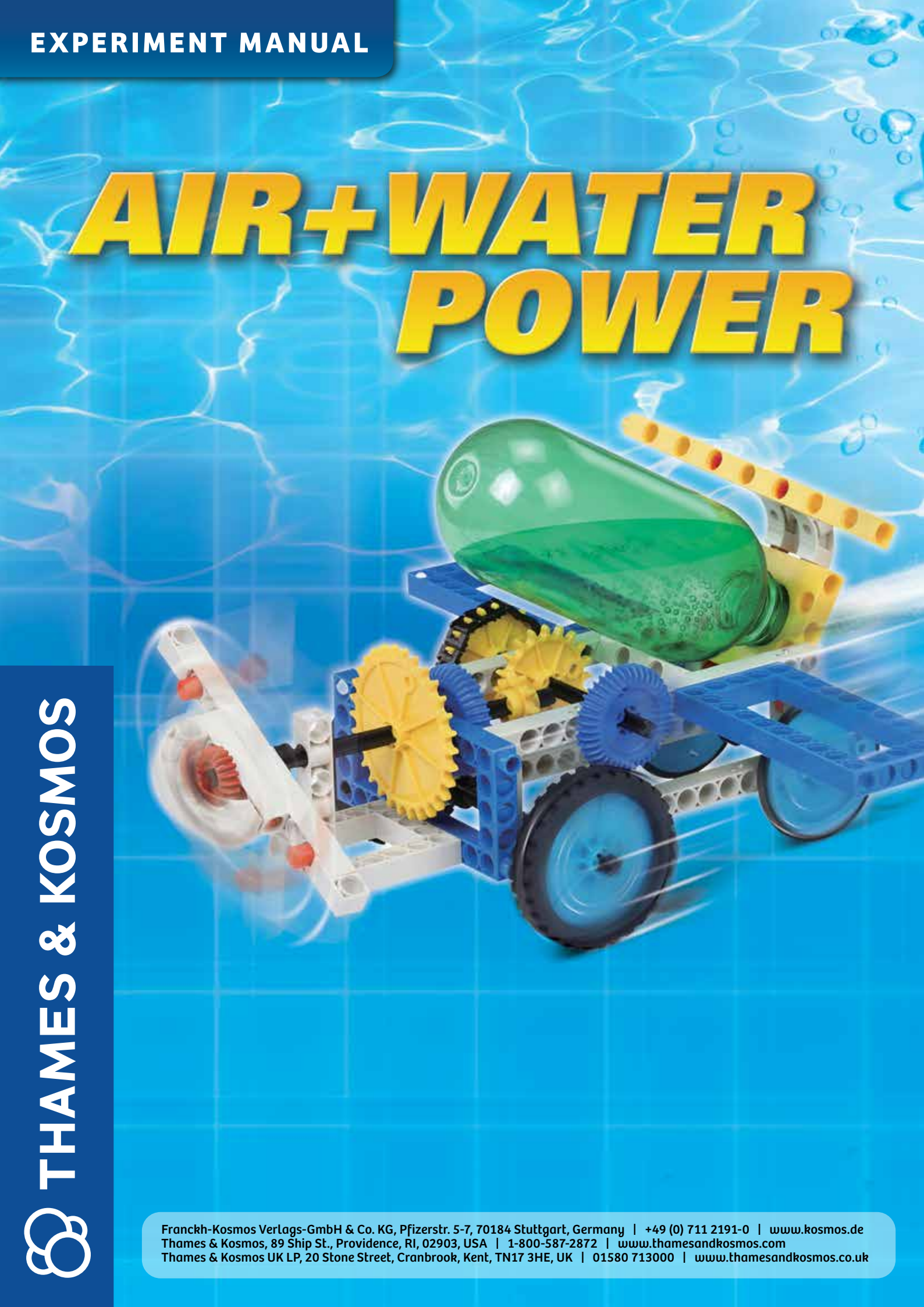
EXPERIMENT MANUAL

AIR+WATER POWER



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WARNING! Not suitable for children under 3 years. Choking hazard — small parts may be swallowed or inhaled. Strangulation hazard — long cords may become wrapped around the neck.

Keep packaging and instructions as they contain important information.

DEAR PARENTS:

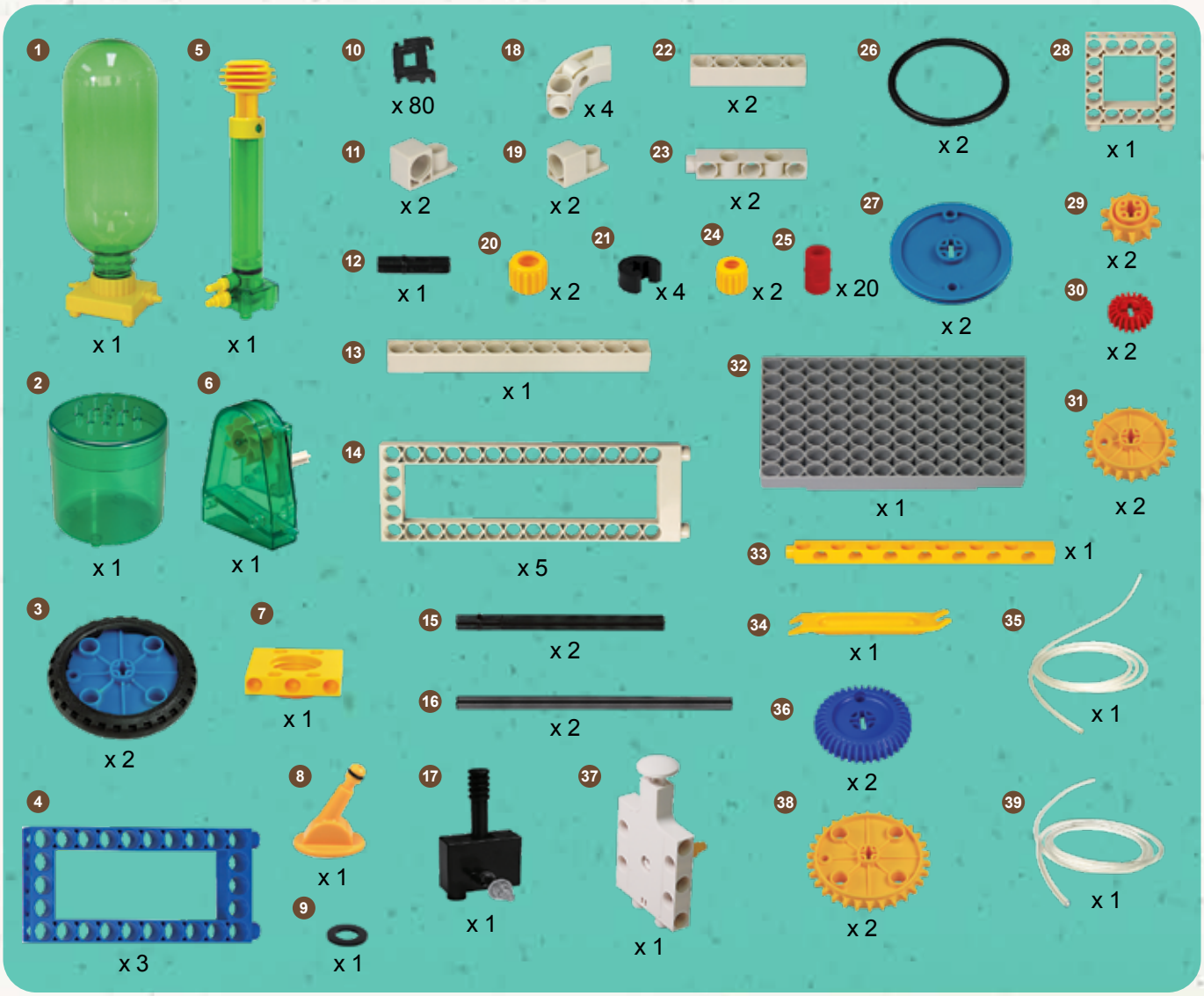
- This is a toy that has been designed for children over 8 years of age. It is not suitable for children under 3 years of age. It contains small parts that a child could swallow, and long tubes, which may become wrapped around the neck. It must be kept out of the reach of very young children.
- Discuss the safety warnings and possible risks involved with the children before allowing them to build these models.

AIR+WATER POWER | Parts List

No	PARTS NAMES	PCS
1	PRESSURIZED AIR+WATER TANK	1
2	WATER STORAGE TANK	1
3	WHEEL AND TIRE	2
4	SHORT FRAME	3
5	PUMP	1
6	AIR+WATER TURBINE	1
7	CAP FOR AIR+WATER TANK	1
8	NOZZLE FOR AIR+WATER TANK	1
9	WASHER	1
10	CHAIN UNIT	80
11	90 DEGREE CONVERTER - L	2
12	SHORT AXLE	1
13	11-HOLE ROD	1

No	PARTS NAMES	PCS
14	LONG FRAME	5
15	LONG AXLE	2
16	EXTRA LONG AXLE	2
17	ONE-WAY SWITCH	1
18	CURVED ELBOW ROD	4
19	90 DEGREE CONVERTER - R	2
20	LARGE (L) SECURITY NUT	2
21	AXLE LOCK	4
22	5-HOLE ROD	2
23	7-HOLE DUAL ROD	2
24	SMALL (S) SECURITY NUT	2
25	ANCHOR PIN	20
26	O RING LARGE	2

No	PARTS NAMES	PCS
27	LARGE PULLEY	2
28	SQUARE FRAME	1
29	SMALL SPROCKET	2
30	SMALL GEAR	2
31	MEDIUM SPROCKET	2
32	BASE PLATE	1
33	LONG ROD	1
34	PART SEPARATOR TOOL	1
35	TUBE B, 120 CM	1
36	MEDIUM GEAR	2
37	LAUNCHER	1
38	LARGE SPROCKET	2
39	TUBE A, 200 CM	1
	TOTAL	165



Gears are wheels with teeth on them. The teeth, or cogs, of one gear mesh with the teeth of another gear to transmit force between them. A combination of two or more gears is called a transmission, or gear train. You can see transmissions with meshing gears inside old toys or old clocks. Gearboxes can be found inside the transmission system of cars, which combine meshing gears of different sizes. This allows the car's driver to easily change between different speeds.

Do you know how gears work? You can learn how gears work and why they are useful by reading this manual and building the models in this kit that use gears. The building blocks in this kit were designed based on the number ten and its multiples, including the size of the components, the distance between the holes, or the unique gears. This makes it easy to both assemble the gears and also conveniently calculate the gear ratio or change the rotary speed. Different from other gear designs that use the number seven or eight as their fundamental number, these gears were created to be perfect for teaching science to kids because they are easy to assemble and they make it easy to calculate gear ratios (explained below).

We recommend a gradual learning process using these gears, which begins with very basic assemblies to understand how each of the components fit together. After you build all of the models in this instruction book and understand how to use gear trains, you can put your unlimited creativity to work and design vehicles and machines on your own. Let your imagination guide you!

Now let's look closely at gears and how we use them. Find the gears in this kit. The wheels which have many tooth-shaped objects sticking out of their edges are gears. Two gears can mesh with each other using the teeth on the edges. When one gear rotates, the other one will be driven to rotate as well. The intermeshing teeth of the two gears transmit torque (turning force) and rotation.

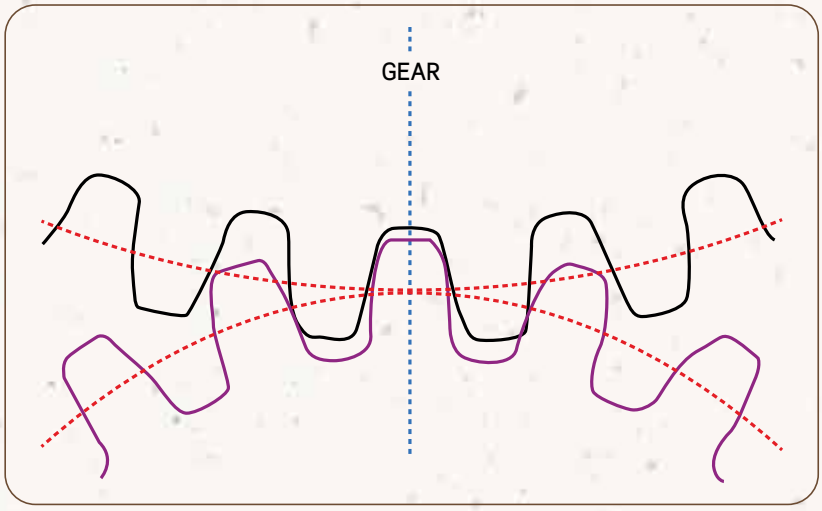


Fig. A
The intermeshing of gears can effectively transmit force to cause rotation. The red circle represents the actual diameter of the transmission, which is called the pitch diameter. The special shape of the teeth allows for smooth intermeshing and transmits power along the pitch.

A simple gear train uses two gears with the same or different sizes. If one of these gears is attached to a motor or a crank, it takes the role of the driver gear. The gear that is turned by the driver gear is called the driven gear. Gears of different sizes are used to increase or decrease the speed or the power of rotary motion. The relationship between the number of teeth on intermeshing gears is called the gear ratio (or speed ratio). The gear ratio reveals the change in speed or power from one gear to the other.

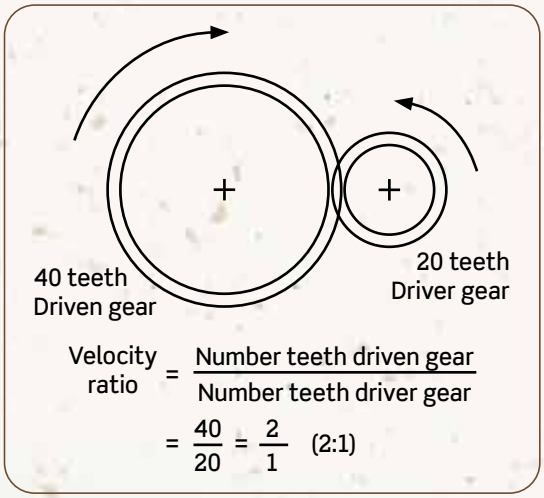


Fig. B
Illustration of gear ratio calculation

The big gear has more teeth than the small gear. Despite the number of teeth or the size of the gears, all of the teeth on all of the gears in the same gear system must all be the same size. In simple gear trains, the driver and driven gears will rotate in opposite directions. When a third gear is inserted between the driver gear and driven gear, and makes them rotate in the same direction, it is called an idler gear.

The gears in this construction system come in five different types: 20T, 40T, 60T, 80T, and 160T, the extra large gears. This particular kit only contains 20T and 40T gears. The other gears can be found in other kits.

The gear system contains both spur and bevel gears. This kit contains "spur gears," which mesh in the same plane and regulate the speed or the turning direction of the shafts, and "bevel gears" (the beveled edges of the gears) which mesh together at right angles to the initial turning plane of the gears and shafts to change the plane of rotation.

The pitch diameter of the gears in this gear system is proportional to the number of gear teeth. In other words, the pitch diameter of the 20T gears is 20 millimeters while the pitch diameter of the 40T gears is 40 millimeters. Again, the pitch diameters are the imaginary circles between the meshed gear teeth as shown in Figure E.

The gears are easy to install on the rods and frames in this kit, because the rods and frames have holes positioned in increments of ten millimeters. The pitch diameters are in multiples of 20 millimeters, and thus the distance between the center points of the gears is in multiples of ten millimeters.

In Fig. E, the distance between the centers of the two gears is calculated like this:

$$R1 + R2 = \frac{20\text{ mm}}{2} + \frac{40\text{ mm}}{2} = 30\text{ mm}$$

Therefore you can easily place the two gears on a rod or frame so that they mesh together smoothly. The other sizes of gears are designed with the same elegantly simple concept, so that all of the gears can easily be assembled into working gear trains.

According to the instructions above, can you figure out how many holes there are between a 40T and a 60T gear when they are meshed?

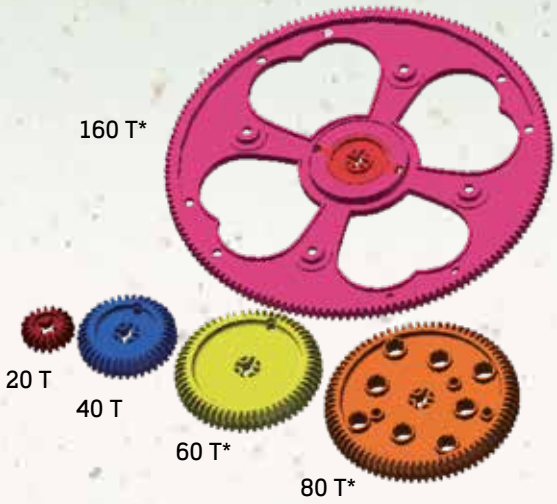


Fig. C Gears (T = Number of teeth)
(*Not included in this particular kit.)

Fig. D Characteristics of gear teeth

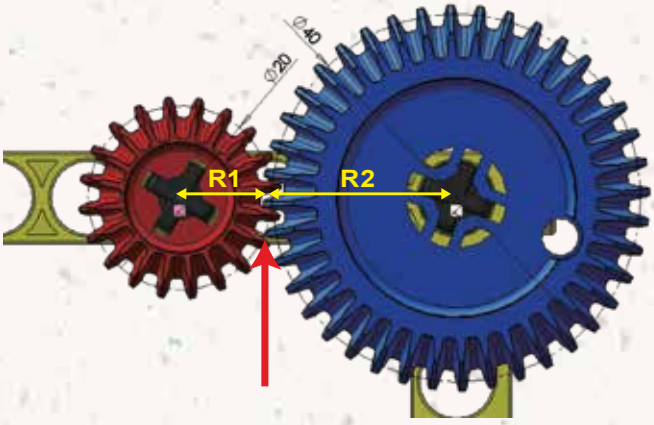
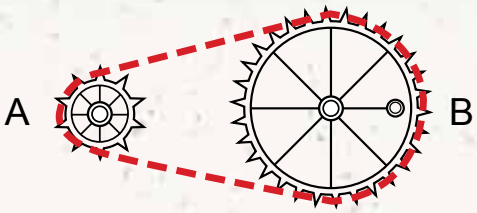


Fig. E The transmission between the pitches during the meshing of two gears

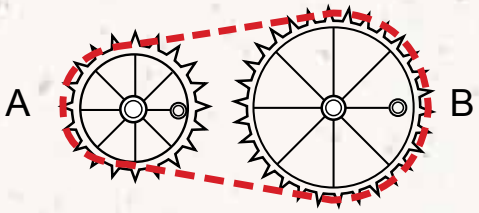
1. The power transmission in chain gear systems depends on chains instead of the direct meshing of gears. Chains must fit on the teeth of chain gears. Gears used with chains are called sprockets. The "working" diameters of the sprockets in this kit are about 10 mm (10-tooth), 20 mm (20-tooth) and 30 mm (30-tooth). Try to ensure that when connecting drive chains they are neither too tight nor too loose so that the motion of one is transmitted efficiently to the other. If the chain lengths do not exactly fit, opt for adding an extra chain segment: a chain that is a little loose will work better than one that is too tight. However, the chain has to be tight enough so that it does not fall off the sprockets. Chain gear systems can be found in normal bikes or escalators.

2. Connect a 10-tooth sprocket to a 30-tooth sprocket as shown.

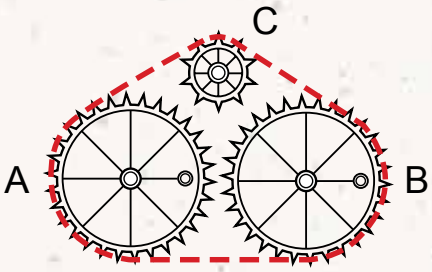


3. Use a pencil point, or something similar, to turn sprocket B.
Which direction does sprocket A turn?
Would this be the same if A and B were two gears meshing?
How many times do you have to turn A for B to rotate once?
The gear ratio of these two sprockets would be __ to __ ?

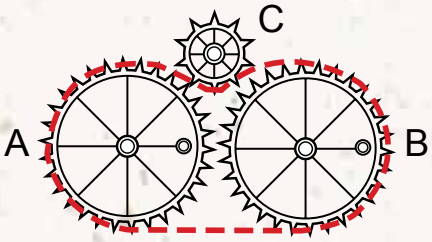
4. Repeat the experiment for the two assemblies below and make a table of your results for all three.



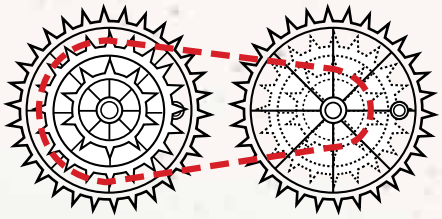
5. Try chaining a 10-tooth sprocket and two 30-tooth sprockets together as shown. Turn A clockwise.
What happens to B and C?
Do they turn in the same direction?
Do they turn at the same speed?



6. Now try to chain the 10-tooth sprocket C as shown.
Turn A clockwise. What happens to B and C?
Do they turn in the same direction?
Do they turn at the same speed?



7. By connecting two sets of chain gears together three speeds can be obtained.
This system is widely used in the transmission on bicycles by adding a gear shift in between.



ATTACHING BASE PLATES, RODS, AND FRAMES

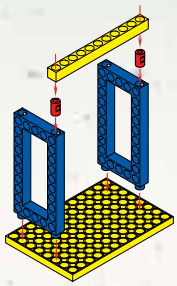


Fig. 1

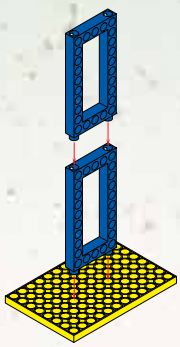


Fig. 2

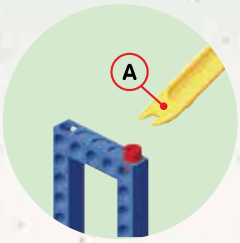


Fig. 3

1. The anchor pin can be used to join rods and frames (Fig. 1).
2. Frames can be connected directly to each other end to end (Fig. 2).
3. You can use the end "A" of the part separator tool to pry an anchor pin out of a hole (Fig. 3).

ATTACHING GEARS

Attaching gears to the frame

When connecting gears onto the frame with a drive axle, be sure to keep a proper gap (about 1 mm) between the gears and the frames. Try to turn the gear and confirm that every gear in the gear train turns smoothly so that friction is minimized. This is how you can achieve efficient power transmissions (Fig. 4 & 5).

NO! (without a space)

Fig. 4

YES! (with a space)

Fig. 5

Holding gears in place

Axle locks are designed to prevent a pulley wheel or gear from moving along the axle, or slipping. They are easy to install without removing the wheel or axle (Fig. 6).

Fig. 6

Lengthening drive axles

Use a small sprocket to connect two drive axles together to lengthen when necessary (Fig. 7).

Fig. 7

Arranging gear wheels symmetrically

When you use a motor to drive a wheeled vehicle, the gear wheels should be arranged symmetrically (the holes on the two opposite chain gear wheels must be placed in a horizontal line parallel to the axle) and be kept at the same driven speed, or the motor will stall and the vehicle won't move (Fig. 8).

TIP! These two holes must be placed in a horizontal line.

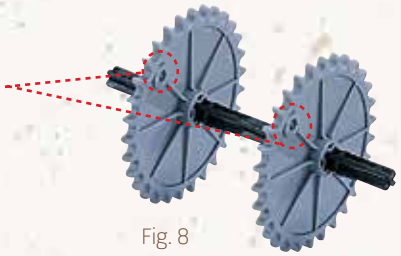


Fig. 8

Meshing gears at 90°

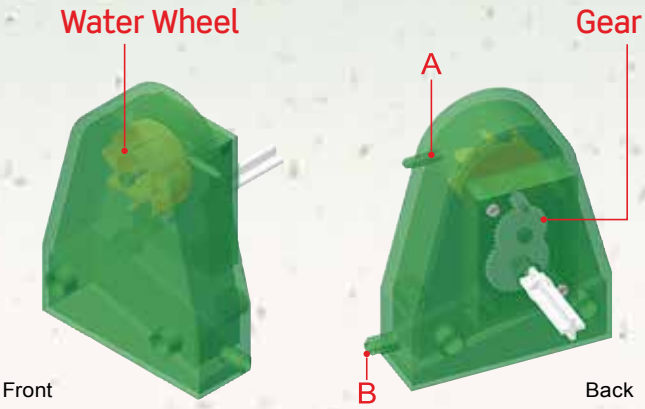
When the two red gears mesh with each other at 90°, the one on the drive axle must be assembled as close as possible to the outer end of the axle so that a good mesh can be ensured (Fig. 9).

Fig. 9

Connecting chain links

Make sure that you attach the chain links together with the smooth side always on the inside, so that the transmission can run efficiently and smoothly (Fig. 10). Note: Not all chain link colors shown are included in this kit.

