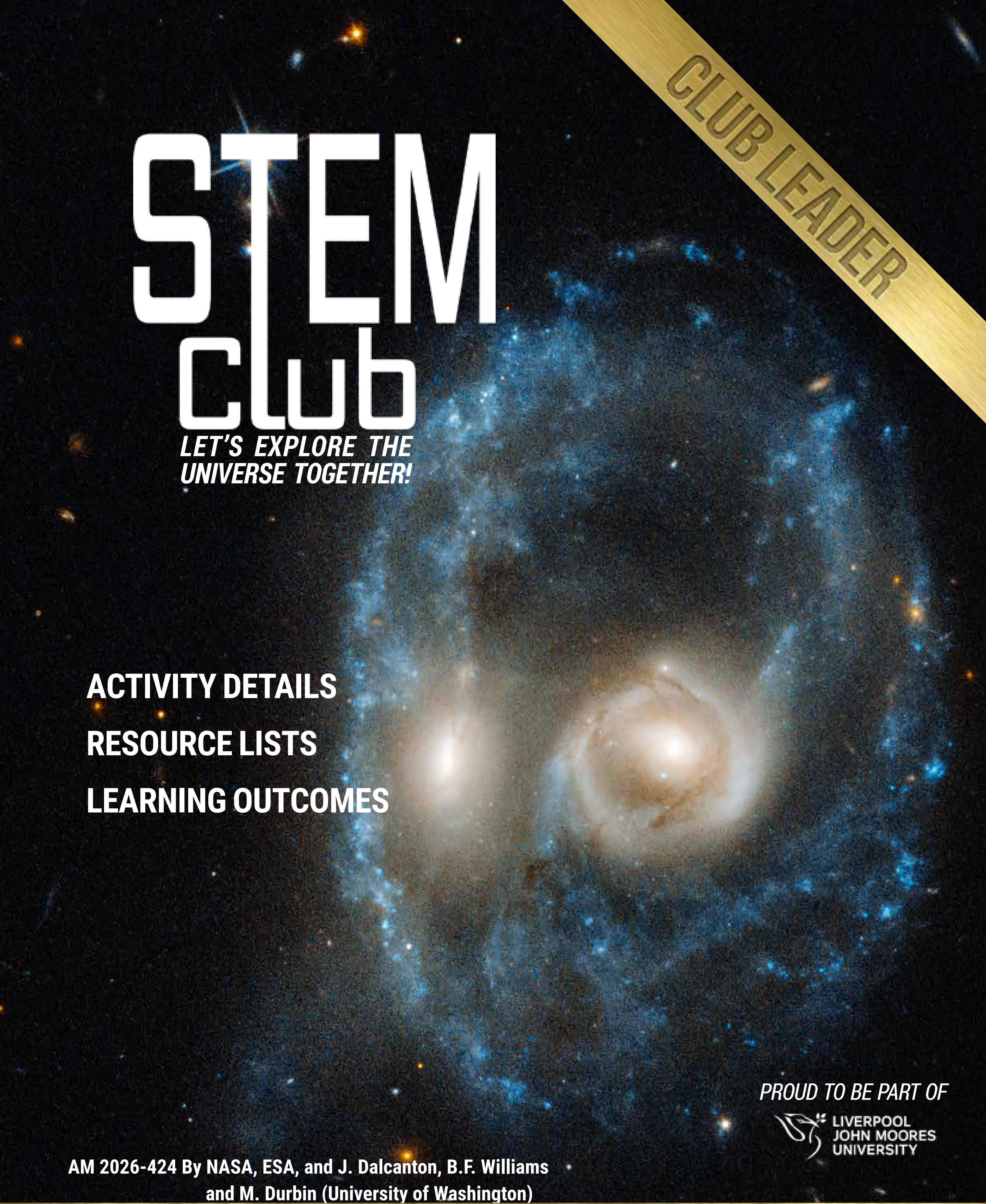
CLUB LEADER

STEM Club

LET'S EXPLORE THE UNIVERSE TOGETHER!



ACTIVITY DETAILS

RESOURCE LISTS

LEARNING OUTCOMES

PROUD TO BE PART OF

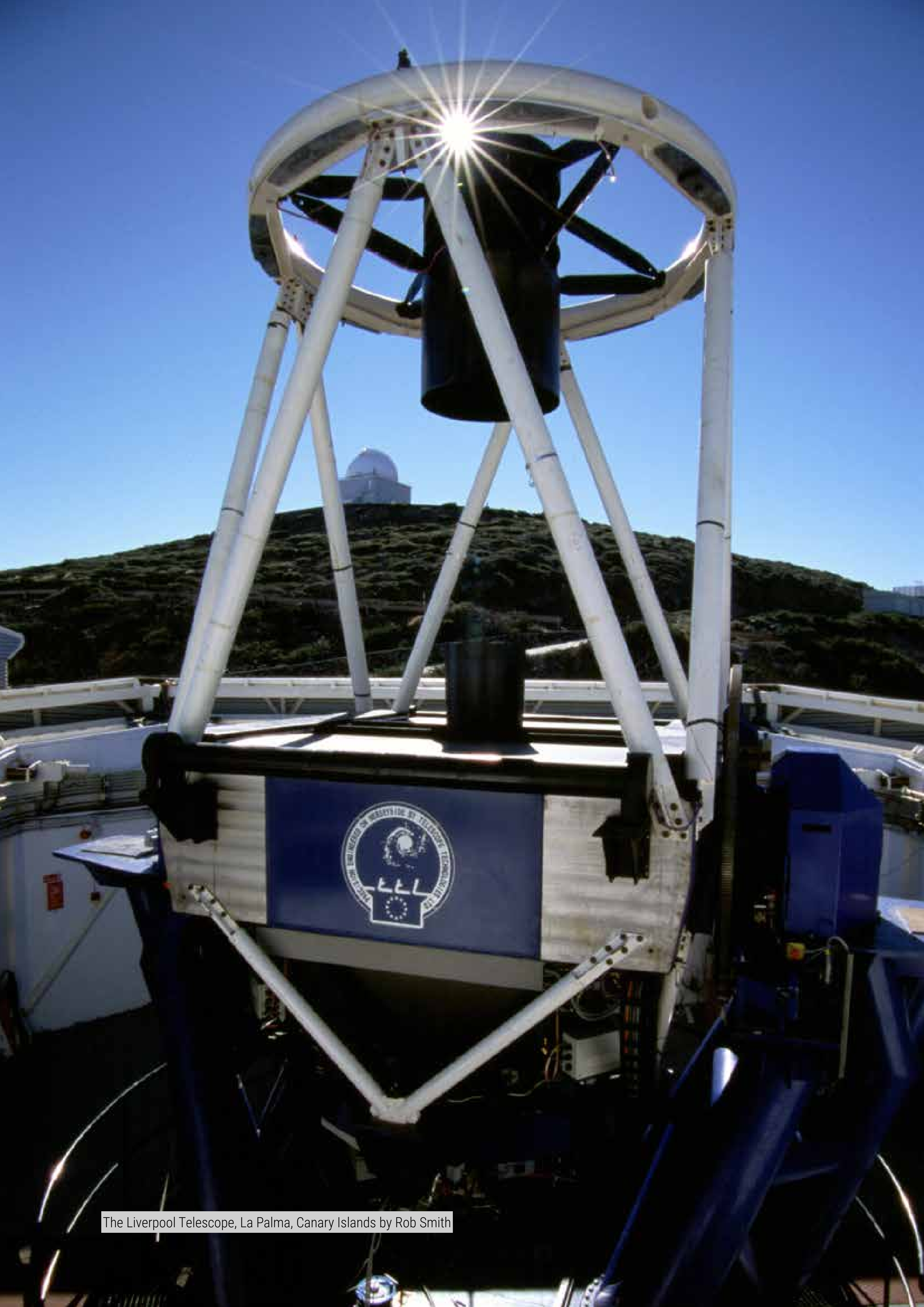
LIVERPOOL JOHN MOORES UNIVERSITY

AM 2026-424 By NASA, ESA, and J. Dalcanton, B.F. Williams and M. Durbin (University of Washington)

GOLD

SECONDARY EDITION

THE SCHOOLS' OBSERVATORY



The Liverpool Telescope, La Palma, Canary Islands by Rob Smith

CONTENTS

Secondary STEM Club - Gold Award - Club Leader Edition

Rose Galaxy by The Schools' Observatory

NGC 7129 by The Schools' Observatory

GC 2261 by The Schools' Observatory

INTRODUCTION

The Schools' Observatory (TSO) is passionate about inspiring the next generation of scientists, programmers, engineers and mathematicians. We provide free access to the world's largest fully robotic telescope, and use the wonders of space to excite and amaze students of all ages and develop their love of STEM education.

What is The Schools' Observatory STEM Club Programme?

This STEM Club programme provides three levels of activities; Bronze, Silver and Gold, with each level taking six weeks to complete. The activities are designed to take around an hour each week and can be run by someone with little-to-no science background, making them ideal for a parent, teaching assistant or even an older student.

The programme includes two resource booklets and a series of supplementary documents, hosted on www.schoolsobservatory.org/stem-club. The STEM Club Leader booklet (this booklet) provides guidance notes on the activities, and details the resources and knowledge needed to successfully and easily run each session. The student booklet contains step-by-step instructions for each activity and spaces for students to record their work throughout the programme. The student booklet forms their individual record of achievement as they progress through the levels.

How To Use This Booklet:

This booklet contains six sessions. Each session will briefly explain the pupil activities, list the necessary resources you'll need and contains additional useful information, such as facts or web links. It will also give learning objectives for the session and provide any answers if relevant.

