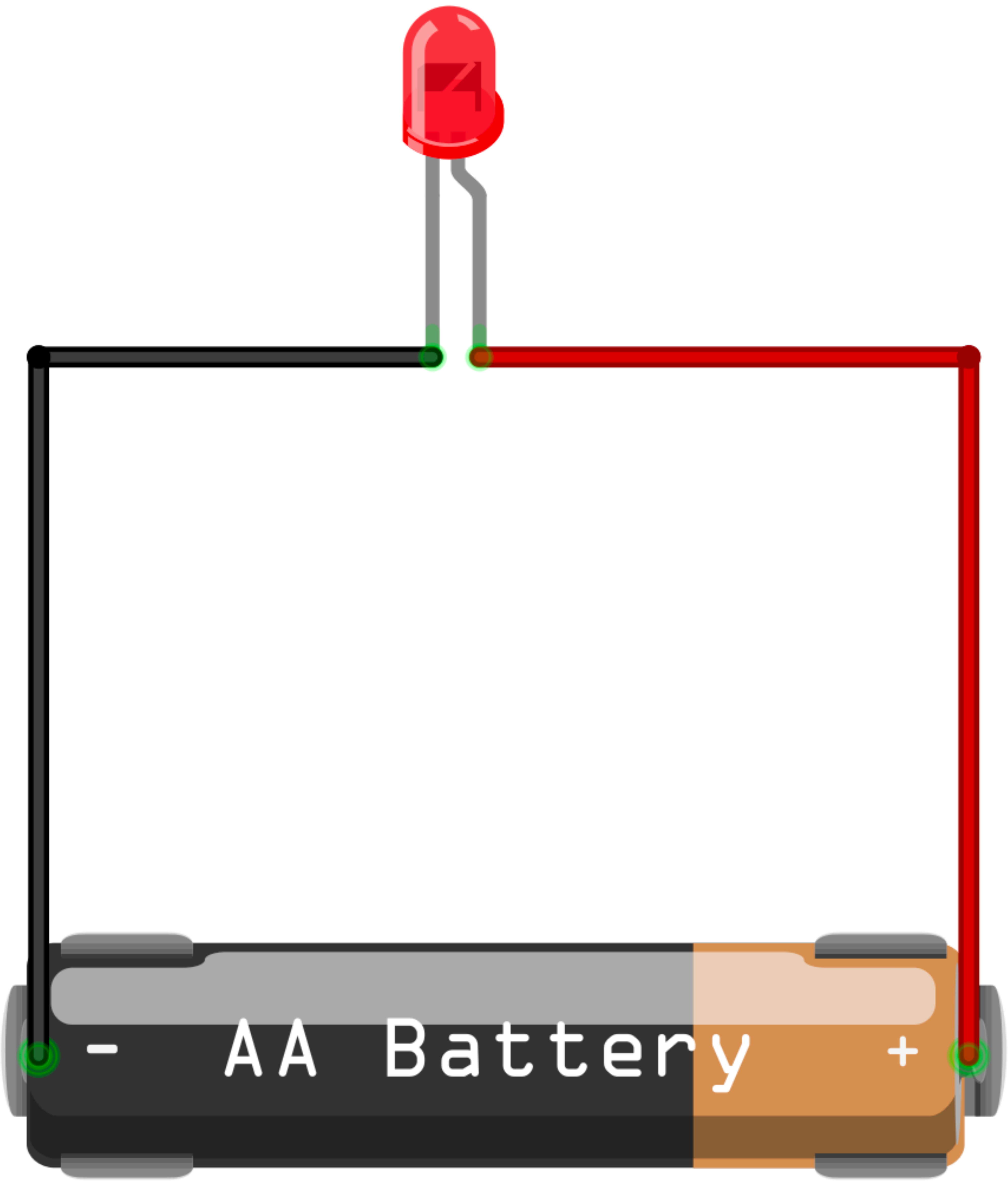
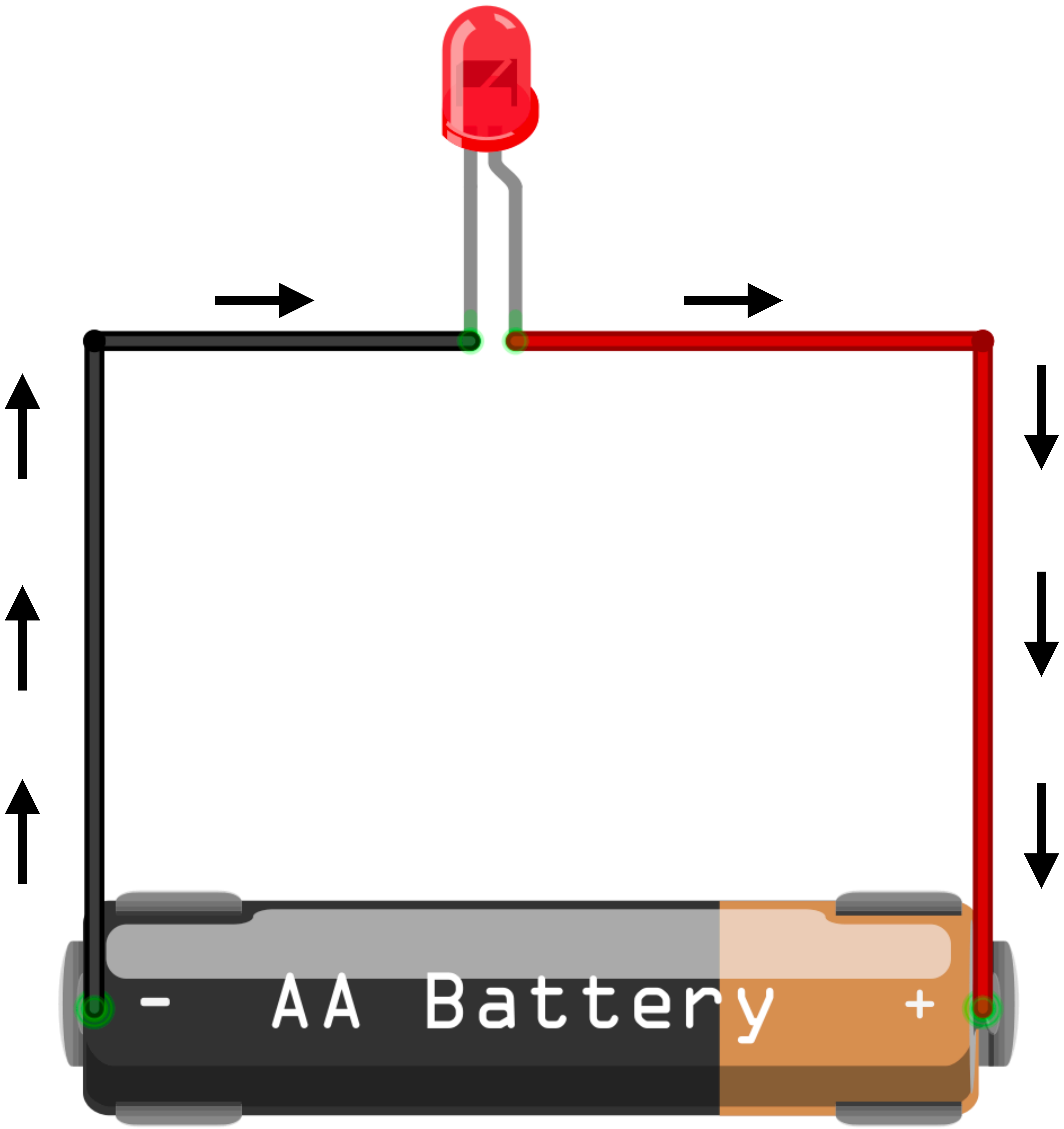
INTRODUCTION TO CIRCUITS AND ELECTRICITY (and the lab)

What is a Circuit?

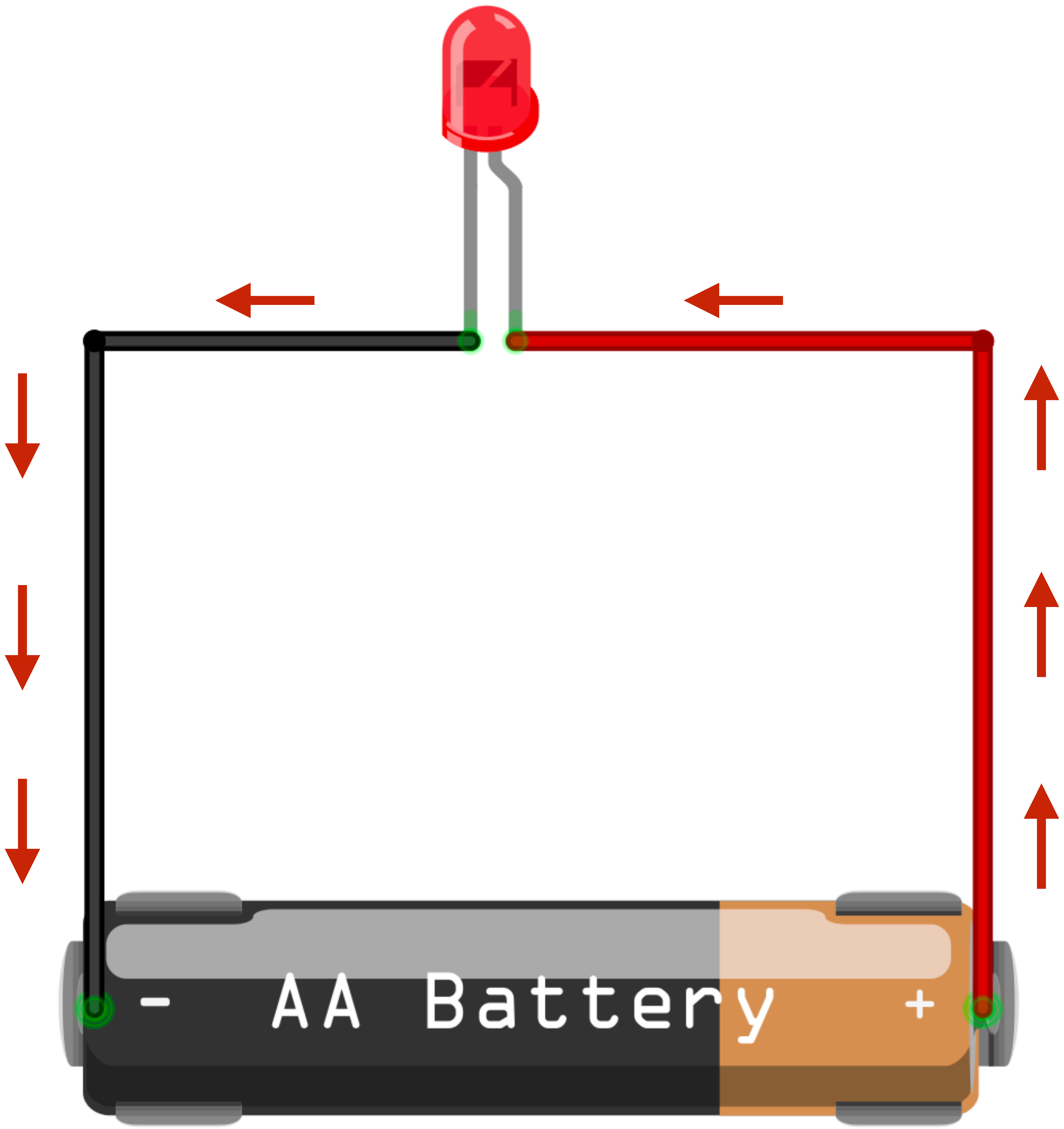
A circuit is a closed loop that carries a current.

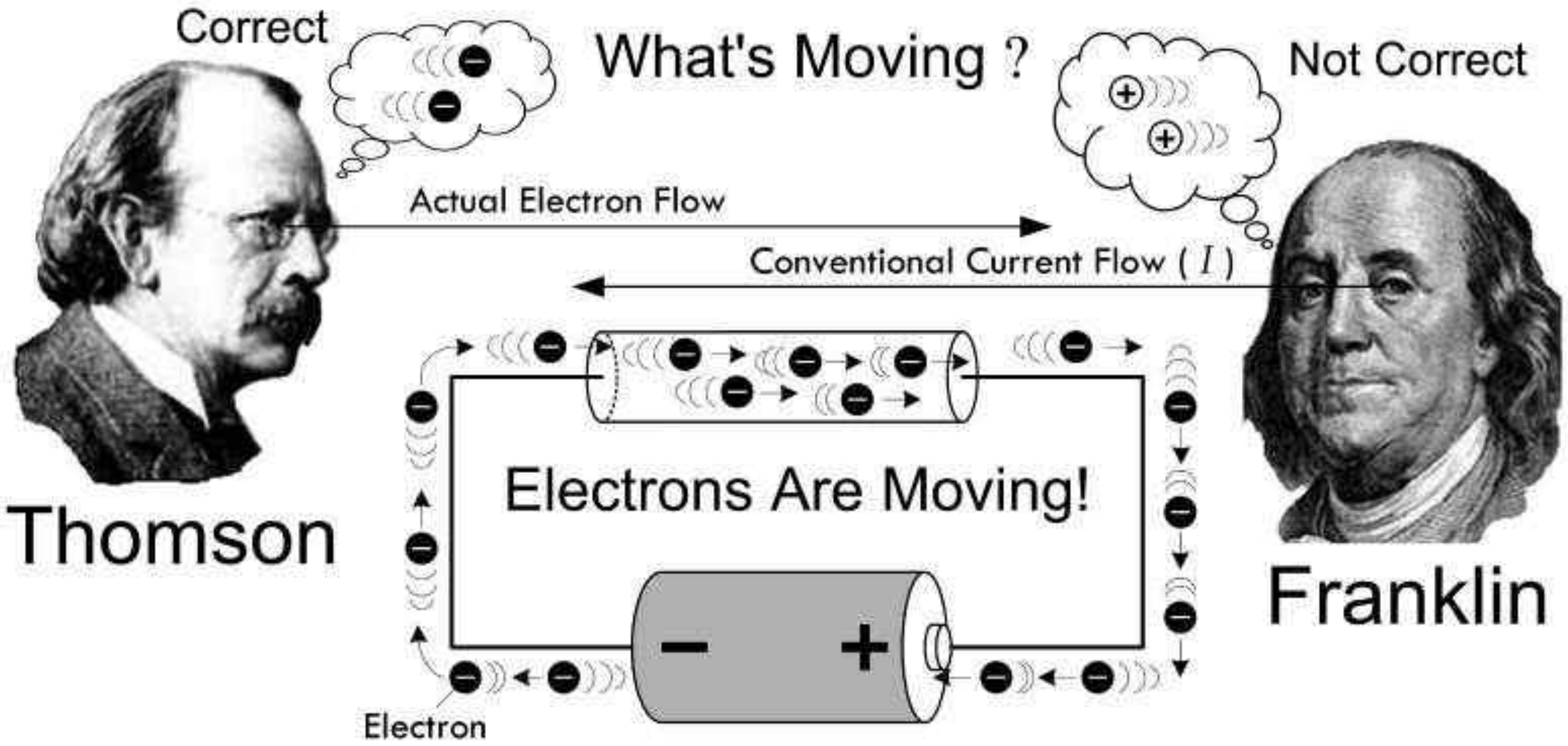


The “actual” direction of current is from negative to positive.



But we generally talk as if the current flows the other direction.




Correct
What's Moving ?
Not Correct
Actual Electron Flow
Conventional Current Flow (I)
Electrons Are Moving!
Thomson
Franklin
Electron
−
+

Three Key Elements of Electricity

1. Current
2. Voltage
3. Resistance

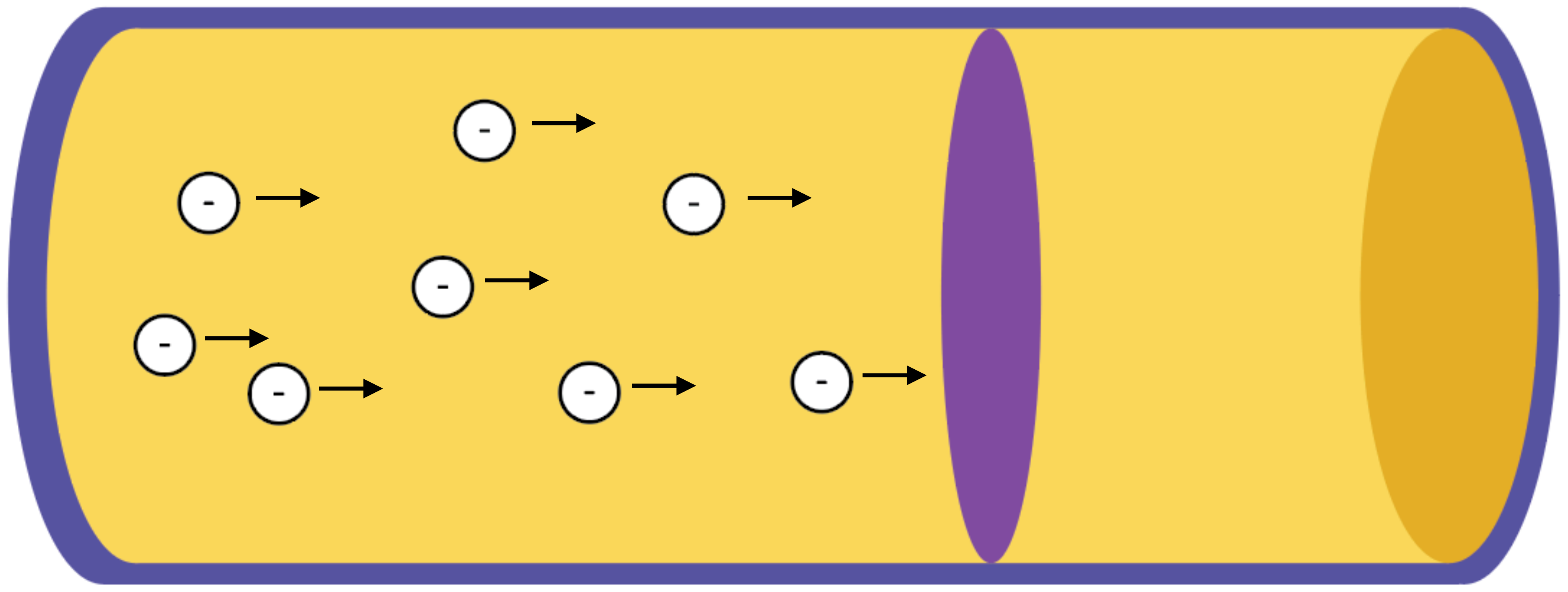
What is Current?

Current is the flow of electrons through a circuit.

Measured in Amperes or Amps.

Amps are symbolized as "A" and current as "I"

An <u>amp</u> is a measure of how many electrons pass through a point in a given amount of time.



What is Voltage?

Voltage is the amount of potential energy between points in a circuit. It is the “push” that causes the electrons to flow.

Measured in Volts and symbolized as “V”

What is Resistance?

Resistance is how much a circuit resists the flow of current.

Measured in Ohms and symbolized with “Ω”

Ohm’s Law

Ohm's law states that the current through a conductor is directly proportional to the voltage across the two points.

$$V = I \times R$$

V is <u>voltage</u>
I is <u>current</u>
R is <u>resistance</u>

$$V = I \times R$$

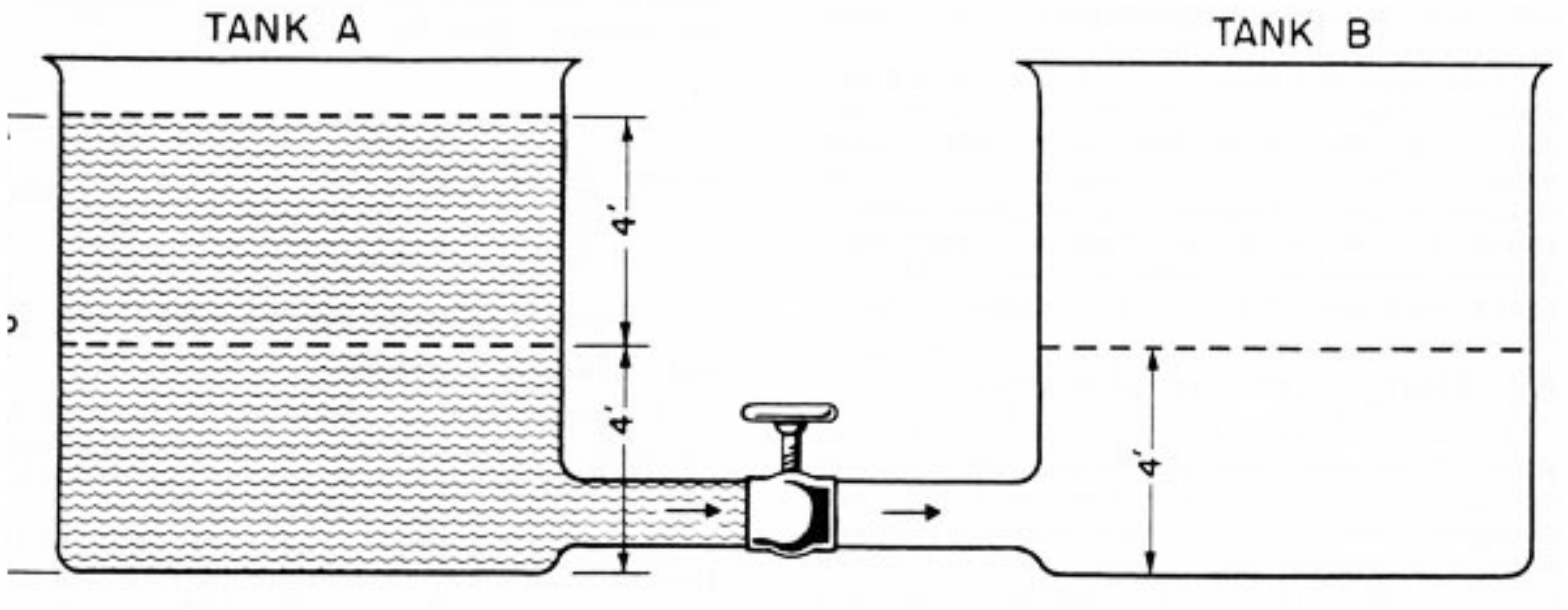
$$I = V / R$$

$$R = V / I$$

V is <u>voltage</u>
I is <u>current</u>
R is <u>resistance</u>

$$V = I \times R$$

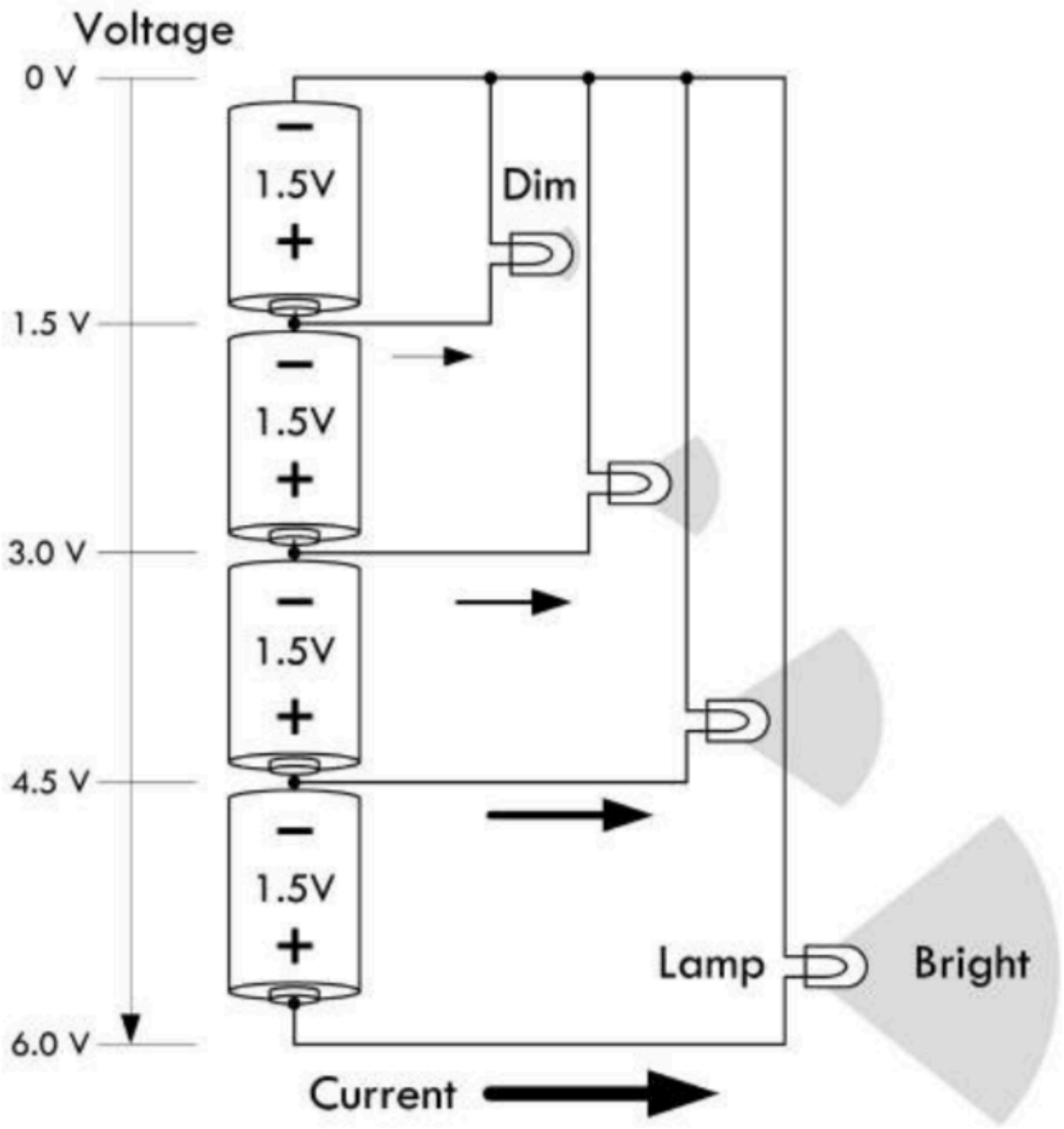
This means that an increase in voltage causes a proportional increase in current.



