AMBER
Advancing Materials for Impact

Materials Science, Literacy and Art for 4 – 8 year olds

SUNPILOT

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General Introduction - teaching materials science through inquiry, literacy and drama

Materials science is everywhere and, although often taken for granted, it plays an essential role in our lives. From mobile phones and batteries, to water bottles and coffee cups, we use engineered materials everyday. The AMBER Education programmes are designed to introduce students to the world of materials science and the scientists that are advancing our understanding of these materials as they work toward making our world a better place through innovation and engineering. We have developed programmes from infants class through 6th class that support teachers and students as they discover, engage with and investigate materials and their properties in unique and interesting ways.

This resource focuses on how scientists working on the Horizon 2020 EU project, SunPilot, investigate properties taking inspiration from the plants and animals around us to make better materials for our everyday use. This process is called biomimicry and can be gently introduced to young learners by having them learn about plants and animals and investigate specific properties of nature and materials.

This resource focuses on integration of science lessons with literacy, drama, and design and make; developing children's skills in working scientifically, while also meeting literacy and drama objectives. The modules provide teachers with a framework to build a narrative with young learners, with the express objective of developing oral language skills, cooperation, art, design, and STEM learning.

The approach for each module is to keep the lessons student-centred and inquiry based. Scientific investigations are embedded into experiential learning and integrated with drama, storytelling, and literacy. The lessons are developed as a sequence of activities and discussions, which ultimately lead students toward a better understanding of materials and nature of science.

Each module comes with background knowledge for the teacher, comprehensive lesson plans which include learning objectives and curriculum links, pointers towards assessment and supporting material, ia power point, relevant images, templates and video. Any additional materials suggested in this programme are easy to source and safe for children to use.

Teaching nanoscience to young learners

Nanoscience is about studying how materials behave at a very small scale. A nanometre is one millionth the size of a millimetre. Structures that small (nanostructures) have unique and special properties that we can use to make anti-reflective screens, waterproof and dirt-proof clothes, and much more. These applications of nanoscience are our starting point. All children can relate to the challenge of seeing a phone or tablet screen in sunlight. While it might be useful for you, as teacher, to have an awareness of the size of nanomaterials, this can be challenging for young children. Instead we focus on the properties as of materials and draw on imaginative activities to think about how these materials can be used in their lives. This resource brings to life the practice of materials and nano science, and how it impacts' on our lives.

In nature, nanostructures give certain animals and plants different properties; the colour of a butterfly's wing, the waterproofness of a leaf, both are properties associated with nanostructures on the wing and leaf. In turn, materials scientists and engineers have observed these sought after properties (colour and waterproofness in this case) and investigated how to recreate these structures using man-made materials in a lab. This is called biomimicry - mimicking what we find in nature.

By allowing children to investigate different properties found in nature, learn about the plants and animals that show these properties and discover how we use these properties to advance our technology and make our lives better, they can begin to understand science, nano and materials science in a non-threatening way. This initial introduction can be the foundation for a spiral curricular approach to learning about nanoscience using AMBER resources.

Programme Outline

Two modules have been developed: **Module 1** for infants classes, **Module 2** for 1st – 2nd class.

Each module contains three lessons, with each lesson building from the experiences in the previous lesson. The key experiences associated with each lesson are:

- Building Understanding through scientific inquiry

- Building Empathy through drama and story telling and

- Building Ideas - design and make.

Each Module is briefly described below with background information to provide context.

Module 1: Theme - Staying dry and keeping clean [4 – 6 yrs old]

Background information:

Some materials we use every day are waterproof and others absorb water. To encourage children's inquiry, these concepts are placed in the context of natural and -man-made material. Students will sort, predict, and investigate the properties of waterproof material. They will also consider that if it is waterproof – it is much easier to clean.

Some animals and plants that exhibit the wet/dry properties. Specifically, in this module we look at the differences between a cat, duck and lilypad.

Ducks and lilypads both have small nanostructures which make their feathers and leaves repel water (and mud). A duck's bill has little teeth (like a comb) which they use to keep their feathers aligned so the structures are oriented correctly and maintain their waterproofness. In addition, ducks spread an oil through their feathers to keep the feather supple and to help maintain the feather structures. This oil is at the base of their tail; ducks spread it all over their feathers. Both of these make duck feathers very waterproof. Combing out their feathers and keeping them covered in oil is called 'preening'.

