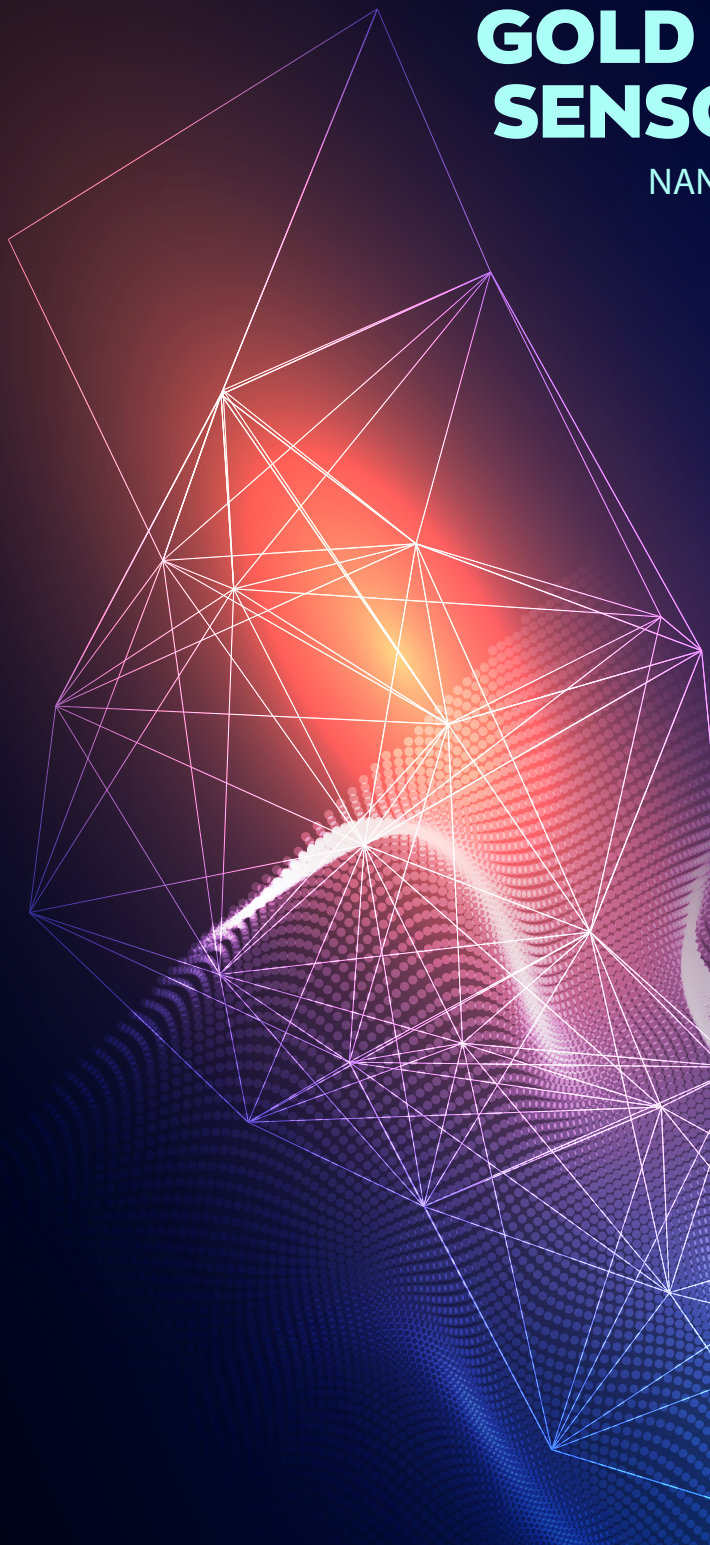
GOLD NANOPRISMS FOR SENSOR DEVELOPMENT

NANOSCIENCE SCENIC ARTS MANUAL

TEACHER'S WORKBOOK



UREK Art

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EUREKArt
Gold Nanoprisms

IN THIS WORKBOOK:

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EUREKArt

EXPLORING NANOSCIENCE

EurekArt is an innovative Erasmus+ educational project developed to promote and increase societal **scientific knowledge** among students aged 12 through 16. It provides broad social value through an educational synergy between the **visual and performing arts** framed by cutting edge research in nanotechnology.

