Lesson 2.4
Design Arguments About Devices
Lesson Overview

Students gather evidence for and write their first design arguments. The lesson begins with making a claim about the possible solution the class identified in the previous lesson and a discussion about the importance of evidence in a design argument. Then, using the Energy Conversions Simulation, students create and compare simple electrical systems—one that includes an LED and one that includes an incandescent lightbulb—and they gather evidence about energy-efficient lighting. Students turn to the reference book for additional evidence. Based on all this evidence, students write an argument stating how the solution meets the criteria. This lesson gives students the opportunity to argue for a solution to the blackout problem that they have been investigating, and it introduces students to several key practices of engineering.

Anchor Phenomenon: Ergstown has frequent blackouts.  
Design Problem: Reduce the number of blackouts in Ergstown.

Students learn:

- Engineers argue for one solution over others based on how well it meets criteria.
- Certain devices are made to be energy efficient—they use less electrical energy than other devices to produce the same amount of the output energy that we want.
- An LED is an energy efficient light.
Gathering Evidence in the Sim

Students test energy systems in the Sim to gather evidence that replacing old lights with LEDs will use less energy and help reduce blackouts in Ergstown.

Instructional Guide

1. **Project the Energy Conversions Simulation from the Students Apps Page.**

   We want to find out if replacing old streetlights with new LED streetlights would save energy. But we can’t really replace streetlights in Ergstown to test that out. So, we are going to use the Sim to gather evidence.

   Explain that certain electrical devices are made to be energy efficient—they use less electrical energy than other devices to produce the same amount of the output energy that we want.

   For example, an energy-efficient radio would use less electrical energy to produce the same amount of sound energy as a radio that is not energy efficient.

2. **Point to the LED and the lightbulb in the Sim.** Explain that students will use the Sim to find out which kind of light uses less energy; this will help them understand whether changing streetlights to LED lights in Ergstown might help solve their blackout problem.

3. **Model setting up a system with a lightbulb.** In the Sim, set up a system with fuel as the source, an engine, a generator, and a lightbulb.

   - Ask students what kind of energy they want to get out of a lightbulb. [Light energy.]
   - Call students’ attention to the energy source slider. Move the slider to 100. Remind students that this represents the amount of energy that will be transferred into the system.
   - Ask students what type of energy will be transferred out of this system. [The lightbulb would transfer light energy and thermal energy out of the system.]
   - Press RUN.
4. **Project the notebook.** Have students turn to pages 33–34, Gathering Evidence in the Sim, in their notebooks. Point out the following:

- Students will build and run tests of four different systems. Building these systems will allow students to test two energy systems that include lightbulbs and two that include LEDs.
- The first two systems are the same except that their first test will include a lightbulb and the second test will include an LED. The third and fourth tests are also the same except that one has a lightbulb and the fourth has an LED.
- After running each energy system, students should press ANALYZE to see the data about the energy transferred into and out of the system.
- For each test, students should record energy transferred into and out of the system, and the amount of each form of output energy.
- The goal is to get at least 10 units of light energy transferred out from every system—the systems that have a lightbulb and the systems that have an LED.
- In order to figure out how much input energy is required to make the LED produce about the same amount of light energy as the lightbulb, students will need to try running the system a few different times, each time adjusting the amount of energy being input into the system by moving the energy source slider.

5. **Assign student pairs.** Distribute one digital device per pair. Explain that one student will test the lightbulb, and the other student will test the LED. Point out that both students should record the evidence in their own notebooks.

6. **Have pairs run tests in the Sim.** Circulate and support students as necessary. Remind them to record their results in their notebooks. After a few minutes, tell students to complete their first system test (using the lightbulb) and to prepare to switch Sim “drivers” and to build the new system (using the LED). Give a similar signal for students to complete the remaining tests. Once pairs have completed their tests and recorded their data, have them review their results and respond to the two questions at the bottom of page 34 in the notebook.
7. Collect the devices.

Teacher Support

Background

Science Note: Incandescent and LED Lights
The Energy Conversions Simulation models for students the difference between LED (light emitting diode) lights and incandescent lights. The purpose of the Sim activity is to help students understand that while both types of lights produce light energy as an output, the LED lights use significantly less input energy to function. The bar graphs and numerical representations of output energy in the Simulation show students that incandescent lights produce thermal energy in addition to light energy. As students test putting different amounts of electrical energy into the system with the LED, they will begin to note that the LED uses much less energy to produce approximately the same amount of light.