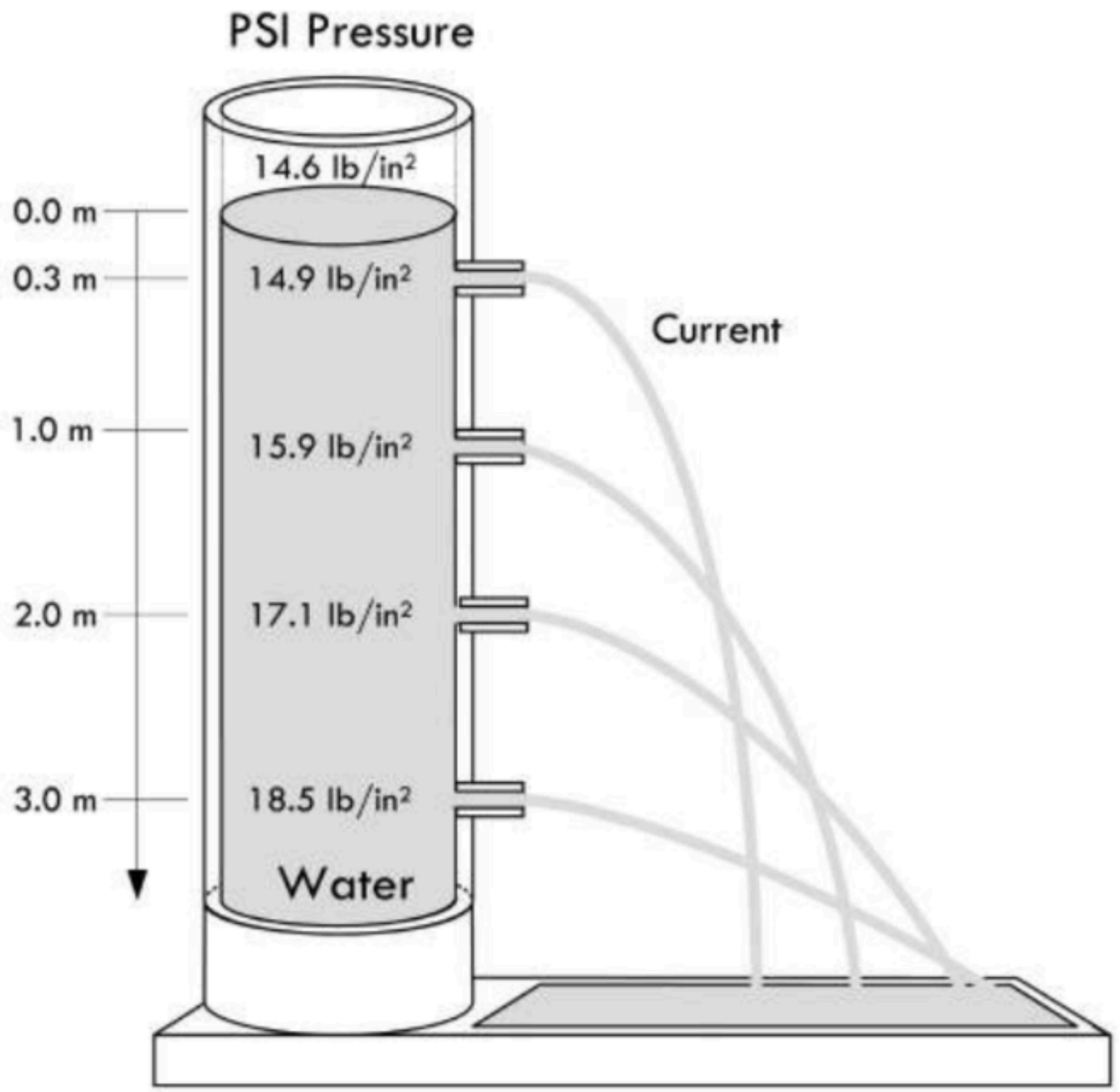

```
R (resistance) = V (voltage) / I (current)
V = R * I
I = V / R
```

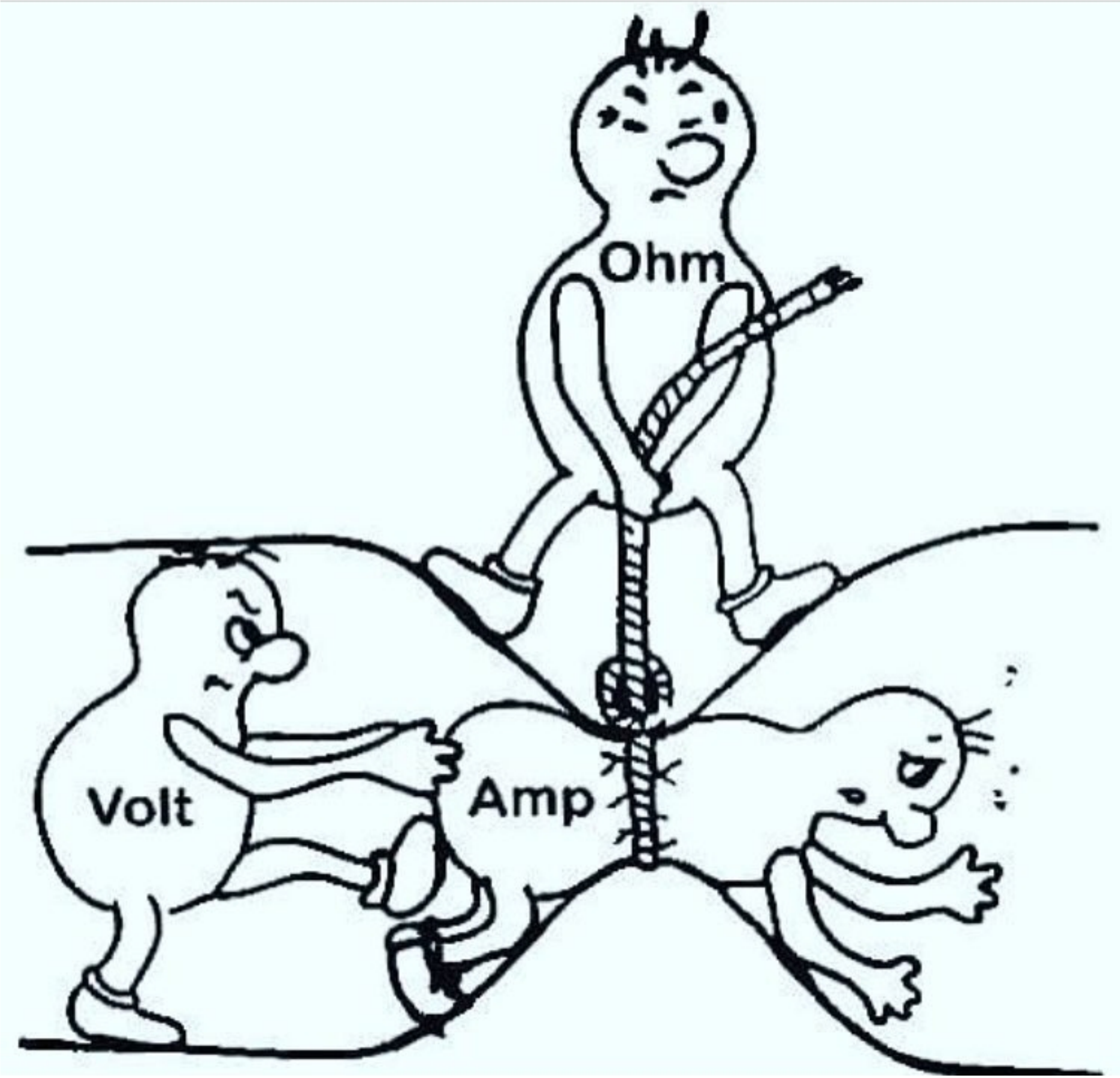
This is the only rule that you really have to memorise and learn to use, because in most of your work, this is the only one that you will really need.

Electrical System

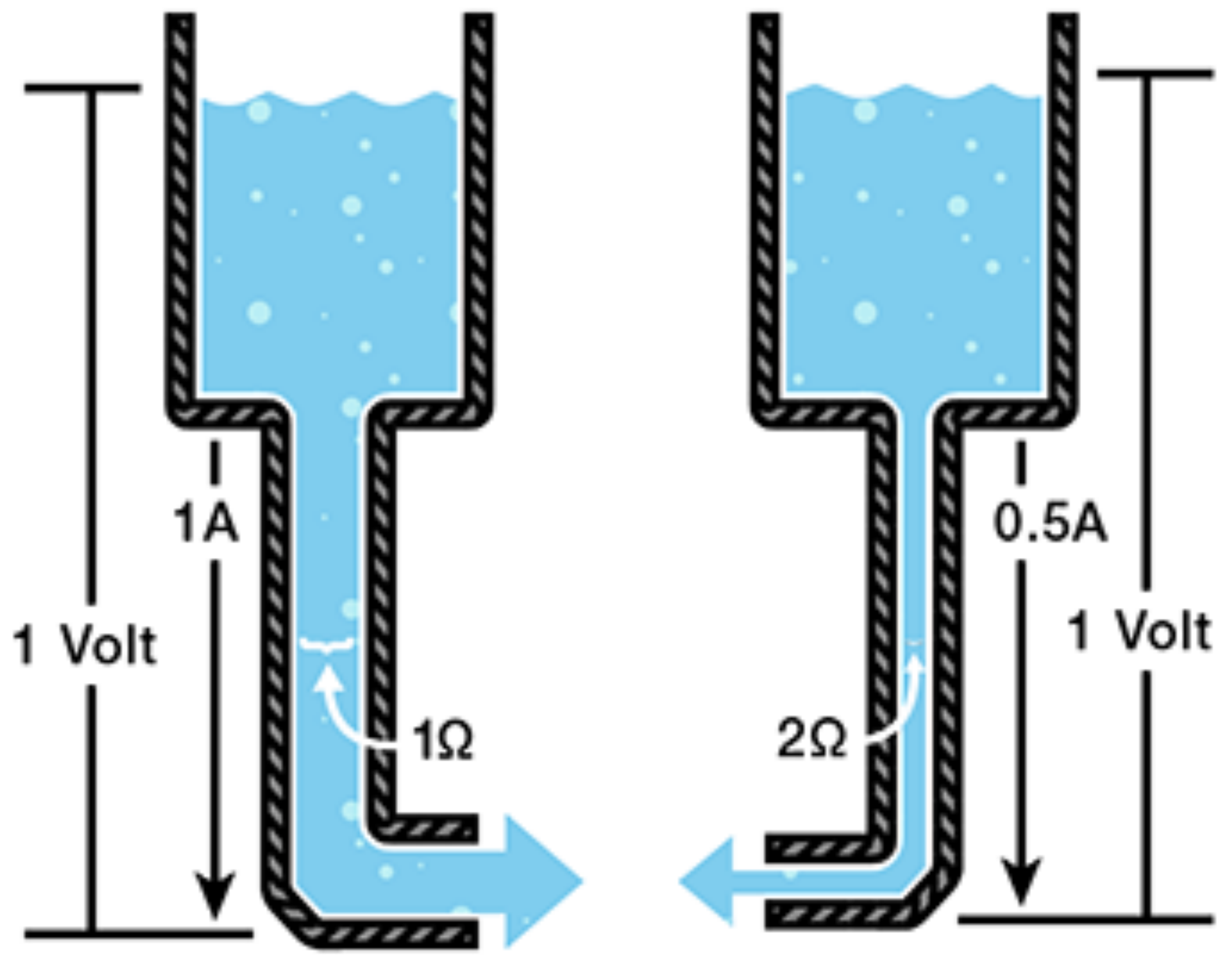


Water System




Ohm
Volt
Amp

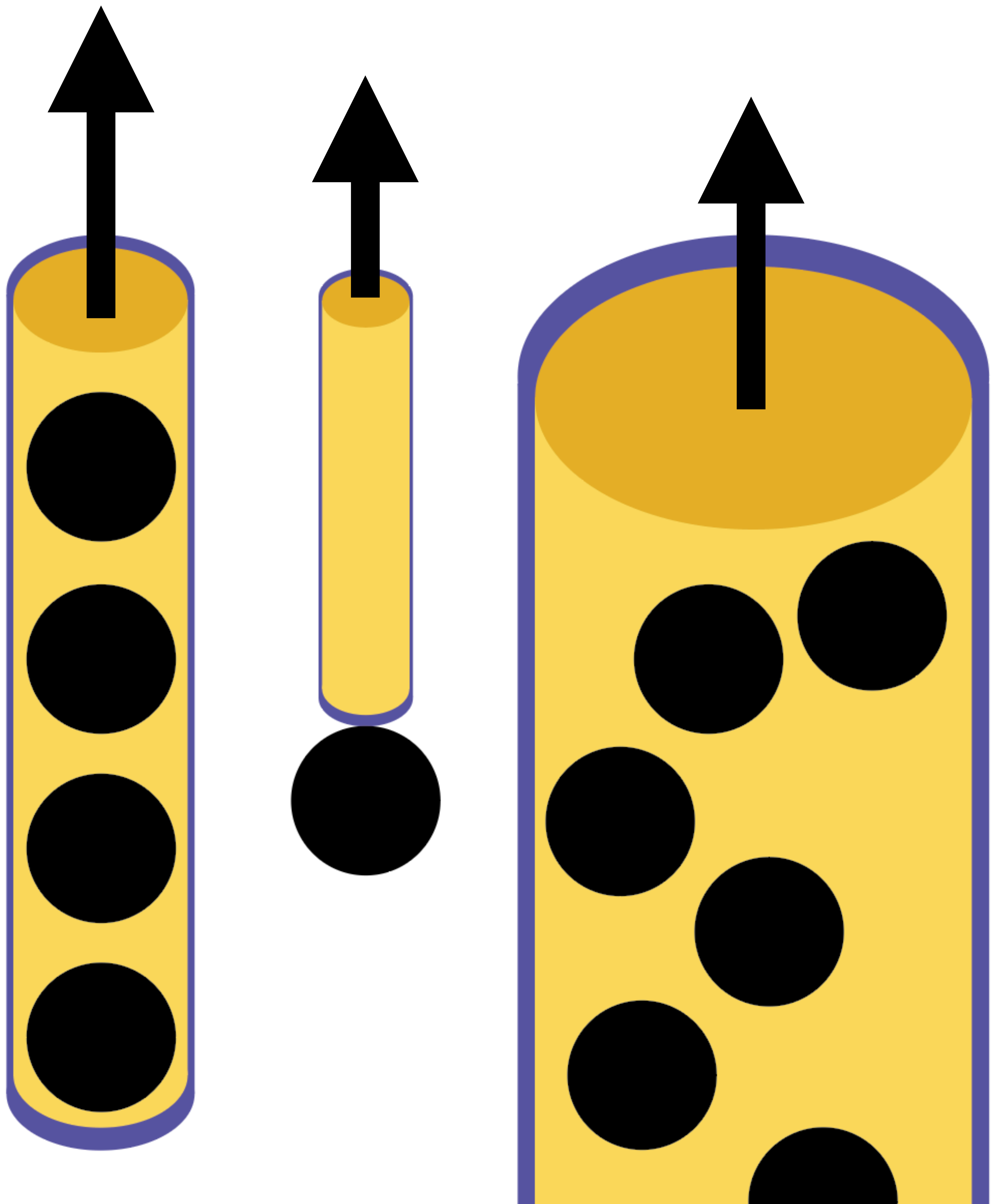
$$V = I \cdot R$$



V = VOLTAGE IN VOLTS
I = CURRENT IN AMPS
R = RESISTANCE IN OHMS

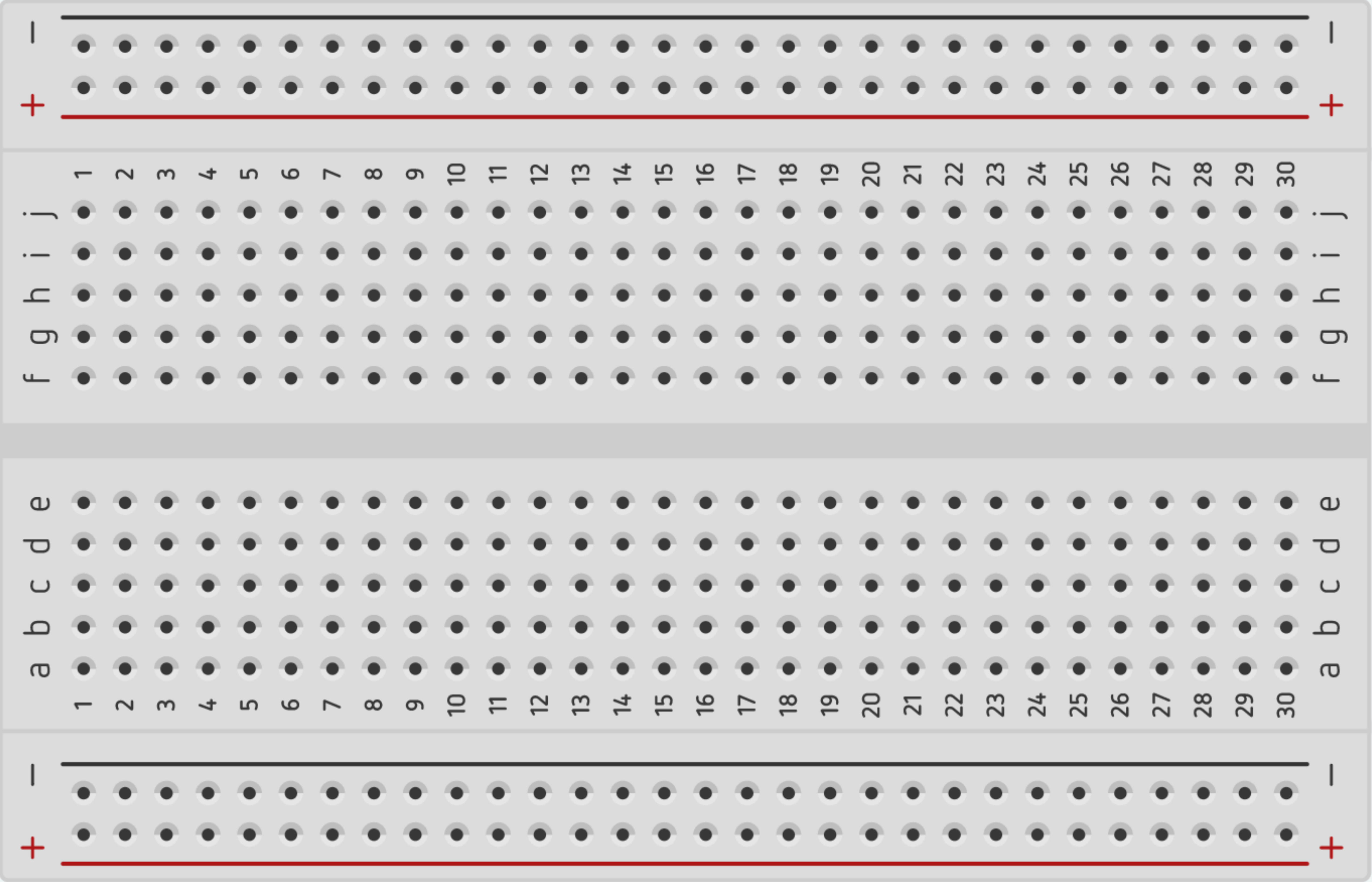
In the boba analogy,

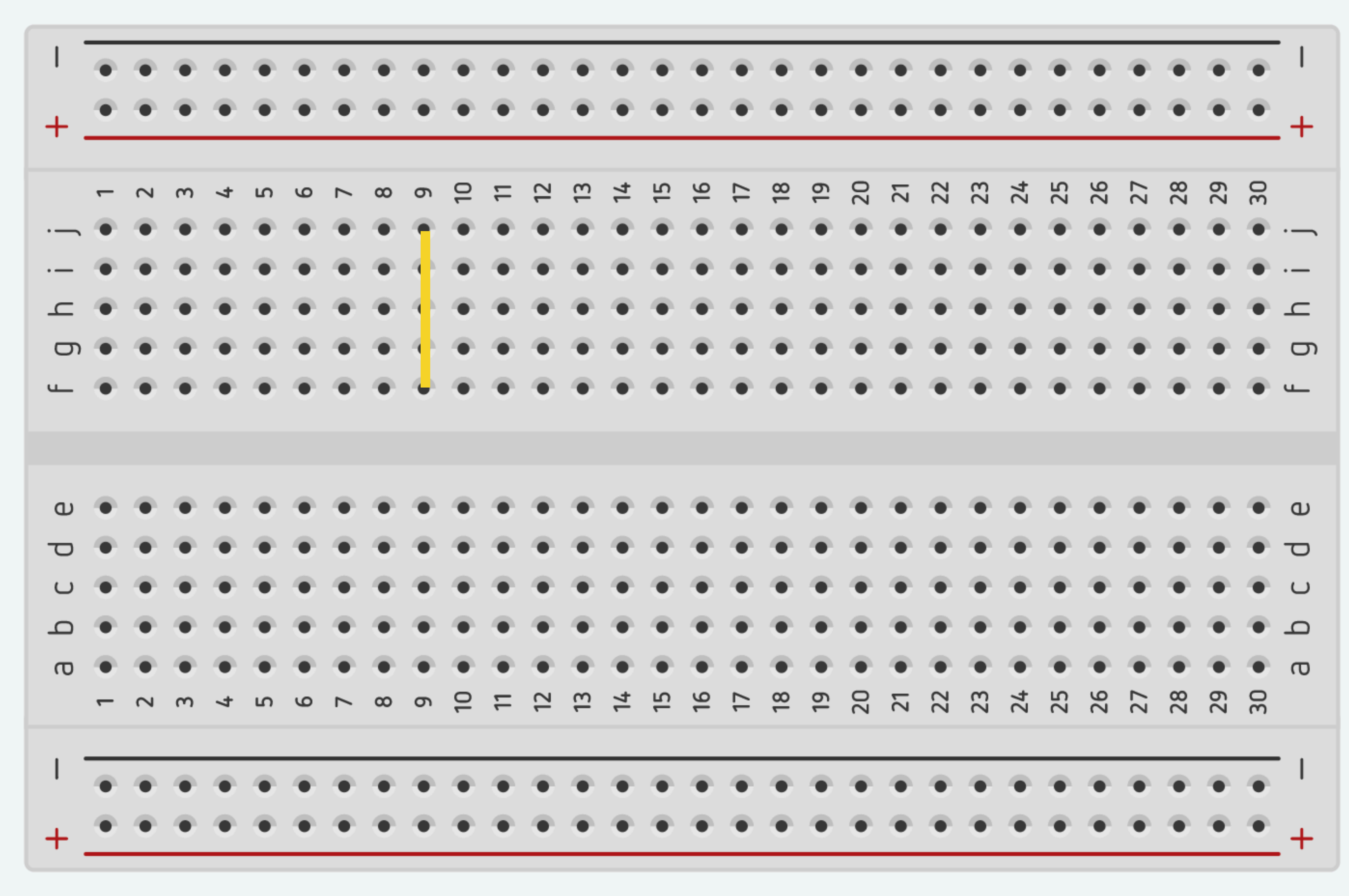
- the straw size is the resistance,
- the strength of the sucking is the voltage
- and the number of boba per second is the current