EurekArt aims to **generate connections** between different areas of education by means of the following actions:

- Encourage and develop **students' curiosity** about the process that leads from creativity to **culture creation**.
- Develop an interest in **scientific knowledge** with social value through an educational synergy between the **visual and performing arts** together with nanotechnology.
- Develop **innovative practices** in the field of education, by combining performing and plastic arts with nanotechnology.
- Provide young adults with the necessary **tools** and **skills** to find creative and innovative solutions that allow them to face unprecedented social risks and challenges.

Furthermore, it provides **useful tools for teachers who want to use the scenic and plastic arts in their school teaching curriculum**.

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ed objectives

CONNECTING TO SCHOOLS

This workbook contains a series of exercises to teach topics such as nanotechnology and nanoparticles to young students by using a scenic arts approach. Here we focus on **Gold Nanoprisms**. In order to make our approach more exciting and useful, we will also suggest some soft skills and story writing exercises. This way the students will access this material from a multidimensional approach for a well rounded experience. More specifically, we will explore:

Scientific content

The topics treated in this worksheet will link to a school science curriculum. More specifically, students will touch upon the topic of **periodic table, precious metals, astrophysics, economics, medical issues.**

Creating connections

Research on Gold Nanoparticles is extremely active. They are used in the construction of bio-sensors for all kinds of diseases, ranging from cancers to Covid-19. What is usually seen as a precious metal can be even more precious when applied to health issues.

Soft Skills

Students will learn skills linked to **teamwork, public speaking** and **storytelling** during their work of co-creation of knowledge. Group activities will improve **critical thinking** and **negotiation** skills while enabling students to discover deeper meaning of the scientific topic.

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instructions

TEACHERS BECOME GUIDES

This activity has been created **for the teachers of every subject,** to allow them to introduce the topic of **Gold Nanoprisms** connecting this issue to the school curriculum and at the same time to society.

At the heart of our approach is the idea that the students should find **ways to connect their own universes to each topic with a creative attitude,** while getting a general understanding of the science behind it. We propose that the teachers guide the students through a series of exercises where the students become **explorers,** taking a **voyage of discovery.** Teachers will also explore the topics with the students and **gain a potentially new awareness** around how such topics impact society and they will also learn a **new teaching technique.**

The approach we have used is that of **informal learning** where students don't face a typical frontal lesson, but they access the topics through a **learn-by-doing** approach.

Although being a science teacher could be useful when giving students some basic information about nanoscience, **teachers don't need to be science experts**: EurekArt is an **interdisciplinary project.** Students will be doing their own research to find scientific information and when the moment to write their stories comes, humanities teachers could find themselves in the right place.

What teachers really **must have** is an **open mind**! In the **Soft Skills workbook** teachers will find tips and exercises to give students (and themselves) a set of tools to begin their nanoscientific journey with.

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If you haven't read it yet, **start with the Soft Skills** workbook and decide which of the proposed activities would benefit the most for you and your students. Then **come back to this workbook** to get your hands dirty with nanoparticles!

TIMELINE OF THE PROJECT

To explore nanoscience through the lens of scenic arts requires several meetings with the students because of all the different aspects involved in the project. Here we suggest a possible path, but **teachers can personalise EurekArt**: change the order of the meetings, choose only the ones they need, or share the load with colleagues who teach different subjects, to make sure interdisciplinarity is on the plate.

Suggested meetings (maximum 10 hours):

- Soft skills on scenic arts (1 to 3 h): especially needed if the students come from different classes and/or the teacher is not familiar with theatrical approaches or storytelling techniques;
- The hero's journey (1 h): brief frontal lesson or video resources;
- Introduction to nanoscience (1 hour): go through the proposed keywords, background and curiosities and make research on what you want to know better;
- Scenic arts and nanoscience (1 to 2 h): physical embodiment of the scientific concepts to better understand them and... have fun!
- Story writing (1 h): recap on storytelling, analysing a famous story and collectively improvising a new one, plus giving the assignment of writing a story;
- Story reading (1 to 2 h): students read their stories to teachers and peers and get feedback. This meeting can be repeated multiple times to read the stories improved by the feedback.

