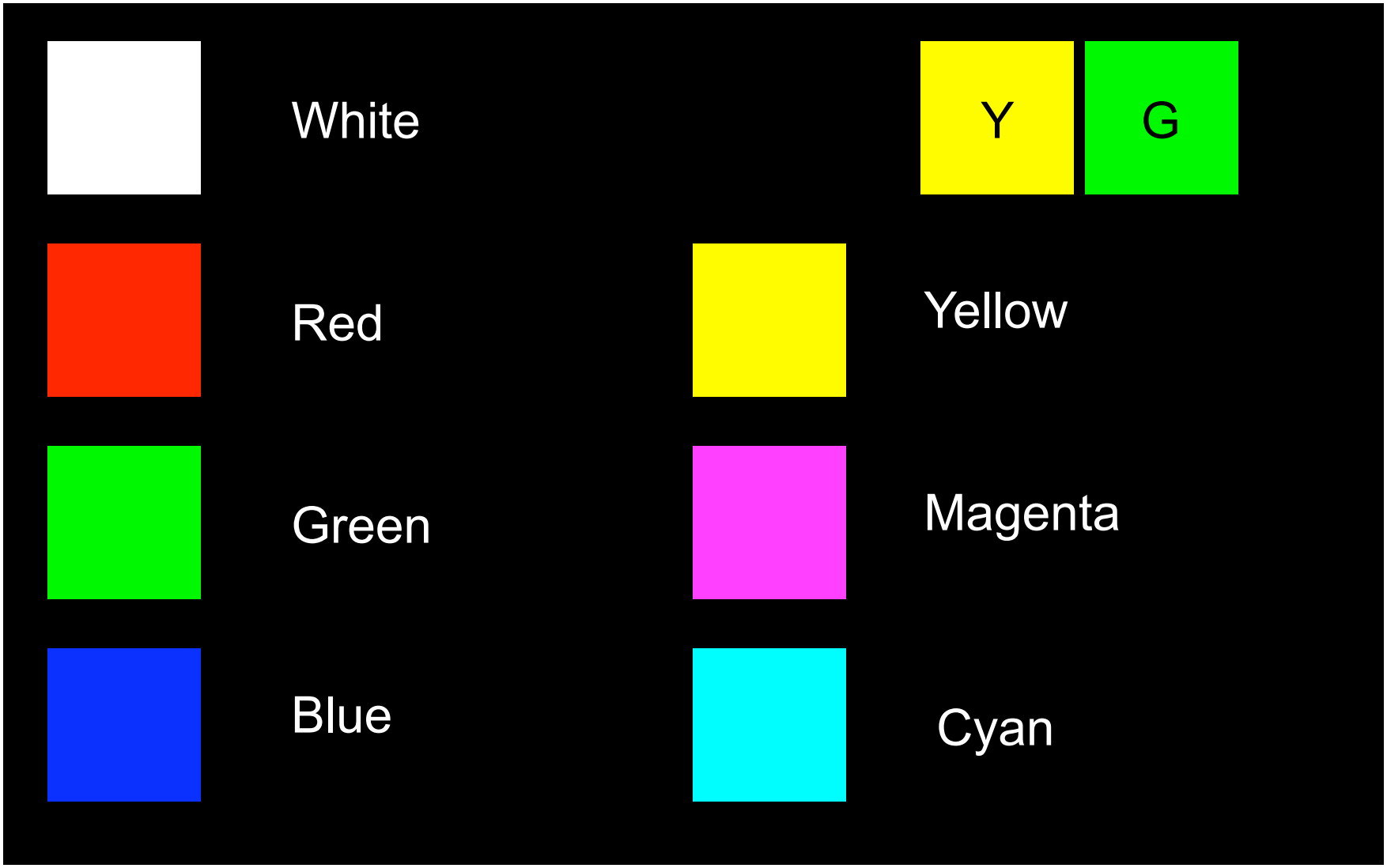
From Molecular Cores to Stars

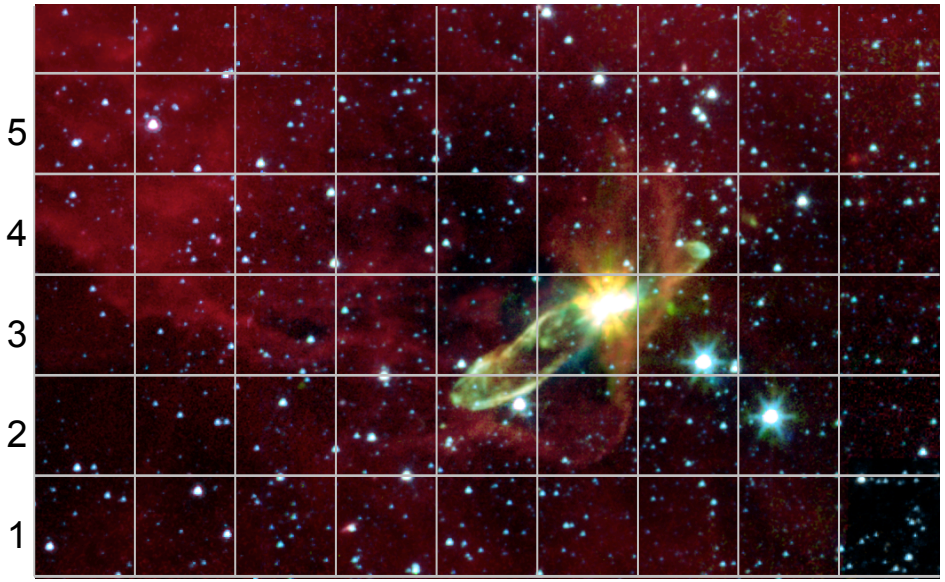
Examining Herbig-Haro 46/47

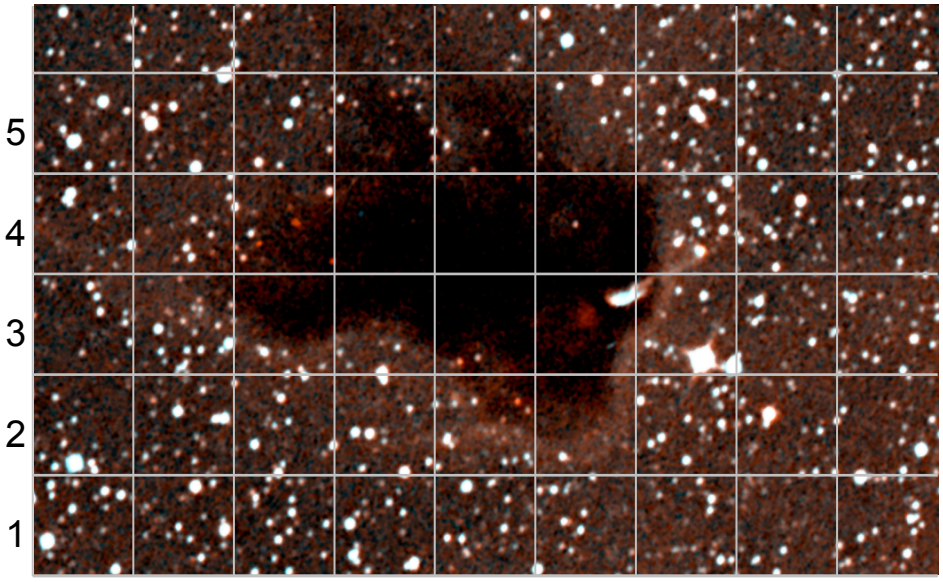
Production supported by a NASA Education/Public Outreach grant

Color Calibration

Make sure that your video projector accurately reproduces these colors, especially yellow (Y) and green (G).







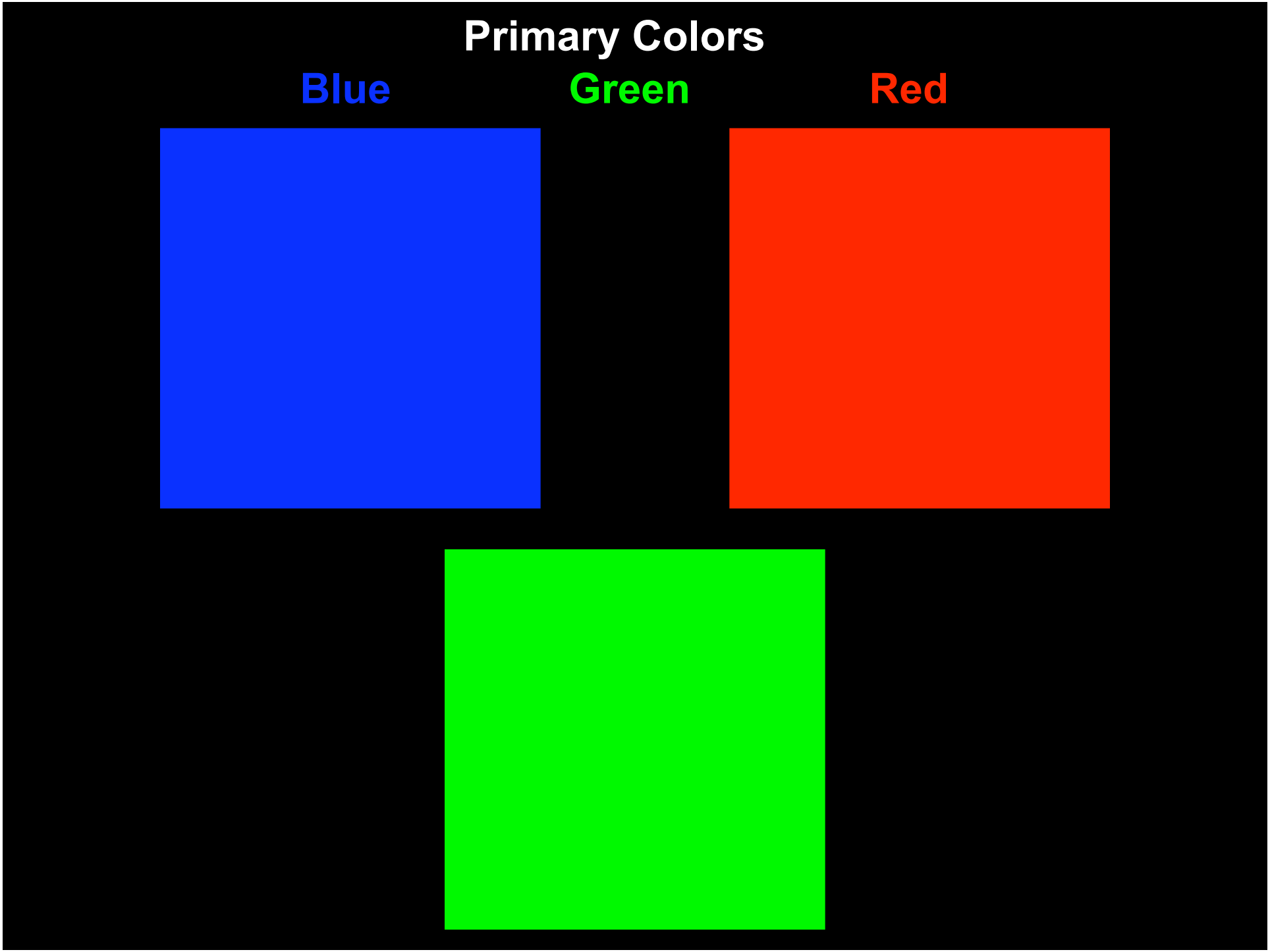
1. What part of the electromagnetic spectrum are you seeing in each image?

The tiny dots of light are stars. Most of the stars are far behind this nebula in the foreground that is made of gas and dust.

i. Which image shows the infrared light?