ELECTRICAL COMPONENTS

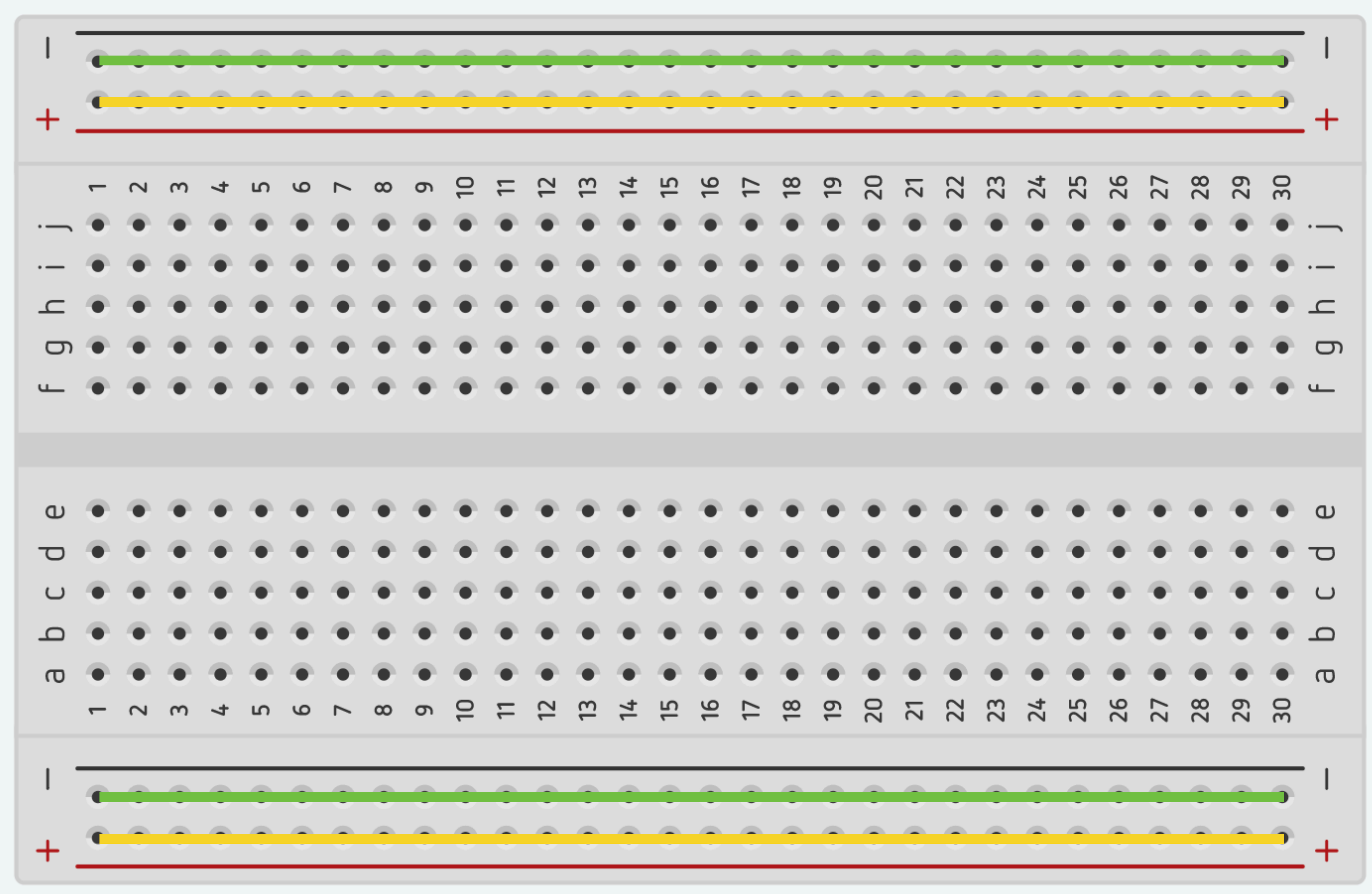
Breadboard


−
+
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
j i h g f
e d c b a
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
−
+



−
+
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
j i h g f
e d c b a

RAILS
(typically for connecting power)



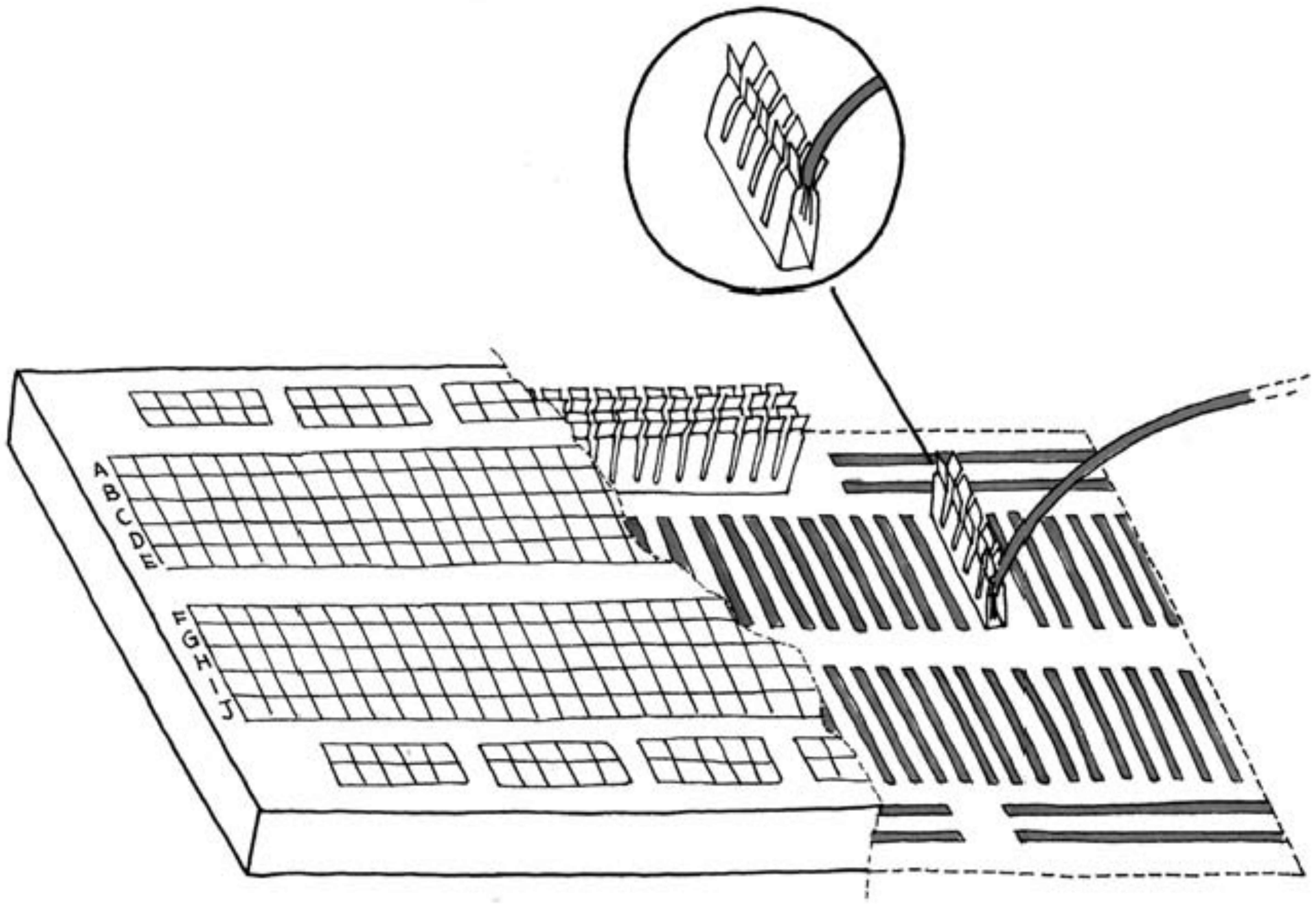
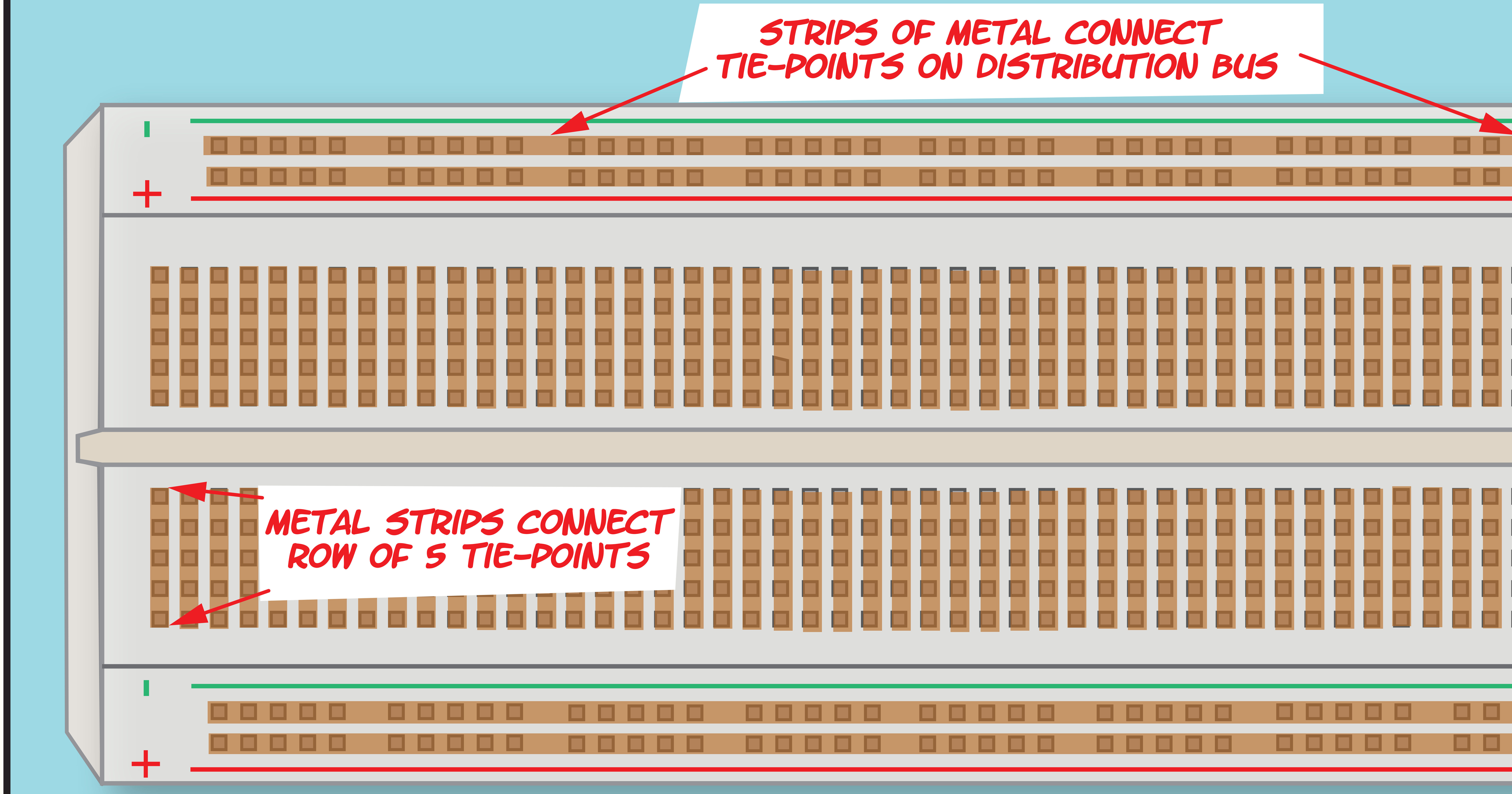
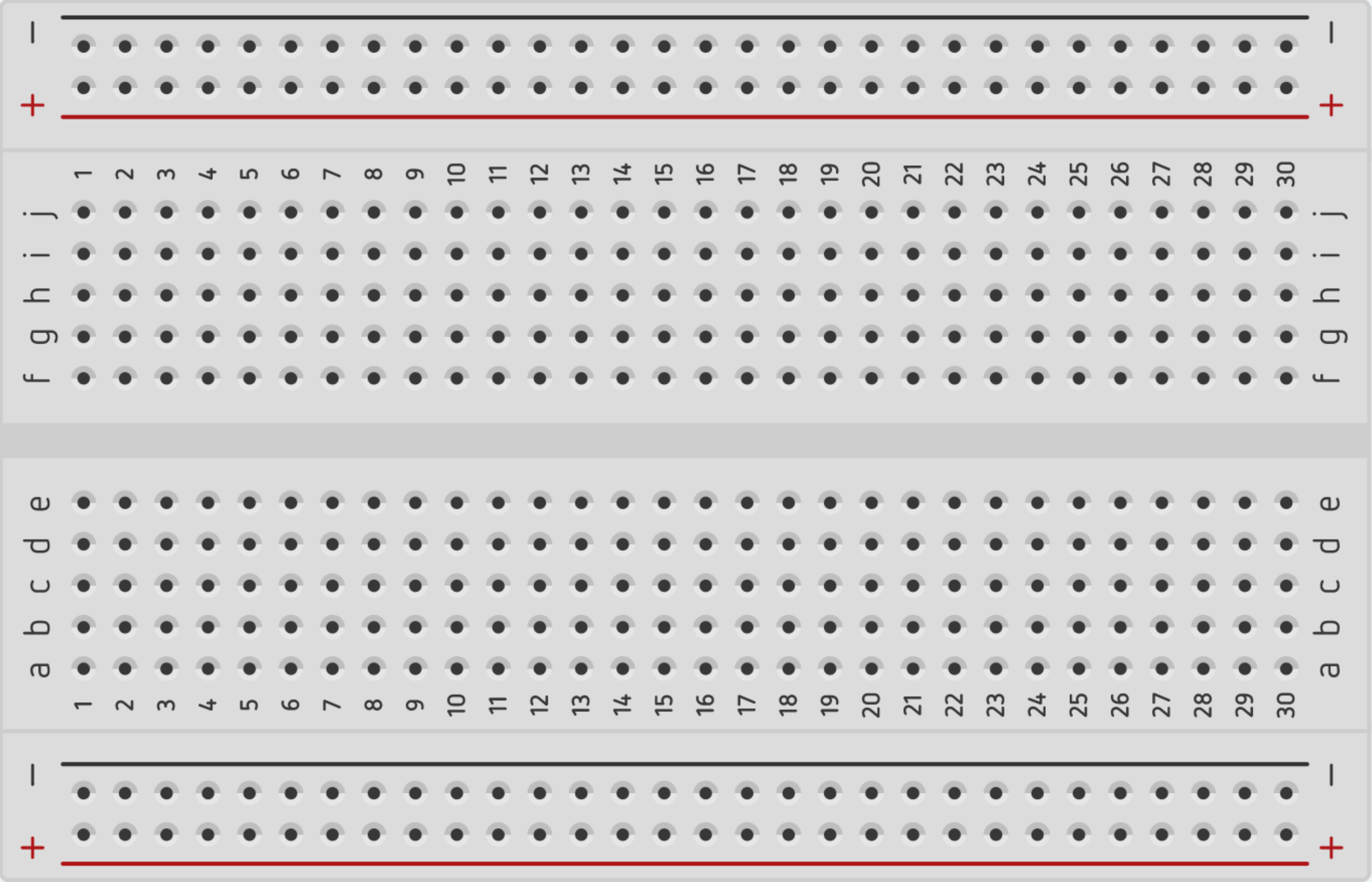


Figure A-1.
The solderless breadboard


STRIPS OF METAL CONNECT TIE-POINTS ON DISTRIBUTION BUS
METAL STRIPS CONNECT ROW OF 5 TIE-POINTS
-
+



–
+
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
f g h i j
a b c d e

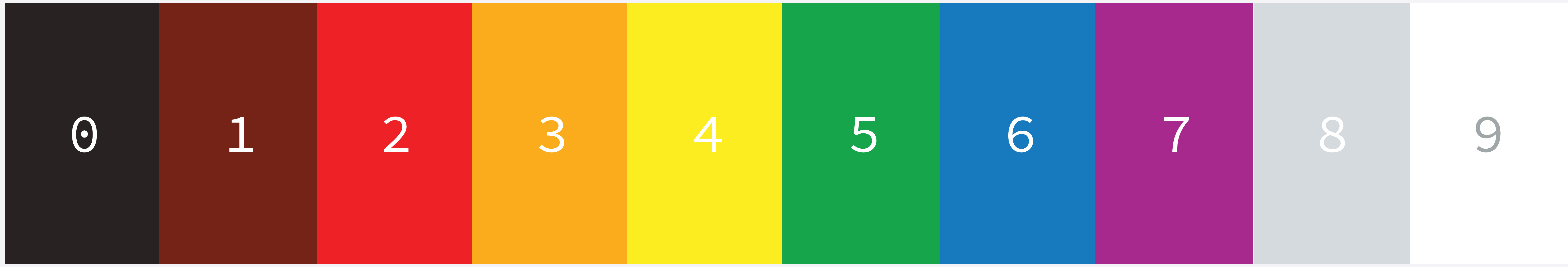
Resistor

Resistor

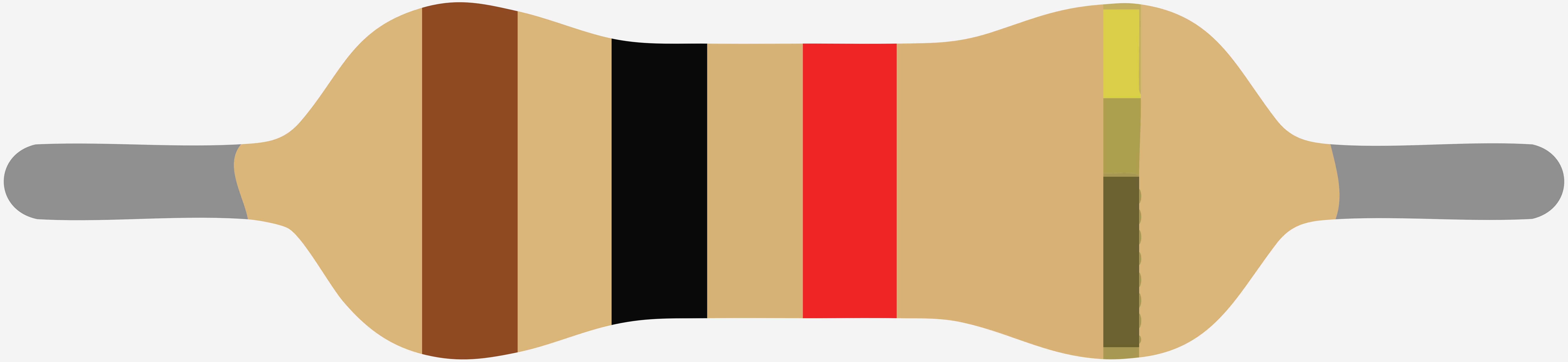
A resistor is a component that **creates electrical resistance** in a circuit.

