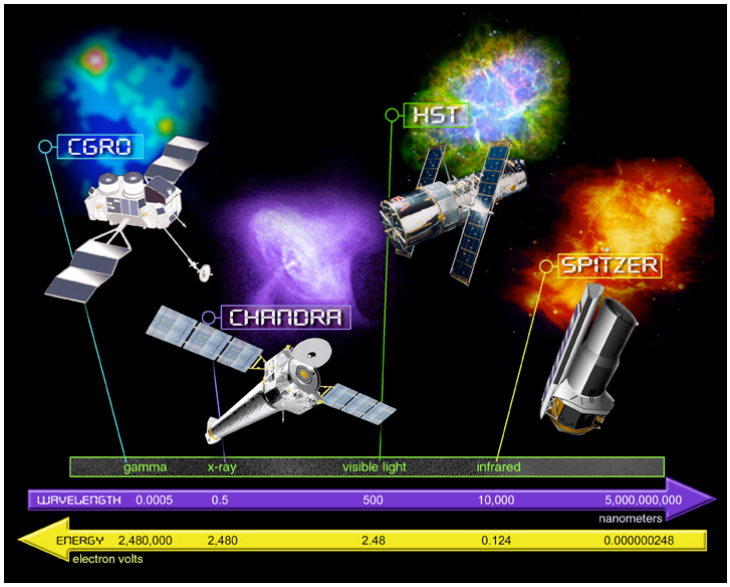
Activity: Multiwavelength Bingo

BACKGROUND:

Almost everything that we know about distant objects in the Universe comes from studying the light that is emitted or reflected by them. The entire range of energies of light is called the electromagnetic spectrum. Our eyes are sensitive only to a narrow band of electromagnetic radiation called visible light, but luckily NASA's great observatories allow us to look into the invisible!



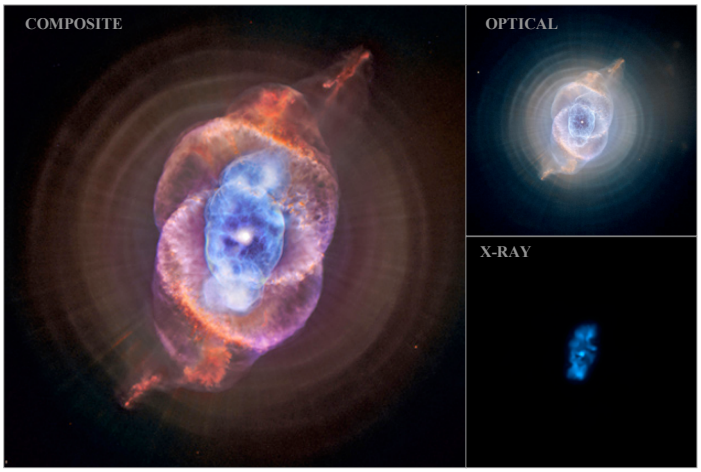
From high energy, short wavelength to low energy, long wavelength, the electromagnetic spectrum is divided into gamma rays, x-rays, ultraviolet, optical (visible light), infrared, microwaves, and radio waves. The image to the right shows four of NASA's great observatories and the area of the electromagnetic spectrum in which they collect data. By taking a multiwavelength approach to viewing the cosmos, scientists gain a greater understanding of the workings of the Universe.

HOW TO PLAY MULTIWAVELENGTH BINGO:

- ✓ Choose one person to be the "caller." Pass out a bingo board to all other players.
- ✓ Cut out the bingo calling cards along the dotted lines and put them into a container. The caller draws a card from the container, reads it out loud, and puts the card to the side.
- ✓ Players mark the corresponding image on his/her board with a bingo token using the flash cards as a guide.
- ✓ The caller continues drawing cards from the container, until a player has 5 marked images in a row (vertically, horizontally or diagonally) and yells "bingo!"

- ✓ If the caller verifies that the player indeed has bingo, that player wins. If not, incorrect tokens are removed and play continues until "bingo" is called again and verified.

WHAT FEATURES CAN YOU SEE AT DIFFERENT WAVELENGTHS OF THE ELECTROMAGNETIC SPECTRUM?

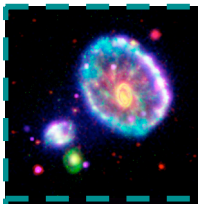


CAT'S EYE NEBULA

Credit: X-ray: NASA/CXC/SAO; Optical: NASA/STScI

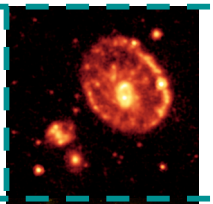
The Cat's Eye Nebula represents a phase of stellar evolution that the Sun should experience several billion years from now. This composite of data from NASA's Chandra X-ray Observatory and Hubble Space Telescope shows various features of this so-called planetary nebula. When a star like the Sun begins to run out of fuel, it becomes a red giant. In this phase, a star sheds some of its outer layers, eventually leaving behind a hot core that collapses to form a dense white dwarf star. A fast wind emanating from the hot core rams into the ejected atmosphere, pushes it outward, and creates the graceful filamentary structures seen in the optical data collected by Hubble. Chandra's X-ray data shows that its central star is surrounded by a cloud of multi-million-degree gas.

