WORKSHEET SOLUTIONS FOR TEACHERS

These worksheets are designed to accompany the 'It's on like Exciton!' games.

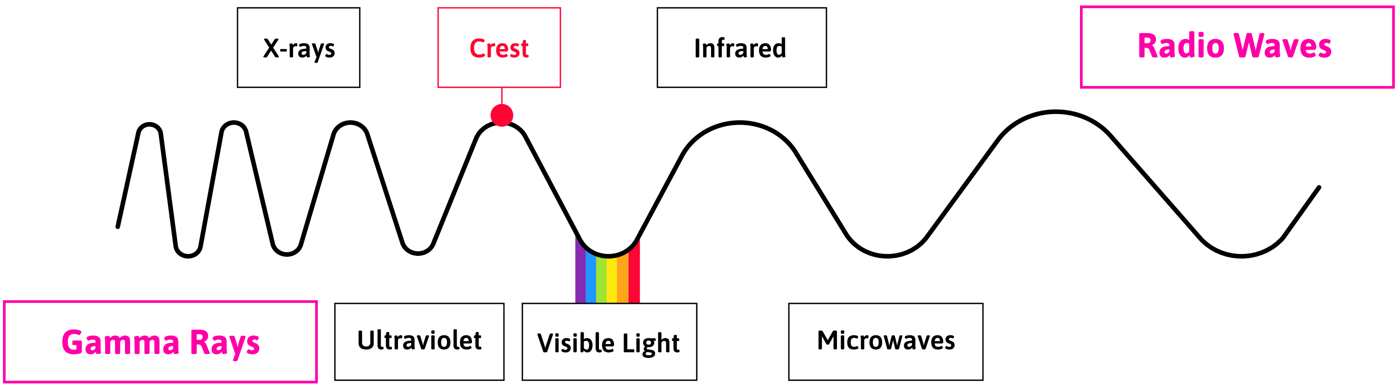
An introduction to light

At Exciton Science, understanding light and how we can use it is important for all our scientists. We design materials and devices that collect light from the sun, and we design devices that emit light using less electrical power.

So, what is light?

Light is a form of energy that exists as a wave. A packet of light is called a photon. Energy in this form is called electromagnetic radiation. Electromagnetic radiation comes in a range of wavelengths. Gamma rays have a very short wavelength but are high energy, whereas radio waves have a long wavelength and low energy. Visible light is the only type of energy that humans can see, and it sits near the centre of this range as shown below.

The electromagnetic spectrum below shows the range of wavelengths that electromagnetic radiation exists in.



QUESTION 1

Using the terms gamma rays and radio waves, fill in the two blank boxes above with labels based on where these types of energy sit on the electromagnetic spectrum.

QUESTION 2

Considering that photons with longer wavelength have lower energy and photons with shorter wavelength have higher energy, use the diagram above to complete the table below about visible light.

Shortest wavelength colour of visible light	Lowest energy colour of visible light	Highest energy colour of visible light
Violet	Red	Violet

EXCITING LASERS!

Have you played our game **Exciting Lasers!?**

In this game you need to target your energy beam to power up as many of the molecules in the laser cavity at one time as you can. This is just like in a real laser! Once a threshold amount of the molecules are at a higher energy level, a laser beam can form. Depending on the type of molecule in the laser, the colour of the laser light will change.

To investigate lasers further, here are several important definitions.

- **Monochromatic light-** Light where all photons have the same wavelength, meaning the light is made up of only one colour.
- **In phase-** Light waves travelling together with their crest (top of the wave- see page 1) in sync.
- **Coherent light-** Light in which all photons have the same wavelength (monochromatic) and are in phase.
- **Diffuse light-** Light composed of photons with varying wavelengths and that are not in phase with another.

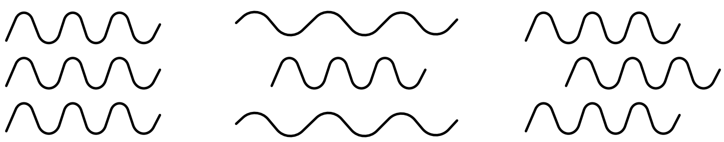
QUESTION 3

Using the definitions above, label the below sample of light each with the following number 1, 2 or 3 as aligned with the below possibilities

1. Monochromatic light that is not in phase

2. Coherent light

3. Diffuse light



2 | 3 | 1

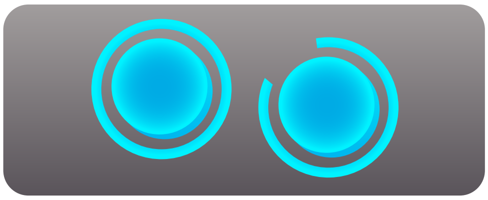
QUESTION 4

Consider the different light sources listed below and decide if these light sources are likely to be monochromatic light or diffuse light.

- **Sun light** — Diffuse
- **Laser light** — Monochromatic
- **Campfire light** — Diffuse

QUESTION 5

In Exciting Lasers! the challenge is to always energize the same type of blue molecule. Why do you think it's important that there is only one type of molecule in the laser cavity?



To create laser light it is important to energise a pure sample of molecule.