Please note that when **introducing Nanoscience** to your class, you will only use **background** and **curiosities** sections of this workbook.

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The purpose is to **engage the students** around the topic. Then you can ask them to **search online** for some **keywords**, and discuss with them the meaning of what they found, using the content of the **keywords** section of the workbook as a backup.

It is important for the students to **learn how to make a research online** on their own and to understand that some **sources** are reliable, while some others are not. Later on, when they'll be writing their stories, they will have to search for proper sources of scientific knowledge. You could even ask them to take notes of the sources they consulted. It's a good exercise of **scientific citizenship**!

The suggested meetings are very important to give the students a sense of direction towards a goal, but after they receive their assignment, is fundamental that they can **count on the teacher(s) to ask for any clarification**. Make sure they know you will guide them in their research of information or with developing a good story. Teachers should make themselves available at least once to check in with the students on the developing of their work.

Remember that, for a student, the **most difficult** part of scientific story writing is... **science**! They may write a beautiful story but forget to make science an important part of it, or the other way round: they might write a complete explanation of a phenomenon but little to no plot. Be patient. Give them feedback on how to make their story shine and **get ready to be amazed** by your students' creativity.

The workbooks and the video resources on the EurekArt website contain everything you need to follow this path, but it's important that teachers feel free to change, modify and hack the proposed exercises. Nothing is written in stone! Depending on the class size and disposition, teachers can choose whether to make students work independently or in groups, explore variations of the exercises or even **invent brand new ones**!

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our journey

WE ARE THE HEROES!

EurekArt is a **journey of discovery** that teachers and students undertake together.

As stated in the **Soft Skills Workbook**, our adventure needs some basic ingredients: the **HERO**, who is the main character, a **COMPLICATION** to overcome, the **TRIALS** needed to overcome it and the **SOLUTION** to the complication. At the end of the story the hero learns an important lesson about life that s/he is ready to share with the world. We call this the **ELIXIR**!

In EurekArt, **we are the heroes**!

We face the **complication** of having to deal with new knowledge: **keywords**, **background** and **curiosities** on nanoscience could easily scare us. That's some hot stuff!

Now we have to tackle the problem with some **trials**, so we take **action**. We embody the nanoparticles to better understand the processes of deterioration and protection of our tangible cultural items. Our last, but finally successful action is **story writing**, which leads us to the **elixir**: we learn that the new knowledge we were facing can be part of our lives and we are proud to tell the world our stories.

EurekArt involves **performing arts** to promote **knowledge** and skills in **scientific areas** by influencing domains of **cognition** and **motivation**.

Let the journey begin!

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background

UNDERSTANDING IS POWER

STORY BEHIND THIS TOPIC

It would be great that when you go to a medical appointment, the clinician was able to take a drop of your blood or a sample of your saliva and check immediately with a quick test if there is something wrong (an infection, a marker of a disease, etc). Getting quick results would be extremely helpful in medicine practice. The biggest problem is that frequently, the molecules we want to detect are scarce, making it difficult to identify them.

Gold nanoparticles can act as amplifiers of the molecules that we want to detect, as a flare to call our attention.

CONNECTION TO SOCIETY

Gold nanoprisms are real gold nanoparticles that are not used for their esthetic of economic value, but because they are quite useful for medical purposes. So maybe we should start saving up on gold before it becomes a scarce commodity! Point-of-care testing (POCT) is widely used for early diagnosis and monitoring of diseases, where the lateral flow assay (LFA) is one of the most successful commercial tools for POCT. Gold nanoparticles play a key role in this by assisting the development of smart sensors and detection agents where their high surface-to-volume ratio and unique optical properties facilitates the development of high sensitivity analytical bio-sensing tools.

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curiosities

COOL THINGS TO KNOW

Gold is really a precious metal but most of us don't really know much about it. So here are some cool curiosities:

Periodic Table

Gold fits the 79 position in the Periodic Table, close to Mercury (atomic number 80) and Lead (atomic number 82). These are all quite a heavy elements, with high atomic masses. The symbol is "Au" that comes from "Aurum" the Latin word for Gold.

