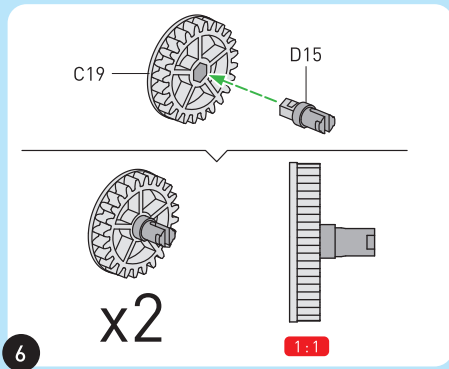
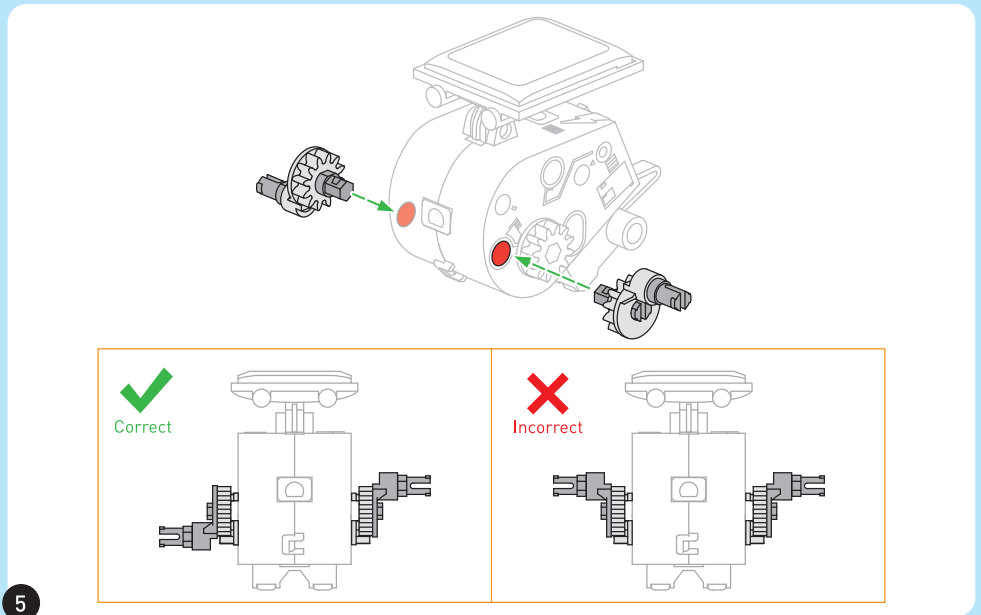
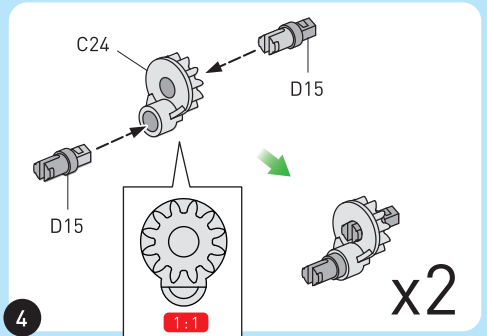
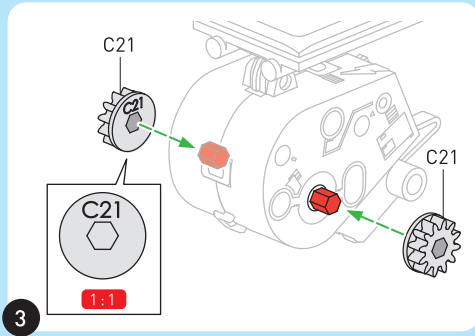
I'M READY TO ROLL!
SHINE LIGHT ON MY
SOLAR PANEL AND I'LL
START ROLLING!



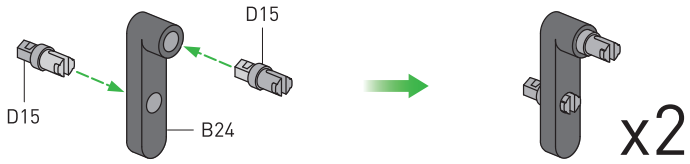
Disassembly tip: Use the tool (A28) to remove the D6 and D15 parts.

BRONTO

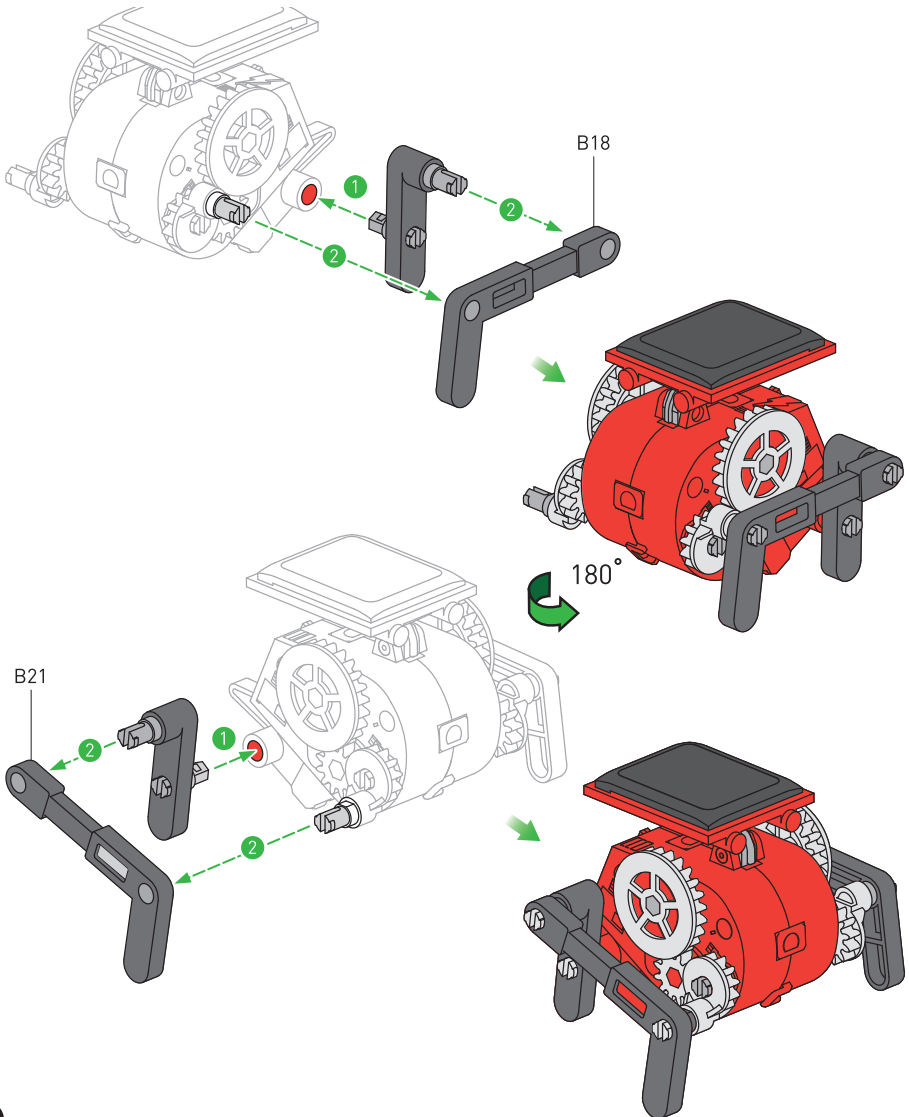




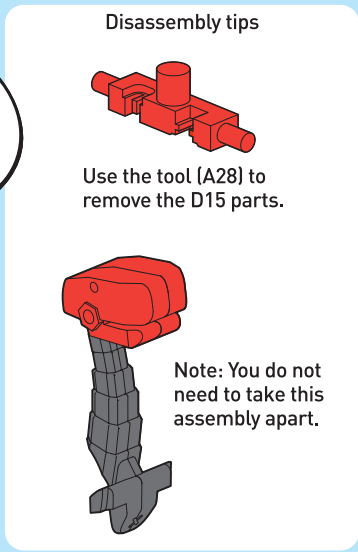
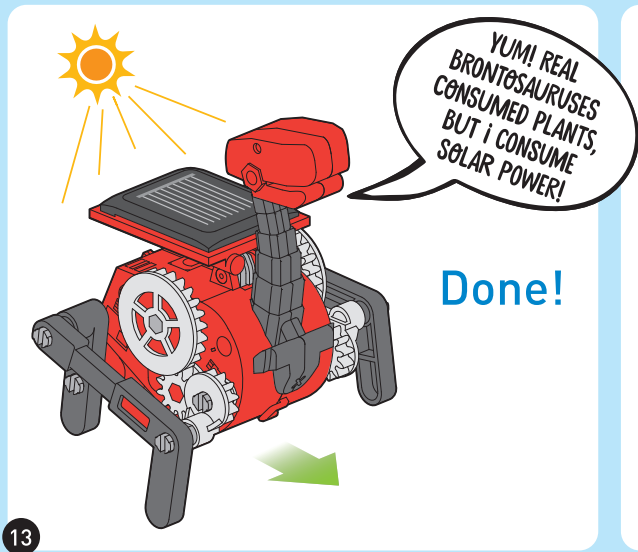
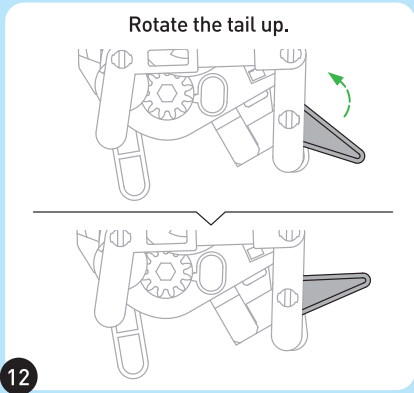
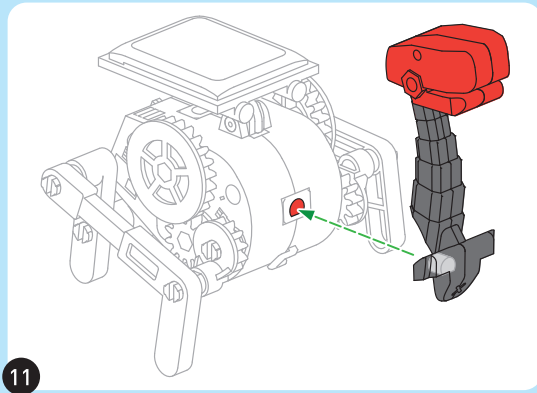
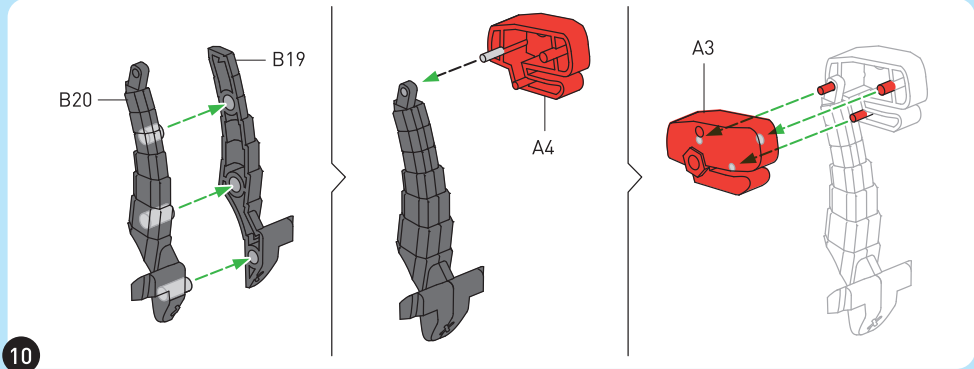
8



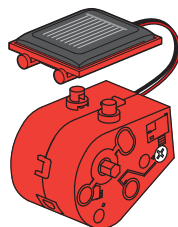
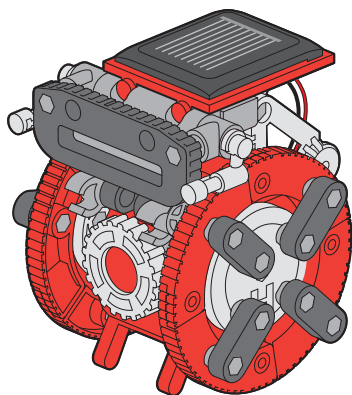
9



