Electromagnetic Spectrum and Multi-wavelength Astronomy

Learning Plan
Day 9: What are some ways of thinking that scientists use when doing research?

Targeted Idea: Scientists may consider one or more Crosscutting Concepts in their approach to a research question. The CCCs are mental tools students can use to help them understand a phenomenon from a scientific point of view.

Overview of Day 9:

Students gather into their assigned groups and discuss their Case Studies through the lens of the Crosscutting Concepts (CCCs). In discussion, the students should think about the different approaches taken by the scientists; for example, did they try to determine if an object is changing or stable, or did they look at many objects at once to search for similarities (a pattern)? The groups reference the Student Support Guide for CCCs (from Days 7 & 8) as they discuss their Science Case Studies while considering the Crosscutting Concepts. Groups then present highlights of their discussion points. This is an opportunity to review all the Case Studies, discuss the various approaches that scientists may take, and discuss the general question of "What are scientists looking for when they study the Universe at multiple wavelengths?"

The class then overviews the unit organizer and does a final reflection on the Fancy Cameras Probe before receiving the final assignment.

Middle School Performance Expectations (PEs) and Disciplinary Core Ideas (DCIs) relevant to Day 9:

PE MS-PS4-2 Waves and their Applications in Technologies for Information Transfer
Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. [Clarification statement: Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.]

DCI MS-PS4.B Electromagnetic Radiation
When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light.

Students are building their understanding toward these High School Disciplinary Core Ideas (DCIs) during Day 9:

PS4.B.1 Electromagnetic Radiation
Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave~~ of changing electric and magnetic fields or~~ ~~as particles called photons~~. The wave model is useful for explaining many features of electromagnetic radiation ~~while the particle model explains other features~~.

PS4.A Wave Properties
Information can be digitized (e.g., a picture stored as the values of an array of pixels)in this form, it can be stored reliably in computer memory ~~and sent over long distances as a series of wave~~

~~pulses~~.

PS4.C Information Technologies and Instrumentation
Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them.

PS4.B.4 Electromagnetic Radiation
Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities.

ESS1.A The Universe and Its Stars
The study of stars' light spectra and brightness is used to identify compositional elements of stars ~~their movements, and their distances from Earth~~.

Students are building their skills in / understanding of these Science and Engineering Practices (SEPs) and Cross Cutting Concepts (CCCs) in Day 9:

SEPs

Analyzing and Interpreting Data

- Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.

Obtaining, Evaluating, and Communicating Information

- Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

CCCs

Patterns

- Empirical evidence is needed to identify patterns.

Stability and Change

- Much of science deals with constructing explanations of how things change and how they remain stable.

Electromagnetic Spectrum and Multi-wavelength Astronomy

Instructional Materials	Resources
Handouts: • Infrared Discovery Matrix • Final Assignment	• PowerPoint for Day 9

Day 9	
Teacher Role	**Student Role**
• Distribute materials. • Encourage students to use their own words, and find ways to summarize their own learning, especially during the review of the graphic organizer.	• Contribute to group discussions. • Listen to peer ideas. • Make notes in preparation for sharing.

Steps to follow:

1. *Elaborate:* Students gather into their assigned groups and discuss their Case Study through the lens of the Crosscutting Concepts.
   - Student groups should review their assigned CCC answers to the questions from the
   - Student Support Guide for CCC with the group.
   - Every group member should make careful notes in preparation for sharing with the class.
   - Each group shares their CCC discussion summary for both CCCs.

2. Staying in the same group, coach students to use their completed unit organizer and other aspects of the unit to create a 2-sentence response to the question, “What are scientists looking for when they study the Universe at multiple wavelengths?”

3. Share out.

4. Review the Fancy Camera Probe (Day 1). Take student responses by show of hands.

5. *Evaluate: Assign homework:* Day 9 Final Assignment. Distribute the Infrared Discovery Matrix for use in completing the final assignment.

6. If time allows: Hold a gallery walk to allow students an opportunity to see how other groups’ explanations with model and Claim Evidence Reasoning (CER). Allow students to place a check mark next to ideas that they also felt they now understood, and to add any further ideas to the bottom of the chart paper.

