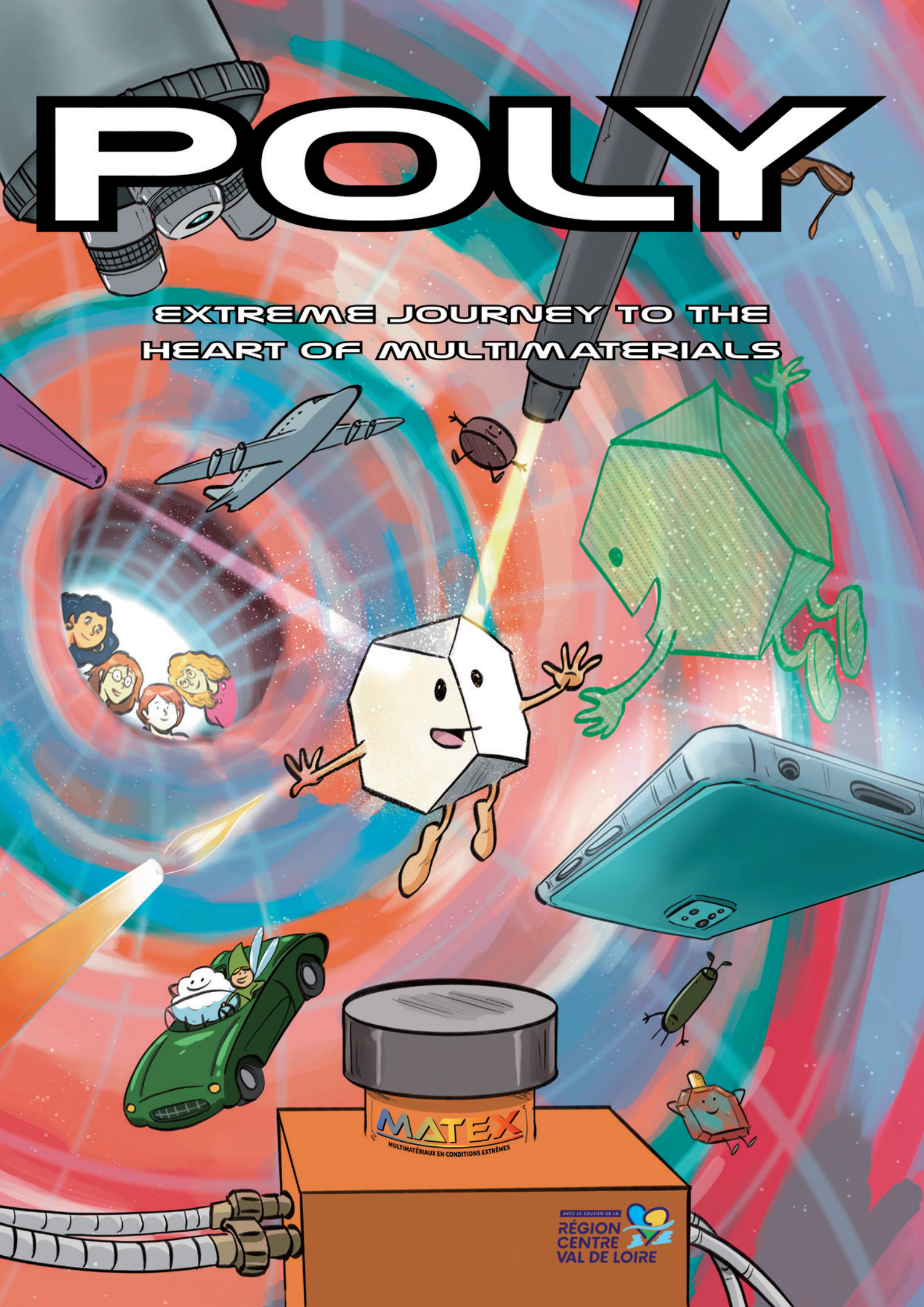


POLY

EXTREME JOURNEY TO THE
HEART OF MULTIMATERIALS



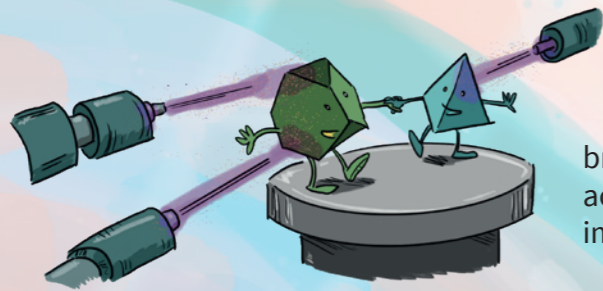
AVEC LE SOUTIEN DE LA
RÉGION
CENTRE
VAL DE LOIRE

This comic book is brought to you by MATEX, a research program funded by the Centre-Val de Loire region focusing on multimaterials in extreme conditions.

What does that mean exactly?

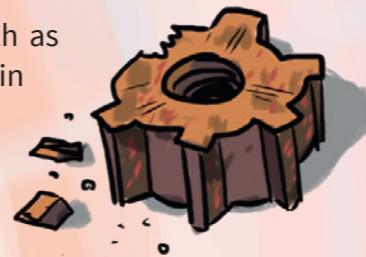
Multimaterials

These are assemblies of materials (metal, rubber, glass, etc.) that have very different properties. Each brings its «superpower» and together they can even acquire new ones, allowing us to imagine new uses or improve current applications.



Extreme conditions

These are situations where a material is used under stress: such as exposure to high heat, being run over by a car wheel, working in hostile environments (under high pressure, in radioactive settings, in intense magnetic fields, etc.), being heated in an oven, etc. Scientists test them by subjecting them to many constraints to verify their ability to withstand such conditions.



Preface

A collaborative program

MATEX aims to unite academic and industrial actors in research, innovation, and training by creating a dynamic around multimaterials in extreme conditions.

The Centre-Val de Loire region has a significant industrial network comprising large groups, small and medium-sized enterprises with strong research and development potential. Several research and higher education institutions with high-level scientific and technical expertise on multimaterials in extreme conditions are located in Centre-Val de Loire: the National Center for Scientific Research (CNRS), the University of Orléans, the University of Tours, and INSA Centre Val de Loire.

One of the advantages of multimaterials is their ability to combine complementary functionalities and capabilities, allowing them to be used in harsh environments or under extreme stresses (beyond usual usage conditions). The full exploitation of multimaterials' potential, and their industrial deployment, requires studying their behavior and understanding the physico-chemical phenomena involved, particularly at the interfaces, in research laboratories.

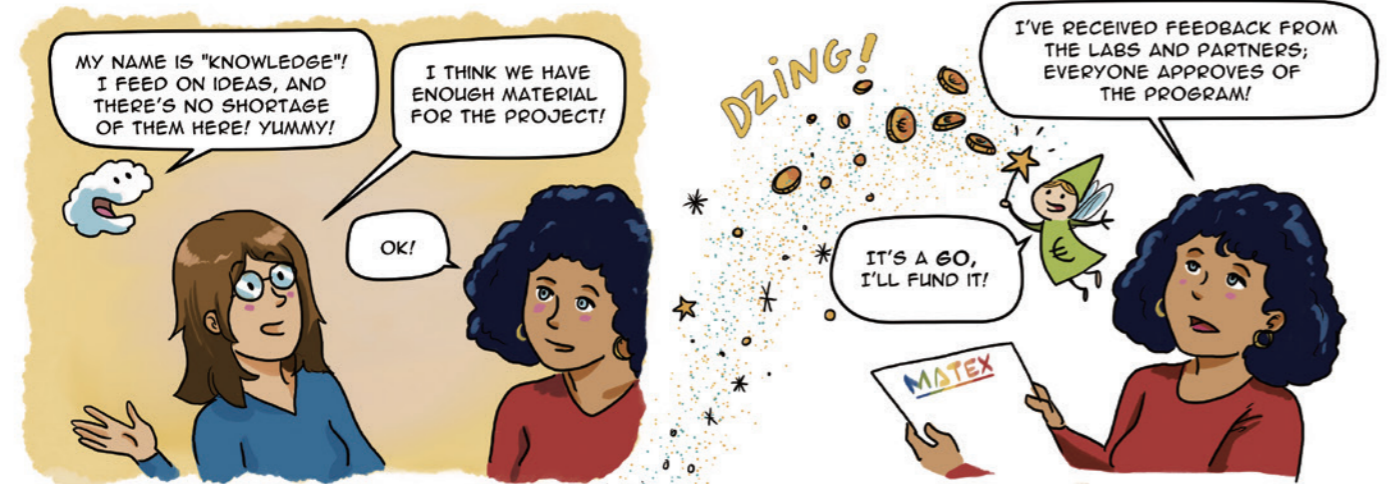


ONE DAY, IN THE CENTRE-VAL DE LOIRE REGION, RESEARCHERS GATHERED TO DISCUSS THEIR RESEARCH.

MULTIFUNCTION..., BLAH BLAH... MATERIALS...

... BLAH BLAH... MATEX, BLAH BLAH...

BLAH BLAH... EXTREME CONDITIONS...



MY NAME IS "KNOWLEDGE"! I FEED ON IDEAS, AND THERE'S NO SHORTAGE OF THEM HERE! YUMMY!

I THINK WE HAVE ENOUGH MATERIAL FOR THE PROJECT!

OK!

DZING!

I'VE RECEIVED FEEDBACK FROM THE LABS AND PARTNERS; EVERYONE APPROVES OF THE PROGRAM!

IT'S A GO, I'LL FUND IT!



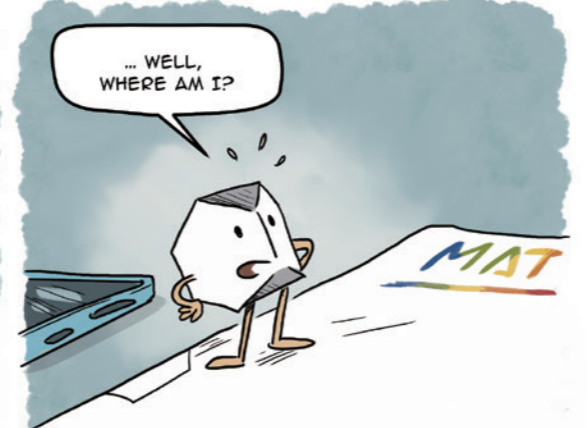
WELL... WHAT'S HAPPENING?



GRUNT...



HOP!



... WELL, WHERE AM I?



YOU ARE IN A RESEARCH LABORATORY!