This ensures that the laser beam formed is made up of all the same wavelength and is therefore monochromatic and coherent. If many different types of molecules were in the laser cavity, then multiple different wavelengths of light would be formed and the laser beam would not be monochromatic or coherent, and hence, not a true laser.

POWER MATCH!

In our game Power Match, your mission is to match the same coloured quantum dots before the sun goes down. But what is a quantum dot?

Quantum dots- an emerging technology

Quantum dots are small crystals about one million times smaller than a 5 cent coin. As a result of their size, they are called nanoparticles.

Here are some cool facts about quantum dots

- They are fluorescent, which means they can absorb UV light and as a result, glow very brightly. This can be seen in the diagram to the right.
- Even though they are made of the same material, the size of the particle decides the colour of the glow as shown in the diagram below.
- They can be used like little antennae to catch the sun's light.
- They can be embedded into glass and Perspex to create solar windows.

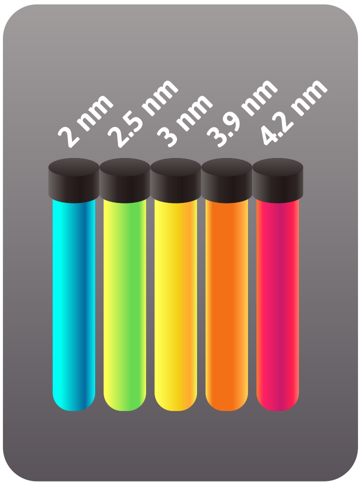


Diagram 1: CdSe quantum dots in test tubes of various sizes under UV light with approximate QD diameter labelled.

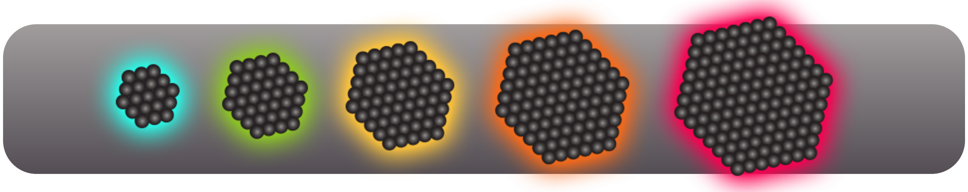


Diagram 2: A representation of quantum dots of various sizes.

QUESTION 6

Why are quantum dots appropriate to use in the collection of light from the sun specifically?

The sun contains a range of wavelengths of light, including UV light (this is what causes us to get sunburned if we are outside and exposed for too long).

Therefore, as quantum dots effectively absorb UV light, they are appropriate for use in the collection of sunlight.

QUESTION 7

In the test tube samples in diagram 1, are pure or impure samples of quantum dot sizes likely to be present and why?

Most likely pure samples of quantum dot sizes as the colours glowing from the test tubes appear to be a fairly specific or discreet in colour.

For example, this means that the test tube that glows green is filled with quantum dots that are all about the same colour and therefore size too.

QUESTION 8

Remembering what you learned about light, wavelength and colour on page 1, describe the relationship between a quantum dot's size and the energy of coloured photon is emits (or shines). Use diagram 2 to help you answer this question.

The smaller quantum dots are violet/blue in colour and the larger quantum dots are orange/red. So, the smaller the quantum dot, the shorter the wavelength of light and higher the energy of the light it emits. The larger the quantum dot, the longer the wavelength of light and the lower the energy of the light it emits.

SOLAR SLIDER

Solar Slider is a tricky problem-solving game where you need to build a solar panel, starting at the atom! Just like for our scientists, there is much trial and error, mistakes and starting again required to complete this challenge.

Why do we need to build new types of solar panels?

Unfortunately, the current commercially available solar panels that are made of silicon are

- Expensive
- Don't work when it's not sunny
- And only capture about 20% of the available light from the sun

New solar cell possibilities

At Exciton Science we are investigating the potential of many new technologies in the design of new solar cells, including

- Organic solar cells (ones made with molecules containing carbon)
- Printable and flexible solar cells
- Solar cells that can self-assemble (or build themselves)

Only about 20% of the available light from the sun is captured with commercial silicon solar panels

QUESTION 9 - Do some research

Why is it preferable to create solar cells out of organic materials?

Organic materials are those made up of carbon. They are readily available as they are found all around us.
Organic materials are also very versatile and can be changed and rearranged into many different useful structures including polymers (the long chains created in the Solar Slider game) that are flexible but still durable.
Because they are readily available, these materials also tend to be much cheaper to access and create which makes them a very attractive prospect for solar cells.

QUESTION 10 - Do some research

How could flexible and printable solar cells be used differently from existing silicon solar cells?

Current commercial solar panels made of silicon are rigid, opaque and heavy structures that need to be placed on the roofs of houses or in dedicated solar harvesting fields.
However, flexible and printable solar cells could be used in a far larger variety of settings including on building walls, windows and integrated into other devices and infrastructure. The possibilities are endless!

ACTIVITY TO DO AT HOME

Create your own self-assembling structures. All you need is 6-8 straws, a 300-700mL plastic bottle and tap water

1. Cut up the straws in equally sized pieces, approximately 3-4cm long
2. Place the straws in the bottle and fill approximately ¾ full of water. Place the lid on tightly.
3. Shake/sway the bottle gently on its side and observe the straws line up and come apart again, just like the structures that form when solar cell materials self-assemble.