For infants and junior classes it is enough for the children to understand that the special shape of feathers allows them to be waterproof. Cats, on the other hand, do not have this property and are notoriously unhappy in water (although there are exceptions). A cat will get soaked to the skin if in water, while a duck will stay dry.

Note: in this lesson we have the cat and duck become friends and try to play together. Cats are generally smaller than ducks and can live together very well (think of farm animals). Although cats may eat some small song birds they eat animals the size of mice, they will not eat ducks.

Scientists look to nature to see what features and properties of natural materials may benefit us and if there is a way to recreate those properties using technology. This is the case for waterproof material. This approach to using nature for technological advances is called biomimicry – mimicking what we find in nature. There are many advances on this technological front and this is a good way to introduce students to the idea of design thinking and design and make. For infants and junior classes, introducing the concept of biomimicry and having them see how nature can inform technology is a great way for getting them to think about the purpose behind design and make activities.

Module 2: Theme Colour and light in the day and night [6 – 8 yrs old]

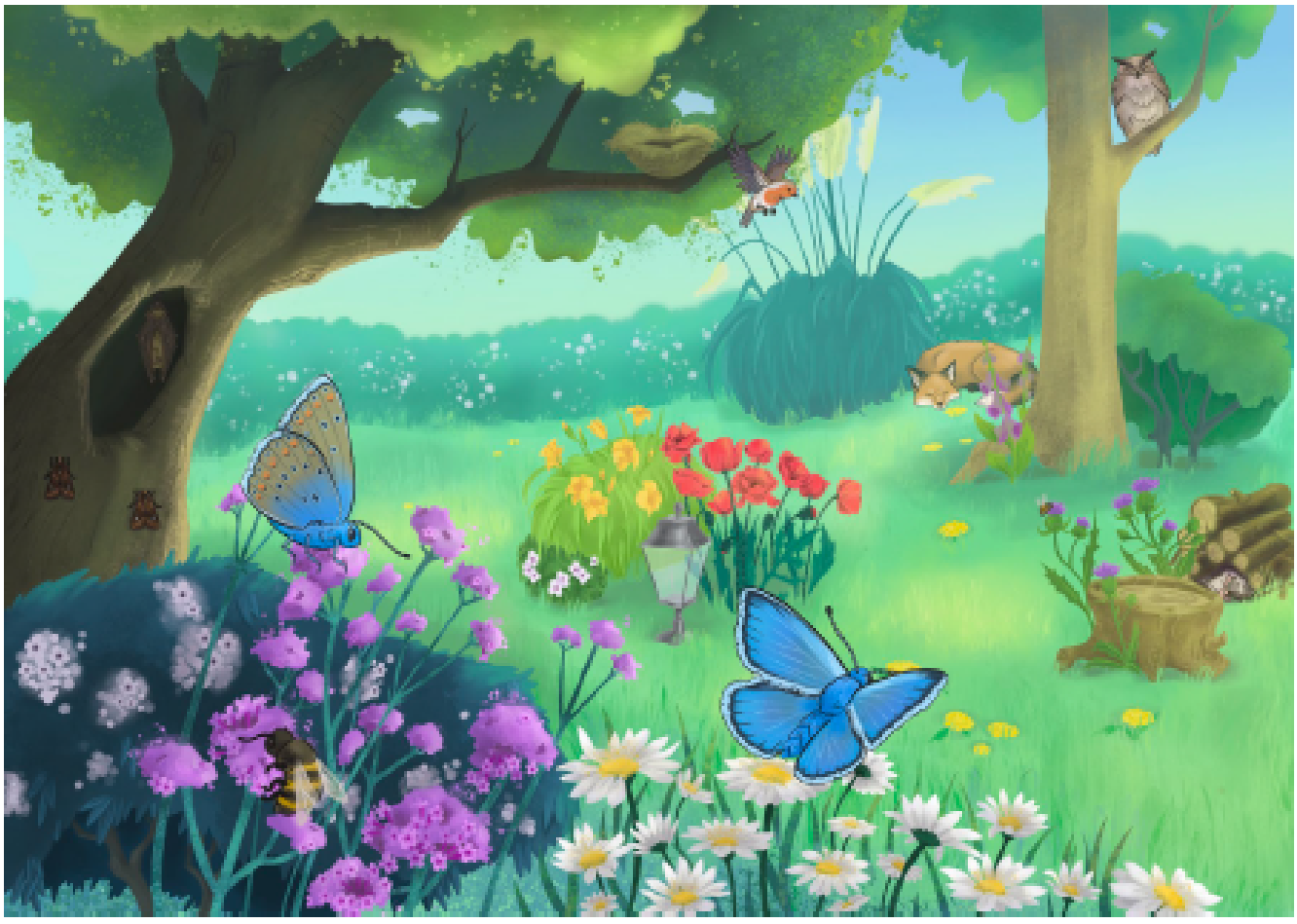
Background information:

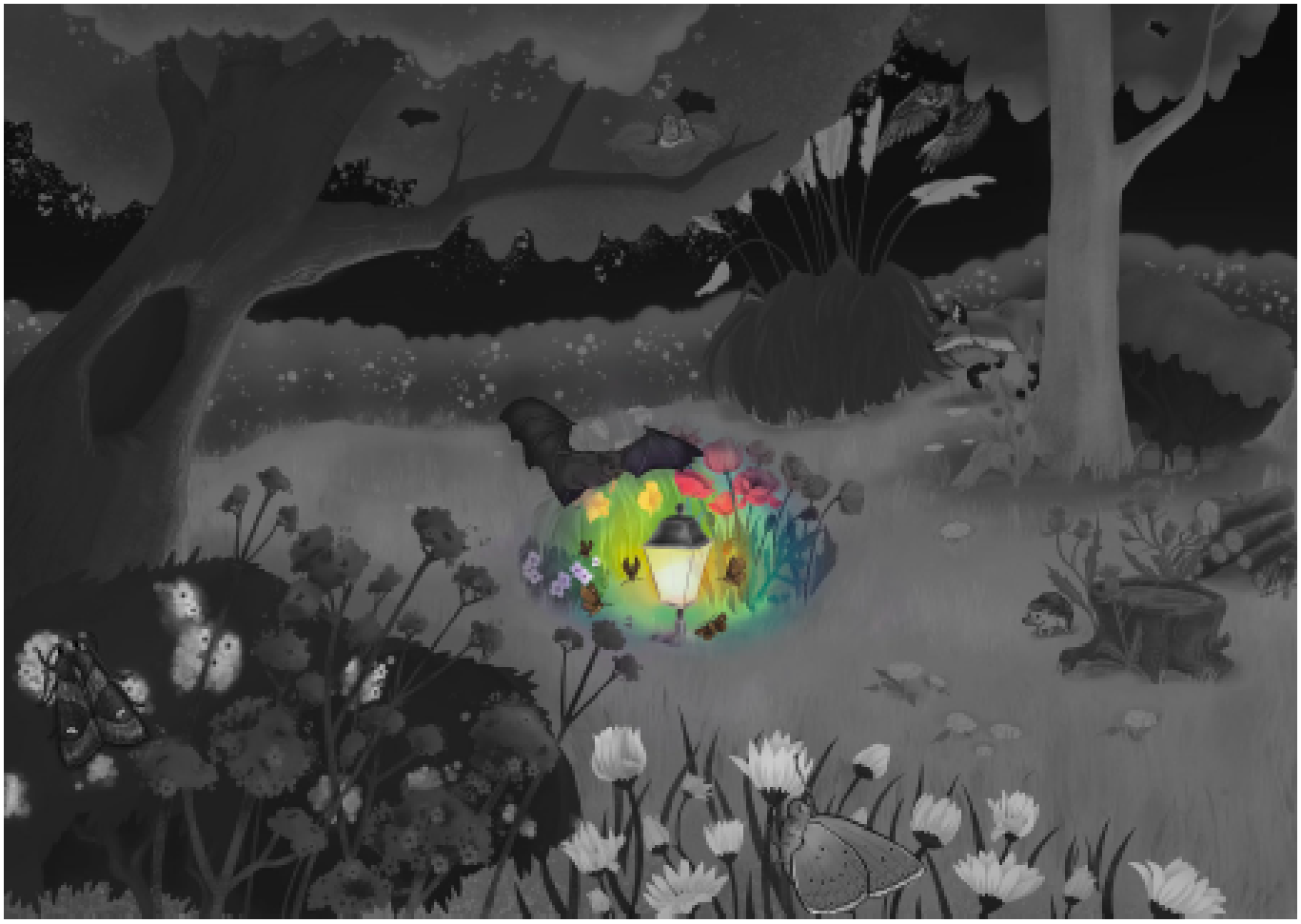
This module considers the effects of light on reflective and nonreflective surfaces and investigates the idea of seeing at night versus during the day. Students are introduced to the concept of daytime and night time animals and learns about the Common rustic moth and European common blue butterfly. Characteristics of these animals associated with nanostructures that materials scientists are investigating will be examined. Background for you the teacher is provided below, followed by a breakdown of each lesson within the module and overarching learning outcomes.