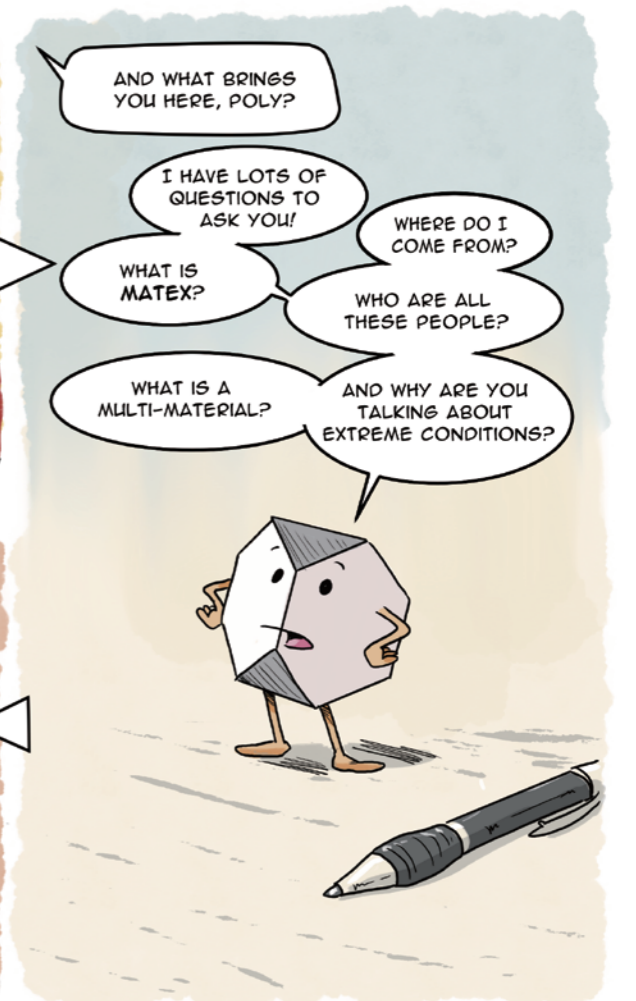
WHO ARE YOU?

I'M CALLED POLY, AND I'M A SOLID!



WELL, THAT'S A LOT OF QUESTIONS! LET'S PROCEED IN ORDER!

I WANT TO KNOW WHAT RESEARCH IS!



AND WHAT BRINGS YOU HERE, POLY?

I HAVE LOTS OF QUESTIONS TO ASK YOU!

WHERE DO I COME FROM?

WHAT IS MATEX?

WHO ARE ALL THESE PEOPLE?

WHAT IS A MULTI-MATERIAL?

AND WHY ARE YOU TALKING ABOUT EXTREME CONDITIONS?

HOW SHALL I PUT IT... RESEARCH DELVES DEEP INTO NATURAL AND SOCIAL PHENOMENA TO SURPASS THE BOUNDARIES OF KNOWLEDGE. THIS EVER-EVOLVING SCIENCE IS A SOURCE OF PROGRESS FOR SOCIETY!

OUR COMMON GOAL IS TO CREATE KNOWLEDGE!

YES, KNOWLEDGE IS YUMMY!



IN THE REGION, WE HAVE LABORATORIES SPECIALIZED IN MATERIALS!

WE GATHERED, AND WE SECURED REGIONAL FUNDING!

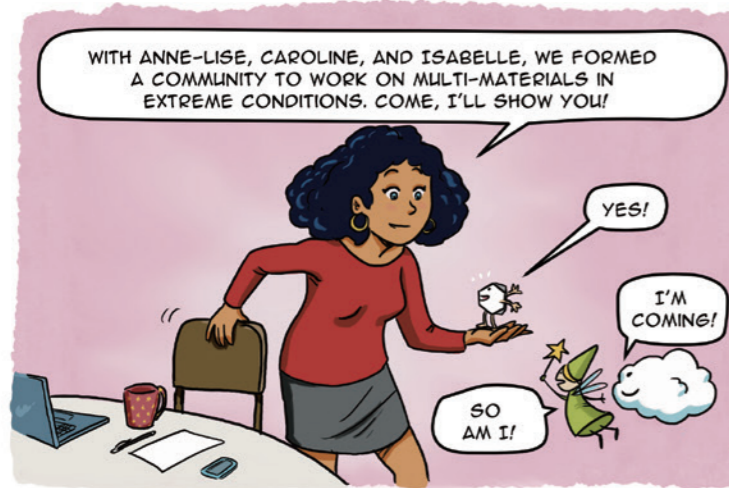
I'M NANCEMENT, BUT YOU CAN CALL ME "GODMOTHER"!

THE CENTRE-VAL DE LOIRE REGION! IT'S HERE!



ALRIGHT!





WITH ANNE-LISE, CAROLINE, AND ISABELLE, WE FORMED A COMMUNITY TO WORK ON MULTI-MATERIALS IN EXTREME CONDITIONS. COME, I'LL SHOW YOU!

YES!

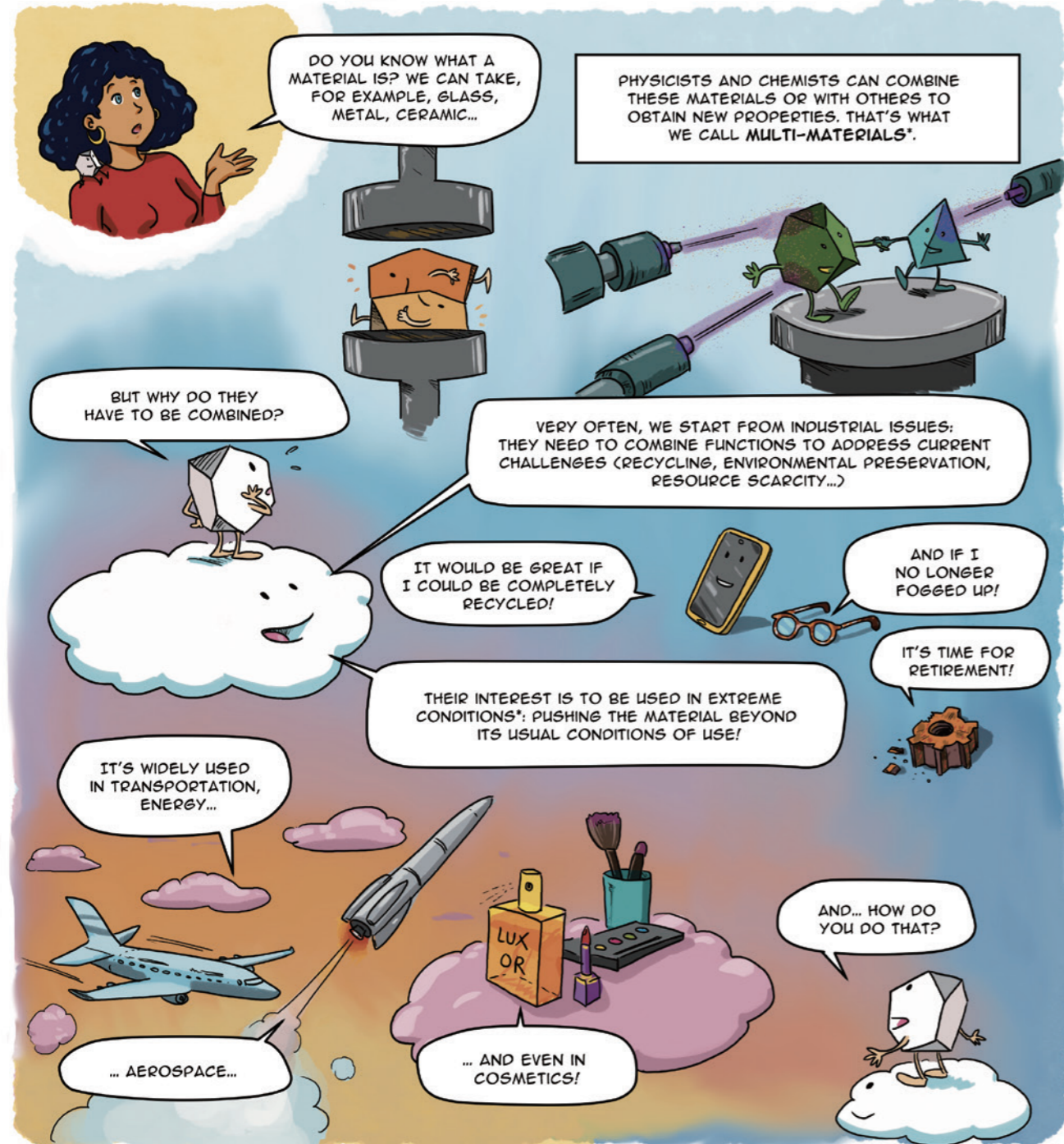
I'M COMING!

SO AM I!



TELL ME, CAN YOU EXPLAIN WHAT A MULTI-MATERIAL IS?

YES, I'LL START WITH THAT, YOU'RE RIGHT!



DO YOU KNOW WHAT A MATERIAL IS? WE CAN TAKE, FOR EXAMPLE, GLASS, METAL, CERAMIC...

PHYSICISTS AND CHEMISTS CAN COMBINE THESE MATERIALS OR WITH OTHERS TO OBTAIN NEW PROPERTIES. THAT'S WHAT WE CALL MULTI-MATERIALS*.

BUT WHY DO THEY HAVE TO BE COMBINED?

VERY OFTEN, WE START FROM INDUSTRIAL ISSUES: THEY NEED TO COMBINE FUNCTIONS TO ADDRESS CURRENT CHALLENGES (RECYCLING, ENVIRONMENTAL PRESERVATION, RESOURCE SCARCITY...)

IT WOULD BE GREAT IF I COULD BE COMPLETELY RECYCLED!



AND IF I NO LONGER FOGGED UP!



IT'S TIME FOR RETIREMENT!



THEIR INTEREST IS TO BE USED IN EXTREME CONDITIONS*: PUSHING THE MATERIAL BEYOND ITS USUAL CONDITIONS OF USE!