BINGO CALLING CARDS



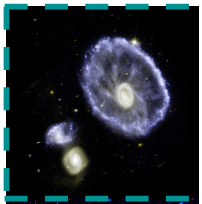
CARTWHEEL GALAXY

composite



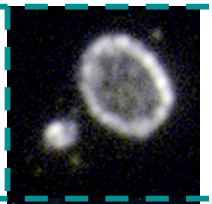
CARTWHEEL GALAXY

infrared



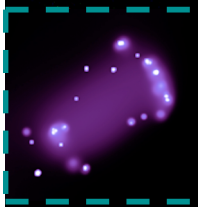
CARTWHEEL GALAXY

optical



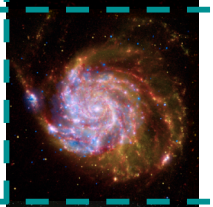
CARTWHEEL GALAXY

ultraviolet



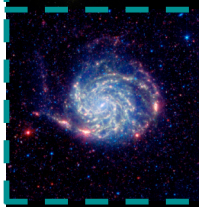
CARTWHEEL GALAXY

x-ray



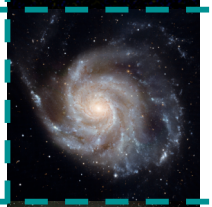
M101

composite



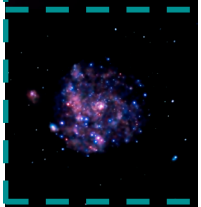
M101

infrared



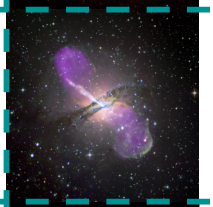
M101

optical



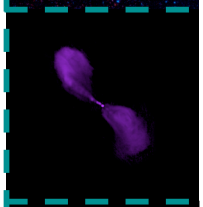
M101

x-ray



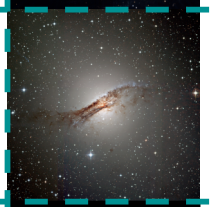
CENTAURAS A

composite



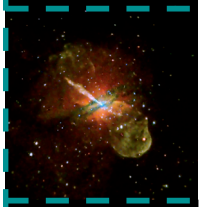
CENTAURAS A

radio



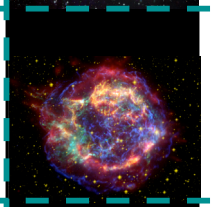
CENTAURAS A

optical



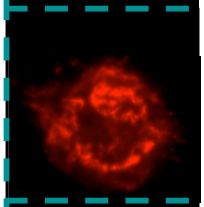
CENTAURAS A

x-ray



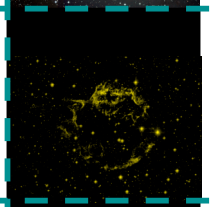
CASSIOPEIA A

composite



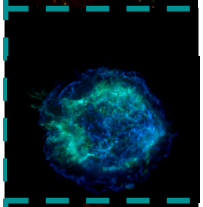
CASSIOPEIA A

infrared



CASSIOPEIA A

optical

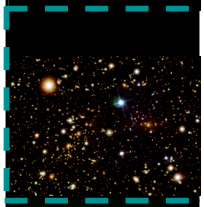


CASSIOPEIA A

x-ray

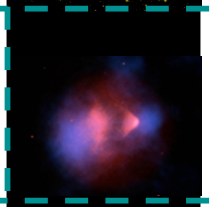
BULLET CLUSTER

composite



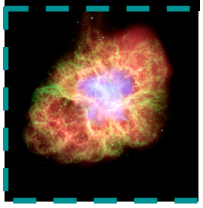
BULLET CLUSTER

optical



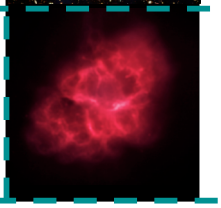
BULLET CLUSTER

x-ray/ lensing map



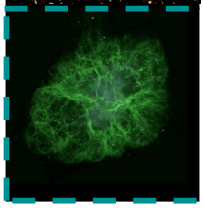
CRAB NEBULA

composite



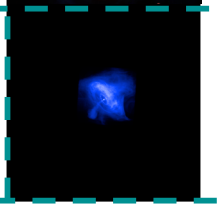
CRAB NEBULA

infrared



CRAB NEBULA

optical



CRAB NEBULA

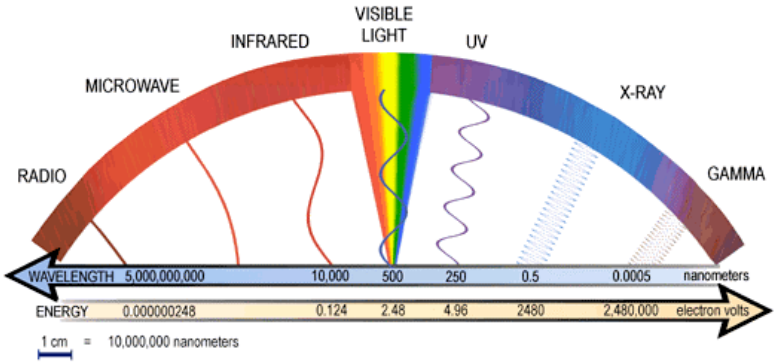
x-ray

FOR MORE INFORMATION ON MULTIWAVELENGTH ASTRONOMY AND THE ELECTROMAGNETIC SPECTRUM, VISIT:

The Multiwavelength Milky Way
http://mwmw.gsfc.nasa.gov/

Touch the Invisible Sky
http://chandra.harvard.edu/edu/touch/

Modeling the Electromagnetic Spectrum
http://chandra.harvard.edu/edu/formal/ems/

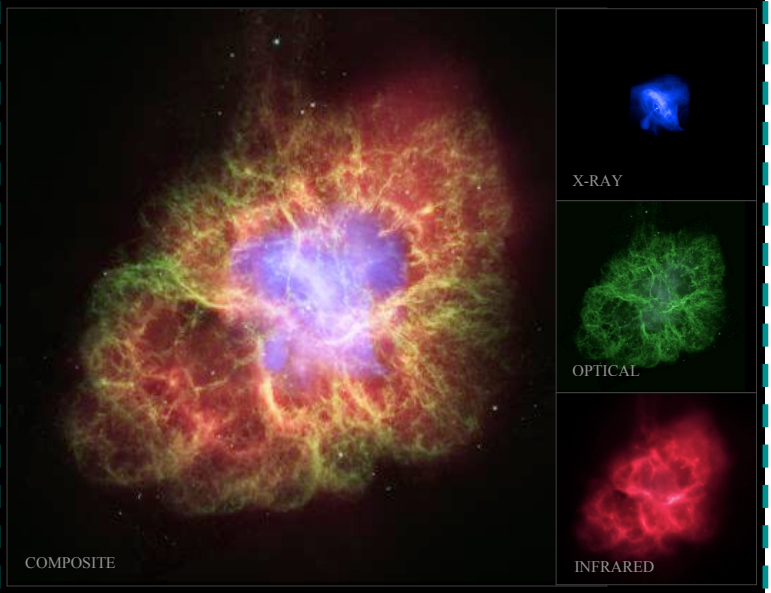


MULTIWAVELENGTH BINGO FLASH CARDS

BULLET CLUSTER (3.4 billion light years)

The Bullet Cluster" galaxy was formed when two large groups of galaxies collided, the most energetic event known in the Universe since the Big Bang. Data from the Hubble Space Telescope and visible light telescopes on the ground show how dark matter (blue) has separated from normal matter in the form of hot gas (pink) detected by the Chandra X ray Observatory.

Credit: X ray: NASA/CXC/CfA/M.Markevitch et al.; Optical: NASA/STScI; Magellan/U.Arizona/D.Clowe et al.; Lensing Map: NASA/STScI; ESO WFI; Magellan/U.Arizona/D.Clowe et al.