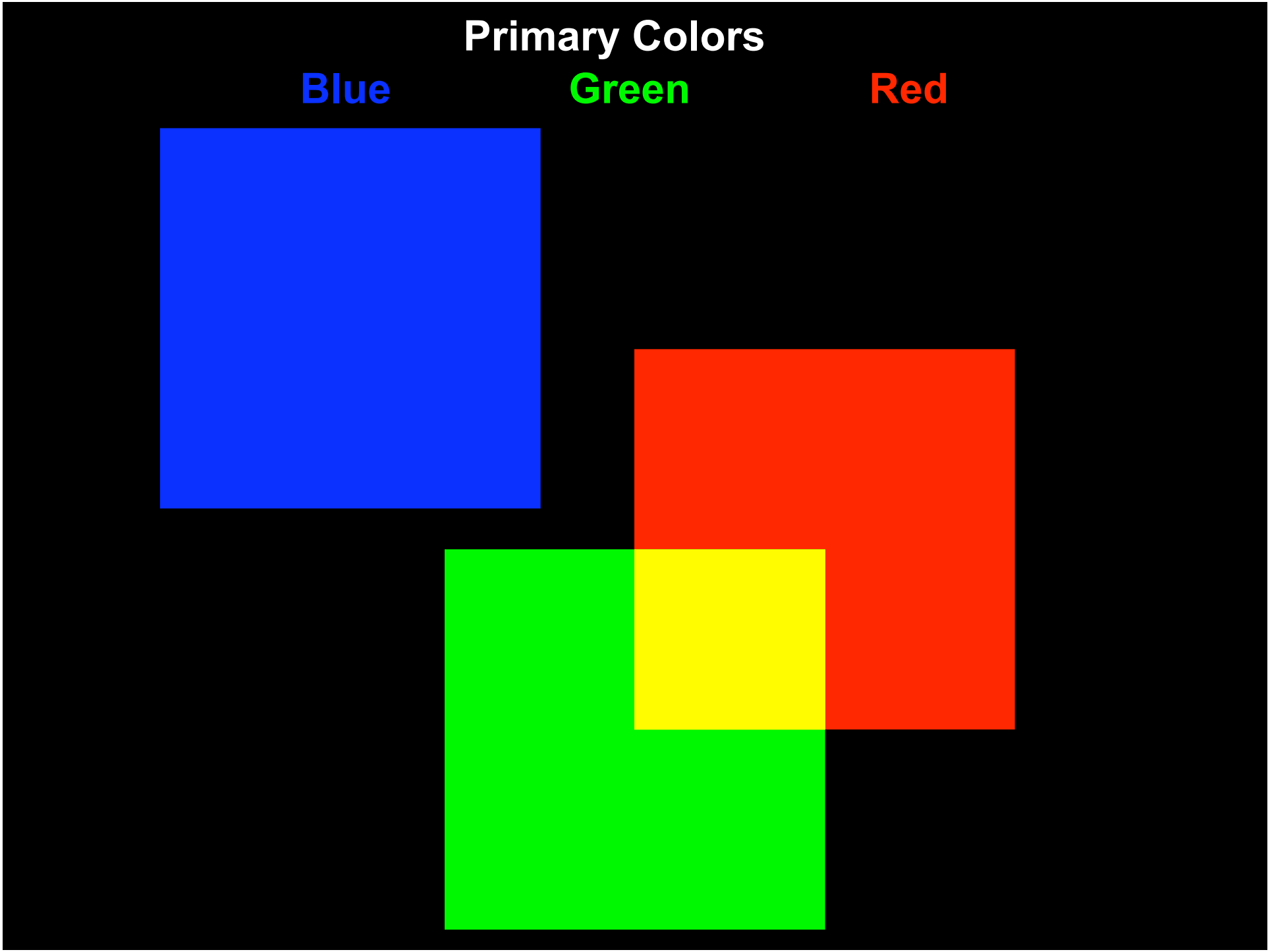
ii. Which image shows the visible light?

iii. What evidence in the images supports your decision?