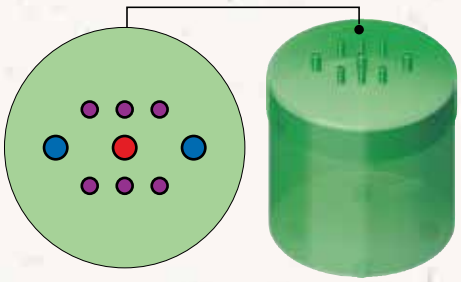
Fig. 10



Air+Water Turbine Engine

Air and water enter the turbine engine through the entrance nozzle "A", pushing on and turning the water wheel, which drives the gear train behind it to turn the axle. Then the water flows back to the water storage tank through the exit nozzle "B" for repeated use.

Water Storage Tank



- Exit
- Hose B Entrance
- Hose A Entrance

Pay attention to the difference between the "water storage tank" and the "air+water tank" — you will need to be able to tell them apart by name to properly build the models!

Pump

"A" is the entrance nozzle and "B" is the exit nozzle. You use the pump to pump water from the water storage tank into the pressurized air+water tank. When the pump handle is pulled up, air and water will come into the pump through the entrance nozzle. When the pump handle is pushed down, the air and water will be pushed into the pressurized air+water tank through the exit nozzle.

Pressurized Air+Water Tank

"A" is the entrance nozzle and "B" is the exit nozzle. Air and water from the water storage tank come into the pressurized air+water tank through the entrance, and leave through the exit.

One-Way Switch

"A" is the entrance nozzle and "B" is the exit nozzle. When the switch lever is in the middle, the exit is closed, and air and water cannot pass through the one-way switch. When the switch lever is turned toward the side of the entrance nozzle, the exit is opened and the air and water can flow through.

Refer back to these notes when you are building the models.

1. NOTES FOR ASSEMBLY:

- Insert a 9.5 cm long tube into the protruding nozzle on the underside of the lid of the water storage tank, and cut its other end diagonally (Fig. 11). Position the diagonally cut end to rest on the inside bottom of the storage tank so that water will easily enter the hose when pumping. You can attach it to the bottom with a piece of tape if necessary.
- The lengths of hoses for the models given in this manual are for reference only. Be sure not to make the hoses too tight, twisted, or compressed (Fig. 12). Water must be able to flow through them smoothly.
- Slide a security nut onto a hose and screw it in completely when connecting the hose to the pressurized water tank and pump (Fig. 13 & 14).
- Use an L security nut for tube A, and an S security nut for tube B. After repeated use, the hoses might become worn and come off the connection nozzles. The solution is to cut about 1 to 1.5 cm off the end of the tube. Be sure to wipe the nozzle dry with a paper towel before the refreshed hose is installed again.
- The cut hoses can be used again and again for different models.

Fig. 11

Fig. 12

Fig. 13

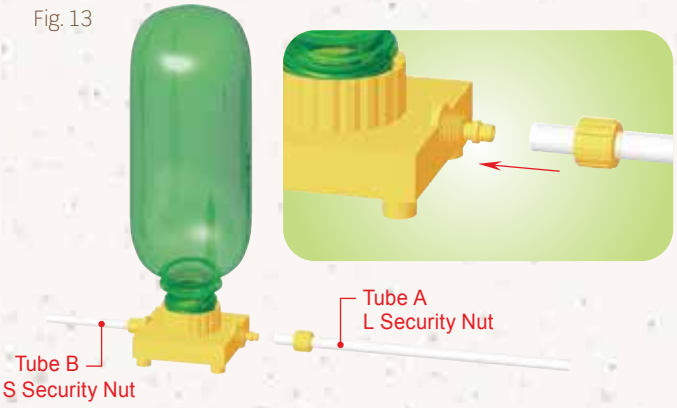
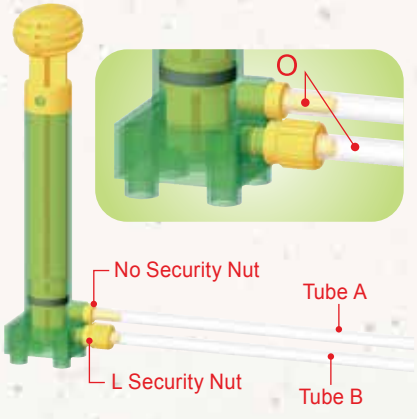
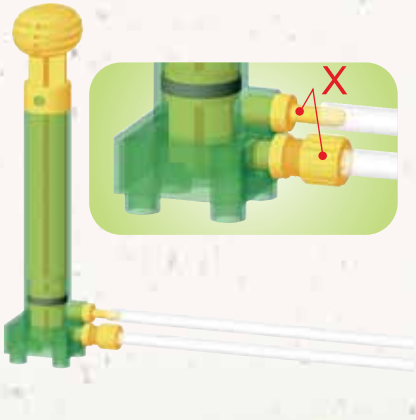
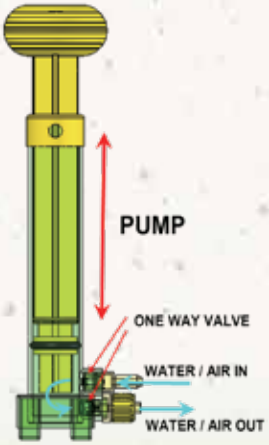


Fig. 14





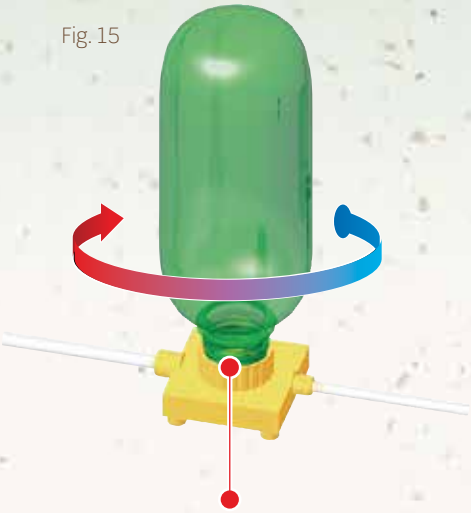


Refer back to these notes when you are using the models.

2. NOTES FOR OPERATION:

- Check to ensure that all of the hoses are fixed to the correct positions before pumping.
- Check to ensure that the air+water tank is screwed to the end (Fig. 15). The air+water tank should be half-filled with water and thus half-filled with air, but you can experiment with different fill levels.
- Check to ensure that the switch lever is set to the middle of the switch (i.e. in the closed position, as Fig. 16 shows) before pumping, so that the pumped air and water can't escape.
- Close the switch lever tightly so that air and water cannot leak out. It may take a decent amount of force to move the lever.
- Move the pump from the model to the tabletop whenever you pump it, and put it back after you finish pumping (Fig. 17).
- About ten pumps are needed to start pushing water from the water storage tank into the pressurized air+water tank. Hold the pump handle up for two or three seconds before you push it down again so that the most water can be driven into the pump cylinder during each pump (Fig. 18).
- Pump no more or less than 50 times. If you pump it more than 50 times, the basic parts might come under too much pressure and become damaged. On the contrary, if you pump it less than 50 times, the power might be too weak to lead to smooth operation. The more air you pump into the tank, the higher the air pressure will be, and the more energy is stored.
- Don't pull off any of the hoses — either during operation or before all the water returns to the water storage tank. Otherwise, the water stream could spurt out of the hose and might hurt you or make a mess.
- If a hose becomes disconnected at any time during operation, turn off the switch by shifting the switch level back to the middle to stop the spray of water, and wipe the hose end and nozzle dry before reattaching.
- Use the one-way switch to release the air and water remaining in the pressurized air+water tank before you put the model away.

Fig. 15



Screw in the air+water tank tightly.

Fig. 16

Set the lever in the closed position.

Fig. 17

Pump on a table, countertop, or floor.

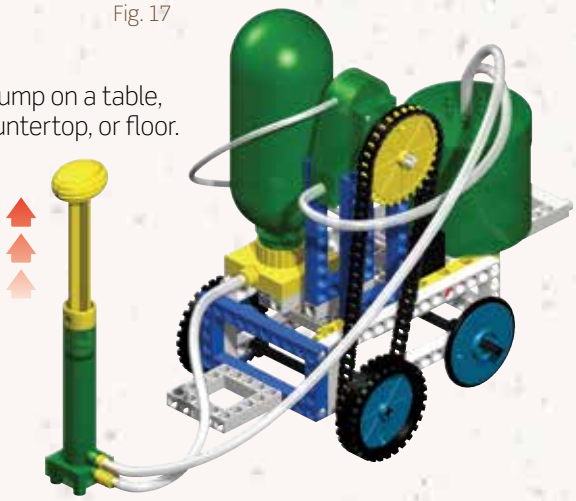


Fig. 18

SCIENTIFIC PRINCIPLES :

When the pump moves water from the water storage tank into the pressurized air+water tank, the water squeezes the air inside the pressurized air+water tank upward. Air is a compressible fluid. In other words, the volume of air can be reduced by compressing it, whereas water cannot be compressed. When more and more water is added into the air+water tank, the water takes up more and more space. Since the space within the air+water tank is limited, the increasing volume of water compresses the air inside the air+water tank more and more. As a result, the pressure inside increases and becomes higher than the air outside the air+water tank. This high-pressure air pushes on the water in the air+water tank, and the water pushes outward on all sides of the tank in an attempt to escape and resume pressure equilibrium, or balance.

After the pump first draws water into the pressurized air+water tank, and is then pumped another 40 times, more air is pumped into the remaining fixed space occupied by the water. Thus the air pressure becomes even higher.

These phenomena include many principles from physical science:

1. Water is incompressible, whereas air is compressible.
2. Boyle's law: For a fixed amount of gas kept at a fixed temperature, the product of the volume and pressure is constant.

   (P1 · V1 = P2 · V2) (P1 : P2 = V2 : V1) P = Pressure and V = Volume

   When more air is pushed inside a fixed volume, the air pressure will rise.
3. Pascal's principle, also called Pascal's law, is a term in fluid (gas or liquid) mechanics. It states that if pressure variation occurs in one part of a static fluid within a closed container, the pressure transfers to every part of the fluid equally in all directions, and pushes outward on the container wall without any loss.

How much energy is stored within the pressurized air+water tank?

According to the following experiment, when the pump draws water into the pressurized air+water tank and is then pumped another 40 times, the pressure is approximately 3.5 kg/cm^2.

AIR+WATER TURBINE

The first seven models in this kit use an enclosed water turbine to drive their gears and wheels.

1 atmospheric pressure (atm)
= 760 mmHg (torr) = 76 cmHg
= 76 · 13.6 g/cm^3 (density of mercury)
= 1033.6 g/cm^2 = 1.0336 kg/cm^2

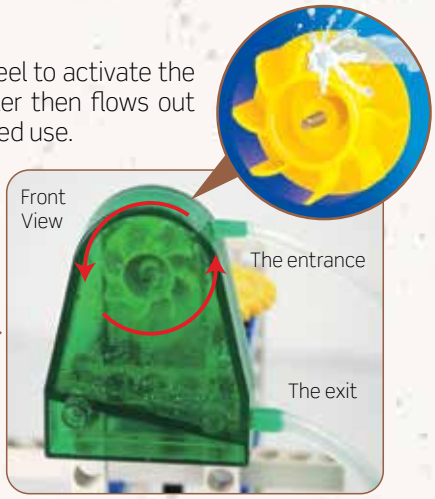
Therefore, 3.5 kg/cm^2 of compressed air is equal to 3.4 atm. To grasp the potential energy of this pressure, you have to realize that mercury is 13 times denser than water. So, a pressure of 3.4 atm equates to the pressure of a 1-by-1 cm column of mercury that is 76 cm tall, or a 1-by-1 cm column of water that is 35 meters tall! That is the height of a 10-story building! This is why you can power your models with the energy created by simply pumping air into the air+water tank.

HOW TO OPERATE THE AIR+WATER TURBINE

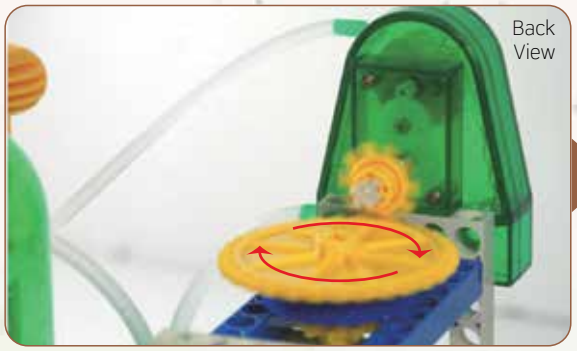
1. Fill the air+water tank about half full of water and attach it onto the system. Pump the pump about 10 times to get all water from water storage tank into the pressurized air+water tank, and keep pumping another 40 times to compress the air and build up the pressure in the air+water tank.
2. Move the level of the one-way switch to open it.
3. The released water will spray out and strike the blades of the water wheel to activate the air+water turbine, and drive the geared mechanism behind it. The water then flows out through the exit nozzle and returns to the water storage tank for repeated use.

Step 1 Pump 50 times.

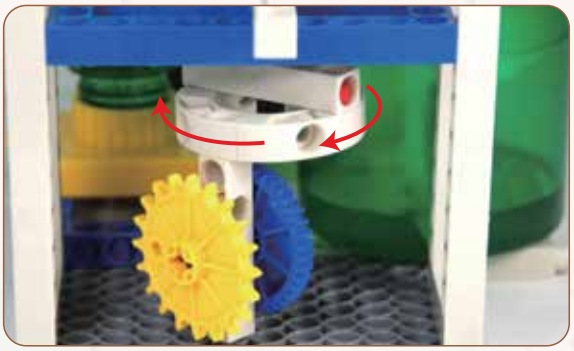
Step 2 Turn on the switch...



Step 3 ...to spin the turbine...



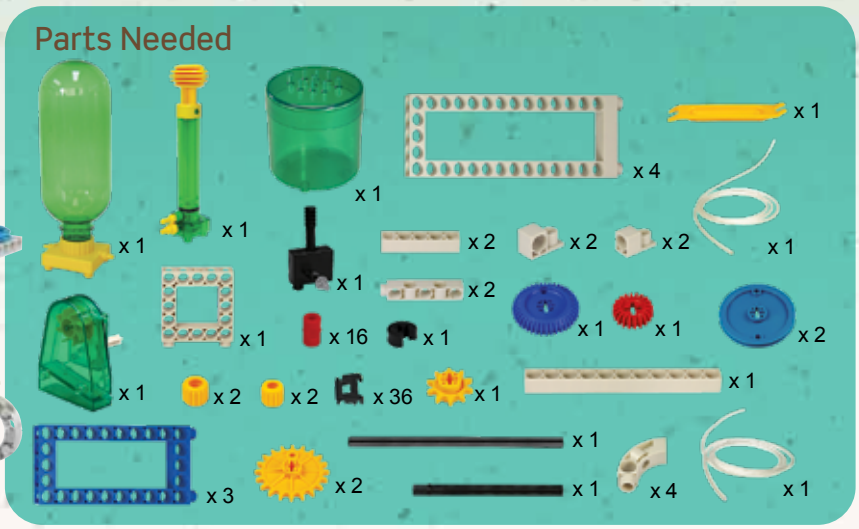
...which drives the geared mechanism behind it.



The model begins to move! (Note: Gears shown here may differ from those in the kit.)

Cutting Machine

Parts Needed

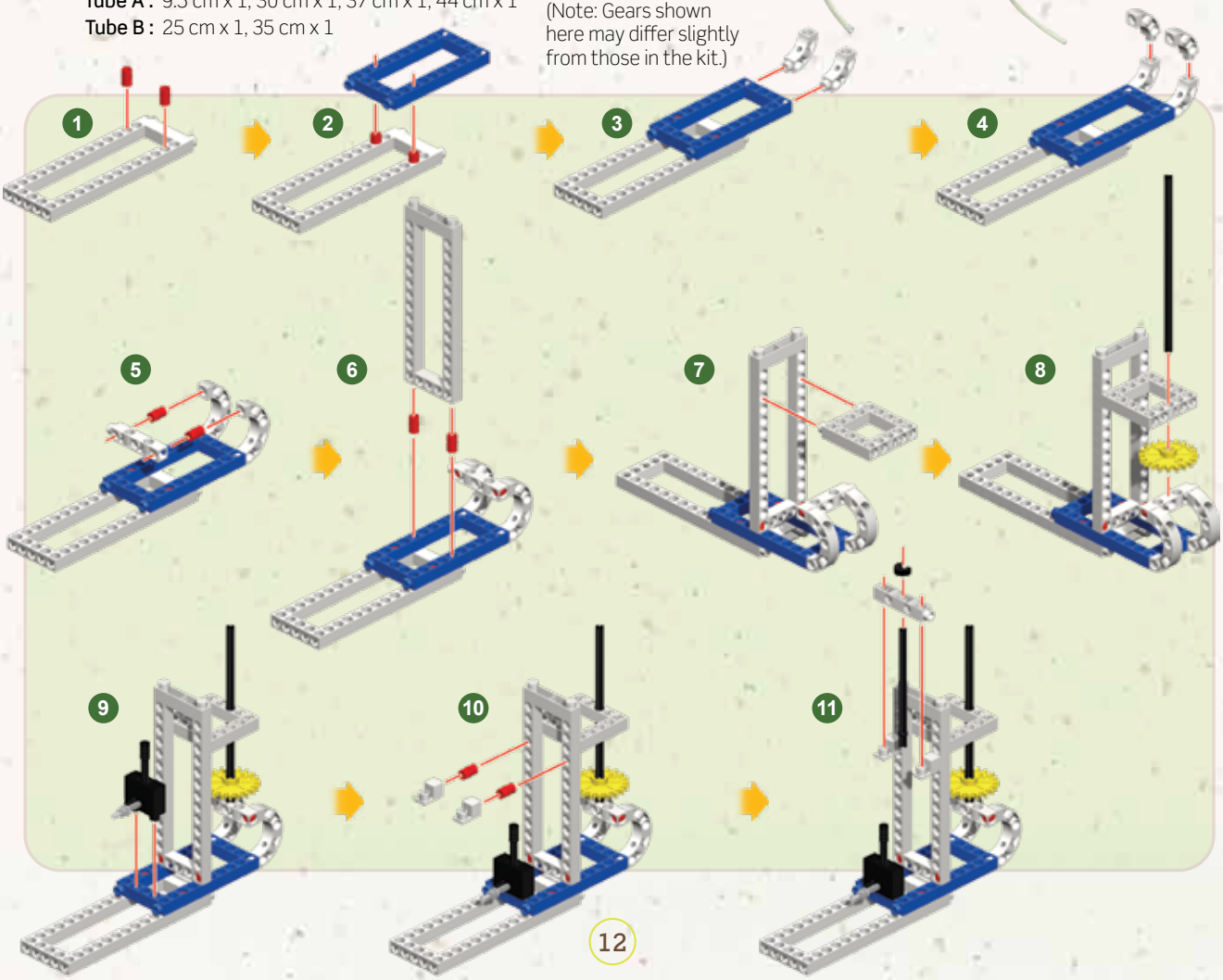


Assembly Notes

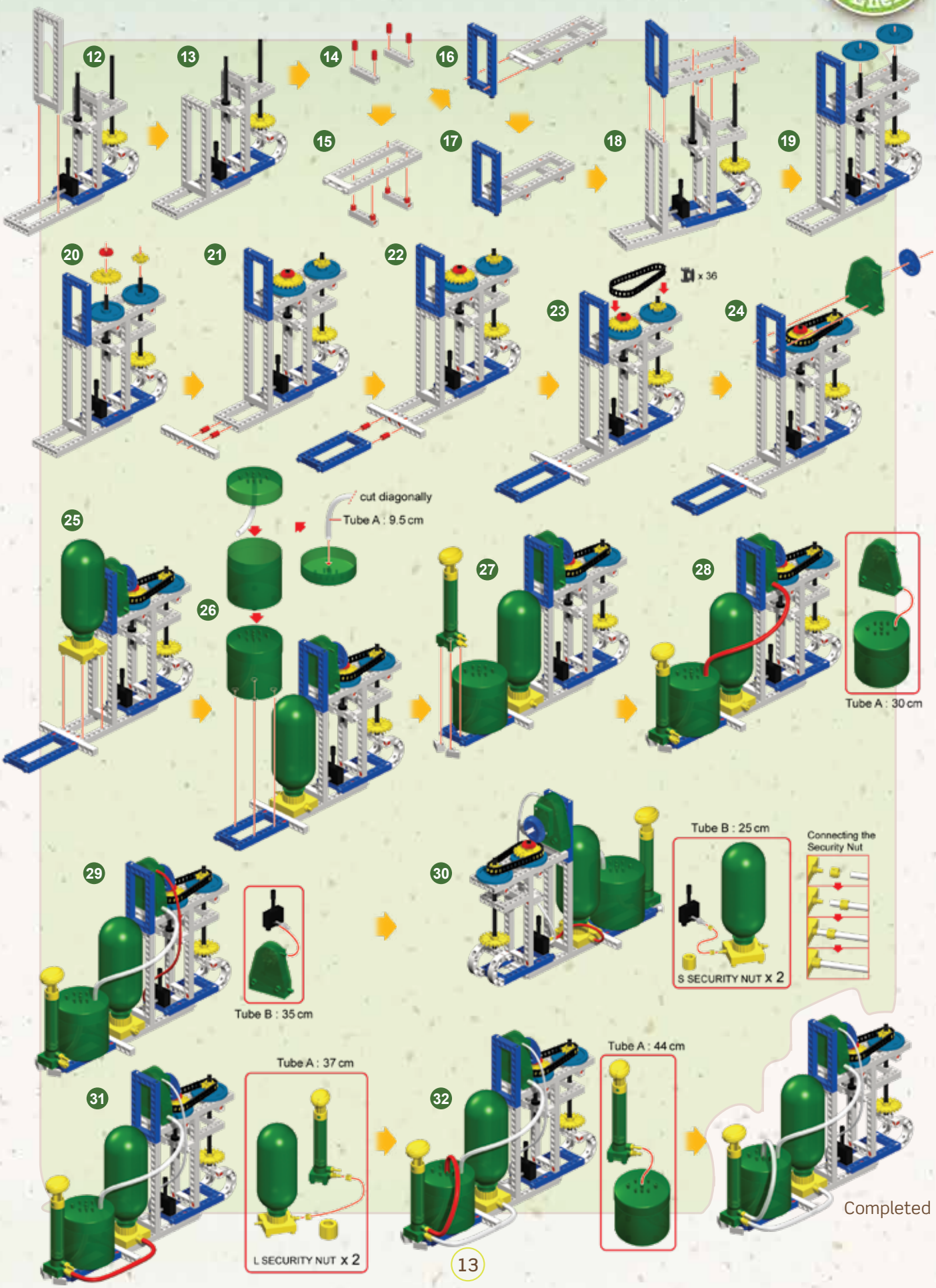
1. The gears should mesh well with each other in order to operate smoothly. We encourage you to tinker and improve the design to make the models run smoothly.
2. Note that the sprockets must be aligned in order for the chain to operate smoothly.
3. Cut Tube A and Tube B to get tubes of the following lengths for this model. (The same tubes will be used for all models.)

   Tube A : 9.5 cm x 1, 30 cm x 1, 37 cm x 1, 44 cm x 1
   Tube B : 25 cm x 1, 35 cm x 1

(Note: Gears shown here may differ slightly from those in the kit.)