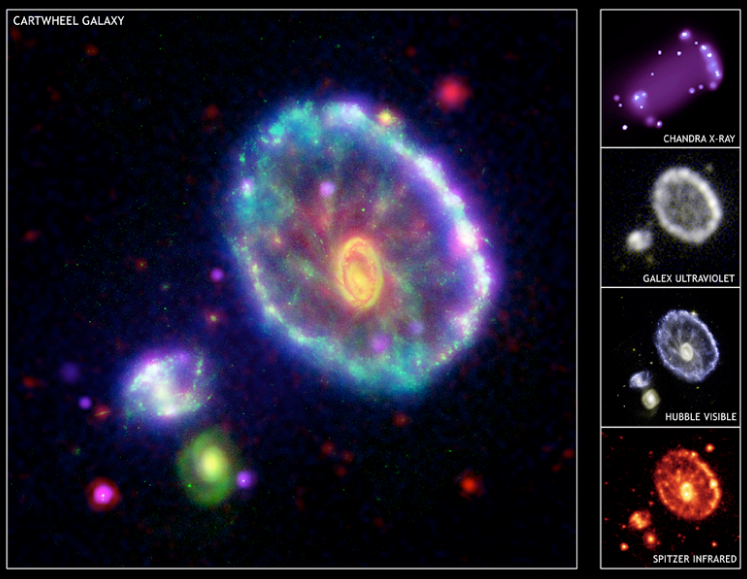


CRAB NEBULA (6000 light years)

The Crab Nebula is the remnant of a supernova explosion recorded by Chinese and Arab astronomers in 1054. At its peak it would have been brighter than every star and planet in the night sky. In its wake the explosion left us the ever expanding nebula, and a rapidly spinning neutron star called a pulsar at its center. This image was made by the Spitzer Space Telescope (red), the Hubble Space Telescope (green and dark blue) and the Chandra X ray Observatory (light blue).

Credit: X ray: NASA/CXC/ASU/J.Hester et al.; Optical: NASA/ESA/ASU/J.Hester & A.Loll; Infrared: NASA/JPL Caltech/Univ. Minn./R.Gehrz

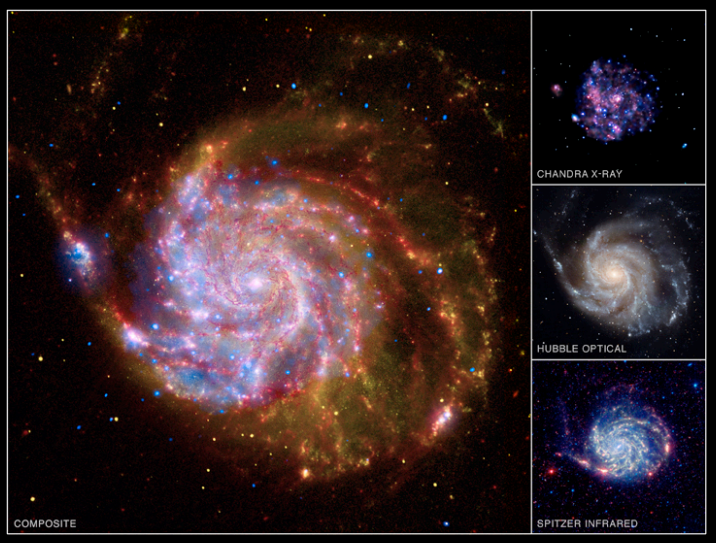
MULTIWAVELENGTH BINGO FLASH CARDS - PAGE 2



CARTWHEEL GALAXY (400 million light years)

The unusual shape of the Cartwheel galaxy results from one of the smaller galaxies to the left passing through it about 100 million years ago. This created a huge compression wave, like a ripple in a pond, and this wave triggers intense bouts of star formation. Four of NASA s orbiting observatories collaborated to make this image: the Chandra X ray Observatory, GALEX in ultraviolet, the Hubble Space Telescope in visible, and the infrared Spitzer Space Telescope.

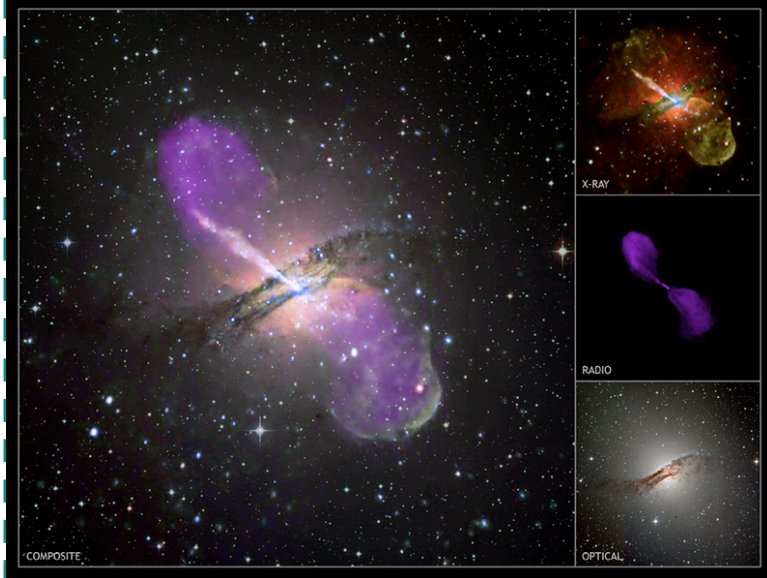
Credit: Composite image made by P. Appleton et al. for NASA / JPL Caltech / ESA.



M101 (23 million light years)

The galaxy Messier 101 (M101) is a swirling spiral of stars, gas, and dust whose diameter is nearly twice that of our Milky Way galaxy. Infrared data from Spitzer reveals the galaxy s delicate dust lanes. In Hubble s visible light image, the bright clumps are regions where new stars have formed, while the core consists mainly of old stars. Meanwhile, X rays from Chandra show the remains of exploded stars and million degree gas that permeates the galaxy.

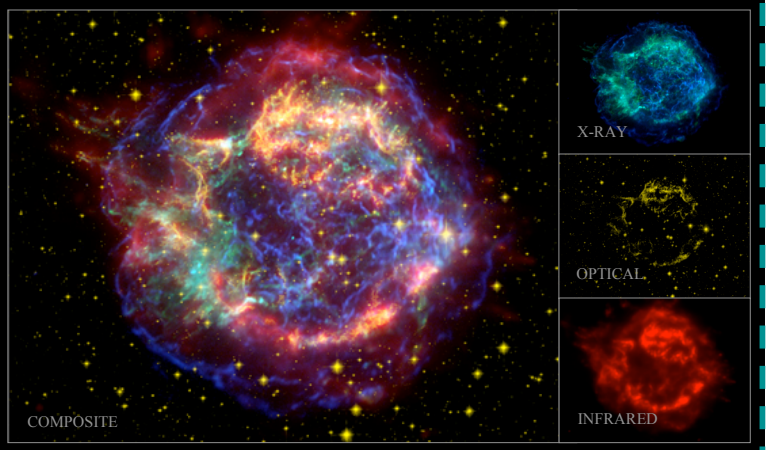
Credit: X ray: NASA / CXC / JHU / K.Kuntz et al; Optical: NASA / STScI; Infrared: NASA / JPL Caltech.



