# Activity 1. Your Role in Research (ΝΕΜΟ)

1. **Learning outcome(s):** (list up to 3)
   * 1. Students are practically engaged in STEM content by performing research experiments by themselves.
     2. Students learn to alternate between specific details of a task and the bigger picture of their research.
     3. Students look into the work of a real scientist, get acquainted with different roles of scientists within a industry and are introduced to the role that science plays in society.
2. **Relation of activity with the STEM, gender inclusiveness and Entrepreneurship:** (text, not bullets, explaining the relation of the activity to 3 above)

Students meet an actual STEM professional. It gives an image of the work a scientist/researcher can do and helps the students to see science as a serious career choice. STEM professionals are preferably chosen with different backgrounds and gender.

1. **Indicate the area of focus:**

**☒ STEM**

**☒ Gender inclusiveness**

**☒ Entrepreneurship**

1. **Materials:** (including ppts, videos, hands-on material)

* 3 resealable zipper bags of 1 L (Max. 1,5 L)
* 20 mL bottle containing bromothymol acidity indicator (BTB), diluted in demineralised water
* Pipette
* Black pot with calcium chloride (CaCl2)
* White pot with sodium bicarbonate (NaHCO3)
* 3 small measuring cups or one measuring spoon
* Pen or pencil
* Paper or notepad
* Mortar
* Protective lab coat
* Protective eyewear
* Paper towels
* Guideline for facilitator
* Guideline for students

1. **Preparation:**Every group of 3-4 students will need a working table. Choose the facilitator and scientists with care. Students might react better to a charismatic person that has experience in leading conversations with students or some might react better to a young person with whom they can identify better. Ensure that the involved science educators  and scientists reflect a variety of personalities and characteristics and roles within the organization! Make sure the level of ranking is not divided high = male, low = female. Instruct the students’ regular teacher to prepare an introduction about the industry, the scientist and his/her field of work. Make sure that the room in which you receive the students has the possibility to do the experiment and have a group discussion.
2. **Duration:** 60-90 (minutes)
3. **Target group:** 12-16 (student age)

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1. **Description of the activity:**

**Introductions, 5 minutes**

The facilitator shows the materials, explains the safety rules and introduces his/herself, their role in research and how they got to their current position (e.g. education and prior employments), their daily activities on a regular day, with whom they work and how their responsibilities relate to science. The facilitator briefly explains what is to be expected. Students are about to do the work that a scientist normally does, doing their own inquiry with experiments they’ll choose themselves.

Start with a general question that will be answered in this experiment and make the connection to a real life problem. The facilitator will ask the students this question and will overview the answers.

* Have you ever been in a chemistry lab?
* What, do you think, does a chemist do?
* How do you become a scientist?
* What, do you think, is a reaction?

**Part 1:  The experiment**

The facilitator explains that the following experiment they will do provokes a chemical reaction determining whether a substance is alkaline or acidic.  For example, evaluate cleaning products: acidic products react with calcium (lime scale in the bathroom), and basic products react with grease (in an oven).

Guided experiment, 15 minutes

Sometimes scientists need to follow specific guidelines to discover and understand the specific characteristics of substances. First students will perform an guided experiment in a zipper bag.   
Each group (4-5 students) has a kit with:

* 3 zipper bags
* a bottle 50 mL BTB diluted in distilled water
* a black pot with CaCl2
* a white pot with NaHCO3
* 3 measuring cups
* 1 measuring spoon
* a mortar (if needed)
* a pen and paper for notes
* paper towels.

Make sure students wear safety goggles and a lab coat during the experiment.

The facilitator performs the experiment with the students and guides them through the steps.  
1.    Grind the chunks of CaCl2 with the mortar.   
2.    Put three teaspoons of NaHCO3 and one teaspoon of CaCl2 in a zipper bag.   
3.    Fill the measuring cup with 10 mL BTB in H2O and place it upright on the bottom of the  
 bag.   
4.    Close the bag and try to squeeze out the air while the measuring cup stays upright.  
5.    Shake the bag and see what happens.   
6.    Write down all the observations.  
7.    The students collect observations.

The facilitator moves between groups and focuses on the comments about changes in colour, change in temperature, the formation of foam and volume changes. He/she does not yet comment on them. When mixing CaCl2, NaHCO3 and BTB in zipper bags, several observations can be made:

* Increasing or decreasing temperature in the bag.
* The change of the colour.
* Formation of foam resulting in the inflation of the bag.

The activity is continued without discussing the observations, but can illustrated by the story of entrepreneur Ernest Solvay. You can find a biography in the following link:

[Biography of Ernest Solvay](https://www.encyclopedia.com/people/science-and-technology/chemistry-biographies/ernest-solvay)

Ernest Solvay was a Belgian chemist that never had extended education, but while working in his uncle’s chemical factory experimented with a lot of the same chemicals that the students use in this activity.

**Open experiment, 15 minutes**

In some cases scientists will conduct a more open experiment or procedure if the research question is more open. For example when they want to know how reactions are different with different equivalents.   
Freely experiment with zipper bag. The facilitator explains that, to find out what is happening, students are going to repeat the experiment by changing the variables. For example, we may choose to use only two substances at a time. Each group of students gets two extra zipper bags and two extra measuring cups and are free to choose variables to experiment with. The students collect observations. The facilitator moves between groups.   
N.B. An often seen difficulty created by students is that they immediately throw all the ingredients into the zipper bag. To avoid this, ask students to first think of the questions they would like to research.