Instructional Suggestion

Classroom Management: Helping Students Work Effectively with a Partner
In this lesson, students work with a partner, taking turns “driving” the Energy Conversions Simulation. It will be well worth the time to discuss your expectations for partner work with the class beforehand. Guidelines to cover might include procedures for recording ideas, sharing the digital devices, listening to each other, and overall cooperation. Discuss your expectations explicitly and specifically with regard to conversations staying focused on the school work at hand. You might invite a pair of students to model effective partner work in front of the class. Consider assigning partners so that those students who have difficulty focusing or need support with the content have a partner who is stronger in those respects. Note that some students may need more time to complete the activity. If needed, you can let some students know that doing just the first two tests should still provide them with enough information to answer the questions on page 34.

Instructional Suggestion

Going Further: Mathematical Thinking
As students create different energy systems in the Energy Conversions Sim, they can compare the results of their various systems using >, =, and <. For instance, set the Energy Slider to 50 and run a Sun/Solar Panel/Lightbulb system. Compare the “Energy Transferred Out” results to those of a Sun/Solar Panel/LED Lightbulb system—in this case, students will be comparing thermal energy and light energy.

Practice saying the results aloud.

Q: How would you compare the results of Thermal Energy transferred by the two systems?
Example 1: Sun/Solar Panel/Lightbulb > Sun/Solar Panel/LED
43 > 12

Q: How would you compare the results of Light Energy transferred by the two systems?
Example 1: Sun/Solar Panel/Lightbulb > Sun/Solar Panel/LED
7 < 38

Q: What does this say about the use of an LED compared to a lightbulb?
Two other examples, for reference:

Q. How would you compare the results of Sound Energy transferred by two systems?

Example 1: Wind/Flywheel/Generator/Music Player > Crank/Flywheel/Generator/Music Player

\[ 22 > 0 \]

Example 2: Wind/Flywheel/Generator/Music Player > Fuel/Engine/Generator/Music Player

\[ 22 > 16 \]

Possible Responses

**What students should do and notice:** Students build and run tests on four systems—two three-part systems and two four-part systems. The systems in each pair are the same except that one system includes a lightbulb and the other includes an LED. For each energy system, students adjust the amount of energy transferred into the system so that at least 10 units of light energy are transferred out of the system. These tests are designed to help students compare energy input and output to determine which type of light uses less energy. Students should notice that energy systems that use LEDs use much less energy than energy systems that use lightbulb to produce an equivalent amount of light energy.

**Investigation Notebook**

Gathering Evidence in the Sim (page 33–34)

**Test 1**

Energy Transferred In: 80
Light: 11
Thermal: 69
Sound: 0

**Test 2**

Energy Transferred In: 20
Light: 15
Thermal: 5
Sound: 0

**Test 3**
Energy Transferred In: 80
Light: 11
Thermal: 69
Sound: 0

Test 4

Energy Transferred In: 20
Light: 14
Thermal: 6
Sound: 0

What happened when you switched from lightbulbs to LEDs?
More light energy was transferred out, and less energy was transferred out as thermal energy.

Will Ergstown use less energy by replacing streetlight lightbulbs with LEDs?
Yes, if Ergstown switches to LEDs instead of lightbulbs, they will be able to produce enough light energy but use less energy.
More Evidence from the Reference Book

Students gather evidence from the *It’s All Energy* reference book to support their proposed solution of replacing the lights in Ergstown.

### Instructional Guide

1. **Prepare students to gather more evidence.**

   We’ve just used the Sim to gather evidence to see if there is support for the claim that Ergstown should replace older streetlights with LED streetlights.

   Reference books are also a great place to go to find specific information. Let’s look at *It’s All Energy* to see where in the book we might look for evidence that supports that claim.

2. **Assign student pairs.** Distribute one copy of *It’s All Energy* to each pair.

3. **Have students turn to page 3, Contents.** Review the sections that the students have read so far. Ask students which sections could supply evidence that supports the claim that replacing streetlights would help save energy.