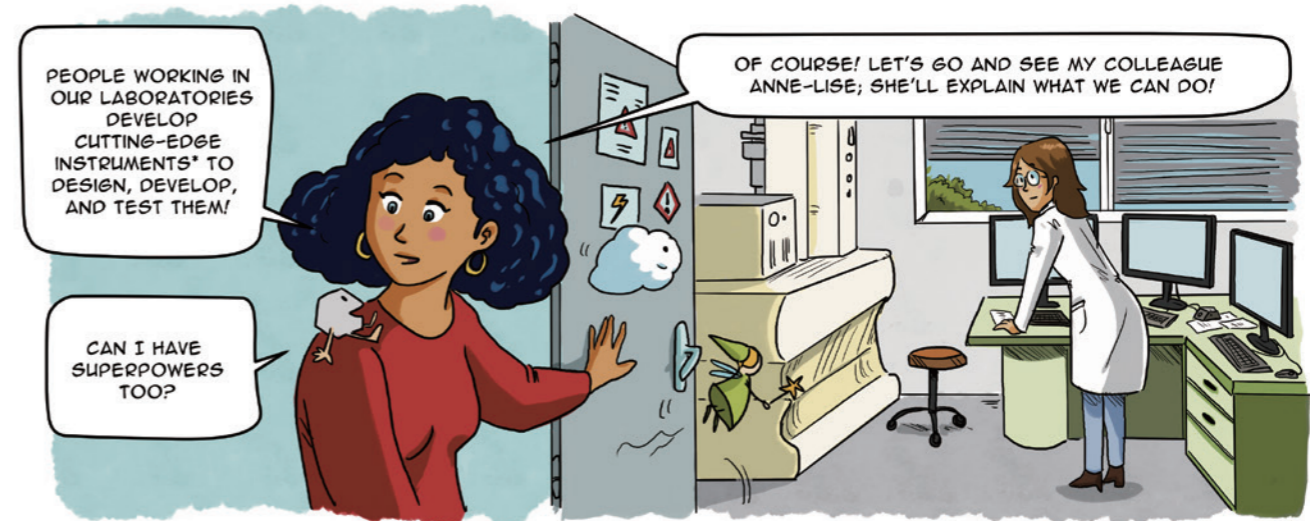
IT'S WIDELY USED IN TRANSPORTATION, ENERGY...

... AEROSPACE...



... AND EVEN IN COSMETICS!

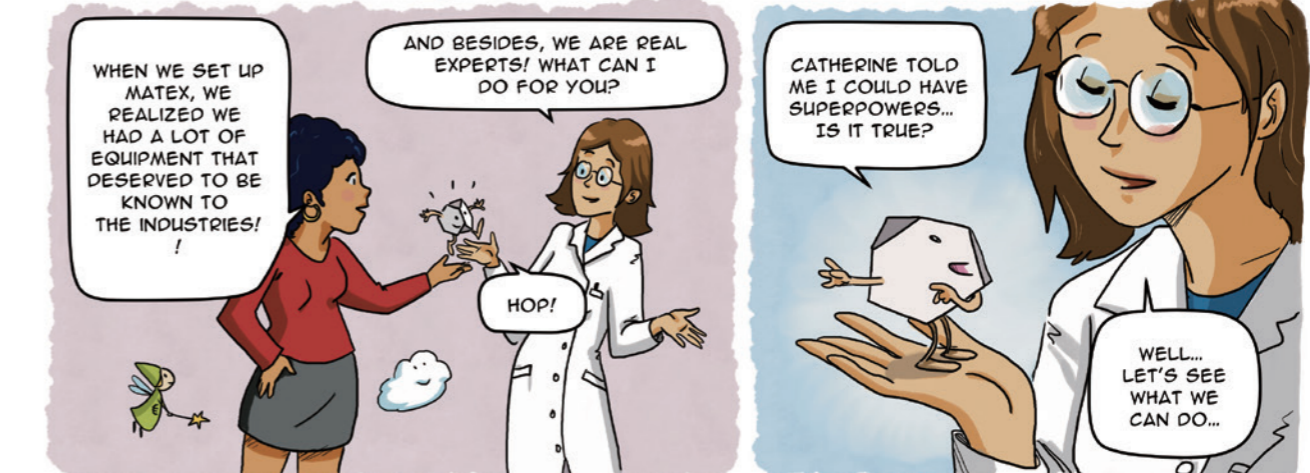
AND... HOW DO YOU DO THAT?



PEOPLE WORKING IN OUR LABORATORIES DEVELOP CUTTING-EDGE INSTRUMENTS* TO DESIGN, DEVELOP, AND TEST THEM!

OF COURSE! LET'S GO AND SEE MY COLLEAGUE ANNE-LISE; SHE'LL EXPLAIN WHAT WE CAN DO!

CAN I HAVE SUPERPOWERS TOO?



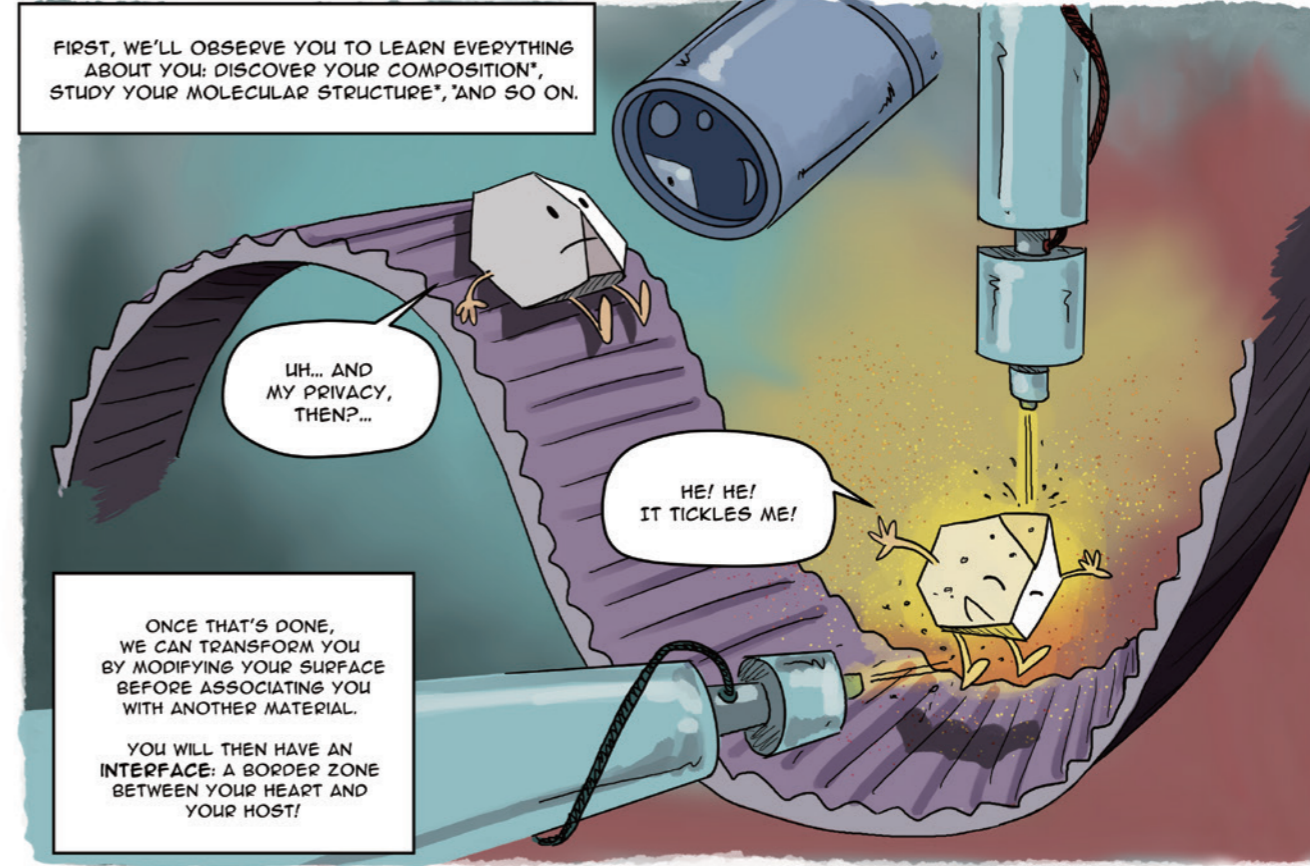
WHEN WE SET UP MATEX, WE REALIZED WE HAD A LOT OF EQUIPMENT THAT DESERVED TO BE KNOWN TO THE INDUSTRIES!

AND BESIDES, WE ARE REAL EXPERTS! WHAT CAN I DO FOR YOU?

HOP!

CATHERINE TOLD ME I COULD HAVE SUPERPOWERS... IS IT TRUE?

WELL... LET'S SEE WHAT WE CAN DO...



FIRST, WE'LL OBSERVE YOU TO LEARN EVERYTHING ABOUT YOU: DISCOVER YOUR COMPOSITION*, STUDY YOUR MOLECULAR STRUCTURE*, AND SO ON.

UH... AND MY PRIVACY, THEN?...

HE! HE! IT TICKLES ME!

ONCE THAT'S DONE, WE CAN TRANSFORM YOU BY MODIFYING YOUR SURFACE BEFORE ASSOCIATING YOU WITH ANOTHER MATERIAL.

YOU WILL THEN HAVE AN INTERFACE: A BORDER ZONE BETWEEN YOUR HEART AND YOUR HOST!



WE CAN ALSO HEAT THE MATERIALS TO BOND THEM...

...OR JUST LIKE HERE, USE PLASMA TO REMOVE A BIT OF MATERIAL AND DEPOSIT A THIN LAYER ON YOU!

WHAT A CLIMB! I UNDERSTAND WHY WE TALK ABOUT EXTREME CONDITIONS!

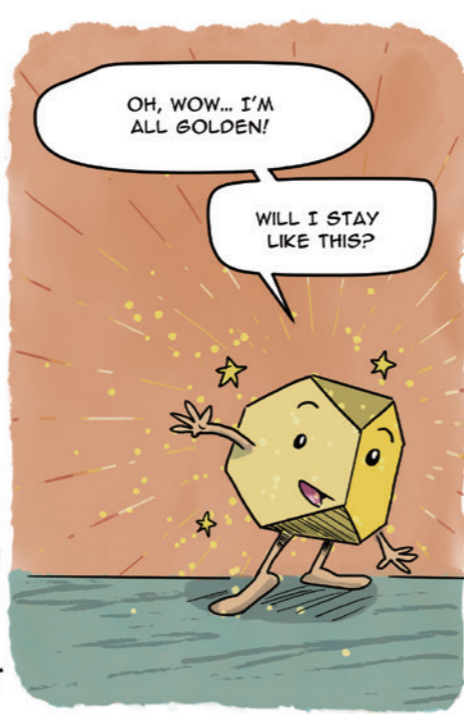
HE, HE! IT STILL TICKLES!