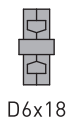
BRONTO



AXEL



Solar Gearbox



D6x18

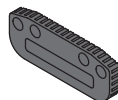
1:1



A1



A18x8



B8



B7x2

1:1



B9x8

1:1



C2



C3



C7



C9



C12



C13



C16



C23



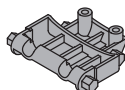
D3



D4



D8x2



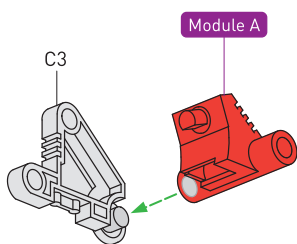
D12



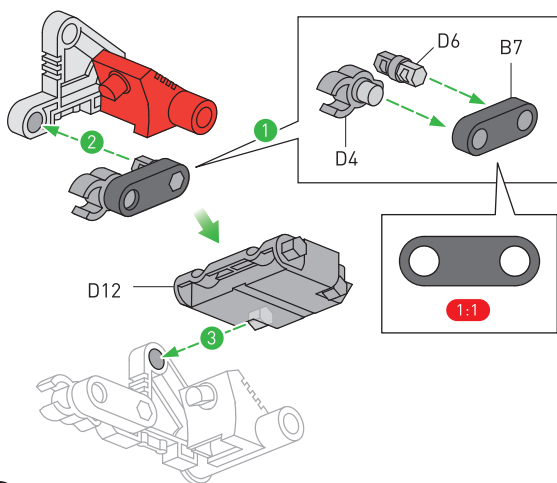
D13



Module A

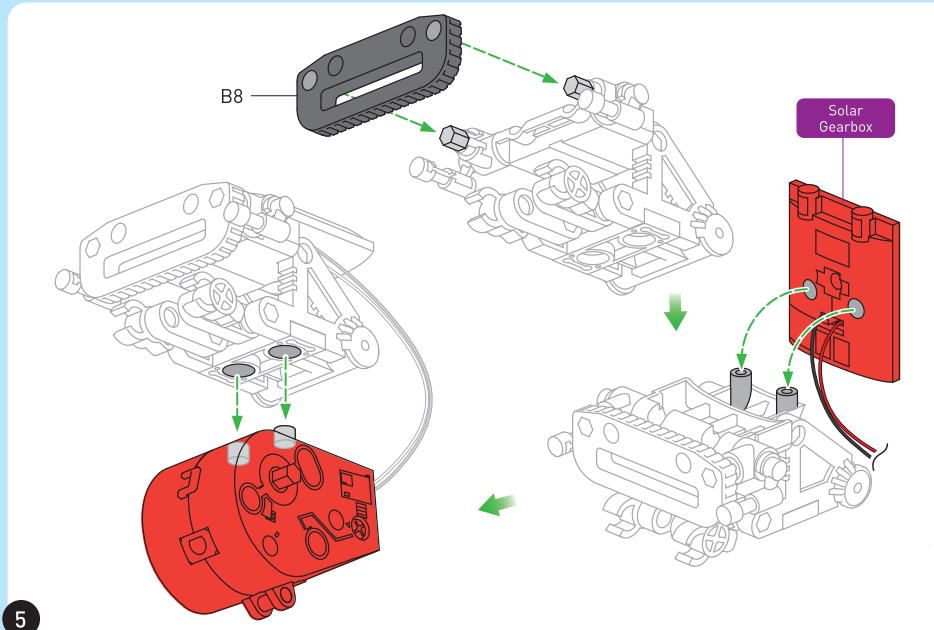
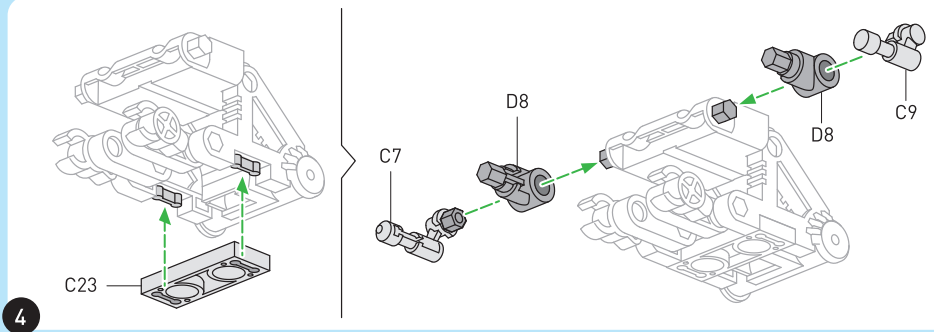
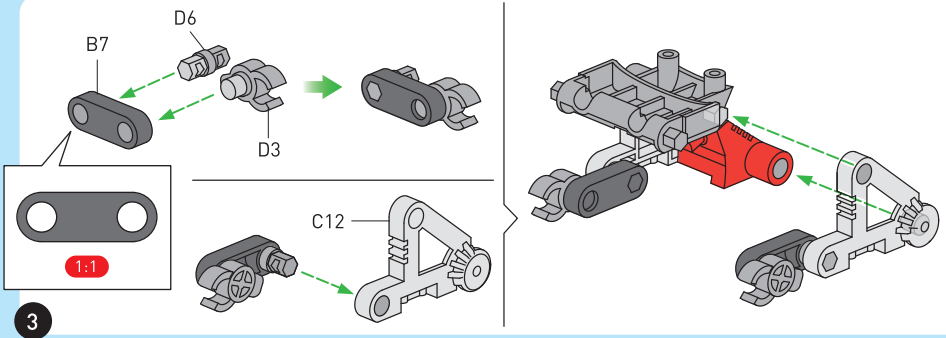


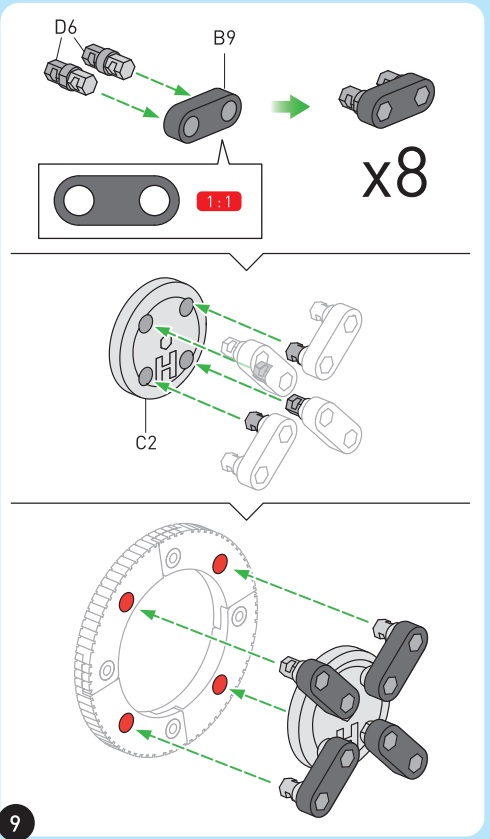
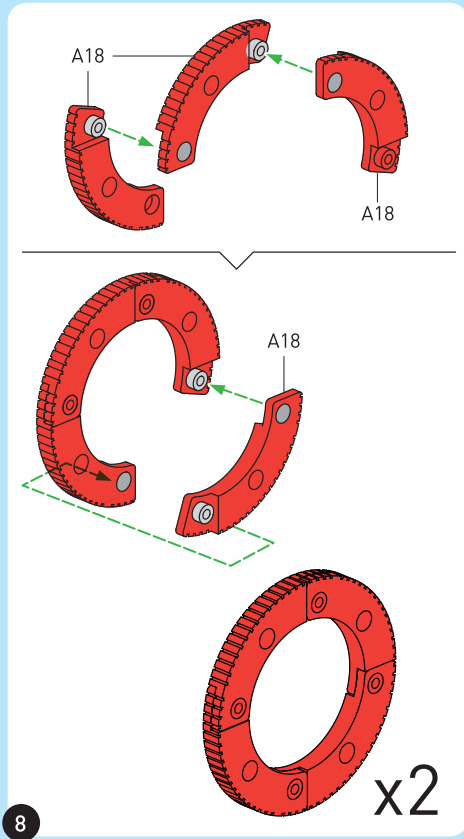
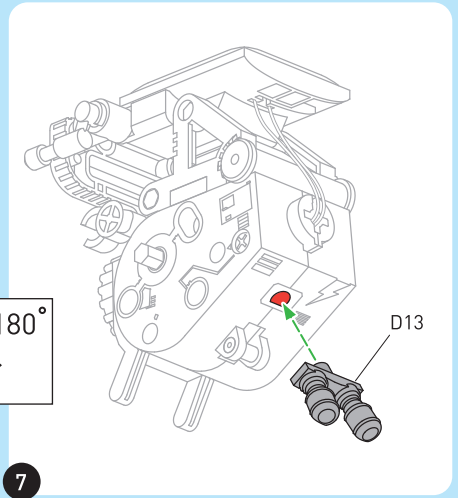
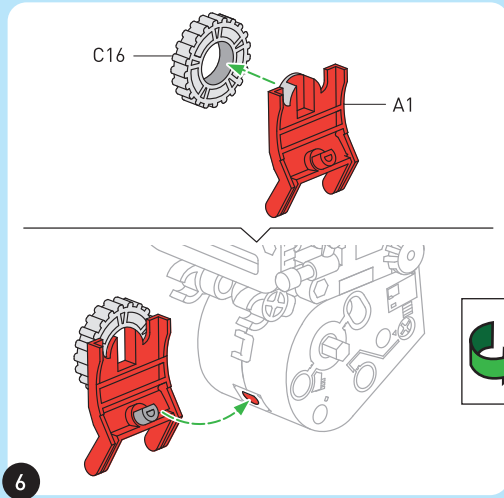
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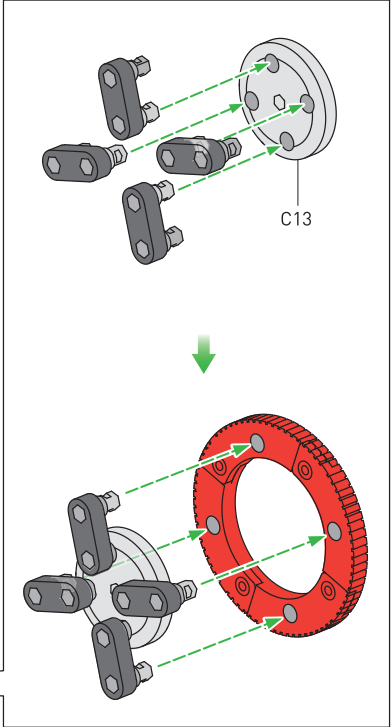
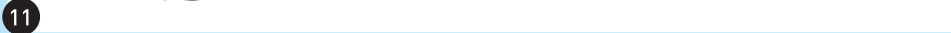
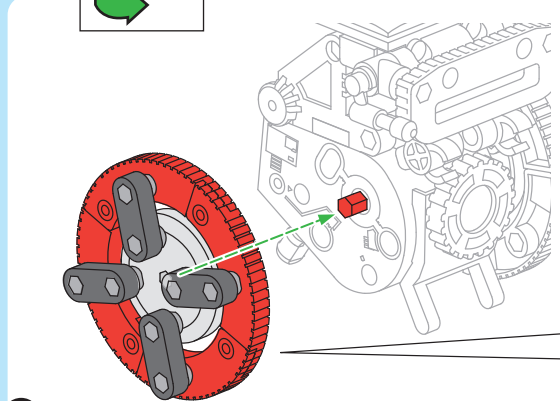
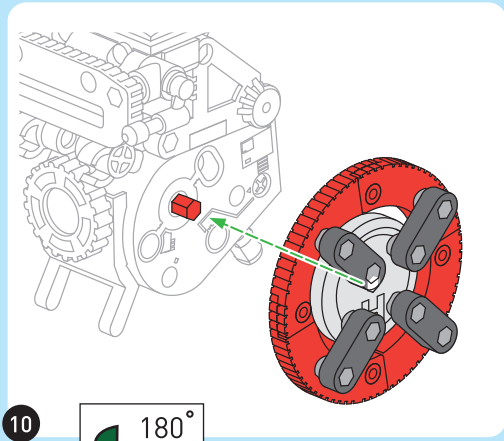


2

AXEL



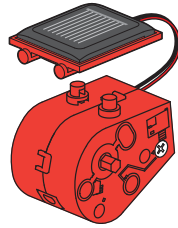
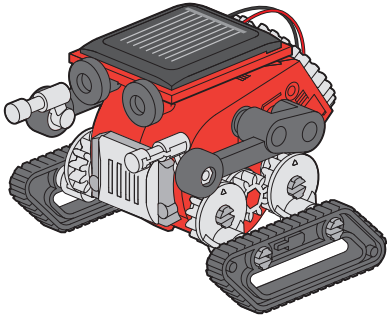




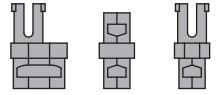
Disassembly tip

Use the tool (A28) to remove the D6 parts.