Learning Plan
Day 10: Final Assessment

Targeted Idea: How do scientists know what they know?

Overview of Day 10:

In this final day of the Electromagnetic Spectrum and Multi-wavelength Astronomy curriculum unit, students will hand in their final assignment. Students can then review the curriculum unit, including looking back to the Unit Graphic Organizer (Day 2), Case Study Focus Questions (Day 2), Student Support Guide for Crosscutting Concepts (Day 8), and Infrared Discovery Matrix (Day 9). Teachers may administer a summative assessment tool of their own design at this point.

Instructional Materials	Resource
• None required	• Unit Graphic Organizer • Case Study Focus Questions • Student Support Guide for CCCs • Infrared Discovery Matrix

DAY 10

Teacher Role	Student Role
• Collect student final assignment. • Facilitate curriculum unit review. • Administer optional final assessment.	• Reflect on the activities, practices, and concepts presented over the past 9 days.

Steps to follow:

1. Congratulate the students on their hard work over the past 9 days.

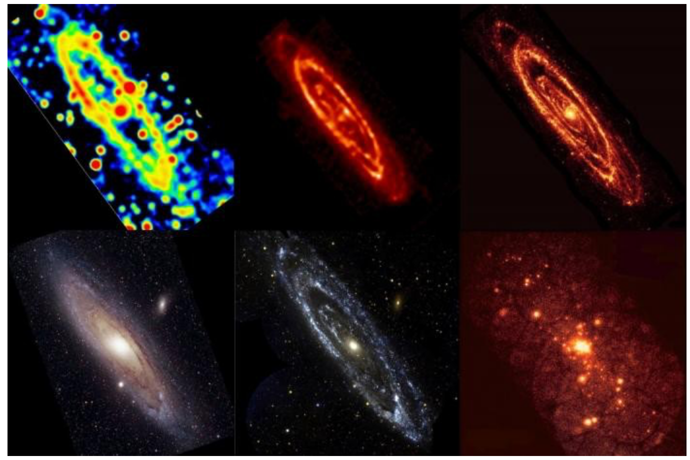
2. Collect the final assignment.

3. Facilitate optional student discussions reviewing the curriculum unit; may include looking back to the Unit Graphic Organizer (Day 2), Case Study Focus Questions (Day 2), Student Support Guide for Crosscutting Concepts, (Day 8) and Infrared Discovery Matrix (Day 9).

4. Administer optional final assessment.

Fancy Cameras

A friend was surfing the internet and came across these images of the same galaxy. They were labeled as radio, microwave, infrared, optical, UV, and X-ray. She pointed it out to her group of friends. They all thought it was really cool but wondered how the same object could look so different in photos. They had a lot of different ideas about the image. Here is what they said:



Credit: NASA

Wei: "I don't think cameras can photograph different wavelengths of light. It's just like one of those Instagram filters that changes colors around after you take the photo."

Latoya: "These can't be real photos. Galaxies don't produce microwaves, radio waves can only be heard and not seen, and the Sun is the only thing that produces UV light."

Juan: "I think they used filters, so that the camera only recorded certain colors of visible light coming from the galaxy. When you combine them together, it makes a photo just like what you would ordinarily see with your own eyes."