YES, YOU RECEIVED A GOLD PLATING! NOW YOU HAVE THE PROPERTIES OF THIS MATERIAL: STAINLESS, ELECTRICAL AND THERMAL CONDUCTOR... AND SO PRETTY!!

... I HOPE IT'S NOT TOO EXPENSIVE!

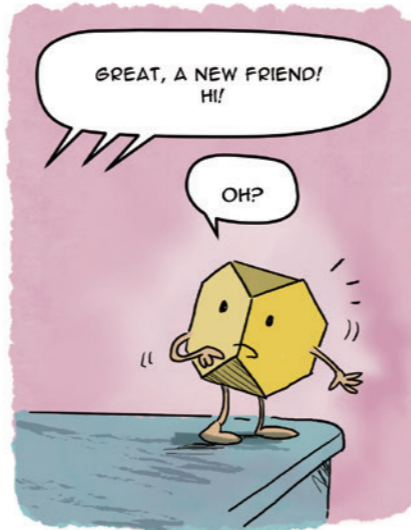
SO... I BECAME...

...A MULTI-MATERIAL?!



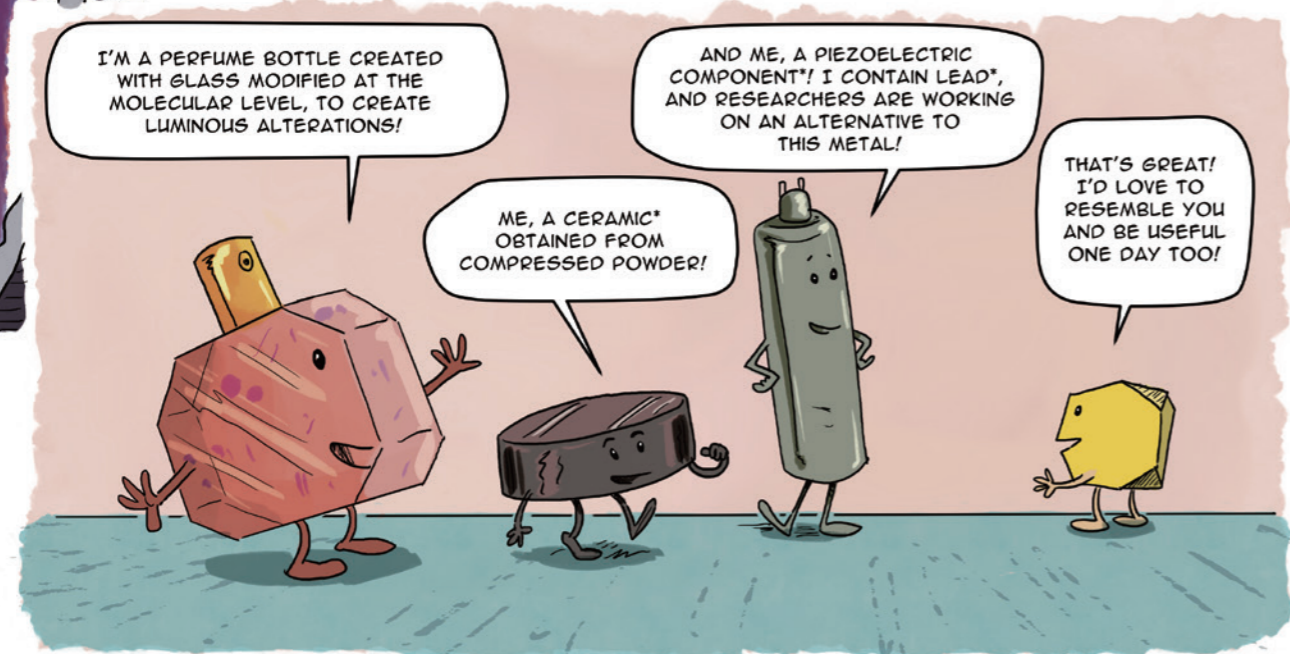
OH, WOW... I'M ALL GOLDEN!

WILL I STAY LIKE THIS?



GREAT, A NEW FRIEND! HI!

OH?

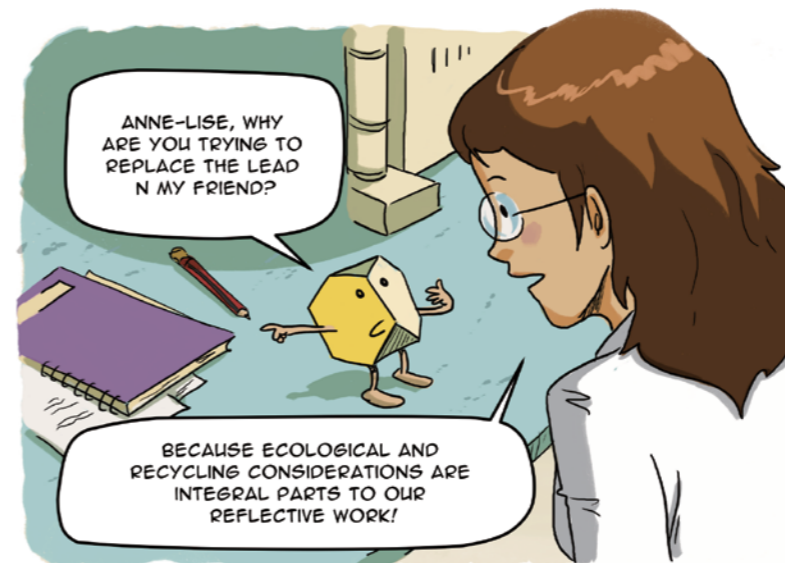


I'M A PERFUME BOTTLE CREATED WITH GLASS MODIFIED AT THE MOLECULAR LEVEL, TO CREATE LUMINOUS ALTERATIONS!

AND ME, A PIEZOELECTRIC COMPONENT! I CONTAIN LEAD*, AND RESEARCHERS ARE WORKING ON AN ALTERNATIVE TO THIS METAL!

ME, A CERAMIC* OBTAINED FROM COMPRESSED POWDER!

THAT'S GREAT! I'D LOVE TO RESEMBLE YOU AND BE USEFUL ONE DAY TOO!



ANNE-LISE, WHY ARE YOU TRYING TO REPLACE THE LEAD IN MY FRIEND?

BECAUSE ECOLOGICAL AND RECYCLING CONSIDERATIONS ARE INTEGRAL PARTS TO OUR REFLECTIVE WORK!



NOW, ECOLOGY IS AT THE HEART OF THE LABORATORIES' CONCERNS.

GOLD? TOO EXPENSIVE... LEAD? TOO POLLUTING... LITHIUM? SUPPLY PROBLEMS... WE'LL HAVE TO CREATE SOMETHING NEW!

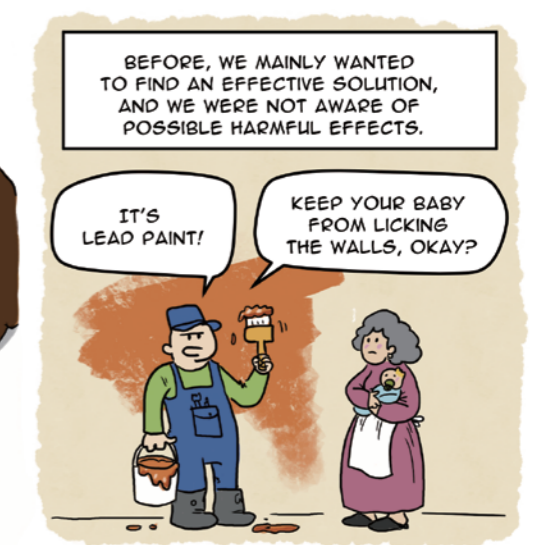
SINCE THEN, THE CHOICE OF MATERIALS (MORE ABUNDANT, IN SEVERAL COUNTRIES, WITH NON-POLLUTING EXTRACTION)...



THANKS TO THIS PROCESS OF CREATING CERAMICS BY POWDER PRESSURE, WE GAIN 200 TO 300°C COMPARED TO TRADITIONAL BAKING!

GREAT!

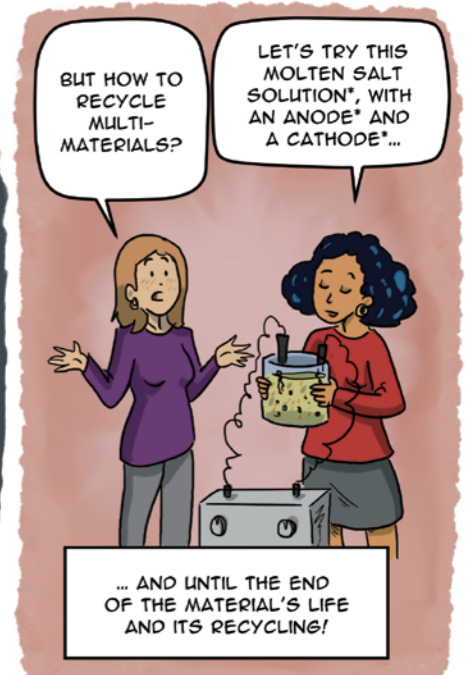
... THROUGH THE ENERGY SUPPLY OF OUR INSTRUMENTS (GREEN ENERGY, LOSS REDUCTION)...



BEFORE, WE MAINLY WANTED TO FIND AN EFFECTIVE SOLUTION, AND WE WERE NOT AWARE OF POSSIBLE HARMFUL EFFECTS.

IT'S LEAD PAINT!

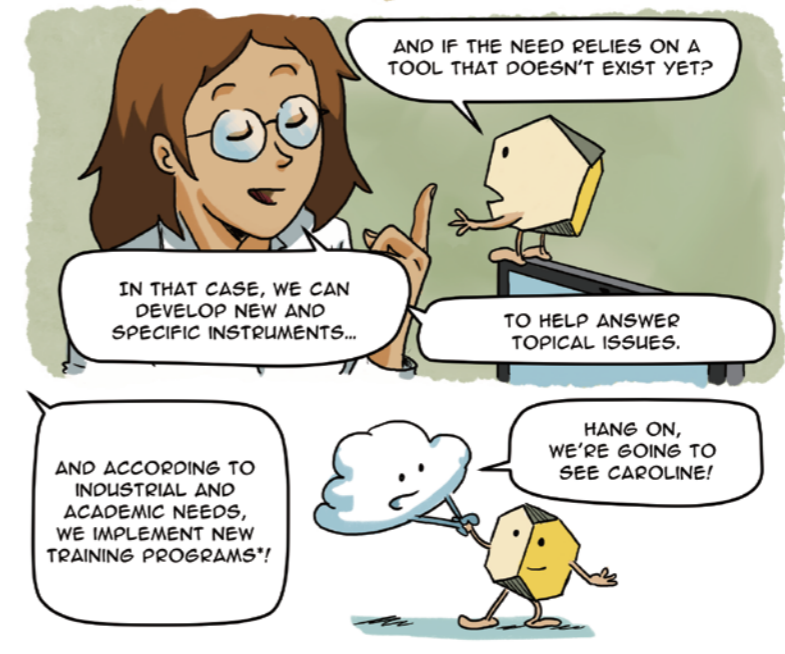
KEEP YOUR BABY FROM LICKING THE WALLS, OKAY?