It would be useful to have your own copy of the student booklet to help you plan and deliver the sessions.

What Happens On Completion?

Once you have finished this STEM Club level you can download a certificate for your pupils from our website. Full details can be found on page 27 of this booklet.

Plan a Star Party:
Session 6 is a celebratory Star Party. You may want to have a look through the session guidance on page 26 and start planning your celebration a few weeks in advance.

ABOUT THE BOOKLETS

Both the STEM Club Leader and student booklets use the same style and formatting. This page contains a full set of examples.

1. Activity steps are numbered like this

Interaction with the booklet comes in the form of questions like this, with room for the student to write their answer.

Full resource lists are included. The tables refer to materials needed per group e.g.

REQUIRED RESOURCES
☆ One piece of A4 paper
☆ One pencil

It would be great if you tagged us on any social media posts **@SchoolsObs.**

This is a tip. Useful information will be written like this to help it stand out from the activity steps.

SESSION 1: DESIGNING A TELESCOPE

Astronomy is driven forward by always asking new questions. When we get to a question that we can't answer, it usually means that we don't have the technology, or the knowledge, to get to the bottom of the problem. This drives technology forward, and there are constantly new telescopes in development.

When deciding upon what new telescope to build, the primary driver is the science – what questions are we trying to answer and what technology do we need to answer them.

For example, to be able to answer the question 'can any exoplanets support life?', we needed to build a telescope that could analyse the atmospheres of these planets and look for biological tracers of life. This is one of the big science questions that the James Webb Space Telescope aims to answer.

In this activity the students are given a big science question and must work together to build a telescope to answer it. They will have a budget to work with and must discuss several options for ultimately selecting:

- ☆ An observing site
- ☆ A telescope mirror design
- ☆ A material to build the telescope structure from

Learning Objectives, students will learn:

1. what requirements go in to selecting an observing site
2. about the engineering challenges involved with telescope design
3. to successfully budget
4. to develop their discussion and persuasion skills
5. to work as a team to reach a consensus

+If choosing to run the workshop in Option 2 below.

*For the extra (optional) activity only.

Each group will require the following:

REQUIRED RESOURCES
☆ Pens/Pencils
☆ Map and fact files of observatory sites
☆ Information page on telescope mirrors
☆ Table on material selection for telescope structure
☆ Poster paper+
☆ Marker pens+
☆ Access to the internet*

The supplementary information on observatory sites, telescope mirrors and materials is available to view and download from this webpage:
www.schoolsobservatory.org/stem-club

Before the Session:
There is very little preparation needed for this session because most of the activities will involve discussion. Students will need access to the map, fact files, mirror information and materials table from the resources section. You can choose to print out a copy to give to each team – or share them on screens directly from our website.

Students will need to complete sections in their workbooks as you go through the tasks.

There are two options on how to run this activity. Decide on which option you will use before the session starts. You can choose which option best suits your club's size and dynamics:

Option 1: Split your club into small groups. Each small group will need to complete activity 1 (observing site selection), 2 (mirror selection) and 3 (telescope structure material selection) together in their team. They can then compare their completed telescope selection with the other groups at the end of the session.

Option 2: Split your club into three groups. One group will lead the selection of the observing site, one will take the mirror selection, and the final group will take the material for the telescope structure. The groups will need to talk to each other during the planning phase as the decisions made by one group will affect the choices of another. Each group should pick their first choice, and then a backup. Once each group has discussed and made their selections, they must all come together and see if their choices are within budget. If not, they must each try to persuade the other teams to take their primary choice, or willingly take the backup option. The three groups must reach a consensus on the telescope site and design which is within budget.

At the beginning of the session:
Introduce the science goal to your students:

In 2015 the first detection of a gravitational wave was recorded. A gravitational wave is a ripple which travels through the fabric of space (often called space-time) much the same as a ripple travels through water when you drop a stone. They were first predicted by Einstein in 1916 with his theory of relativity. They are made when very massive objects move quickly in space. For the ripples to be strong enough to be detected on Earth, the movement of these objects has to be very fast. The following events are likely to lead to gravitational waves:

- Black holes colliding together
- Huge supernova explosions
- Neutron stars colliding together
- Neutron star merging with a black hole

Gravitational wave detectors on Earth 'listen' out for these events. They can measure the size of the waves and then try to figure out what event caused them. To learn more about this new area of astronomy it is useful to also 'see' the events with telescopes. If the source of the waves includes a neutron star or a supernova explosion, then we should be able to see an optical source alongside the gravitational wave detection. This will help scientists to answer questions like:

- Where did the event take place?
- Do gravitational waves travel at the speed of light?
- What is going on inside a neutron star?
- How do stars actually explode?

Set the scene:

- Split your club into groups using either option 1 or 2 outlined above.
- Allocate your students a budget of £150 million to produce a new telescope which will look for the optical counterparts of gravitational waves. Make it clear that the budget does not need to be split equally across the three components they need to select.
- If you're using **Option 1** then go through each activity below in turn.
- If you're using **Option 2** then allocate one of Activities 1 to 3 (below) to each group.

ACTIVITY 1: OBSERVING SITE SELECTION

Allow 10-15 minutes for this activity.

In order to detect the maximum number of gravitational wave sources it is important for the observing site to be close to the equator, from which both the northern and southern hemispheres can be observed. The students must choose between the 6 options for an observing site.

Students should consider:

- How stable the site is in terms of ground movements and air turbulence (seeing).
- The weather on site (cloud cover, wind, rain, dust etc.).
- How easy the site is to access for both building and maintenance of the telescope.
- The cost of land rental for the telescope - this scales with the size of the telescope mirror needed.
- Any special cultural impacts of developing on the site.
- The levels of light pollution.

1. Provide the group(s) with the map of available observing sites for their telescope, and the associated fact files.
2. Instruct the group(s) to consider all the factors for each observing site and come to a decision on which site they would like to select for their primary choice and backup choice.
3. Ensure that the students fill in their workbooks with their primary choice and back up choice, whilst also filling in the table of pros and cons for each site selected.
4. Note down the budget which needs to be allocated to each choice.

ACTIVITY 2: MIRROR SELECTION

Allow 10-15 minutes for this activity.

Gravitational wave sources can come from very distant objects. In order to be able to see these distant sources, astronomers must use telescopes with as large a mirror as possible. The bigger the diameter of the mirror, the more light that can be collected, enabling you to see fainter objects.

Students should consider:

- ☆ How the different shaped mirrors fit together and how much light is lost through any gaps.
- ☆ The overall weight of their mirror – the lighter the better – this will affect which materials they can use for the structure.
- ☆ The total diameter of the mirror – the larger the mirror the fainter the objects they will be able to see – this means that they will be able to look for objects at greater distances.
- ☆ The price of the mirror.
- ☆ How easily the mirror can be transported to site.
- ☆ How easily the mirror can be assembled on site.

1. Provide the group(s) with the mirror information page.
2. Instruct the group(s) to consider the size and shape of the mirrors and come to a decision on which mirrors they would like to select for their primary choice and backup choice.
3. Ensure that the students fill in their workbooks with their primary choice and back up choice, whilst also filling in the mirror diagram, weight and mirror diameter information.
4. Note down the budget which needs to be allocated to each choice.

ACTIVITY 3: TELESCOPE STRUCTURE MATERIAL SELECTION

Allow the students 10-15 minutes for this activity.

Gravitational wave sources are also likely to emit flashes of optical light, which appear and then fade very quickly. This means that the telescope needs to move very quickly to see the light before it disappears. The materials need to be strong enough to support the mirror, but light enough to move at speed.

Students should consider:

- ☆ The material properties (e.g., strength, malleability, weight and stress tolerance).
- ☆ The overall shape of the mirror - a roughly circular shape will focus the most light onto the detectors

1. Provide the group(s) with the Material Selection table.
2. Instruct the group(s) to consider the benefits of each material, balanced against its cost. They should come to a decision on which material they would like to use for their telescope structure, and what their backup choice is.
3. Ensure that the students fill in their workbooks with their primary choice and back up choice, whilst also filling in the pros and cons table.
4. Note down the budget which needs to be allocated to each choice.

ACTIVITY 4: REACHING A DECISION

If you are using **Option 1**:

1. Allow the students 5 minutes in their groups to total up the budget for their primary telescope design. If this exceeds the given budget, then they should decide in their group which backup choices to use to ensure they come in under/on budget whilst maintaining the best telescope they can for the science.

2. Once the group has reached a decision, get them to note this final design down in their workbooks.

If you are using **Option 2**:

1. Allow each group 15 minutes to choose a member (or several) of the group to pitch their primary and back up choices to the rest of the club. The group should transfer their ideas to poster paper to present to the rest of the club. They should justify their decisions and relay the cost implications.

2. Allow each team 5 minutes to pitch their ideas to the wider club and bid for the budget they need.

3. Get the students to vote as a club for the primary or backup option for each aspect of the telescope design. They need to reach a consensus for the telescope which comes in under/on budget.

4. Once a decision has been made, get the students to fill in the rest of their workbooks, under the activity headings their teams did not focus on in stage 1. They only need to complete the details of the consensus for each activity, not any back-up options.

At the end of the session:

If you are using **Option 1**:

1. Bring the club back together.

2. Quickly run through the groups to see if there has been any consensus in the final design decisions of the groups – have they picked the same observing site, mirror setup or material?

3. Ask the group if they have found anything challenging or surprising about this session.

4. Talk to the group about the cost of building various telescopes as listed in the student workbooks. The massive budgets involved mean that countries must work together to develop new technologies. No single state can afford to do this alone.