TANK



Solar Gearbox

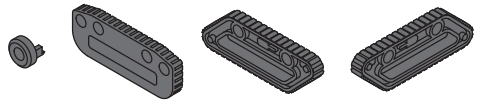


D2x2

D6x4

D15x6

1:1

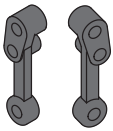


B6x2

B8x2

B11

B12



B17

B22



C7



C9



C15



C25x2



C26x4



C27



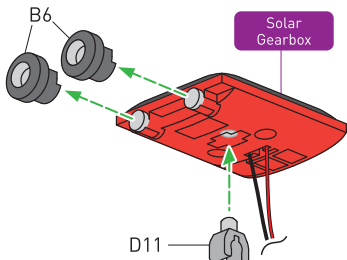
D10



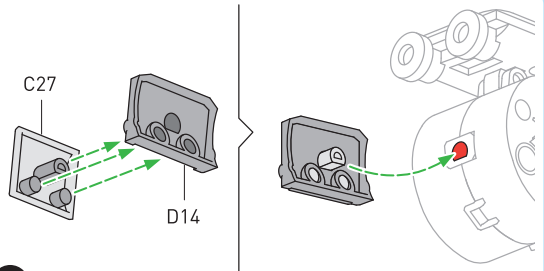
D11



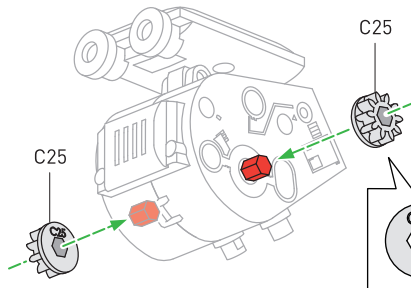
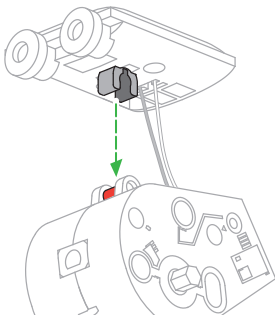
D14



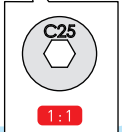
1



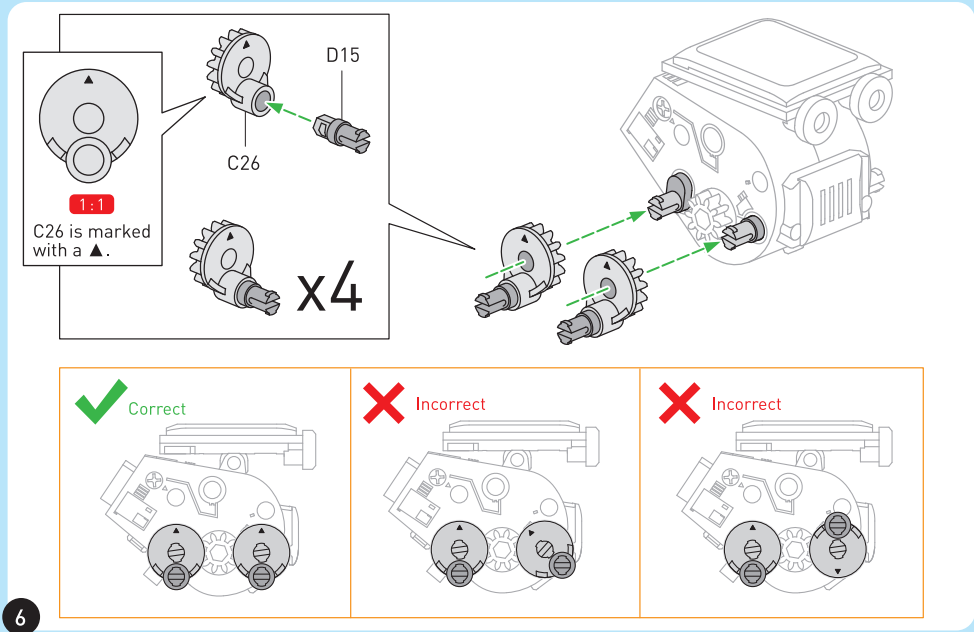
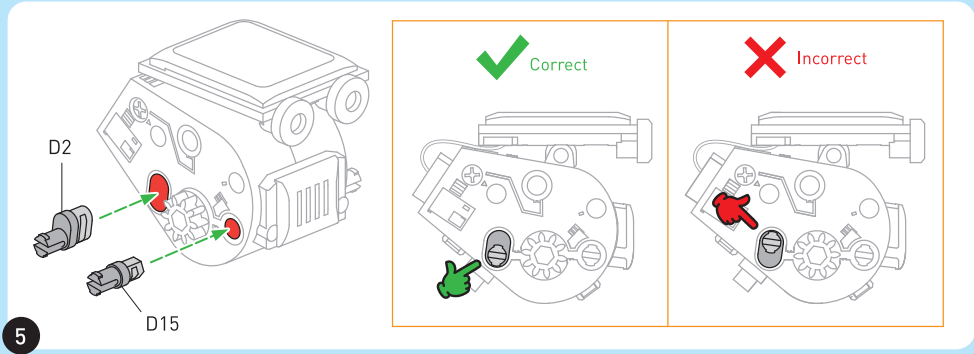
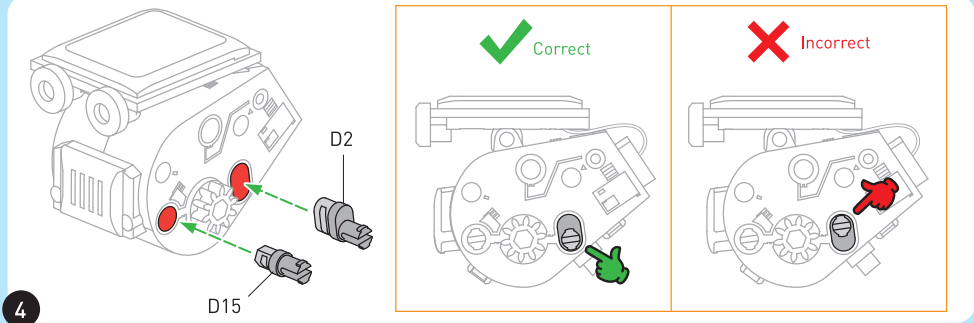
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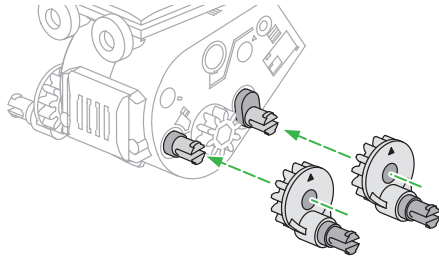


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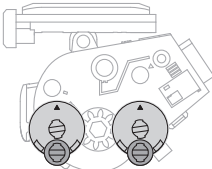


TANK

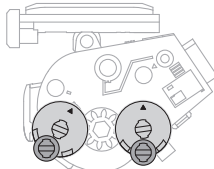




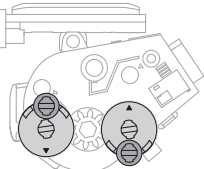
Correct



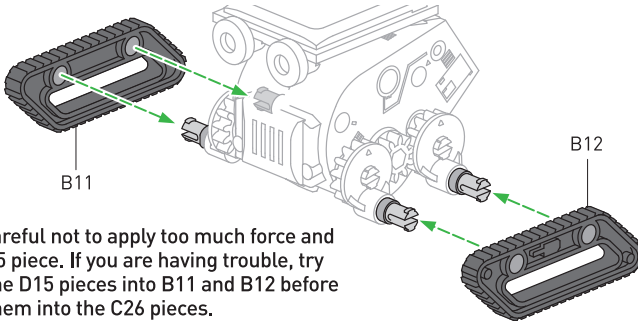
Incorrect



Incorrect

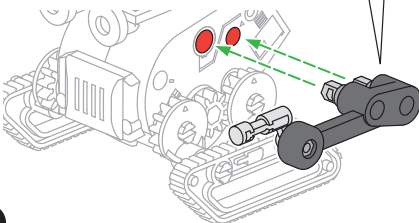
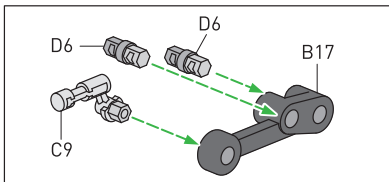


7

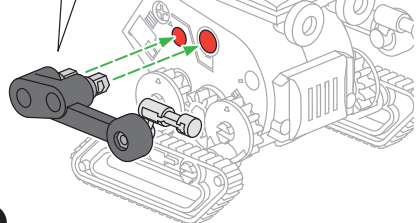
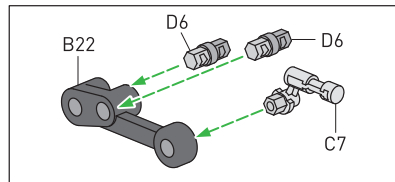


Note: Be careful not to apply too much force and break a D15 piece. If you are having trouble, try inserting the D15 pieces into B11 and B12 before inserting them into the C26 pieces.