BUT HOW TO RECYCLE MULTI-MATERIALS?

LET'S TRY THIS MOLTEN SALT SOLUTION*, WITH AN ANODE* AND A CATHODE*...

... AND UNTIL THE END OF THE MATERIAL'S LIFE AND ITS RECYCLING!



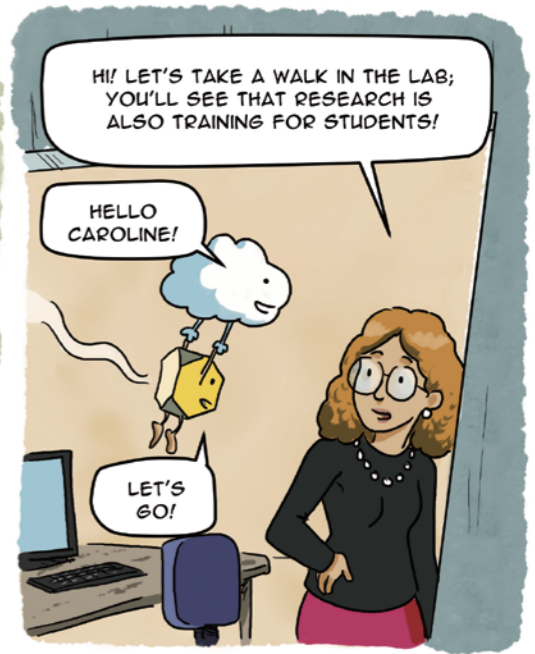
AND IF THE NEED RELIES ON A TOOL THAT DOESN'T EXIST YET?

IN THAT CASE, WE CAN DEVELOP NEW AND SPECIFIC INSTRUMENTS...

TO HELP ANSWER TOPICAL ISSUES.

AND ACCORDING TO INDUSTRIAL AND ACADEMIC NEEDS, WE IMPLEMENT NEW TRAINING PROGRAMS*!

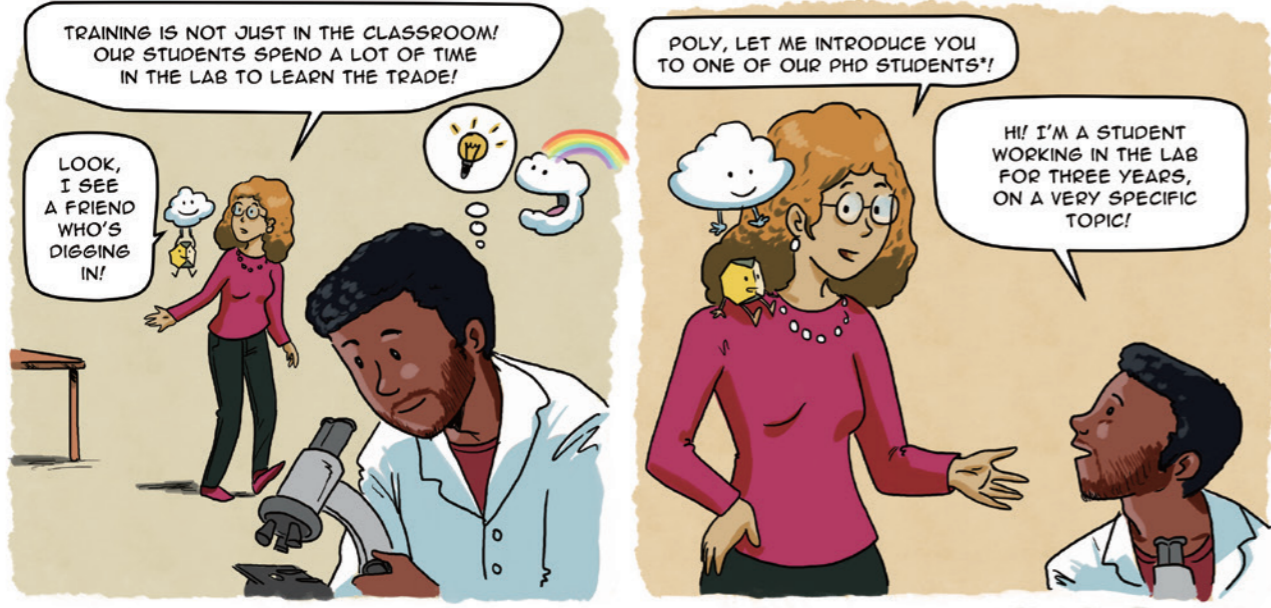
HANG ON, WE'RE GOING TO SEE CAROLINE!



HI! LET'S TAKE A WALK IN THE LAB; YOU'LL SEE THAT RESEARCH IS ALSO TRAINING FOR STUDENTS!

HELLO CAROLINE!

LET'S GO!

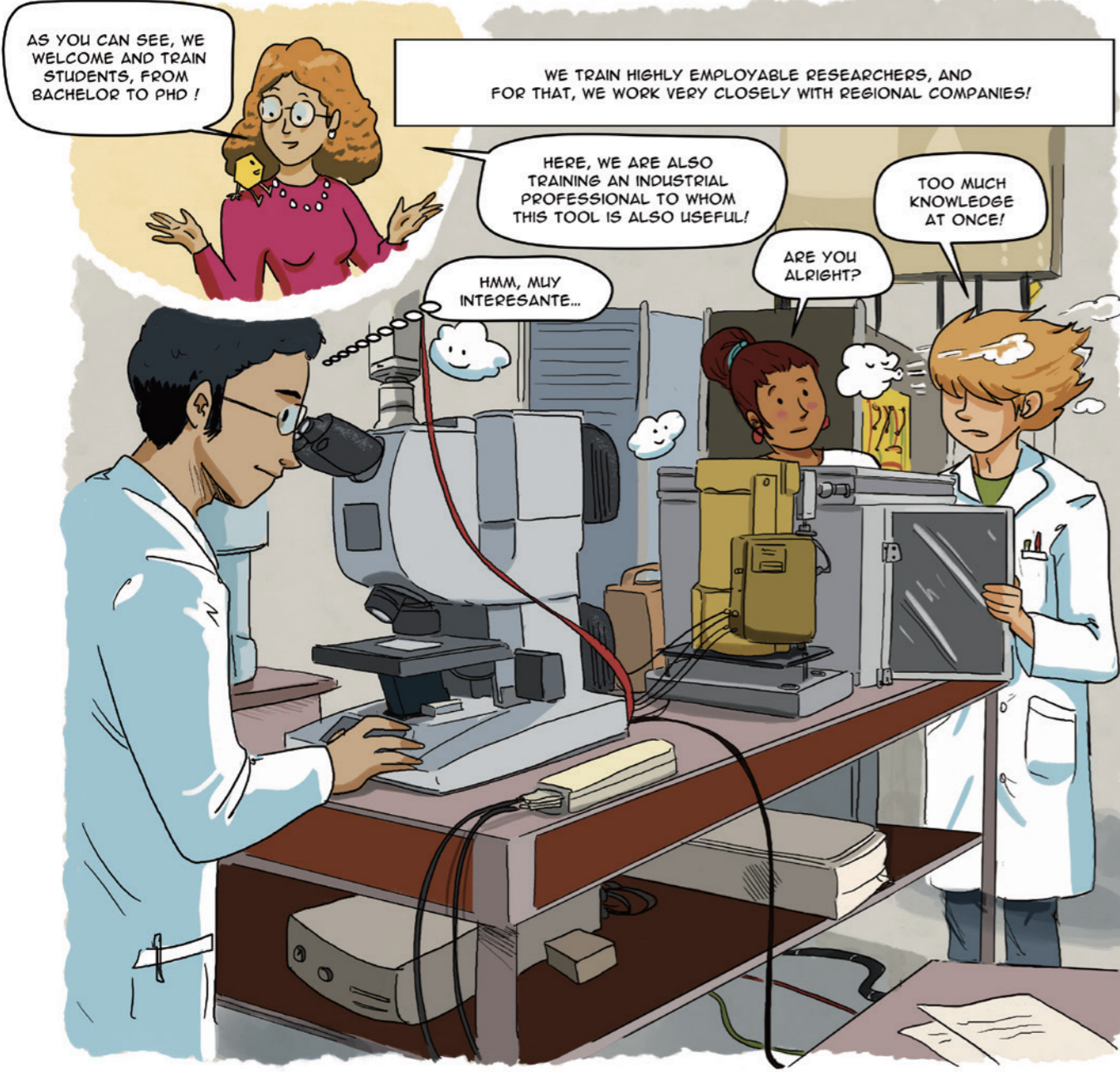


TRAINING IS NOT JUST IN THE CLASSROOM!
OUR STUDENTS SPEND A LOT OF TIME
IN THE LAB TO LEARN THE TRADE!

LOOK, I SEE
A FRIEND
WHO'S
DIGGING
IN!

POLY, LET ME INTRODUCE YOU
TO ONE OF OUR PHD STUDENTS*!

HI! I'M A STUDENT
WORKING IN THE LAB
FOR THREE YEARS,
ON A VERY SPECIFIC
TOPIC!



AS YOU CAN SEE, WE
WELCOME AND TRAIN
STUDENTS, FROM
BACHELOR TO PHD !