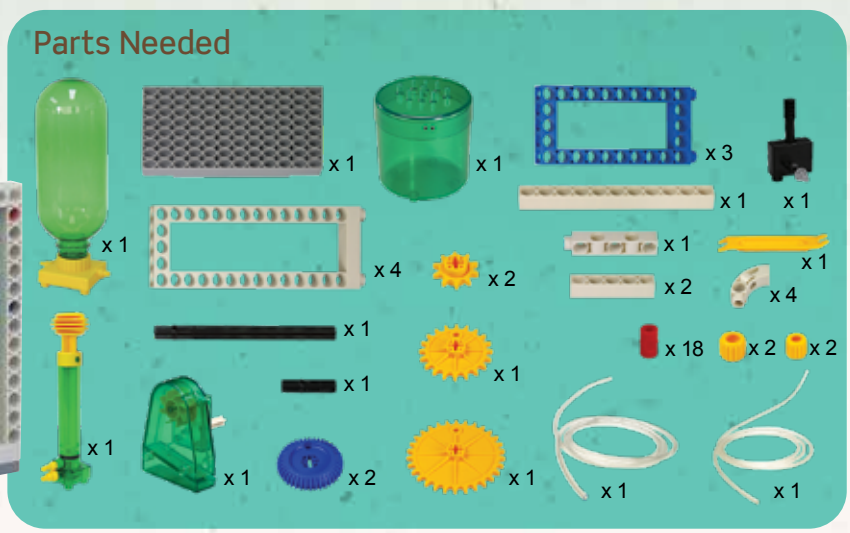


MODEL 1 Cutting Machine | AIR+WATER POWER



Grinding Machine

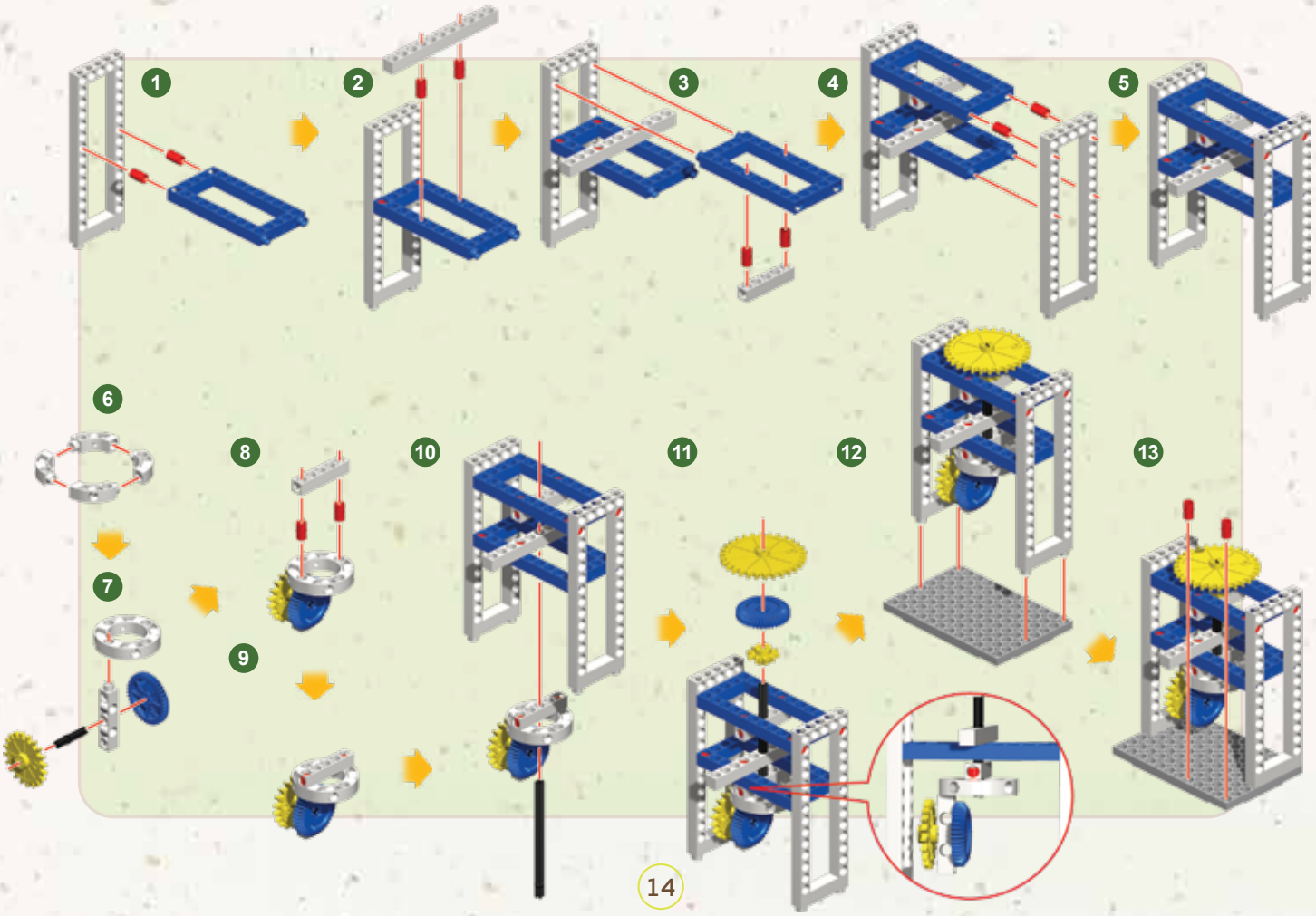
Parts Needed

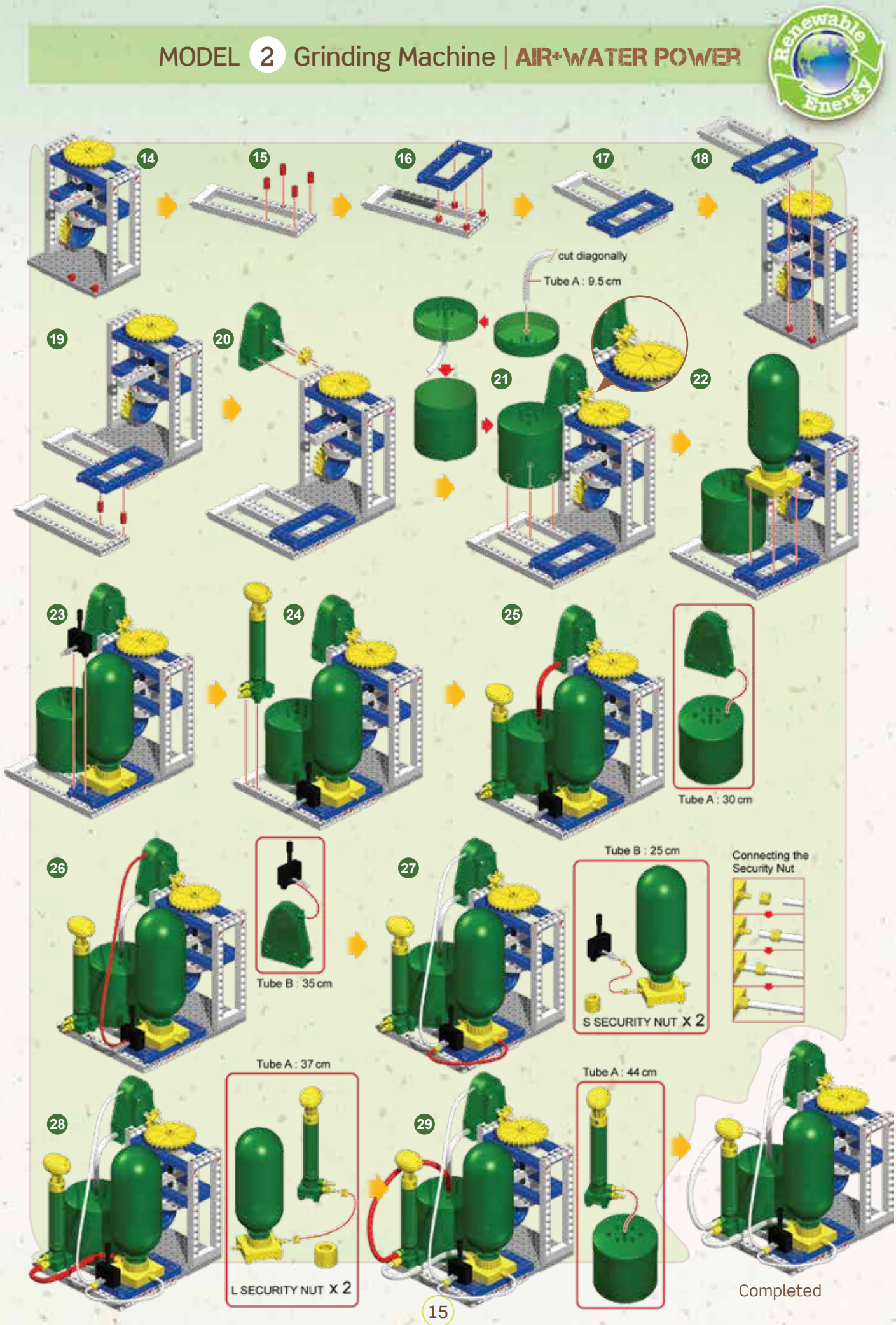


Assembly Notes

1. The gears should mesh well with each other in order to operate smoothly.
2. Cut Tube A and Tube B to get tubes of the following lengths for this model.

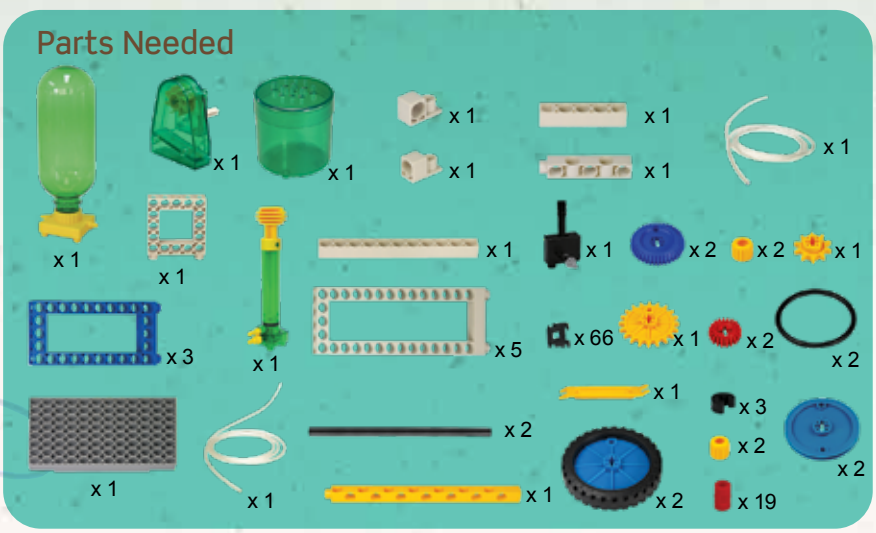
Tube A : 9.5 cm x 1, 30 cm x 1, 37 cm x 1, 44 cm x 1
Tube B : 25 cm x 1, 35 cm x 1




14
15
16
17
18
cut diagonally
Tube A : 9.5 cm
19
20
21
22
23
24
25
Tube A : 30 cm
26
Tube B : 35 cm
27
Tube B : 25 cm
S SECURITY NUT X 2
Connecting the Security Nut
28
Tube A : 37 cm
L SECURITY NUT X 2
29
Tube A : 44 cm
Completed

Truck

Parts Needed

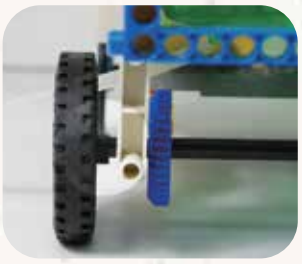


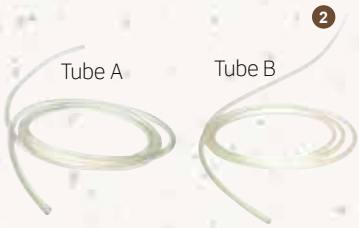
Assembly Notes

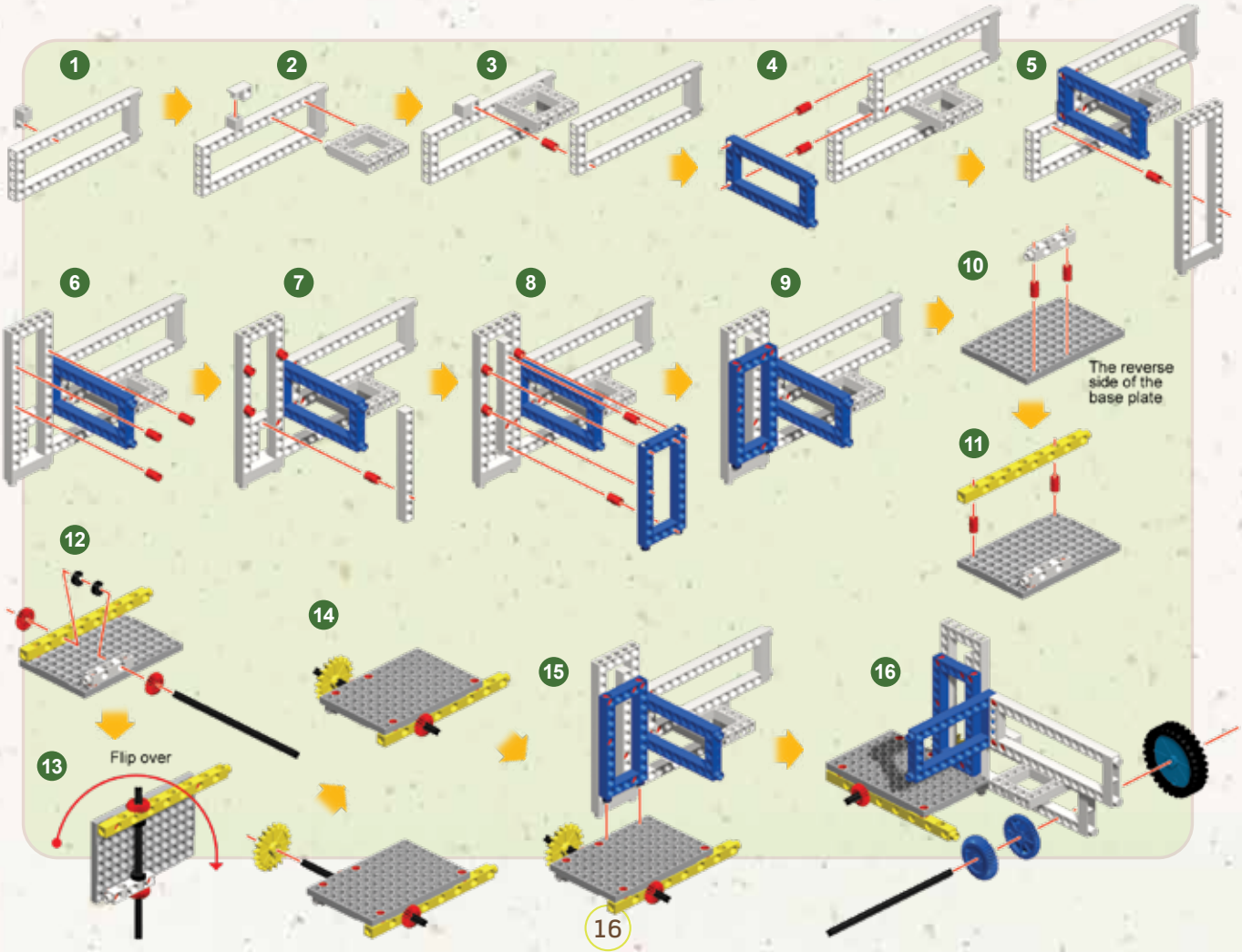
1. Leave a 1 mm gap between the gear and the long frame so that the wheel can turn smoothly.
2. Cut Tube A and Tube B to get tubes of the following lengths for this model.

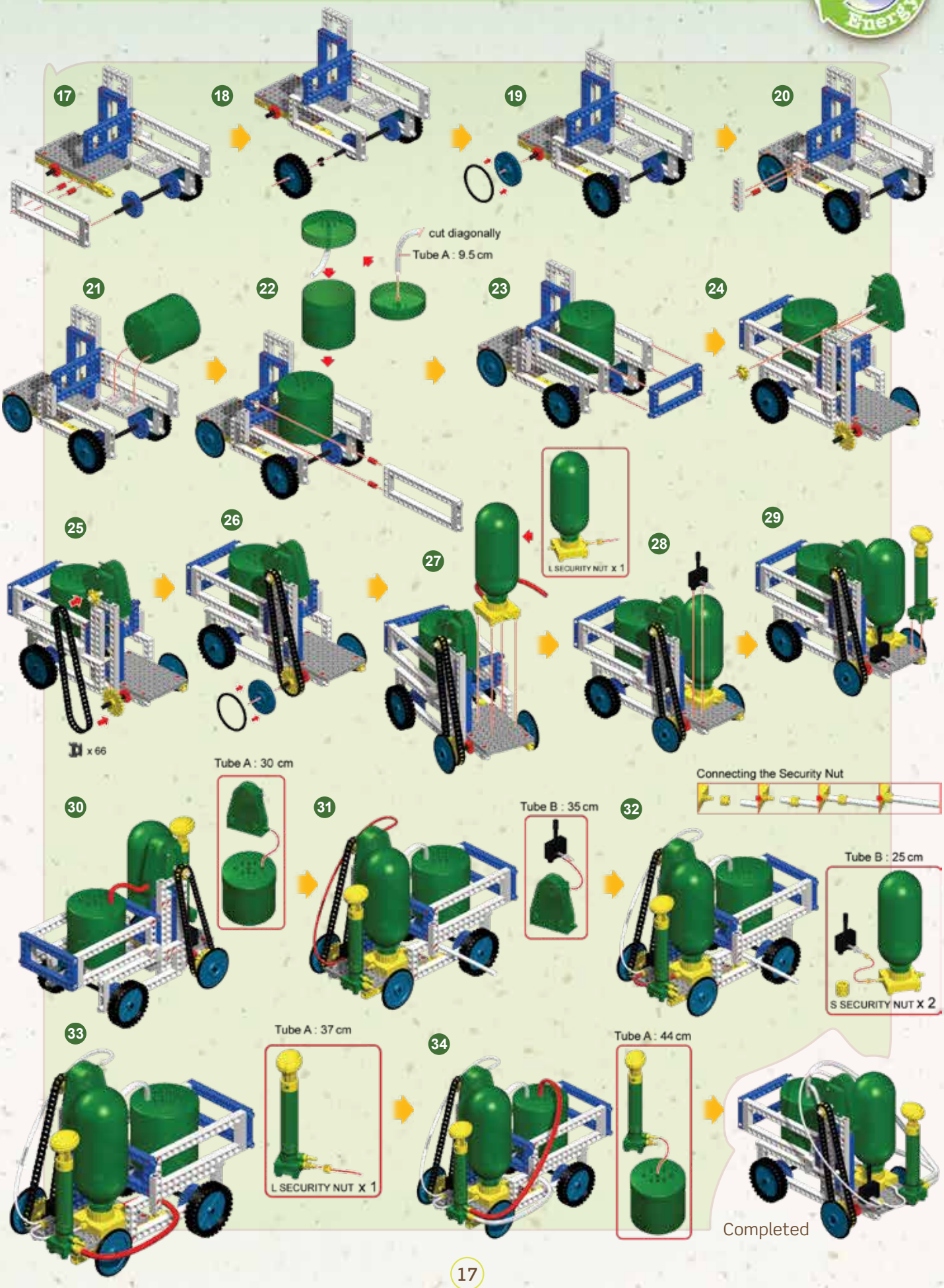
   Tube A : 9.5 cm x 1, 30 cm x 1, 37 cm x 1, 44 cm x 1

   Tube B : 25 cm x 1, 35 cm x 1



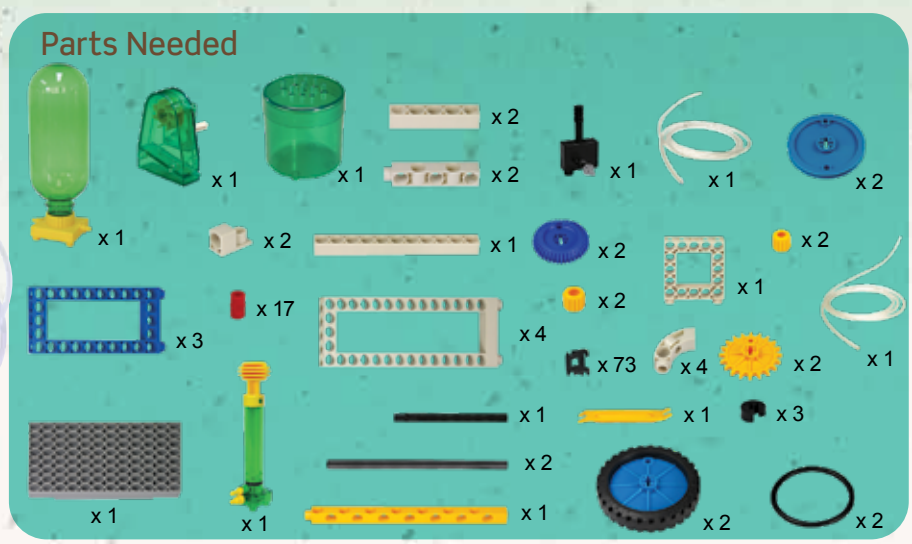





17
18
19
20
cut diagonally
Tube A : 9.5 cm
21
22
23
24
25
26
27
L SECURITY NUT x 1
28
29
x 66
Tube A : 30 cm
Connecting the Security Nut
30
31
Tube B : 35 cm
32
Tube B : 25 cm
S SECURITY NUT x 2
33
Tube A : 37 cm
L SECURITY NUT x 1
34
Tube A : 44 cm
Completed

Excavator

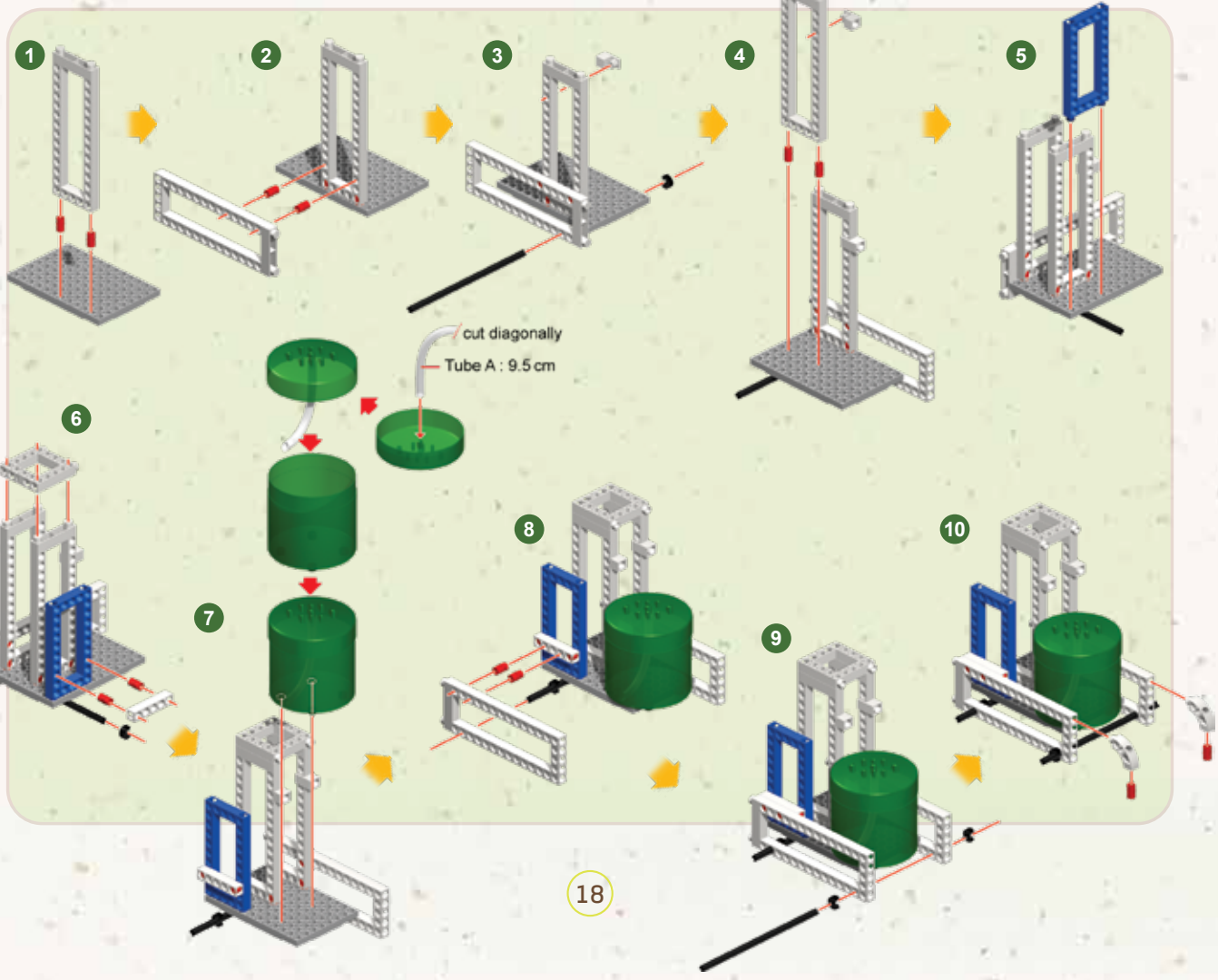
Parts Needed

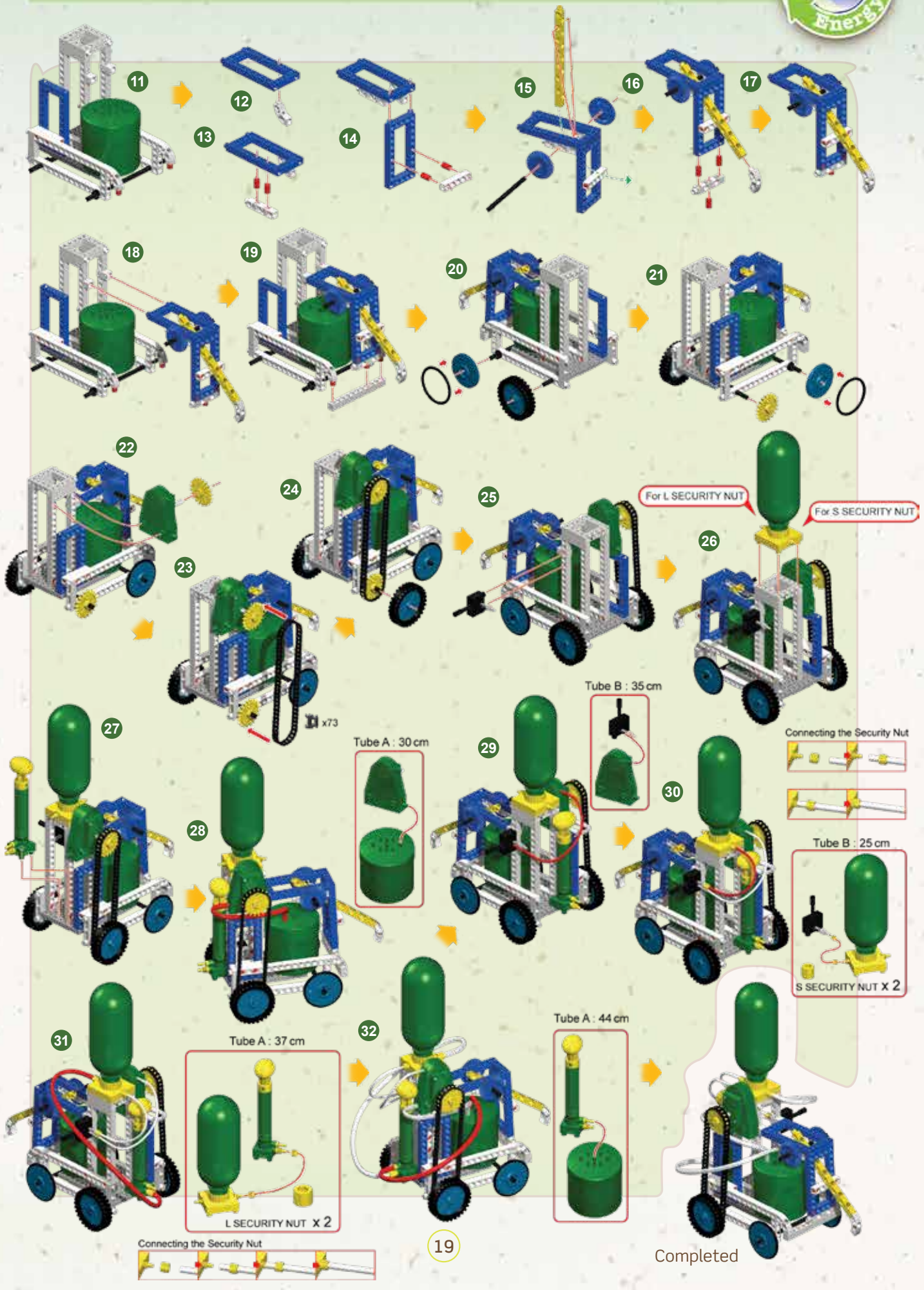


Assembly Notes

1. Note that the sprockets must be aligned in order for the chain to operate smoothly.
2. Leave a 1 mm gap between the axle lock and the long frame so that the wheel can turn smoothly.
3. Cut Tube A and Tube B to get tubes of the following lengths for this model.