8

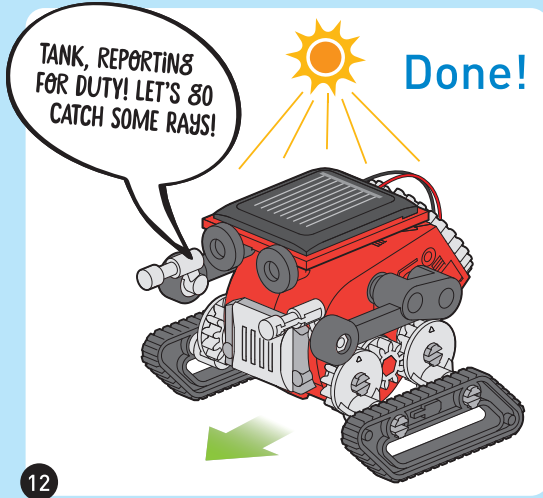
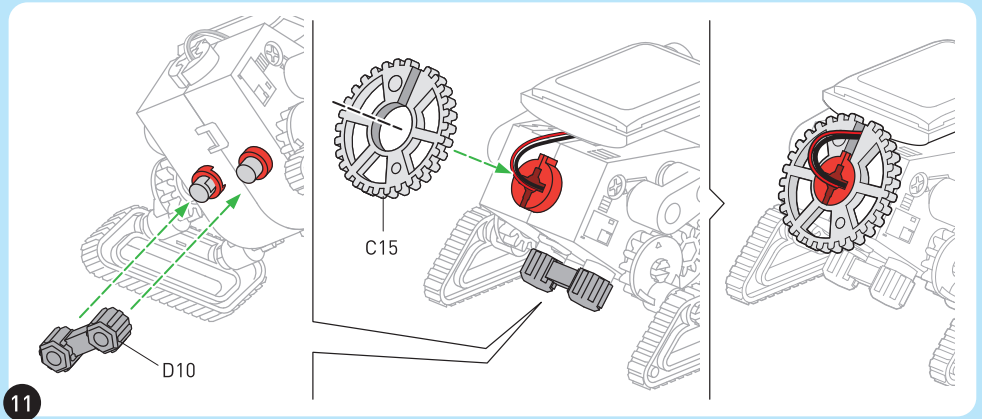


9

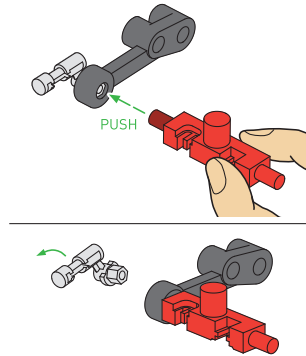


10

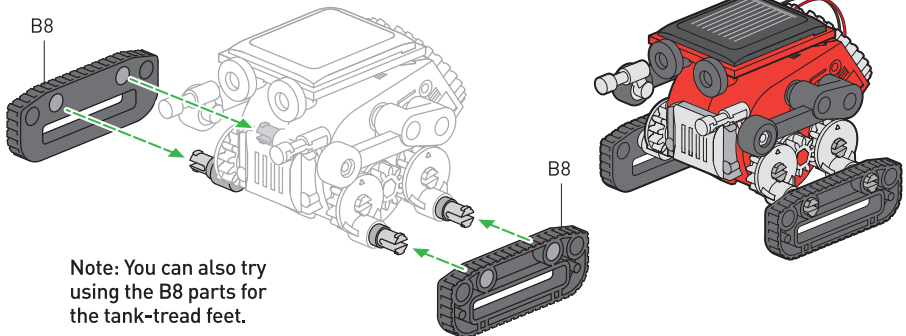
TANK



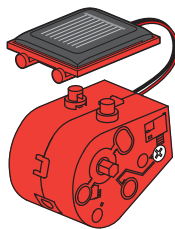
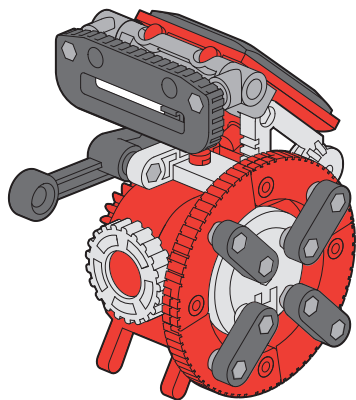
Disassembly tips



Use the tool (A28) to remove the C7, C9, D2, D6, and D15 parts.



DIZZY



Solar Gearbox



D6x9



D15

1:1



A1



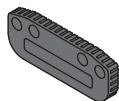
A5



A6



A18x4



B8



B9x4

1:1



B22



C2



C3



C12



C14



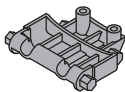
C16



C23



D8x2



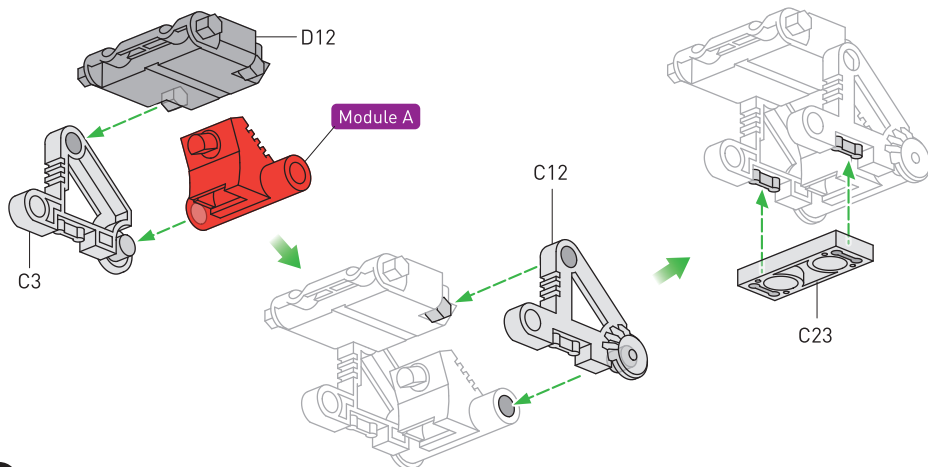
D12



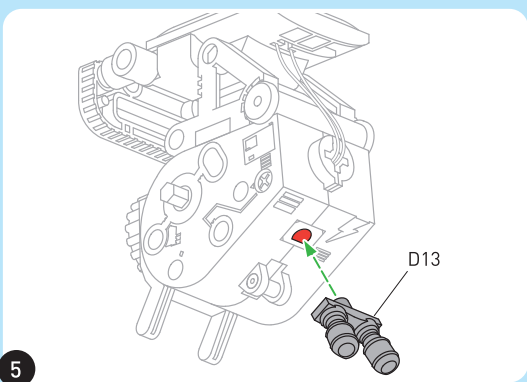
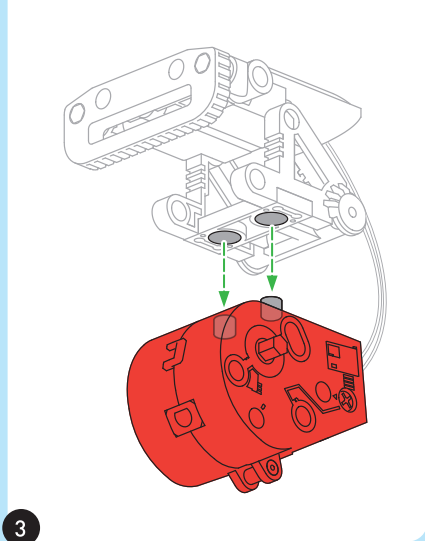
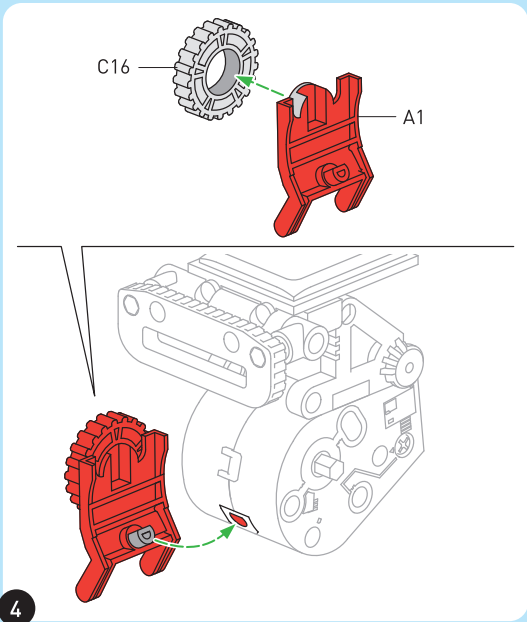
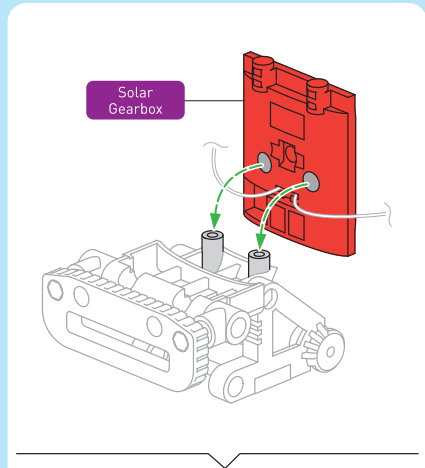
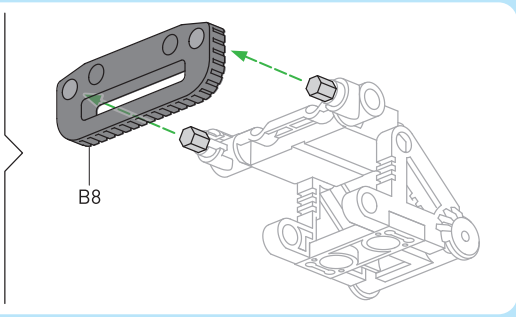
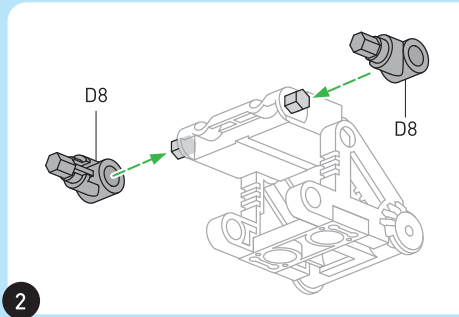
D13

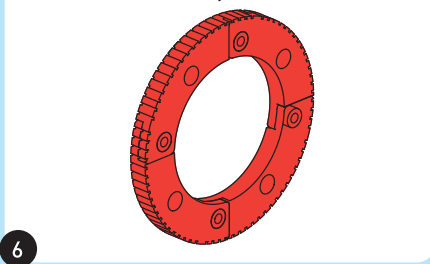
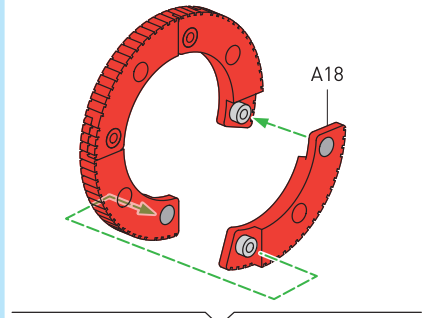
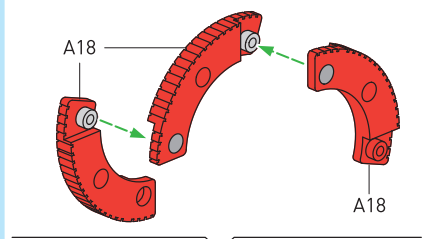
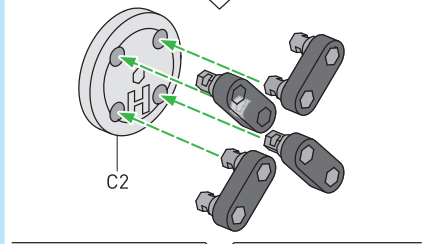
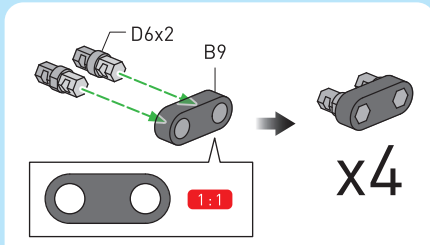


Module A

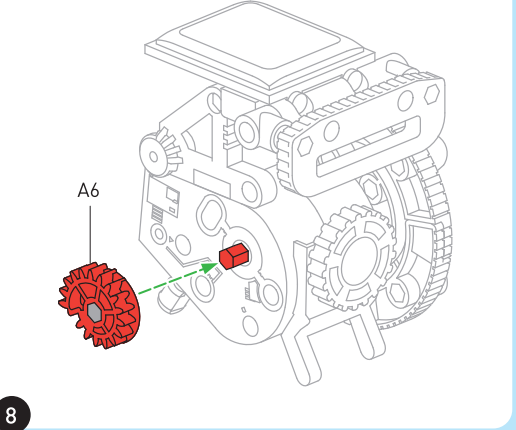
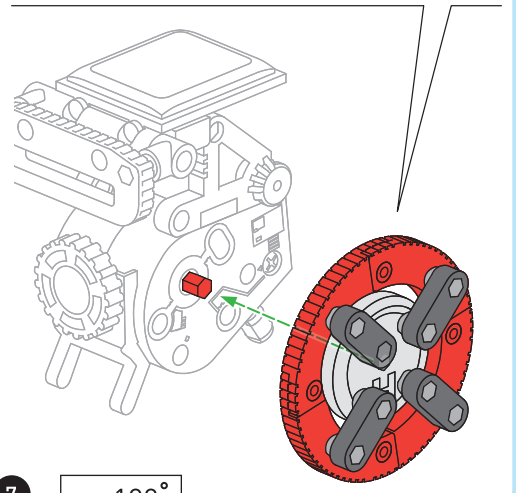
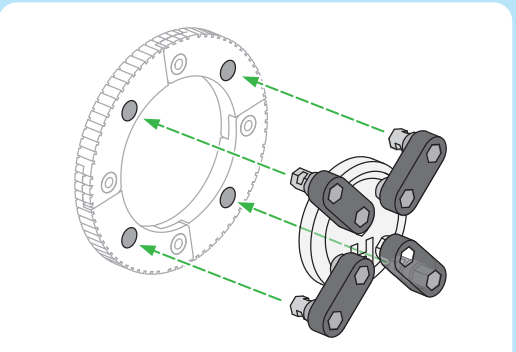