   If I want to find evidence to support the claim *Ergstown should replace older streetlights with LED streetlights*, where should I look for evidence?

   [Page 15, Electric Lamps; page 12, Light Energy.]

4. **Have students turn to page 35, Gathering Evidence from *It’s All Energy*, in the notebook.** Explain the directions and check that students understand their goal.

5. **Pairs look for and record evidence.** Circulate to provide support as students look through the reference book to identify evidence and record it on page 35 of the notebook.
6. **Project and discuss LED Program Report.** Let students know that a town near Ergstown had a program to replace the old lightbulbs with LEDs in residents’ households. Read or have a student read the report. Then ask students to discuss how this affects their thinking about replacing Ergstown’s older streetlights with LED streetlights.

**LED Program Report**

People were given LED lights to replace the old lightbulbs in their houses. They reported that

- the LED lights were easy to install.
- people liked that their lamps still worked the same way, so they didn’t have to do anything differently.
- people liked the brightness of the LED lights.

**Teacher Support**

**Background**

**Literacy Note: Evidence**

In this lesson, students are introduced to what may prove to be a challenging task: connecting their evidence to criteria. In order to allow students to focus on the connections between evidence and criteria, and to think about how their solutions meet the criteria, the process of evidence-gathering has been greatly simplified. Students will find that there is not much evidence from the reference book and no evidence from the Sim to support the claim *People should stop using some electrical devices.* For a truly authentic evidence-gathering experience, students would be given the opportunity to explore numerous sources to look for information that might support their claim. However, that is not the goal of this particular lesson; instead, the goal is to give students practice providing evidence to support a claim and evaluating how well their claim meets certain criteria.

**Background**

**Literacy Note: Finding Evidence in Informational Texts**

Learning effective strategies and approaches for comprehension of informational text is extremely important for success in school, yet reading these texts can be challenging for many students. In this lesson, students may need support to find additional evidence in the reference book. They may think that they need to read through the whole book or through whole sections. Some readers may struggle with understanding where to look. Explain that students should look for evidence that supports the possible claim they chose. Students wanting to find supporting evidence for replacing lights with LEDs should refer to sections of the book related to light energy and lamps (there’s a section titled “Light Energy” and also more information about lamps in the “Energy Converters” section). For students who are looking to support reduced device usage, direct them to find sections in the book that more broadly discuss where the energy to power these devices comes from. Remind students that in addition to the table of contents, they can use the index to look up topics. (For example, they will find an entry in the index for “Lamps, electric.”)
Instructional Suggestion

Promoting Deeper Thinking: Building a Stronger Argument

One way to help students understand the importance of multiple sources of evidence is to use an analogy. One possible analogy is the relationship between a strong foundation and the stability of what gets built upon it. To illustrate this you could use blocks or some other physical material to show that when you try to balance a larger block on a smaller block, it is not fully supported and can be easily knocked down. Then, build a strong foundation by using several smaller blocks for the base. Place the large block upon these to demonstrate your point. Return to the idea that the smaller blocks represent sources of evidence and the large block represents a claim. By building a strong foundation (using several smaller blocks), the larger block can be firmly supported. Likewise, a claim is stronger when it is supported by several pieces of evidence.

Possible Responses

Investigation Notebook
Gathering Evidence from It’s All Energy (page 35)

- page 15
  LED lights are more efficient
  convert most of the electrical energy they use into light energy

  lightbulb converts some electrical energy to light energy but a lot to thermal energy
Gathering Evidence in the Sim

1. In the Energy Conversions Sim, set up each energy system shown below.
2. After you build each system, change the amount of energy transferred in so that at least 10 units of light energy are transferred out of the system.
3. For each system, record the amount of energy transferred in and the amount of light, thermal, and sound energy transferred out.
4. Use what you learn to answer the questions at the bottom of page 34.