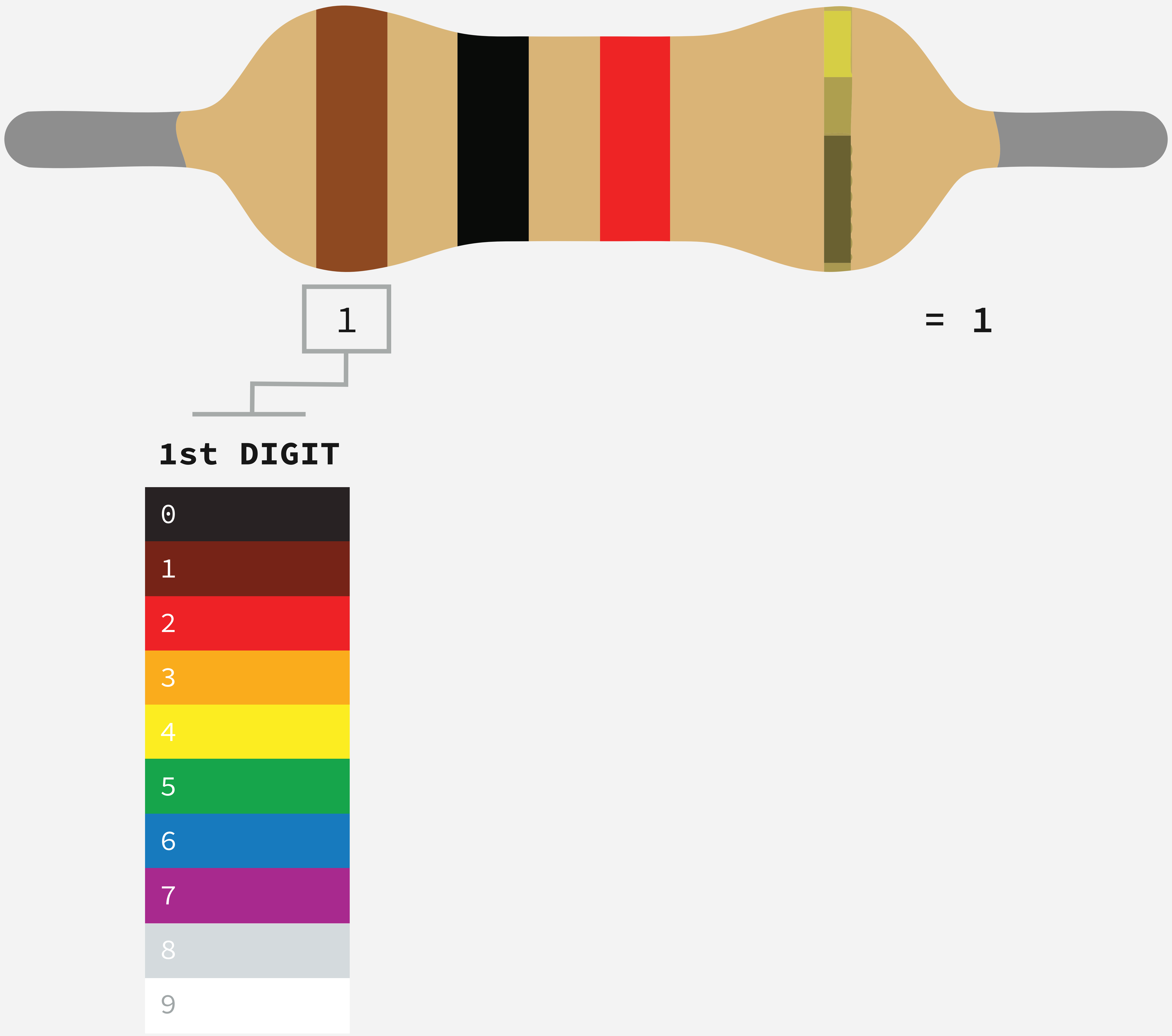
The strength of a resistor can be found using the color bands