CENTAURUS A (11 million light years)

A dramatic image from NASA s Chandra X ray Observatory of the nearby galaxy Centaurus A provides one of the best views ever of the effects of an active supermassive black hole (bright dot at the center). A prominent jet is seen extending for 13,000 light years and points to the upper left in the image, with a shorter counterjet aimed in the opposite direction.

(Credit: X ray: NASA/CXC/CfA/R.Kraft et al; Radio: NSF/VLA/Univ.Hertfordshire/M.Hardcastle; Optical: ESO/WFI/M.Rejkuba et al.)

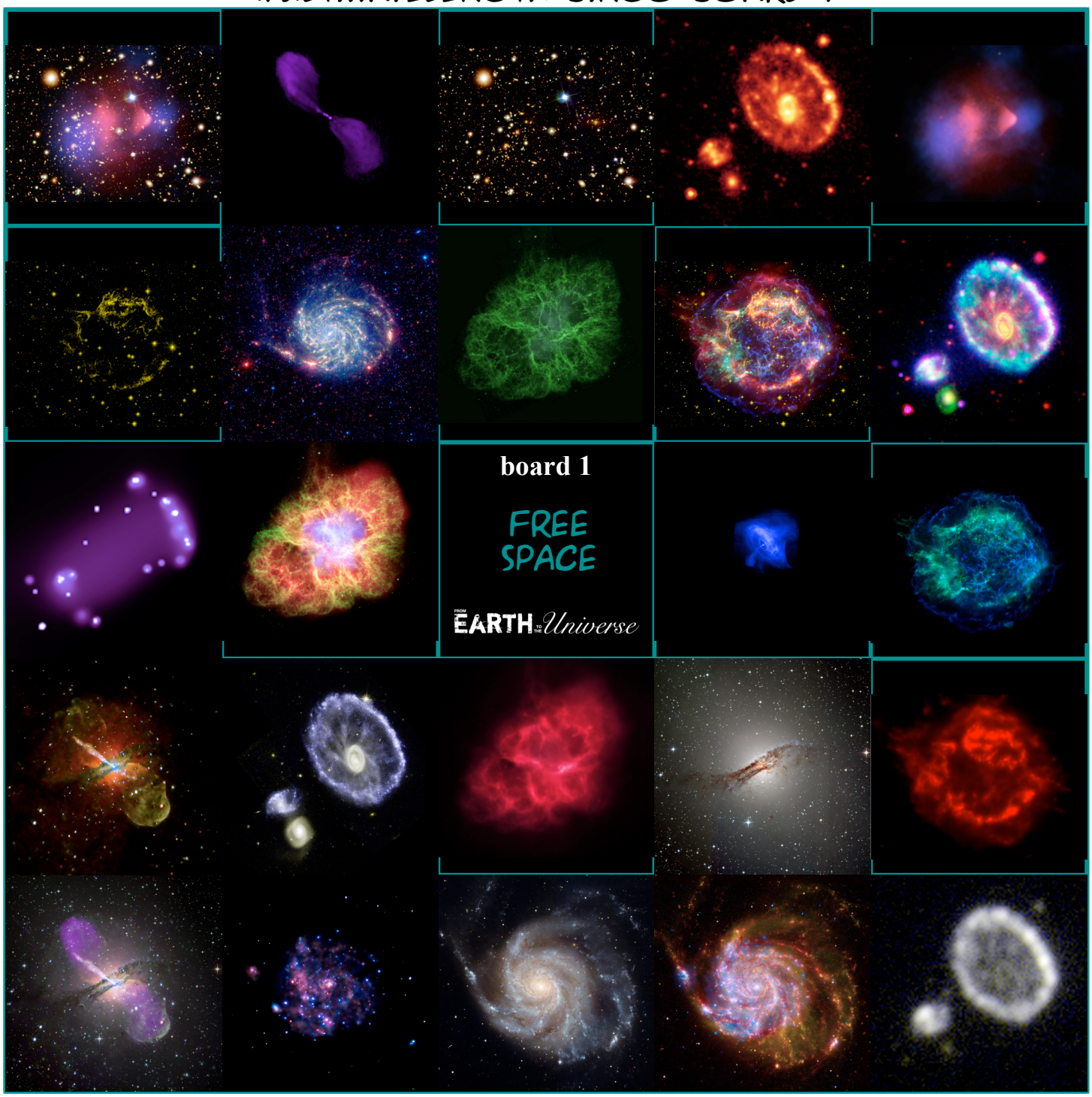


CASSIOPEIA A (11,000 light years)

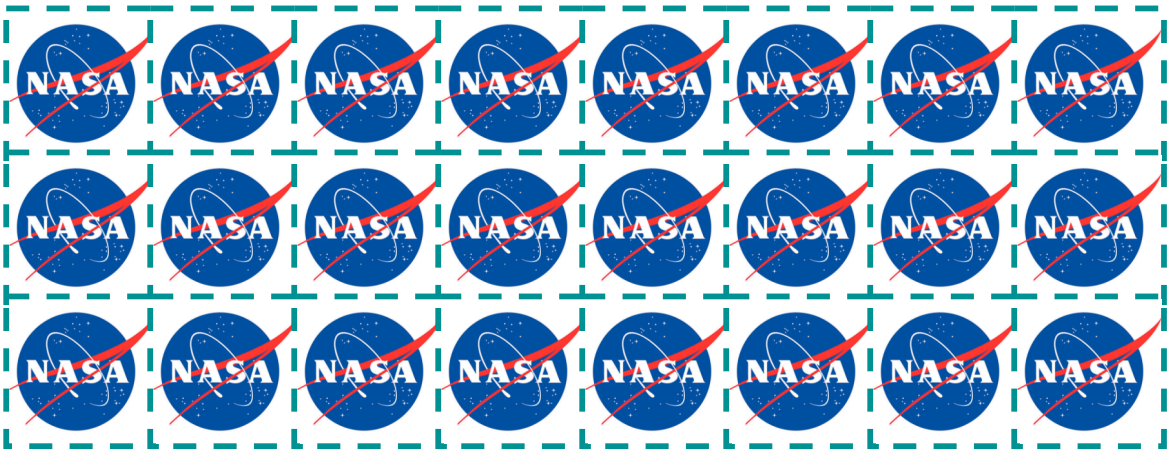
Cassiopeia A is the youngest supernova remnant in our Milky Way Galaxy, believed to be the leftovers of a massive star that exploded over 300 years ago. The material ejected during the supernova smashed into the surrounding gas and dust at about 16 million kilometers per hour. This collision superheated the debris field to millions of degrees, causing it to glow brightly in X rays.