Primary Colors
Blue
Green
Red

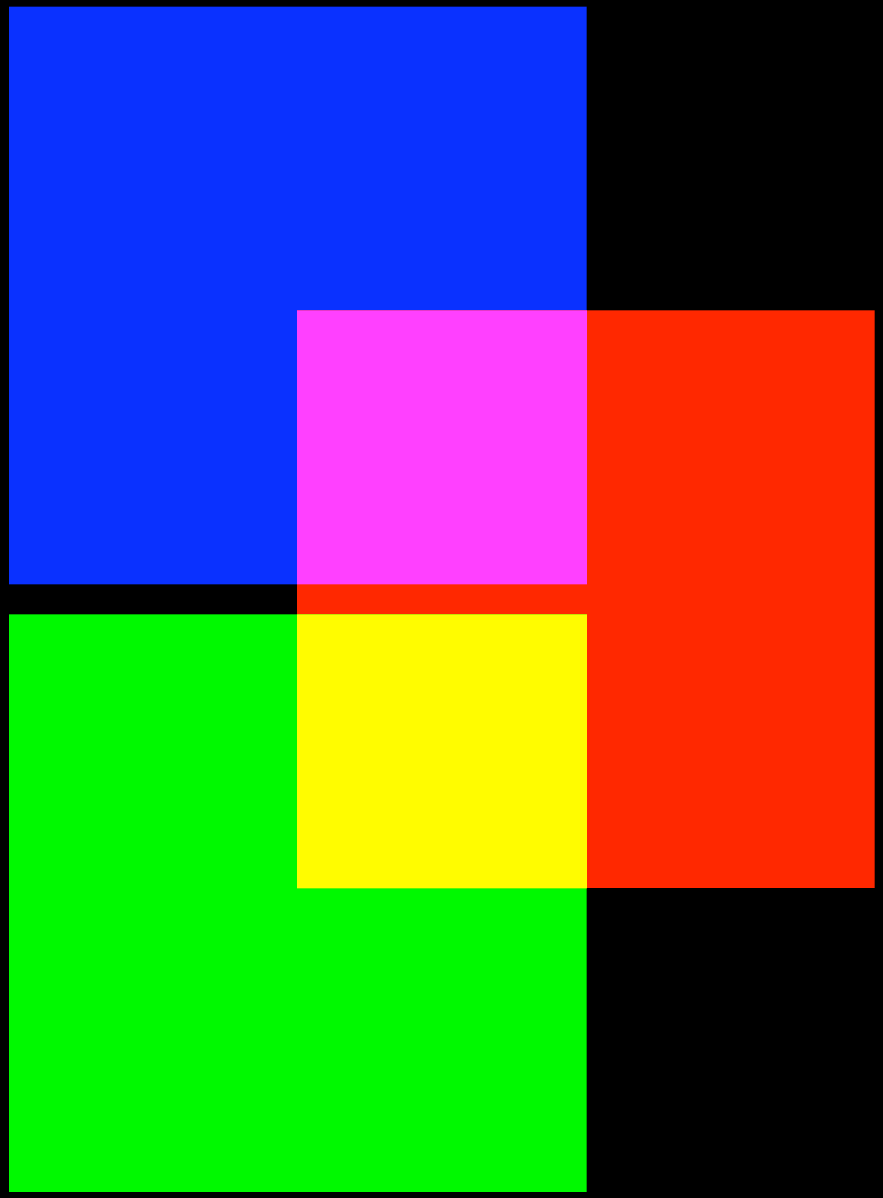
Primary Colors

Blue Green Red



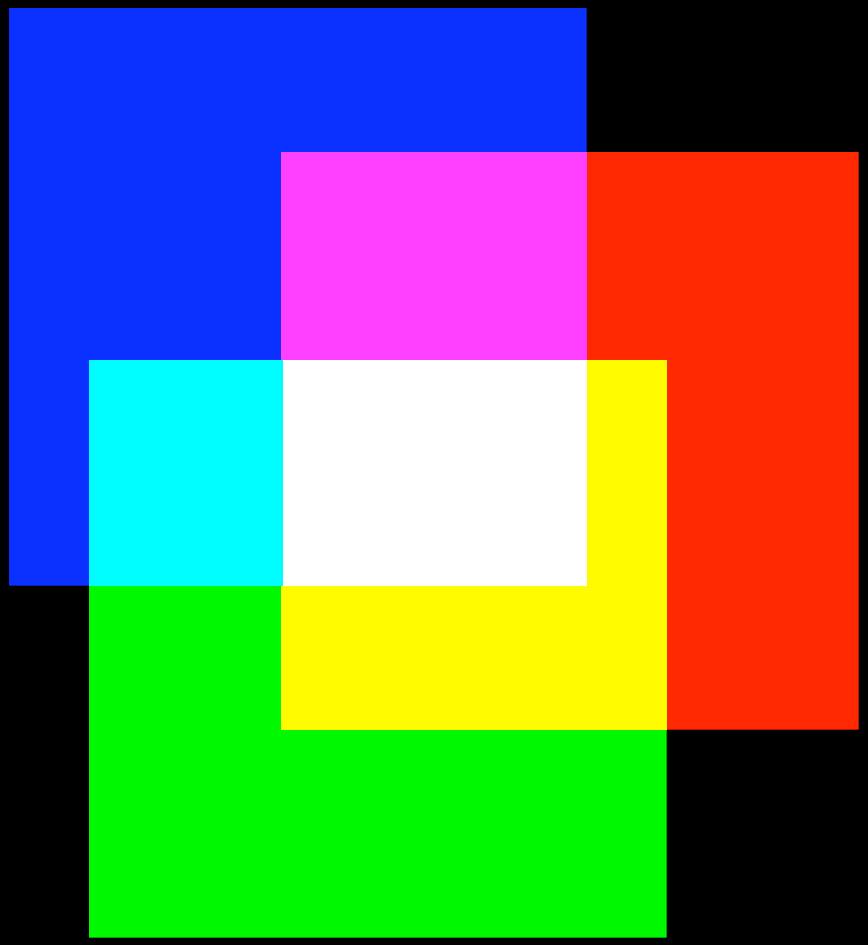
Primary Colors

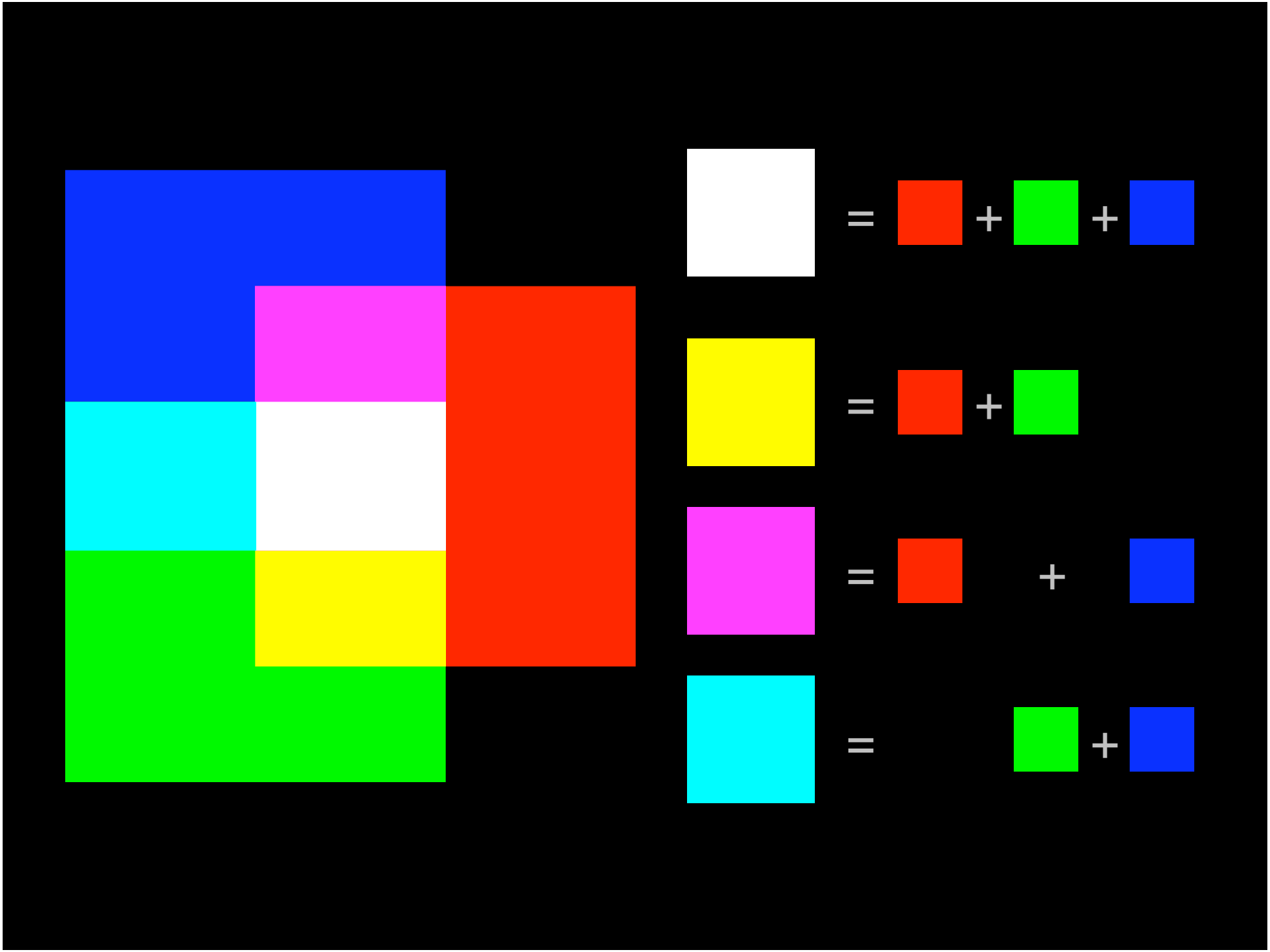
Blue Green Red



Primary Colors

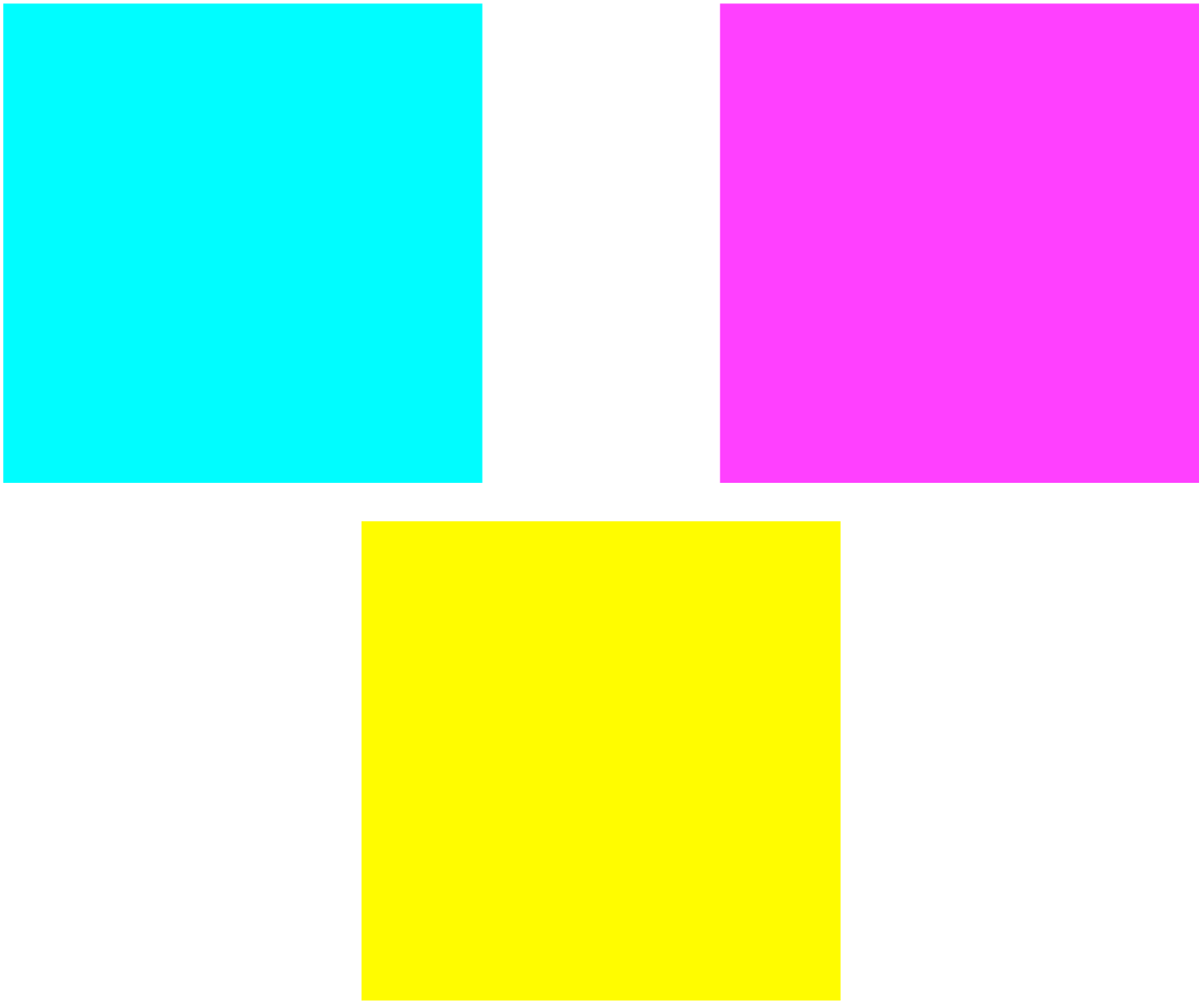
Blue Green Red





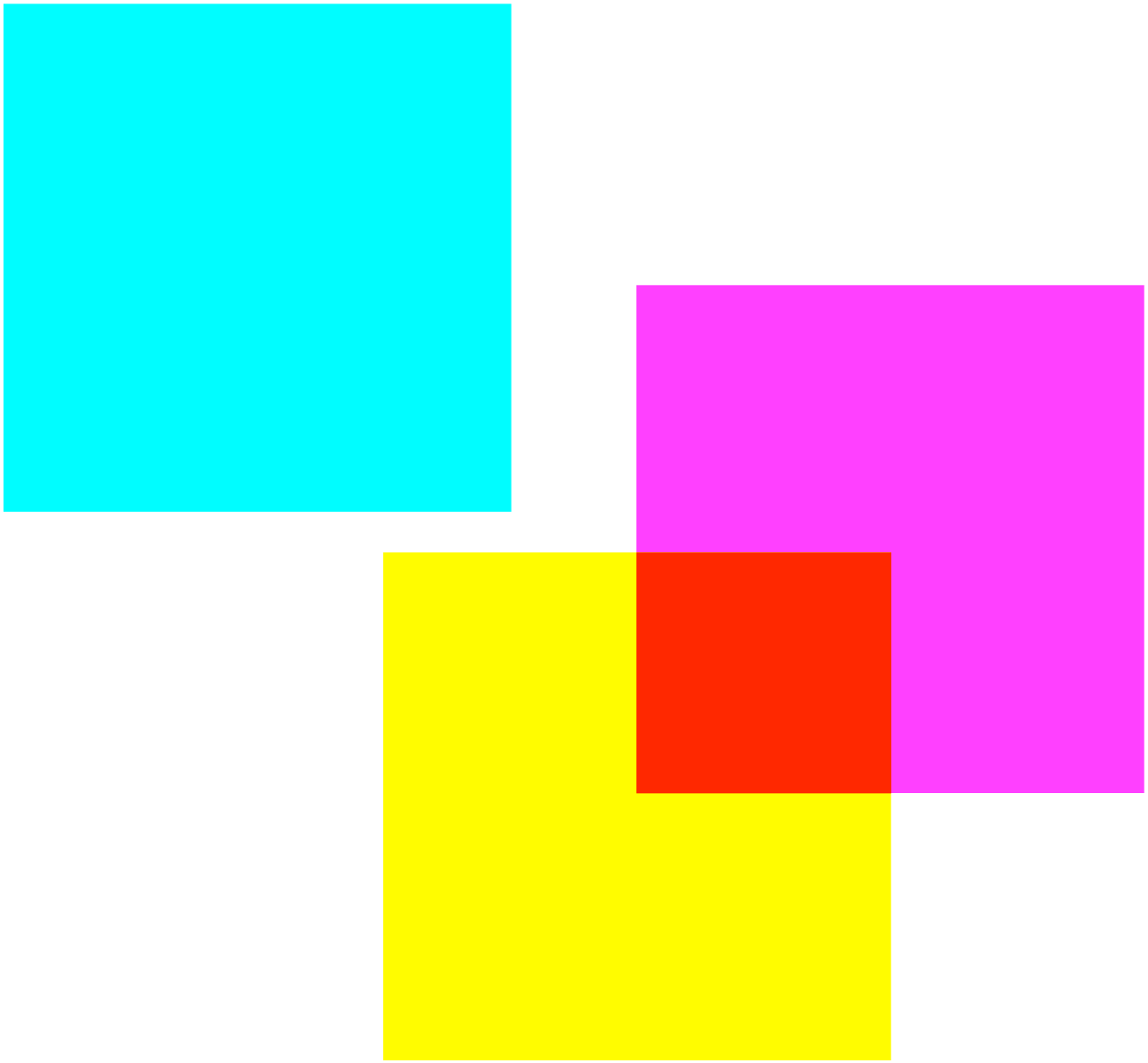
Secondary Colors

Cyan Yellow Magenta



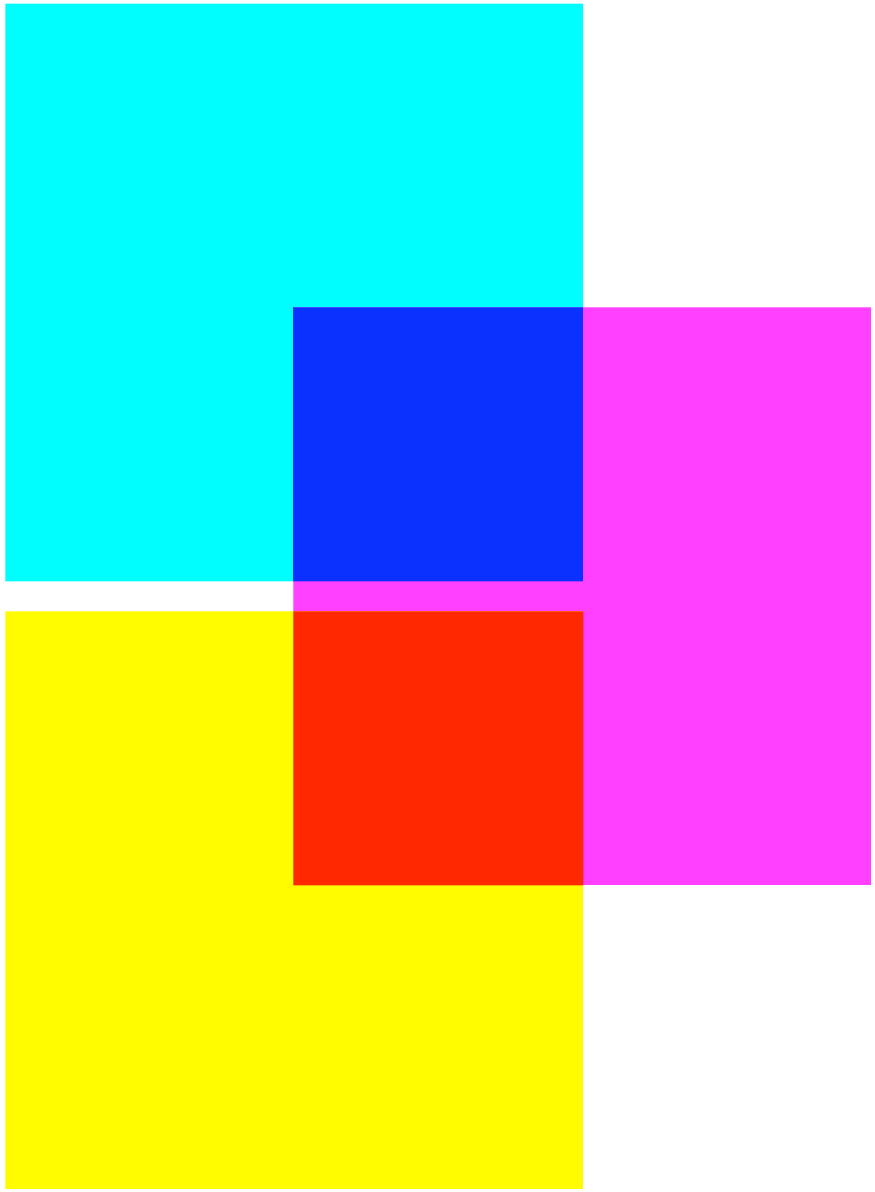
Secondary Colors

Cyan Yellow Magenta



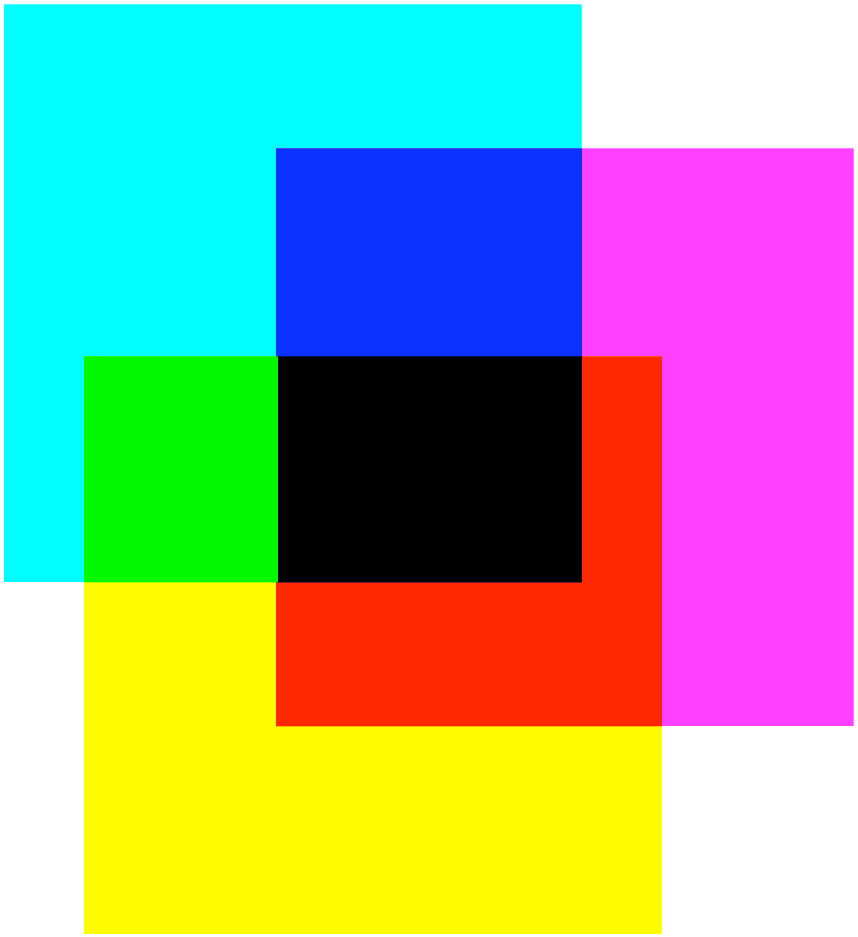
Secondary Colors

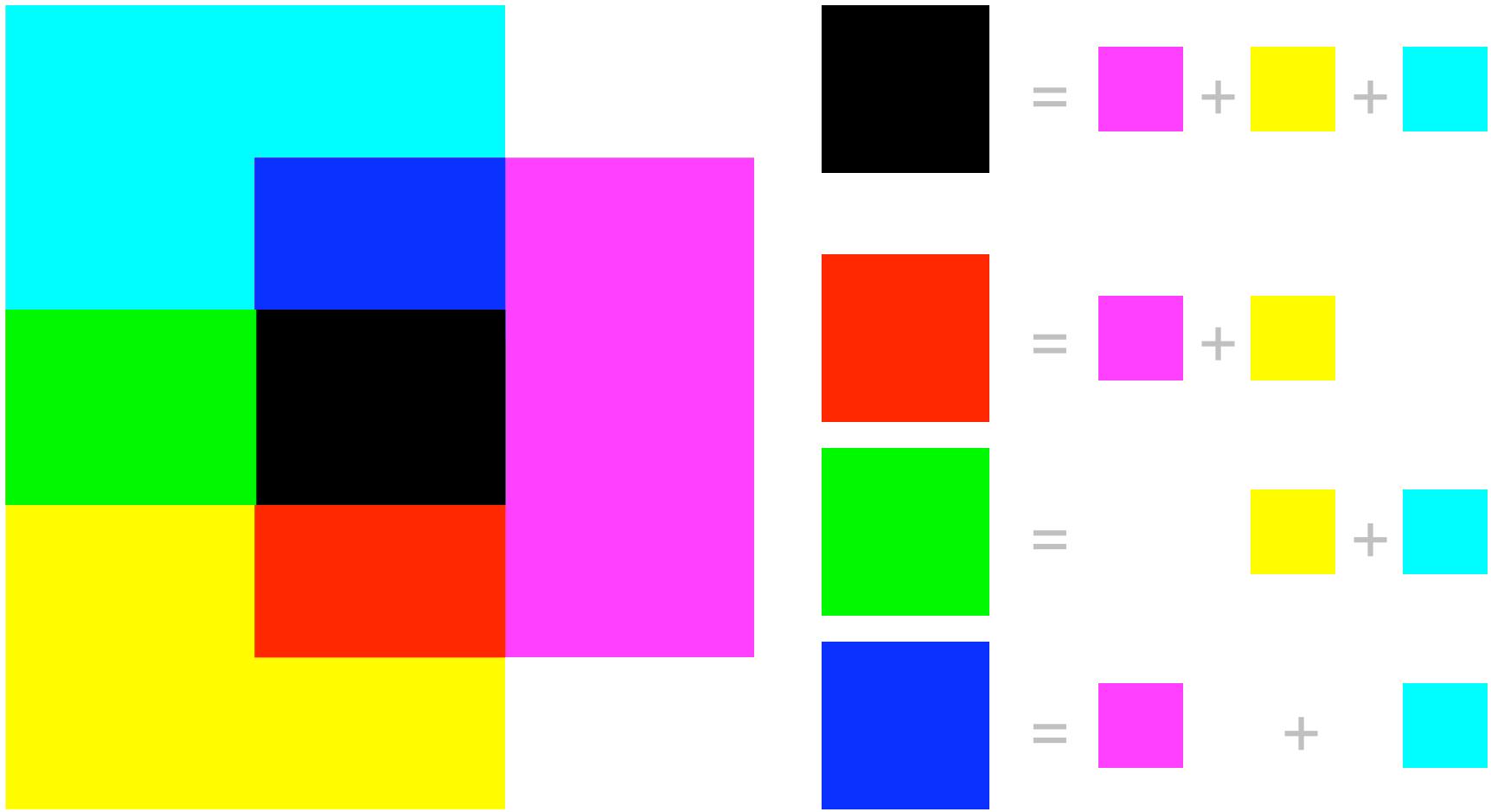
Cyan Yellow Magenta

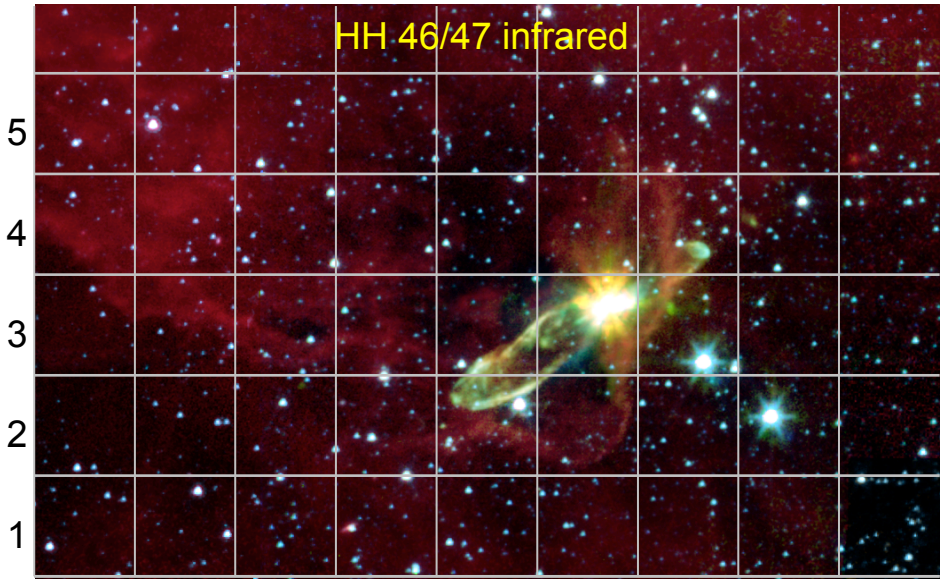


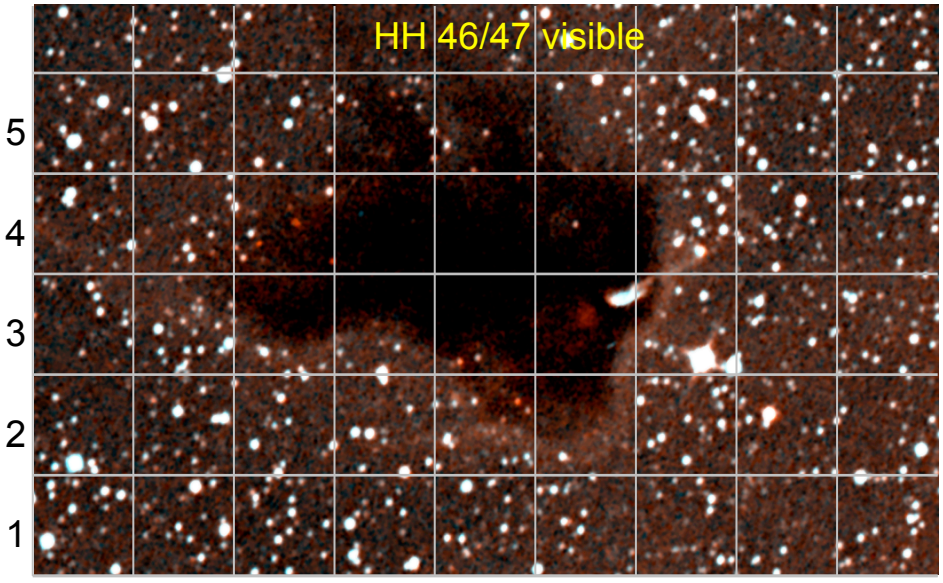
Secondary Colors

Cyan Yellow Magenta





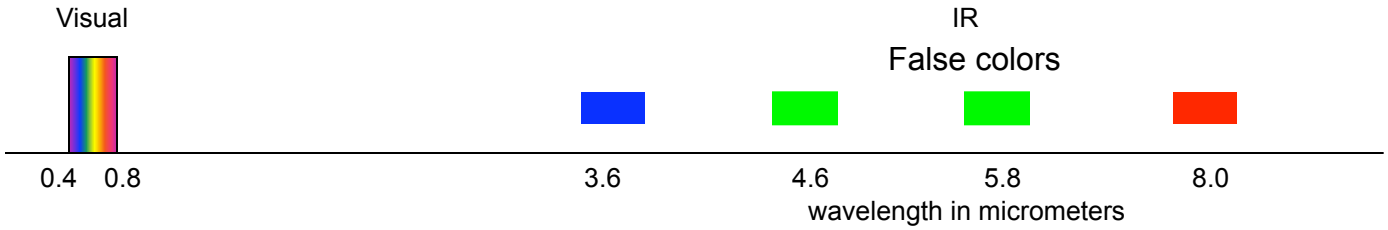


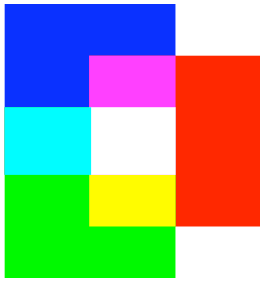


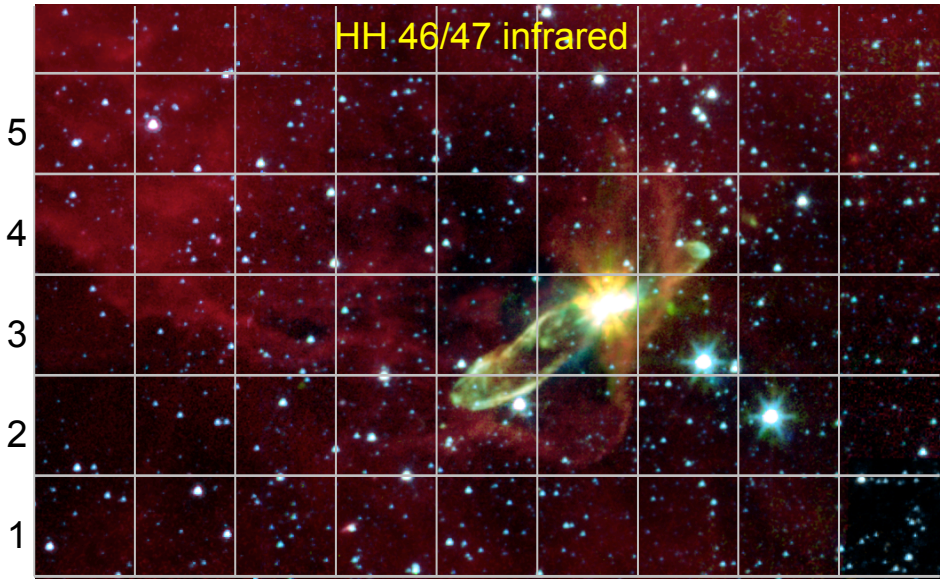