**Test 1:**

Energy transferred in: _______________________

Energy transferred out:
   Light: ___________   Thermal: ___________   Sound: ___________

**Test 2:**

Energy transferred in: _______________________

Energy transferred out:
   Light: ___________   Thermal: ___________   Sound: ___________
Gathering Evidence in the Sim (continued)

Test 3:

Energy transferred in: _______________________
Energy transferred out:
  Light: _____________  Thermal: _____________  Sound: _____________

Test 4:

Energy transferred in: _______________________
Energy transferred out:
  Light: _____________  Thermal: _____________  Sound: _____________

What happened when you switched from lightbulbs to LEDs?
___________________________________________________________________

Will Ergstown use less energy by replacing streetlight lightbulbs with LEDs?
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
Gathering Evidence from *It's All Energy*

1. Think about the claim you want to support.
2. Look through *It’s All Energy* for evidence that will support that claim.
3. Record the evidence you find, along with each page where you found it.
Gathering Evidence in the Sim

Students test energy systems in the Sim to gather evidence that replacing old lights with LEDs will use less energy and help reduce blackouts in Ergstown.

Instructional Guide

1. Project the Energy Conversions Simulation from the Students Apps Page.

   Queremos averiguar si reemplazar los alumbrados antiguos con alumbrados LED nuevos ahorraría energía. Pero no podemos reemplazar de verdad los alumbrados en Ergstown para testear eso. Así que vamos a usar la Simulación para reunir evidencia.

   Explain that certain electrical devices are made to be energy efficient—they use less electrical energy than other devices to produce the same amount of the output energy that we want.

   Por ejemplo, un radio energéticamente eficiente usaría menos energía eléctrica para producir la misma cantidad de energía sonora que un radio que no es energéticamente eficiente.

2. Point to the LED and the lightbulb in the Sim. Explain that students will use the Sim to find out which kind of light uses less energy; this will help them understand whether changing streetlights to LED lights in Ergstown might help solve their blackout problem.

3. Model setting up a system with a lightbulb. In the Sim, set up a system with fuel as the source, an engine, a generator, and a lightbulb.

   - Ask students what kind of energy they want to get out of a lightbulb. [Light energy.]
   - Call students’ attention to the energy source slider. Move the slider to 100. Remind students that this represents the amount of energy that will be transferred into the system.
   - Ask students what type of energy will be transferred out of this system. [The lightbulb would transfer light energy and thermal energy out of the system.]
   - Press RUN.
4. **Project the notebook.** Have students turn to pages 33–34, Gathering Evidence in the Sim, in their notebooks. Point out the following:

- Students will build and run tests of four different systems. Building these systems will allow students to test two energy systems that include lightbulbs and two that include LEDs.

- The first two systems are the same except that their first test will include a lightbulb and the second test will include an LED. The third and fourth tests are also the same except that one has a lightbulb and the fourth has an LED.

- After running each energy system, students should press ANALYZE to see the data about the energy transferred into and out of the system.

- For each test, students should record energy transferred into and out of the system, and the amount of each form of output energy.

- The goal is to get at least 10 units of light energy transferred out from every system—the systems that have a lightbulb and the systems that have an LED.

- In order to figure out how much input energy is required to make the LED produce about the same amount of light energy as the lightbulb, students will need to try running the system a few different times, each time adjusting the amount of energy being input into the system by moving the energy source slider.

5. **Assign student pairs.** Distribute one digital device per pair. Explain that one student will test the lightbulb, and the other student will test the LED. Point out that both students should record the evidence in their own notebooks.

6. **Have pairs run tests in the Sim.** Circulate and support students as necessary. Remind them to record their results in their notebooks. After a few minutes, tell students to complete their first system test (using the lightbulb) and to prepare to switch Sim “drivers” and to build the new system (using the LED). Give a similar signal for students to complete the remaining tests. Once pairs have completed their tests and recorded their data, have them review their results and respond to the two questions at the bottom of page 34 in the notebook.
7. Collect the devices.

Teacher Support

Background

Science Note: Incandescent and LED Lights

The Energy Conversions Simulation models for students the difference between LED (light emitting diode) lights and incandescent lights. The purpose of the Sim activity is to help students understand that while both types of lights produce light energy as an output, the LED lights use significantly less input energy to function. The bar graphs and numerical representations of output energy in the Simulation show students that incandescent lights produce thermal energy in addition to light energy. As students test putting different amounts of electrical energy into the system with the LED, they will begin to note that the LED uses much less energy to produce approximately the same amount of light.

