

## Binary Code & Satellite Images

<b>Topic</b>	Binary Code, Satellite Communications
<b>Subject</b>	Science
<b>Grade Level</b>	4-6
<b>Time</b>	1 hour
<b>Curriculum Alignment</b>	<p>Science 4–2 Identify patterns and order in objects and events studied; and record observations, using pictures, words and charts, with guidance in the construction of charts; and make predictions and generalizations, based on observations.</p> <p>Science 5–2/ 6-2 Recognize the importance of accuracy in observation and measurement; and, with guidance, apply suitable methods to record, compile, interpret and evaluate observations and measurements.</p> <p>6–8 Apply observation and inference skills to recognize and interpret patterns and to distinguish a specific pattern from a group of similar patterns.</p>

<b>Hook:</b>	<b>Notes:</b>
Show Ex-Alta 1 3D Model Video	<a href="https://m.youtube.com/watch?v=Ew2N9OqL-F4">https://m.youtube.com/watch?v=Ew2N9OqL-F4</a>

<b>Introduction:</b>	<b>Notes:</b>
<p><u>What is AlbertaSat?</u></p> <ul style="list-style-type: none"> <li>● AlbertaSat is a student group at the University of Alberta that builds CubeSats</li> <li>● CubeSats are small (like a loaf of bread) satellites made up of standardized cubes. These cubes (known as units) are 10cm x 10cm 10cm</li> <li>● Ex-Alta 1 (Experimental Albertan 1) is a 3U (3 unit/3 cube) CubeSat. It was the first satellite built by AlbertaSat.</li> <li>● Ex-Alta 1 was built as part of an international project, QB50. This project was lead by the European Space Agency (ESA) to study space weather.</li> </ul>	

<ul style="list-style-type: none"> <li>• Ex-Alta 1 was launched to the International Space Station (ISS) in April of 2017 and into orbit in May of 2017.</li> <li>• Show Map of QB50 Satellites</li> <li>• Ex-Alta 1 includes the following payloads: MNLP (Langmuir Probes), Dosimeter (studies radiation), Athena On-board Computer, Magnetometer.</li> <li>• Our Satellite also has a camera which helps us determine where it is and sends images back to earth</li> <li>• Ex Alta-2 will also be a 3U CubeSat, the focus of which will be predicting, tracking, and assessing the after effects of wildfires, which burn 2.5 million hectares of land in Canada annually.</li> <li>• Ex Alta-2 represents an ability to study wildfires at similar resolution to current NASA satellites for a fraction of the cost.</li> <li>• Moving forward with the mission, the following components will be open source: solar cell patch antenna, icarus cubestat structure, electronic power supply board, uhf transceiver, and athena onboard computer.</li> </ul>	
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<b>Background Information:</b>	<b>Notes:</b>
<p>What is the binary system?</p> <ul style="list-style-type: none"> <li>• The Binary system is a type of 'computer language' that allows us to process data over long distances. An image can be sent from a satellite through this 'language'.</li> <li>• Instead of counting from 0-9 we use 0's and 1's. So 0-9 is actually 0- 1001</li> <li>• Students can think of this as the satellite providing a description of the language in number and a computer turning that description into an image.</li> </ul>	<p>Most of the satellites use 512 x 512 pixels to transmit. There are <math>512 \times 512 = 262,144</math> pixels. Assuming it takes one second per pixel to transmit, it would take 262,144 seconds which is equal to more than three days (assuming 24-hour non-stop work). Satellites actually send images much faster than this (Ex-Alta 1 takes 5-15 minutes).</p>

- This done by assigning the pixels (tiny squares that make up the image) to a code. In the case of black and white photos, pixels are represented by 1's and 0's. The 0's and 1's can be combined to form a combination that represents more shades of grey. Basically, There are more numbers for more detailed pictures (a grayscale image taken by Ex-Alt 1 could have a range of 0-255 combinations to form each pixel). This code changes depending on the image.
- Students can think of this like a paint-by-number painting, the more detailed the painting the more numbers there are, however instead of 1-10, numbers like 3 and 6 are represented by combining 0's and 1's in a standardized combination (like a code). Basically, using the basics of binary code, a computer can assign shades and colours numbers which we can then render into an image.