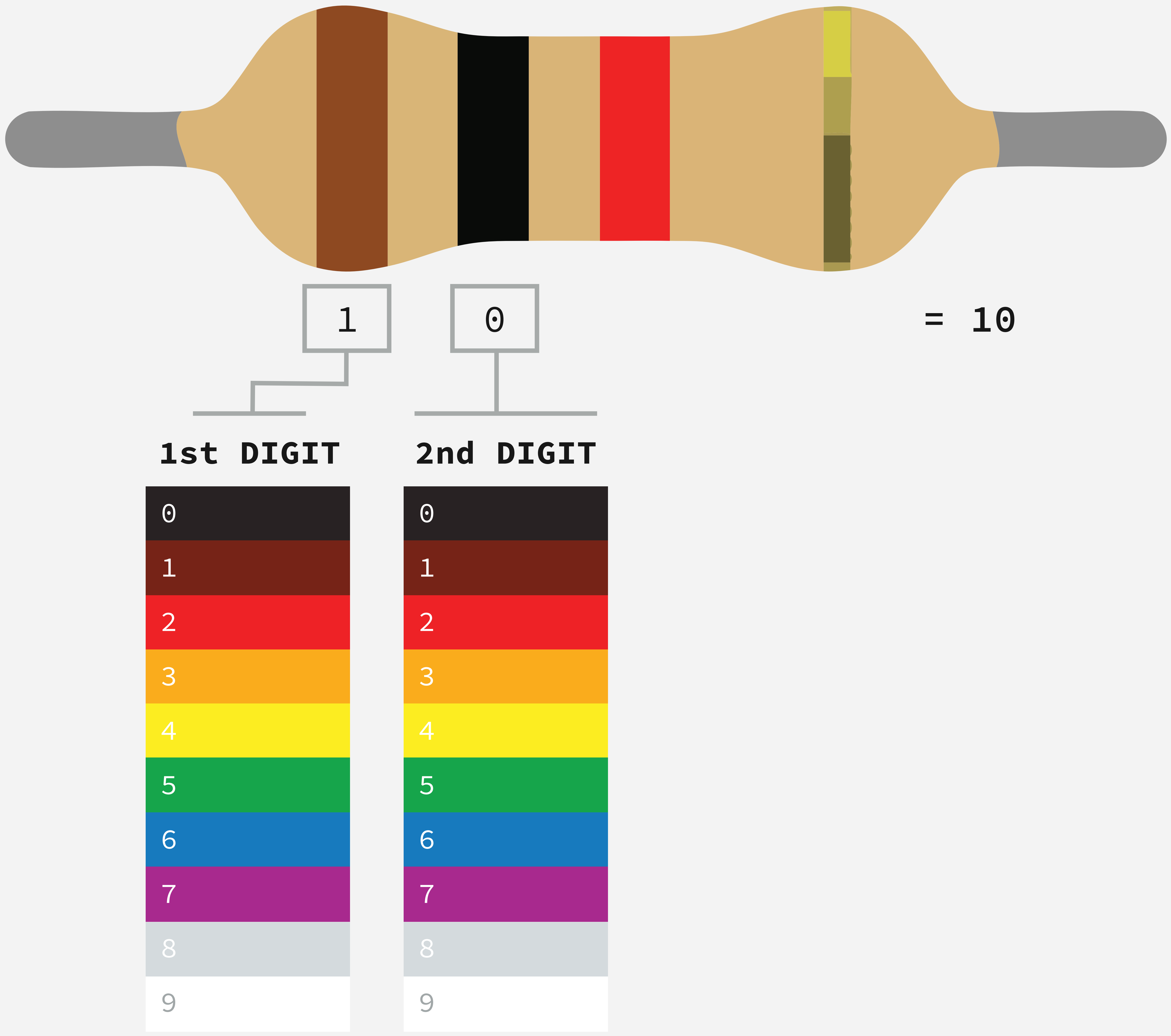
Resistor

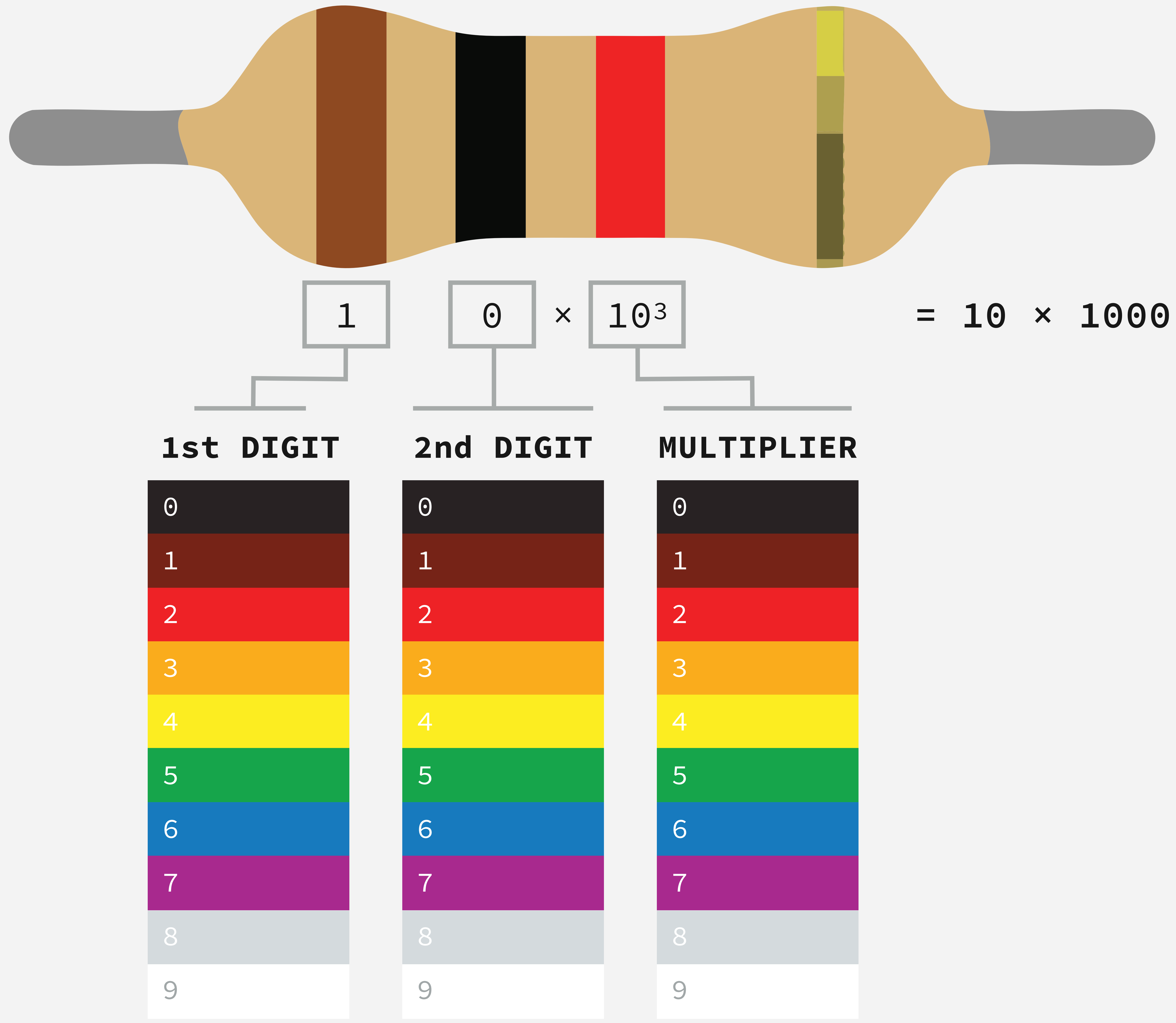


The strength of a resistor can be found using the color bands

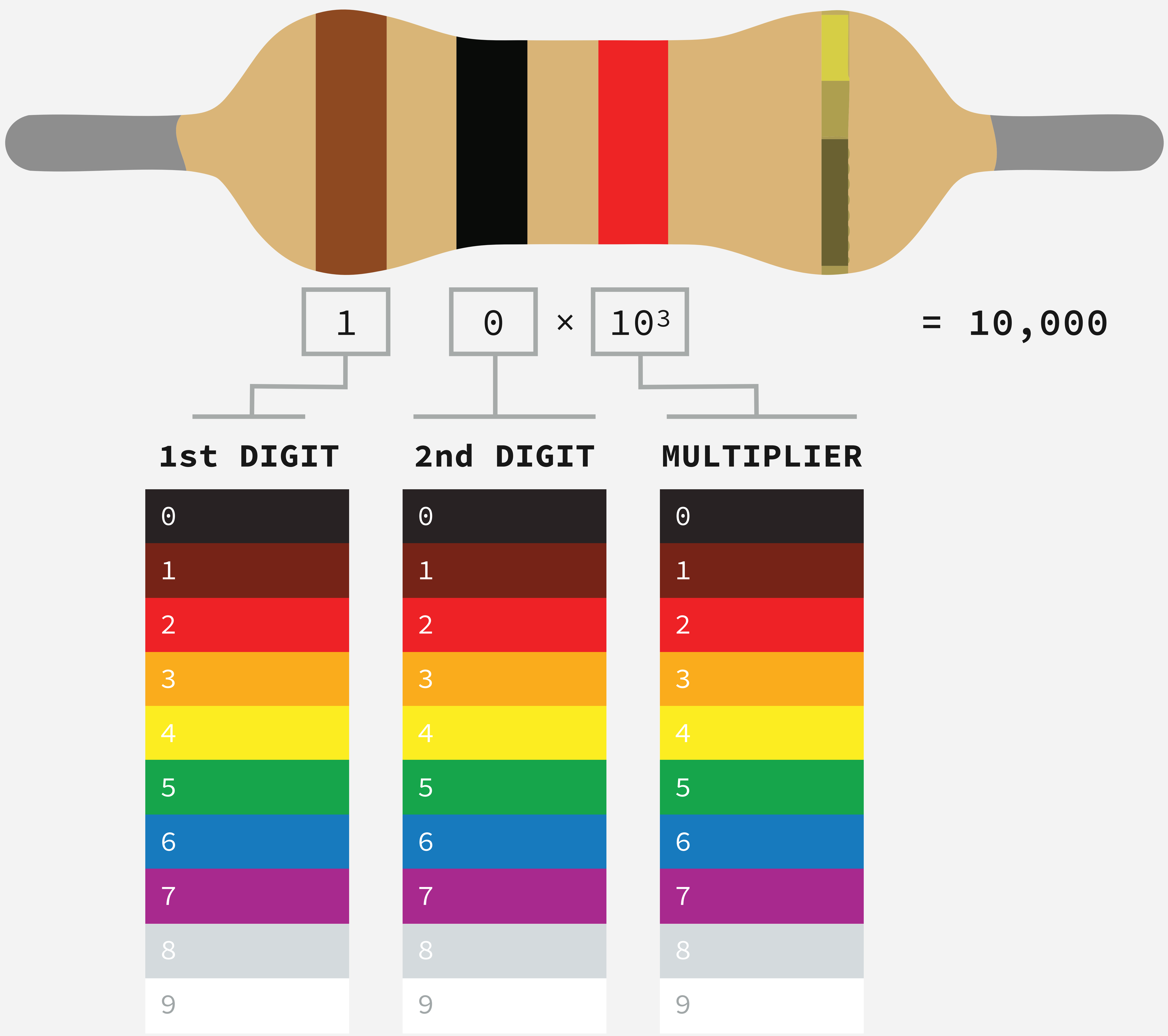


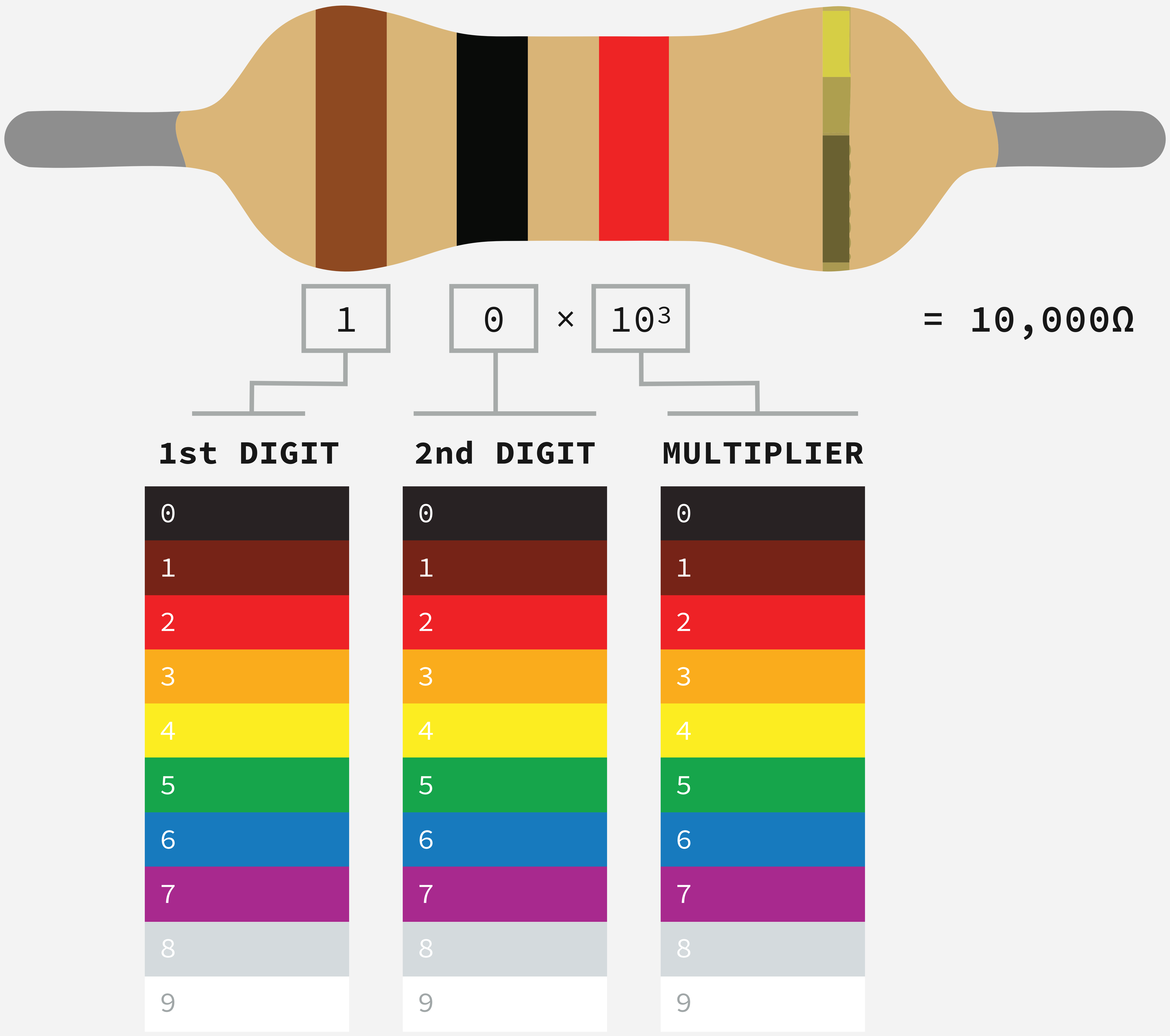

1
= 1
1st DIGIT
0
1
2
3
4
5
6
7
8
9

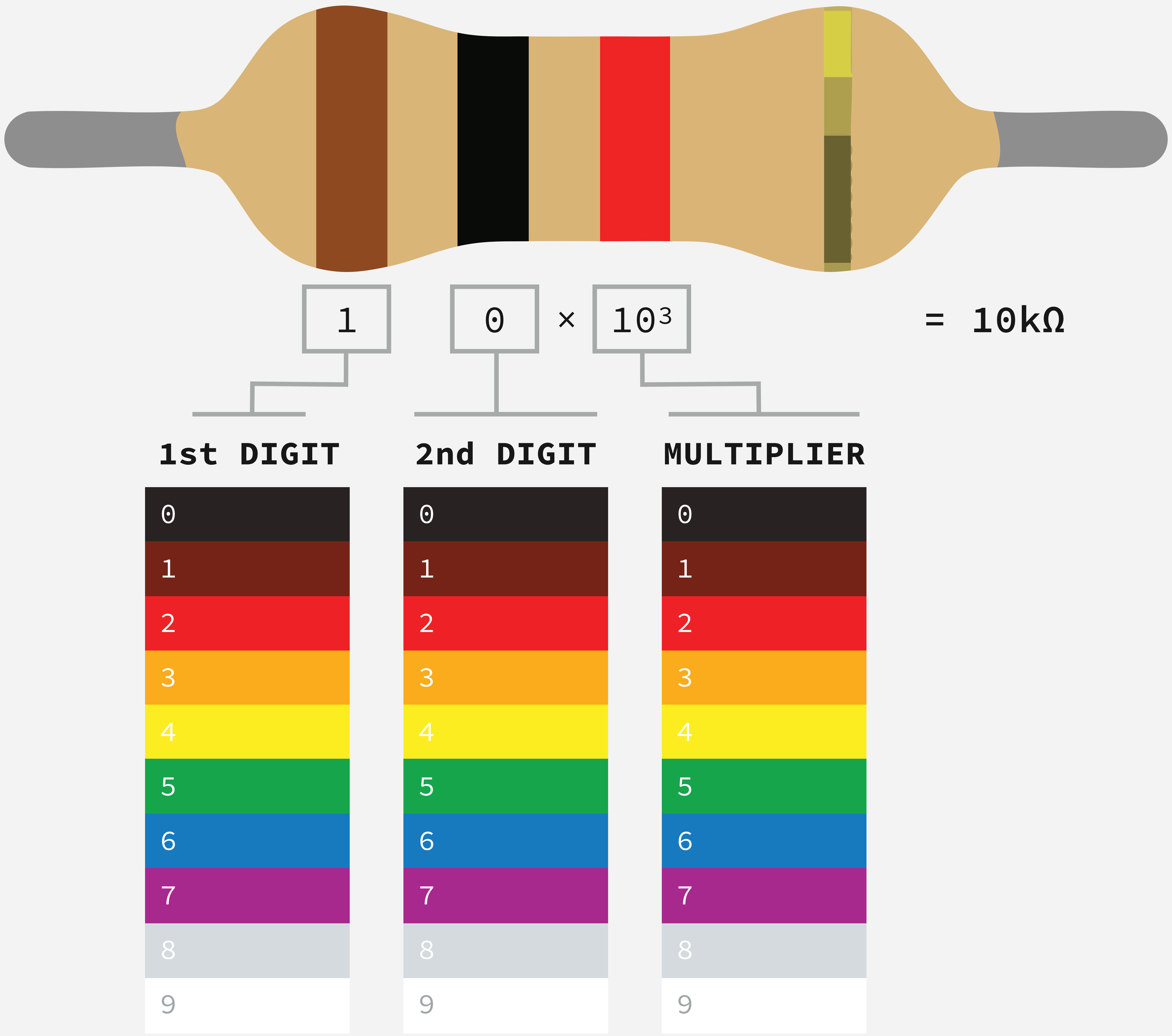

1
0
= 10
1st DIGIT
2nd DIGIT
0
1
2
3
4
5
6
7
8
9
0
1
2
3
4
5
6
7
8
9

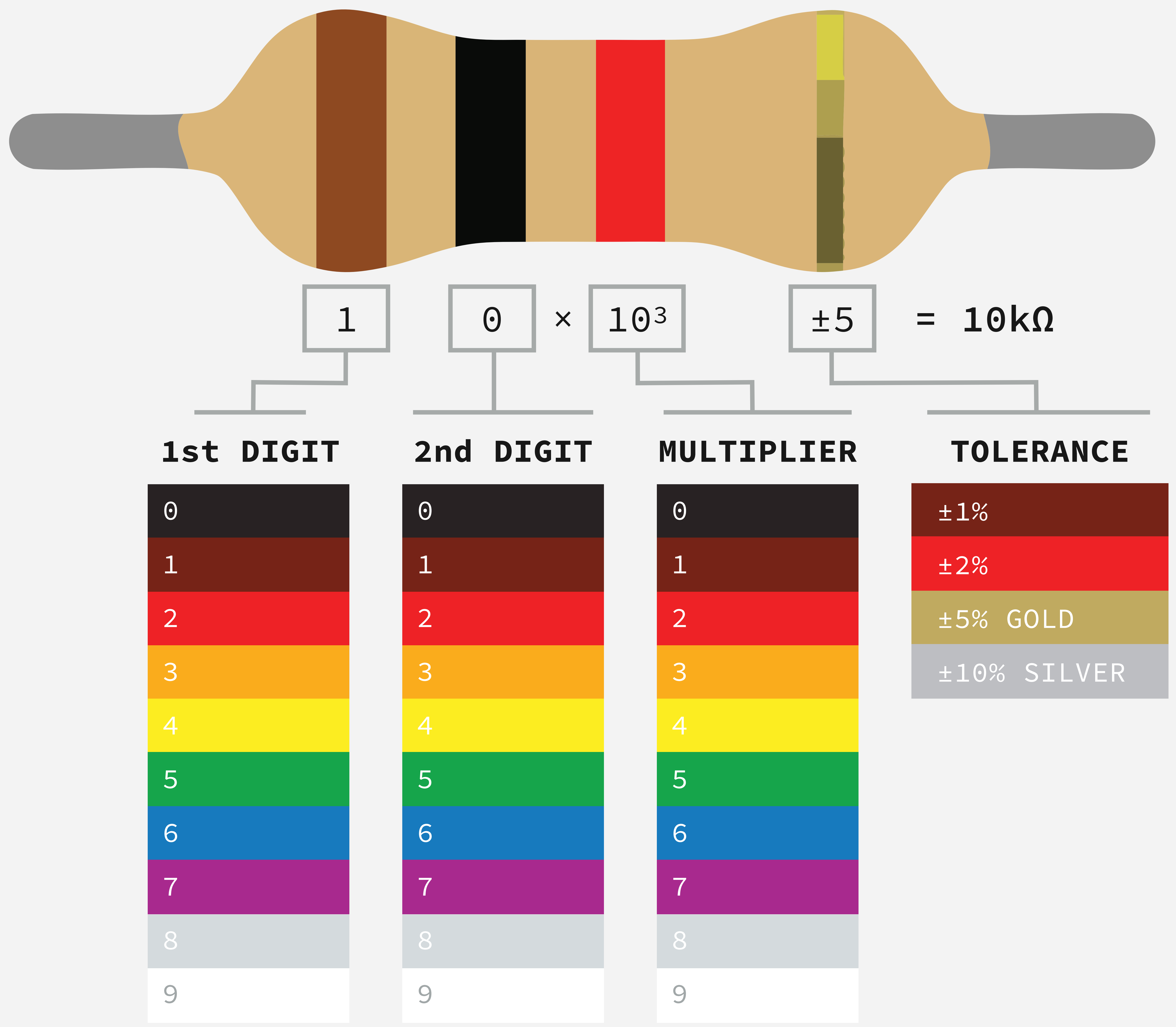


1
0
×
10^3
= 10 × 1000
1st DIGIT
0
1
2
3
4
5
6
7
8
9
2nd DIGIT
0
1
2
3
4
5
6
7
8
9
MULTIPLIER
0
1
2
3
4
5
6
7
8
9

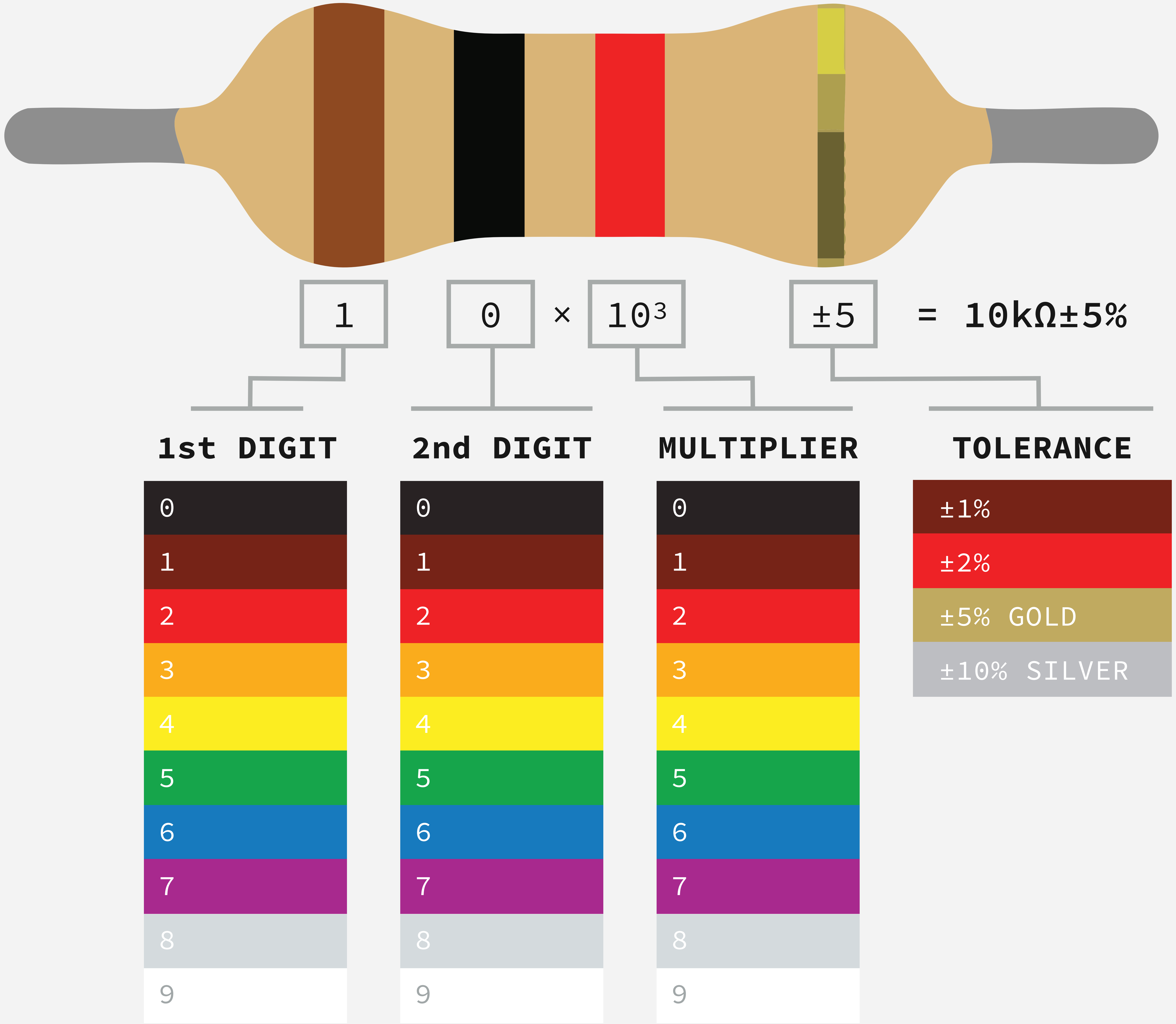

1
0
×
10³
= 10,000
1st DIGIT
2nd DIGIT
MULTIPLIER
0
1
2
3
4
5
6
7
8
9
0
1
2
3
4
5
6
7
8
9
0
1
2
3
4
5
6
7
8
9


1
0
× 10³
= 10,000Ω
1st DIGIT
2nd DIGIT
MULTIPLIER
0
1
2
3
4
5
6
7
8
9
0
1
2
3
4
5
6
7
8
9
0
1
2
3
4
5
6
7
8
9


1
0
×
10^3
= 10kΩ
1st DIGIT
2nd DIGIT
MULTIPLIER
0
1
2
3
4
5
6
7
8
9
0
1
2
3
4
5
6
7
8
9
0
1
2
3
4
5
6
7
8
9



1
0
×
10^3
±5
= 10kΩ
1st DIGIT
0
1
2
3
4
5
6
7
8
9
2nd DIGIT
0
1
2
3
4
5
6
7
8
9
MULTIPLIER
0
1
2
3
4
5
6
7
8
9
TOLERANCE
±1%
±2%
±5% GOLD
±10% SILVER

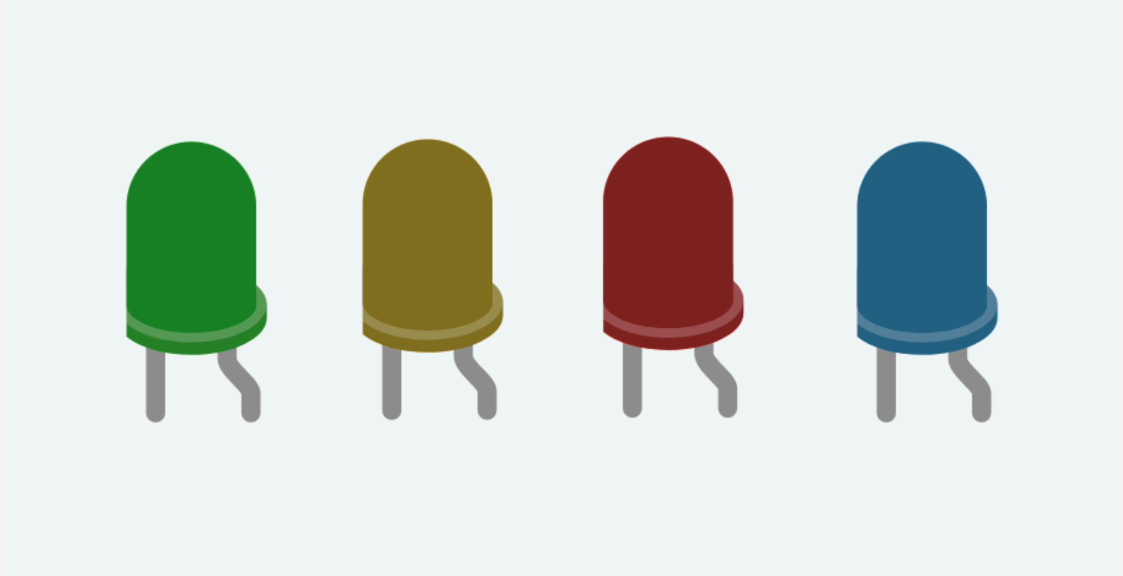


1
0
×
10³
±5
= 10kΩ±5%
1st DIGIT
2nd DIGIT
MULTIPLIER
TOLERANCE
0
1
2
3
4
5
6
7
8
9
0
1
2
3
4
5
6
7
8
9
0
1
2
3
4
5
6
7
8
9
±1%
±2%
±5% GOLD
±10% SILVER

We will use resistors to create the right amount of current for LEDs and to create and calibrate sensors.

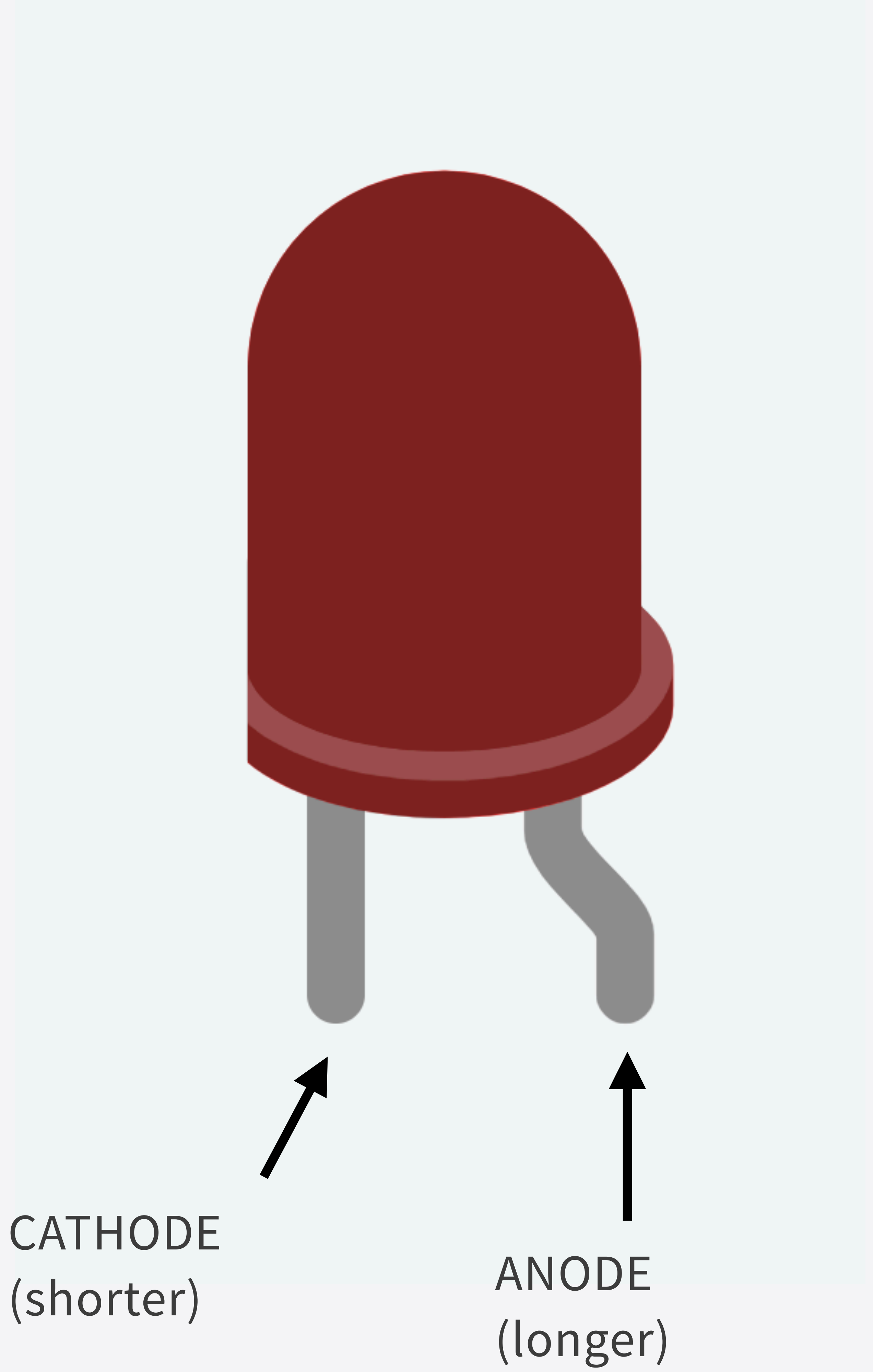
LED

LED

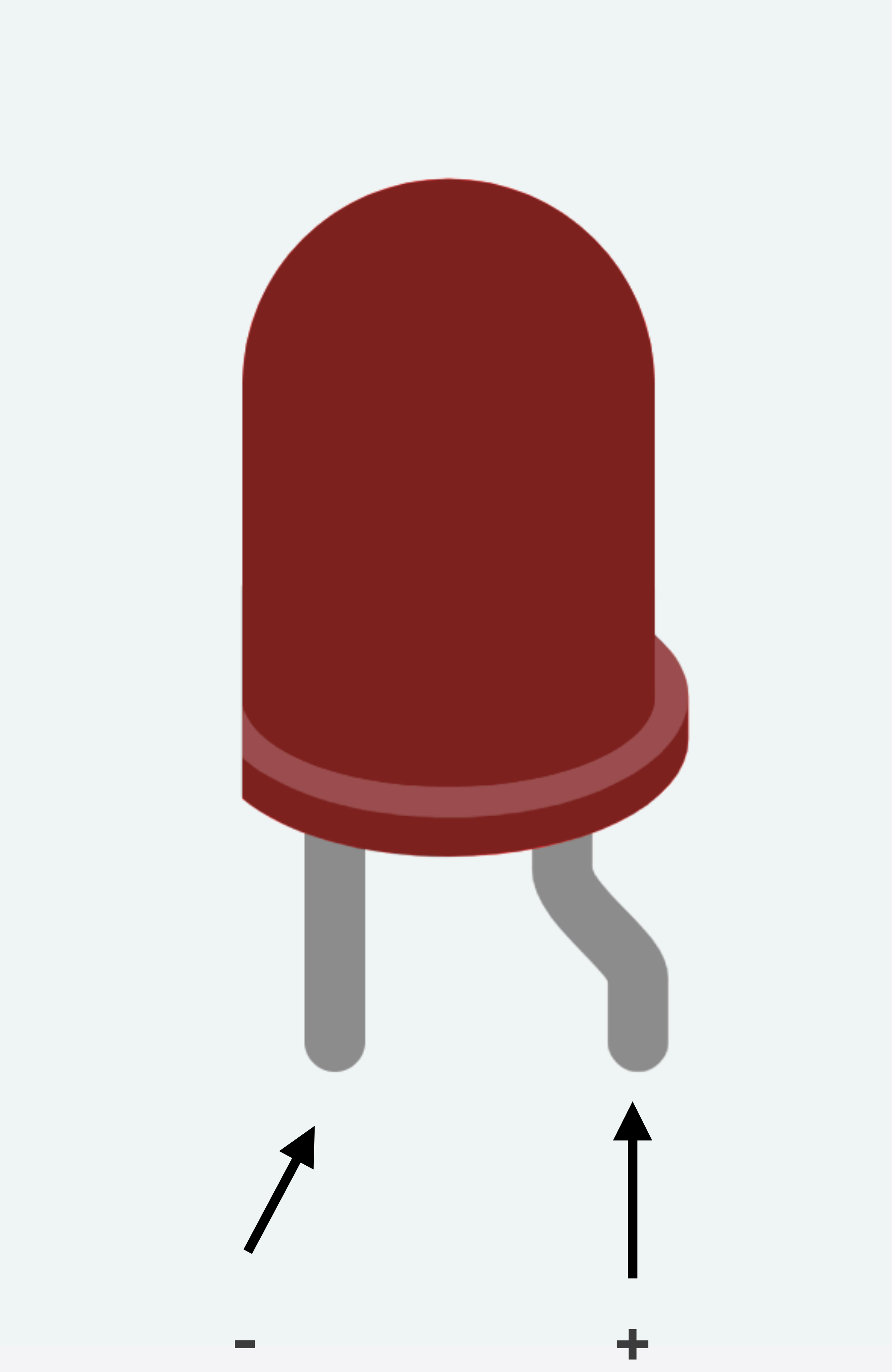


A light-emitting diode (LED) is a semiconductor light source that emits light when current flows through it.

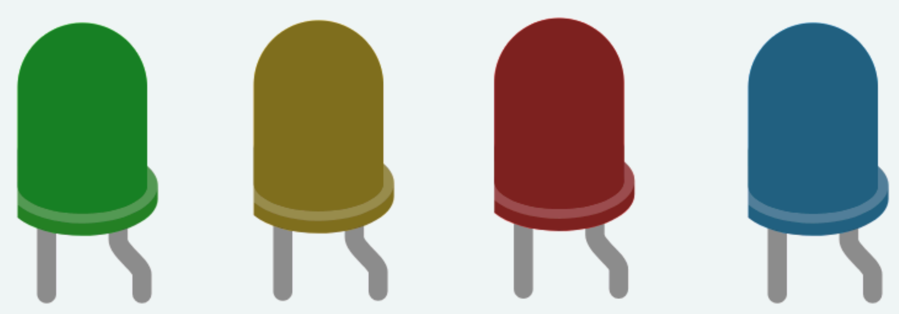
An LED has two legs, a longer one called an <u>anode</u> and a shorter one called a <u>cathode</u>



The cathode must be connected to ground, and the anode connected to power

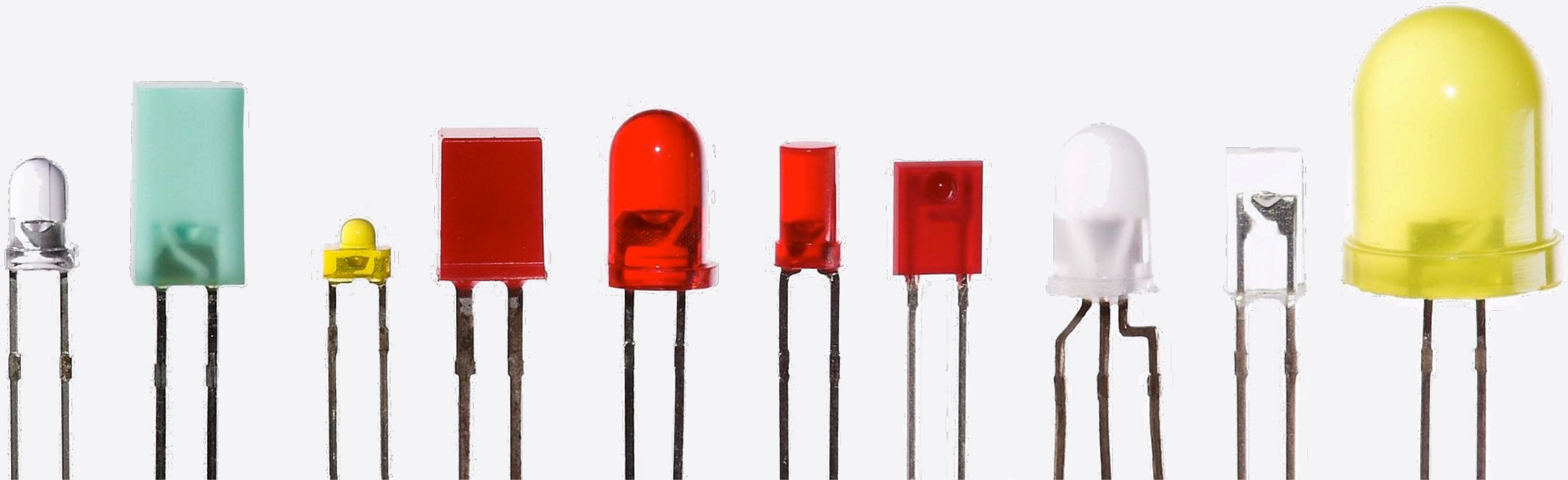


LED

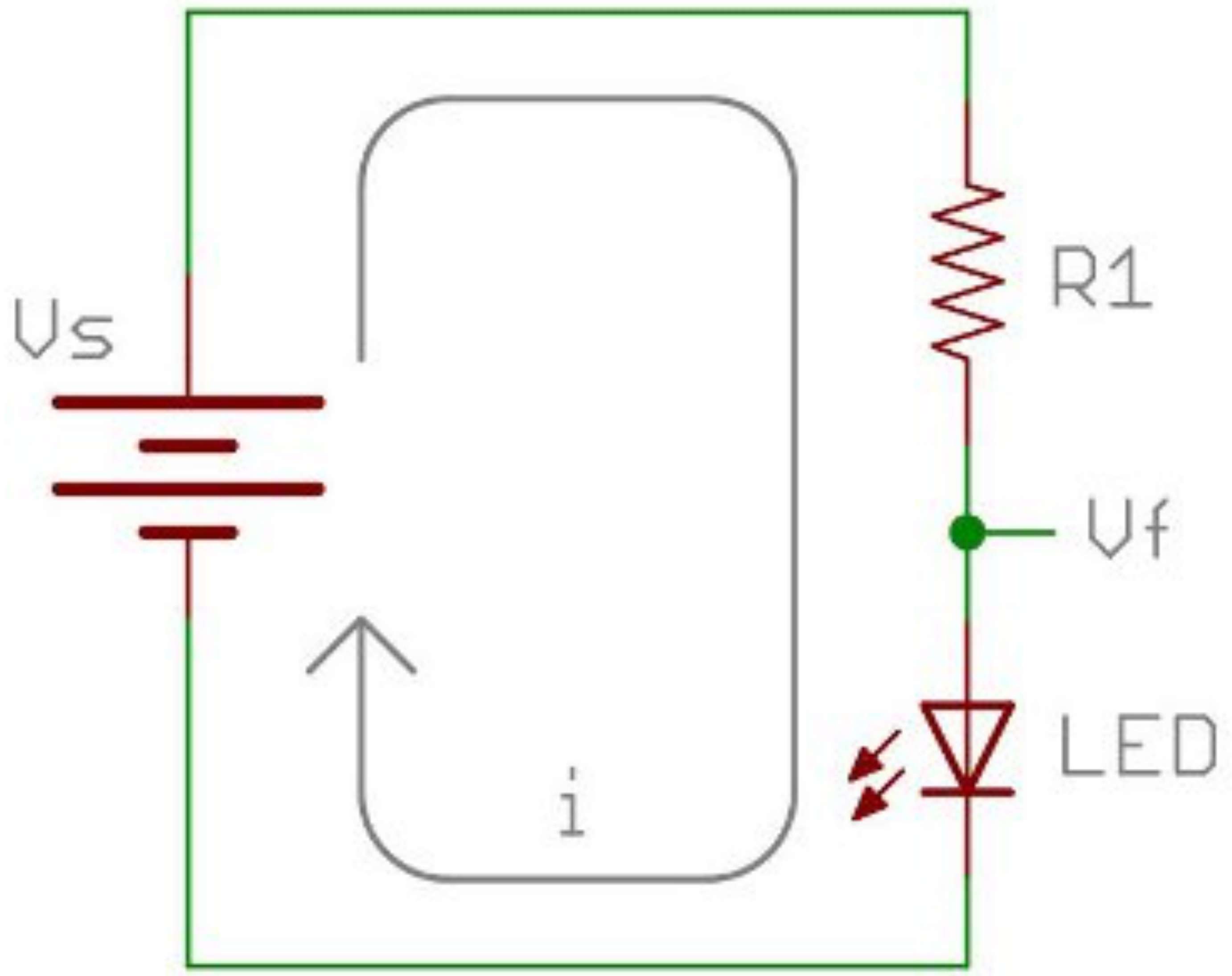


Every LED has a rating for how much current it can handle, and how much voltage is required for it to work

LEDs come in many shapes and sizes. The color is often indicated by the color of the plastic, but not always.