8 μm 4.5 μm + 5.8 μm 3.6 μm

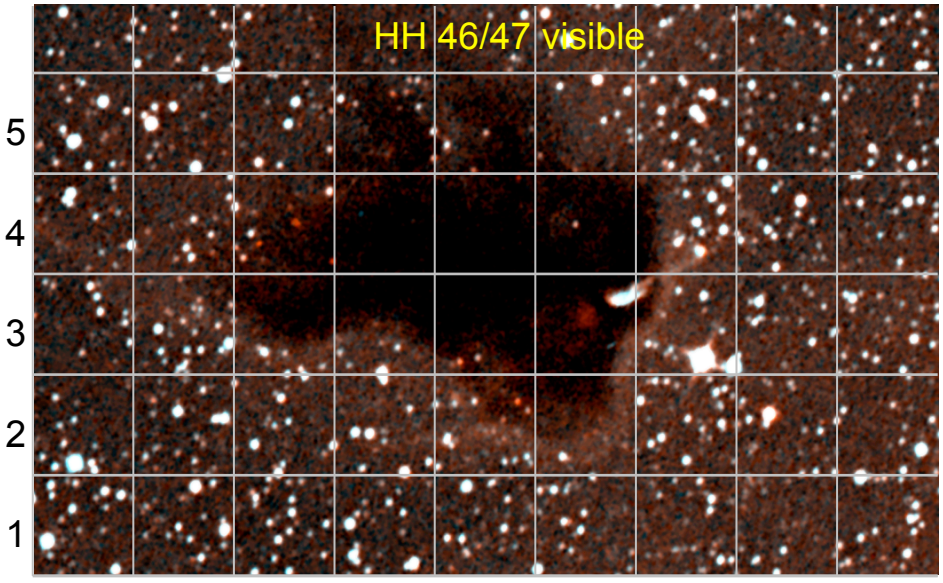
What do the colors in the infrared image mean?

The infrared image "colors" correspond to infrared wavelengths of light, not visible colors. Visible colors range in wavelength from 0.4 to 0.7 micrometers. The light wavelengths in the infrared image range from 3.6 to 8.0 micrometers. To make sense of the infrared image, astronomers assign visible colors to infrared wavelengths to produce a "false color" image, like the one you are examining: 3.6 micrometers = blue (shortest wavelength), 4.6 and 5.8 micrometers combined = green, and 8.0 micrometers = red (longest wavelength).









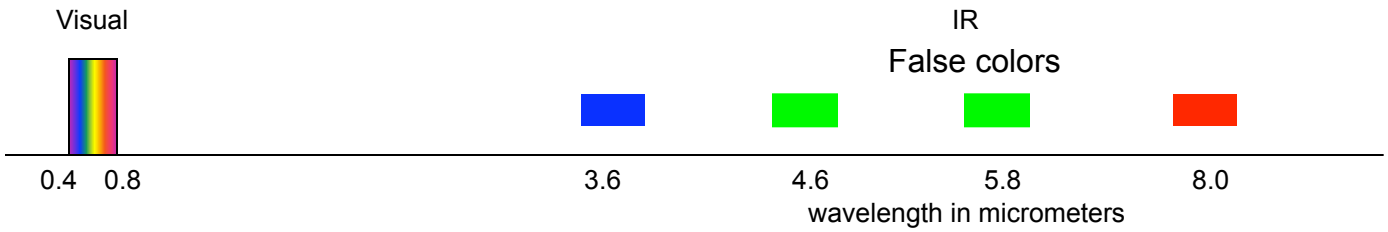
8 μm 4.5 μm + 5.8 μm 3.6 μm

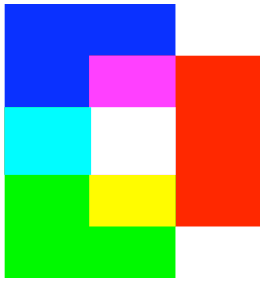
2. Examine the infrared image of HH 46/47