If you are using **Option 2**:

1. Bring the club back together.

2. Ask the group if they have found anything challenging or surprising about this session.

3. Talk to the group about the cost of building various telescopes as listed in the student workbooks. The massive budgets involved mean that countries must work together to develop new technologies. No single state can afford to do this alone.

Extra Activity:
If any of your students have enjoyed this activity they may want to try a more advanced version – designing and launching a space telescope: Chris North's Design a Space Telescope activity:
chrisnorth.github.io/design-a-space-telescope

They might also like the computer game: Kerbal Space Program: www.kerbalspaceprogram.com

SESSION 2: COMPARING STARS

In this session, students will plot, label and interpret the Hertzsprung–Russell Diagram. The diagram shows a relationship between a star's absolute magnitude (luminosity) and its temperature. It was created by astronomers Ejnar Hertzsprung and Henry Norris Russell about 1910, and can be used to chart the life cycle, or evolution, of a star.

Learning Objectives, students will learn:

1. that stars have different luminosities and surface temperatures
2. that a star's position on the chart is linked to the star's size and age
3. to plot, label and interpret the HR diagram

*The star circles are available to download and print from our website:

www.schoolsobservatory.org/stem-club

Each group will require the following:

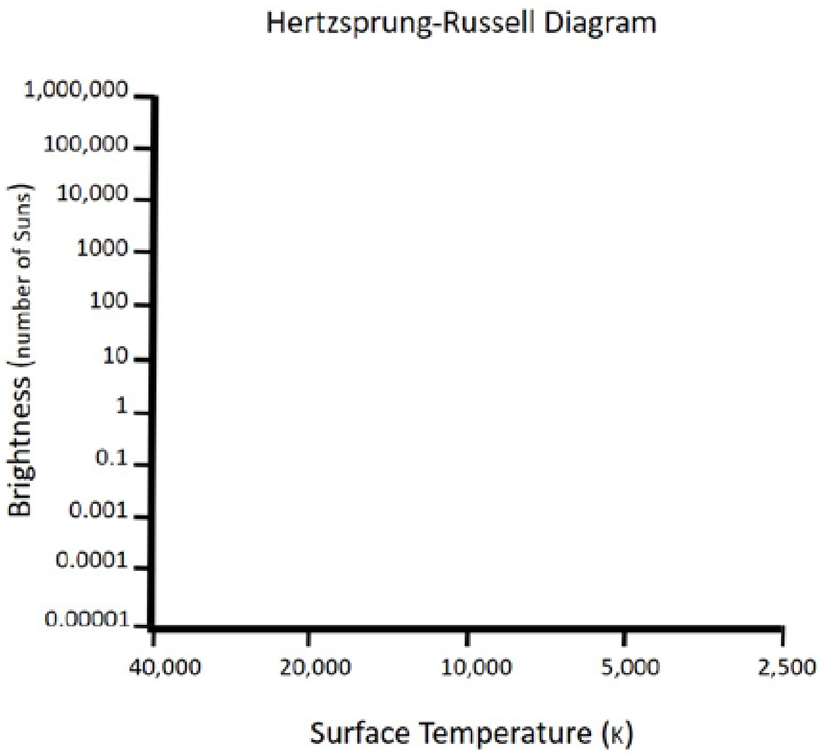
REQUIRED RESOURCES
☆ Sticky notes
☆ Pens or pencils
☆ Large poster paper
☆ Colour-printed star circles*
☆ Scissors
☆ Glue sticks (optional)

Before the Session:

1. Print and cut out the star circles. There are a lot so you may want to get a volunteer to help you! Alternatively, chop the sheets up into pieces with about 3 star circles on each. Students can cut out their own stars at the start of Activity 2.
2. Find a large sheet of paper or stick several large sheets together. The bigger the better, as your whole club will be working together to plot the star data on it. Alternatively you could mark out a large space on the floor using masking tape.
3. Draw and label the axes on the paper so that it looks like the template (right).

IMPORTANT

Notice that the x-axis (horizontal) shows temperature in Kelvin. The y-axis (vertical) shows brightness in terms of number of times the brightness of our Sun. Note that neither axis is linear, this is so the data is easier to plot.



ACTIVITY 1: WHO AM I?

The aim of the game is for one student to determine the star life-stage written on the sticky-note stuck to their head. They do this by asking their partner questions and using the information in their workbooks.

1. Put students into pairs or small groups and introduce the activity.
2. Hand out sticky-notes and something to write with.
3. Remind students to use the instructions and information in their workbooks.
4. Give the students 5 – 10 minutes for this activity.

This activity builds on what students learned in the Silver STEM Club sessions; however, they do not need to have completed Silver STEM Club to carry out the activity.

ACTIVITY 2: CREATE A HERTZSPRUNG–RUSSELL DIAGRAM

The group will work together to create a Hertzsprung–Russell diagram. They will use the star circles and large blank chart you prepared before the session. The activity should take about 30 - 40 minutes. This activity is adapted from 'Astrobiology: An Integrated Science Approach', 2005, TERC, Cambridge, MA, USA. We have included some discussion prompts and background information to help you and the club understand and interpret the diagram.

Instructions:

1. Introduce the activity to the club and hand out the star circles. Each student should have 3 – 6 star circles, but this will depend on the size of your club.
2. Ask students to take turns adding their data to the chart. Make sure they check the chart carefully – taking into consideration that the axis are not scaled linearly. Your club may opt to use glue sticks to fix their stars in place.
3. Encourage the students to ask inquisitive and scientific questions about what they are seeing as they complete the chart. Many students may be surprised that stars come in so many colours, temperatures and luminosities.
4. Keep going until all the data is plotted.

Suggested questions for the students to discuss and answer:

- ☆ What do you notice about the scales on the axes?
- ☆ Can you see a main trend?
- ☆ What is the relationship between temperature and brightness?
- ☆ Which types of stars fall outside the main trend line? Describe them. What are the differences between them?
- ☆ What is the colour of the brightest stars? What about the dimmest?
- ☆ What is the colour of the hottest stars? What about the coolest?
- ☆ Why might stars of one colour be much more abundant than stars of another colour?

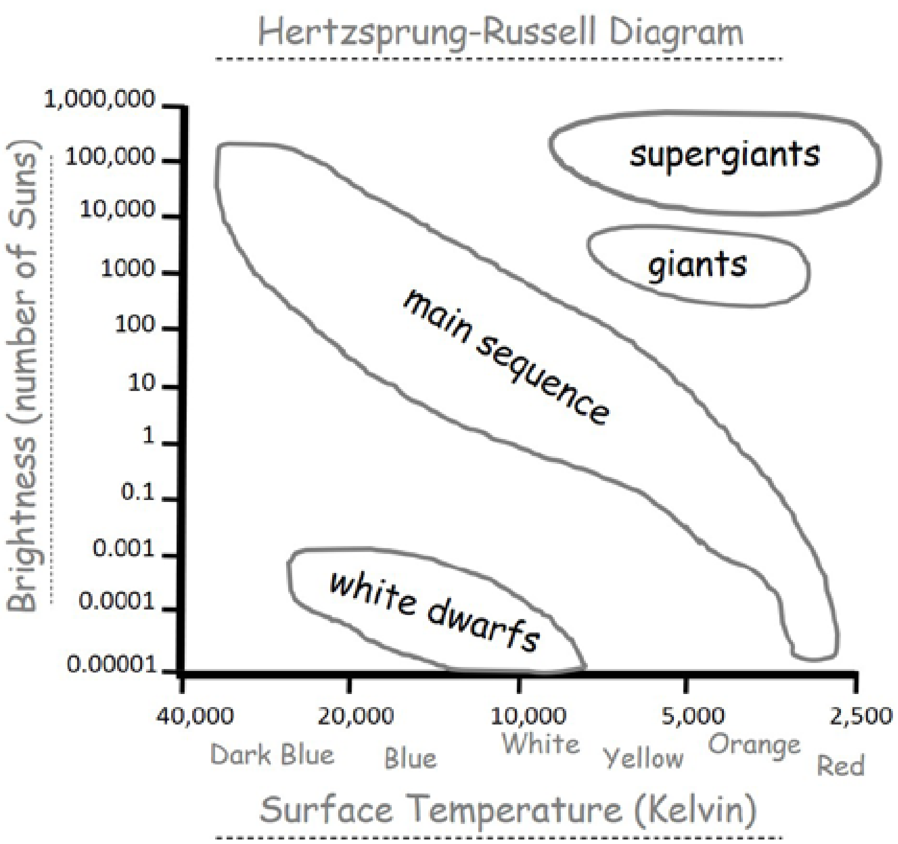
The following information will help you and the club to understand and interpret the diagram:

1. Most stars can be found on the Main Sequence - a prominent band running from the top-left to the bottom-right of the diagram. On the Main Sequence we find that the hotter a star is, the greater its luminosity. Both these factors are determined by the stars mass.
2. Giant and Supergiant stars expand in the final stages of their lives. As a result of this they become cooler. But because they are so big, they are very bright, and so appear above and to the right of the Main Sequence.
3. White Dwarfs are extremely hot and dense, but because of their small size, they are not very luminous. As a result, they can be found below and to the left of the Main Sequence.
4. In general, stars will spend most of their life (~90%) on the Main Sequence before evolving into a giant star for the remaining 10%. Following that, they will either go supernova or become a white dwarf.
5. The Sun is currently in the Main Sequence stage. In the future it will become a red giant, and then a white dwarf.
6. The x-axis (horizontal axis) of the Hertzsprung–Russell Diagram can be given in many different forms, such as the star's temperature (Kelvin), its spectral class (OBAFGKM) or its colour.