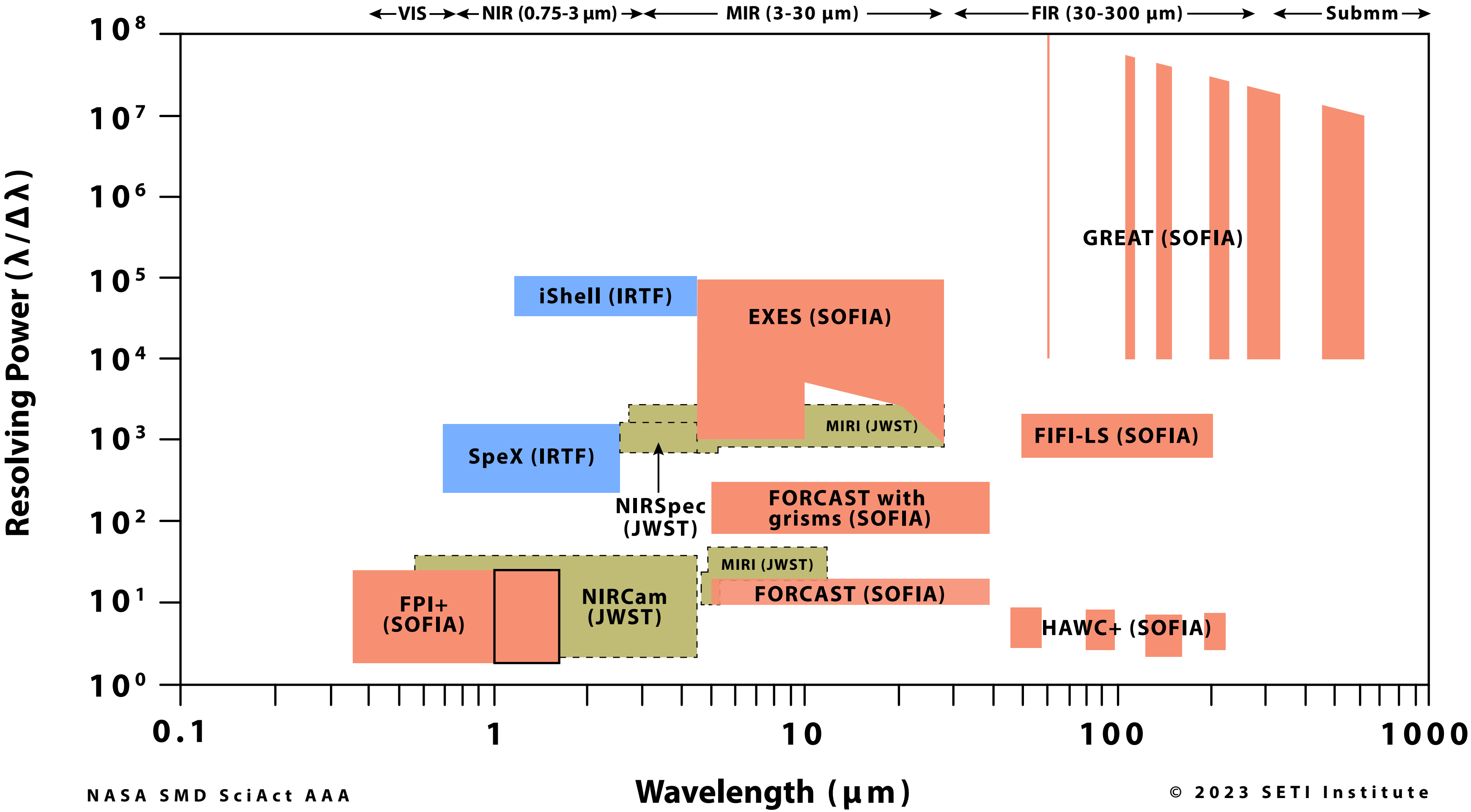
Sofia: "I think each image is recording a different wavelength of light coming from the object. So, the camera must have a sensor that can detect those wavelengths, and then it shows that as different colors.

Jared: "Each image looks different because of the speed of the waves. Like, the radio images looks different because that light travels much slower than visible light, and the infrared light travels the fastest. "