Decimal	Binary
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
10	1010
11	1011
12	1100
13	1101
14	1110
15	1111

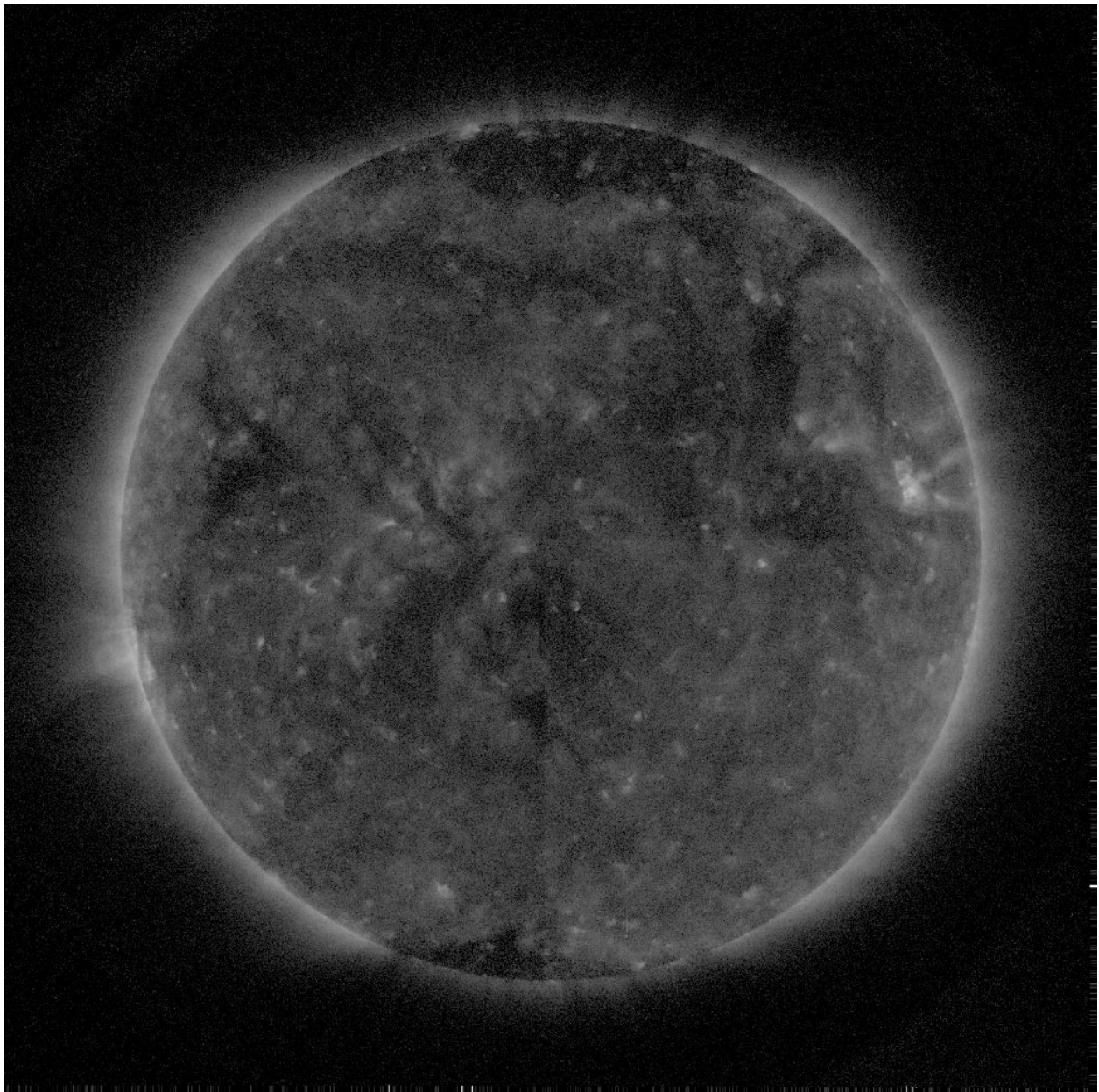
Explanation of Activity:	Notes:
<ol style="list-style-type: none"> <li>1. Students should work individually, on this.</li> <li>2. Review the binary code legend. In this case we have converted the code into four colours (0-3) to make the image clearer.</li> <li>3. Hand out materials:               <ol style="list-style-type: none"> <li>a. Binary image handout</li> <li>b. Pencils</li> </ol> </li> <li>4. Tell students to shade the image on the handout according the binary rules in the legends.</li> <li>5. Students can think of this as rendering an image after a computer has assigned shades and colours numbers based on the code received from a satellite.</li> </ol>	<ol style="list-style-type: none"> <li>1. Extension Activity: Once students have taken a binary image and coloured (as if they are the computer decoding it), they could be given an image and convert it into binary. It is recommended students use a 2-colour code for this.</li> </ol>

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**Materials Required**

- Graph paper, at least 3 sheets per group
- Pencil Crayons, at least 3 per group
- Handout

[Picture of the Sun \(Courtesy of NASA\) for activity](#)





Example worksheet

**Color Image**

0	1	2	3
□	□	□	□

**Four Color Image**

0	1	2	3
□	□	□	□

The image displays a 4x2 grid of binary data. The left column, labeled 'Color Image', shows a grayscale representation of a satellite image. The right column, labeled 'Four Color Image', shows a corresponding four-color representation. Each image is composed of a grid of binary digits (0s and 1s) where the density of 1s represents the intensity of a pixel. The images are partially obscured by dark, irregular shapes, likely representing physical damage or artifacts on the original document.