Where was Gold generated?

While nuclear fusion within the Sun makes many elements, the Sun cannot synthesize gold. The considerable energy required to make gold only occurs when stars explode in a supernova or when neutron stars collide. So gold is produced in these very special circumstances!

How and when did gold end up on Earth?

Ultra high precision analyses of some of the oldest rock samples on Earth by researchers at the University of Bristol in the U.K. has provided evidence that the planet's accessible reserves of gold are the result of a bombardment of meteorites more than 200 million years after Earth was formed.

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How much Gold has been found so far on Earth?

About 244,000 metric tons of gold has been discovered to date. Most of that gold has come from just four countries: China, Australia, South Africa and the United States. All of the gold discovered thus far would fit in a cube that is 28 meters wide on every side.

Most of the gold goes into the manufacture of jewelry, but gold is also an essential industrial metal that performs critical functions in computers, communications equipment, spacecraft, jet aircraft engines, and a host of other products and of course Gold Nanoprisms!

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keywords

LET'S TEACH SOME TERMINOLOGY

Lateral flow assay

Lateral flow assays are diagnostic devices that allow us to detect specific substances. The most commonly known lateral flow assays are the pregnancy test or the COVID-19 antigen test. They consist of a nitrocellulose membrane, through which a liquid containing the substance we want to detect travels until the control and test lines are reached. The molecule we want to analyze will then be captured by specific molecules located in the control and test lines, resulting in a coloured signal that informs of a given result.

POCT - Point of Care Testing

Also known as bedside testing, involves any type of diagnostic test that isn't done in the laboratory.

Gold nanoparticles

Gold nanoparticles are particles made from gold(0) atoms, not the same as shiny gold(III) which is usually yellow or red coloured. They have a diameter between 1 and 100 nm which, once dispersed in water, are also known as colloidal gold.

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Colloidal suspension

Is a mixture in which one substance of microscopically dispersed insoluble particles are suspended in another substance, most often a liquid.

Sensor

Is a device that has a property which is sensitive to a magnitude of the medium, such as temperature or light. This property can change with a certain intensity if the magnitude changes, allowing it to be measured.

Gold Nanoprisms

Triangular shaped gold nanoparticles.

Bio-sensor

A biosensor is an instrument used to measure biological or chemical analytes or parameters. It usually combines a component of a biological nature (such as a protein, and enzyme or DNA) which acts as a receptor and another material (like graphene or a nanoparticle) which acts as a transducer, because its physico-chemical response to binding can be measured (detection).

Biomarker

It is a measurable indicator of some biological state or condition. Biomarkers are often measured and evaluated using blood, urine, or soft tissues.

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actions

LEARNING BY DOING

Basic philosophy of these exercises

Through movements, actions and **personification of scientific ideas** and pretend-embodiment, the students will get a sense for nanoscience. They will also experience the power of **metaphors** making it easier to use them in their storytelling exercise. Moreover, this is a powerful **team building** activity, especially with students from different classes. Here we will work on **Gold Nanoprisms**!

Exercise 1 - Creating Gold

location: empty room/ free space

Gold is created in some really ferocious nuclear reactions when neutron stars merge. So, let's try to see how this can happen: How many people can you squeeze in a squared meter? Draw a squared meter on the floor (use some paper tape, it's easier). Let's split the class into two groups. Now, one by one the students try to fit within the squared meter. How many can you fit? Which group will win? The group that wins has created gold!

Now try with... Lead... how about Uranium?

Note: paper tape or chalk needed

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Exercise 2 - The periodic table

location: empty room/ free space

Chemical elements are positioned on the periodic table in order of increasing number of protons in their nuclei. Roughly speaking, heavier elements are to be found at the bottom of the table, while lighter elements are on top. The same thing applies for atomic radius, with "smaller" elements at the top of the table, and "bigger" ones at the bottom. Gold is number 79 of about 120 elements.

So, now we make our own periodic table: at the clap of the teacher, the students must position themselves in order of height!

What about age?

What other schemes can you think of? (hint: date of birth, hair colour, shoe size, alphabetical order, etc....)