ACTIVITY 3: USING THE HERTZSPRUNG–RUSSELL DIAGRAM

Students use the Hertzsprung–Russell diagram they have just created to draw a sketch of the chart and complete the questions in their workbooks. Remind students that this should be a rough sketch and they do not need to draw each individual star.

Their completed chart should look like this:



SESSION 3: THE SHAPE OF GALAXIES

This session will introduce students to galaxies: what they are made from and what they look like. They will carry out an activity to classify galaxies by their visual appearance in accordance with the **Hubble Tuning Fork** diagram. They will then learn about how galaxies live in groups and plot our local group of galaxies.

Learning Objectives, students will learn:

1. to understand that galaxies come in a variety of shapes and sizes
2. to understand how galaxies are classified
3. to understand how to critique a classification system
4. to understand that galaxies live in groups and interact via gravity

Each group will require the following:

REQUIRED RESOURCES
☆ One or more sets of galaxy images
☆ Pencil and ruler

Before the session:
Photocopy and cut out one or more sets of the galaxy images (pages 17 to 20). You should have enough for each student to classify several galaxies. It is useful if a number (or even all) of the galaxies are repeated (i.e. are classified by more than one student) as that will help with the discussion.

ACTIVITY 1: THE HUBBLE CLASSIFICATION SCHEME

During the activity:

1. Give the students time to read the instructions, or take them through them yourself.
2. Give each student several galaxy images and get them to classify them. You may need to help them to think about things like orientation and contamination:

   Orientation: Elliptical galaxies always appear elliptical no matter what direction we view them from. Spiral galaxies can look quite different when viewed nearly ‘edge-on’ compared to ‘face-on’, so how much they are “tilted” is important.

   Contamination: Sometimes images will have fairly bright stars in them. These stars are actually in our own galaxy but fall in the same area of the sky as the galaxies we are observing. This can cause some confusion.

3. When the students have finished carrying out their classifications (you can give the quicker students extra ones to work on), you should either lead a whole-group discussion, or divide the club into smaller groups to discuss their results.

Important things to consider and discuss are:
Students may disagree about the classification of particular galaxies. This does not mean one is "right" and one "wrong", but they should discuss why they disagree.

Some galaxies are harder to classify than others. Why? Towards the end of the discussion, you should get the students to think about why classification might be useful, and what its dangers are. Good points include:

- ☆ Classification is useful because otherwise you have to try to understand all galaxies separately, which is impossible.
- ☆ Classification schemes like this probably have "physical" reasons behind them (i.e. different galaxies probably look the same because they are actually similar, or were made in the same way).
- ☆ Being too prescriptive about a classification can be dangerous – sometimes galaxies just do not fit the scheme very well, and that can also be interesting as it gives new questions to try to answer (i.e. why does it not really fit?).

Classifications:
Here are the "official" classifications of the galaxies. However, remember that students may get different answers for good reasons.

Image	Name	Class
1	NGC 6015	Sc
2	NGC 4216	Sb
3	NGC 7626	E0/E1
4	NGC 691	Sb
5	NGC 1600	E3
6	NGC 5371	Sb
7	NGC 1073	SBc
8	NGC 6632	Sb
9	Messier 49	E2
10	NGC 2776	Sc
11	NGC 3507	SBb
12	Messier 104	Sa (Edge On)

Image	Name	Class
13	NGC 7479	SBc
14	Messier 74	Sc
15	NGC 2487	SBb
16	NGC 6674	SBb
17	NGC 5850	SBa
18	NGC 7457	E5
19	NGC 4567	Sc
20	NGC 2339	SBc
21	NGC 524	S0
22	NGC 4278	E1
23	NGC 4389	SBc
24	NGC 5846 & NGC 5846A	E0 and E5

ACTIVITY 2: OUR GALACTIC NEIGHBOURHOOD

Galaxies do not exist alone in space – they live in small groups. These small groups are part of larger clusters of galaxies, which can contain hundreds if not thousands of galaxies. Our own Milky Way galaxy lives in a group we call 'The Local Group'.

The example galaxies in Activity 1 are all large galaxies. However, there also exist smaller versions for each type of galaxy. These 'dwarf' galaxies contain 10-100 times fewer stars.

1. Get the students to carry out the grid plotting activity in their workbooks. This will give them a map of our own Local Group of galaxies.
2. Students should put the correct symbol in the correct position on the grid using the galaxy classification in their tables, and the key given in their workbooks. For a dwarf galaxy just make the symbol a little smaller!

Key

Elliptical:

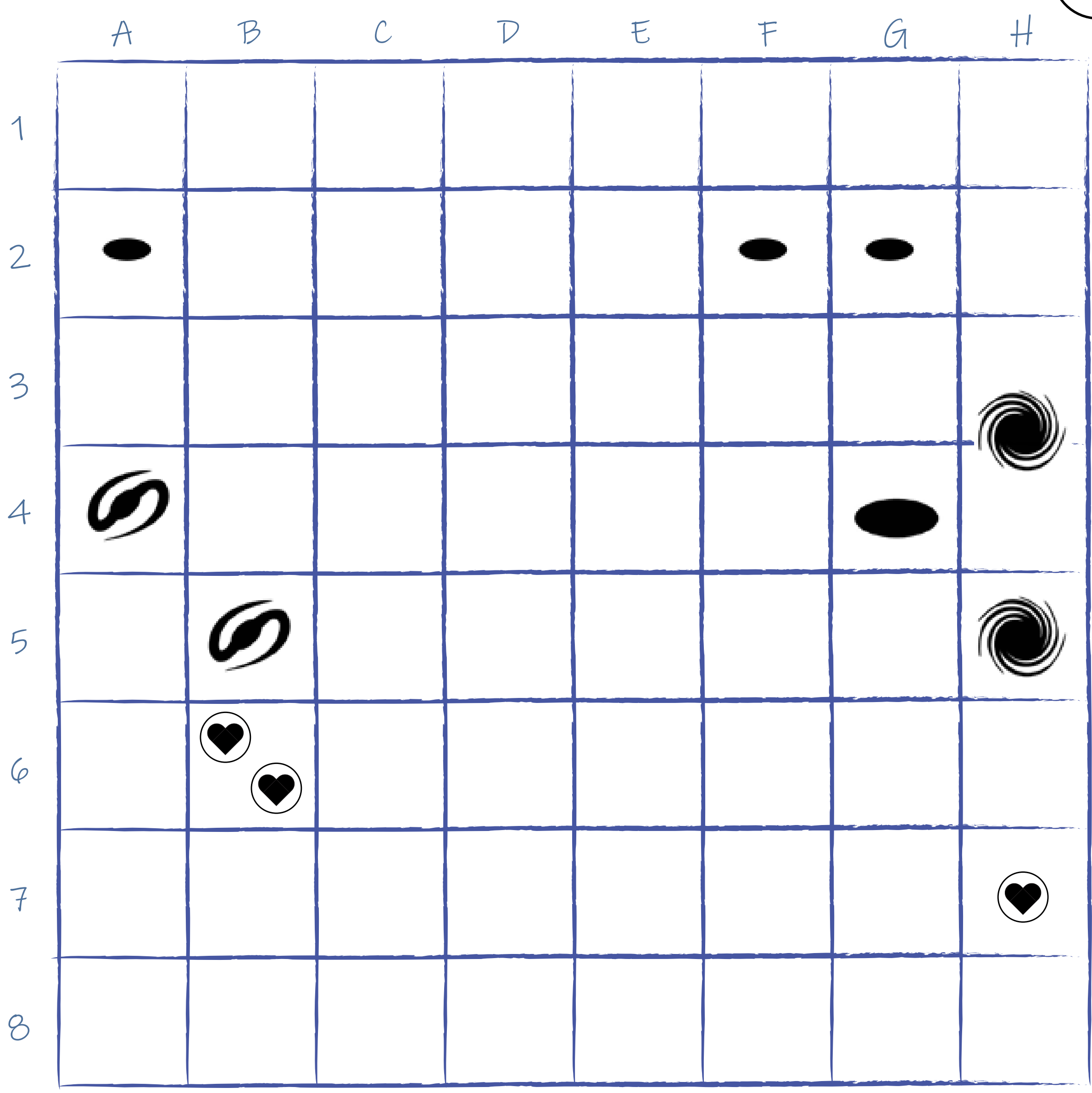
Lenticular:

Barred Spiral:

Spiral:

Irregular:

The students should end up with something which looks like this:



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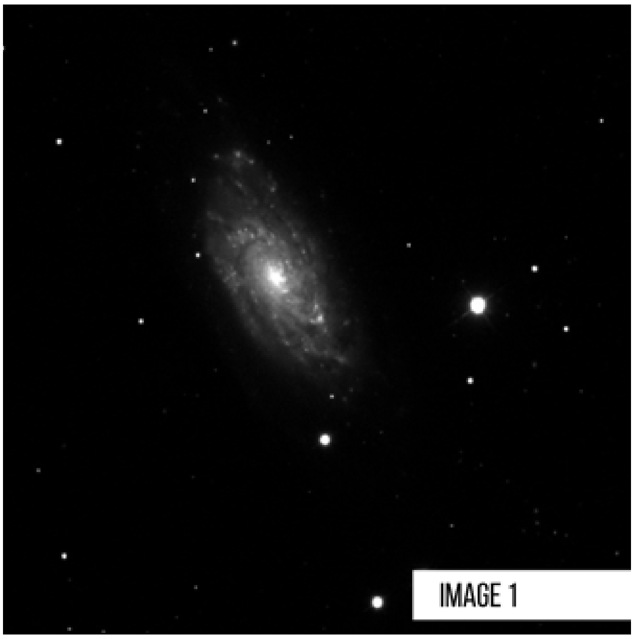