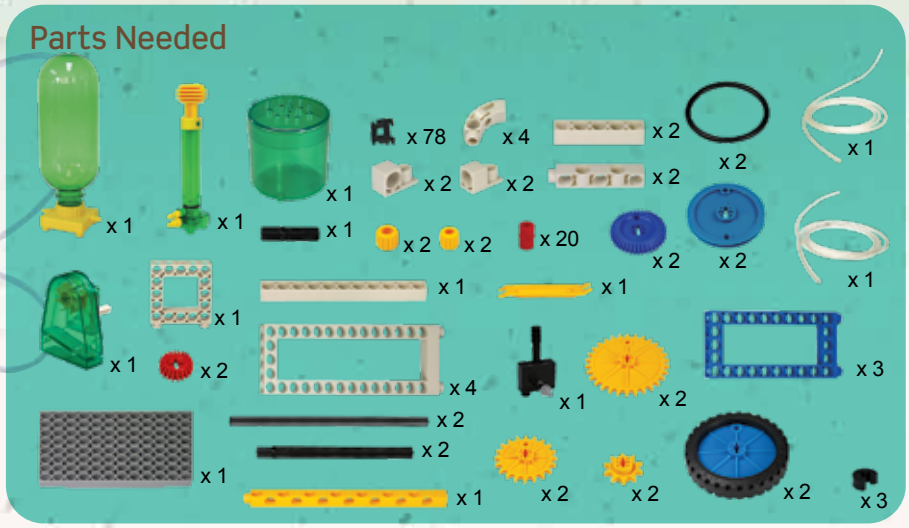
Tube A : 9.5 cm x 1, 30 cm x 1, 37 cm x 1, 44 cm x 1
Tube B : 25 cm x 1, 35 cm x 1




11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
For L SECURITY NUT
For S SECURITY NUT
26
x73
27
Tube A : 30 cm
28
29
Tube B : 35 cm
30
Connecting the Security Nut
Tube B : 25 cm
S SECURITY NUT X 2
31
Tube A : 37 cm
L SECURITY NUT X 2
32
Tube A : 44 cm
Connecting the Security Nut
Completed

Radar Car

Parts Needed

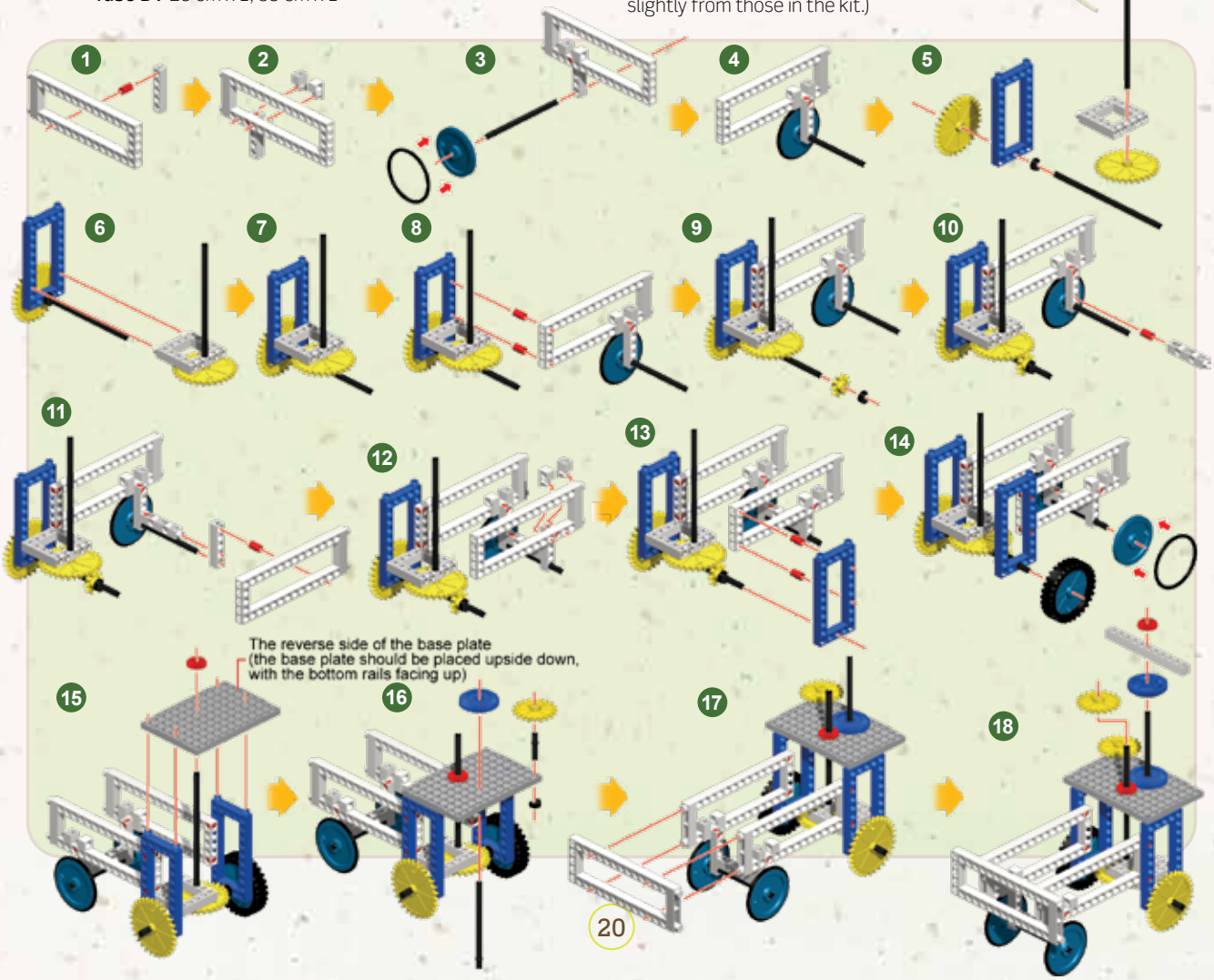


Assembly Notes

1. The gears should mesh well with each other in order to operate smoothly.
2. Leave a 1 mm gap between the axle lock and the long frame so that the wheel can turn smoothly.
3. Cut Tube A and Tube B to get tubes of the following lengths for this model.

Tube A : 9.5 cm x 1, 30 cm x 1, 37 cm x 1, 44 cm x 1
Tube B : 25 cm x 1, 35 cm x 1

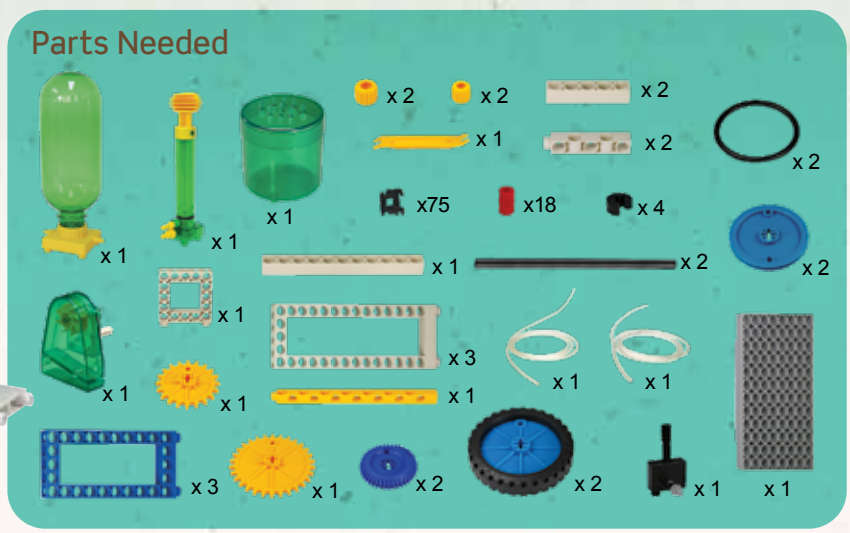
(Note: Gears shown here may differ slightly from those in the kit.)




19
20
21
22
23
24
25
x78
26
27
28
cut diagonally
Tube A : 9.5 cm
29
30
Tube A : 30 cm
31
Tube B : 35 cm
32
Connecting the Security Nut
33
Tube B : 25 cm
S SECURITY NUT x 2
34
Tube A : 37 cm
L SECURITY NUT x 2
35
Tube A : 44 cm
Completed

Tank

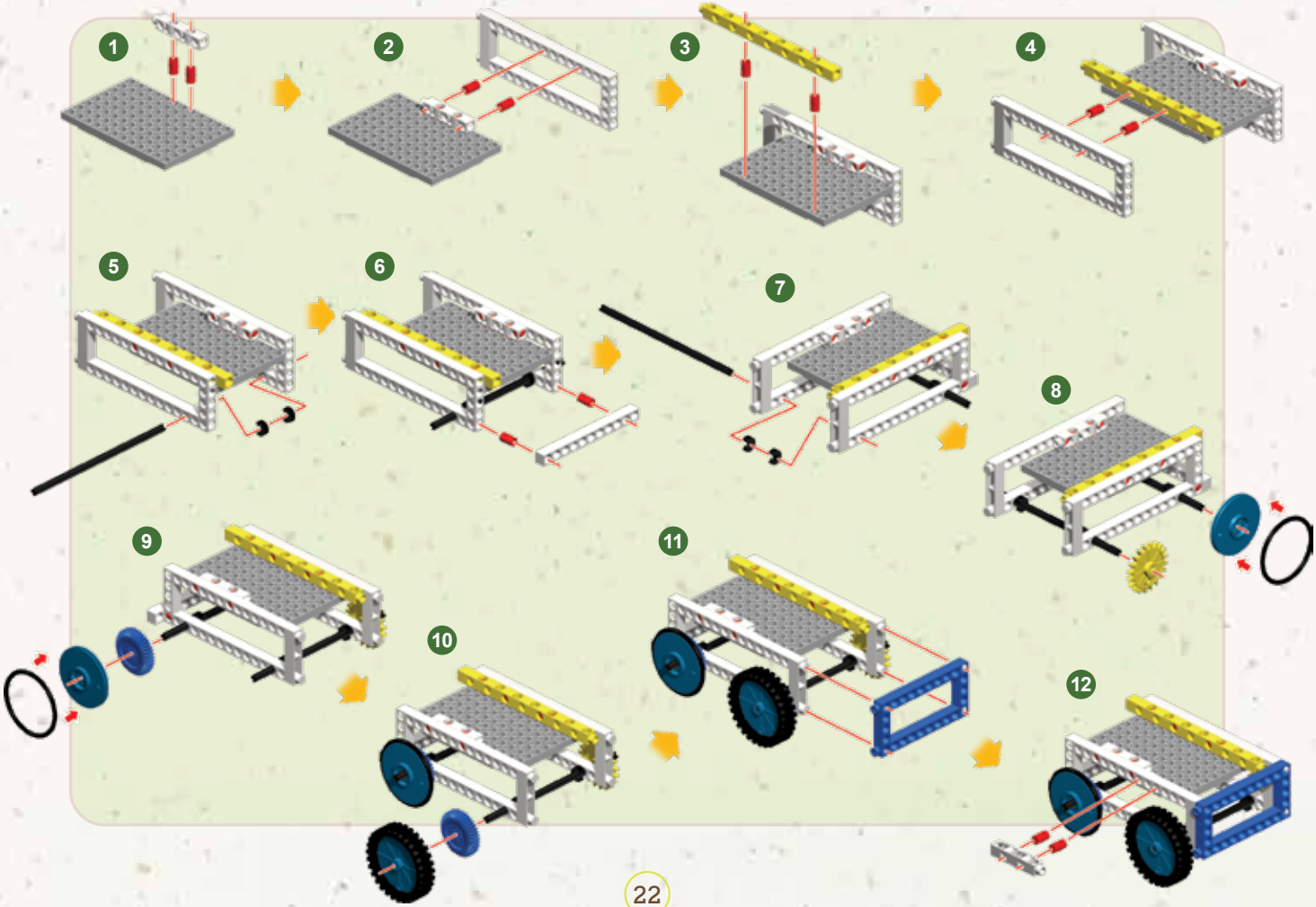
Parts Needed

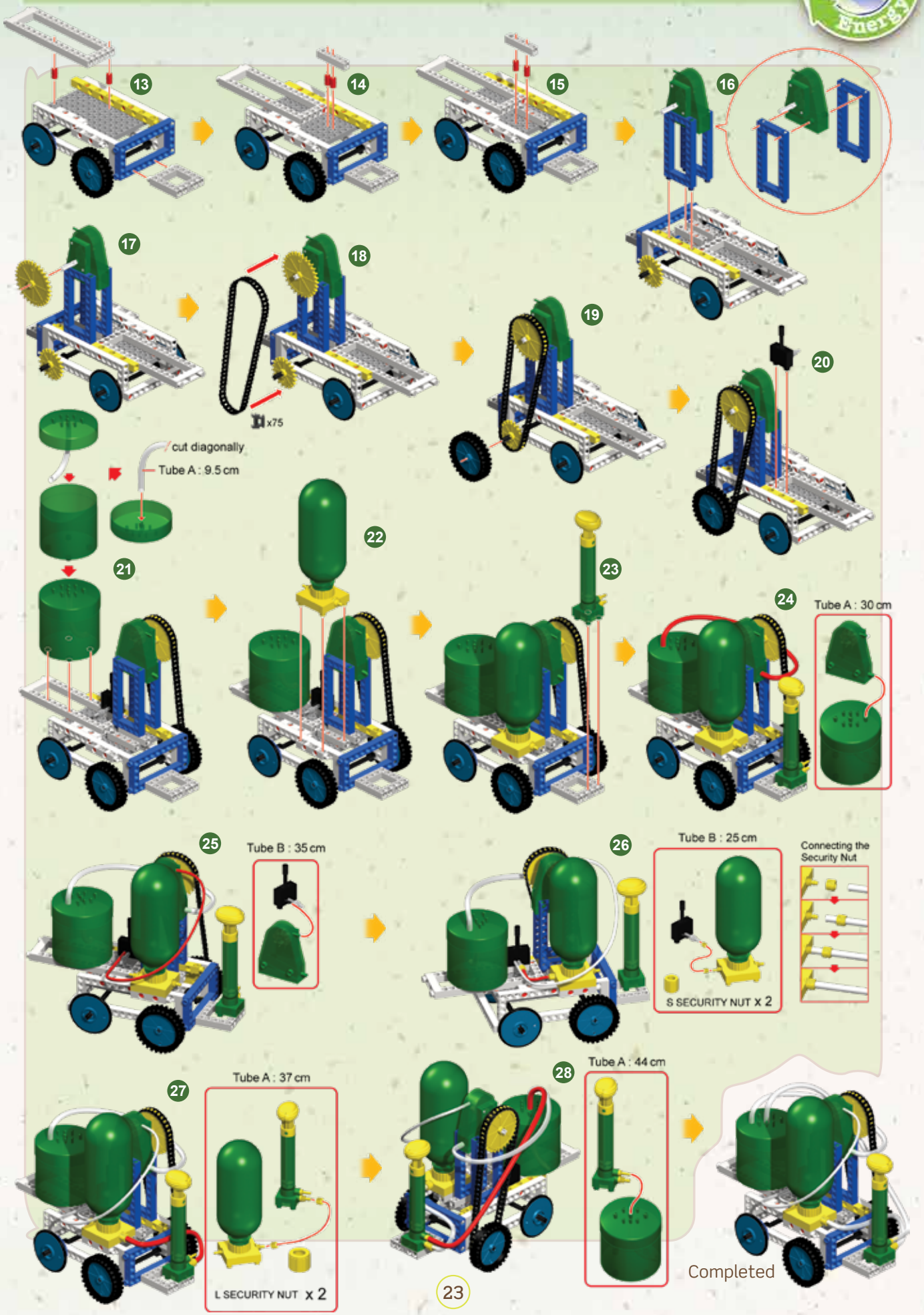


Assembly Notes

1. Leave a 1 mm gap between the axle lock and the long frame so that the wheel can turn smoothly.
2. Cut Tube A and Tube B to get tubes of the following lengths for this model.

Tube A : 9.5 cm x 1, 30 cm x 1, 37 cm x 1, 44 cm x 1
Tube B : 25 cm x 1, 35 cm x 1




13
14
15
16
17
18
x75
19
20
cut diagonally
Tube A : 9.5 cm
21
22
23
24
Tube A : 30 cm
25
Tube B : 35 cm
26
Tube B : 25 cm
S SECURITY NUT x 2
Connecting the Security Nut
27
Tube A : 37 cm
L SECURITY NUT x 2
28
Tube A : 44 cm
Completed

Antique Car

Parts Needed

Assembly Notes

1. Note that the sprockets must be aligned so that the chain can operate smoothly. We encourage you to tinker with this design to improve its performance.
2. Leave a 1 mm gap between the axle lock and the long frame so that the wheel can turn smoothly.
3. Cut Tube A and Tube B to get tubes of the following lengths for this model.

   Tube A : 9.5 cm x 1, 30 cm x 1, 37 cm x 1, 44 cm x 1

   Tube B : 25 cm x 1, 35 cm x 1

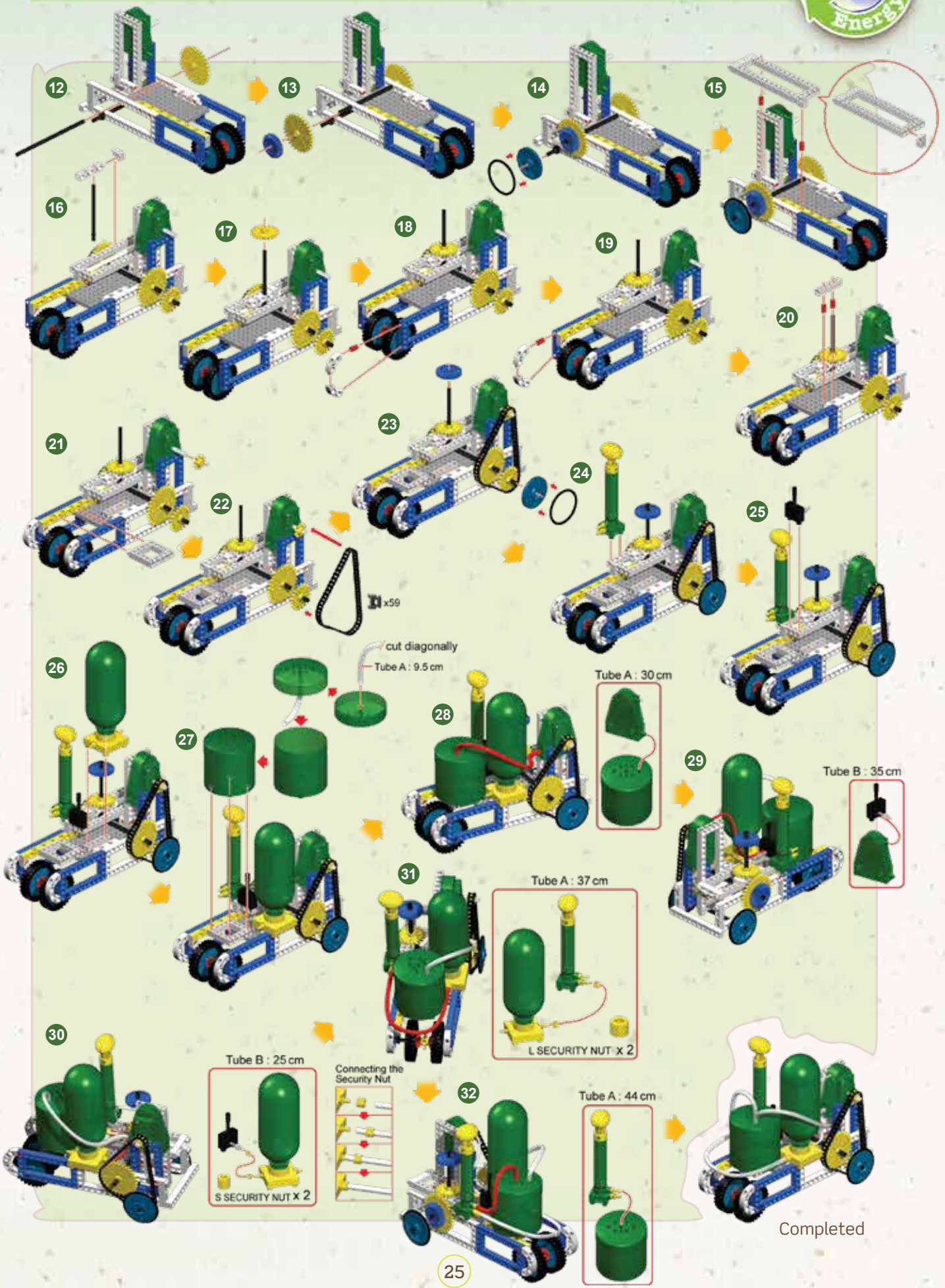
1

(Note: Gears shown here may differ slightly from those in the kit.)

2

3

MODEL 7 Antique Car | AIR+WATER POWER



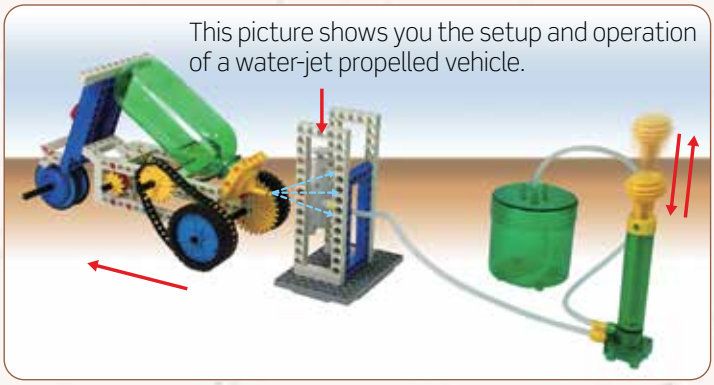
WATER-JET VEHICLES

The water-jet propelled vehicles in this kit do not use the air+water turbine used in the first seven models. The water-jet models consist of two separate parts — the vehicle itself and the launcher — instead of one self-contained system as in the first seven models.