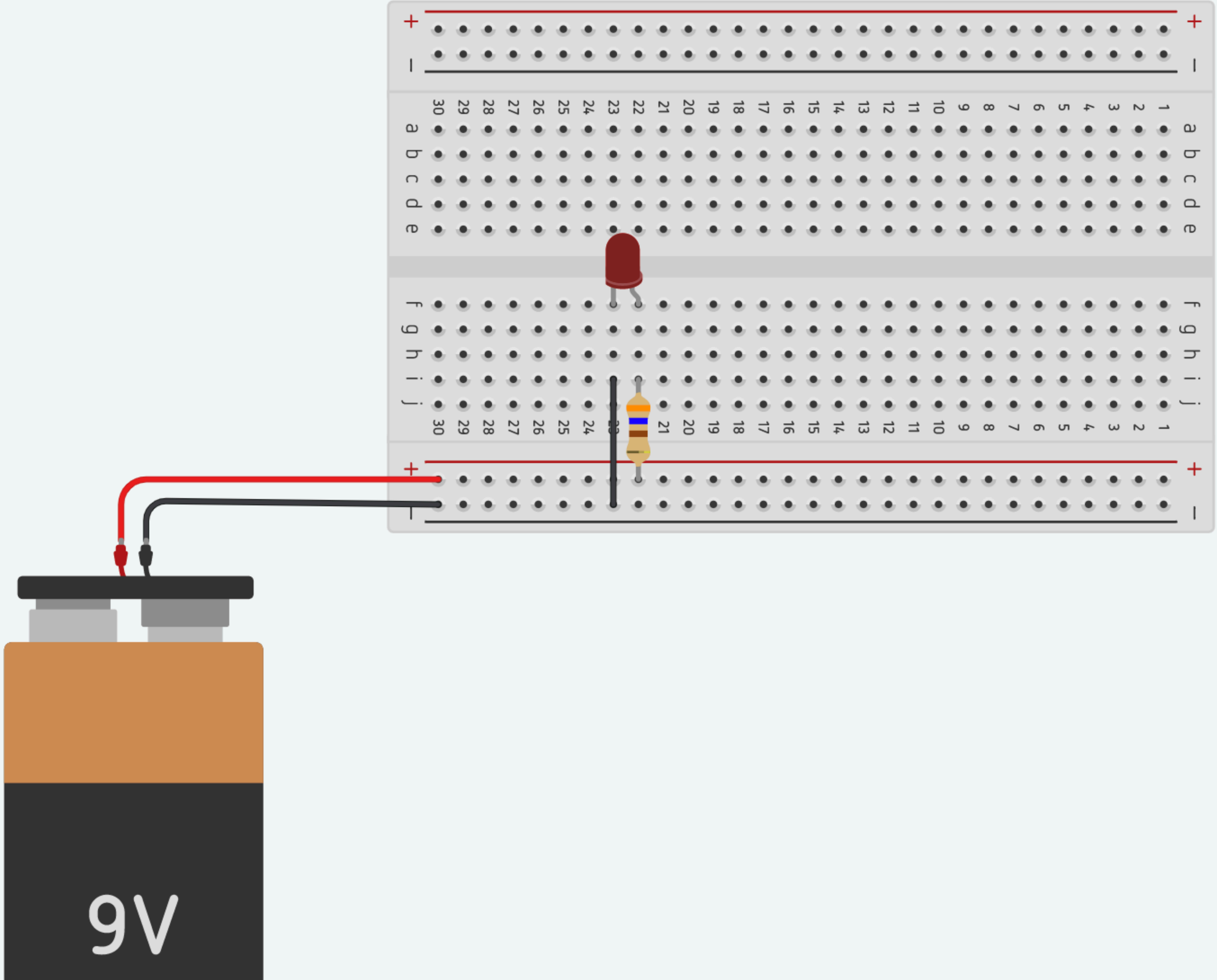
Using LEDs

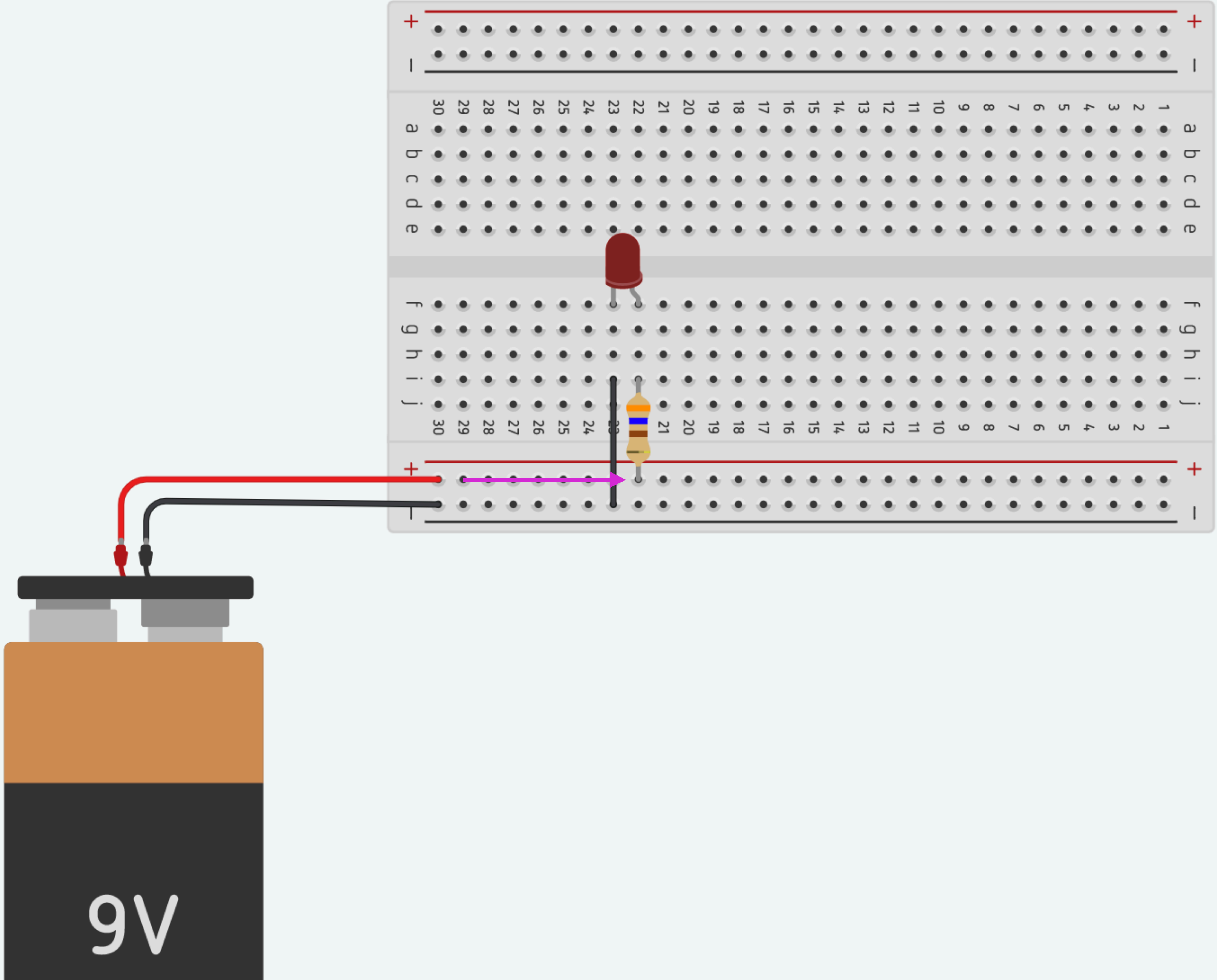



```
i = LED forward current in Amps
    (found in the LED datasheet)

Vf = LED forward voltage drop in Volts
    (found in the LED datasheet)

Vs = supply voltage
```

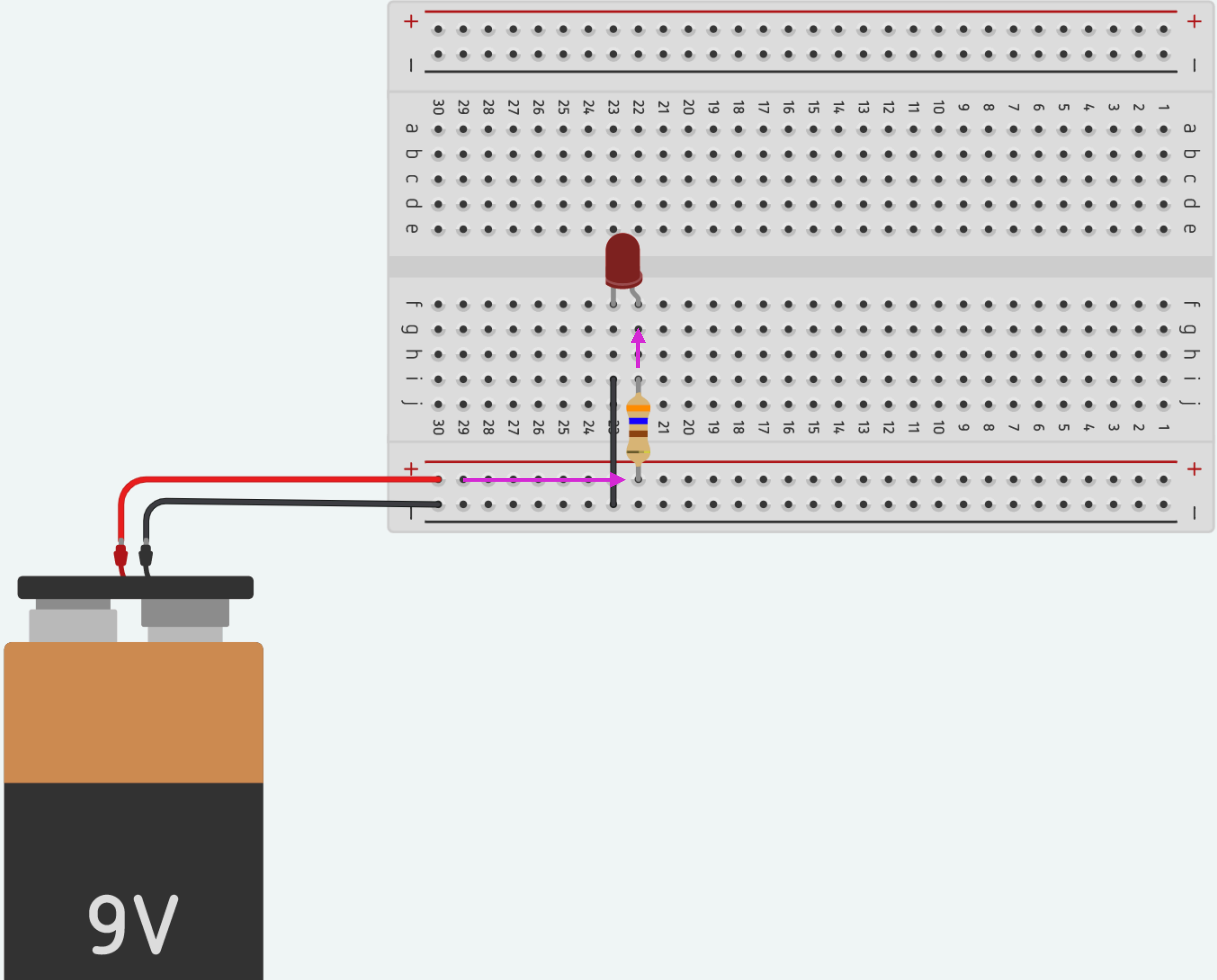
$$R = \frac{Vs - Vf}{i}$$

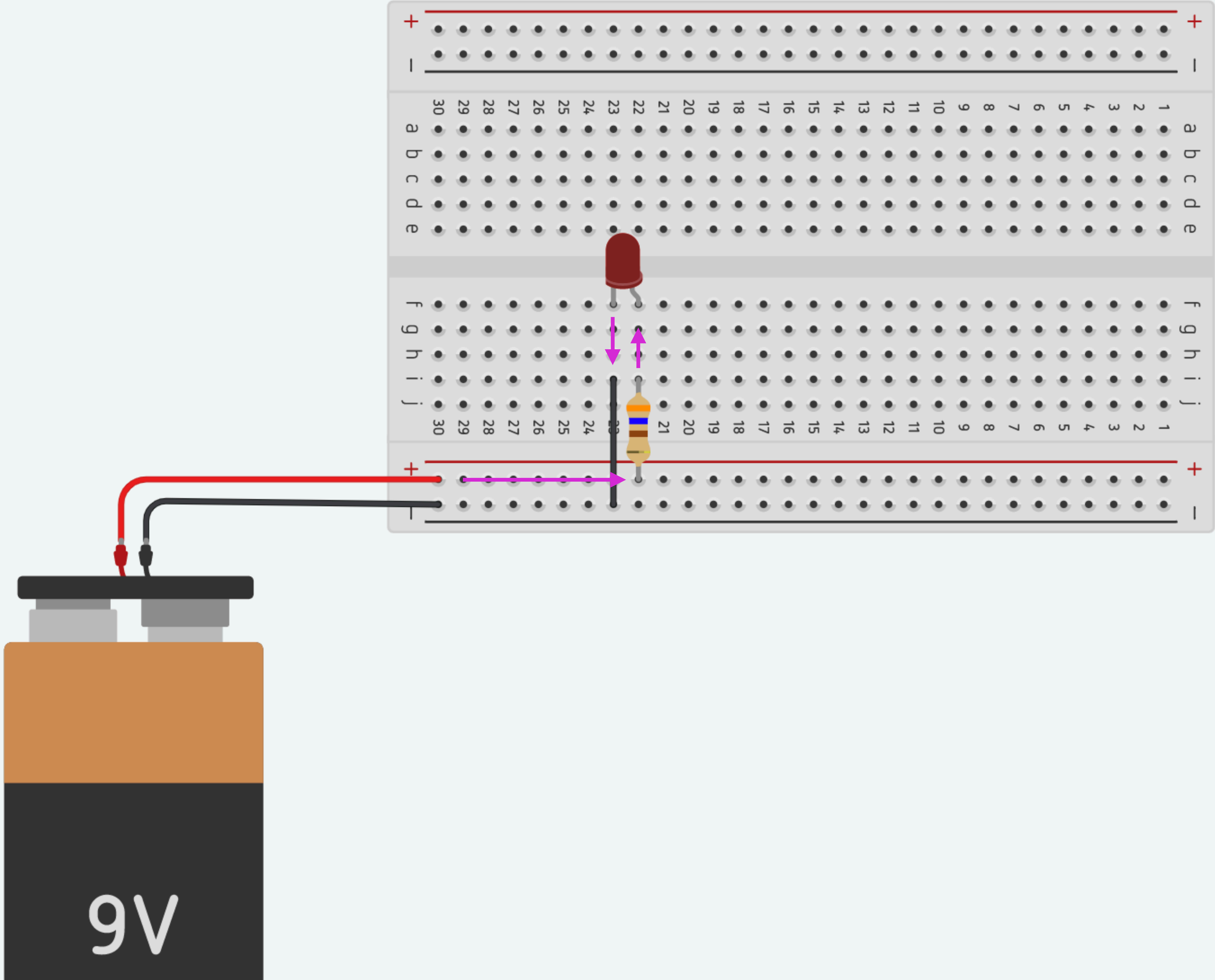
https://ledcalculator.net/

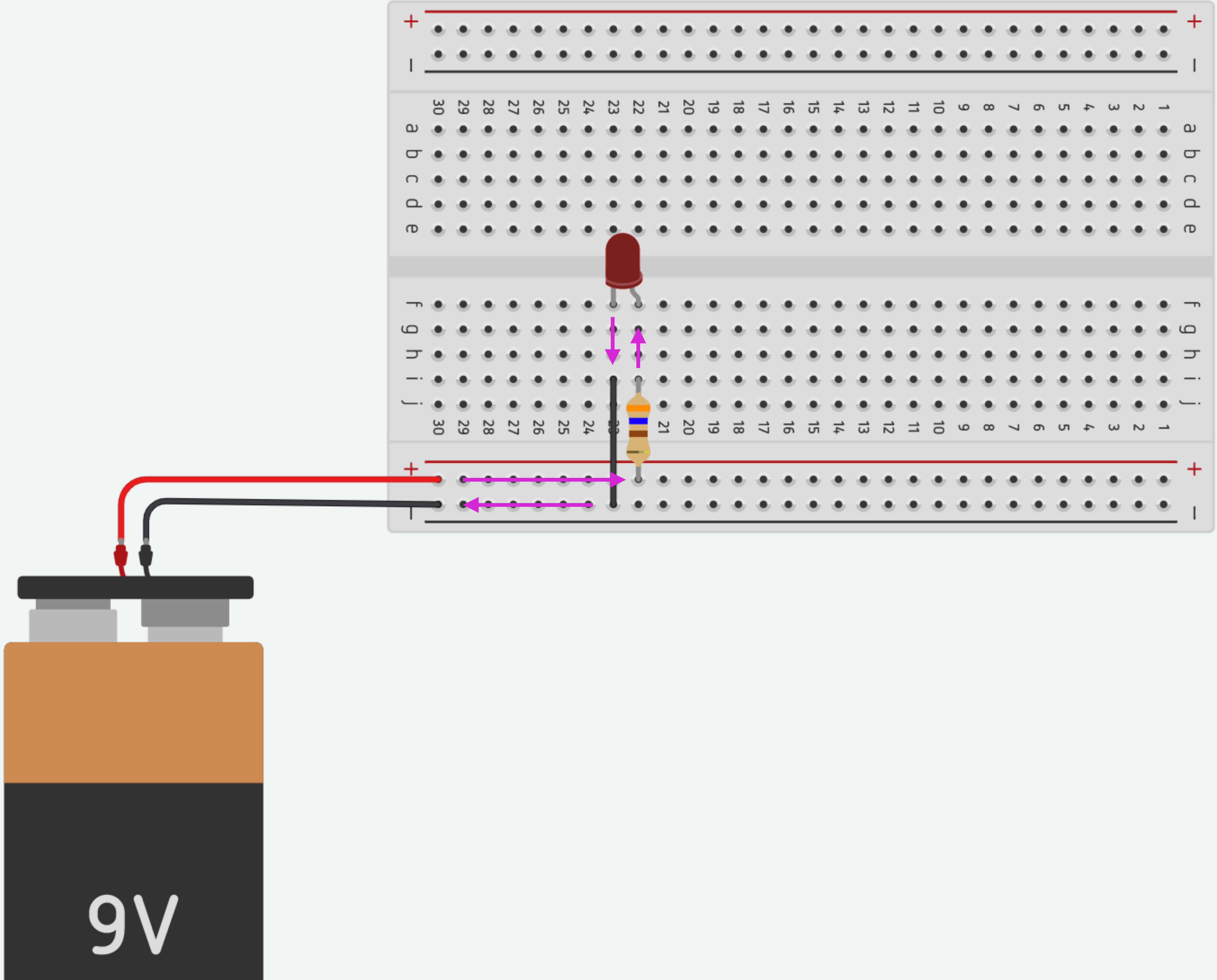

9V



9V

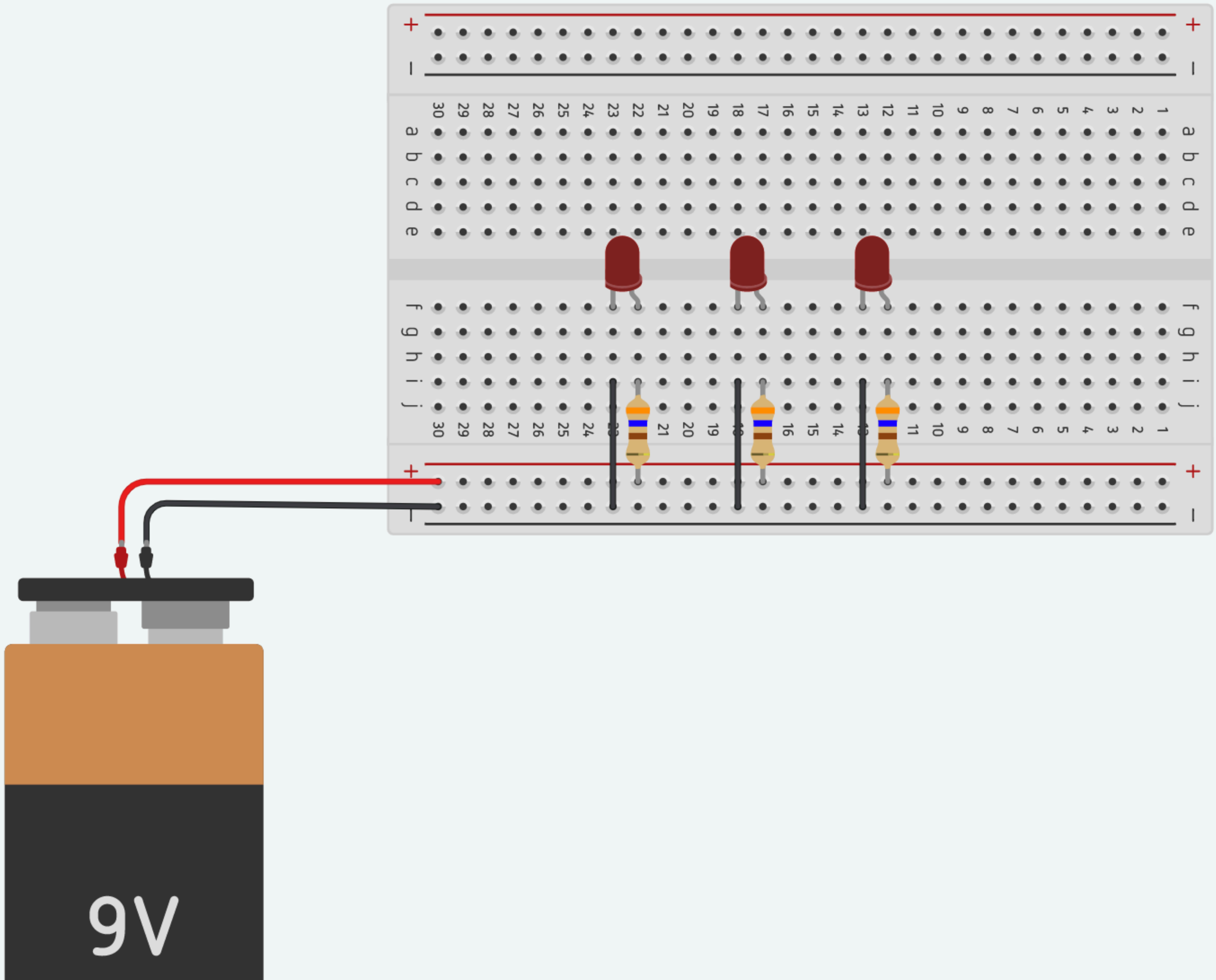

+
–
30 29 28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
a b c d e
f g h i j
9V