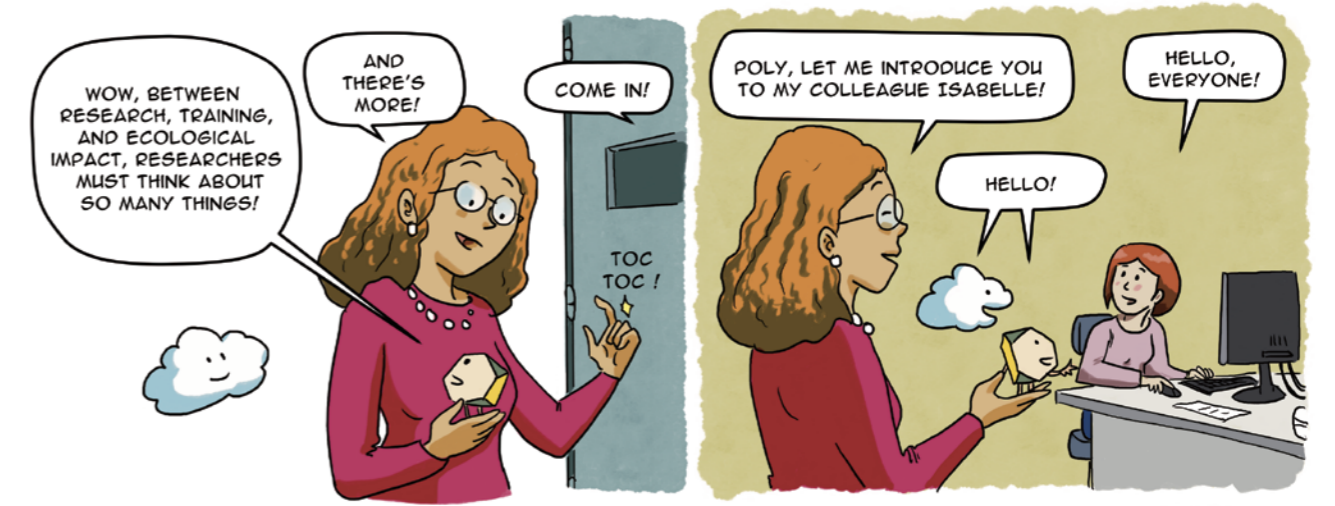
WE TRAIN HIGHLY EMPLOYABLE RESEARCHERS, AND
FOR THAT, WE WORK VERY CLOSELY WITH REGIONAL COMPANIES!

HERE, WE ARE ALSO
TRAINING AN INDUSTRIAL
PROFESSIONAL TO WHOM
THIS TOOL IS ALSO USEFUL!

TOO MUCH
KNOWLEDGE
AT ONCE!

HMM, MUY
INTERESANTE...

ARE YOU
ALRIGHT?



WOW, BETWEEN
RESEARCH, TRAINING,
AND ECOLOGICAL
IMPACT, RESEARCHERS
MUST THINK ABOUT
SO MANY THINGS!

AND
THERE'S
MORE!

COME IN!

POLY, LET ME INTRODUCE YOU
TO MY COLLEAGUE ISABELLE!

HELLO,
EVERYONE!

HELLO!



PHEW, YOU'RE HERE,
IF YOU WANT TO GIVE
ME A HAND? I HAVE
TO ACCOMPANY THE
PHD STUDENTS,
PREPARE FUNDING
APPLICATIONS, AND
DON'T FORGET TO
PUBLISH MY RESEARCH!

THAT'S WHY THE
FOUR OF US WOMEN
ARE LEADING MATEX!

TAKE A BREAK,
ISABELLE,
I'LL TAKE OVER!

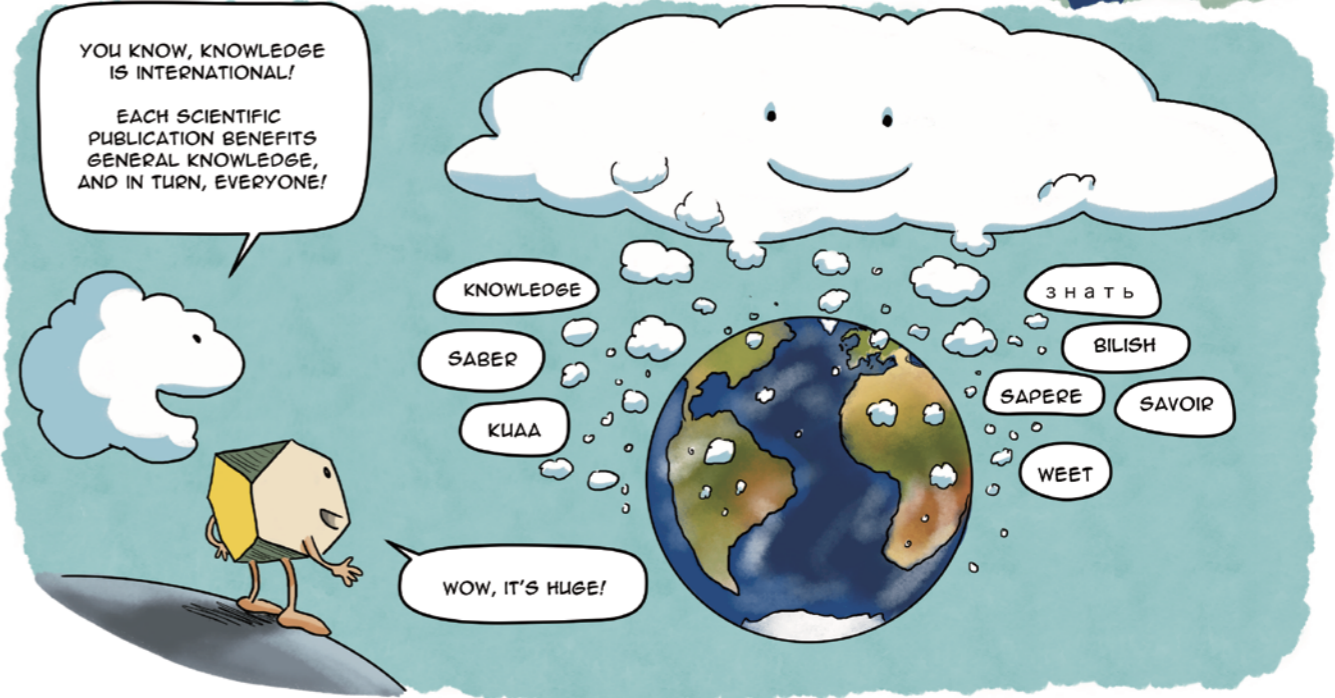
WHY DO YOU HAVE TO
PUBLISH YOUR RESEARCH?

IT'S TO CONTRIBUTE
TO INCREASING
KNOWLEDGE!

THE DAYS ARE NOT
LONG ENOUGH!

PFF!

THANK
YOU!



YOU KNOW, KNOWLEDGE
IS INTERNATIONAL!
EACH SCIENTIFIC
PUBLICATION BENEFITS
GENERAL KNOWLEDGE,
AND IN TURN, EVERYONE!