PRINCIPLE

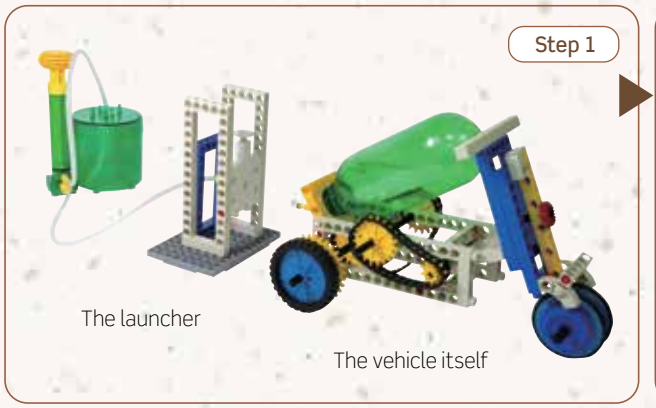
Newton's Third Law of Motion states that when two objects interact, the force from each acts on the other with the same magnitude (amount) but in opposite directions. This law is also known as the law of action and reaction.

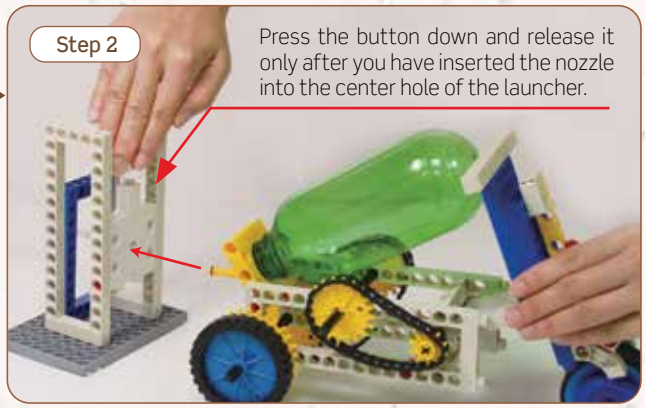
HOW TO OPERATE

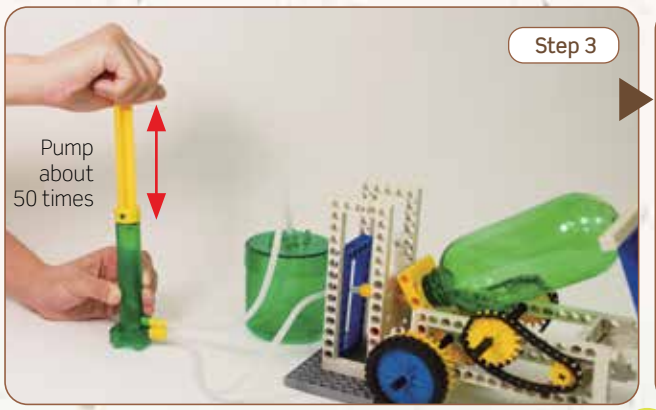


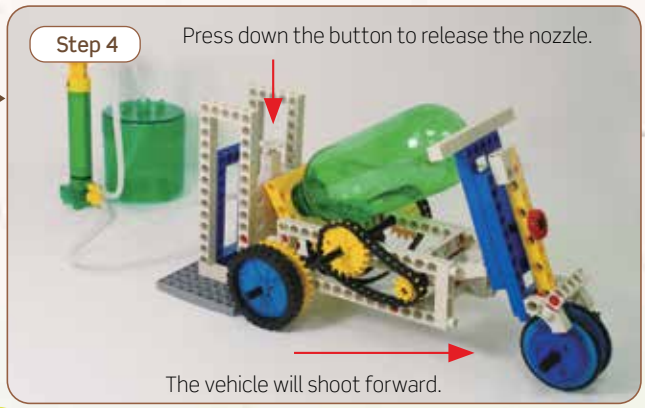
Please follow these steps.

1. Build a model of a water-jet vehicles according to the illustrated instructions given in this instruction manual. If there is no water in the system yet, fill the air+water tank half full of water and pour all the water into the water storage tank.
2. Press and hold the button on the launcher and insert the nozzle of the pressurized air+water tank on the vehicle into the center hole of the launcher. Then release the button so that the vehicle itself and the launcher are securely connected.
3. Pump the pump about 50 times until all of the water comes from the water storage tank into the pressurized air+water tank and the air inside of it is properly compressed.
4. Press down the button on the launcher to release the nozzle. A stream of water will instantly spray out of the highly pressurized tank from the nozzle, pushing the vehicle forward. Make sure you are not in its way!









EXPERIMENT:

If you have equal volumes of water and air, the mass of the water is much greater than that of the air. In the case of your water-jet engines, filling the pressurized air+water tank with water allows for a stronger reaction force than if it were just filled with air, according to conservation of momentum (Newton's Second Law of Motion). However, if too much water is added, it will reduce the space for the air and diminish the potential for the generation of kinetic energy. So, what is the best amount of water? This is a question worth investigating to find out.

Without water to be pumped

With water halfway full

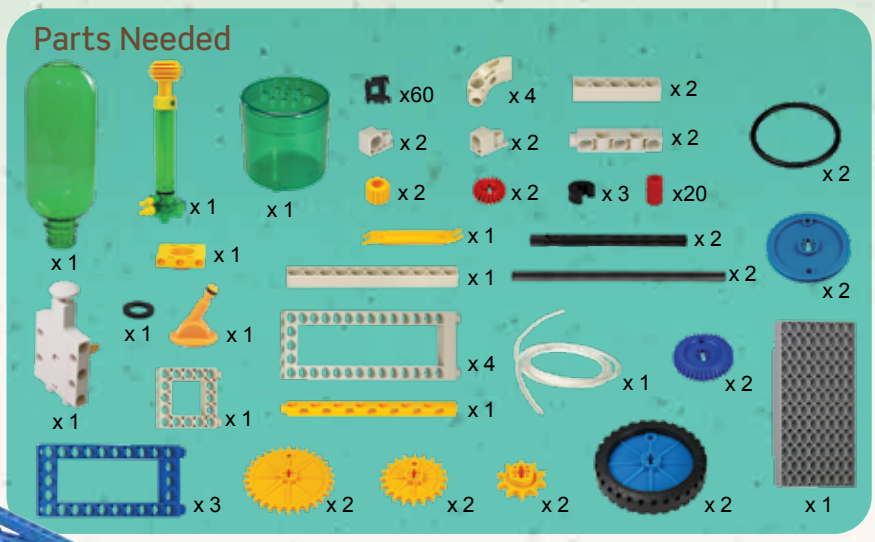
(1) Build model 13 and operate it without any water added to the water storage tank.

If no water is used, no water will enter the pressurized air+water tank. The limited air in the tank will rush out as soon as the nozzle is opened, which leads to only a minor change in momentum for the vehicle. As a result, the vehicle moves forward at a slow speed for only a short distance.

(2) Fill the water tank half full of water and operate the model again.

Add water into the water storage tank so it is about half full. Use the pump to draw water into the pressurized air+water tank, which pumps air into the tank as well. At this time, since the volume of the air+water tank remains the same, the air density in the tank increases as more and more air molecules are pumped into it. These air molecules keep moving and colliding with each other even when the pumping has stopped, and they generate a constant total momentum, which always equals the sum of the momentum of each molecule, according to conservation of momentum. Using the momentum formula: Momentum (Force) = Mass (M) × Velocity (V), and Pascal's Principle: P (Pressure) = F (Force) / A (Area), you can determine that when the area is fixed, force will increase if the pressure increases. Therefore, using the same air+water tank (to keep the volume fixed), a greater force can be derived to run the water-jet vehicle farther by adding greater pressure.

Parts Needed

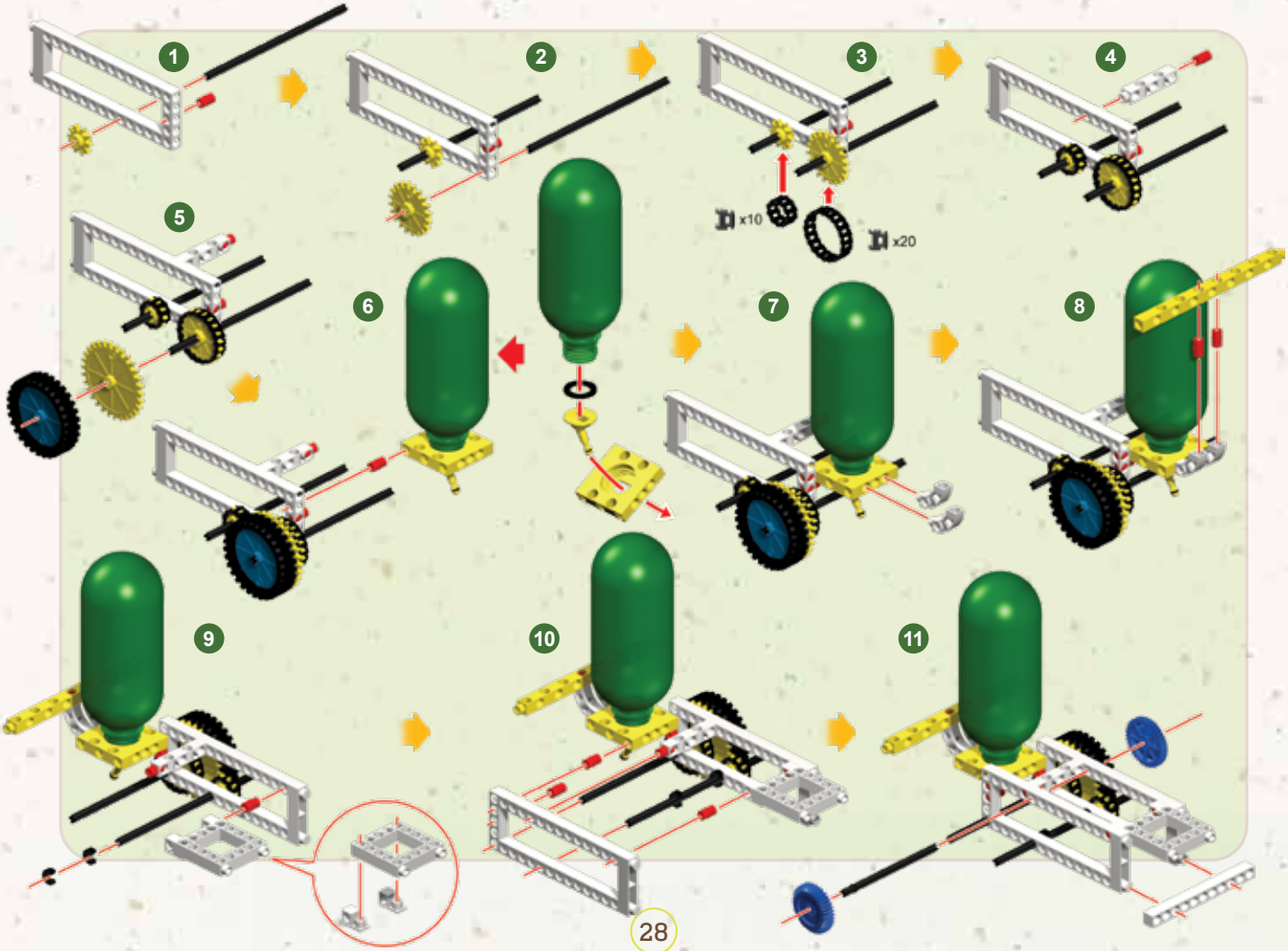


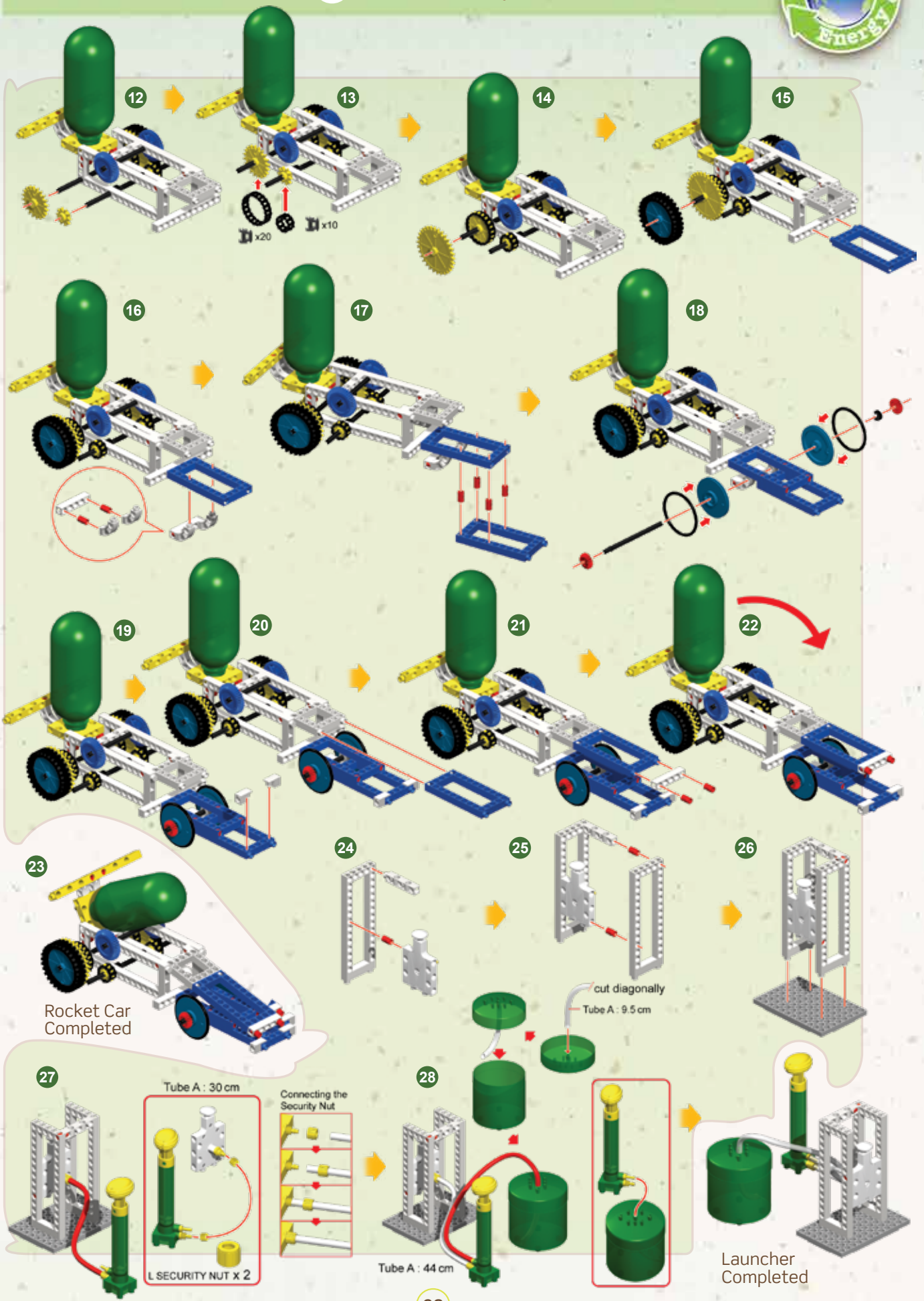
Rocket Car

Assembly Notes

1. Unscrew the original cap of the pressurized air+water tank before starting the assembly. The original cap will not be used in this model.
2. Leave a 1 mm gap between the sprockets and the long frame so that the wheel can turn smoothly.
3. Cut Tube A to get tubes of the following lengths for this model.

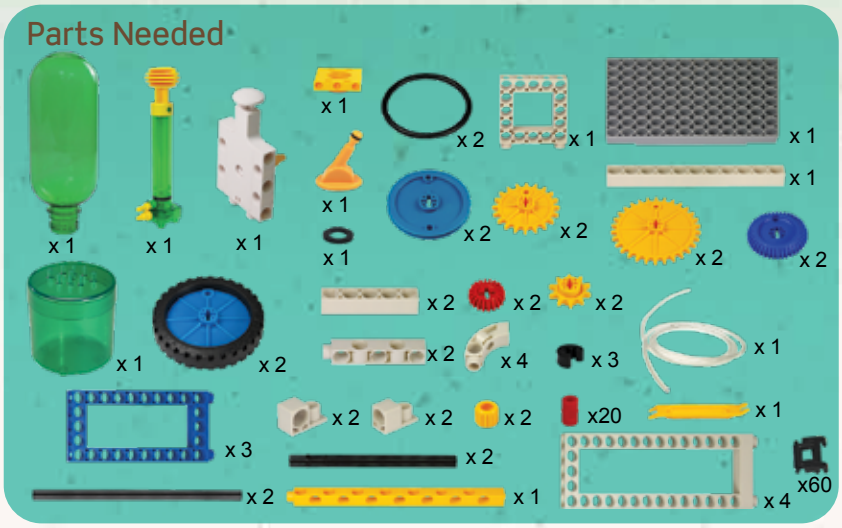
Tube A : 9.5 cm x 1, 30 cm x 1, 44 cm x 1




12
13
x20
x10
14
15
16
17
18
19
20
21
22
23
Rocket Car
Completed
24
25
cut diagonally
Tube A : 9.5 cm
26
27
Tube A : 30 cm
L SECURITY NUT x 2
Connecting the
Security Nut
28
Tube A : 44 cm
Launcher
Completed

Excavator

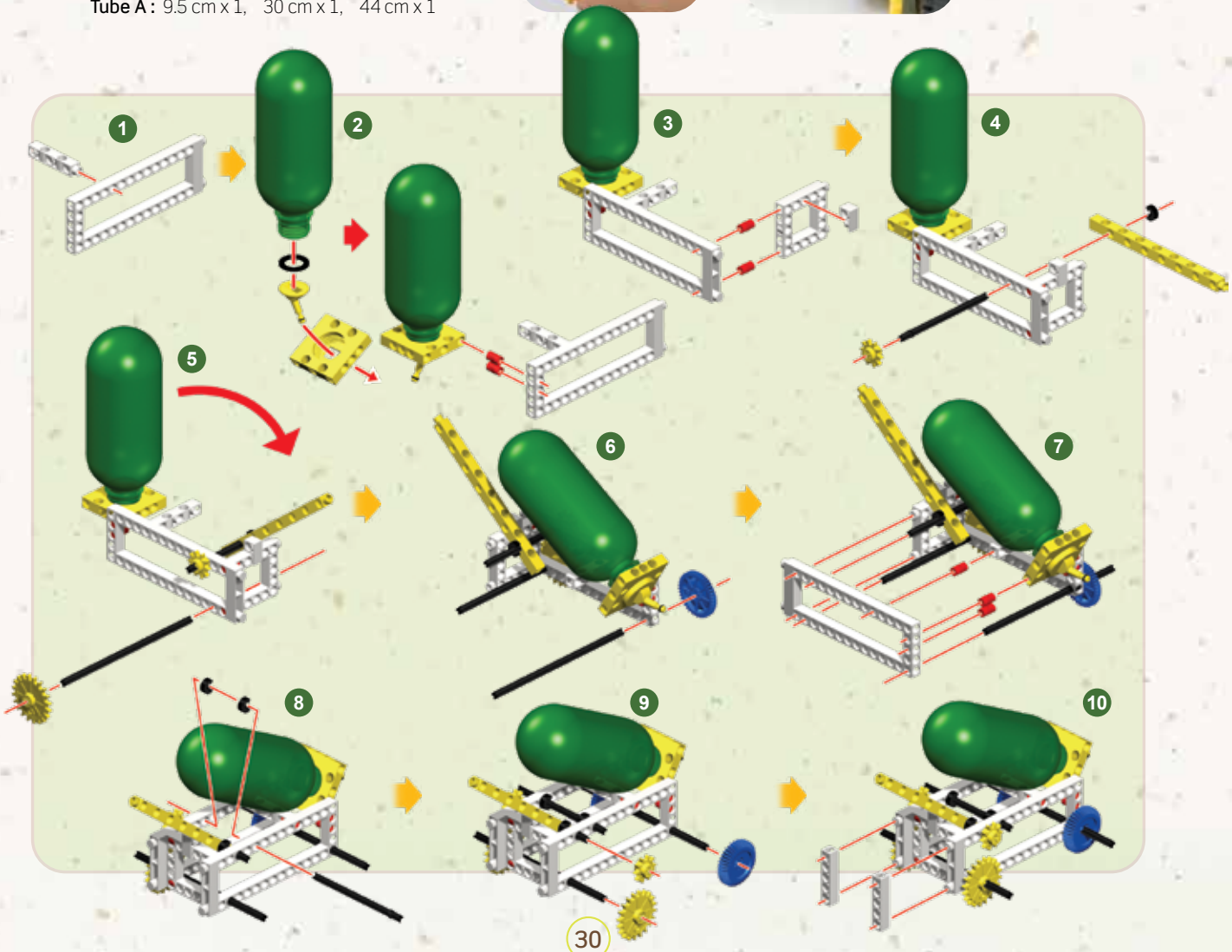
Parts Needed

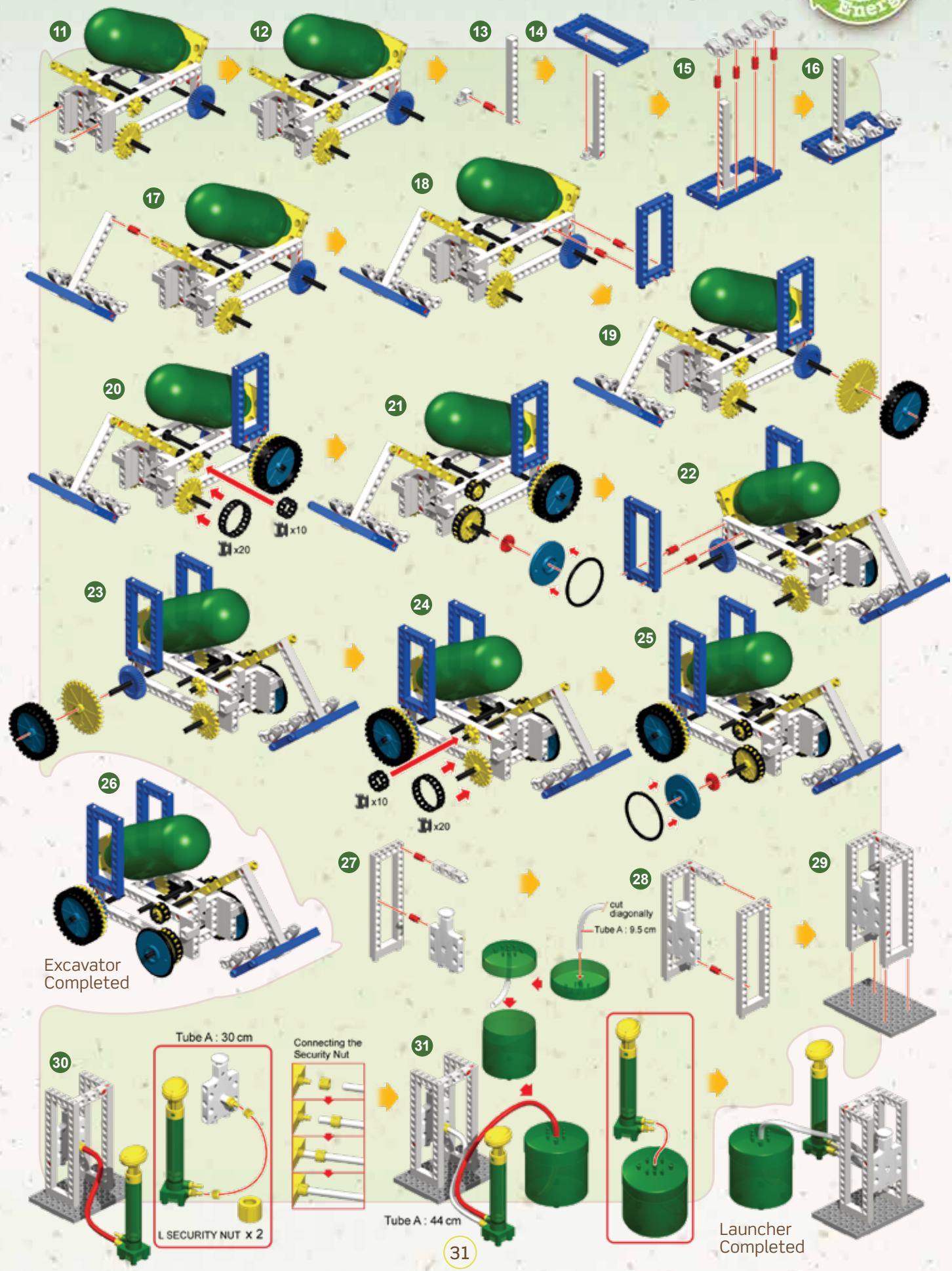


Assembly Notes

1. Unscrew the original cap of the pressurized air+water tank before starting the assembly. The original cap will not be used in this model.
2. Leave a 1 mm gap between the sprockets and the long frame so that the wheel can turn smoothly.
3. Cut Tube A to get tubes of the following lengths for this model.