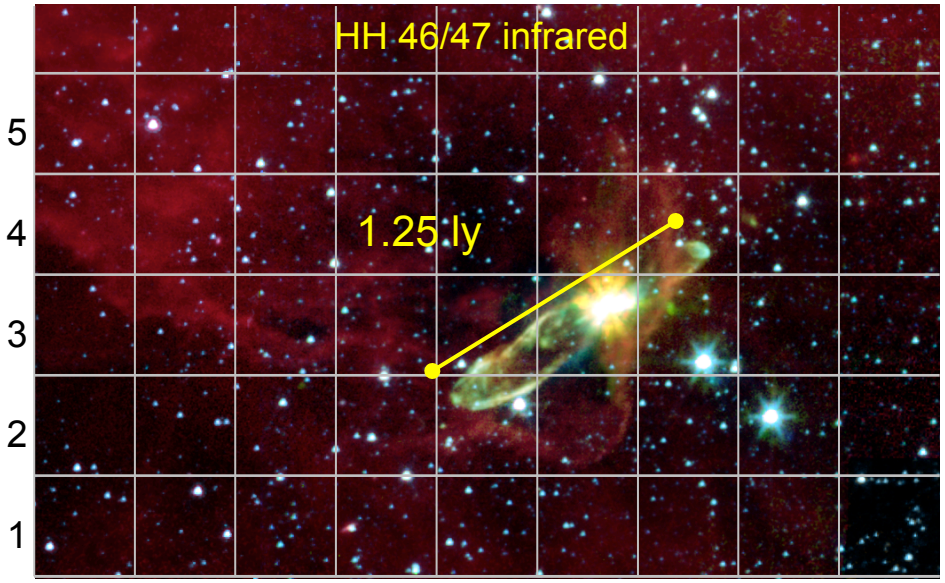
i. Which false colors in the infrared image represent the hottest material? The coolest?

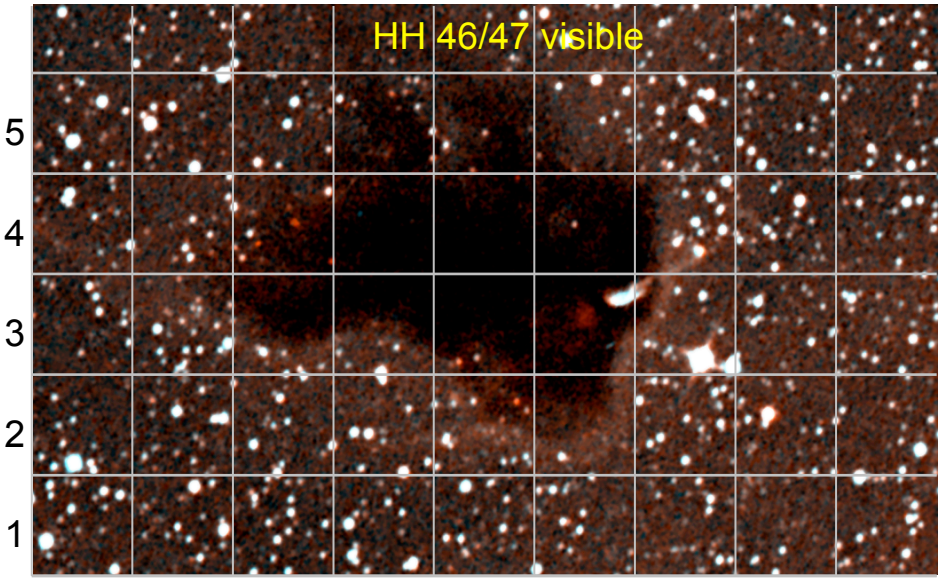
ii. Why do you think the other stars in the infrared image are false blue and white?

iii. If a feature appears white in the infrared image, what does that indicate about the energy distribution in infrared wavelengths?







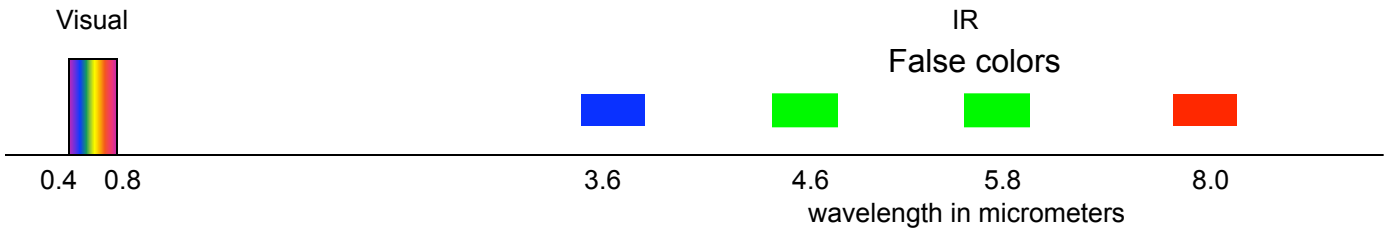


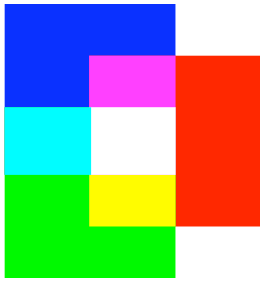
8 μm 4.5 μm + 5.8 μm 3.6 μm

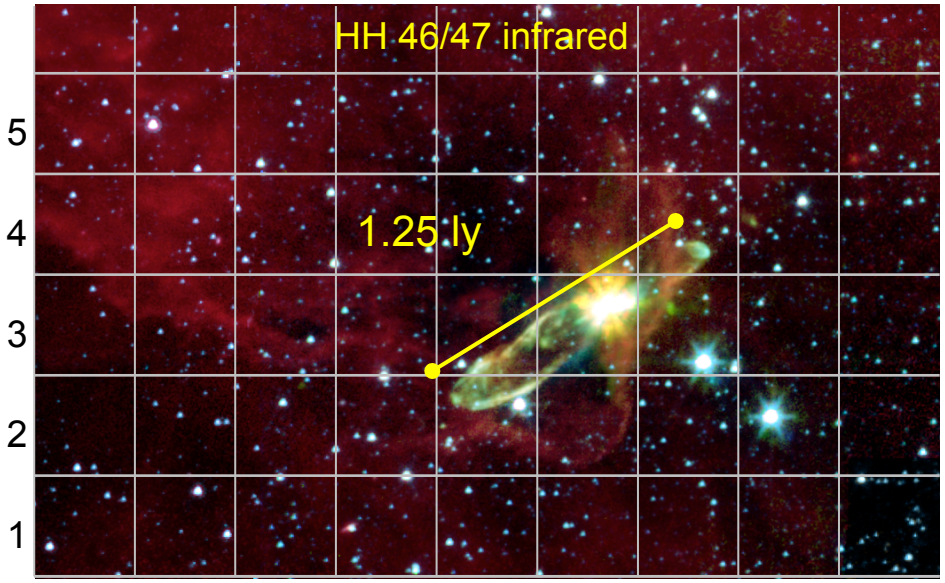
3. Examine the visible light image of HH 46/47

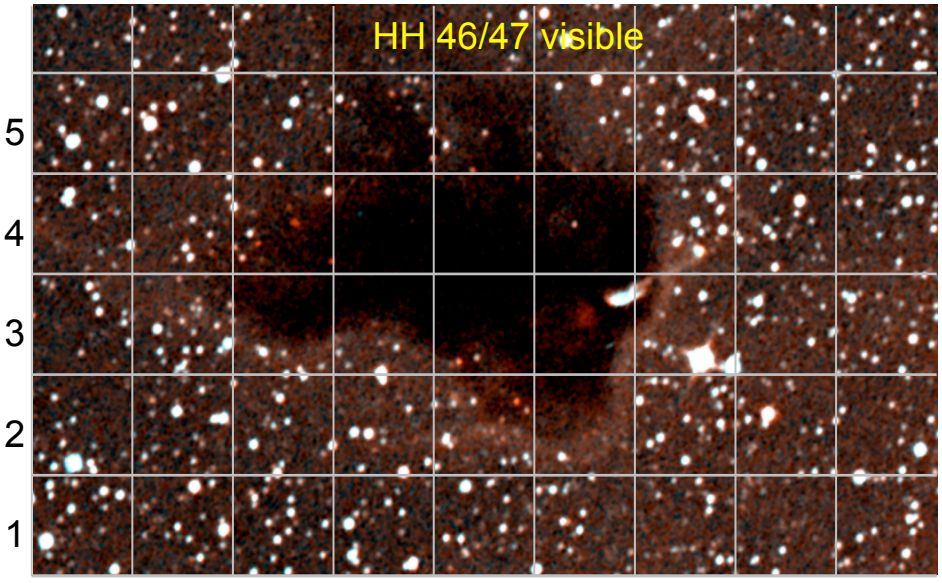
i. What is the dark blob (centered at E4) in the visible light image? Explain.

ii. What are the points of light surrounding the dark blob in the visible light image? Explain.