1

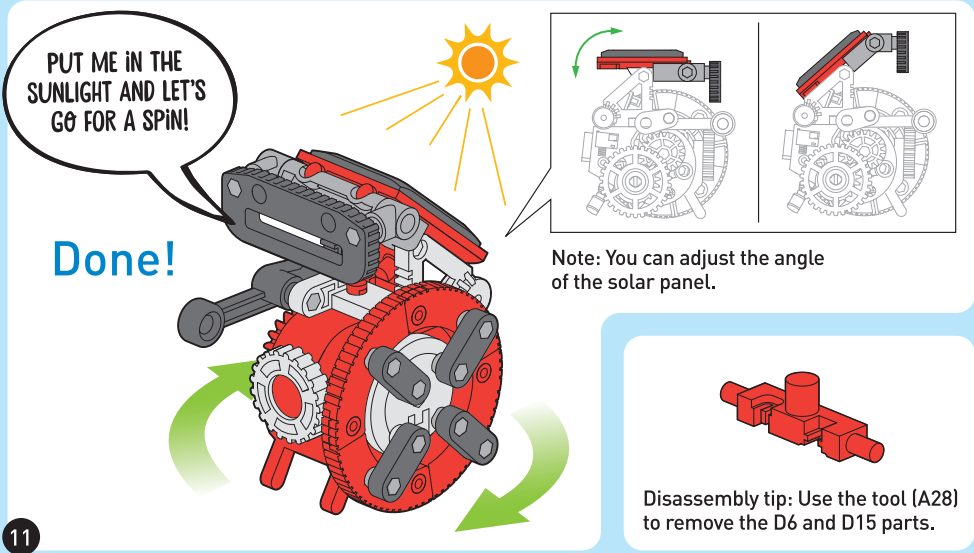
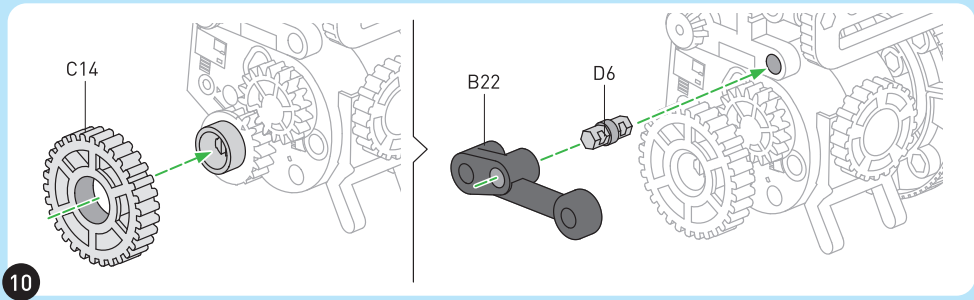
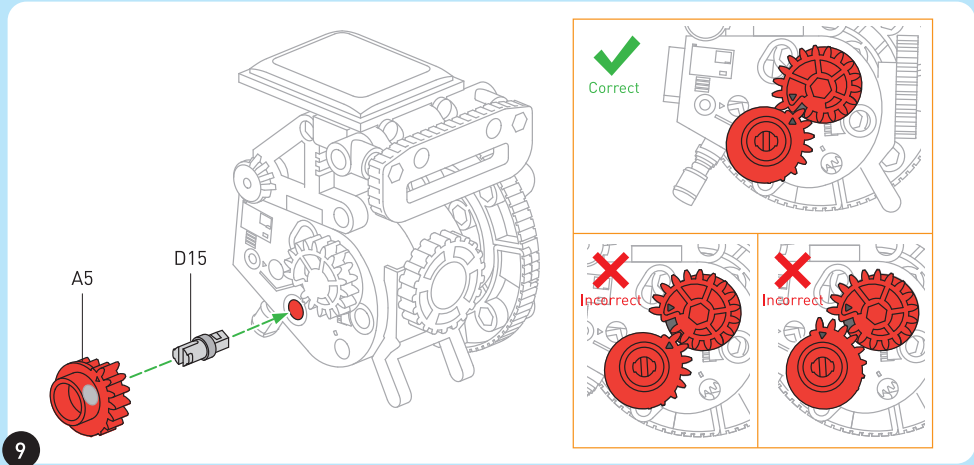




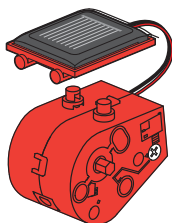
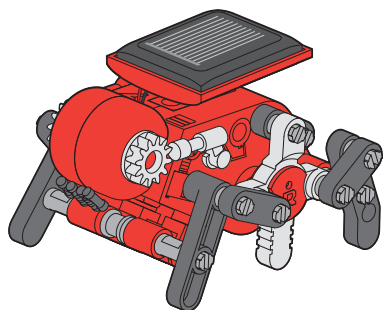
6



8



CRICKET



Solar Gearbox



D15x12



D1x4

1:1



A8



A9



A16



A19



B7x2

1:1



B9x4

1:1



B15



B16



B24xX2



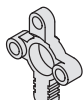
B27



C1x2



C4x2



C5x2



C7



C9



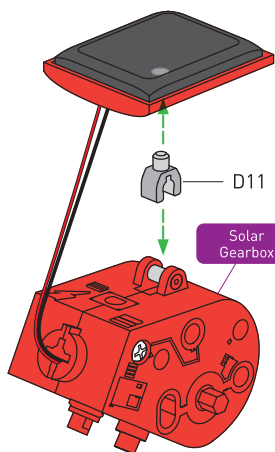
D11



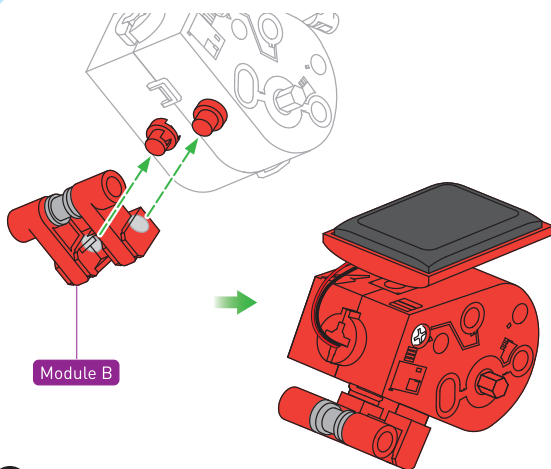
Module A



Module B

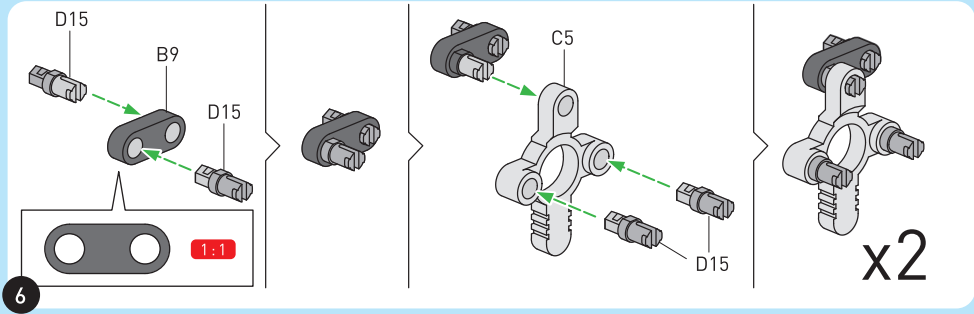
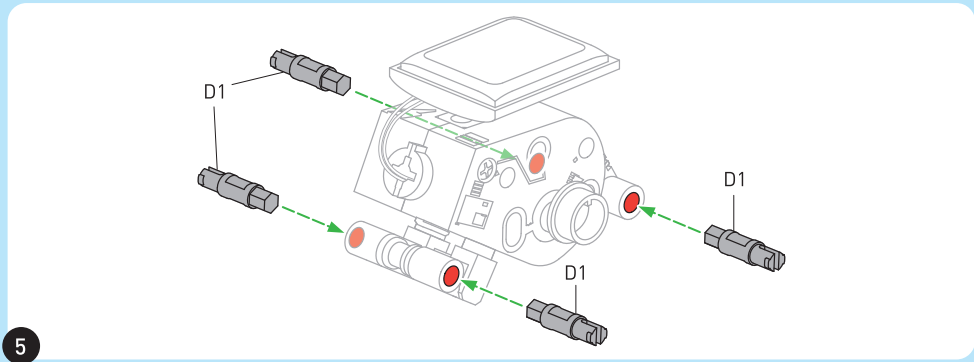
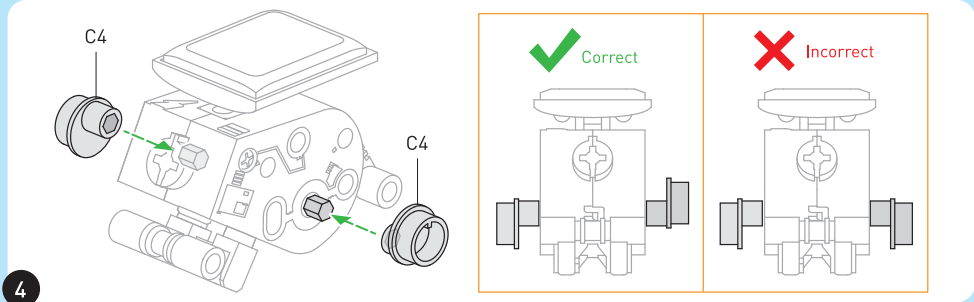
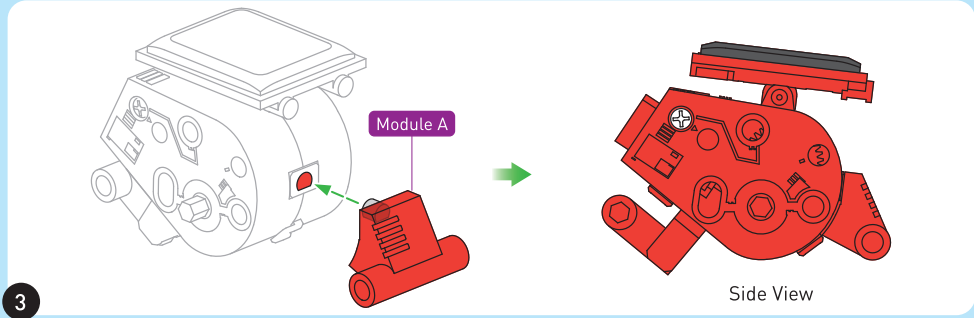