Tube A : 9.5 cm x 1, 30 cm x 1, 44 cm x 1




11
12
13
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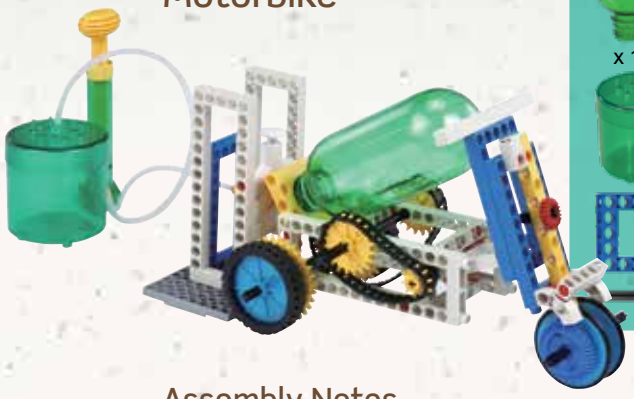
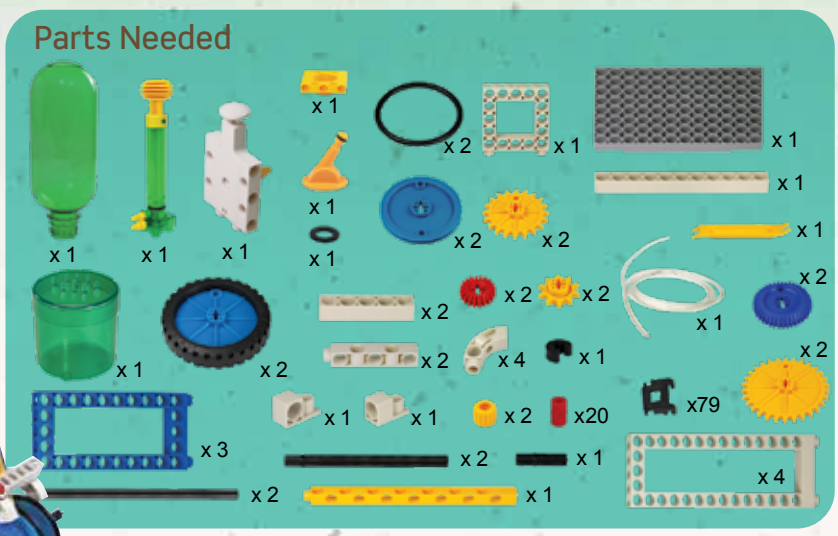
18
19
20
21
22
23
24
25
26
27
28
29
30
31
x10
x20
x10
x20
Excavator Completed
cut diagonally
Tube A : 9.5 cm
Tube A : 30 cm
L SECURITY NUT x 2
Connecting the Security Nut
Tube A : 44 cm
Launcher Completed

Heavy Motorbike



Parts Needed

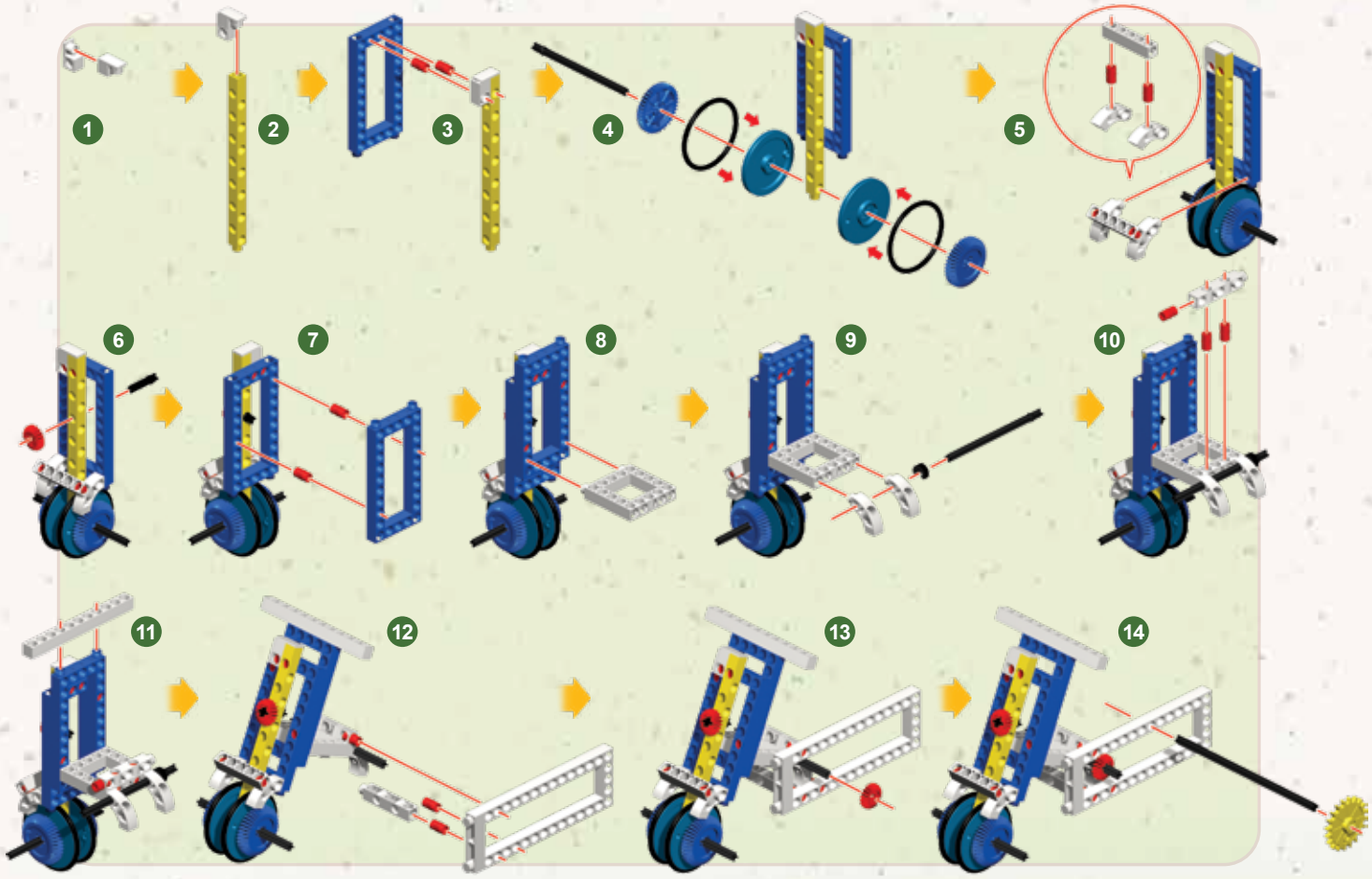


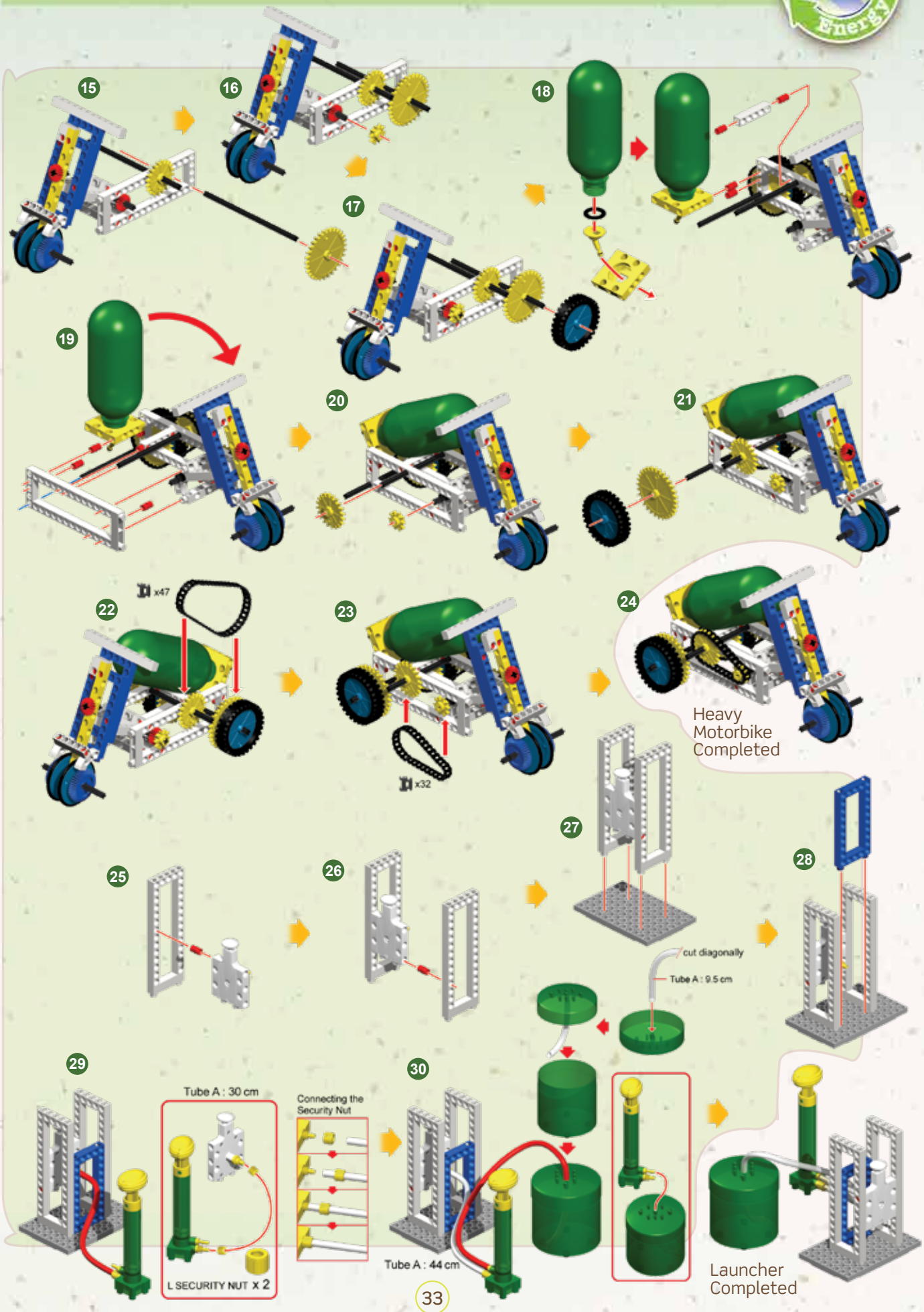
(Note: Gears shown here may differ slightly from those in the kit.)

Assembly Notes

1. Unscrew the original cap of the pressurized air+water tank before starting the assembly. The original cap will not be used in this model.
2. Leave a 1 mm gap between the gears and the long frame so that the wheel can turn smoothly.
3. Cut Tube A to get tubes of the following lengths for this model.

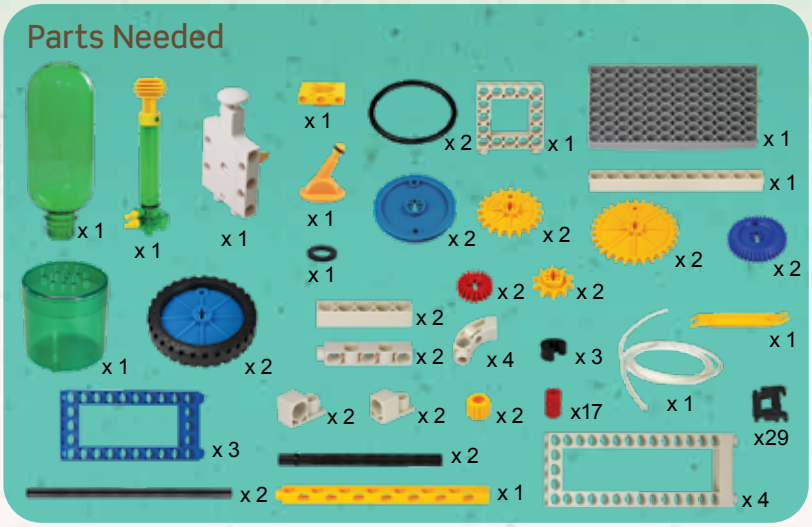
Tube A : 9.5 cm x 1, 30 cm x 1, 44 cm x 1




15
16
17
18
19
20
21
22
x47
23
x32
24
Heavy Motorbike Completed
25
26
27
28
cut diagonally
Tube A : 9.5 cm
29
Tube A : 30 cm
L SECURITY NUT x 2
Connecting the Security Nut
30
Tube A : 44 cm
Launcher Completed

Helicopter

Parts Needed

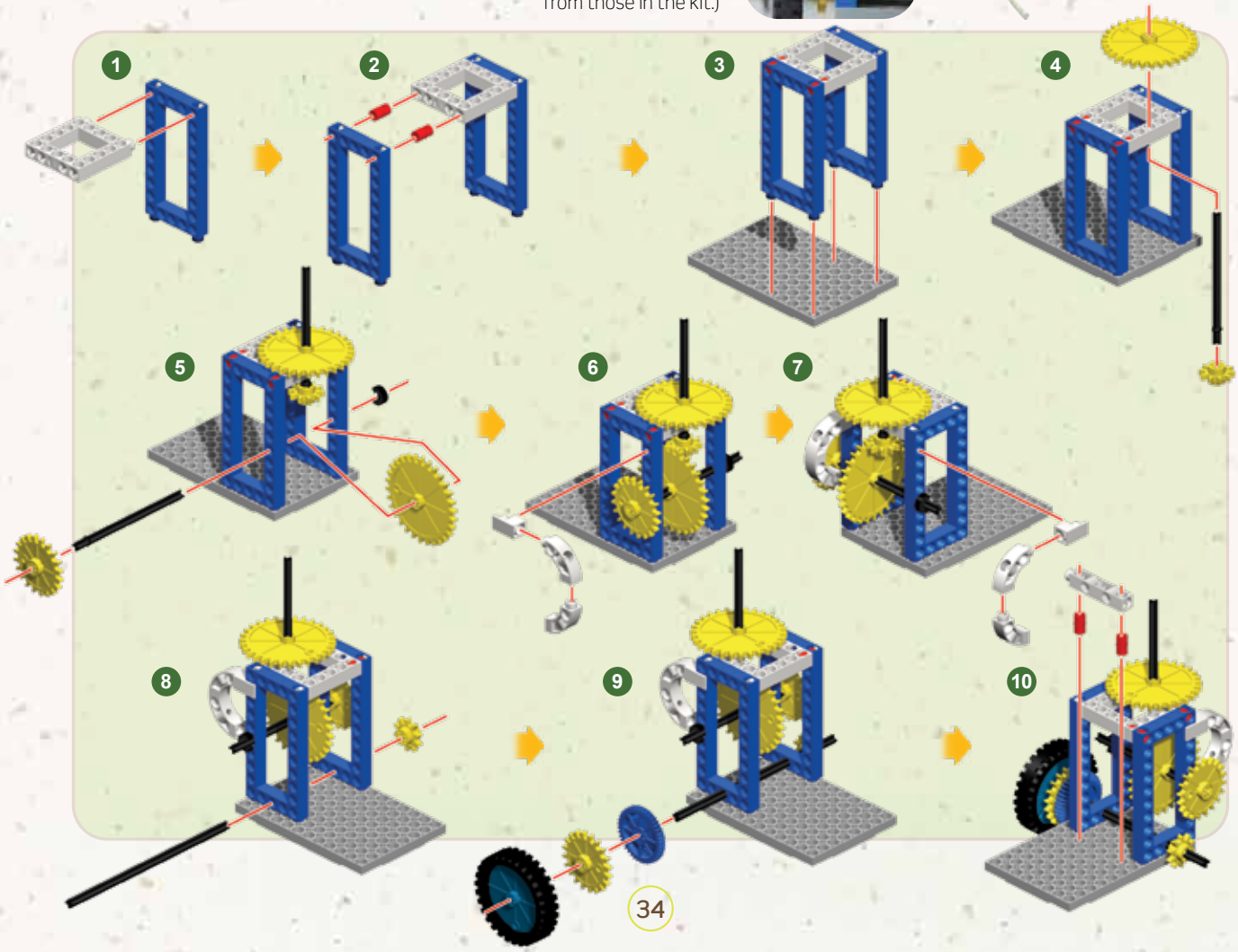


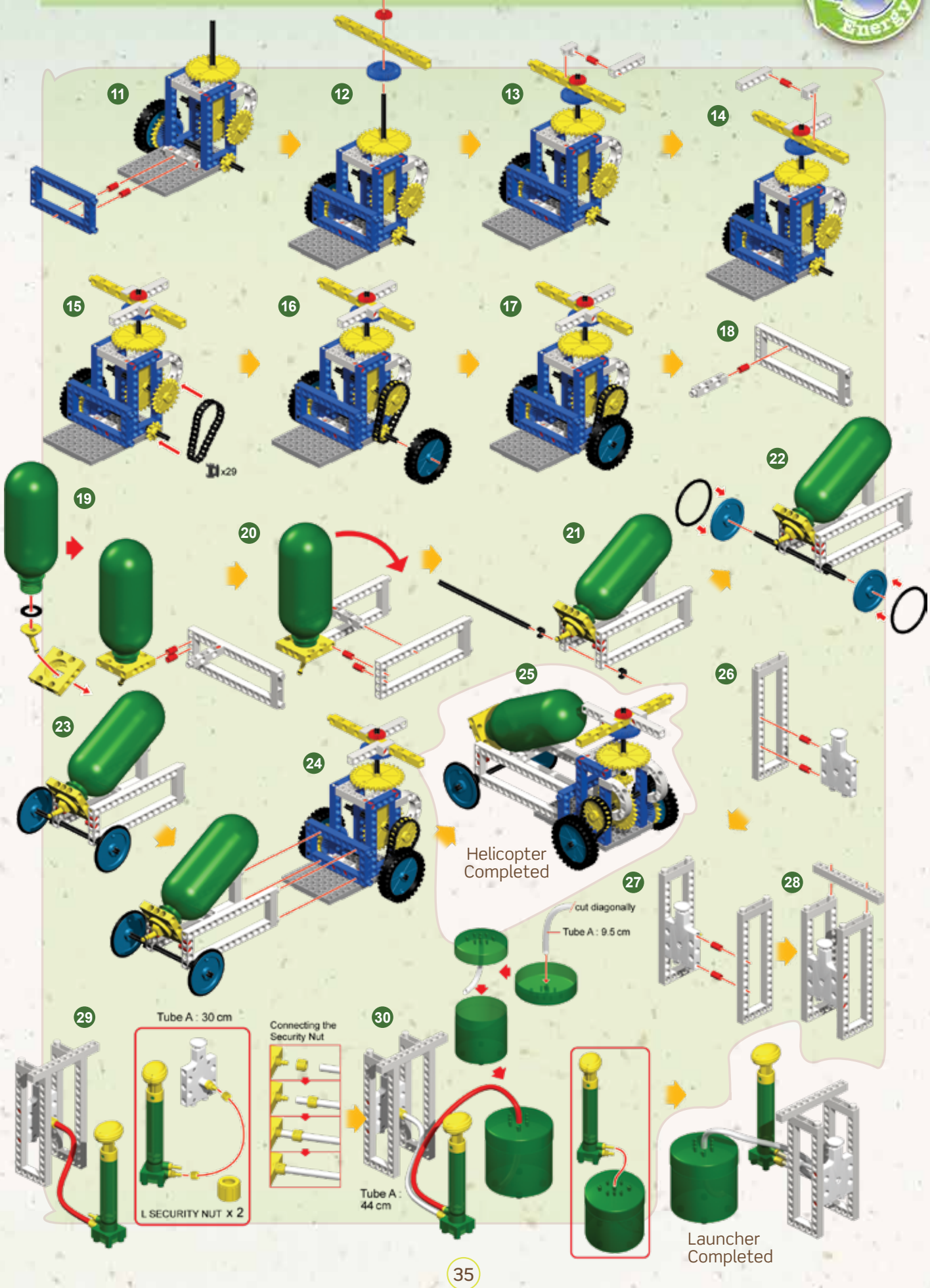
Assembly Notes

1. Unscrew the original cap of the pressurized air+water tank before starting the assembly. The original cap will not be used in this model.
2. The gears should mesh well with each other in order to operate smoothly.
3. Leave a 1 mm gap between the axle lock and the long frame so that the wheel can turn smoothly.
4. Note that the sprockets must be aligned so that the chain can operate smoothly.
5. Cut Tube A to get tubes of the following lengths for this model.

Tube A : 9.5 cm x 1, 30 cm x 1, 44 cm x 1

(Note: Gears shown here may differ slightly from those in the kit.)




11
12
13
14
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x29
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18
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20
21
22
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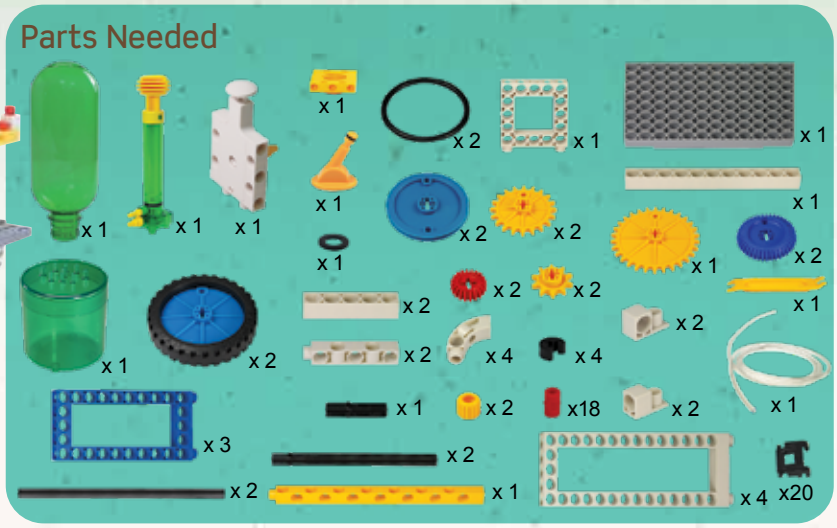
24
25
26
Helicopter Completed
27
cut diagonally
Tube A : 9.5 cm
28
29
Tube A : 30 cm
L SECURITY NUT x 2
Connecting the Security Nut
30
Tube A : 44 cm
Launcher Completed