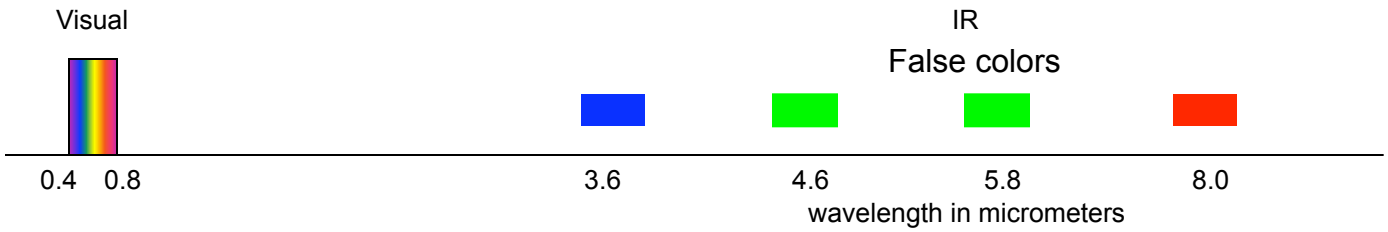


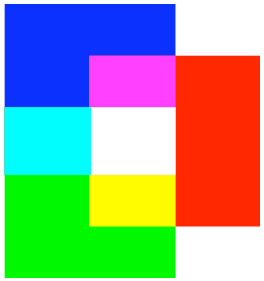
8 μm 4.5 μm + 5.8 μm 3.6 μm

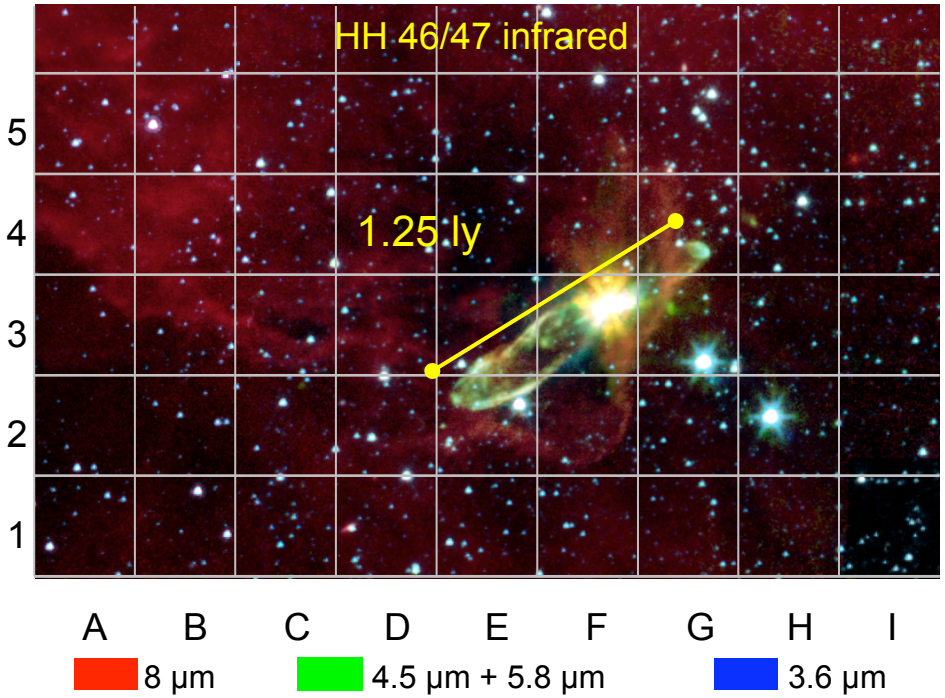
4. Compare and contrast the two images

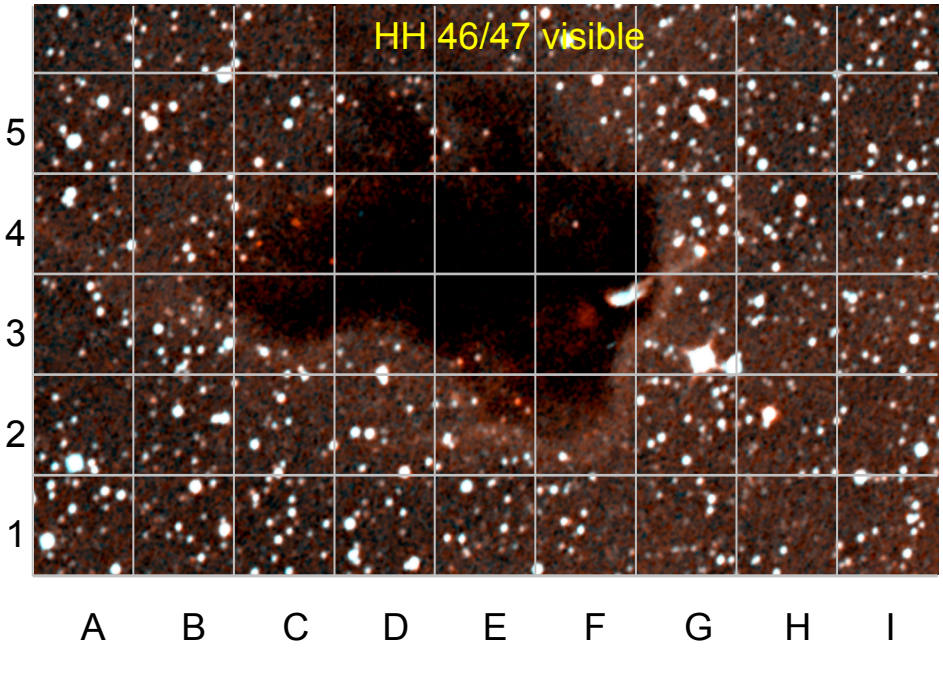
List the prominent features in each image, and how you think they are related.

IR image feature	Visible image feature	Relationship





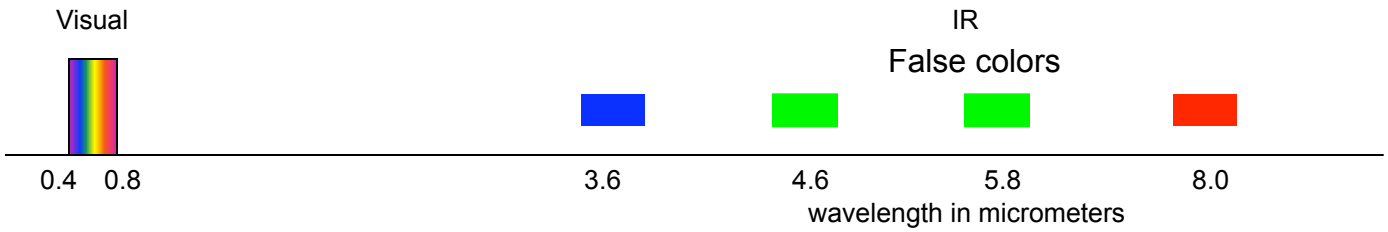


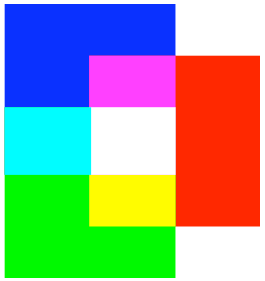


5. Evidence of motion

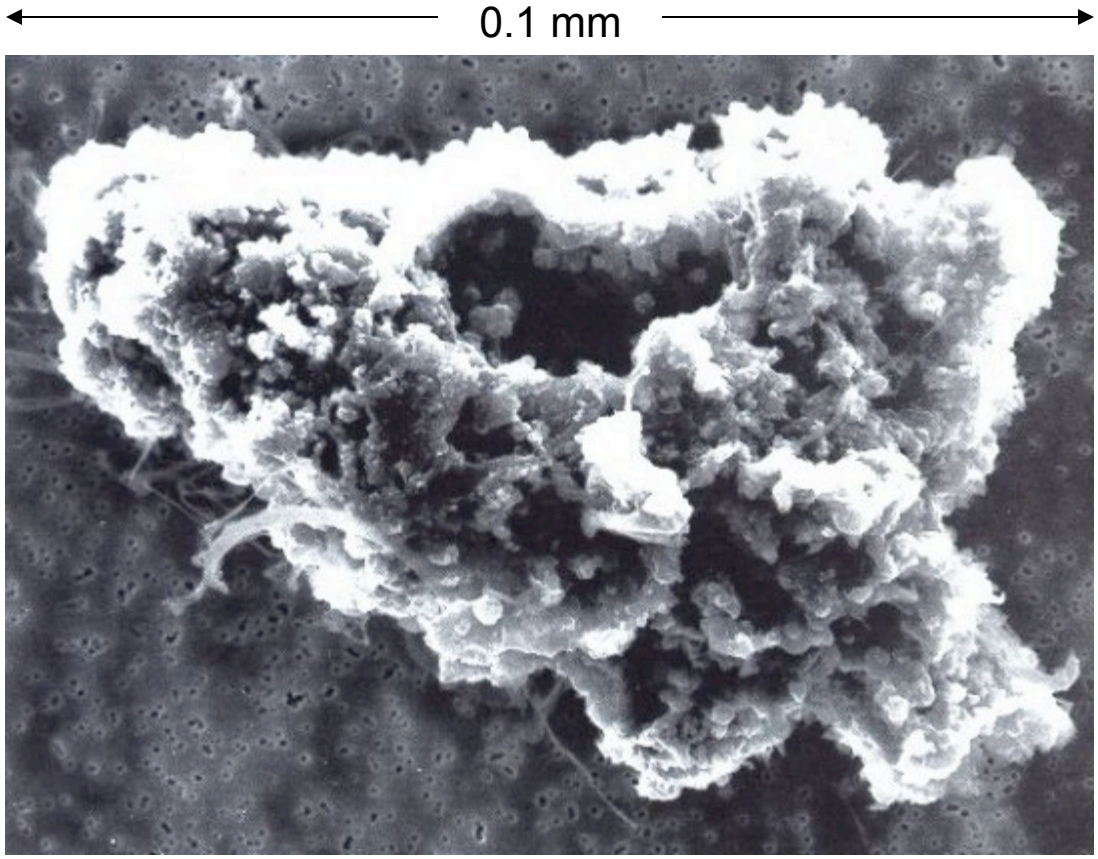
The tube shaped “smoke ring” in the infrared image (E2, E3, F3, G4) is an outflow of gas and dust from the forming star. The gas is expanding rapidly, with maximum speeds approaching 100 kilometers per second. Include supporting evidence in your explanations.

Why do you think the gas and dust are emitting infrared light?