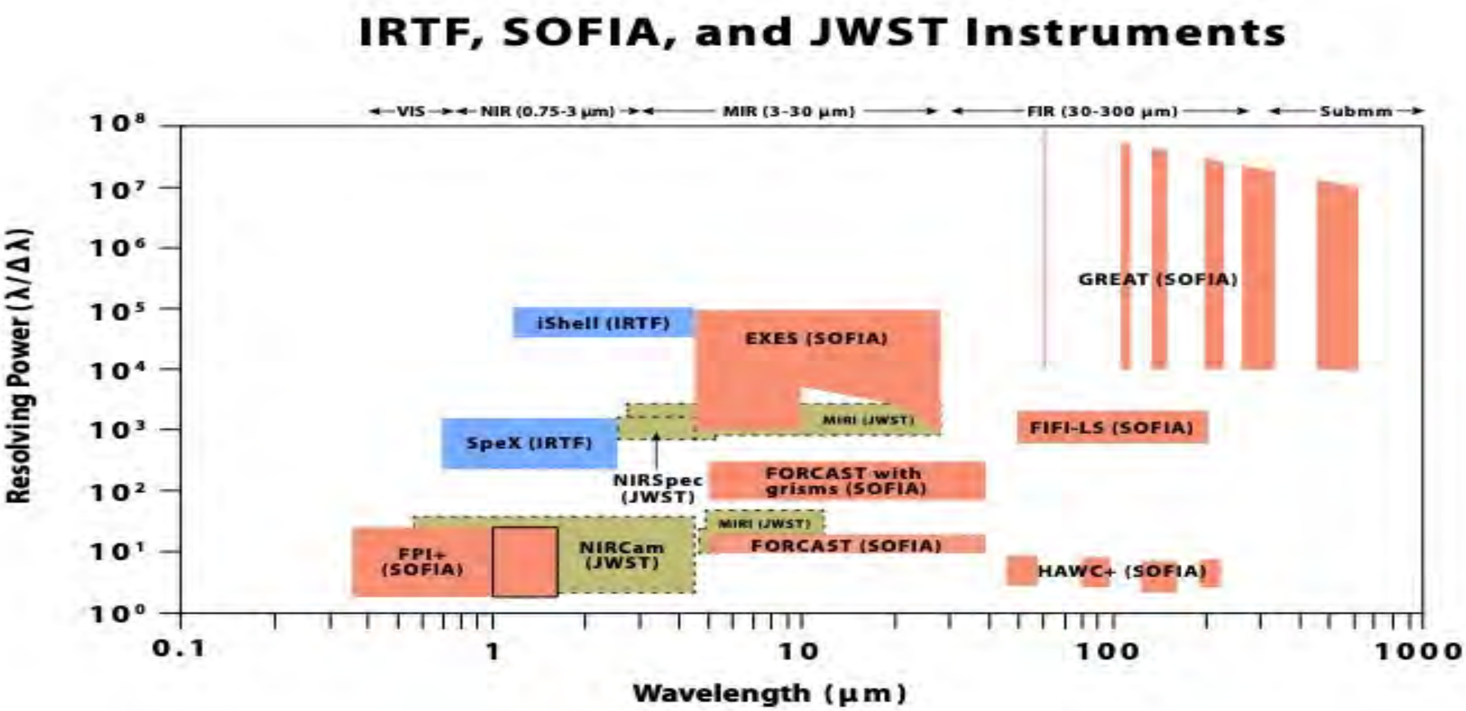
Which student(s) do you agree with the most? ____________________

Explain why you agree.

