TEACHER NOTES – ASTRONOMY IN THE NEWS #01
RETURNING A SAMPLE FROM TITAN

Slide 1 – Background Science: Titan

Titan is a planet-like satellite of Saturn. It is the largest moon of Saturn and is unique in that, other than Earth, is the only known body where bodies of liquid have been found. The allure of Titan is that it is a potential harbour of life outside of Earth. Titan has an atmosphere that is nitrogen rich (like Earth, although it is 97 % compared to 78 % on Earth), and has rivers and lakes. However, the rivers and lakes are made of hydrocarbons, probably methane. Methane is a potentially interesting substance since it is formed by both geological and biological processes so the presence of it may indicate the presence of life.

Along with the presence of this liquid methane, there is believed to be water ice on the surface, along with under the surface, complete with liquid oceans underneath the surface. Depending on the depth of this ocean, there could be more water on Titan than on Earth.

IMAGES:

1. Image of Titan
2. Cross section of Titan, with the ice and subterranean water indicated.
3. Image from Cassini-Huygens of the lakes of hydrocarbons on the surface.

Slide 2: Future Missions to Titan

The next mission to Titan will be the “Dragonfly” mission, to be launched in 2026 and landing in 2034.

The mission will aim to take surface samples, and test the complex chemistry that could be found. This would be the carbon, oxygen, and nitrogen based molecules, including tholins. Tholins are not found on Earth naturally, and are caused by UV irradiation of common compounds, such as hydrocarbons or carbon dioxide/carbon monoxide. They are thought to have once existed on Earth and when combined with water, could be the ingredients from which life is formed. Therefore, the presence and study of them could tell us how life is formed. (The reddish hue of Titan is probably caused by tholins).

The Dragonfly mission will also fly around the planet, taking samples from multiple places including a crater where there is evidence of past liquid water.

IMAGES:

1. Cartoon visualisation of the Dragonfly mission
2. The Selk Crater, the intended landing/resting spot of Dragonfly.

Slide 3 – Activity: How do you fuel the mission?

The current mission plan, Dragonfly, is set to land on Titan and complete all of the experiments on board the hardware. However, recently NASA released the recipients of the current round of Innovative Advanced Concepts (NIAC) award winners. One of these awards was to a project called "A Titan Sample Return Using In-Situ Propellants". The aim of this project is to go down to Titan, take these samples and then return them for further analysis.

Full details can be found here:
https://www.nasa.gov/directorates/spacetech/niac/2021_Phase_I/A_Titan_Sample_Return_Using_In-Situ_Propellants/

The activity associated with this bulletin is to discuss ideas of how to do this. There are two questions to have in mind. The first is "where do you get the fuel?" and the second is "where do you get the oxygen to fuel it?".

The "correct" answers to these questions are from the methane already on the planet (this is the in-situ propellants) and the oxygen would come from the ice (water) on the surface. This could either be from electrolysis or from the expected method, thermolysis, of splitting the water molecules by simply heating them up to dissociate them. The issue with that is how to get enough energy, and this would probably be from a nuclear source.

A common answer to part 2 may be solar power. However, the distances associated plus the thicker atmosphere (at the surface, the atmospheric pressure is 60 times that of Earth, or similar to swimming 15 metres under water) would make this impossible to store up the required energy in a reasonable timescale.

GCSE Specifications:

Specification	Knowledge Point
Pearson Edexcel Astronomy	11.1, 11.6, 11.26, 11.27, 12.5
Pearson Edexcel Chemistry	3.23, 8.1, 9.10
Pearson Edexcel Combined Sciences	3.23, 8.1
OCR Chemistry B	3.3, 3.4
OCR Combined Sciences B	C3.3, C3.4
AQA Chemistry	4.4.3.1, 4.7.1.1
AQA Combined Science: Trilogy	5.4.3.1, 5.7.1.1