Electron Microscope Image of Space Dust

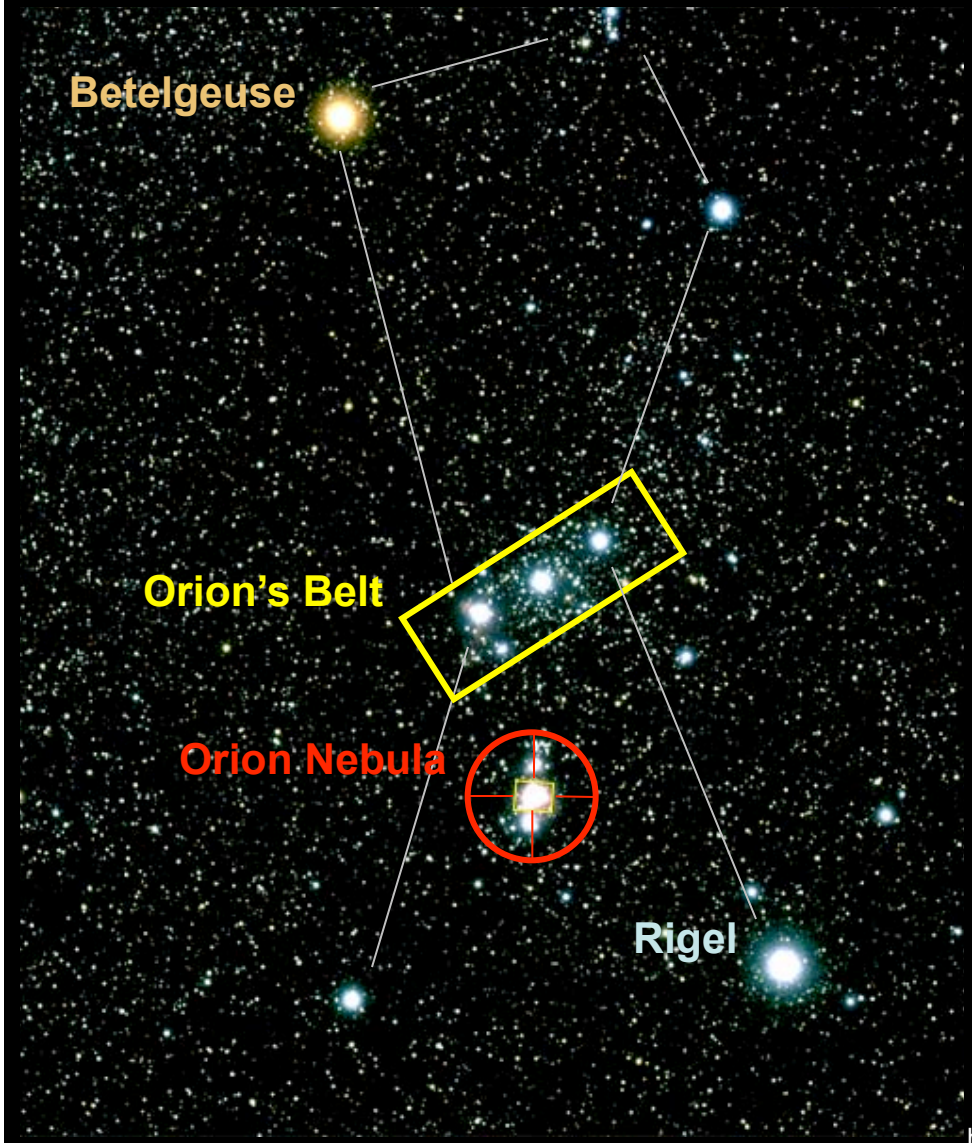


http://www.hq.nasa.gov/office/pao/History/EP-177/ch2-4.html

Displayed in a close-up under an electron microscope, this tiny bit of cosmic dust may be our first sample of a passing comet. Less than one-tenth of a millimeter across, the particle is composed of millions of even tinier crystals. Although chemically similar to some meteorites, its fluffy, crystalline structure is unlike that of any known meteorite.

What is inside the Orion Nebula ?

The constellation of Orion



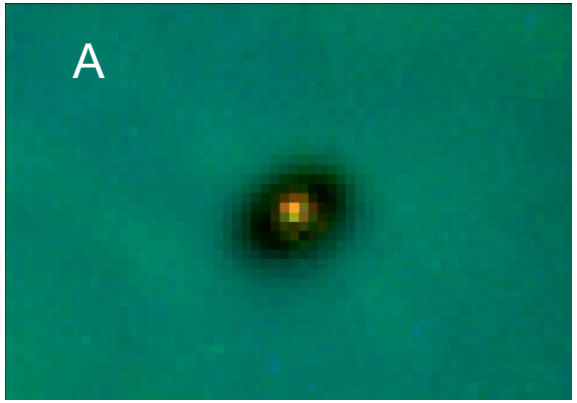
STScI-2001-13 Image by Akira Fujii

Animation Credit: *Zolt Levay (STScI) and Bryan Preston (STScI and Max-Q Digital)*

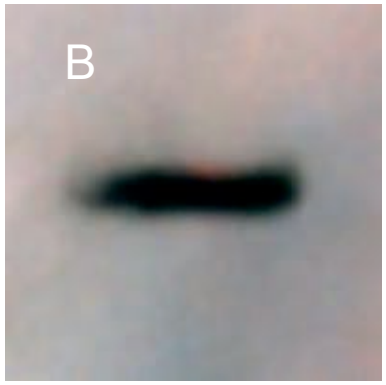
Animation Credit: *NASA and Walt Feimer (STScI)*

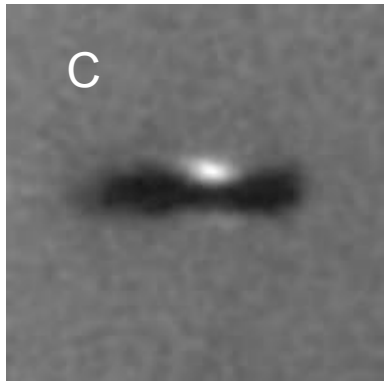
http://hubblesite.org/newscenter/newsdesk/archive/releases/2001/13/video/b

http://hubblesite.org/newscenter/newsdesk/archive/releases/1994/24/video/a



Side view of **A**





6. What happens after star formation?

These is a visible wavelength images of an object in the Orion Nebula taken with the Hubble Space Telescope.

i. What is the bright spot in the center of image **A**?

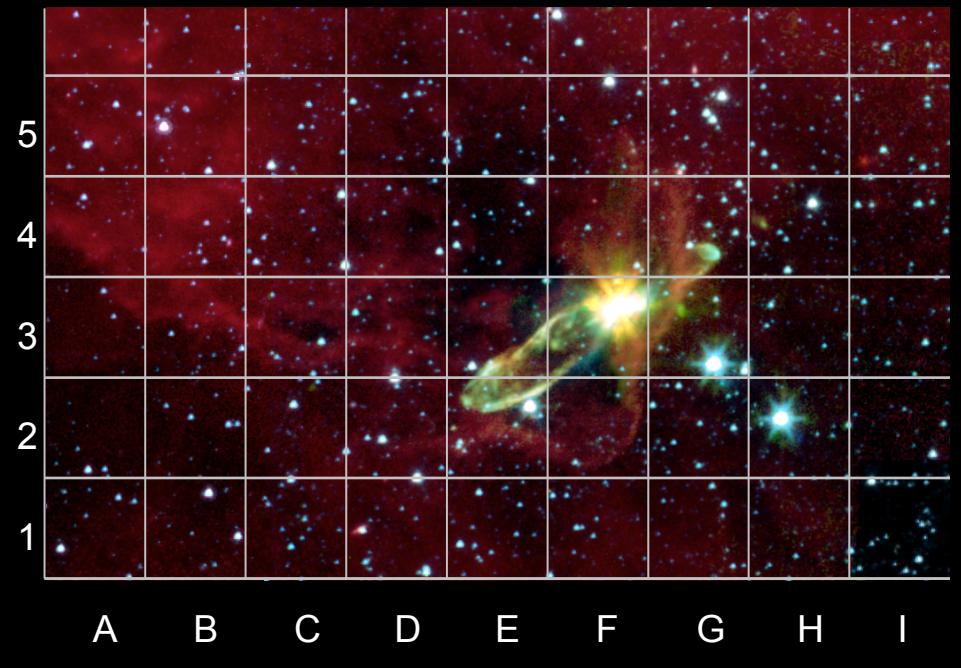
ii. What about the dark oval in image **A** and the dark disk in image **B**?

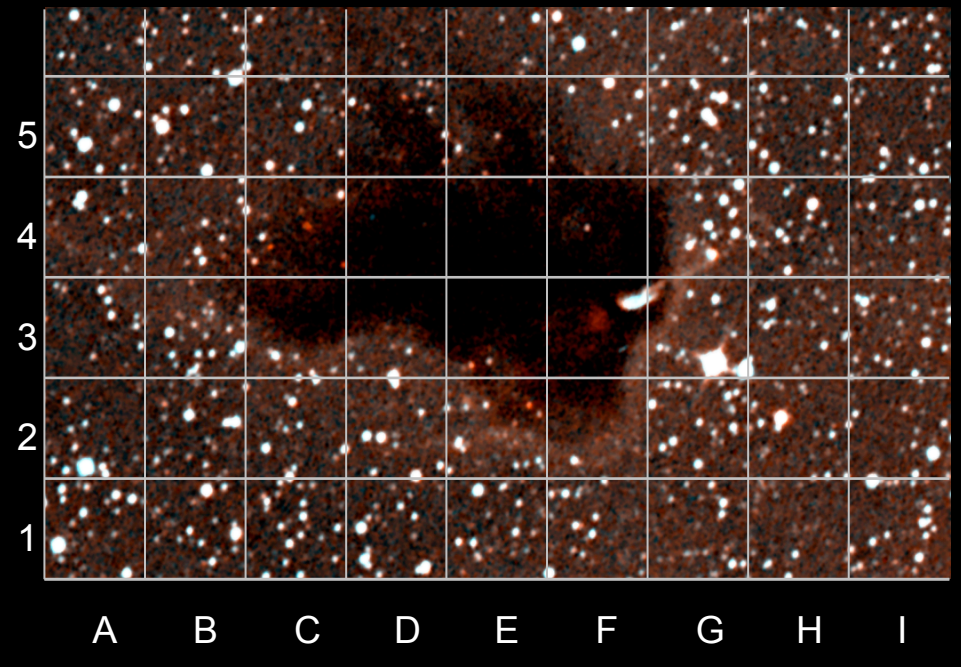
iii. Where do you think the planets would form?

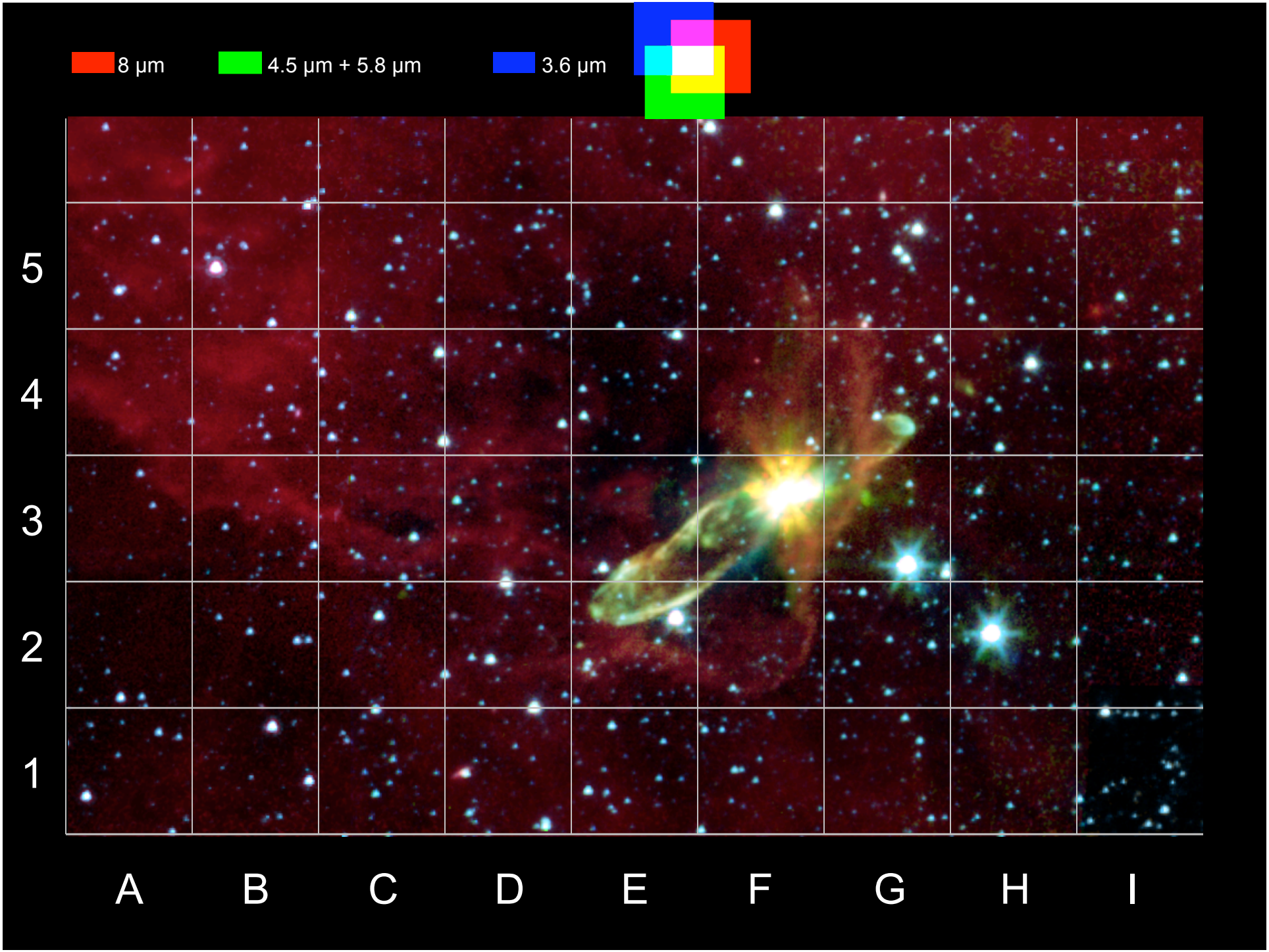
Image Credit: Mark McCaughrean (Max-Planck-Institute for Astronomy), C. Robert O'Dell (Rice University), and NASA
http://hubblesite.org/newscenter/newsdesk/archive/releases/1994/24/image/c