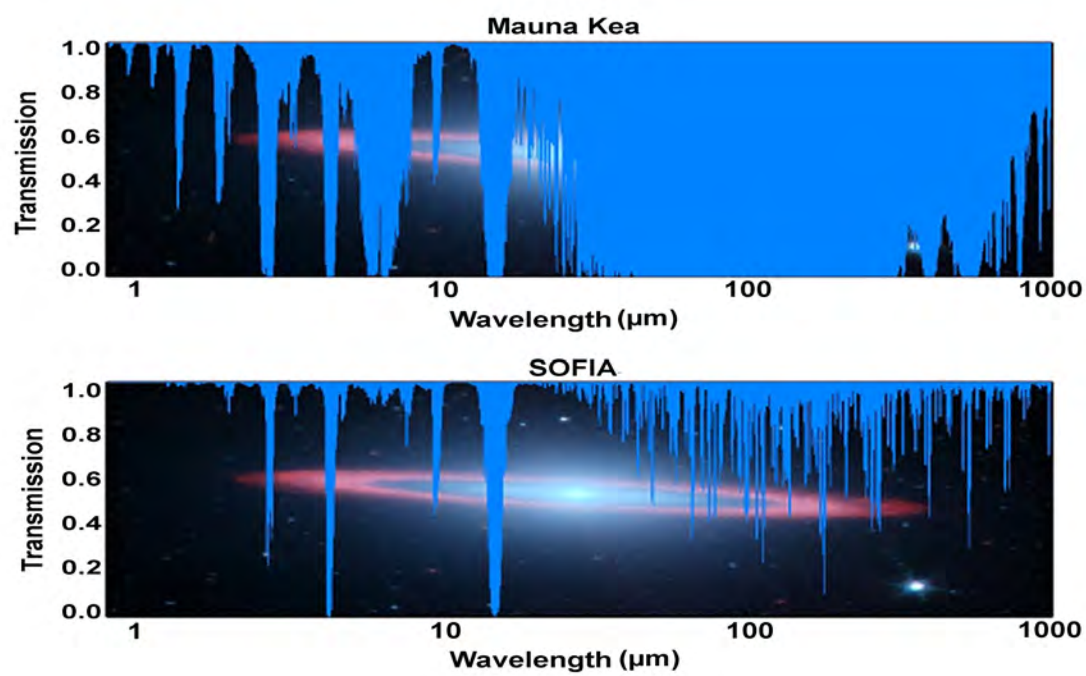
IRTF, SOFIA, and JWST Instruments



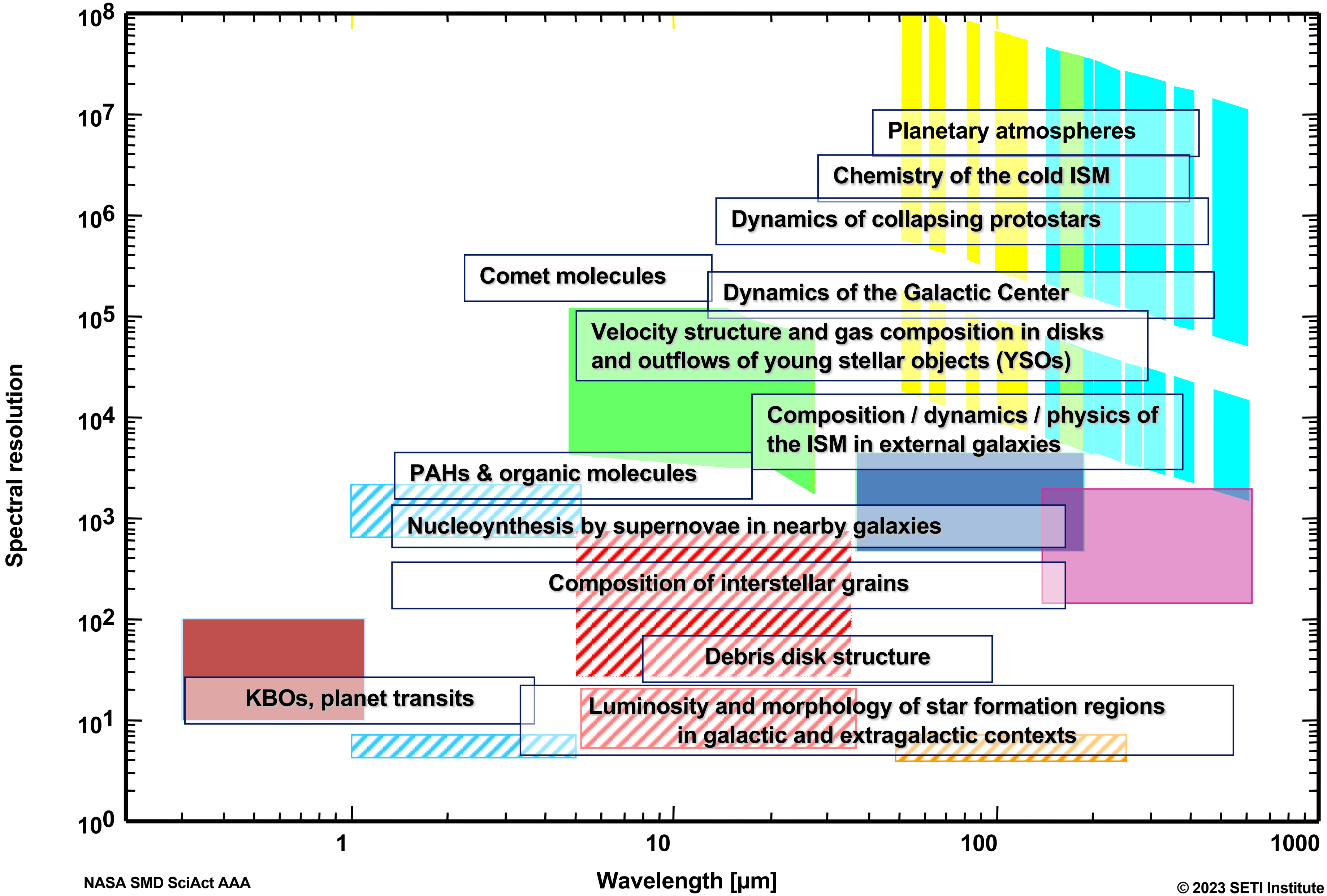
NASA SMD SciAct AAA



IRTF, SOFIA, and JWST Instrument ”footprints” = spectral resolution vs. wavelength



SOFIA: Science for the Entire Astronomical Community



NASA SMD SciAct AAA

IR Discovery Matrix			
Wavelength range	**Objects / systems**	**Prominent spectral features**	**Interesting to astronomers because ...**
Visual to Near-IR	HII (ionized hydrogen) regions	Atomic and molecular emission lines	Raw material for new stars, excited by UV emission from nearby young stars
Visual to Near-IR	Cool stars: M dwarfs, red giants, and red supergiants	Molecular absorption lines and bands	Stellar evolution archetypes; chemical evolution of the Galaxy
Visual to Near-IR	Brown dwarfs	Molecular absorption lines and bands	Star and planet formation processes
Visual to Mid-IR	Planetary nebulae	Atomic and molecular emission lines	Late stage of solar-mass stellar evolution; recycling of chemical elements to the ISM
Near-IR to Mid-IR	Exoplanets	Atomic and molecular absorption lines during stellar transit	Composition and temperatures in exoplanet atmospheres
Near-IR to Mid-IR	Protostars	Atomic and molecular emission lines	Longest-lasting stage of star formation
Near-IR to Mid-IR	Protoplanetary disks	Atomic and molecular emission lines (and absorption lines, if seen edge-on)	Compositions, chemistry, and gas motions In forming planetary systems