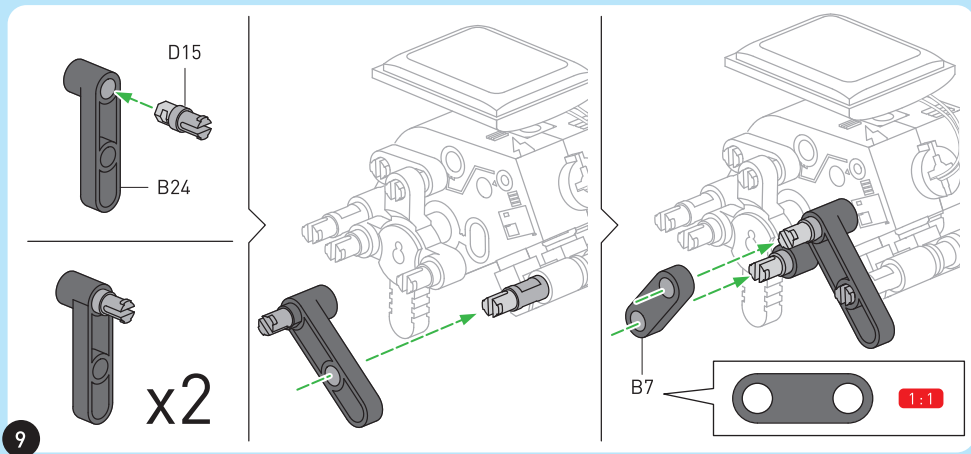
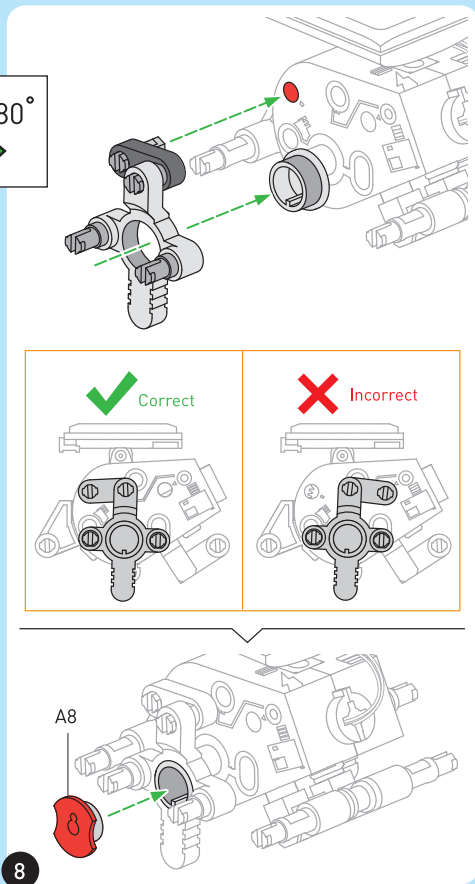
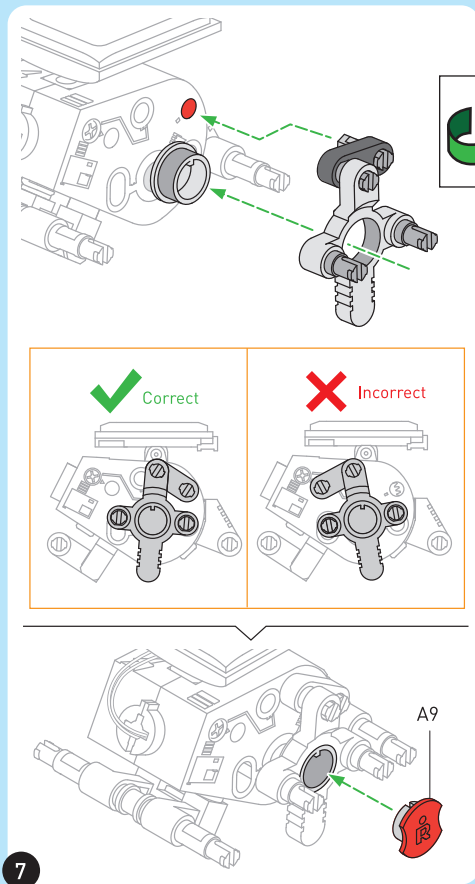
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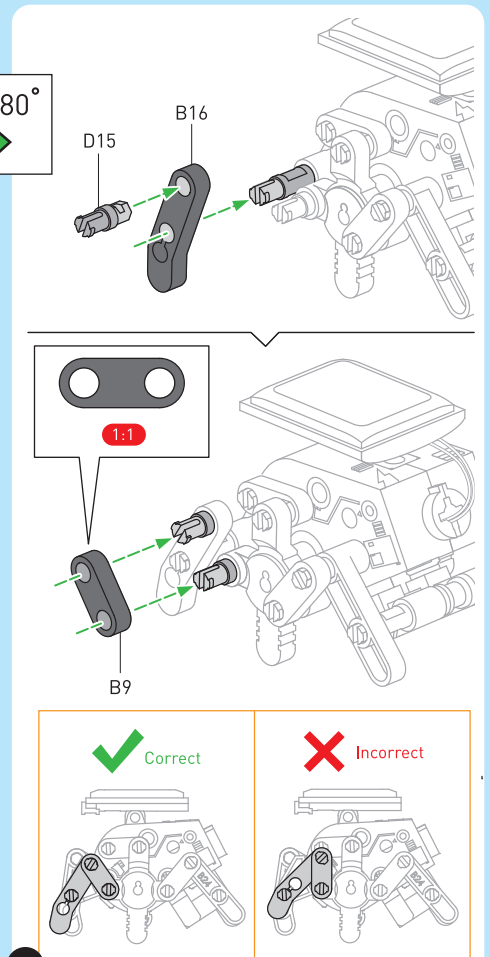
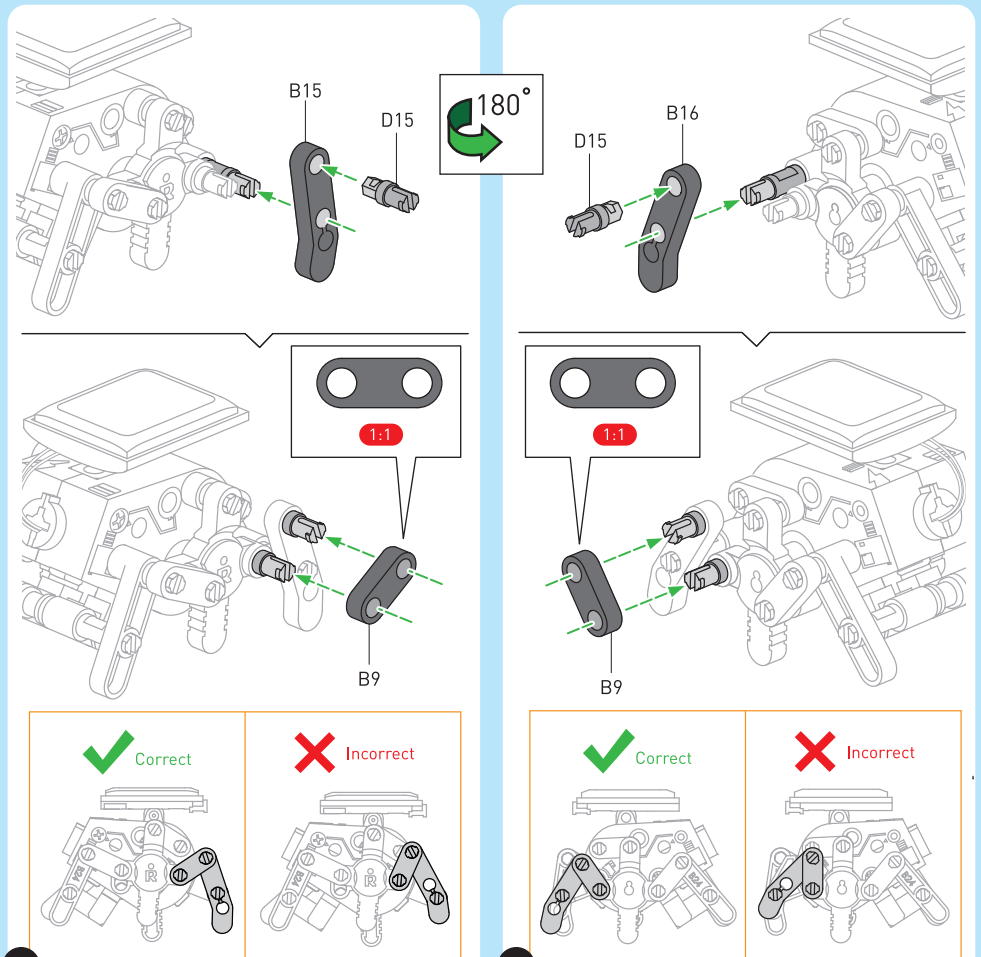
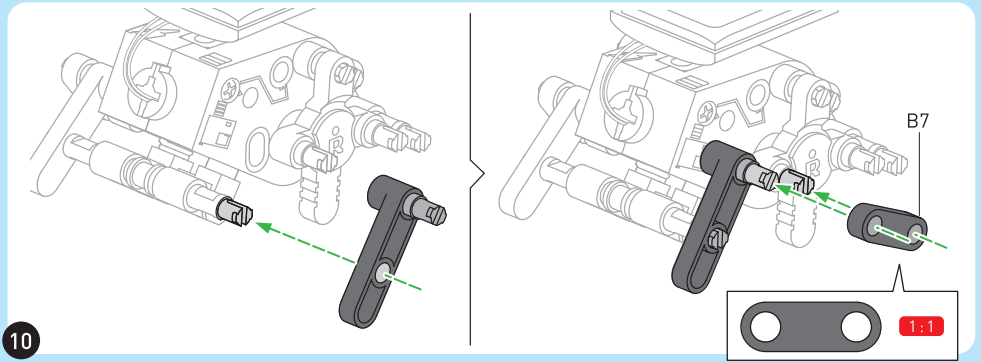


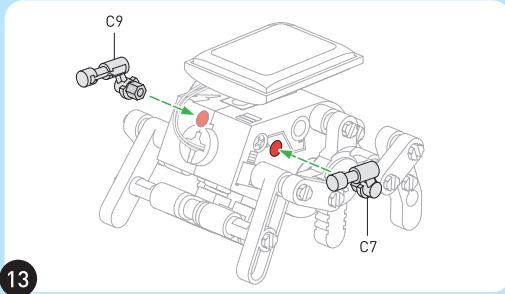
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CRICKET

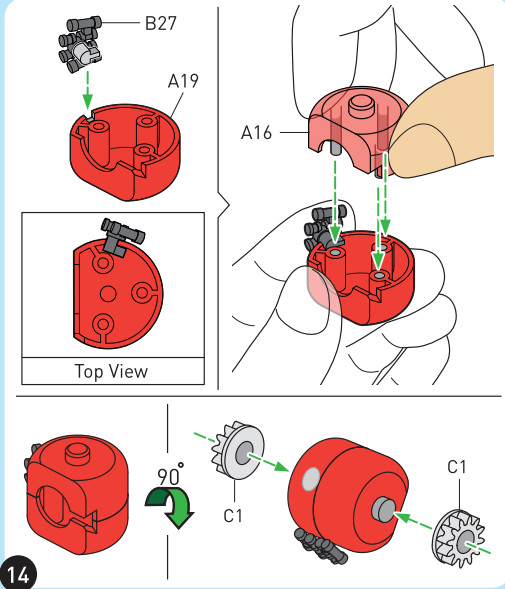
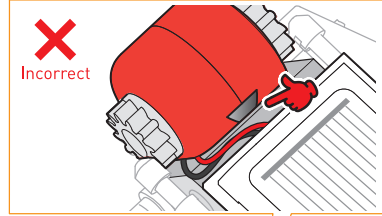
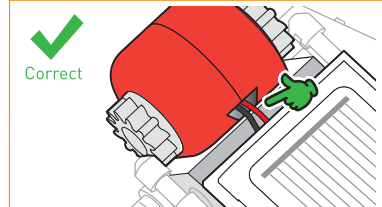






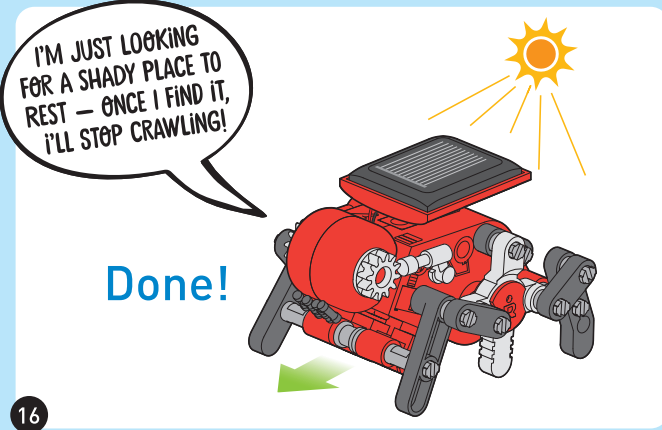
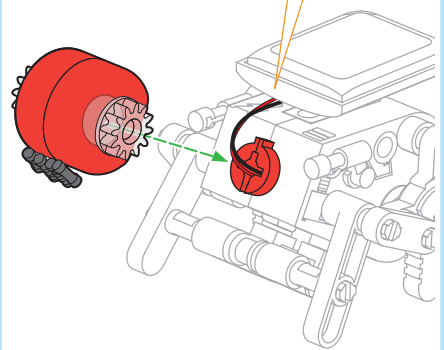


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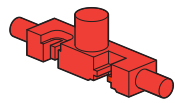
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15

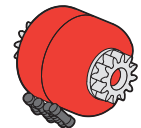


16

Disassembly tips

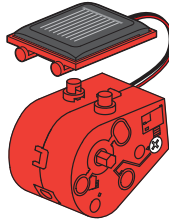
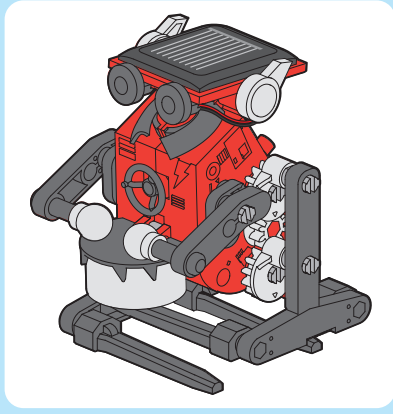


Use the tool (A28) to remove the D1 and D15 parts.