Instructional Suggestion

Classroom Management: Helping Students Work Effectively with a Partner

In this lesson, students work with a partner, taking turns “driving” the Energy Conversions Simulation. It will be well worth the time to discuss your expectations for partner work with the class beforehand. Guidelines to cover might include procedures for recording ideas, sharing the digital devices, listening to each other, and overall cooperation. Discuss your expectations explicitly and specifically with regard to conversations staying focused on the school work at hand. You might invite a pair of students to model effective partner work in front of the class. Consider assigning partners so that those students who have difficulty focusing or need support with the content have a partner who is stronger in those respects. Note that some students may need more time to complete the activity. If needed, you can let some students know that doing just the first two tests should still provide them with enough information to answer the questions on page 34.

Instructional Suggestion

Going Further: Mathematical Thinking

As students create different energy systems in the Energy Conversions Sim, they can compare the results of their various systems using >, =, and <. For instance, set the Energy Slider to 50 and run a Sun/Solar Panel/Lightbulb system. Compare the “Energy Transferred Out” results to those of a Sun/Solar Panel/LED Lightbulb system—in this case, students will be comparing thermal energy and light energy.

Practice saying the results aloud.

Q: How would you compare the results of Thermal Energy transferred by the two systems?
Example 1: Sun/Solar Panel/Lightbulb > Sun/Solar Panel/LED
43 > 12

Q: How would you compare the results of Light Energy transferred by the two systems?
Example 1: Sun/Solar Panel/Lightbulb > Sun/Solar Panel/LED
7 < 38

Q: What does this say about the use of an LED compared to a lightbulb?
Two other examples, for reference:

Q. How would you compare the results of Sound Energy transferred by two systems?
Example 1: Wind/Flywheel/Generator/Music Player > Crank/Flywheel/Generator/Music Player

\[22 > 0\]

Example 2: Wind/Flywheel/Generator/Music Player > Fuel/Engine/Generator/Music Player

\[22 > 16\]

**Possible Responses**

*What students should do and notice:* Students build and run tests on four systems—two three-part systems and two four-part systems. The systems in each pair are the same except that one system includes a lightbulb and the other includes an LED. For each energy system, students adjust the amount of energy transferred into the system so that at least 10 units of light energy are transferred out of the system. These tests are designed to help students compare energy input and output to determine which type of light uses less energy. Students should notice that energy systems that use LEDs use much less energy than energy systems that use lightbulb to produce an equivalent amount of light energy.

**Investigation Notebook**
**Gathering Evidence in the Sim** (page 33–34)

**Test 1**

Energy Transferred In: 80
Light: 11
Thermal: 69
Sound: 0

**Test 2**

Energy Transferred In: 20
Light: 15
Thermal: 5
Sound: 0

**Test 3**
Energy Transferred In: 80
Light: 11
Thermal: 69
Sound: 0

Test 4

Energy Transferred In: 20
Light: 14
Thermal: 6
Sound: 0

What happened when you switched from lightbulbs to LEDs?
More light energy was transferred out, and less energy was transferred out as thermal energy.

Will Ergstown use less energy by replacing streetlight lightbulbs with LEDs?
Yes, if Ergstown switches to LEDs instead of lightbulbs, they will be able to produce enough light energy but use less energy.
More Evidence from the Reference Book

Students gather evidence from the *It’s All Energy* reference book to support their proposed solution of replacing the lights in Ergstown.

Instructional Guide

1. **Prepare students to gather more evidence.**

   Acabamos de usar la Simulación para reunir evidencia para ver si hay respaldo para la afirmación de que Ergstown debería reemplazar los alumbrados más antiguos con alumbrados LED.

   Los libros de referencia también son un lugar excelente para encontrar información específica. Echemos un vistazo a *Todo es energía* para ver en qué parte del libro podríamos buscar evidencia que respalde esa afirmación.

2. **Assign student pairs.** Distribute one copy of *It’s All Energy* to each pair.

3. **Have students turn to page 3, Contents.** Review the sections that the students have read so far. Ask students which sections could supply evidence that supports the claim that replacing streetlights would help save energy.

   Si quiero encontrar evidencia para respaldar la afirmación *Ergstown debería reemplazar los alumbrados más antiguos con alumbrados LED*, ¿en dónde debería buscar evidencia?

4. **Have students turn to page 35, Gathering Evidence from *It’s All Energy*, in the notebook.** Explain the directions and check that students understand their goal.