Exercise 3 - Sensor

location: the whole school

Let's play a game where students become sensors... one of the students – the detector – goes out of the room, the others are in a circle, a leader is chosen and all repeat the same cyclical movement following the leader. When the leader changes movement, everybody must change accordingly. Changes must be subtle! The task of the detector is to identify the leader, the task of the leader is not to be identified and everybody else must help the leader in their task. It all has to happen within a given time, or maybe the length of a song.

Once the detector identifies the leader, the leader becomes the new detector.

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story writing

SCIENCE IN STORY

Finding the Hero
Now it's time for the students to **write their own story**, exploring the scientific topic of **Gold Nanoprisms**. Going from physical embodiment of nanoparticles to story writing seems like a big jump, but it's easier than you could think!.

At first you can **analyse together a story everybody knows** and look for the elements of the **hero's journey**: status quo, complication, trials, solution and elixir. A good **example**, containing unexpectedly accurate science, is *Finding Nemo*. Let the students help you **go through the plot**, step by step, and guess what's true or fiction. Then check the answers online: do turtles migrate? Do clown fishes live in anemones? And so on. Of course you can use other examples. Point out the difference between a fiction based on actual science, like *Gattaca* or *Interstellar*, and a pure science-fiction, like *Transformers*.

The next step is more creative: **inventing a collective improvised story**. One after the other, in a circle, each student will tell a bit of a story, starting with the status quo and getting to the elixir. It's an **experiment**, so you will have to **guide** them through each step, giving them **hints** like "who is the hero?", "now we need a complication" and so forth, until the story ends. Was it too easy? Let's take the game to the next level: **a story about science**!

Students will have to work autonomously: choose a hero, invent a plot and find online reliable sources of contents about nanoscience. Teachers can guide them, but students have to do the job!

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Gold for health?

Gold was created in neutron-stars explosions. Just recently (2017) gravitational wave detectors in Italy (VIRGO) and in the US (LIGO) have made it possible to triangulate on a merger of two neutron stars, where astronomers have seen the creation of gold. That is incredible... gold was made possible by huge cataclysmic events, and now we use it to probe the human body for diseases.

So, why not ask the students to reflect upon these issues and **write a story** about the possible uses of gold? They will work in **small groups** and could even use **different artistic expressions**, if they feel more inclined to **music**, for example, or **painting**, or making a **graphic novel** or an entire story with **memes**. As long as their creation contains all the basic steps of the hero's journey, it's a story!

If the students are stuck, here's a possible start: "an astronomer witnesses the creation of gold in some far away galaxy, and **considers gold to be sacred**. S/he is quite a fundamentalist, fiercely opposed to the commercial use of gold because it is such a precious element... but then their son becomes sick. Nobody can understand what is the disease so doctors suggest Point-of-care testing (POCT) with gold nanoparticles. S/he is confused because gold is sacred! A doctor will explain the details of the process to them and s/he will have to decide whether to accept that commercial use of precious compounds is possible, in some cases." **What will s/he decide? How will the story go?**

Once the students have finished creating the story, why not **share** it with the class? Instruct the students to read it aloud if they wrote it, or present their artistic creation to the rest of the group. If they feel very adventurous, why not **try to act it out**?

With the **feedback** from their peers they'll see if what they wanted to say actually went through. If it did, they found the **elixir**!

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the elixir

YOU ARE THE HERO

What did I learn from this experience?

Teachers and students should dedicate some time to understand what lesson they are taking home from this experience. Just like the protagonist of any story at the end goes back to their world with an "elixir", so should the **teachers** and the **students**. After all, they **are the protagonists of their own stories**!

Let's ask the students these questions: ***if you were to explain to a friend what Gold Nanoprisms are, why are they important and what they are useful for, how would you do it? What would you say?***

Also, let's think about our journey, and ask the students: ***Did you find that telling a story about nanoscience could be easier than explaining in scientific terms what nanoscience is? Did you find it engaging? Did you like to use storytelling to explain science?***

Now, **let's ask ourselves the same questions**!

Note: if you have any comments or suggestions regarding this workbook and the exercises and tasks included in it, please don't hesitate to contact us at *direzione@arditodesio.org*

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