KNOWLEDGE

SABER

KUAA

ЗНАТЬ

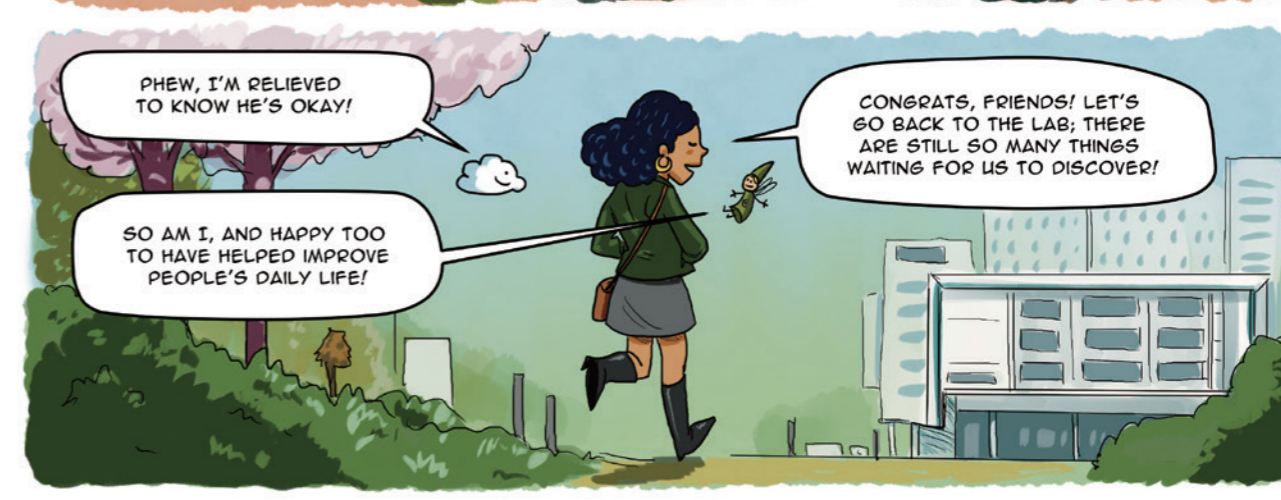
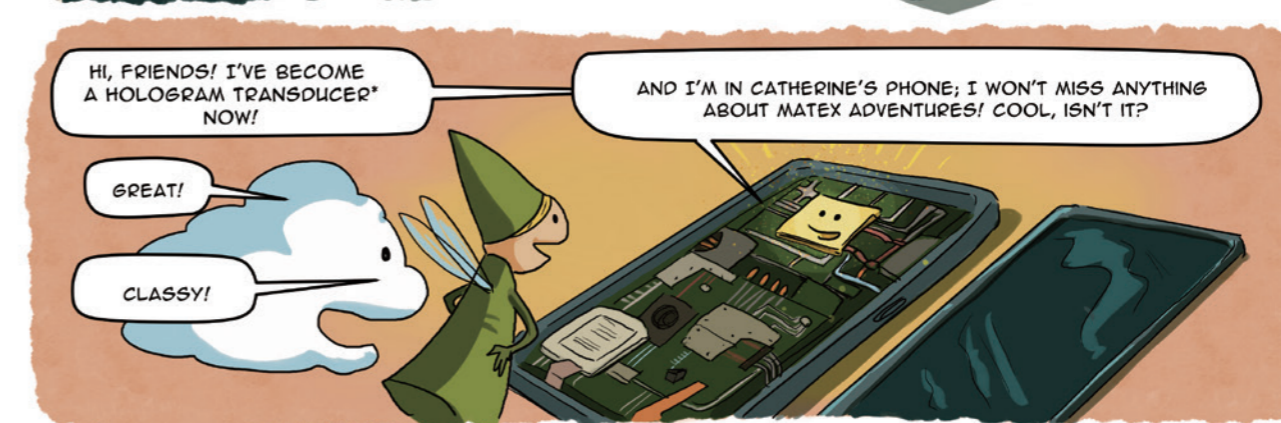
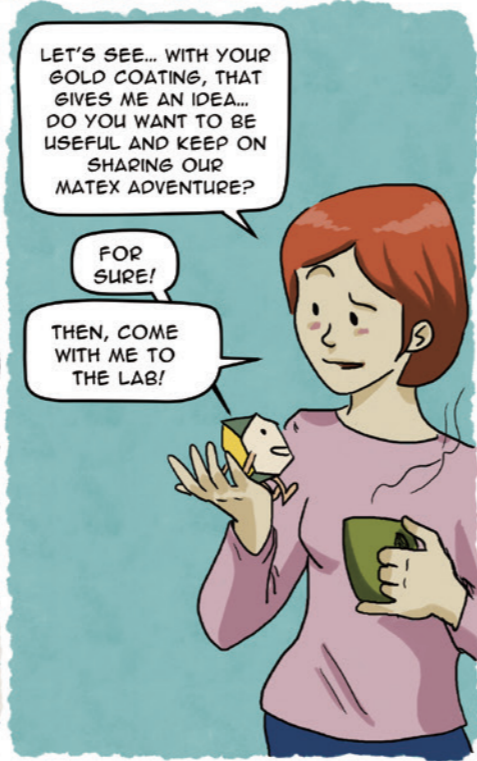
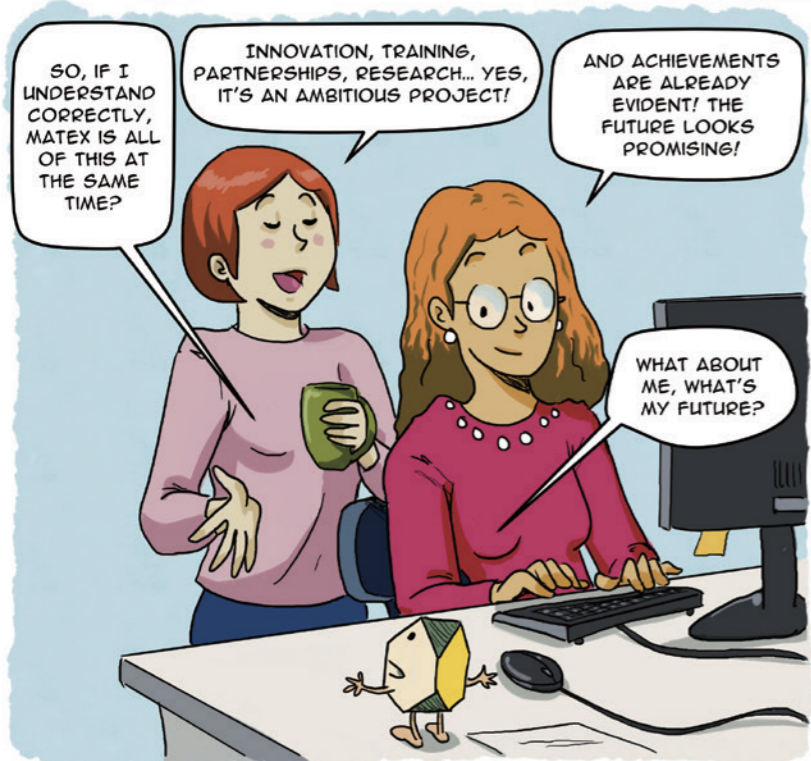
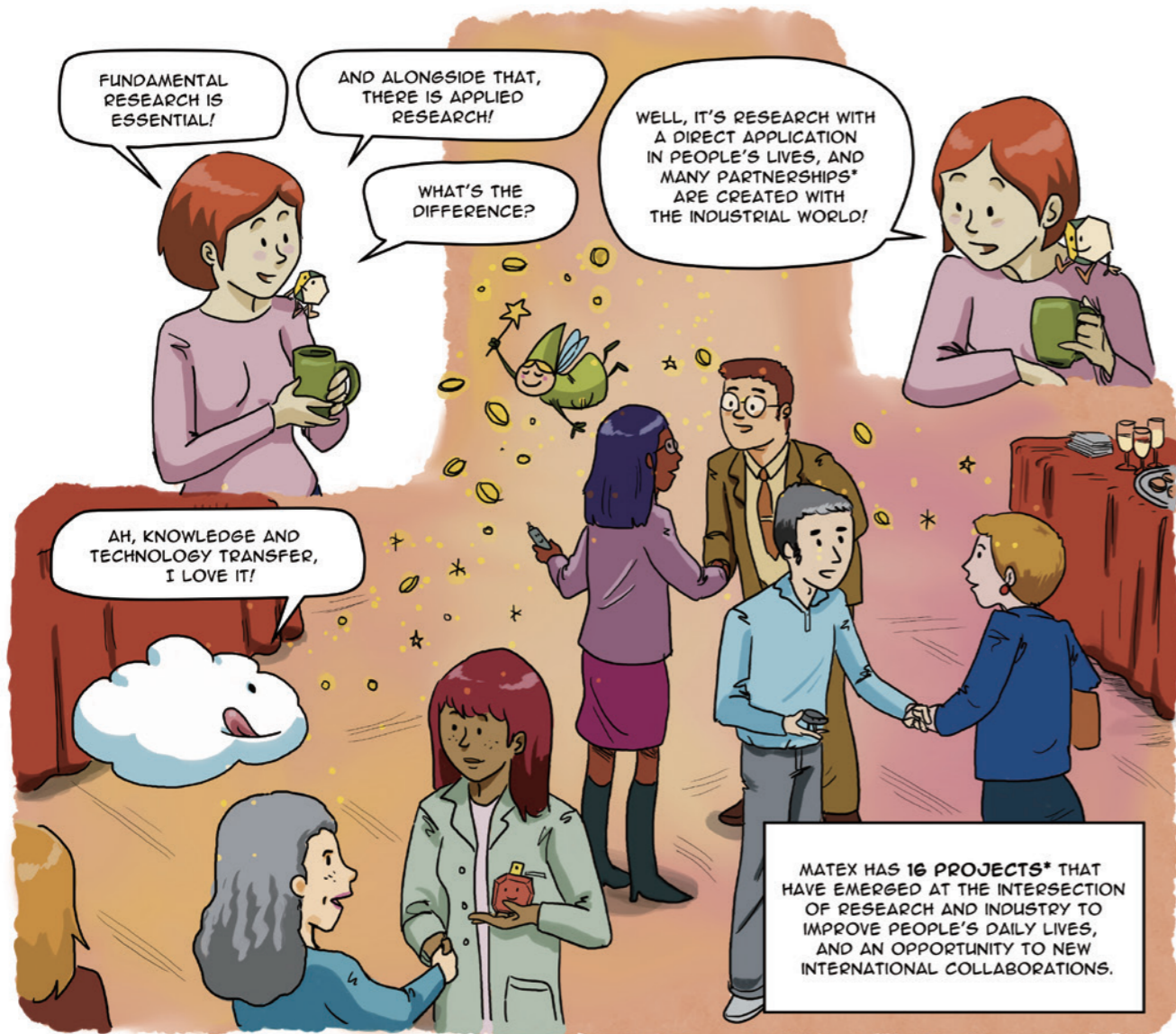
BILISH

SAPERE

SAVOIR

WEET

WOW, IT'S HUGE!



Poly will meet the four coordinators of MATEX, presented here:



Catherine Bessada

She is a research director at the Laboratory for Extreme Conditions and Materials: High Temperature and Irradiation (CEMHTI), CNRS.

For MATEX, she is particularly in charge of the industrial club.

Her secret: going to Brittany as often as possible and bringing back salted butter caramels, very good for good spirit!

Isabelle Monot-Laffez

She is a university professor at the IUT of Blois, in the Research Group in Materials, Microelectronics, Acoustics, and Nanotechnologies (GREMAN), University of Tours/CNRS/INSA-CVL.

For MATEX, she is particularly in charge of international relations.

Her secret: making materials like she cooks, with passion!



Anne-Lise Thomann

She is a research director at the Research Group on the Energetics of Ionized Media (GREMI), CNRS/University of Orléans.

For MATEX, she is particularly in charge of the instrumental park.

Her secret: explaining science to children and especially cultivating their critical thinking!

Caroline Vignolle-Andreazza

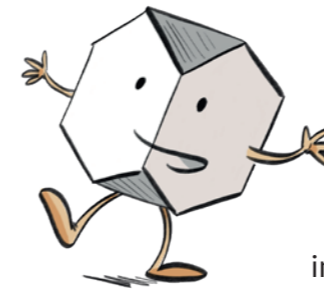
She is a university professor at the Laboratory for Interfaces, Confinement, Materials, and Nanostructures (ICMN), CNRS/University of Orléans.

For MATEX, she is particularly in charge of training.

Her secret: diving into her microscope to explore the infinitesimally small!



Presentation of the Other Characters:



Poly

The mascot of MATEX!

It represents all the materials that can be studied in this project: alloy, polymer, elastomer, glass, ceramic, etc.

It's a truncated tetrahedral shape often found in the intimate structure of materials, such as the native form of common glass structures.

Knowledge

The scientific knowledge, the essential ingredient of any good project like MATEX.

Its superpower? Creating rainbows when it absorbs researchers' ideas.

However, it has an annoying tendency to mess up the hair of those who learn!



Nancement

Her name is a play on words in French, « la Fée Nancement », Nancement fairy, for « Financement », because she finances MATEX. It symbolizes the Centre-Val de Loire region. It supports MATEX as part of its Ambition Research and Development (ARD) program.

Since 2014, the Centre-Val de Loire region has been strengthening its research and development skills with a clear ambition: to provide new answers to major socio-economic development and environmental urgency issues, for the benefit of the region's inhabitants and businesses.





Appendix

Page 5

Regional funding: To work on certain research topics, researchers must secure funding for small and large equipment, consumables, etc. Proposals are written and submitted to various funders throughout the year. Local governments, like the Centre-Val de Loire region for MATEX, can finance this type of research.

Page 6

Multimaterials: These are assemblies of materials (metal, rubber, glass, etc.) with very different properties. Each material brings its own «superpower,» and together, they can even acquire new properties that allow for the creation of new applications or the improvement of existing ones.

Extreme conditions: These are scenarios where a material is subjected to significant stress, such as exposure to high heat, being run over by a car, or operating in a hostile environment (under high pressure, in radioactive settings, in intense magnetic fields, etc.). Scientists test these materials by subjecting them to various constraints to ensure they can withstand such conditions. Among extreme conditions you can find very high or very low temperatures or pressures, laser, plasma, or UV radiation, material aging or fatigue, corrosion, etc.