IMAGE 1

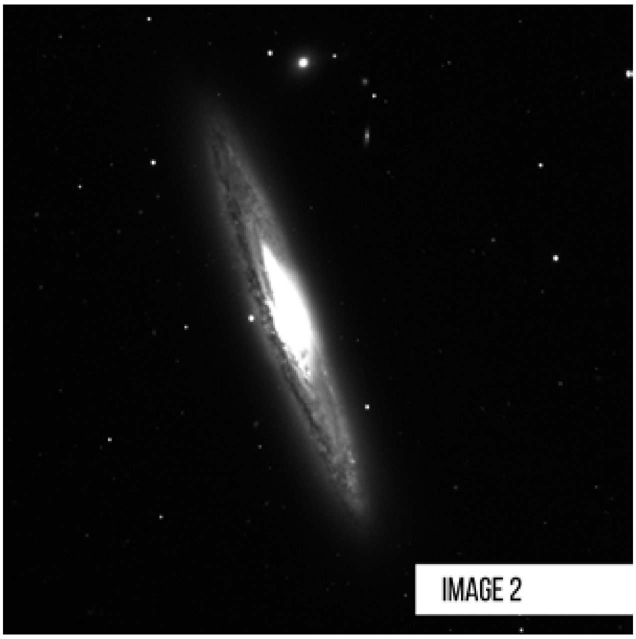
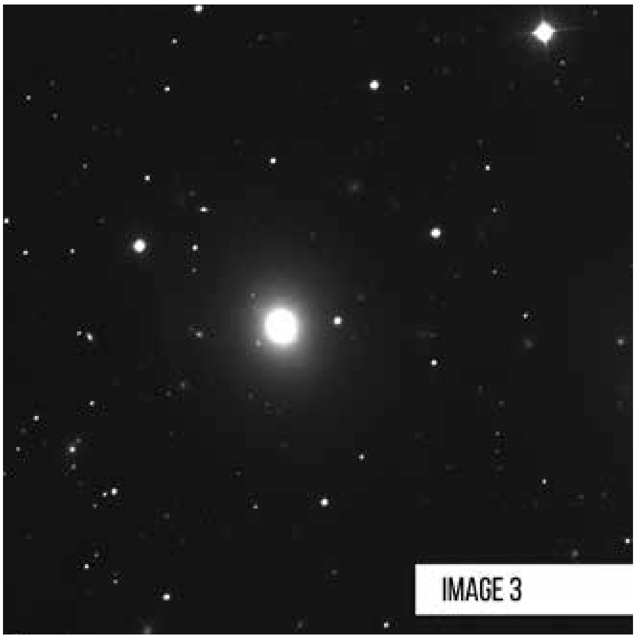


IMAGE 2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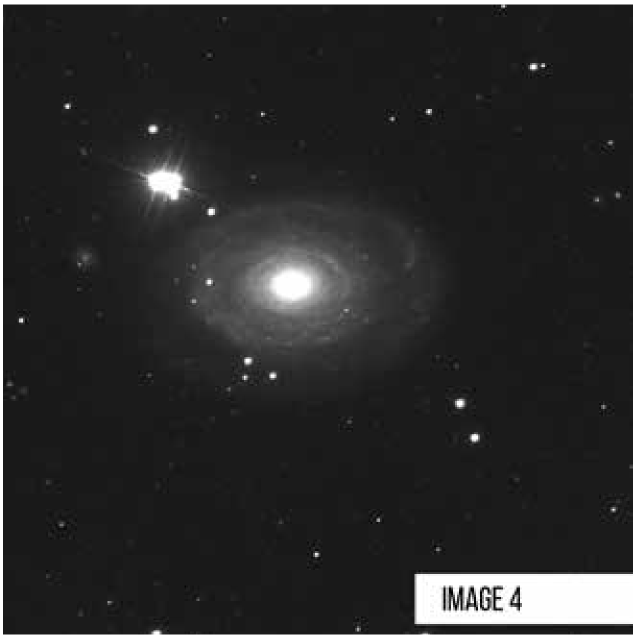
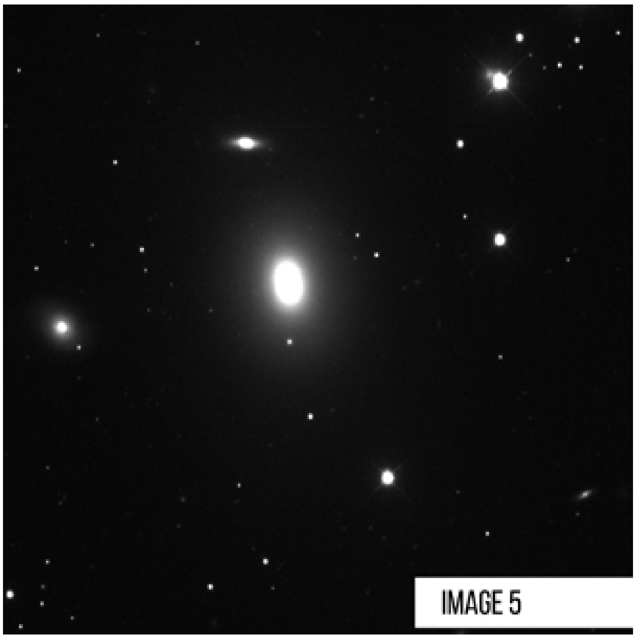


IMAGE 4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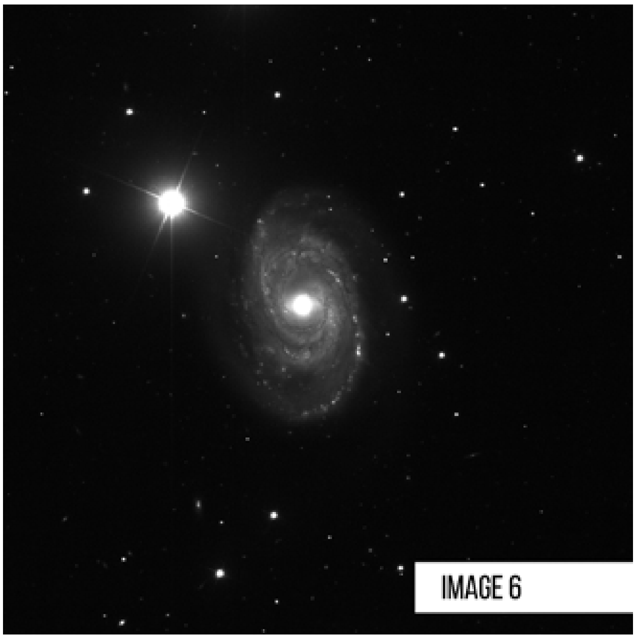