Radar Car

Parts Needed

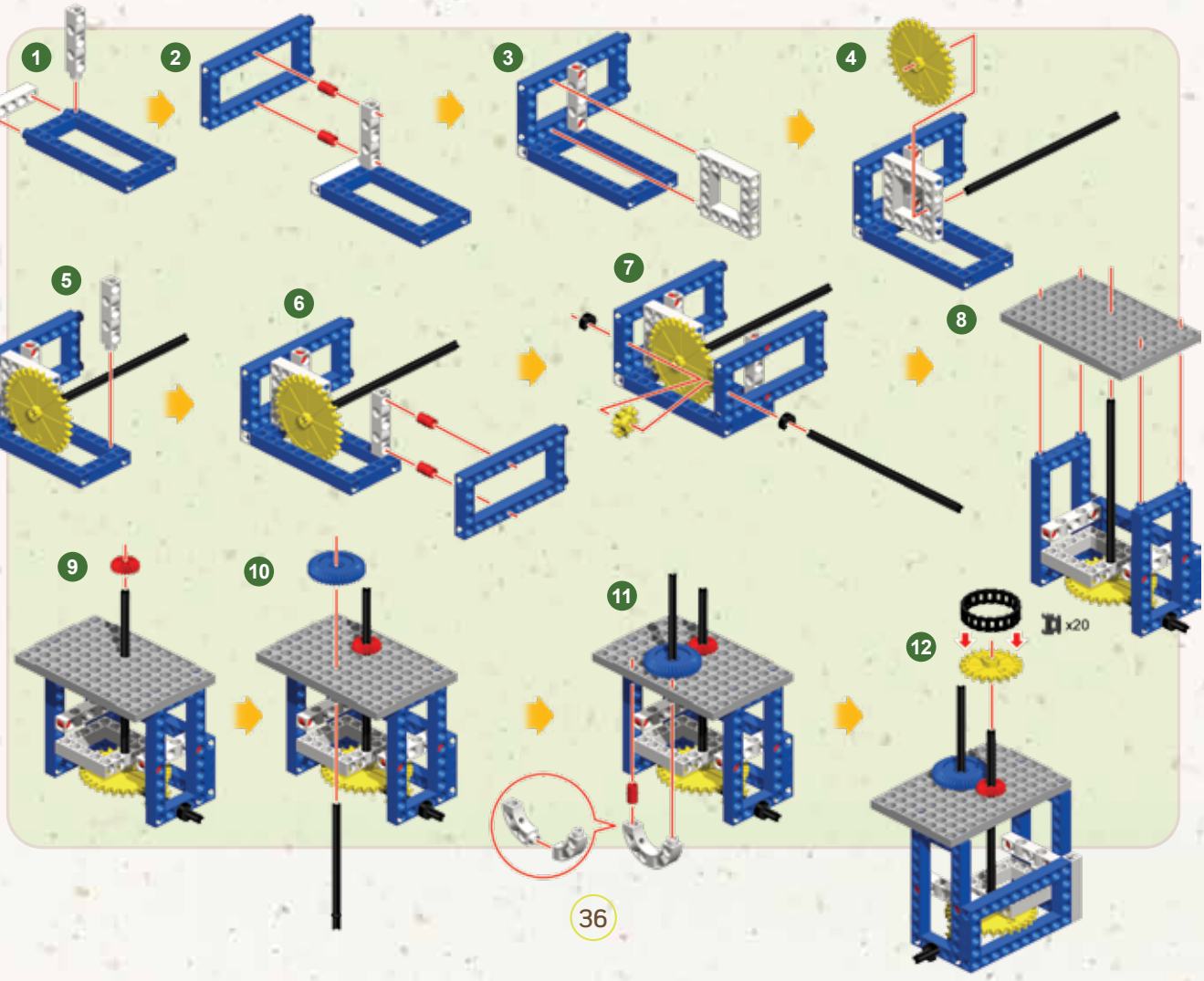


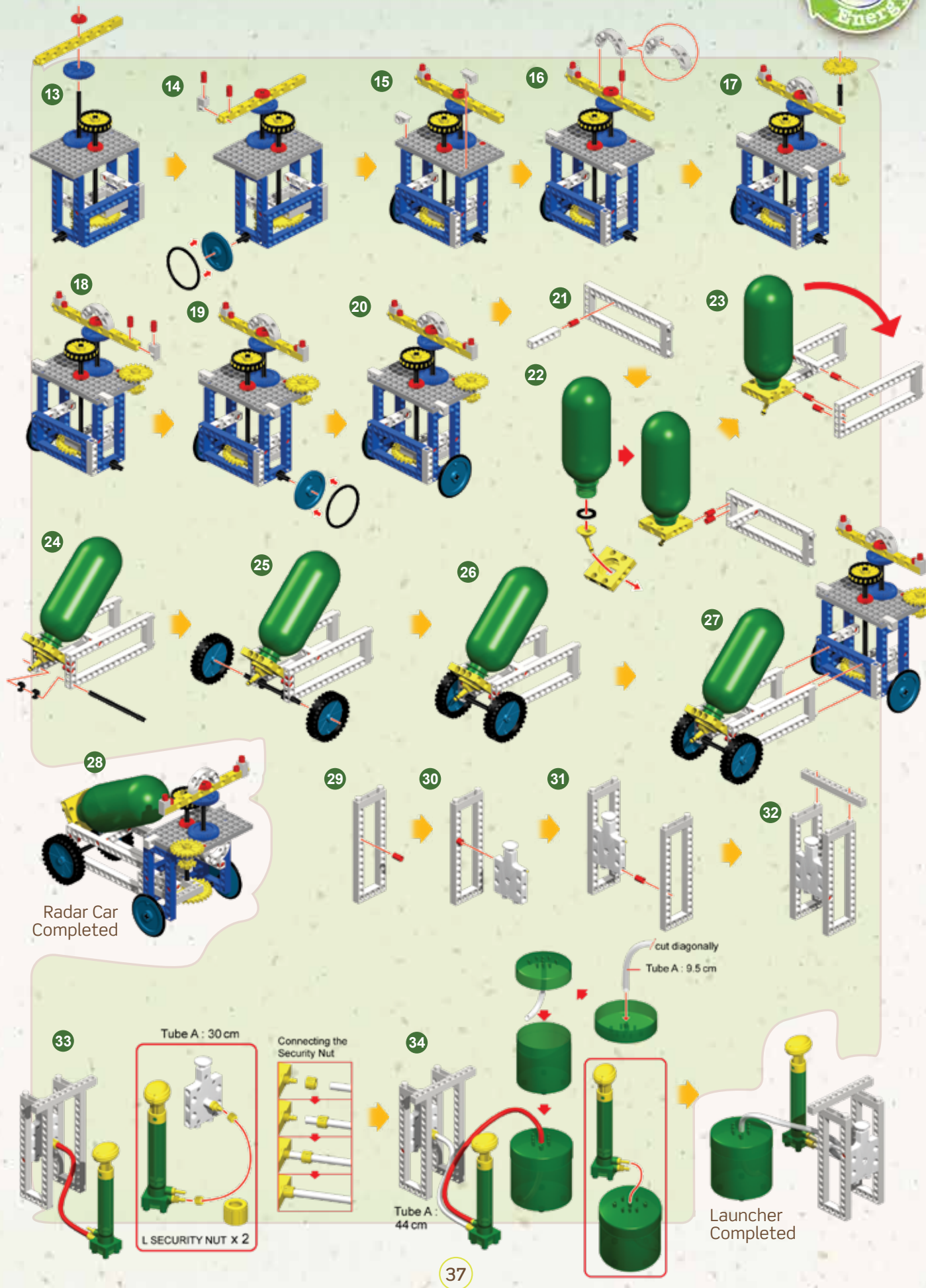
Assembly Notes

1. Unscrew the original cap of the pressurized air+water tank before starting the assembly. The original cap will not be used in this model.
2. The gears should mesh well with each other in order to operate smoothly.
3. Leave a 1 mm gap between the axle lock and the long frame so that the wheel can turn smoothly.
3. Cut Tube A to get tubes of the following lengths for this model.

Tube A : 9.5 cm x 1, 30 cm x 1, 44 cm x 1

(Note: Gears shown here may differ slightly from those in the kit.)




13
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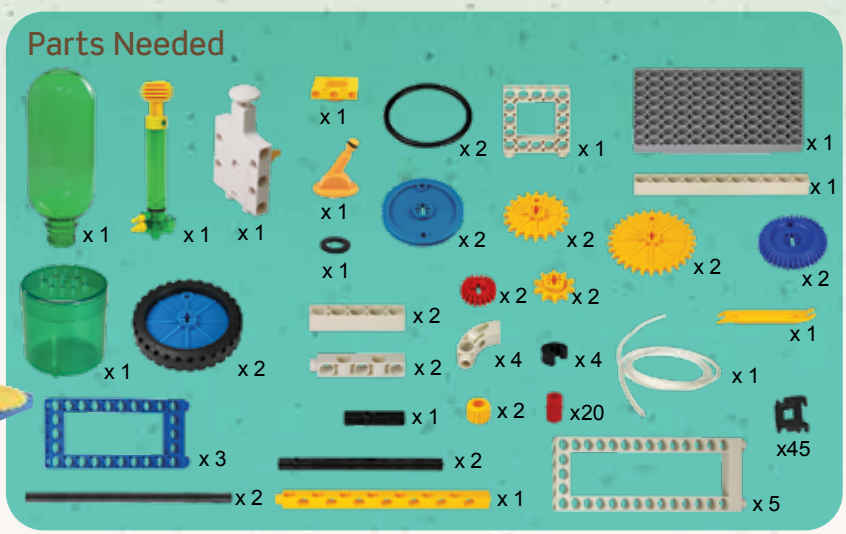
27
28
Radar Car Completed
29
30
31
32
33
Tube A : 30 cm
L SECURITY NUT x 2
Connecting the Security Nut
34
Tube A : 44 cm
cut diagonally
Tube A : 9.5 cm
Launcher Completed

Forklift

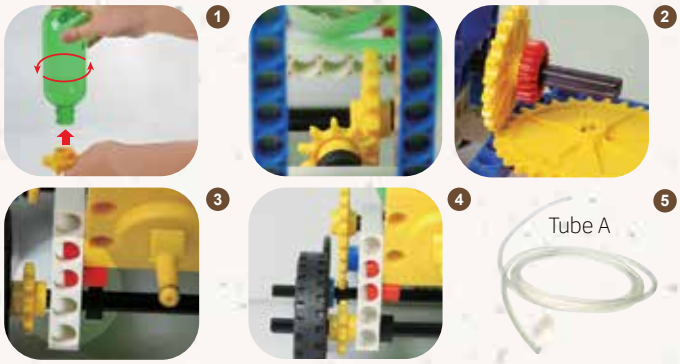
Parts Needed

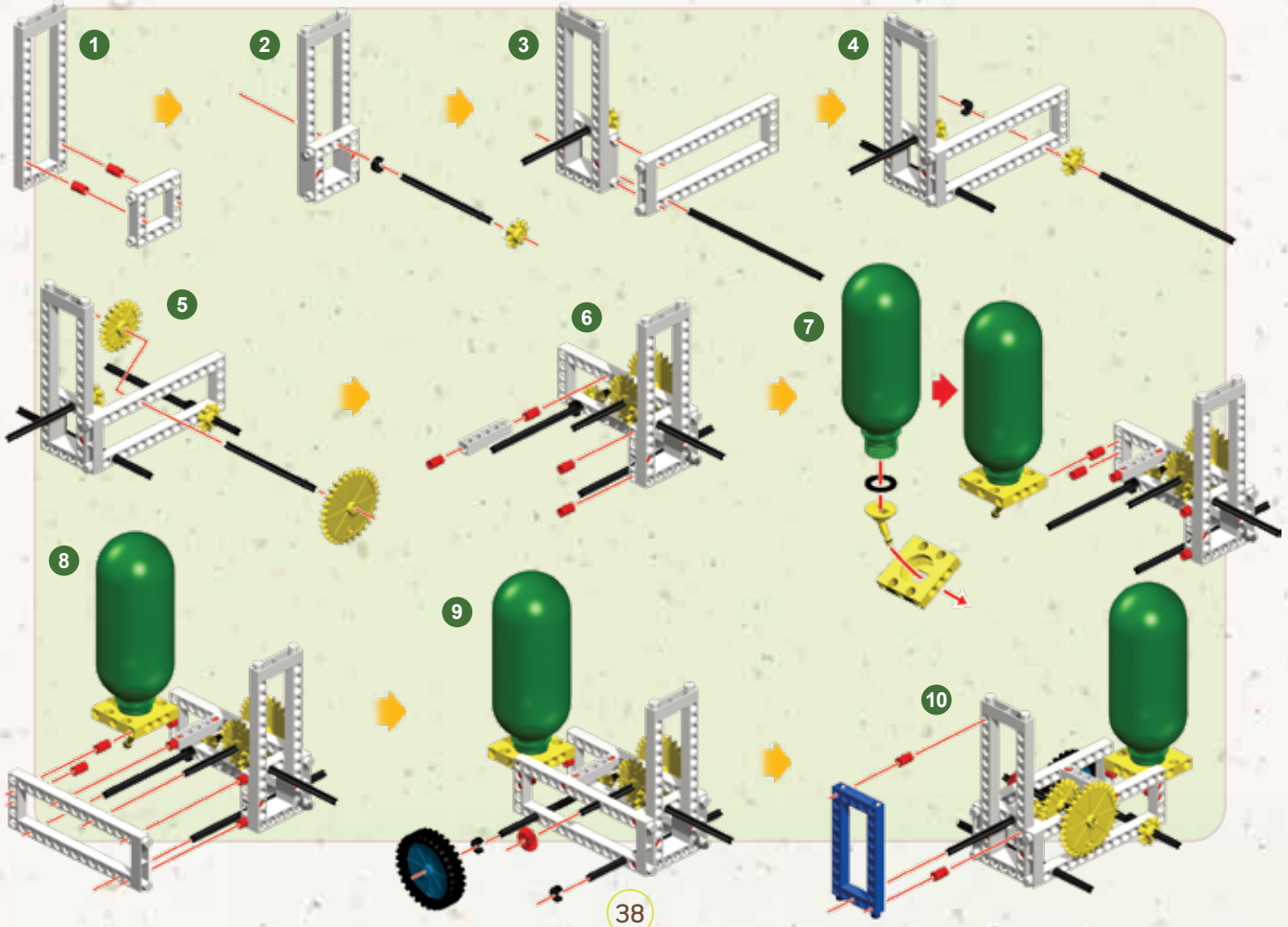


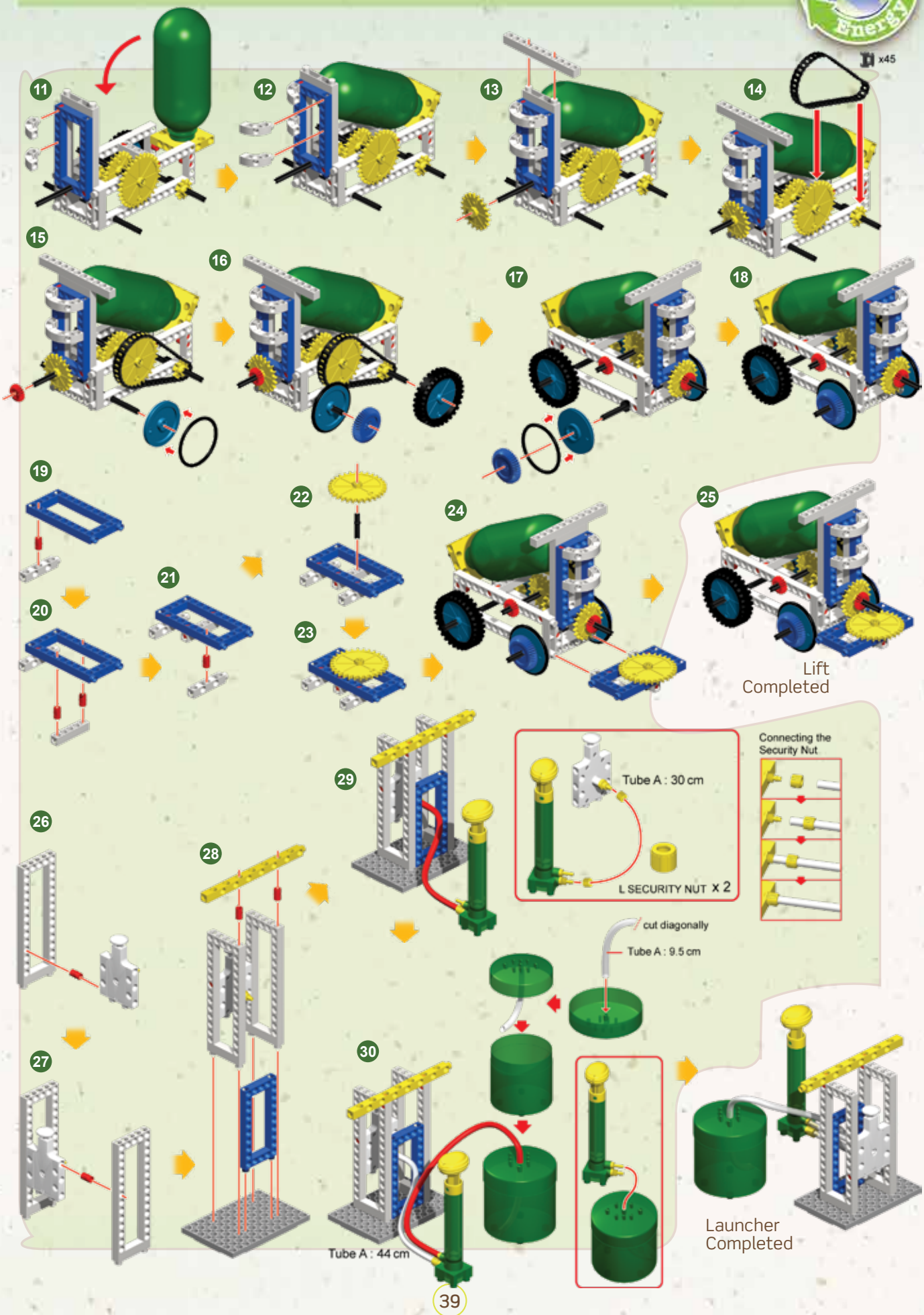
Assembly Notes

1. Unscrew the original cap of the pressurized air+water tank before starting the assembly. The original cap will not be used in this model.
2. The gears should meshed well with each other in order to operate smoothly.
3. Leave a 1 mm gap between the axle lock and the long frame so that the wheel can turn smoothly.
4. Note that the sprockets must be aligned so that the chain can operate smoothly.
5. Cut Tube A to get tubes of the following lengths for this model.

Tube A : 9.5 cm x 1, 30 cm x 1, 44 cm x 1






x45
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Lift
Completed
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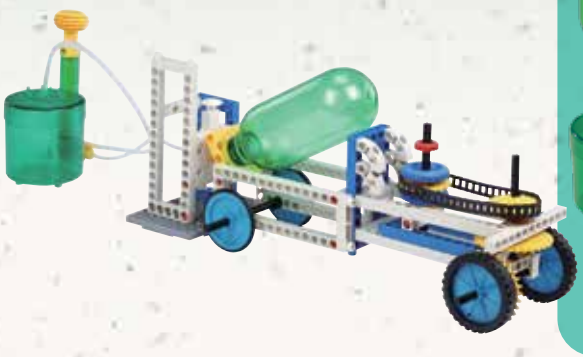
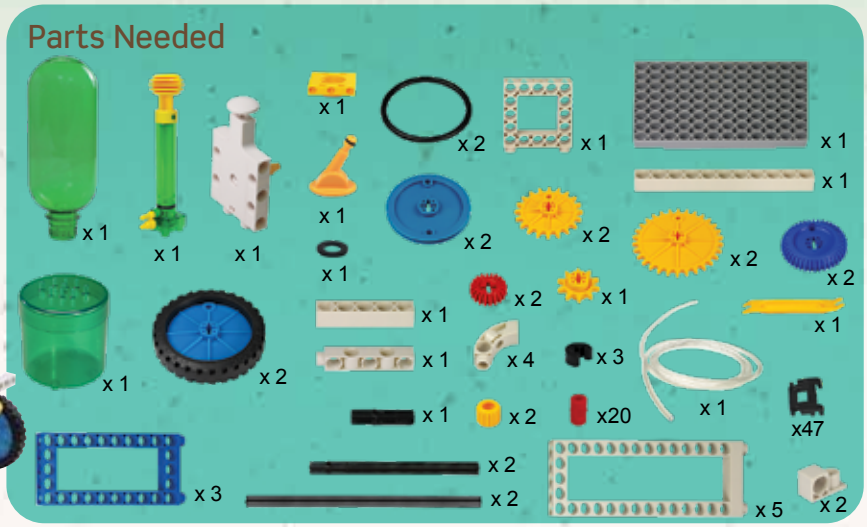
30
Tube A : 30 cm
L SECURITY NUT x 2
Connecting the
Security Nut
cut diagonally
Tube A : 9.5 cm
Tube A : 44 cm
Launcher
Completed

Antique Car



Parts Needed

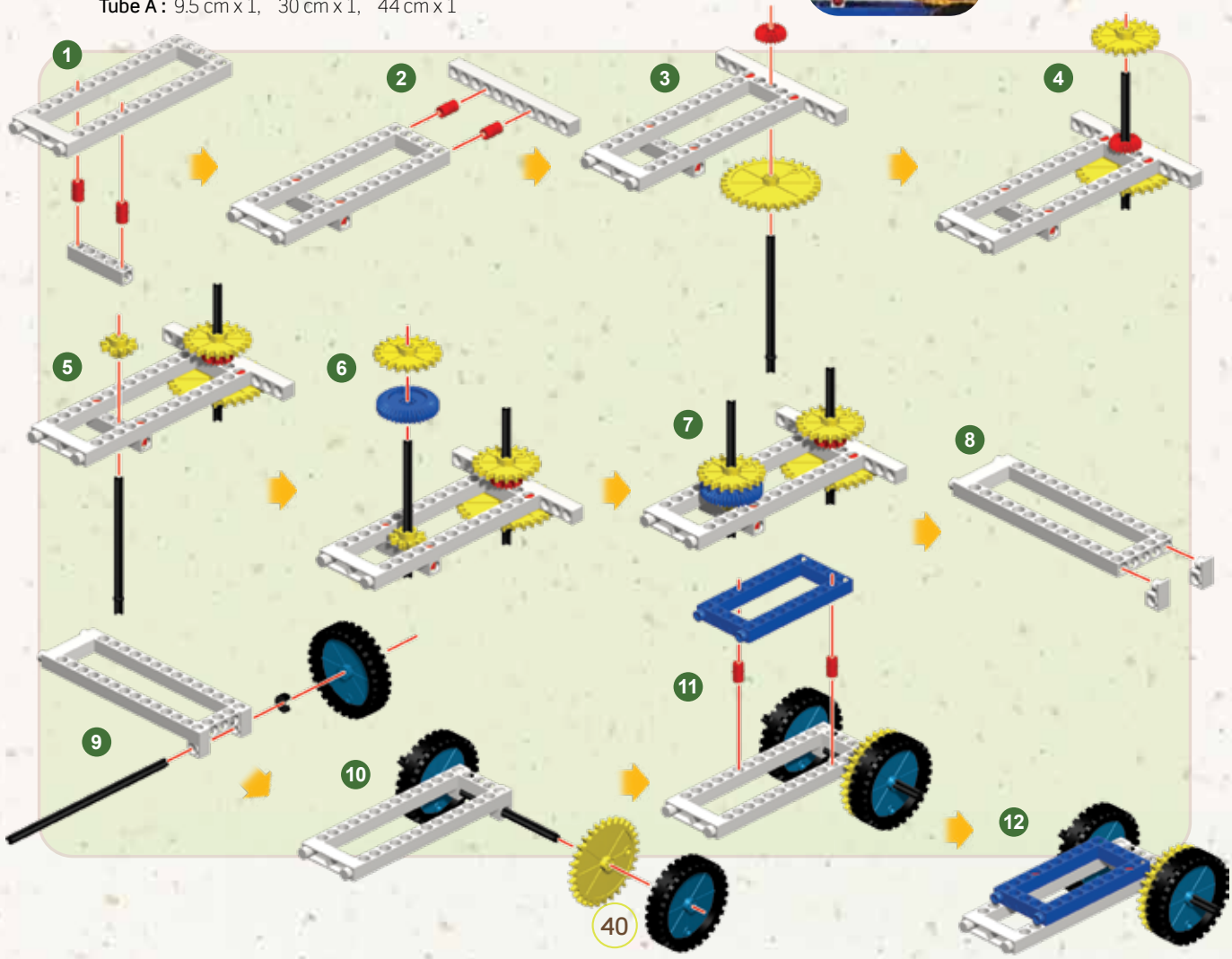


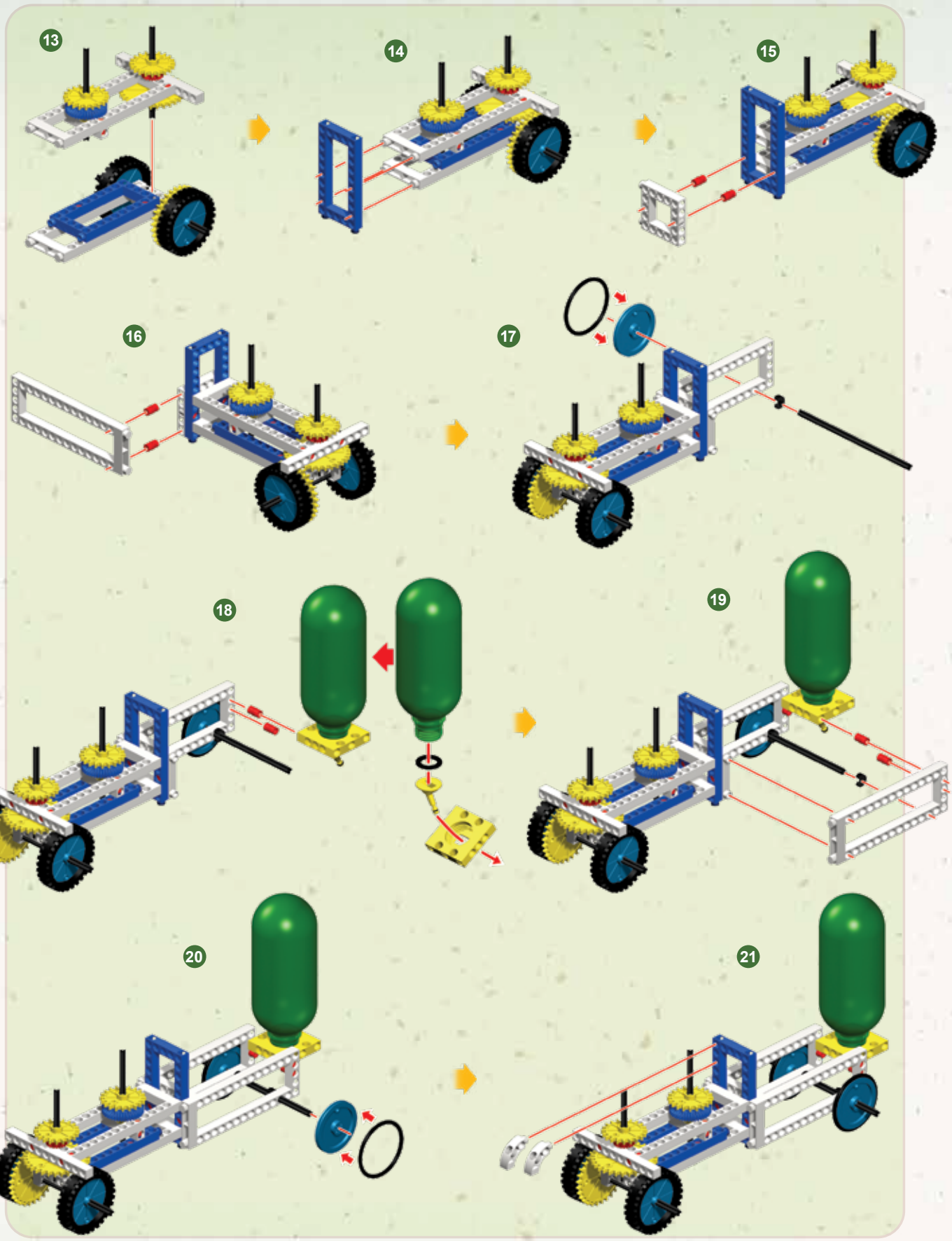
Assembly Notes

1. Unscrew the original cap of the pressurized air+water tank before starting the assembly. The original cap will not be used in this model.
2. The gears should mesh well with each other in order for the chain to operate smoothly.
3. Note that the sprockets must be aligned so that the chain can operate smoothly.
4. Cut Tube A to get tubes of the following lengths for this model.