At night, when light levels are low, we cannot detect colour and only see in shades of grey. There are two reasons for this:

1. Colour receptors in our eyes (called cones) need a certain level of light to be activated. At night, the light level is too low to stimulate our colour receptors.

2. We have non-colour receptors in our eyes for night time (called rods), these can be activated in very low light but we are only actually detecting light levels so see the shapes and 'brightness' of an object but no colour. [Rods are found mostly on the periphery of our vision, the centre of our vision is made of cones, so it is easier to look at things at night, sideways. Look at a star at night – if you look directly at it, it tends to disappear, look at it slightly off-centre and you can see it.]





Colour

Daytime animals (diurnal animals) are often brightly coloured and do not have the features associated with nightlife. The butterfly, the cousin to the moth is active in the day and is often brightly coloured and very shiny. The blue colour and the shininess (iridescence) that can be seen is not due to pigment, but due to light refraction – there are tiny nanostructures on butterflies wings which catch the light so that only the blue light colour reflects back. This is an adaptation to being diurnal; as the butterfly flaps its wings, the colour and shininess will change depending on the angle of light, this confuses predators as it becomes difficult for the predator to focus in on butterfly while they fly (that is also why butterflies flutter – more difficult for predators to 'get a lock' or anticipate where they will fly). In nature, most blue seen on feathers and insects along with any iridescence is due to light refraction and not pigment.

Animals that are active at night (nocturnal animals) might not to be very colourful for reason 1 above: There is no point in having bright colours as the light level is too low for other animals to see them, so no need to show them off! Also being darker helps an animal blend in, in the dimmer light to help with hunting or hiding. Certainly some nocturnal animals have colour and this is usually associated with camouflaging themselves while they sleep in the day or it could be part of warning or mating signals. The moth we meet in this module is a very lovely brown – but it sleeps on tree trunks so needs to blend in during the day to hide from it's predators.

Eyes

Nocturnal animals also have to be able to see well in low light, they will often have a reflective surface at the back of the eye (called the tapetum). This bounces the light back onto the receptors and amplifies the low light so they can see better at night (think about the glowing eyes of cats and dogs when light catches their eyes at night – that's the tapetum). In addition, animals that are prey (such as moths) do not want their eyes to reflect light as it might attract predators, so (although they may have a tapetum so they can see better themselves) they have antireflective nanostructures on the surface of their eyes so light does not reflect off the surface of their eyes. These structures allow the light to get into the eye but prevent most of it from bouncing back (reflect). This means the eye minimises 'glint' in light but the light is still amplified within the eye so they can see better.

Biomimicry

Scientists are developing nanomaterials by mimicking the anti-reflective nature of a moth's eye or by modifying light refraction to make colour in novel technologies. The specific animals in this module are the Common rustic moth and European common blue butterfly. They both have similar habitats and ranges.

European common blue butterfly: Polyommatus icarus; The European common blue butterfly has a wide range across Europe, North Africa and into Asia and has been spotted in North America. It prefers flowery or grassy areas and can be found in almost any grassy habitat.

Common rustic moth: Mesapamea secalis; The Common rustic moth also has a wide range across Europe, North Africa and into western Asia. It can be found in a wide range of grassy habitats including gardens, pastures, verges, heathland, and forest edges.

Look out for lesson icons

Each lesson includes:
- **resources**
- **curriculum links**
- **discussion supports**
- **activities for your class**
- **learning extension ideas**
- **assessment suggestions**

symbol	meaning
	presentation
	teacher demonstration
	student activity
	whole group wrap-up