IMAGE 6

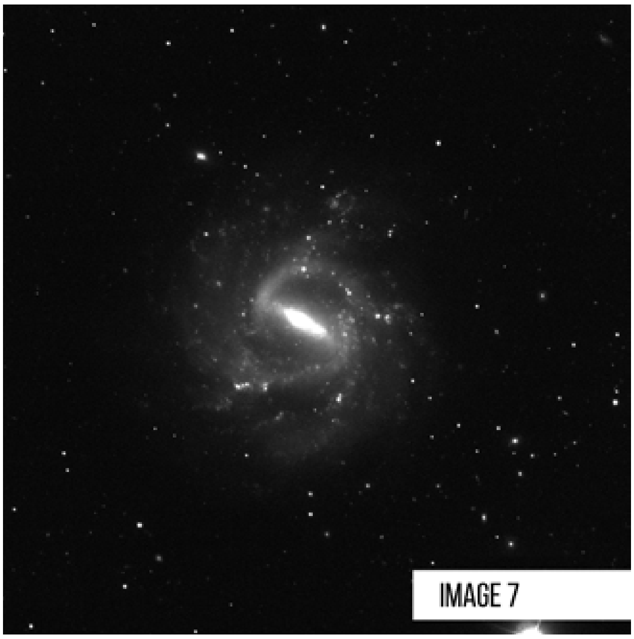


IMAGE 7

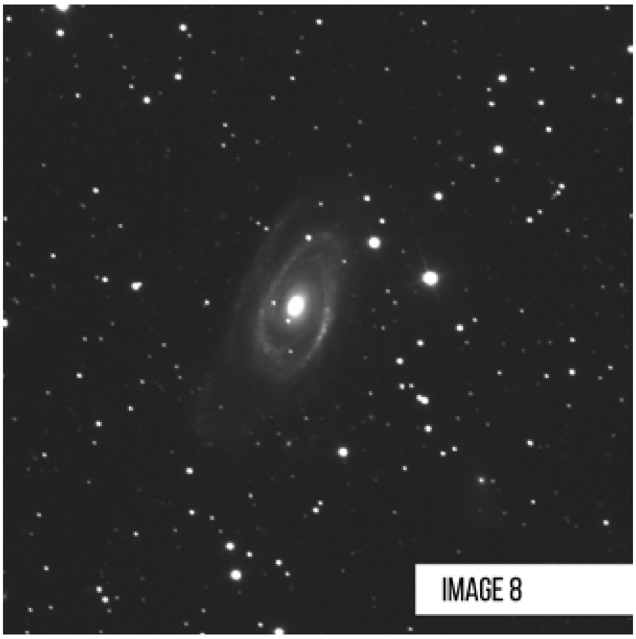


IMAGE 8

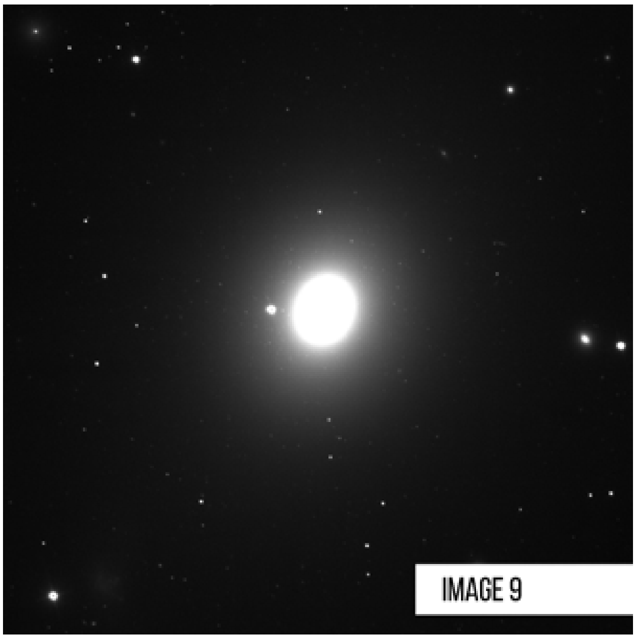


IMAGE 9

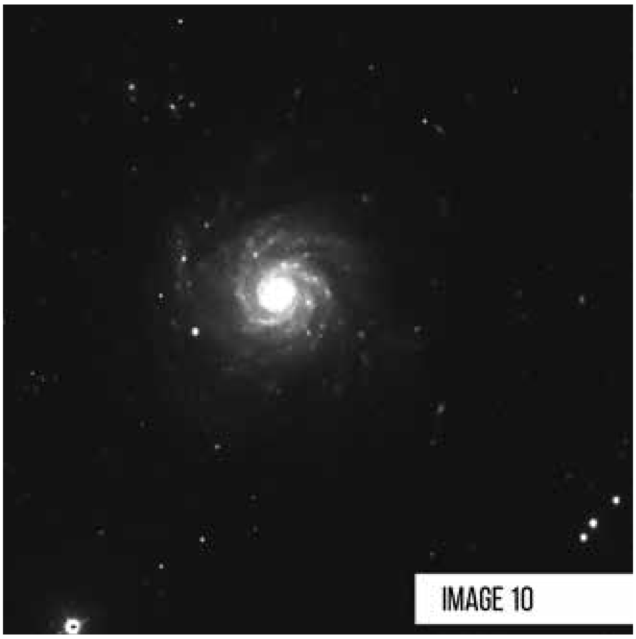


IMAGE 10

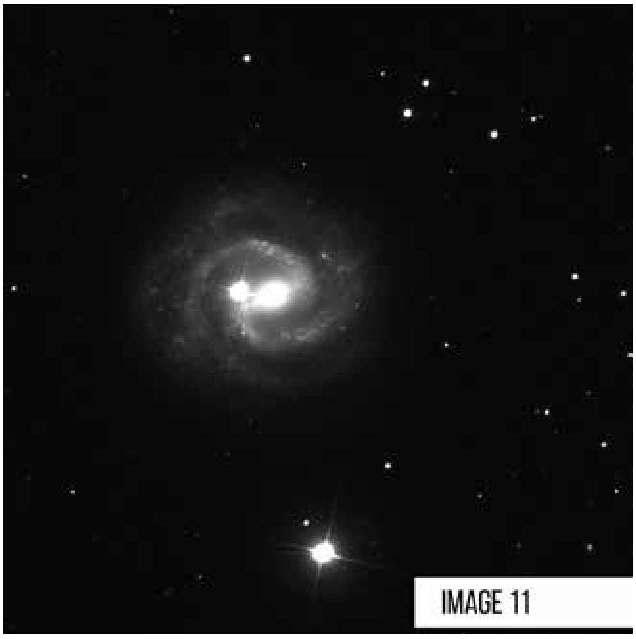


IMAGE 11

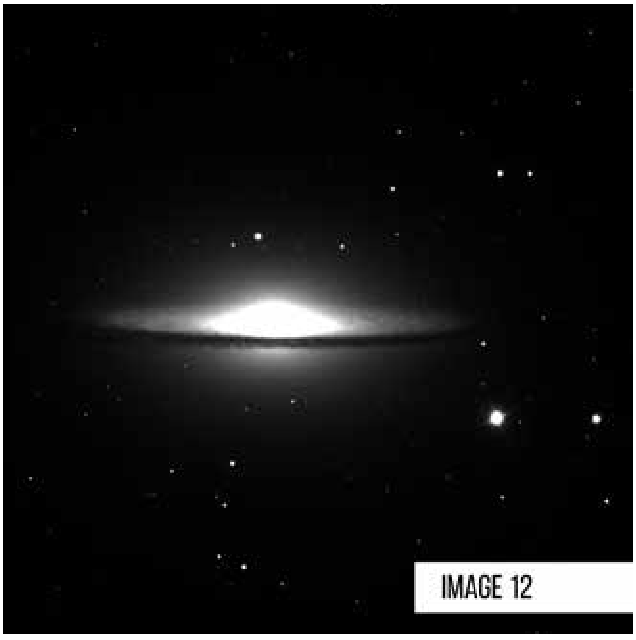


IMAGE 12


IMAGE 13


IMAGE 16

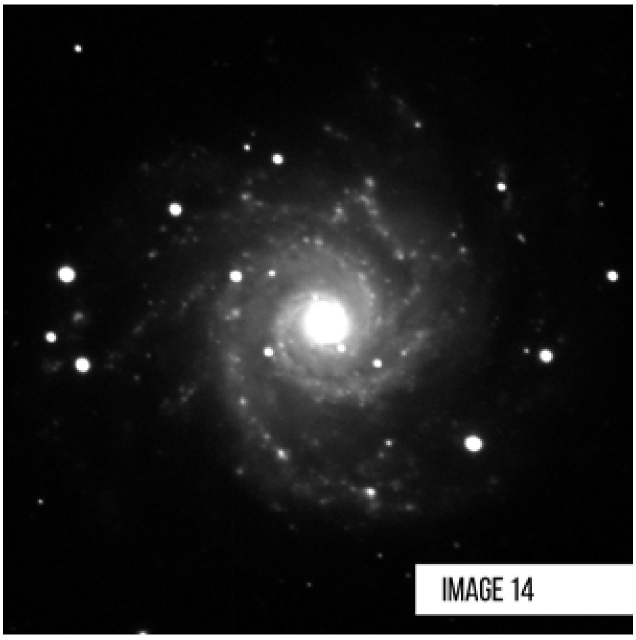
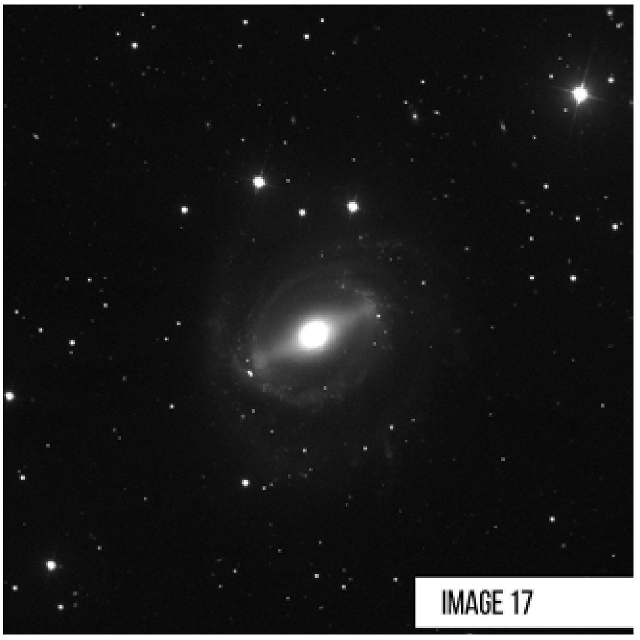