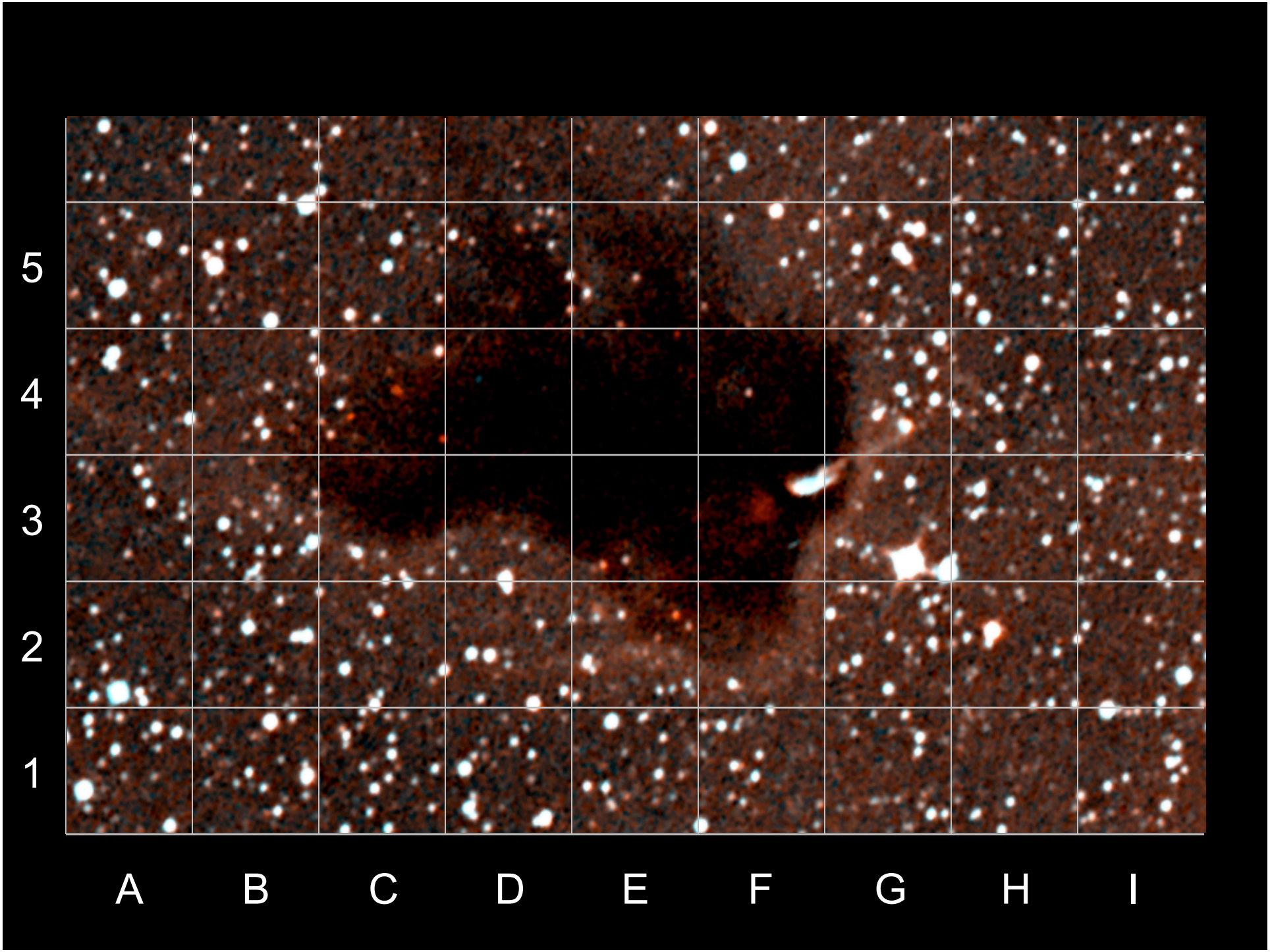
Wink slides:

Switch, or wink, between the two following slides to compare and contrast the images.

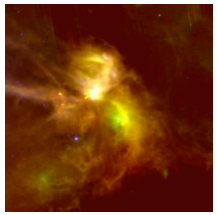


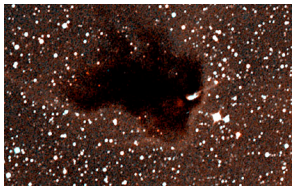



8 μm
4.5 μm + 5.8 μm
3.6 μm
5
4
3
2
1
A
B
C
D
E
F
G
H
I


5
4
3
2
1
A
B
C
D
E
F
G
H
I

Dust to Dust Cycle



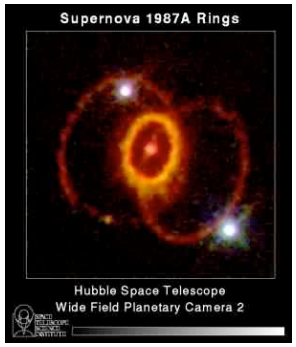


Big Bang

H and He

Clouds

Clump & Collapse



Neutron Star

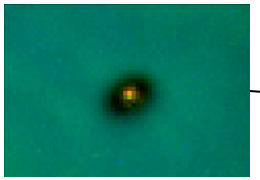
Dust & Gas

Proto Star

Proto Planetary Disc

Sub-stellar

Supernova

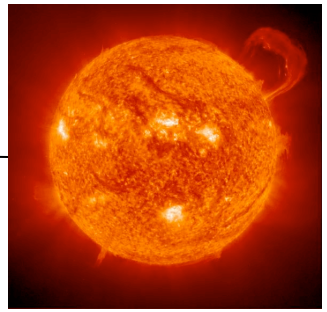


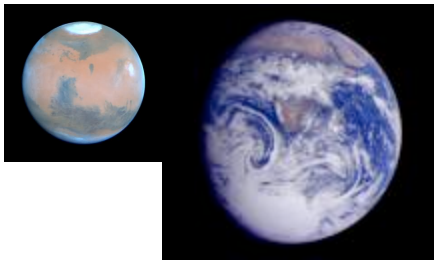
Black Hole

Star

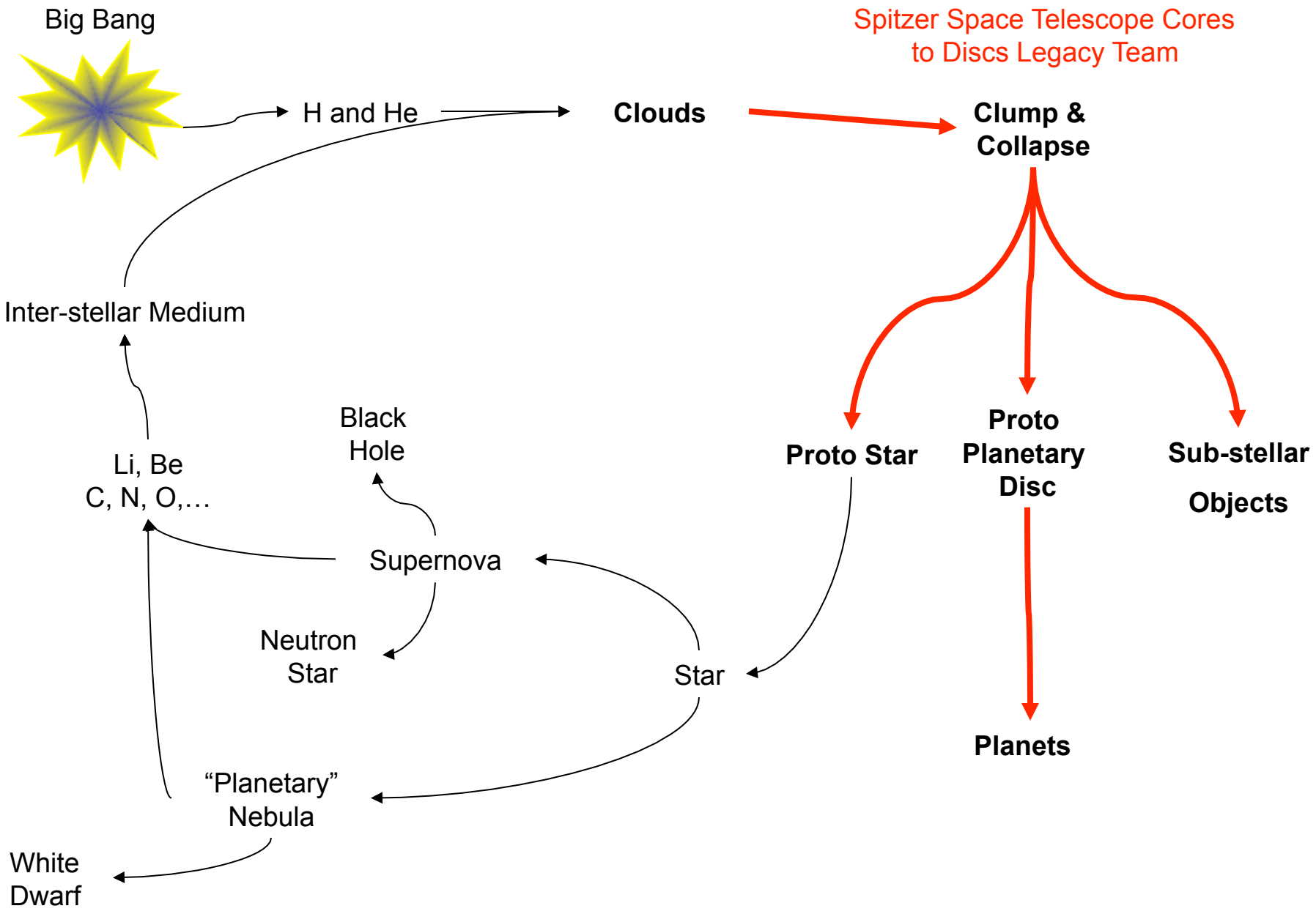
Planets

Planetary nebula





White Dwarf


Big Bang
H and He
Clouds
Spitzer Space Telescope Cores
to Discs Legacy Team
Clump &
Collapse
Inter-stellar Medium
Black
Hole
Proto Star
Proto
Planetary
Disc
Sub-stellar
Objects
Li, Be
C, N, O,…
Supernova
Neutron
Star
Star
Planets
“Planetary”
Nebula
White
Dwarf