Credit: X ray: NASA/CXC/SAO; Optical: NASA/STScI; Infrared: NASA/JPL Caltech

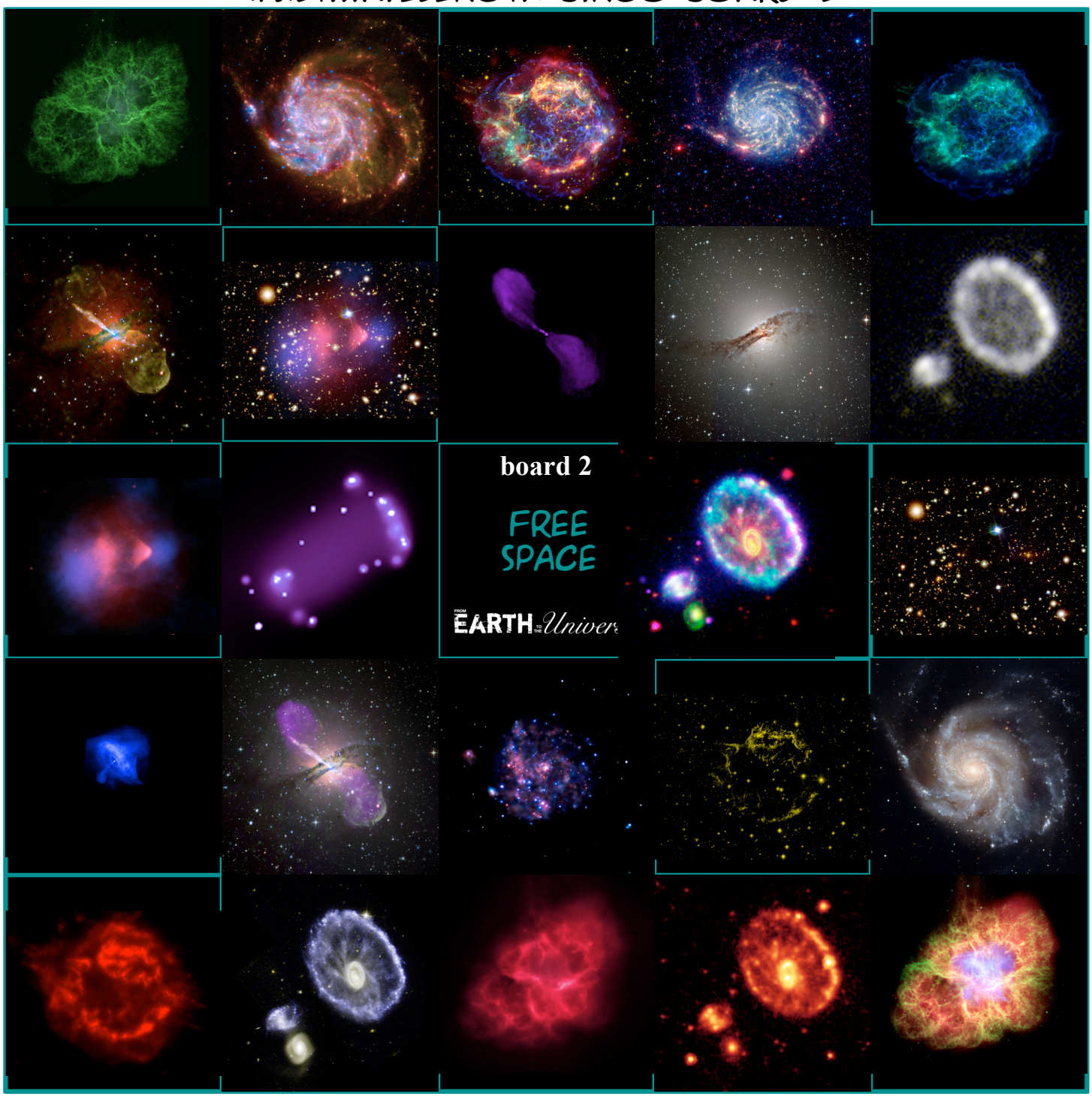
MULTIWAVELENGTH BINGO BOARD 1



BINGO TOKENS→
(CUT OUT)