IMAGE 14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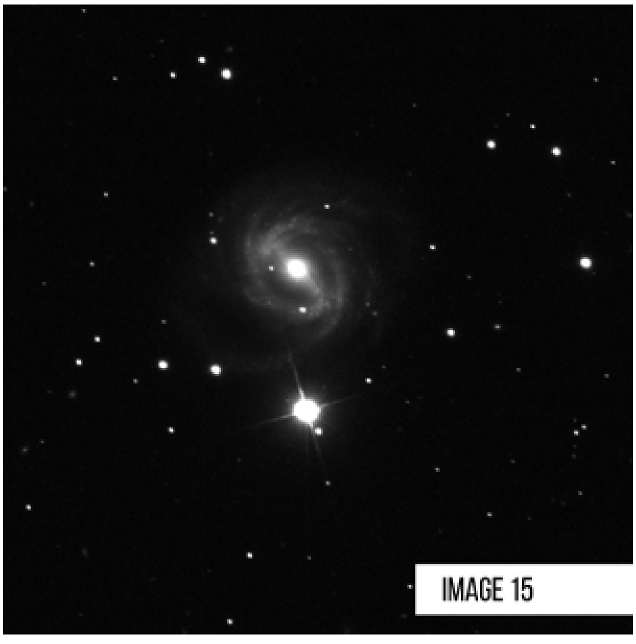
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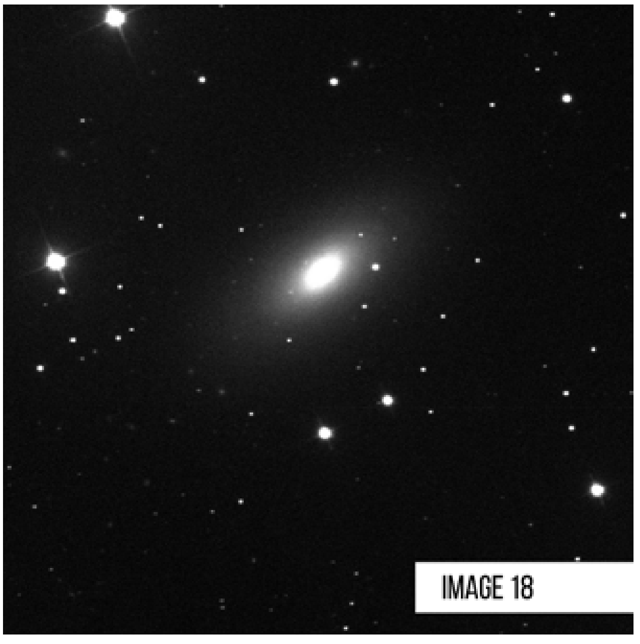
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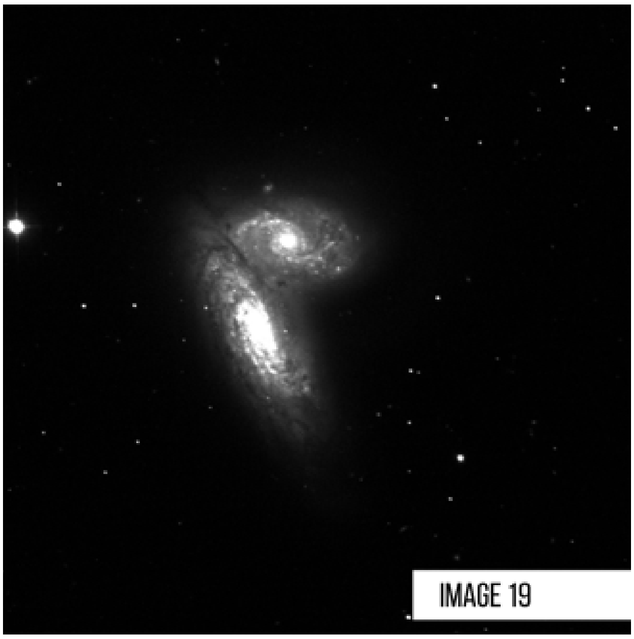

IMAGE 19

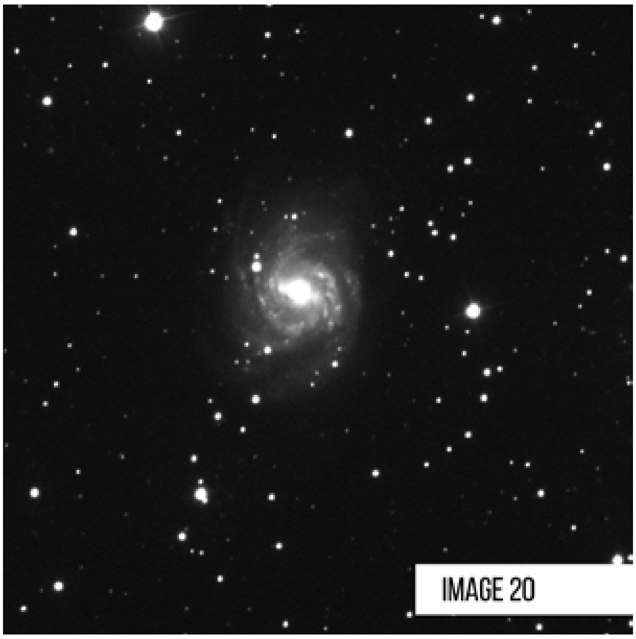

IMAGE 20

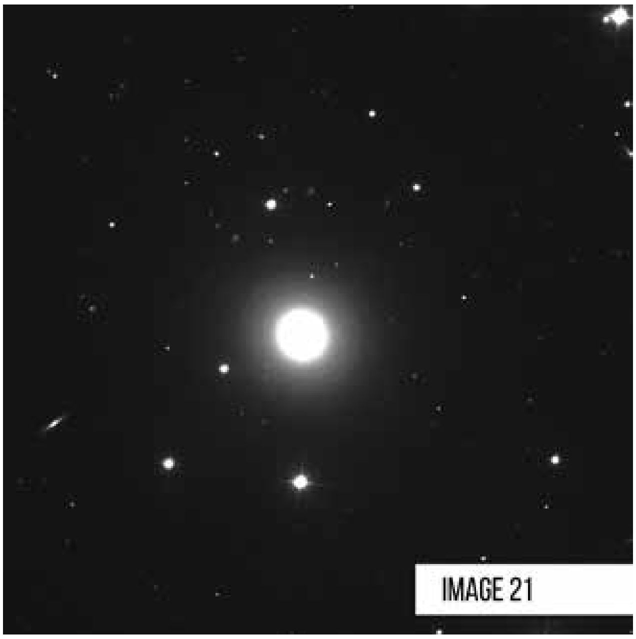

IMAGE 21

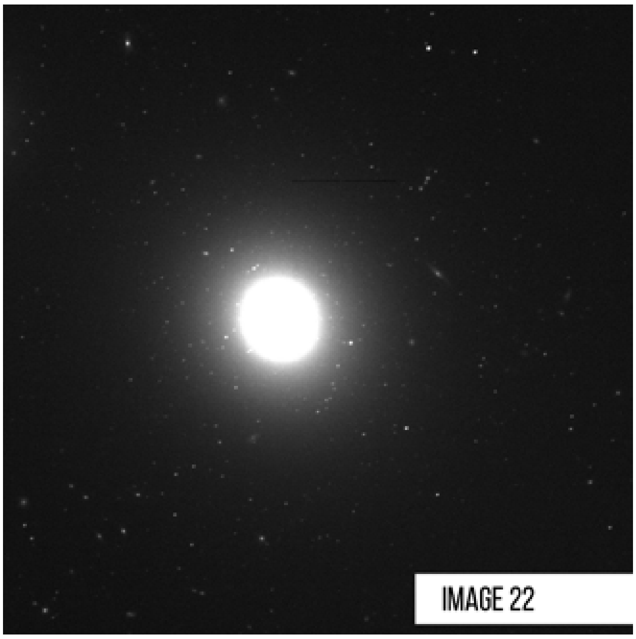

IMAGE 22

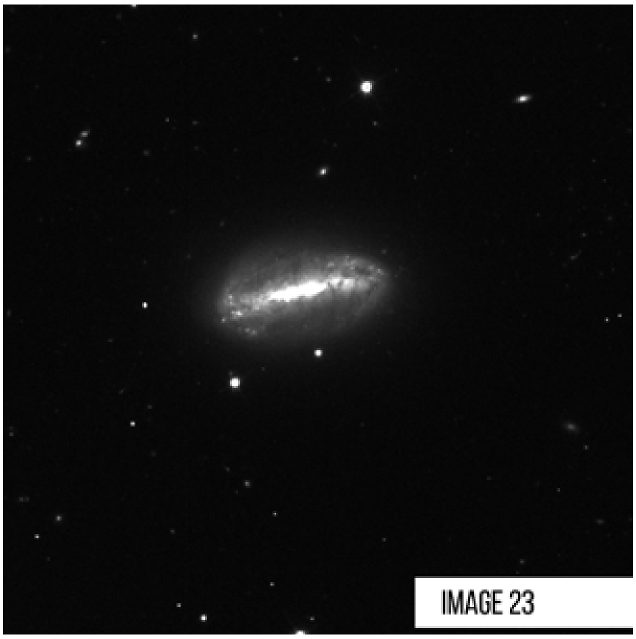

IMAGE 23

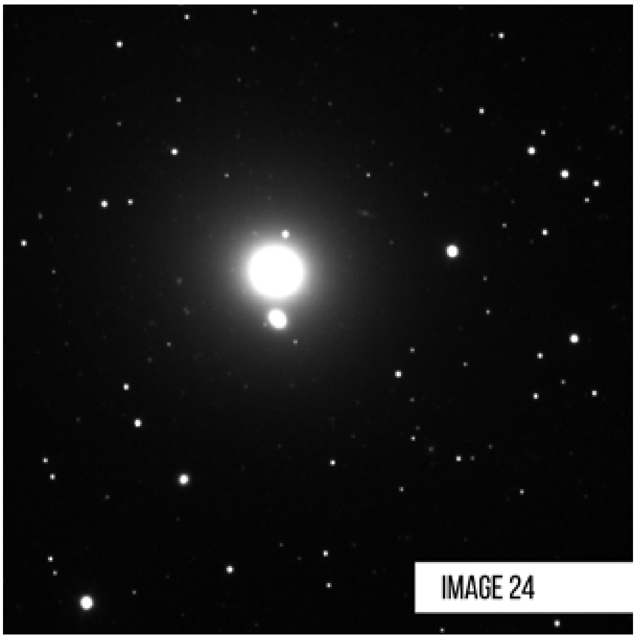

IMAGE 24

SESSION 4: 3-COLOUR IMAGE PART II

In this session, students will be creating a colour image using archive data from the Liverpool Telescope. This builds on the '3-Colour Image Part 1' activity from the Silver booklets. However, students do not need to have previously completed that activity in order to successfully carry out this Gold level activity.

The students will search The Schools' Observatory Archive to find and download images of their chosen object. They will then use our free software to combine three images taken by the Liverpool Telescope (a red image, a green image and a blue image) to make a colour picture. They will use the software to align and scale the images.