9V

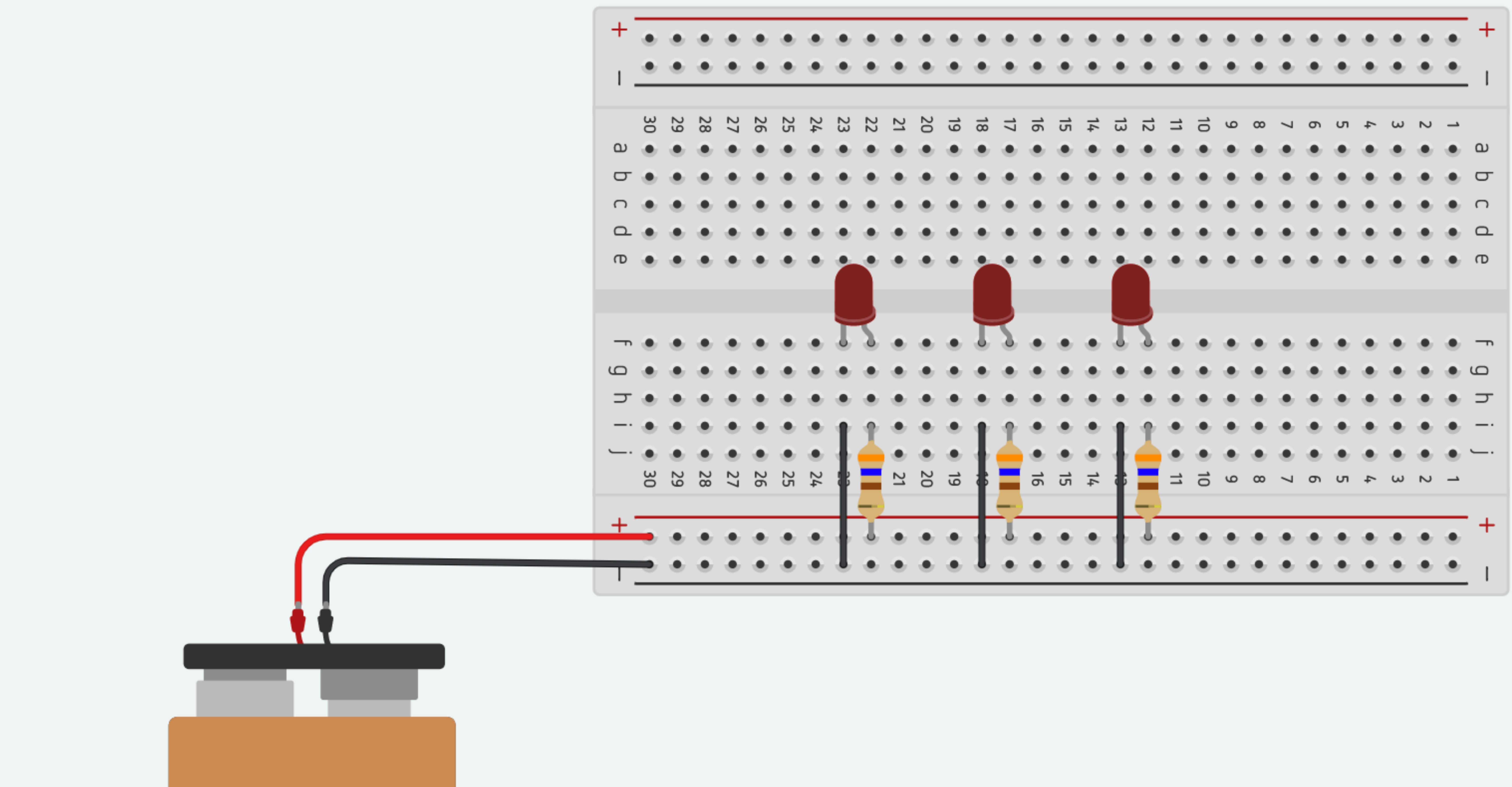


9V

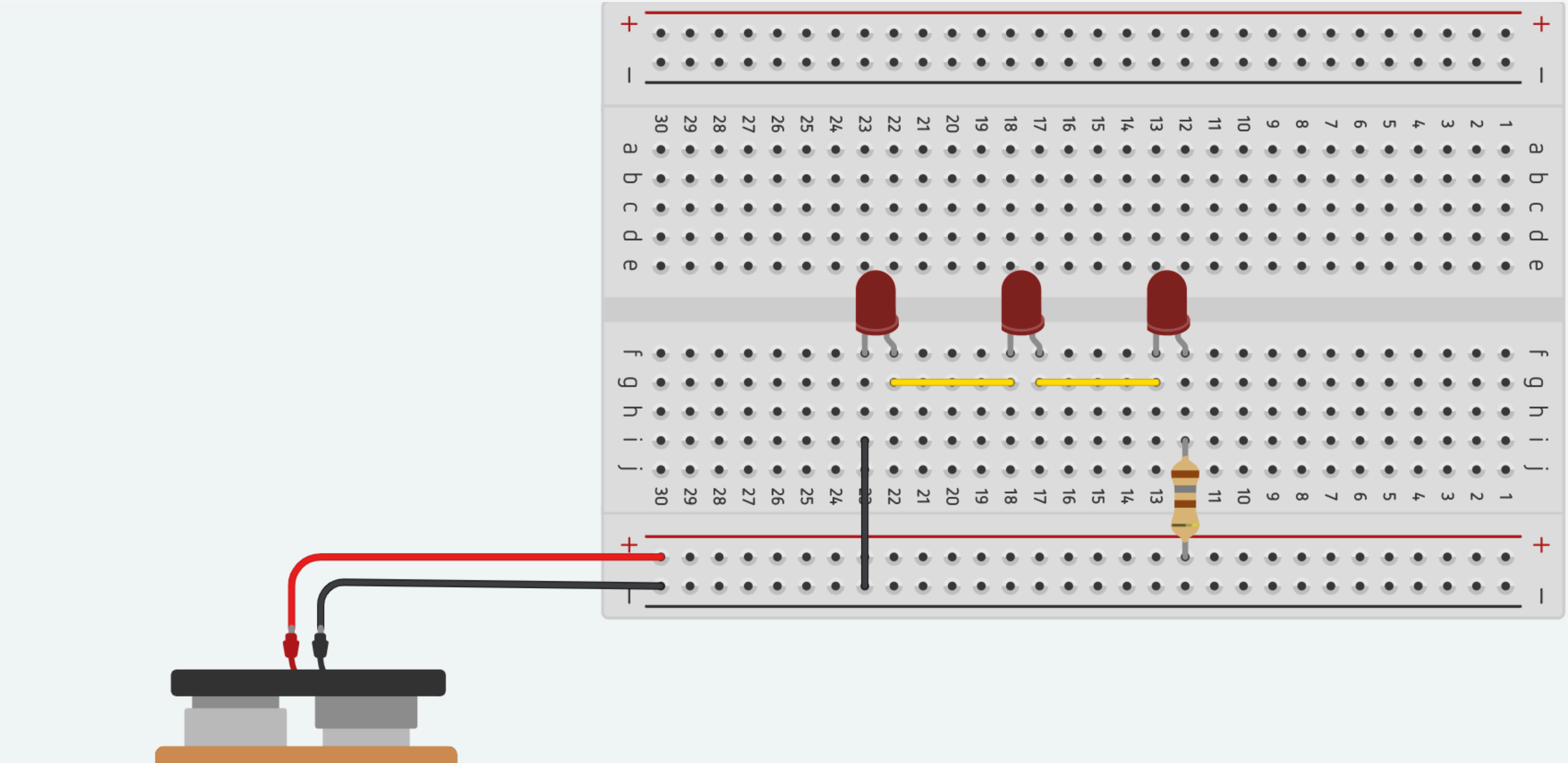
Try adding more LEDs


9V

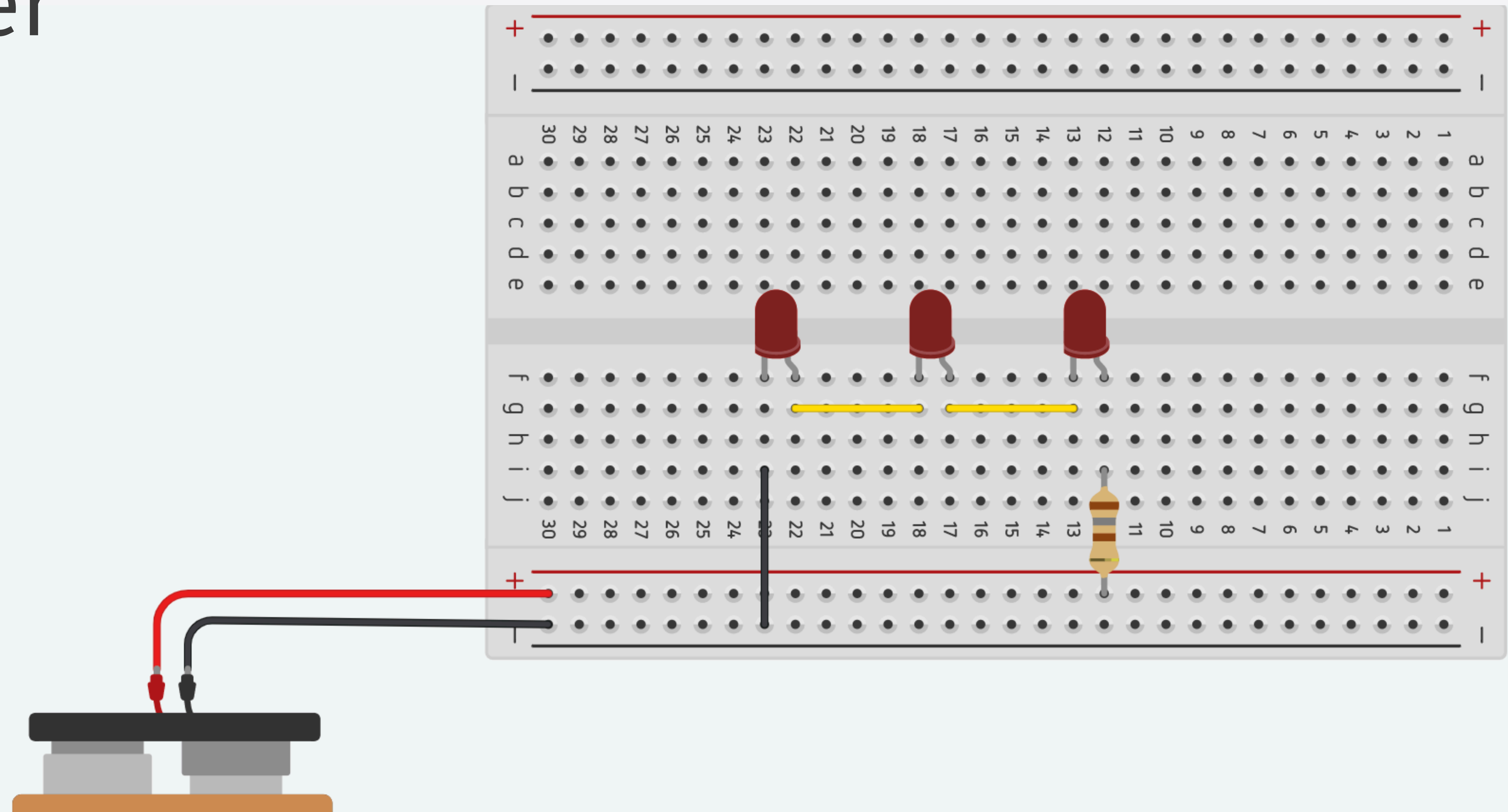
This layout is called parallel because it is as-if there are 3 separate circuits, one for each LED



You can also connect them in series, with each LED connected to the next, and a smaller resistor.

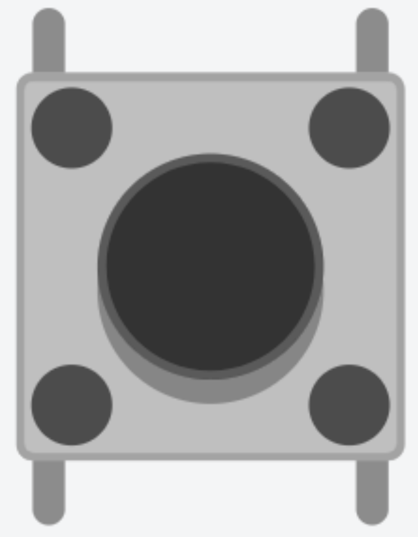


Connecting them in series is more likely to fail because if one component breaks, they all stop working, however it uses less components and the wiring is much simpler



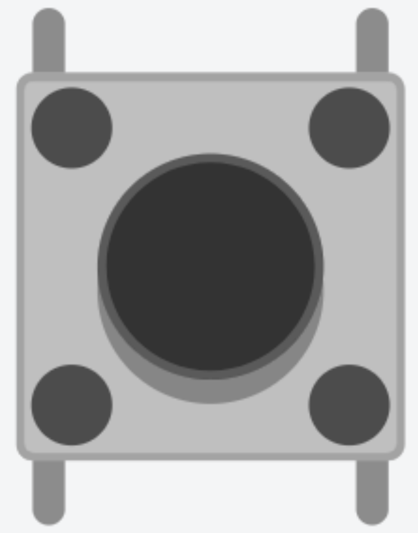
Buttons

Buttons



A button is a simple switch mechanism that completes or breaks a circuit when pushed.

Buttons

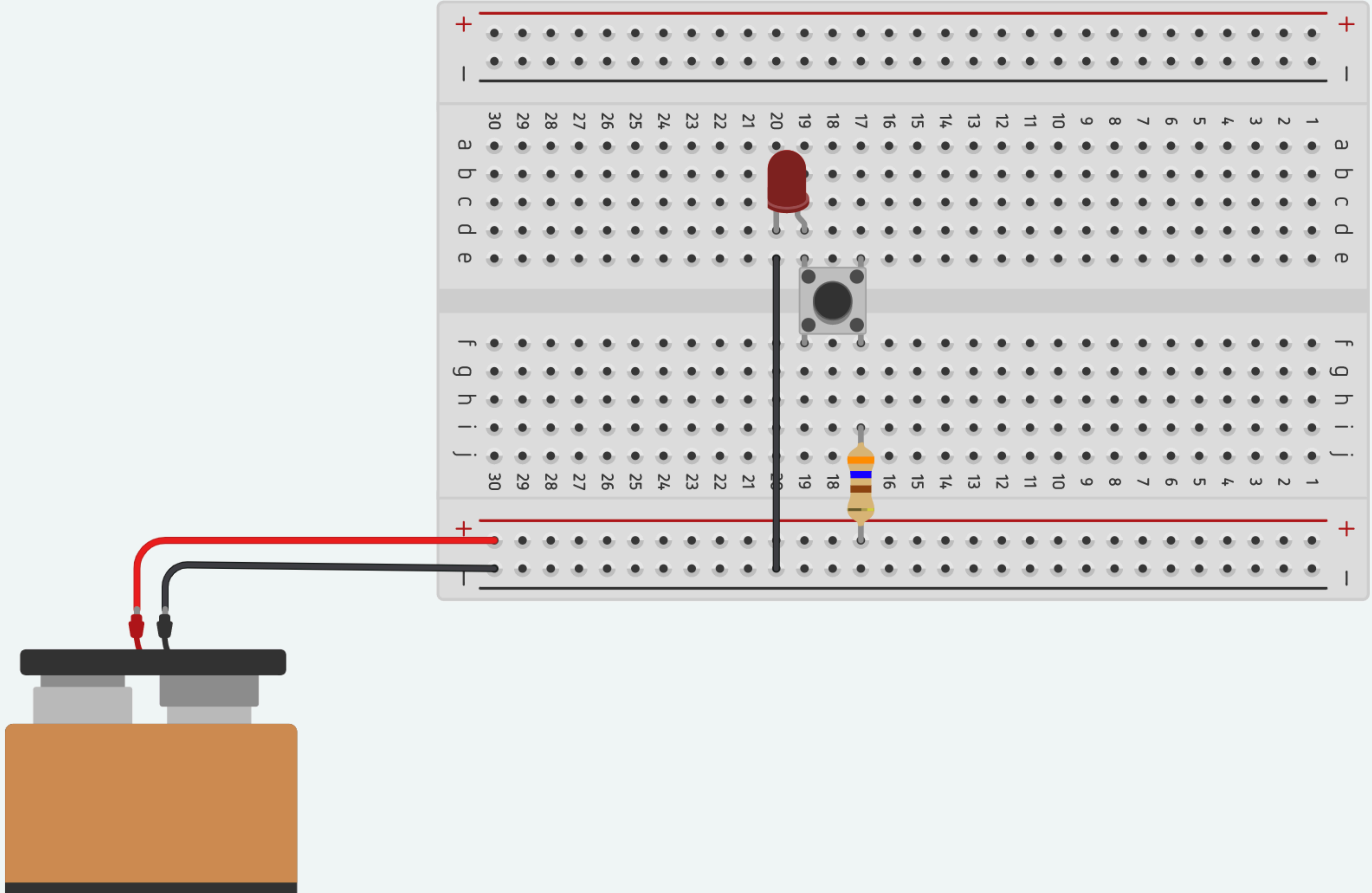


Buttons typically come in two types normally closed (NC) and normally open (NO). NO buttons complete the circuit when pressed, NC buttons break the circuit when pressed.

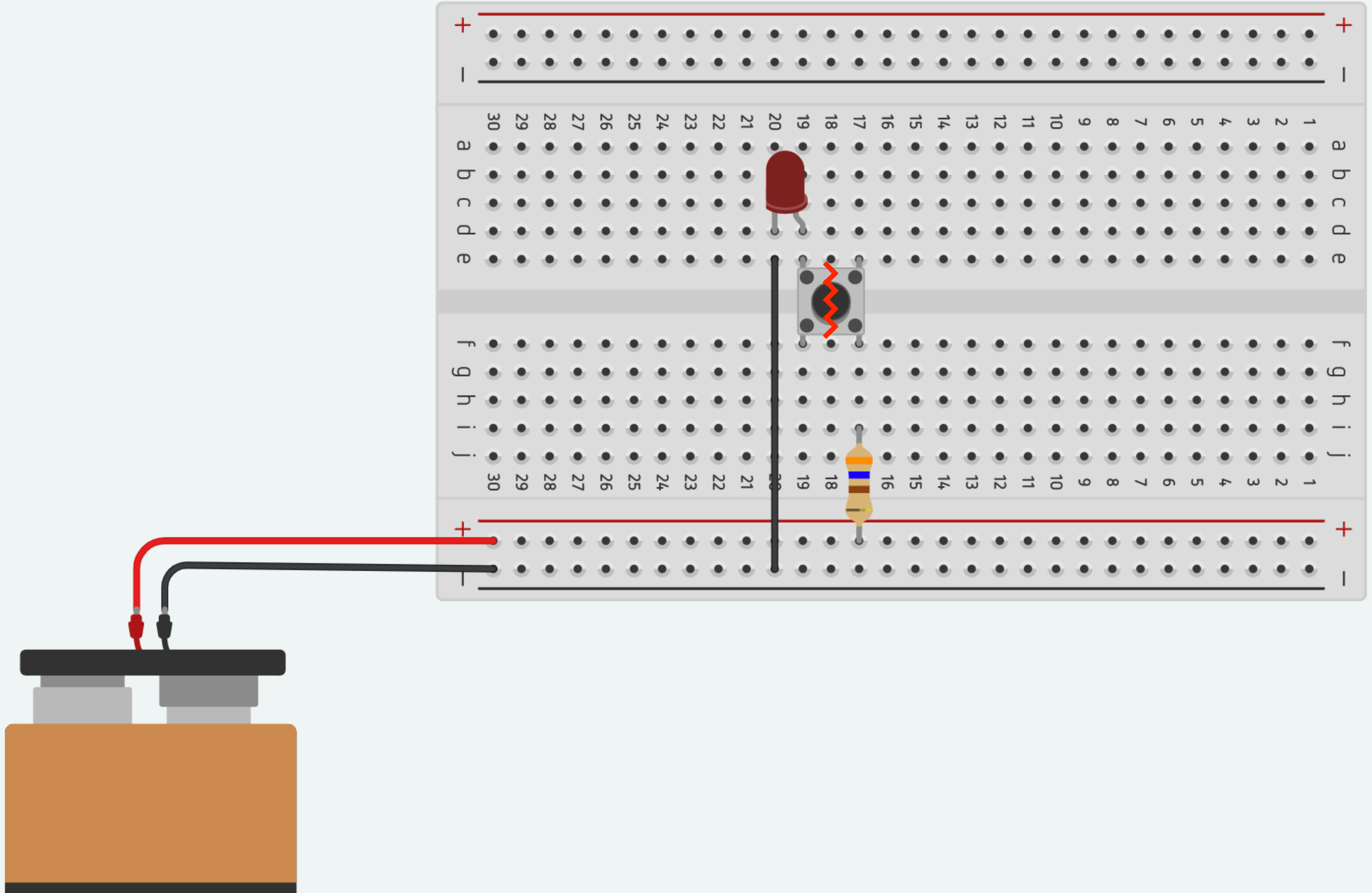
When pressed, a NO button connects the legs from one side to those on the other side. Most of the buttons we will use are NO

Using Buttons (with LEDS)

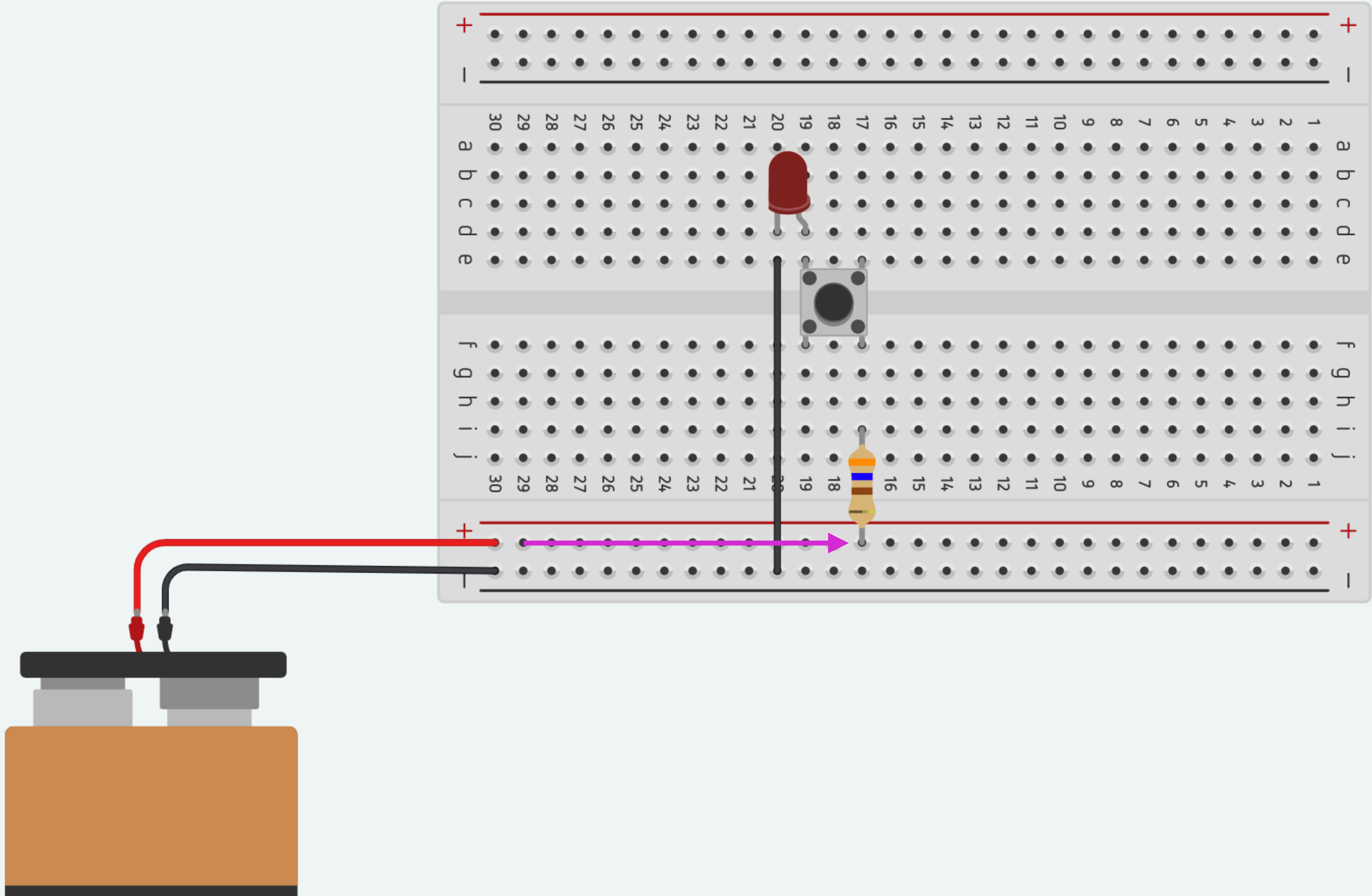
Our first LED circuit with a button. The LED will light when the button is pressed.