MULTIWAVELENGTH BINGO BOARD 2



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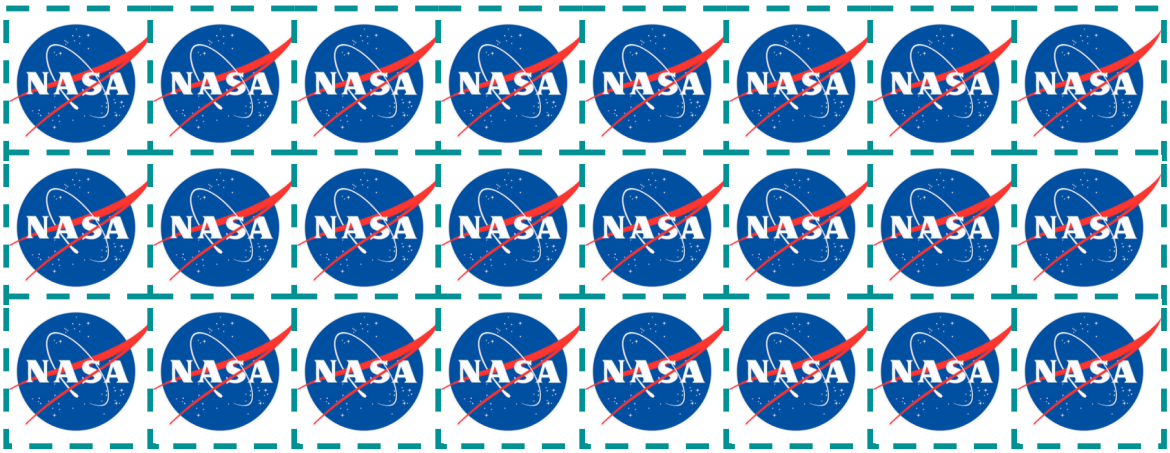
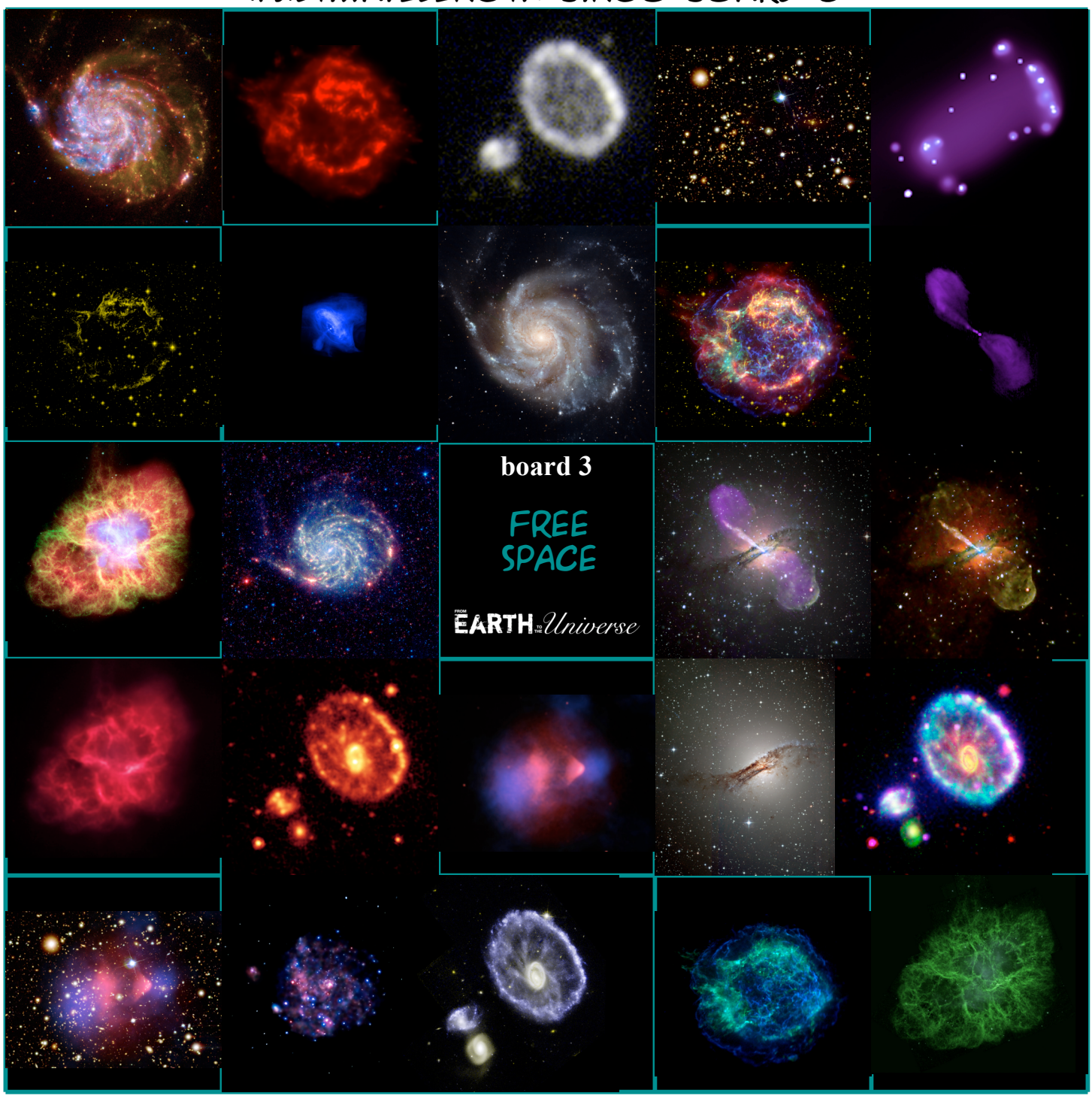


MULTIWAVELENGTH BINGO BOARD 3



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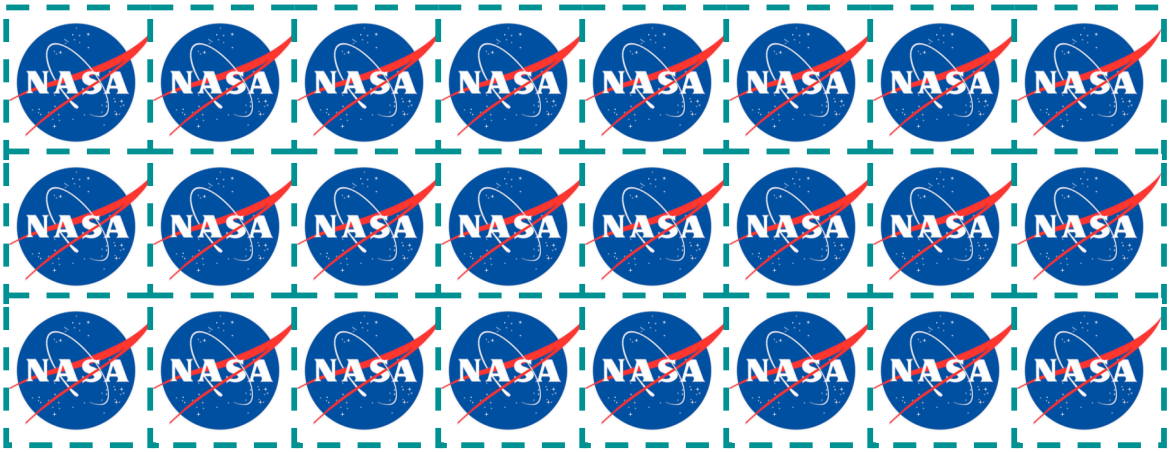
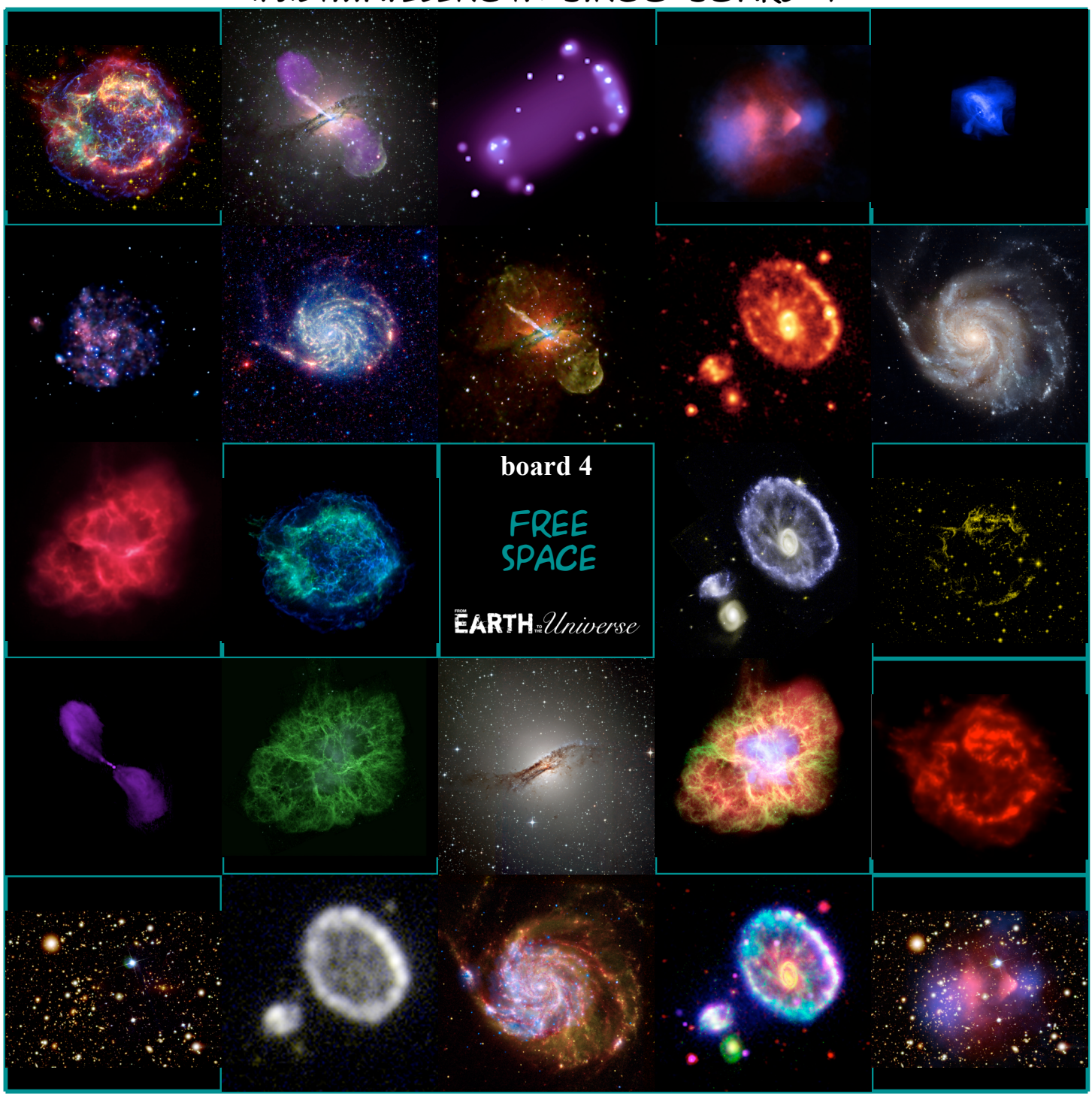