Learning Objectives, students will learn:

1. to search and download data from a web archive
2. to develop skills in using astronomical image processing software
3. to produce a 3 colour image using astronomical software

*If your room does not have internet access, download the files and copy them on to the students computers.

Each group will require the following:

REQUIRED RESOURCES
☆ Computer
☆ Internet access/downloaded files*
☆ Student usernames & passwords

Before the session:
We recommend you look up the software in advance of the session and play around with it so that you are comfortable. We have several help videos available to guide you.

The software is available from our website:
www.schoolsobservatory.org/get-started/view-images

At the beginning of the session:
Introduce the session and read through the introductory information at the top of the student's workbooks with the students. The students also have full instructions for the following activities in their workbooks.

ACTIVITY 1: SEARCH THE ARCHIVE

The students will search the archive for a suitable observation using the '...Taken for this Observing Programme:' option. Ensure they select one of these categories: '3-colour galaxy', '3-colour nebula', or '3-colour observation'.

Students will download 3 image files for their chosen observation. Ensure they download red, green and blue image files. The red images will have '000' at the end of their filename, the green images will have '001', and the blue images will have '002'. All three will have the same numbers at the beginning of the filename. For example, 10308F000.fits is the red image and 10308F001.fits is the green image from the same observation.

Students need to save their files somewhere they can find them again for Activity 2.

ACTIVITY 2: LOAD AND COMBINE THE IMAGES

The students will need to process the images using our free software. You may have chosen to download the software in advance depending on your group and set up.

If required, demonstrate how to load images into our software. Make sure the students follow the instructions in their books carefully and open the files in the correct order: If the files are not in the correct order, their image won't look quite right in the later steps.

Students will use the fourth image selection window to combine the files into a 3-colour image. When the students first 'Make a new image', their images will probably be mostly black. This is normal at this stage, so no need to worry. The students will scale the image to reveal the colours as part of this activity.

ACTIVITY 3: ALIGN THE IMAGES

The software has done its best to line up the red, green and blue images on top of each other, but it may not have done it perfectly. The students will correct any misalignment in this activity. Encourage them to carefully check the alignment of the image by following the instructions in their booklets.

If students cannot find a suitable "dot" to use to check the alignment, they can move on to 'Activity 4', and come back and align the images later.

ACTIVITY 4: SCALE THE IMAGE

Up until this activity, the software is only showing the very brightest parts of the image. Students will now 'scale' their image to reveal more of the object.

Encourage students to use trial and error during this activity. There is not one correct solution. They should change the red, green and blue colour values in turn, checking the result in the preview and image windows until they are happy with their image.

ACTIVITY 5: SAVE THE IMAGE

Students should follow the instructions in their booklets to save their picture. They can save multiple versions if they want.

Direct students to a suitable folder where they can save their image. Images can be saved as a JPG and then printed out.

At the end of the session:

- ☆ As a class look at a selection of the images produced. Can students correctly identify if images are of nebulae (colourful, cloud-like) or galaxies (see examples in session 3).

- ☆ Discuss the challenges students faced when processing astronomical data and the skills they used.

Extension: Students can have another go at the session but with a different 3-colour observation from the archive.

SESSION 5: CAREERS IN SPACE

The space sector in the UK is one of the fastest growing industries and by 2030 around 30,000 new jobs are expected to be created in the sector.

Although opportunities are available all around the world to work in this industry, and most space projects work collaboratively between countries, the UK is a world leader in space technology and science.

Jobs can involve working on space missions: from robots visiting distant planets to satellites monitoring the Earth's climate. Roles can involve analysing and interpreting data, writing computer code, engineering new machines and producing new ideas about our Universe. Space sector technology is vital for many industries, including communications, navigation and finance.

There are an enormous number of opportunities available in the space sector. This activity will introduce students to some of these careers.

Learning Objectives, students will learn:

1. about the diversity of careers available in the space sector
2. how different people and job roles must work together
3. about the skills and experiences needed to succeed in the sector
4. to assess their own interests and skills and think about where this could take them

Each group will require the following:

REQUIRED RESOURCES
☆ Pens/Pencils
☆ Access to the internet*

*For the extra (optional) activity only

Before the session:
There is very little preparation needed for this session because most of the activities will involve discussion. Students will need to complete sections in their workbooks as you go through the tasks. If you have time, you might like to familiarise yourself with some of the careers available by visiting: www.schoolsobservatory.org/careers or take a look at websites such as SpaceCareers.uk.

At the beginning of the session:

- ☆ Start an initial discussion into the topic of space careers. You can use some of the information in the introduction above.
- ☆ Ask the students to think of careers that involve space or astronomy.
- ☆ Find out if any of the students are thinking about a career in this sector.

ACTIVITY 1: MANAGING A SPACE AGENCY

The students will assume the role of the head of a space agency. Their task is to assemble a team to travel on a 2-year crewed mission (this assumes new technology not yet invented) to a recently discovered dwarf planet. Their mission is to scope out the planet's surface for potential future base camp locations. Start the activity by discussing as a group what skills or job roles might be needed on this mission.

- You may want to discuss what could go wrong and who they would want in that situation; e.g. a medic?
- What does it take to get a crewed mission into space; e.g. might they want a pilot, a mechanic or engineer?
- How about when they reach the planet and want to explore?

They might consider a drone pilot, a geologist, or a botanist. There are a huge number of possible combinations of people and skills needed.

1. Give the students some time to work independently, or in small teams, to decide upon ten job roles they would like to be covered by the mission crew.
2. It's likely that all of the teams will have at least 3-4 job roles in common, for example a pilot, a medic of some kind, and a scientist of some kind. Find out which roles each of the groups have in common.
3. Ask the students to share with the wider club one of the roles they think is the most interesting, such as a role other people might not have thought about.
4. Ask the students which role appeals to them most personally. They can make a note of this in their workbooks.

ACTIVITY 2: CAREER FOCUS

Ask the students to independently select one of the job roles they have chosen for the mission crew. This could be a role they see themselves in, or just one that they find interesting.

The students must then create a CV for an imaginary person who could fill this role. The student workbooks contain a blank CV form to guide their thinking process. Students can fill in the blank form or they can create their own from scratch and place a copy into the workbook.

Students will need to think about:

- What skills this person needs.
- What experience do they have?
- What qualifications have they achieved?
- What did they study at school/college/university?
- What personal attributes do they have?
- What are their interests outside of work?

ACTIVITY 3: JOB TASKS

During this activity, students must think about the tasks the person fulfilling their chosen job role will need to carry out on the mission. There is space in their workbooks for students to list a few of the main tasks and explain why they are important to the mission.

Bring the club back together and get them to discuss anything that has surprised them while carrying out this session.

Take a vote:

- ☆ How many of your students would like to take part in a crewed mission to space?
- ☆ How many might like a career in the space sector, but one that is based on Earth?

Extra Activity:
If you have some keen students, why not encourage them to visit the Careers section of our website (www.schoolsobservatory.org/careers) to explore the careers profiles of some real people working in the space sector.

There are a wide range of careers in space and astronomy, some of which might be surprising! We have a great video highlighting these career options: www.youtube.com/watch?v=_ly4xLtnChc&t=1s

SESSION 6: STAR PARTY

In this session, your club will celebrate completing The Schools' Observatory STEM Club with a Star Party! Give the students some time to reflect on what they have done over the last few weeks and complete the questions in their workbooks.

How you celebrate is up to you and your club, but we have included some ideas here:

- ☆ Have a prize giving and hand out the students' certificates*.
- ☆ Display the work students have created around the room.
- ☆ Repeat a favourite activity from one of the STEM Club booklets.
- ☆ Get creative and make space-themed objects. Hang them around the room.
- ☆ Put on a space-themed playlist to soundtrack your Star Party.
- ☆ Watch an appropriate space-themed film with popcorn.
- ☆ Do some astronaut training!
  There's plenty of ideas here: www.nasa.gov/tla/activities/english.
- ☆ Include some space-themed snacks. What do astronauts eat in space?

*Instructions on how to obtain your certificates are given on page 27.

If you have clear, dark skies, you might want to go outside to do some observing. If so, here are some resources which might make it easier!

- ☆ Binoculars
- ☆ Telescope
- ☆ Star Chart
- ☆ Mobile app for finding stars (e.g. SkyView Lite, Star Walk 2)
- ☆ Free Stellarium software to plan your observing

Take some photos of your party and share them with us! We have included a space for a photo from the star party in the student workbooks.

NEXT STEPS...

Congratulations on completing the Gold level of The Schools' Observatory STEM Club!

We hope your students have enjoyed the last 6 weeks and are proud of their completed workbooks. You will notice that the final page of their workbooks contains a space for a certificate. To obtain your certificates, please complete this short online form:

www.schoolsobservatory.org/stem-club/certificates

Once you submit the form, you will be able to download your certificate.

Thank you for being part of The Schools' Observatory STEM Club!

JUST FOR FUN

We love to see the images that pupils have created from their observations! On page 24 of the student booklet there are details on how to share students' astronomical observations with us. The images you share with us may be showcased in our Galleries on The Schools' Observatory website.

You can share students' images with us by:

- ☆ Tagging @SchoolsObs on Twitter or Instagram

By sharing pupils' images with The Schools' Observatory, you consent for us to use those images on our website and social media accounts and/or for publicity.

FEEDBACK

We love to hear from our users about how we can improve our services. If you or your students have ideas about how we can improve these booklets please email SchoolsObs@ljmu.ac.uk

THE SCHOOLS' OBSERVATORY

For more lesson ideas and interactive workshops visit the 'Things to Do' section of our website.

WWW.SCHOOLSOBSERVATORY.ORG/THINGS-TO-DO

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