**Conclusion   
Part 2: The discussion, 20 minutes**Discussion of the results & findings of each group. What did they discover in this experiment?

* A solution of CaCl2 is slightly acidic, BTB colours the solution yellow. Explain the terms acid and base.
* A solution of NaHCO3 is alkali, BTB colours the solution blue.
* When mixed, these substances provoke an acid-base reaction, releasing (CO2-) gas. At first it generates bubbles and the air blows up the bag (CO2 carbon dioxide- generated by the reaction of CaCl2 and NaHCO3 with H2O  
  **NaHCO3(s) + CaCl2(s) + H2O(l) → CaCO3(s) + CO2(g) + NaCl(aq) + HCl(aq)**)
* At first, increasing temperature is observed, due to the exothermic reaction between CaCl2 and H2O.
* Secondly, decreasing temperature is observed due to the endothermic formation of CO2.
* The essence of the trial is an acid/base reaction with BTB as an indicator.

What did each of you just do? What different roles did you have/what role does a scientist have in these kinds of experiments? (e.g. selecting variables, observing, documentation).

The facilitator might add specific skills as well, speaking from experience: persistence, diligence, patience, being able to work alone and in a team.   
  
*Ernest Solvay experimented a lot with these substances too. During one of his experiments he accidentally found a method of producing soda (NaHCO3) from carbon dioxide gas (CO2), ammonia and simple table salt.. Ernest soon started his first chemical factory. The company Solvay grew to a multinational, now with expertise in the production of plastics.*   
  
Ernest Solvay chose a career in entrepreneurship, but this is just one of the many careers a chemist can choose. Ask students, what other kinds of jobs can a chemist do?  
  
The facilitator can point out the following examples when the students don’t think of them: Such as teacher, explainer, interviewer, writer, advising politics, creator of research plans, quality analysis.  
During the discussion the facilitator may elaborate on their own job (what does an average day look like? Who does (s)he work with? What are the different activities that are typical to his/her function?)

While going into this, (s)he explains the practical work in laboratories:

* Substances that do not exist in nature are synthesized
* Substances that do exist in nature can be purified
* Production of chemicals
* Research into materials
* Analytical laboratories (for example researching soil samples or developing household cleaners).

Ask students: what do you think we do in these kind of laboratories?

Explain that laboratories can be part of a hospital or a university, but also be part of a small or large company, or a government agency. Next to laboratories for scientific research there are also laboratories for practical uses:

1.    Quality Laboratory   
Many companies have a quality laboratory, where they test the purity and properties of raw materials, auxiliary materials, semi-finished and finished products. In the pharmaceutical and food industry a microbiological laboratory is essential to avoid the risk of food poisoning and contamination of the final product, and new pills and pharmaceutical products are tested for safety and effectiveness. The general question in a quality laboratory is: what’s in it?  
  
Ask students which organizations or individuals they think could benefit from quality laboratory.   
Possible answers: government when they want to test the quality of waste water or drinking water, large chemical factories that are responsible for control of the compounds in emission, car factories that need to evaluate which substances are emitted etc.

2.    Hospital Laboratory   
Hospitals have in general a clinical chemical/haematological, medical, microbiological, pharmaceutical toxicological and pathological laboratory. To examine all bodily fluids, but especially blood, urine, feces, sputum and tissue. Mainly the general clinical chemical/haematological laboratories perform a 24/7 role and are continuously available for urgent analysis. The other laboratories listed are not constantly being used, only when needed. At the head of a hospital laboratory is a laboratory specialist. In the case of the clinical chemical laboratory, this is the clinical chemist. In the case of the microbiological laboratory, this is the clinical microbiologist. At the pathology lab, this is the pathologist. And the hospital pharmacist manages the pharmaceutical toxicological laboratory.   
Ask students which organizations or individuals they think could benefit from a hospital laboratory.   
Possible answers: Hospitals for diagnosis of patients, national health organizations, blood banks that check the blood that is donated.

3.    Forensic laboratory

A forensic laboratory investigates traces to determine the facts of crimes and identify the perpetrators. The investigation into traces of DNA has boomed in recent years, so even older crimes can be solved, where researchers previously searched for a solution unsuccessfully.

4.    Construction Physical Laboratory  
Some examples of research are:

* wind nuisance and wind loads on and around buildings in the wind tunnel
* sun and shade on and around buildings
* air- and waterproofness of facade elements
* sound insulation of walls, doors and facade elements
* fire resistance of structural parts.

Ask students which organizations or individuals they think could benefit from a construction laboratory.   
Possible answers: Construction workers, car manufacturers, architects, plane manufacturers etc.

Ask students: What aspects of this work do you think is most socially relevant and why? How can we impact the society most?

The facilitator notes and points out his/her observations in this: different type of people, gender etc. He/she also emphasizes that the products and services mentioned above are used on a daily level: bridges, roads, water parks, pills, pharmaceutical products, cleaning products, toothpaste, toys. The development of these products was once started in a laboratory, by a scientist.

*When Ernest Solvay continued his career, he took on many different roles a scientist can take. He opened schools and libraries to promote education, organized big conferences to bring together scientists in the whole world, an impressive achievement in a time where travelling was not as easy as it is now. He was highly invested in the establishment of labour rights and even chose a political career as a senator.*

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*Photography: DigiDaan*

1. **Link to curriculum:** chemistry and professional orientation.