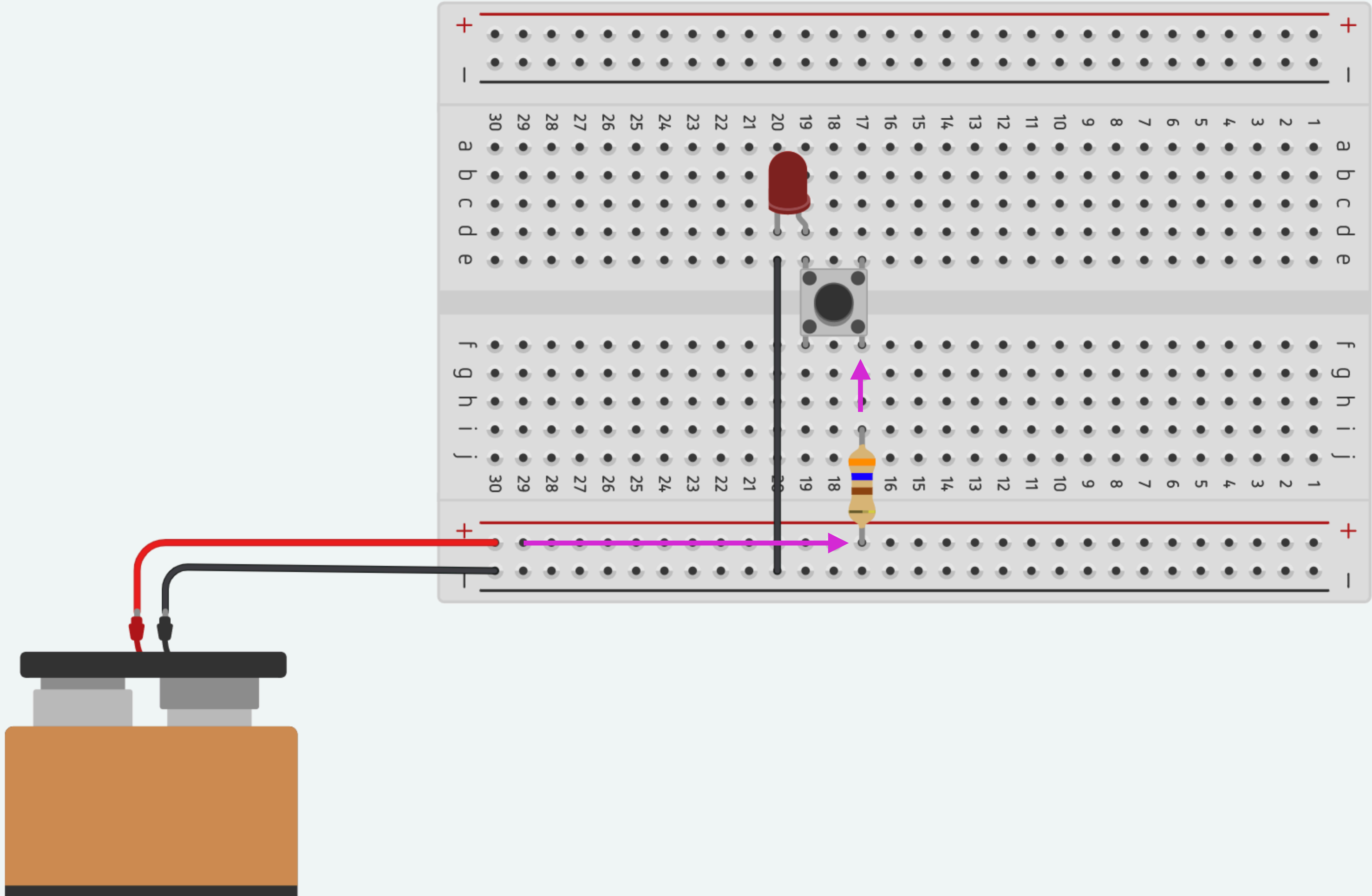
Our first LED circuit with a button. The LED will light when the button is pressed.



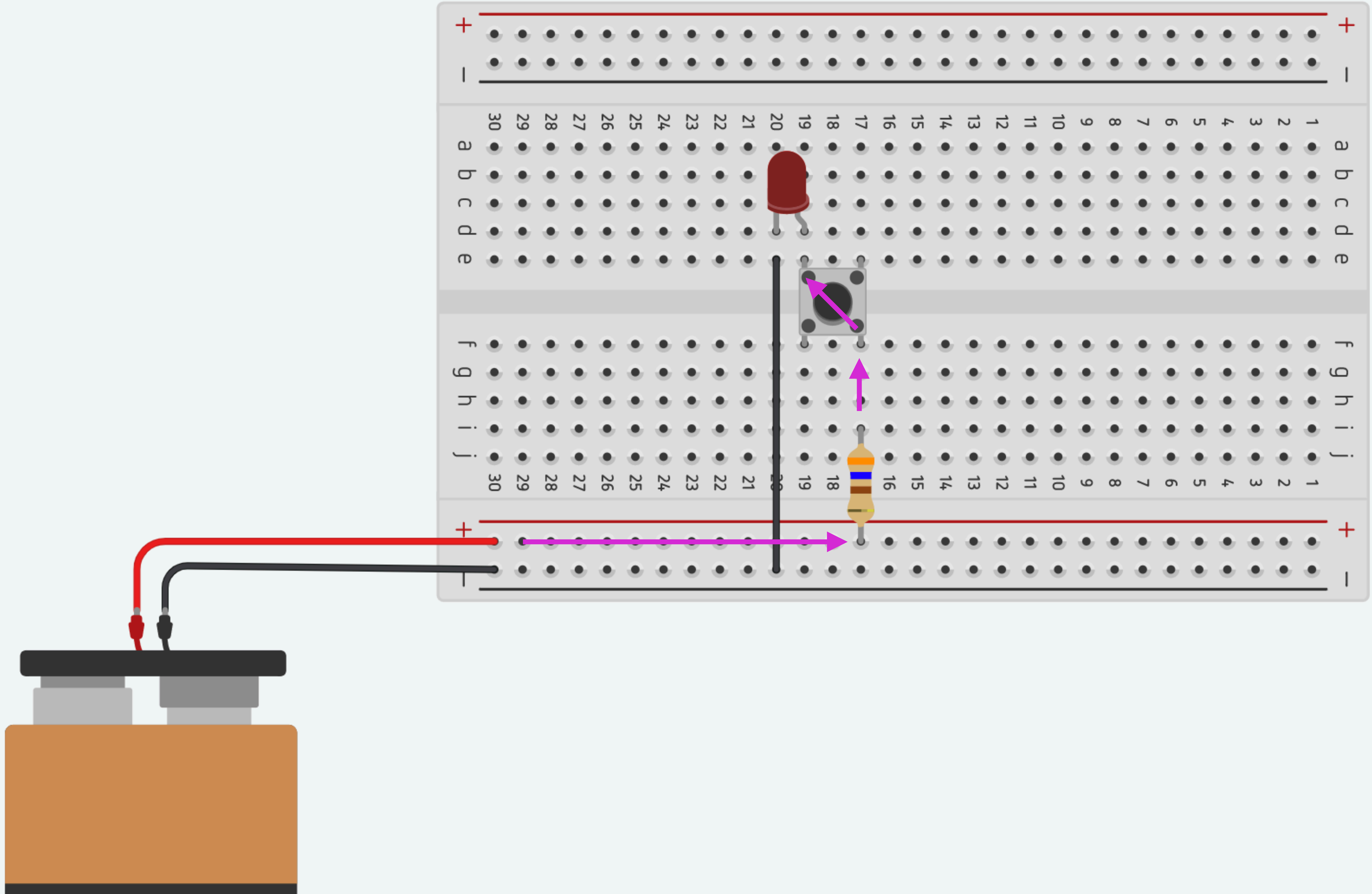
Our first LED circuit with a button. The LED will light when the button is pressed.



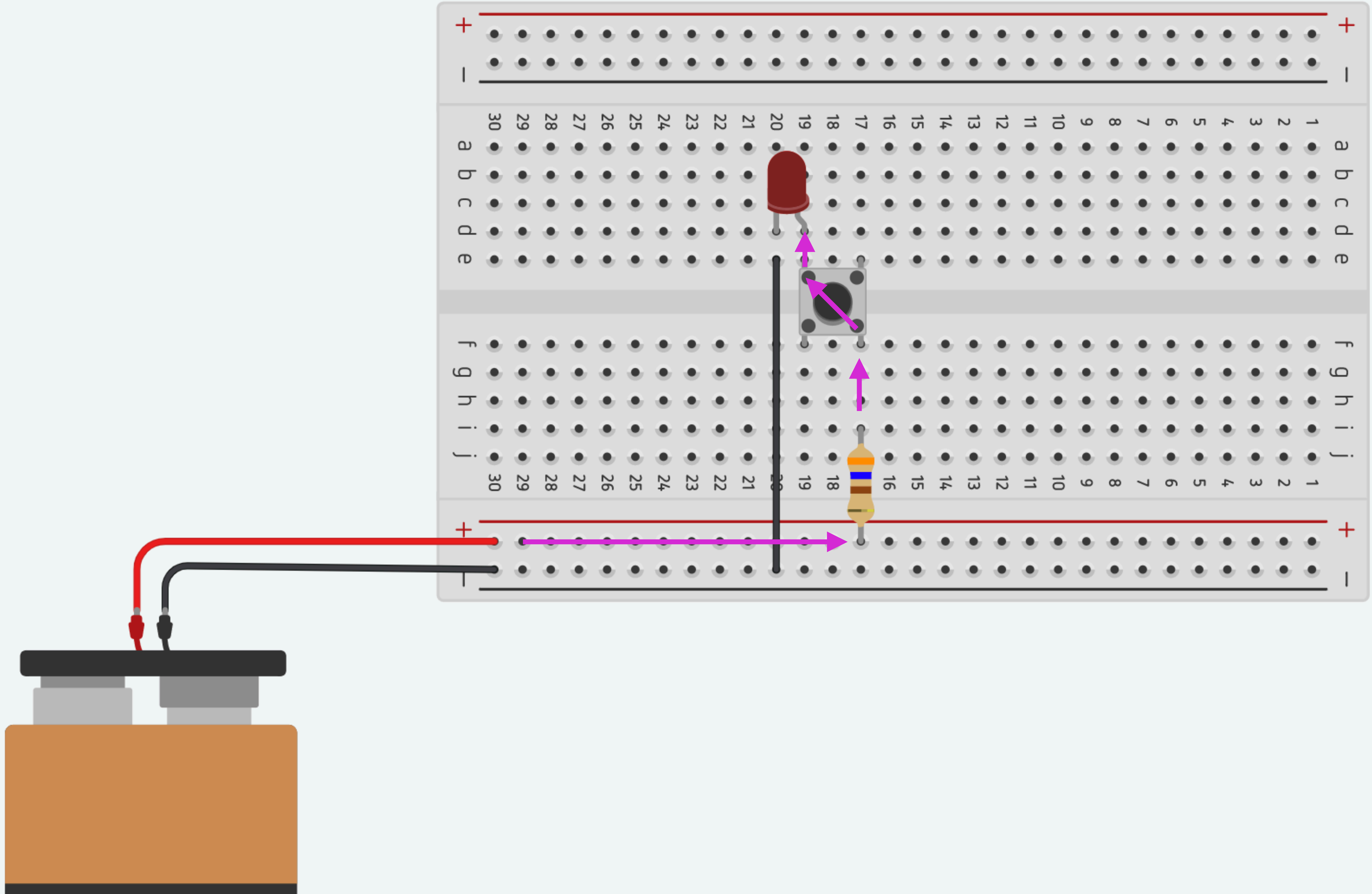
Our first LED circuit with a button. The LED will light when the button is pressed.



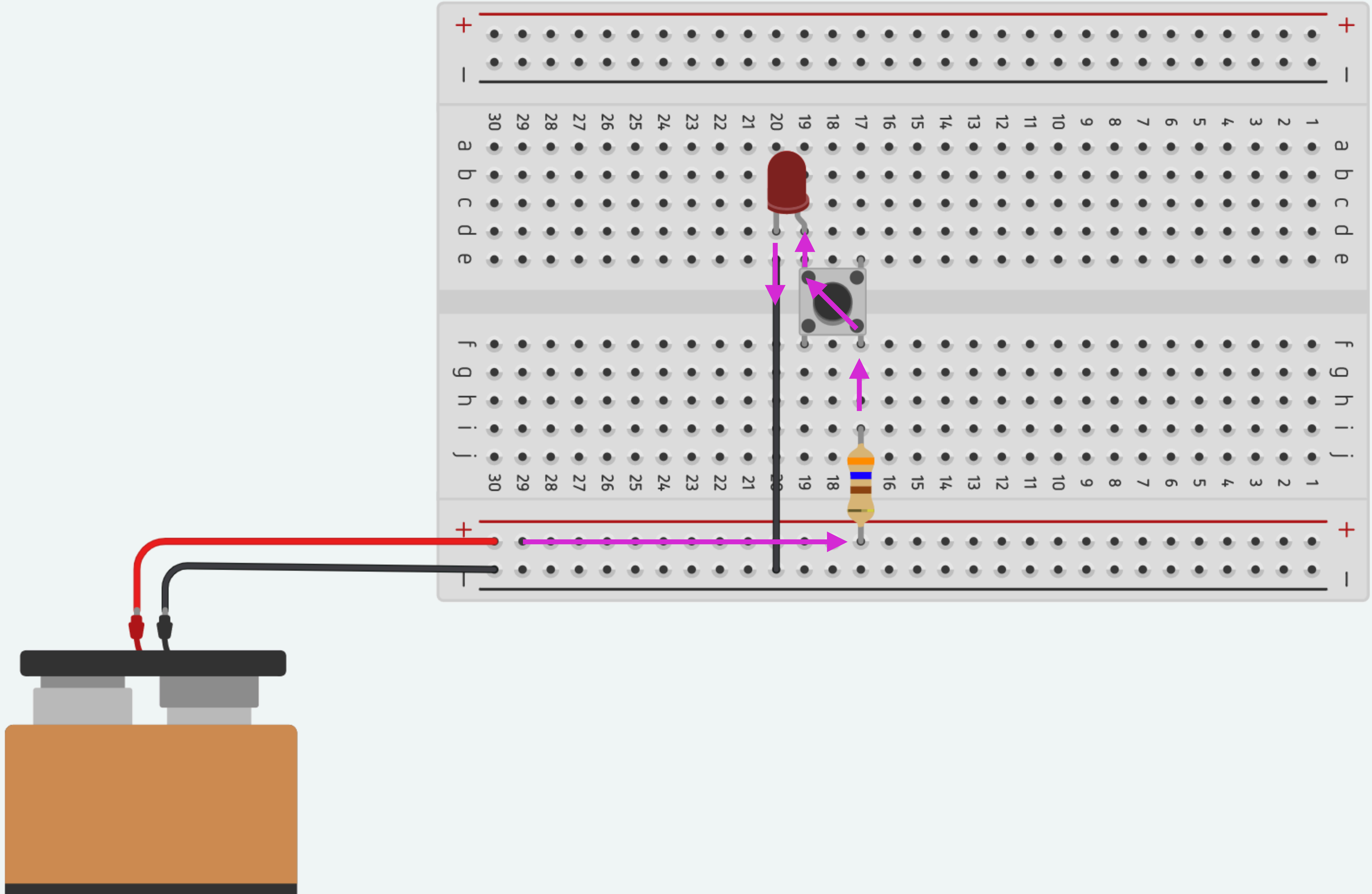
Our first LED circuit with a button. The LED will light when the button is pressed.



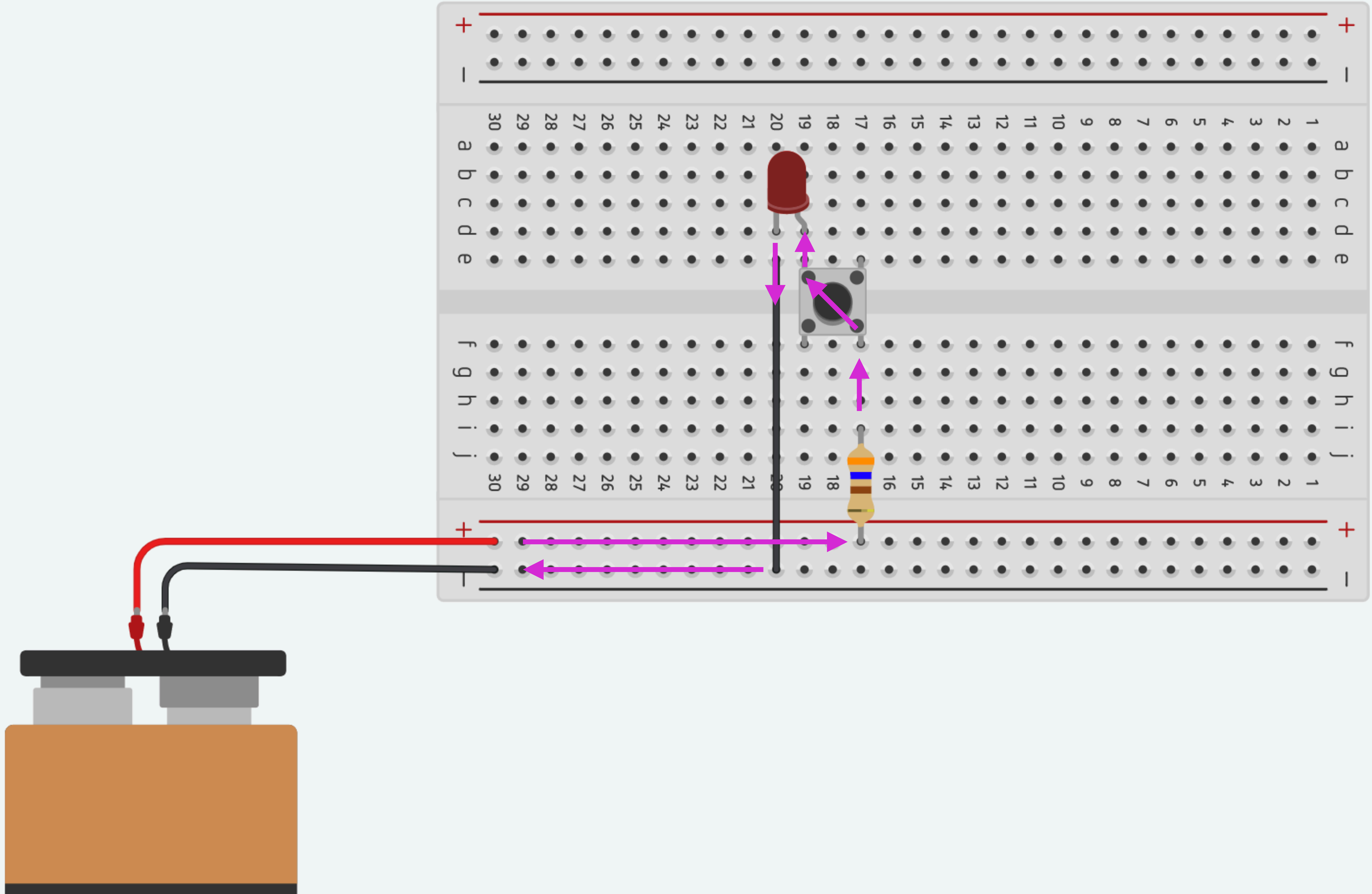
Our first LED circuit with a button. The LED will light when the button is pressed.



Our first LED circuit with a button. The LED will light when the button is pressed.



Our first LED circuit with a button. The LED will light when the button is pressed.



TERMS YOU MAY HAVE HEARD

AC and DC

DC - constant current flow in one direction. Think batteries, computer chargers, etc.

AC - Alternating current moves back-and-forth. This is what comes out of a wall socket.

(We mostly care about DC)

Short Circuit

When the positive and negative wires, instead of being put to work, are connected directly together.

This is bad because the resistance is so low that the current will be very very high which generates heat.

Try duplicating the button circuit to add more buttons and LEDs.

Experiment with controlling multiple LEDs with one button, or using different buttons to control different colors or patterns.