MULTIWAVELENGTH BINGO BOARD 4



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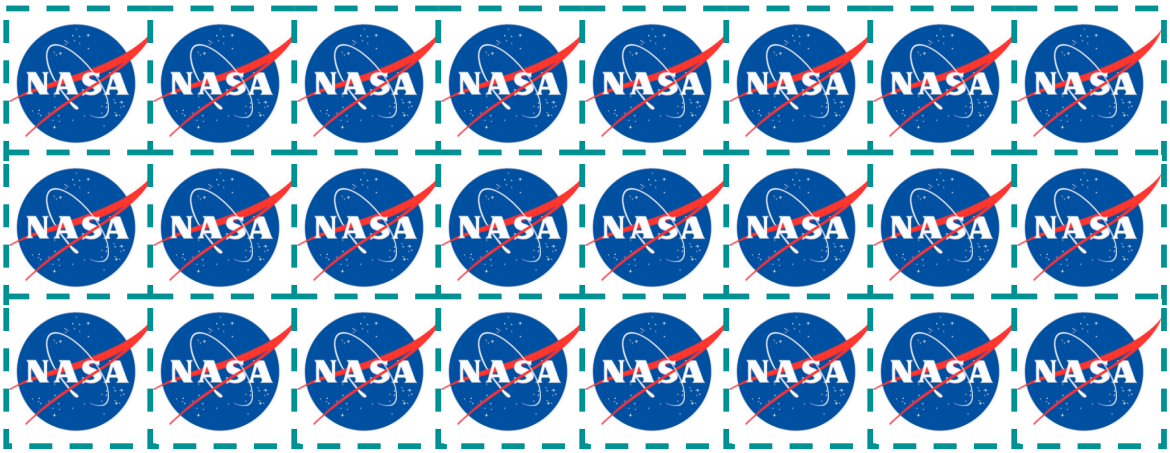
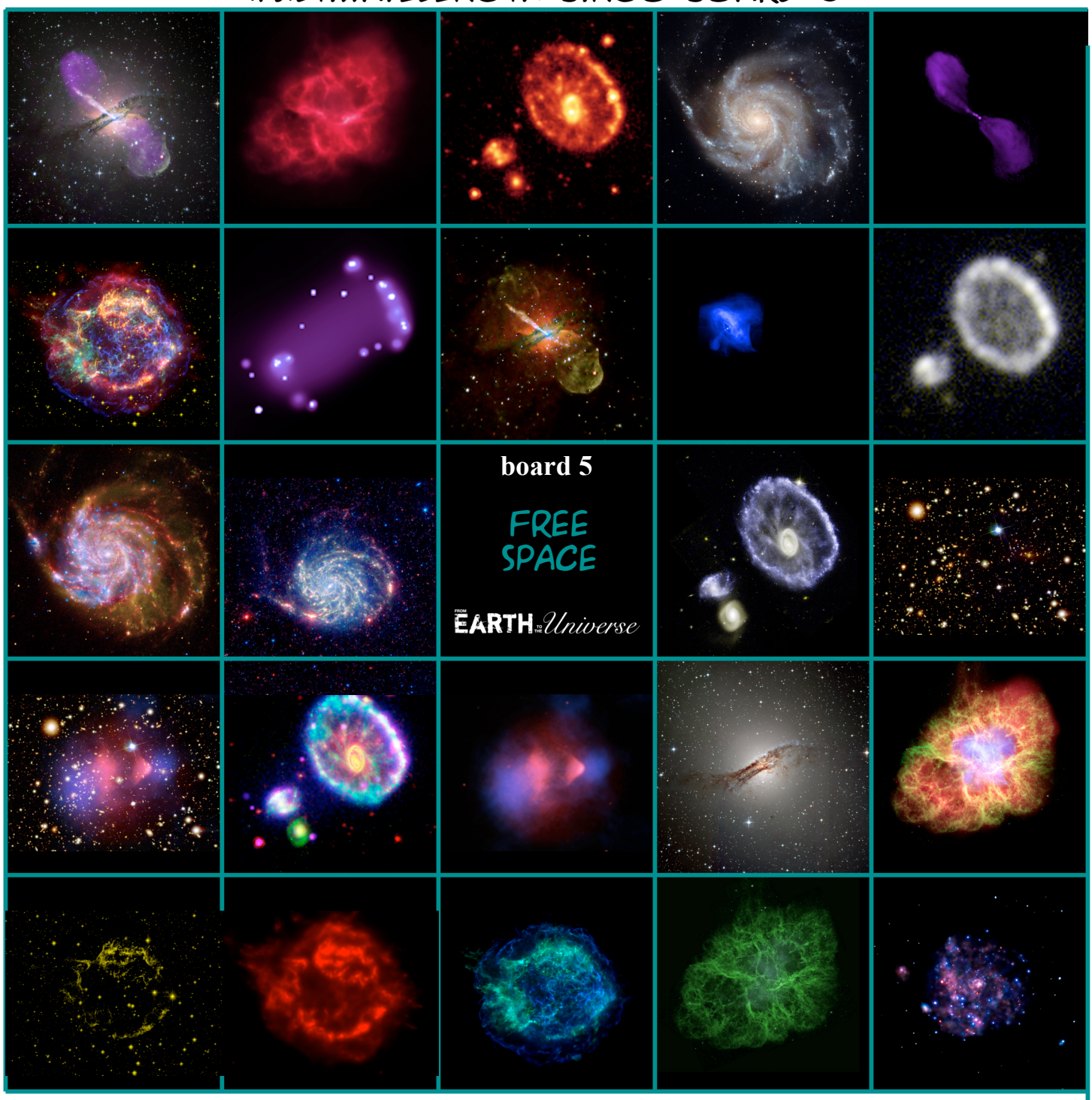