Page 7

Cutting-edge instruments: MATEX has a collection of more than 200 cutting-edge instruments available in laboratories or technological resource centers that may interest industrial partners. The goal is to provide current or future partners with privileged access to these research tools and to address the challenges of multimaterials in extreme conditions by leveraging the expertise gathered within MATEX.

More information on: www.ard-matex.fr/industrial-park.html

To discover the instruments: www.youtube.com/@ARDMATEX (in french)

Composition: These are the chemical elements that make up a material. In the lab, scientists can identify them separately and determine their respective proportions and sometimes their distribution within the material.

Molecular structure: Scientists seek to understand how these ingredients are positioned relative to each other, like bones in a dinosaur skeleton!

Page 8

Piezoelectric component: A material that generates electricity when compressed or deformed when an electric current is applied. It is widely used in cars, and if you have a watch, it likely contains this type of material!

Ceramic: A broad family of materials that includes clay-based pottery, bricks, tiles, cinder blocks, porcelains, and glass, as well as highly technical materials (carbides, nitrides, oxides) that are all known for their ability to withstand high temperatures. These materials are called refractory. They are used in industrial furnace materials or even in protective tiles for space shuttles.

Lead: A chemical element abundant in the Earth's crust, used since the Bronze Age (2700 BC) to build pipes or stained glass, for example! However, it has since been discovered to be toxic to nature and humans, which is why alternatives are being sought for all its common uses.

Page 9

Molten salt solution: A molten salt is one that has been heated to its liquid phase. Table salt, which is primarily composed of sodium chloride (NaCl), has entirely different properties when molten. This is also true for chlorides and fluorides used for metal production, like aluminum by electrolysis in molten salts, or nitrates used in solar power plants for heat storage.

Anode and cathode: These are the two poles of a battery. Electrons that make up the current flow from the anode to the cathode. In electrochemistry, the anode is the battery's negative pole (-), and the cathode is the positive pole (+).

Training programs: The training programs identified in MATEX and offered by higher education and research institutions in Centre-Val de Loire come in three types: initial training for students and continuing education for those already working. Numerous training programs are available to students, ranging from the University Bachelor's Technology to engineering cycles, including Bachelor's, Master's, and Ph.D. programs. These programs can also be offered through work-study, combining academic and professional training with professionalization and apprenticeship contracts.

For more information: www.ard-matex.fr

Page 10

PhD student: They are students who are preparing a thesis. The thesis is a degree, completed over 3 years, that can be obtained at universities in France (abroad, this degree is called a PhD). One can begin a thesis after 4-5 initial years of study. PhD students work in research laboratories, where they «work» and receive a salary! Their thesis topic, which is very specialized, contributes to the advancement of research and allows them to become future competent researchers who can be recruited by an academic laboratory or in research and development at an industrial company! PhD students can also share their time between an academic laboratory and an R&D (research and development) lab of a company. The contract, slightly different, is then called a CIFRE for «Convention industrielle de formation par la recherche» (Industrial Agreement for Training through Research).

To learn more: www.youtube.com/@ARDMATEX (in french)

Page 12

Partnerships with the industrial world: A «club of industrials» has been created for MATEX, serving as a platform to share ideas, confront experiences, and above all, to unite forces and strengthen ties with the academic world to enable a more innovative and sustainable industry in the field of multimaterials under extreme conditions.

Pour en savoir plus : www.ard-matex.fr/industrial-club.html

The 16 research projects: All of these research projects funded by the Centre-Val de Loire Region as part of MATEX involve researchers from laboratories working with a company. The intended applications in these projects are numerous and varied, covering fields such as transportation (space, automotive, aeronautics), energy, luxury, medical, etc. The projects aim to improve people's daily lives, reduce the need for natural resources, replace pollutants, imagine innovative objects, find solutions to energy needs, etc.

More information on: www.ard-matex.fr/scientific-projects.html

Page 13

Hologram: It's a 3D photograph with depth! The image, which appears to be floating in the air, is produced using powerful lasers that «holograph» the object to create a duplicate of the exact same size.

Hologram transducer: It's like a video projector that allows the reconstruction of a hologram in space from the data of the object you want to see appear.



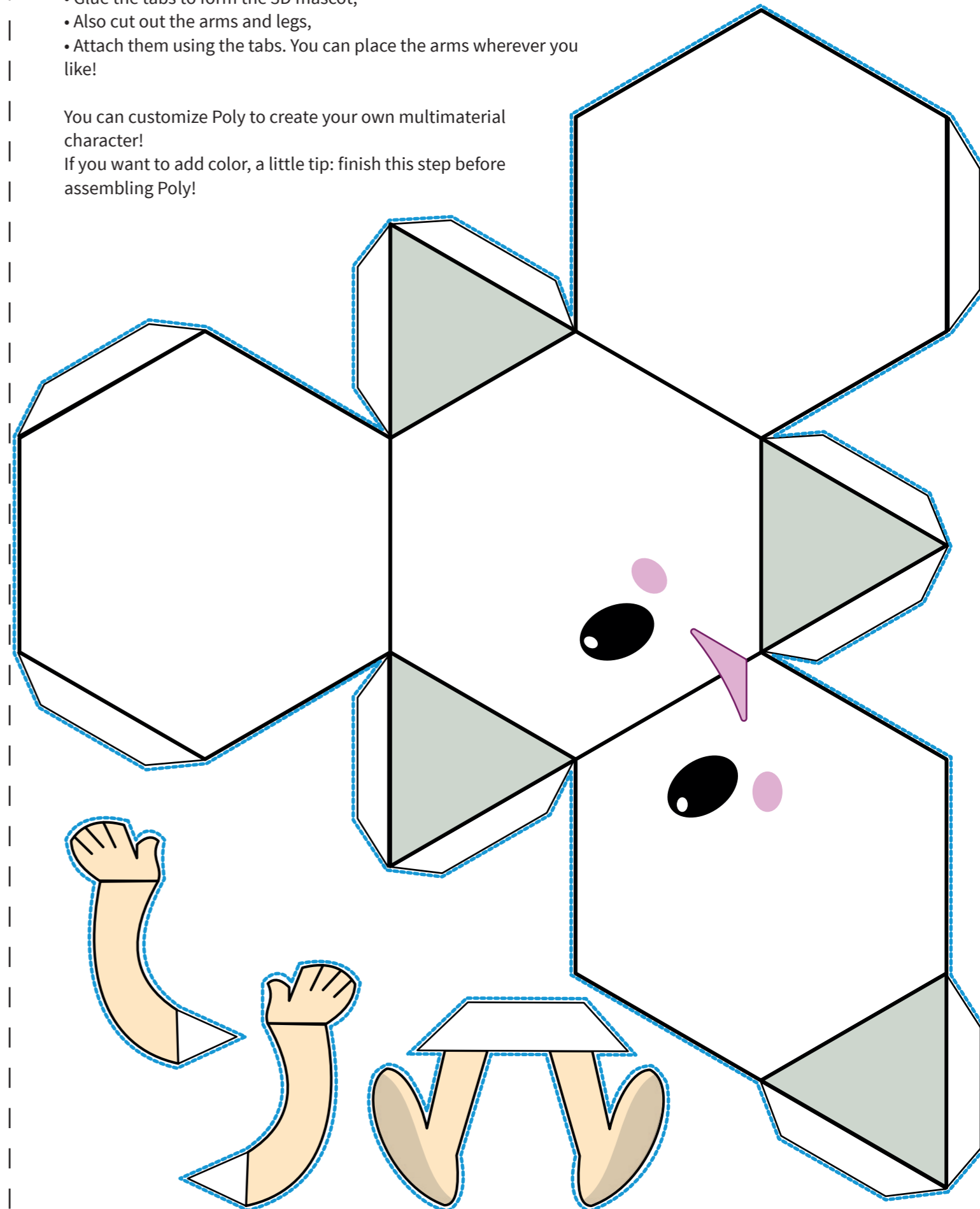
Poly template to cut out. Instructions:

Start by removing the sheet from the comic. Then:

- Cut out the Poly template by following the lines along the blue outline,
- Glue the tabs to form the 3D mascot,
- Also cut out the arms and legs,
- Attach them using the tabs. You can place the arms wherever you like!

You can customize Poly to create your own multimaterial character!

If you want to add color, a little tip: finish this step before assembling Poly!



Story and illustrations: Anne Bernardi - notescroques@gmail.com - www.vivredudessin.com

Contributors: Catherine Bessada, Isabelle Monot-Laffez, Anne-Lise Thomann et Caroline Vignolle-Andreazza

Project oversight: Marie-Laure Thurier - CNRS

Scientific committee: Louis Hennet, Nadia Pellerin, Marjorie Roulet et Élodie Salager

English translation of comic strips: students from the Maurice Genevoix high school in Ingré (45)

Other pages translation: Lucie Pigeon - CNRS

CNRS - 2024



IS FINANCED BY THE CENTRE-VAL DE LOIRE REGION AS PART OF ITS
AMBITION RESEARCH AND DEVELOPMENT SYSTEM

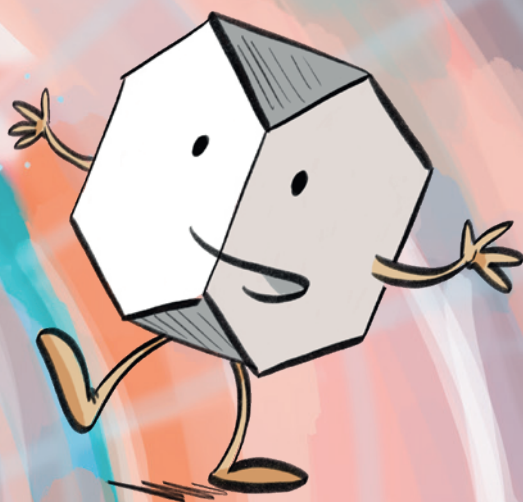


RESEARCH LABORATORIES



PARTNERS





Poly

Extreme journey to the heart of multimaterials

Poly is a strange little character, straight out of a research project on multimaterials in extreme conditions. Curious, he asks lots of questions to understand why he's there and sets out to explore the different aspects of research today with the help of the project leaders. In addition to discovering the many instruments used by scientists, he meets Knowledge and Nancement, takes a stroll through the laboratories in Centre-Val de Loire, and encounters all the research actors and industrial partners.

After undergoing various transformations, he contributes to research and becomes useful to society.