Life & Death of Stars
Composer/program notes

This suite explores the birth and death of stars through the lens of two images from *NASA's Chandra X-ray Observatory*: The **Crab Nebula** and the **Pillars of Creation**. I was inspired by the cyclical nature of a star's life cycle; how new stars are born from matter left over by dying stars.

This piece was written as a sonification, meaning every aspect from timbre to form is derived from the image. I used a systematic approach of matching musical parameters to different data points of the image.

The **Crab Nebula** is the remnant of a supernova explosion in which the matter contained inside a dying star is dispersed into interstellar space. Eventually, this matter becomes incorporated into dense interstellar clouds that can form new stars.

The **Pillars of Creation** is an area of dense clouds of gas and dust in which protostars are already actively forming. Although these two objects are physically separated, together they tell a story of star death and rebirth. Although these movements are meant to be played as a set, they can stand alone as well.

I.   *Return to Dust*

This piece is based on a composite image made from X-rays from *Chandra* data and infrared observations from *NASA's James Webb Space Telescope* of the **Crab Nebula**, the supernova remnant of a star that exploded in 1054 C.E.

The piece starts with an explosion: frenzied motion in the strings and winds culminate in a burst of sound in the entire ensemble. When the explosion has reached its peak, it cuts off suddenly, leaving a quiet pulsing sound in its wake. These soft repeated piano notes and harmonics in the strings represent the spinning pulsar at the center of the Crab Nebula.

As we zoom in on the Crab Nebula, we begin to hear more and more rapidly developing 16th note figures in the winds, strings and mallet percussion, depicting the endless spinning of the pulsar. The rapid spinning is interspersed with hits in the bass and snare drums, representing the jets spewing gas and dust out into the atmosphere. As we expand outwards, the spinning slows, and we are left with the lingering clouds of gas and dust, endlessly expanding into the universe.

At the end of the piece, it returns to the center of the pulsar, and ends with the 16th note figure fading away, showing that the pulsar continues to spin eternally, rotating 30 times per second.

I.   *Cathedrals of Dust and Light*

Based on the *Chandra* X-ray and *Webb* infrared composite image of the **Pillars of Creation**, this piece explores an area of the universe in which protostars form inside clouds of gas and dust.

The piece begins with sustained, low chords in the bass clarinet and low strings, representing the clouds of dust surrounding the Pillars. Single note hits in the marimba and plucked piano strings represent the dimmer stars in the dust clouds surrounding the pillars.

As we start to zoom in to the Pillars themselves, the pace speeds up and repeated rhythms in the glockenspiel and piano grow into a spiralling texture, representing the gas and dust spiralling and gaining matter deep inside the pillars.

Out of this growing momentum, a brighter, bouncier texture emerges in the flute and mallet percussion, depicting the stellar nursery, or the millions of protostars forming inside the "Evaporating Gas Globules" or Eggs. This texture full of pure bright tones represents all of the young stars that emit X-ray light.

The final section of the piece zooms in on a single star in the Pillars. The texture continues to spiral, representing the protostar gaining matter and growing denser as it forms into a star. The chords at the end of the piece climb higher and higher, representing the heat of the star, until it culminates in a final piercing tone, which represents the protostar gaining enough heat to finally become a star.

The following chart provides each image parameter and its musical equivalent:

Pillars of Light Parameters:	Musical Parameters:
Type of light (Xray, Infrared) ● X-ray (transparent): Young stars ● Infrared (opaque) : Pillars	Timbre ● X-ray (hottest): Pure/bright timbres ● Infrared (warm): darker timbres + Discordant
Heat ● Surrounding dust (coolest) ● Pillars (cool) ● EGG (warm), protostars form ● Stars (hot) form when temp reaches 10 mil. K. (H=>He)	Register ● The hotter the particles, the higher the pitch (energy around young stars) ○ Dust = low register ○ Pillars, EGG = mid register ○ Stars = high register
Morphology	Resonance

(point-like=individual pixel, diffuse=cloud of gas) - Gas, Pillars (dense dust+gas), EGG+Stars	- Pixels=attacks - Clouds=longer resonances Layers of sound - Background: surrounding gas - Middleground: pillars - Foreground: EGG + Stars
Brightness of light	Dynamic - Brighter=louder - Dimmer=softer Note→Noise spectrum - Less light=noise - Brighter light=purer note
Density of particles	Musical texture - The denser the image, the denser the texture Consonance→Dissonance - Denser = more dissonant - Sparser = more consonant