Tube A : 9.5 cm x 1, 30 cm x 1, 44 cm x 1

(Note: Gears shown here may differ slightly from those in the kit.)

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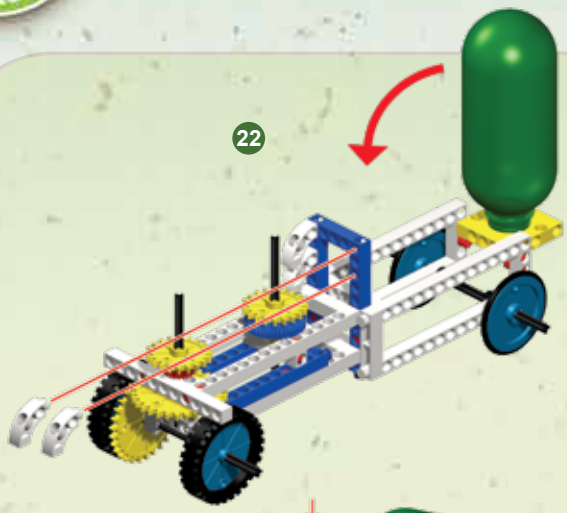
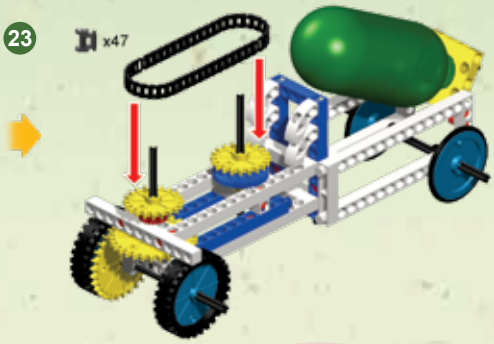
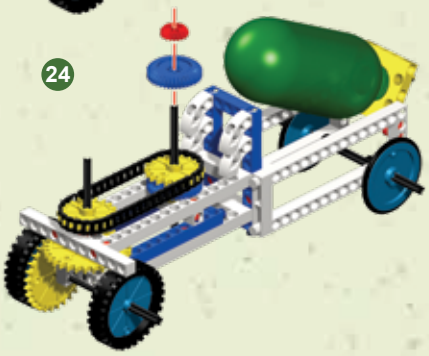
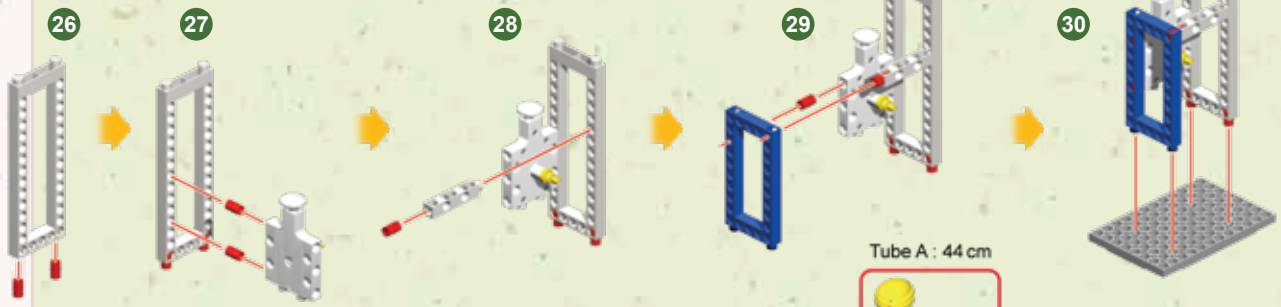

22


23
x47


24


25
Antique Car
Completed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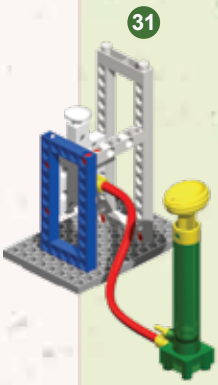
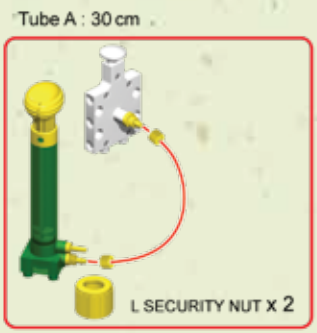
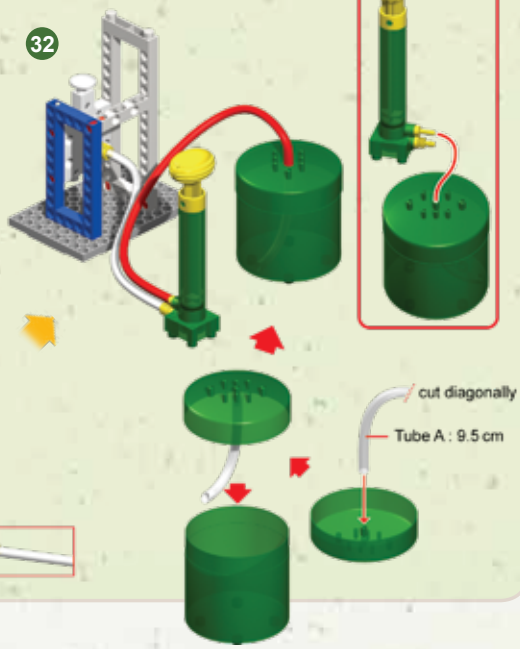
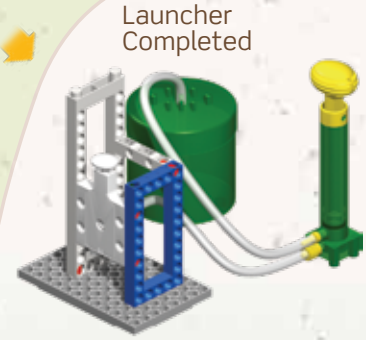

31


Tube A : 30 cm
L SECURITY NUT x 2

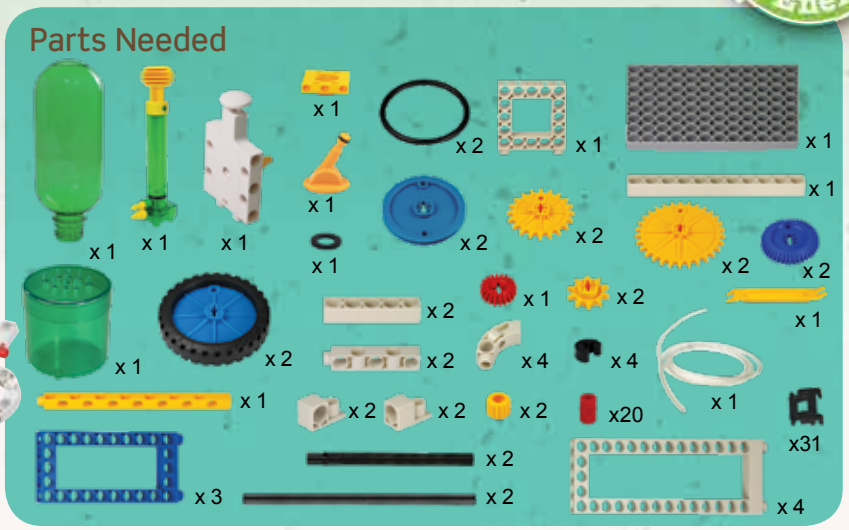

Connecting the Security Nut


32
Tube A : 44 cm
cut diagonally
Tube A : 9.5 cm


Launcher
Completed

Propeller Aircraft

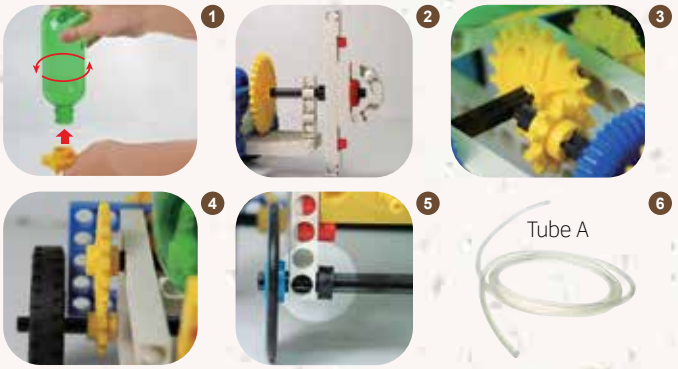
Parts Needed

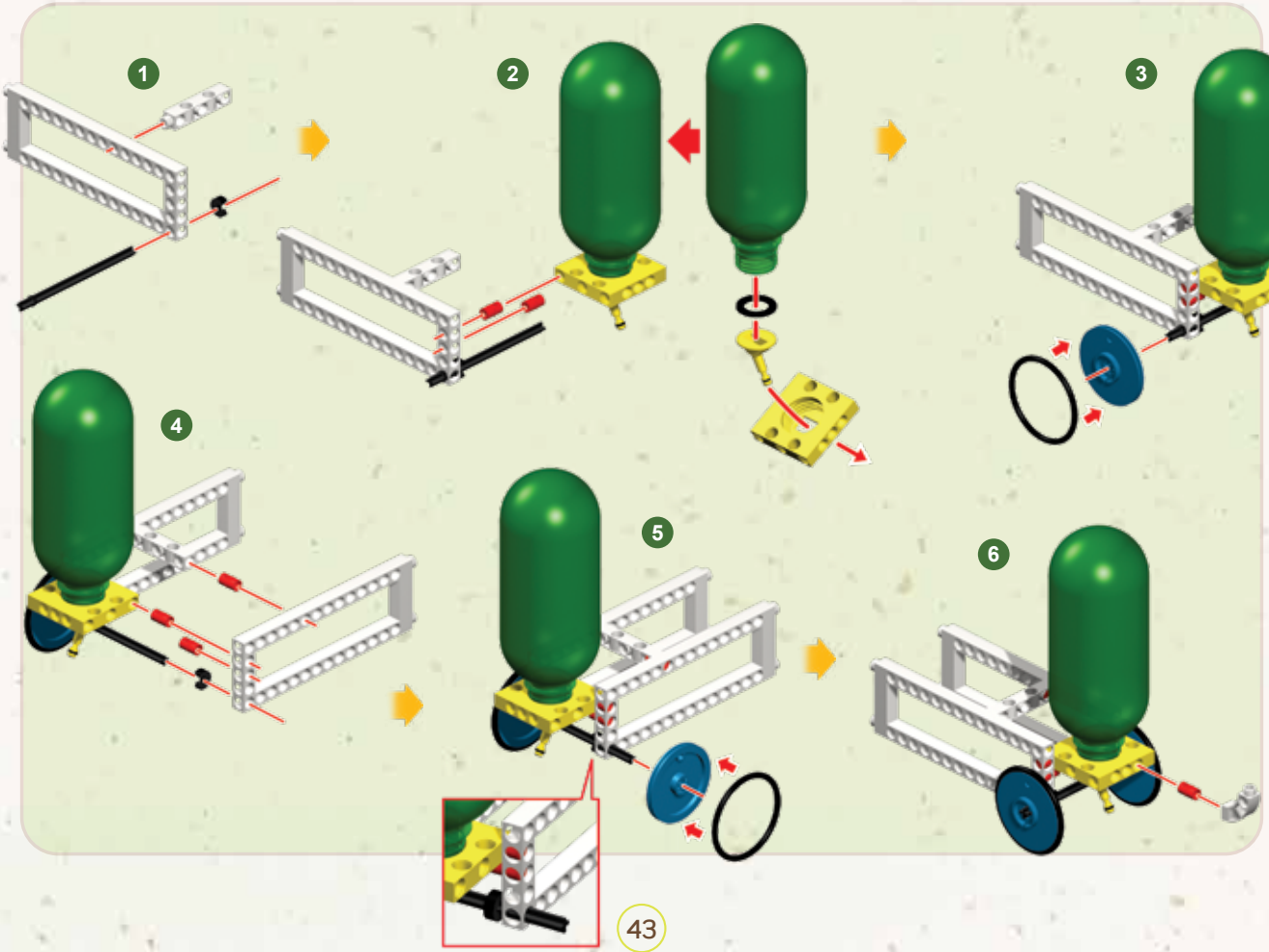


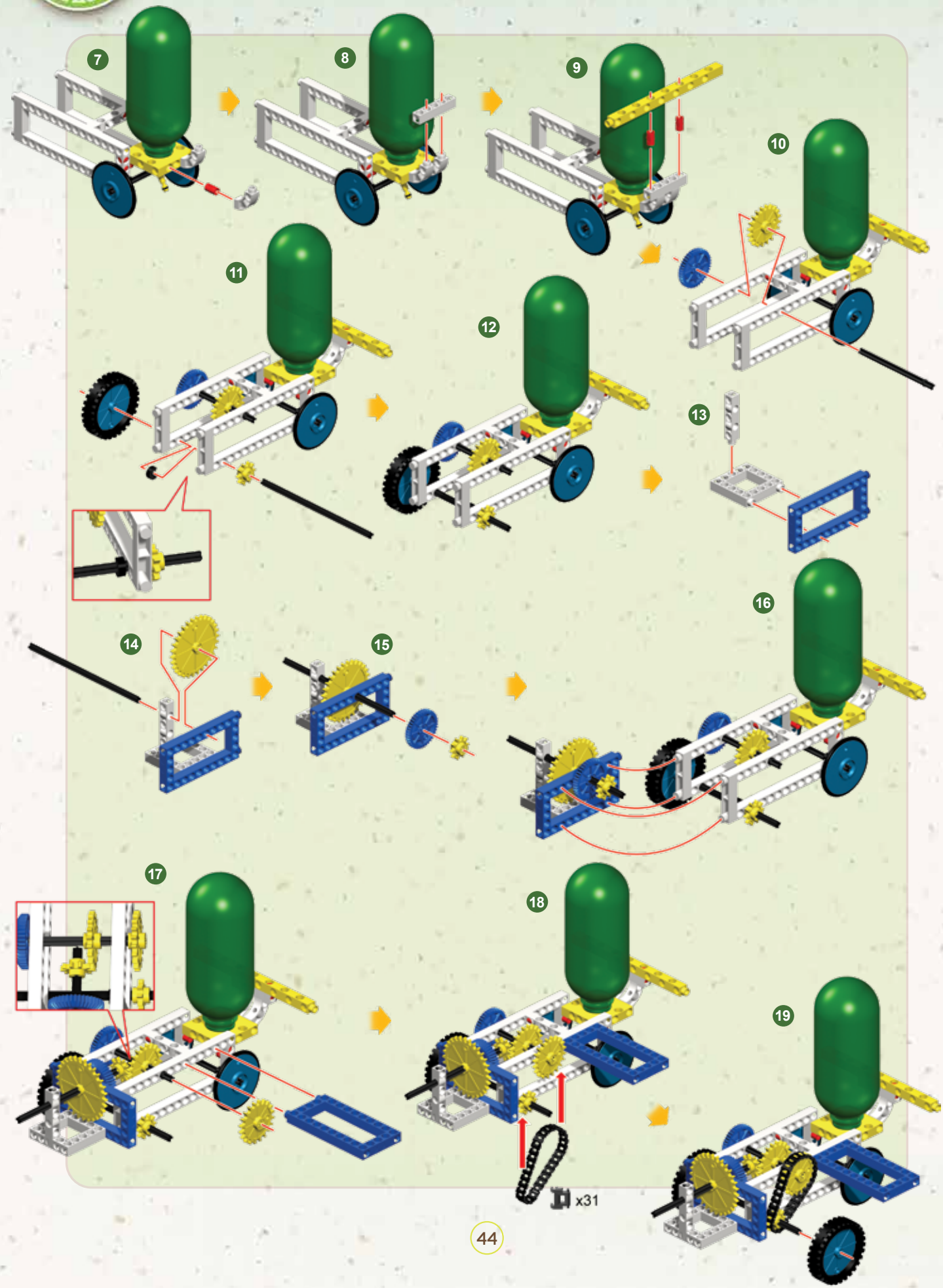
Assembly Notes

1. Unscrew the original cap of the pressurized air+water tank before starting the assembly. The original cap will not be used in this model.
2. The parts shown here on the model must be tightly fixed together so that the propeller can rotate.
3. The gears should mesh well with each other in order for the chain to operate smoothly.
4. Note that the sprockets must be aligned so that the chain can operate smoothly.
5. Leave a 1 mm gap between the axle lock and the long frame so that the wheel can turn smoothly.
6. Cut Tube A to get tubes of the following lengths.

Tube A : 9.5 cm x 1, 30 cm x 1, 44 cm x 1



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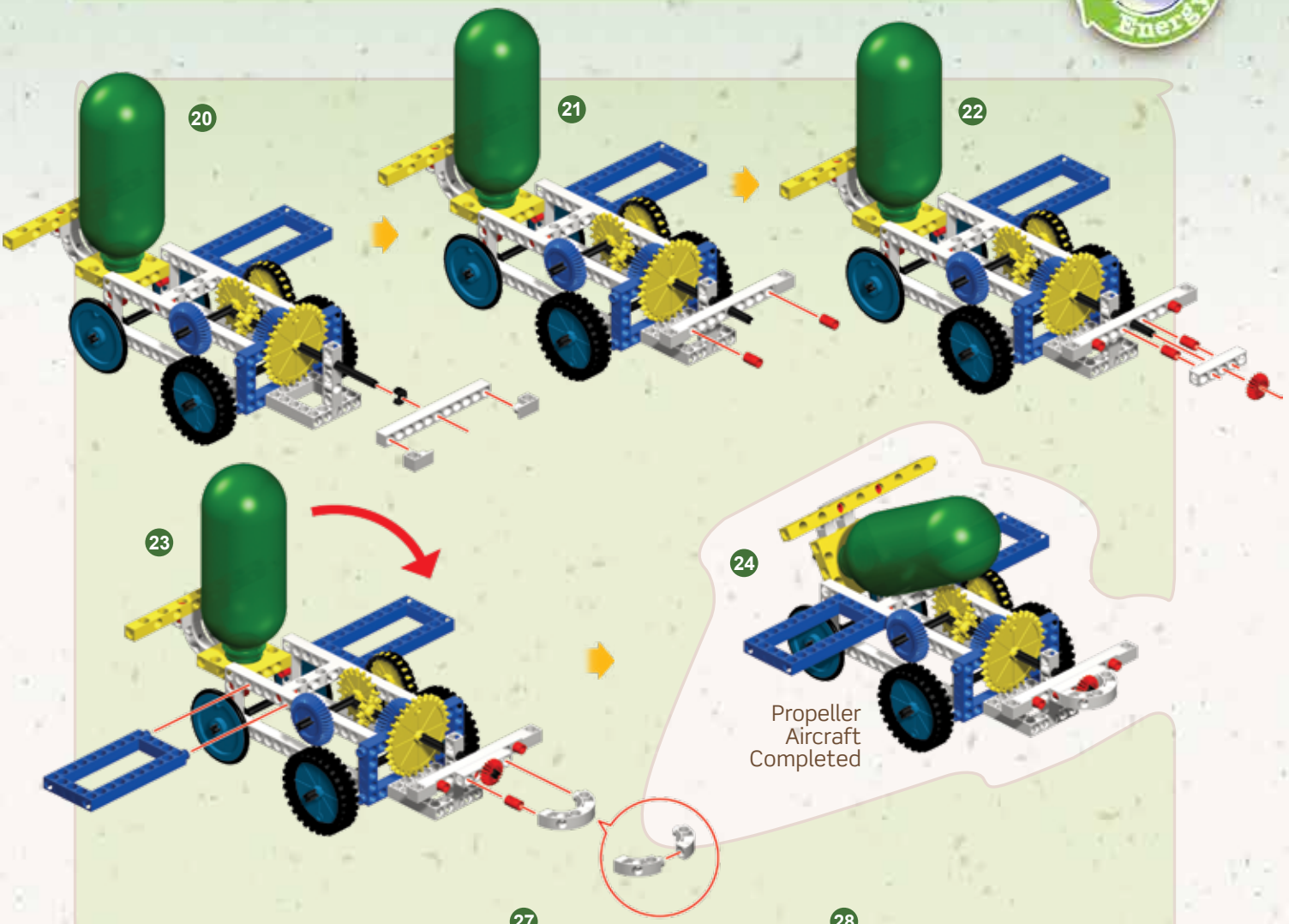
x31


20
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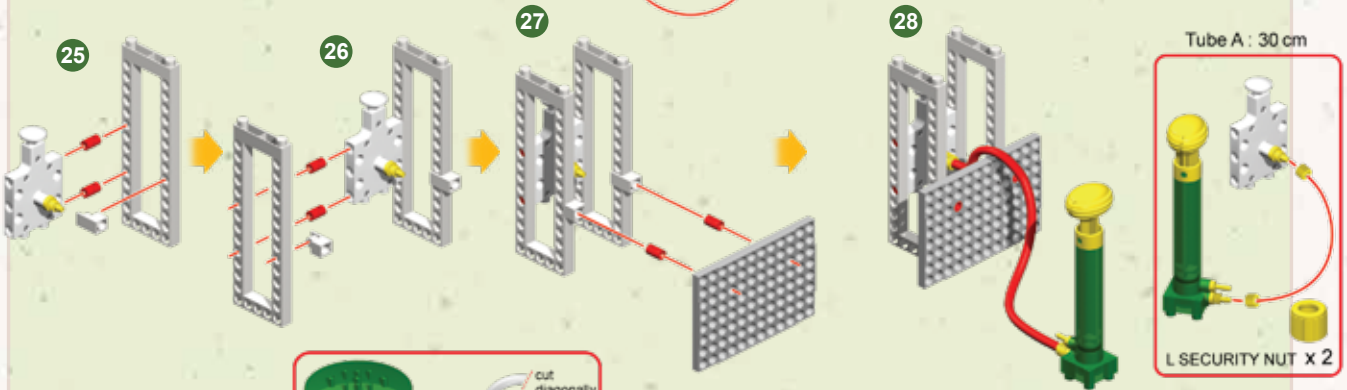
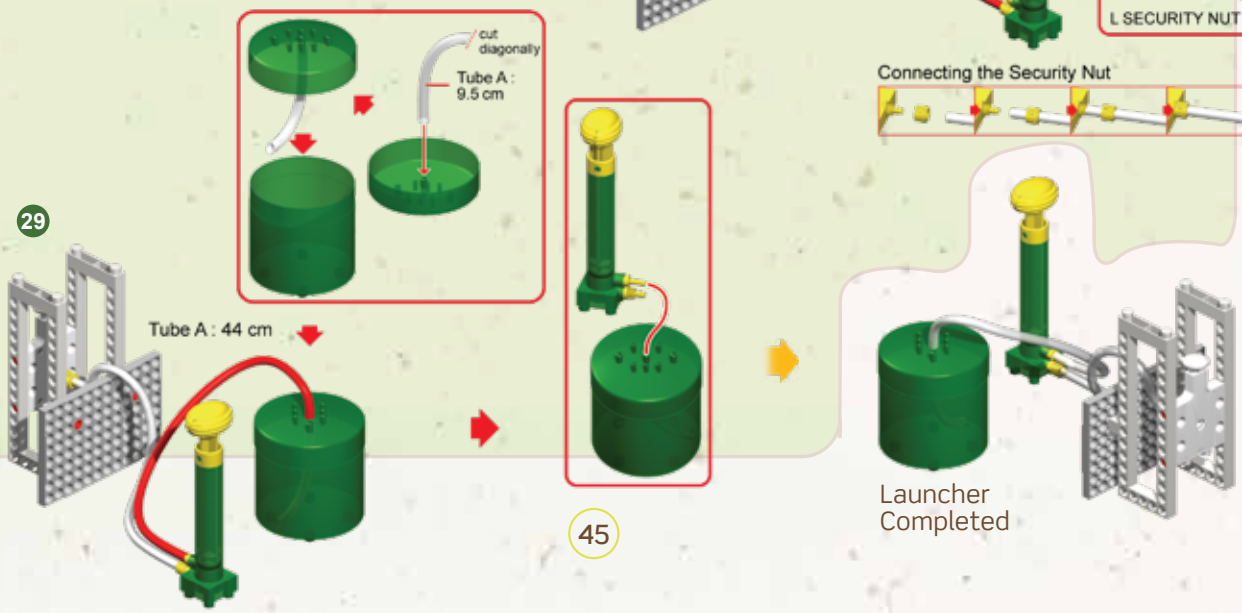
24
Propeller Aircraft Completed


25
26
27
28
Tube A : 30 cm
L SECURITY NUT x 2
Connecting the Security Nut


29
cut diagonally
Tube A : 9.5 cm
Tube A : 44 cm
Launcher Completed

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