5. **Pairs look for and record evidence.** Circulate to provide support as students look through the reference book to identify evidence and record it on page 35 of the notebook.
6. Project and discuss LED Program Report. Let students know that a town near Ergstown had a program to replace the old lightbulbs with LEDs in residents’ households. Read or have a student read the report. Then ask students to discuss how this affects their thinking about replacing Ergstown’s older streetlights with LED streetlights.

Informe del programa LED

La gente recibió luces LED para reemplazar las bombillas viejas en sus casas. La gente reportó que:

- las luces LED eran fáciles de instalar.
- a la gente le gustó que sus lámparas aún funcionaban de la misma manera, así que no tuvieron que hacer nada en forma diferente.
- a la gente le gustó la brillantez de las luces LED.

Teacher Support

Background

Literacy Note: Evidence

In this lesson, students are introduced to what may prove to be a challenging task: connecting their evidence to criteria. In order to allow students to focus on the connections between evidence and criteria, and to think about how their solutions meet the criteria, the process of evidence-gathering has been greatly simplified. Students will find that there is not much evidence from the reference book and no evidence from the Sim to support the claim *People should stop using some electrical devices.* For a truly authentic evidence-gathering experience, students would be given the opportunity to explore numerous sources to look for information that might support their claim. However, that is not the goal of this particular lesson: instead, the goal is to give students practice providing evidence to support a claim and evaluating how well their claim meets certain criteria.

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Instructional Suggestion

Promoting Deeper Thinking: Building a Stronger Argument
One way to help students understand the importance of multiple sources of evidence is to use an analogy. One possible analogy is the relationship between a strong foundation and the stability of what gets built upon it. To illustrate this you could use blocks or some other physical material to show that when you try to balance a larger block on a smaller block, it is not fully supported and can be easily knocked down. Then, build a strong foundation by using several smaller blocks for the base. Place the large block upon these to demonstrate your point. Return to the idea that the smaller blocks represent sources of evidence and the large block represents a claim. By building a strong foundation (using several smaller blocks), the larger block can be firmly supported. Likewise, a claim is stronger when it is supported by several pieces of evidence.

Possible Responses

Investigation Notebook
Gathering Evidence from *It's All Energy* (page 35)

page 15
LED lights are more efficient
convert most of the electrical energy they use into light energy

lightbulb converts some electrical energy to light energy but a lot to thermal energy
Nombre: ______________________________________  Fecha: _______________

Reunir evidencia en la simulación

1. En la simulación Conversiones de energía, construye cada uno de los sistemas de energía que se muestran a continuación.

2. Una vez que construyas cada sistema, cambia la cantidad de energía que se transfiere hacia dentro, de modo que por lo menos 10 unidades de energía de la luz se transfieran hacia fuera del sistema.

3. Para cada sistema, apunta la cantidad de energía transferida hacia dentro y la cantidad de energía de la luz, energía térmica y energía sonora transferida hacia fuera.

4. Usa lo que aprendas para responder las preguntas en la parte inferior de la página 34.

Prueba 1:

Energía transferida hacia dentro: __________________________
Energía transferida hacia fuera:
Energía de la luz: _______  Energía térmica: _______  Energía sonora: _______

Prueba 2:

Energía transferida hacia dentro: __________________________
Energía transferida hacia fuera:
Energía de la luz: _______  Energía térmica: _______  Energía sonora: _______
Reunir evidencia en la simulación (continuación)

Prueba 3:

Energía transferida hacia dentro: __________________________
Energía transferida hacia fuera:
Energía de la luz: _______ Energía térmica: _______ Energía sonora: _______

Prueba 4:

Energía transferida hacia dentro: __________________________
Energía transferida hacia fuera:
Energía de la luz: _______ Energía térmica: _______ Energía sonora: _______

¿Qué sucedió cuando cambiaste de bombillas a luces LED?
___________________________________________________________________

¿Consumirá menos energía Ergstown al reemplazar las bombillas de los alumbrados con luces LED?
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
Reunir evidencia de  Todo es energía

1. Piensa en la afirmación que quieres respaldar.
2. Repasa Todo es energía para buscar evidencia que respalde esa afirmación.
3. Apunta la evidencia que encuentres, junto con cada página en donde la encuentres.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________