Near-IR to Mid-IR	Planetary surfaces	Silicate and ice reflection absorption bands	Composition of planetary surfaces
Near-IR to Far-IR	Asymptotic Giant Branch (AGB) red giant stars and carbon stars	Molecular absorption lines & bands; maser emission lines	Late stages of stellar evolution; recycling of chemical elements to the ISM
Mid-IR to Far-IR	Planetary atmospheres	Atomic and molecular emission and absorption lines	Composition and gas motions in planetary atmospheres
Mid-IR to Far-IR	ISM dust	Near-IR ice and organic absorption and emission bands; Mid-IR silicate bands (usually absorption)	Composition of raw material for new stars and planets
Mid-IR to Far-IR	Debris disks	Atomic and molecular emission and absorption lines	Nearly-mature planetary system
Far-IR	Molecular cloud cores	Atomic and molecular emission lines	Earliest star formation processes, before protostar stage

Final Assignment

1. Plan an astronomy investigation that would yield infrared spectra. What astronomical object would like to investigate? What telescope and instrument would you use? Why?

2. Explain how scientists know and understand a science research finding from data collected by a scientific instrument using a model; show your reasoning in your response. Include the following labels, words, and/or items in your explanation:

    - Infrared
    - Emit
    - Reflect
    - Data
    - Telescope
    - Instrument
    - Directional arrows

    Optional terms/ labels:

    - Transmit
    - Speed of light
    - Other items or ideas you wish to add