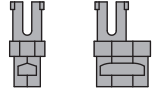


Note: You do not need to take this assembly apart.

MAJOR



Solar Gearbox



D15x8

D2x2

1:1



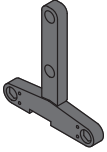
B4

B5x2

B6x2

B10

B13X4



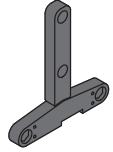
B14



B15



B16



B23



B25



B26



B31



C8



C10



C20



C22x2



C25x2



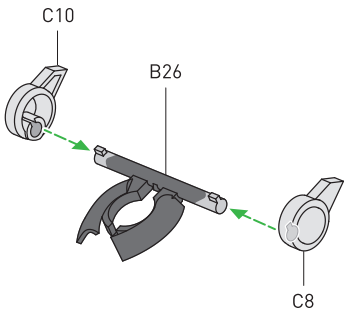
C26x4



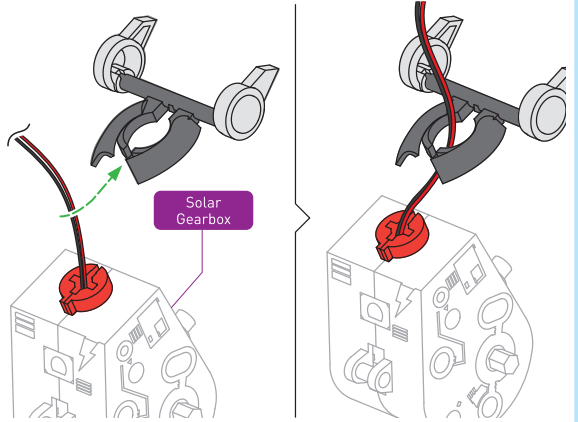
D9



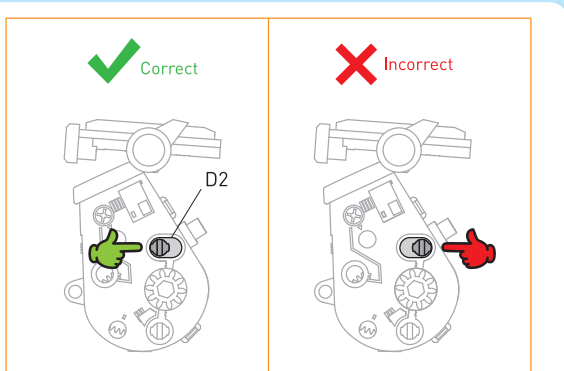
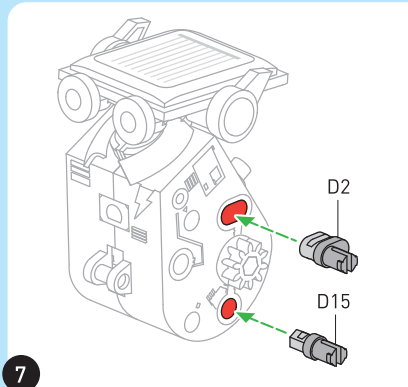
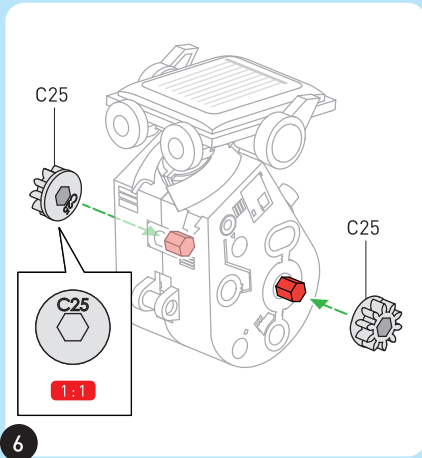
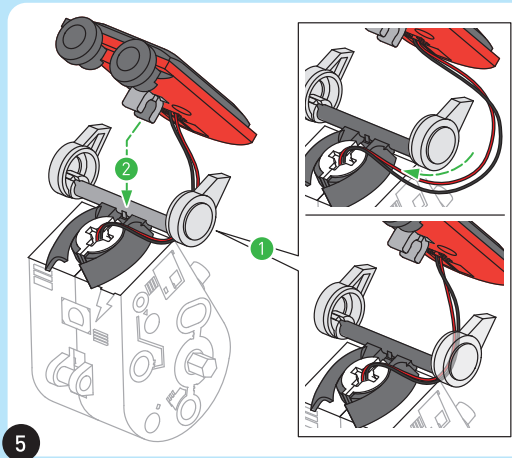
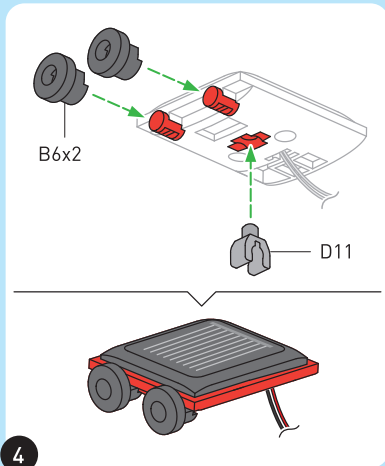
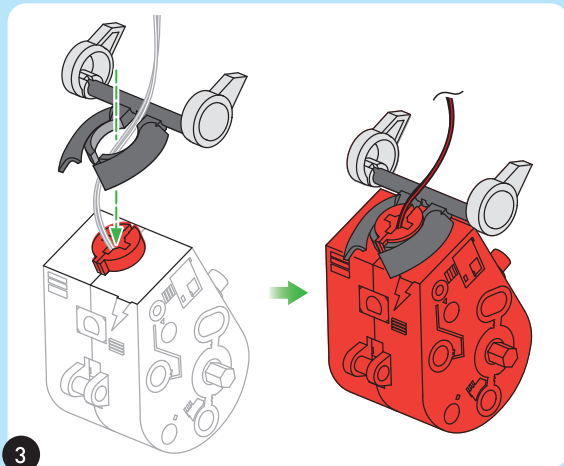
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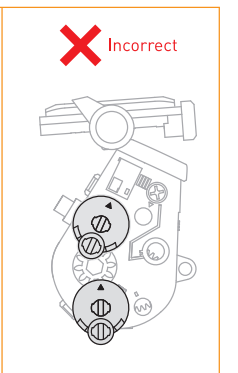
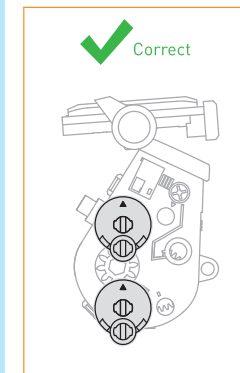
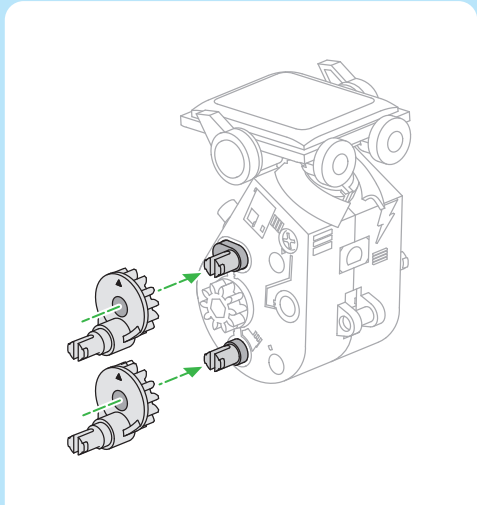
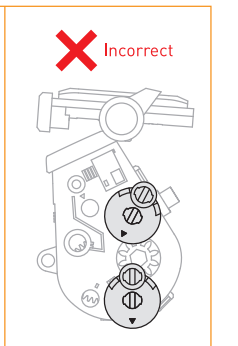
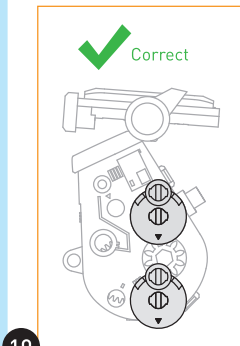
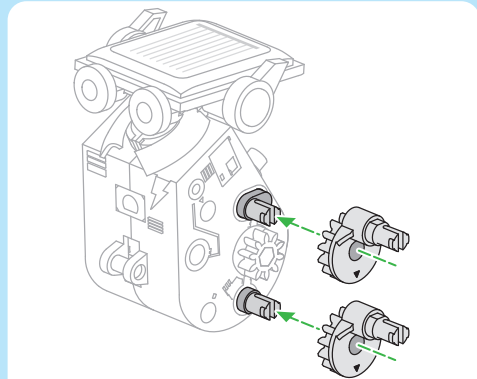
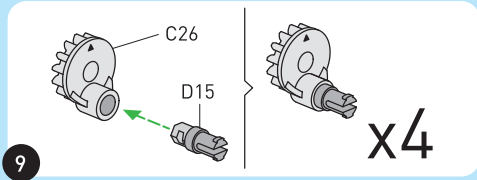
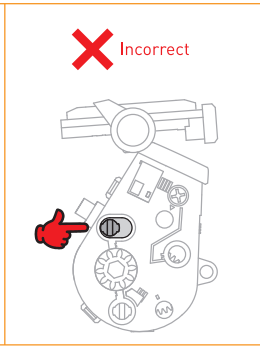
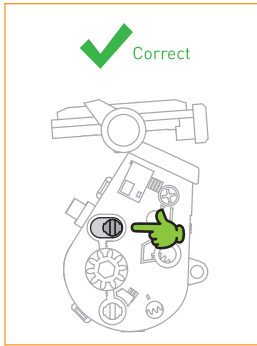
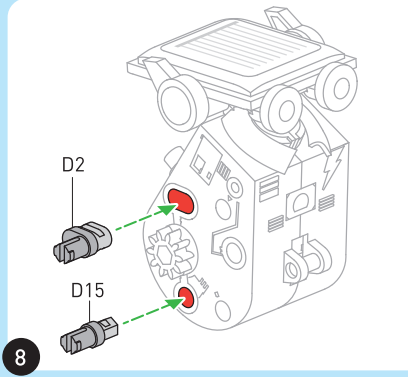