MULTIWAVELENGTH BINGO BOARD 5



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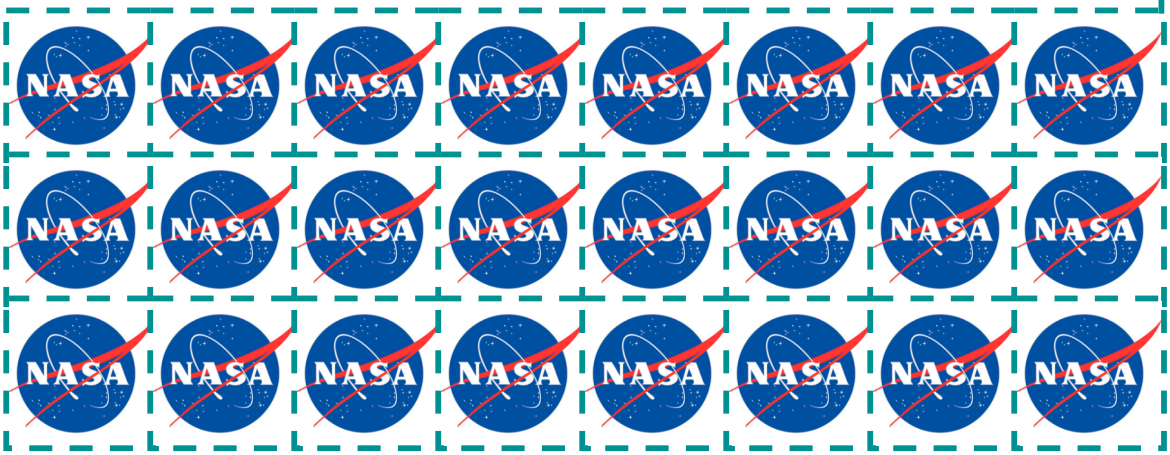
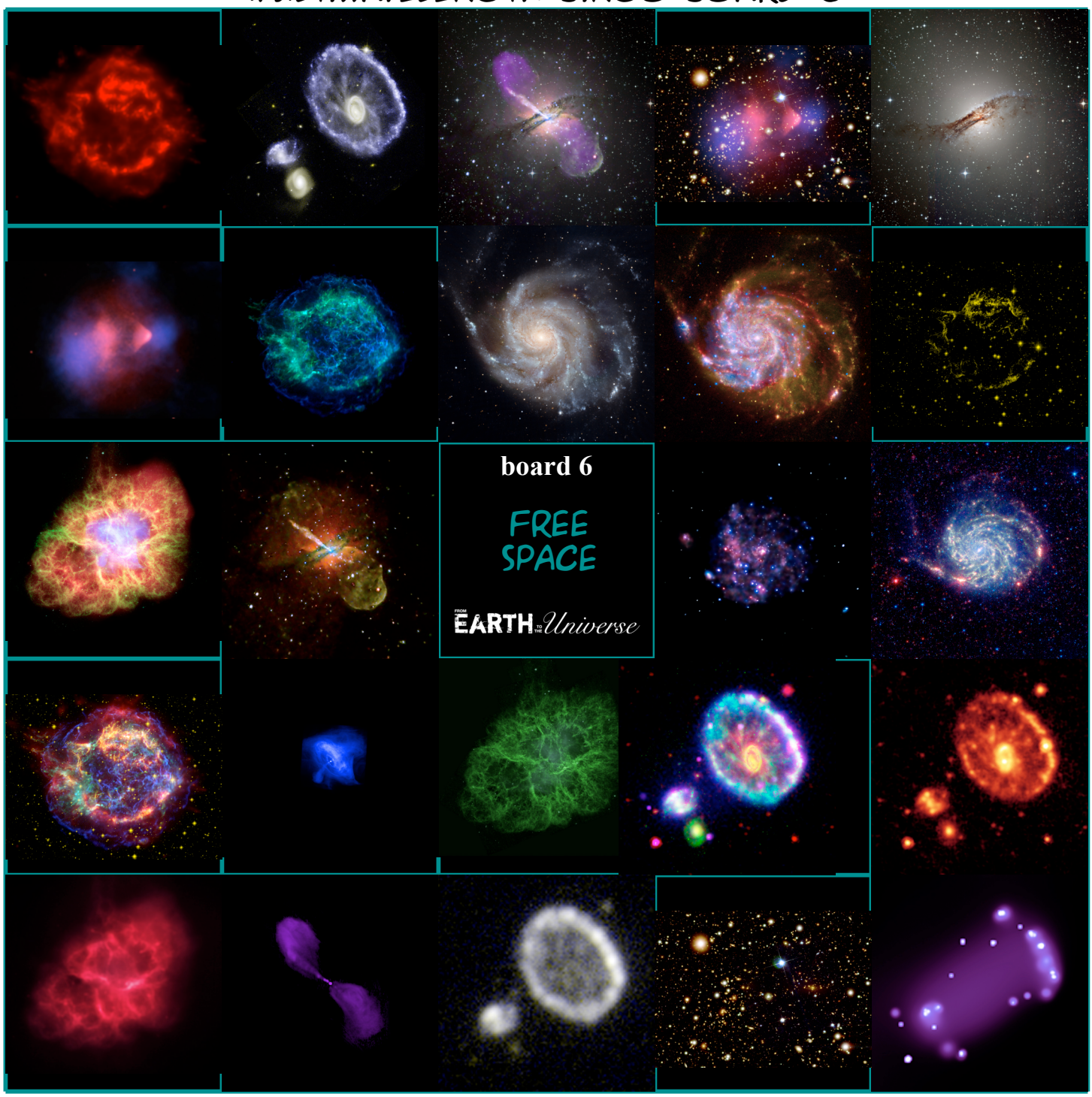


MULTIWAVELENGTH BINGO BOARD 6



BINGO TOKENS→
(CUT OUT)