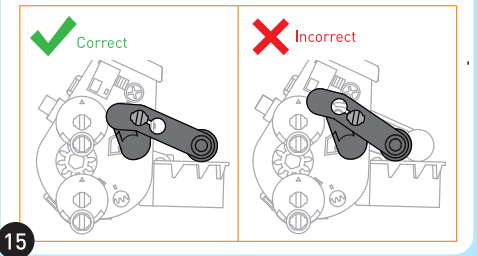
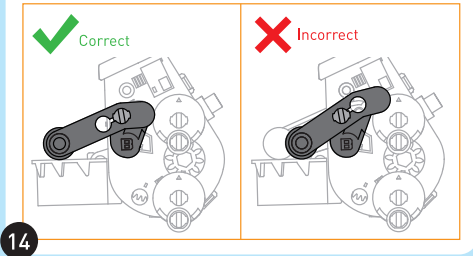
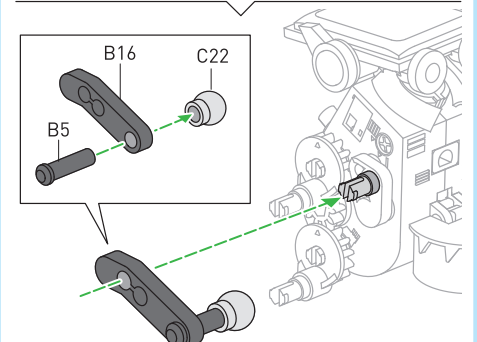
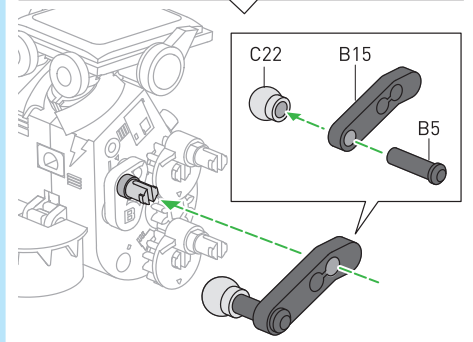
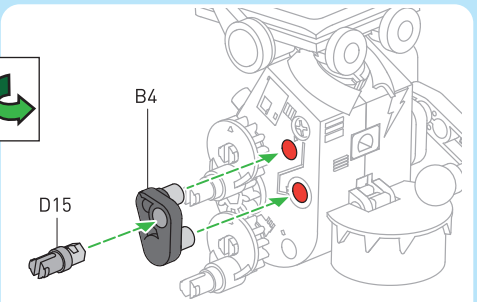
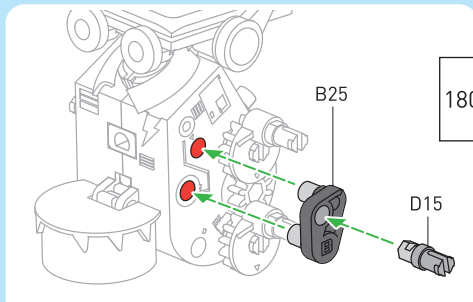
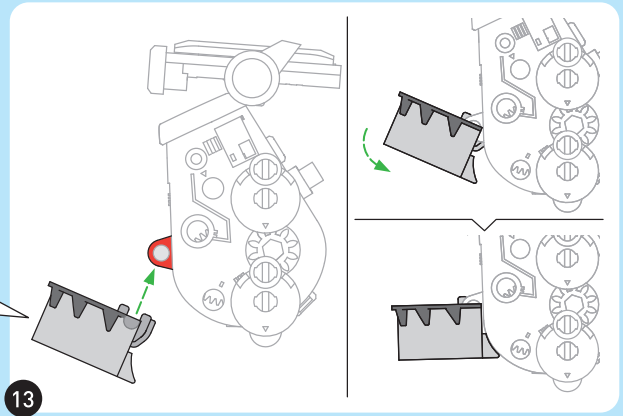
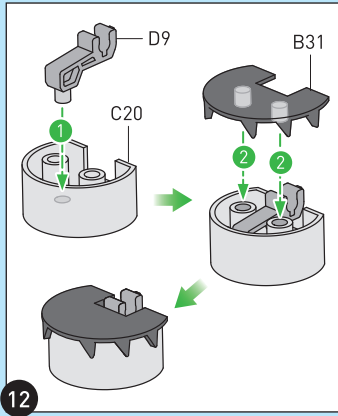
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2

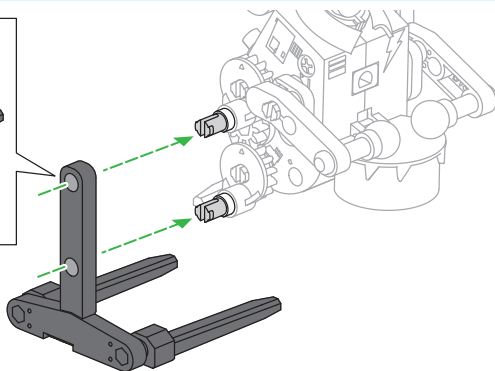
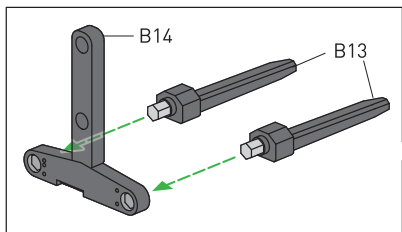




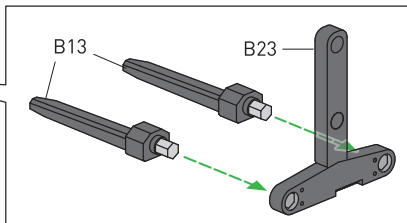
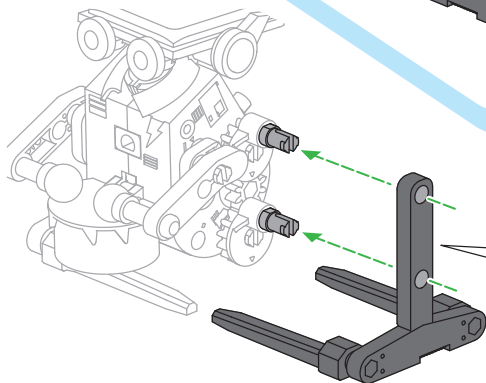


MAJOR

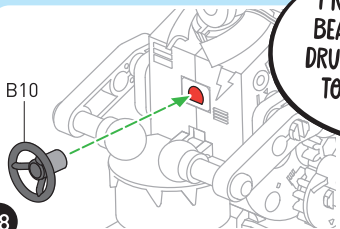
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17

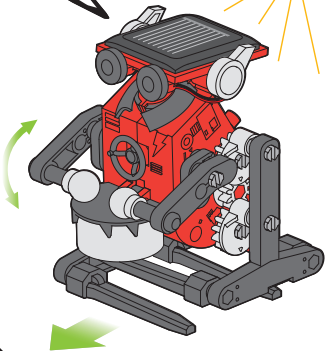


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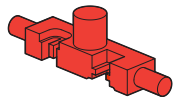


I MARCH TO THE BEAT OF MY OWN DRUM – AND ALSO TO THE RAYS OF THE SUN!

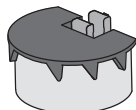
Done!



Disassembly tips



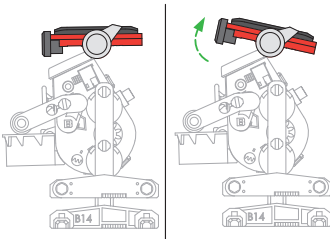
Use the tool (A28) to remove the D2 and D15 parts.



Note: You do not need to take this assembly apart.

19

The angle of the head is adjustable.



CHECK IT OUT

ENERGY FROM THE SUN

The terms “solar energy” and “solar power” refer to the energy of the solar radiation that we are able to harness and use. The sun is a star that is 150 million kilometers from Earth. Despite this immense distance, solar energy has an enormous impact on our lives: Life is not possible without the sun!

You can feel how strong solar energy is on any sunny day. Just lay out for a bit in the sun in the middle of summer. But be careful — you need to protect yourself adequately against sunburn. The sun emits so much energy because it is a gigantic nuclear reactor. It is so hot on the inside that the atoms, the building blocks of all matter, fuse together. Even on the sun’s surface, it is still around 5,500 degrees Celsius. The nuclear fusion produces nearly inexhaustible amounts of energy. This is radiated out into space. And some of it strikes Earth’s surface as electromagnetic radiation, as light.



AMAZING ENERGY RESERVES

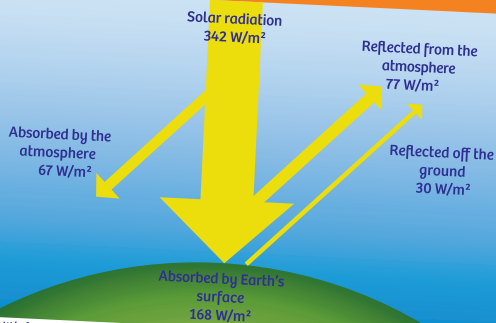
The solar energy striking Earth’s atmosphere each year is an unimaginable 1,500,000,000,000,000 kilowatt hours. This corresponds to about 10,000 times the energy consumption of all of humanity (as of 2010). By comparison: A three-person household in a single-family home consumes 4,000 kilowatt hours of power each year on average, which is but a tiny fraction of the incident solar energy.

However, a large portion of the solar energy is lost in the atmosphere, since it is “swallowed up” there or reflected back. The rest of it is enough, though, to give us sunlight that we can use to generate electricity.



Incident Solar Energy: the radiant solar energy that hits Earth’s surface and is referred to as “global radiation” on a surface.

Kilowatt Hours: a measure of electrical energy equivalent to a power consumption of 1,000 watts for 1 hour.





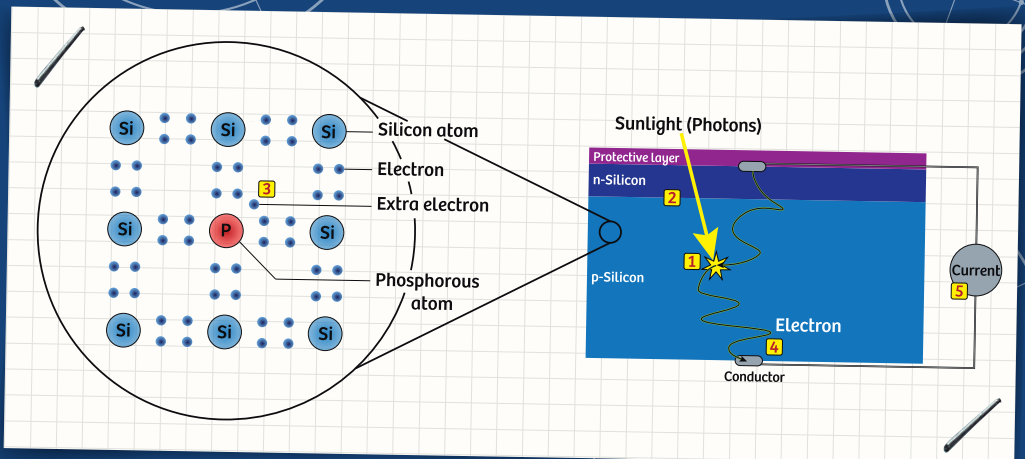
HOW DOES A SOLAR CELL WORK?

The solar cell in this experiment kit consists mostly of a material called silicon, which is a special semi-metal. Nine out of ten solar cells made worldwide are made of silicon, which is also the primary material in computer chips.

Electrons — those tiny, negatively charged particles flying around atoms — give rise to electric current. They are located directly on silicon atoms. Movement of electrons leads to a change in electrical charge and is known as electric current. To generate electricity, you need to make the electrons move. That actually happens automatically when light strikes the silicon. Light particles, called photons, are able to displace electrons from their spots on the silicon atom (1). But how does the electron know that it's supposed to move in a certain direction, such as through the wire into your motor? This is where the structure of silicon and the design of the solar cell come into play.

Since current is to be generated in a solar cell, the electrical properties of silicon are important. Silicon is a semiconductor. During the manufacturing process, its electrical properties can be precisely specified by introducing other elements (such as phosphorous) into the semi-metal. In a solar cell, two silicon layers that have been altered in different ways are sandwiched together (2). This results in additional electrons being present (3) and electrons only being able to move in a certain direction. All of the electrons that are set in motion under the light end up flowing through on a conductive material (4).

However, since the material is not lacking electrons, it has to be “emptied” from the other side. A circuit (circular flow) is formed, and current flows through it (5).





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