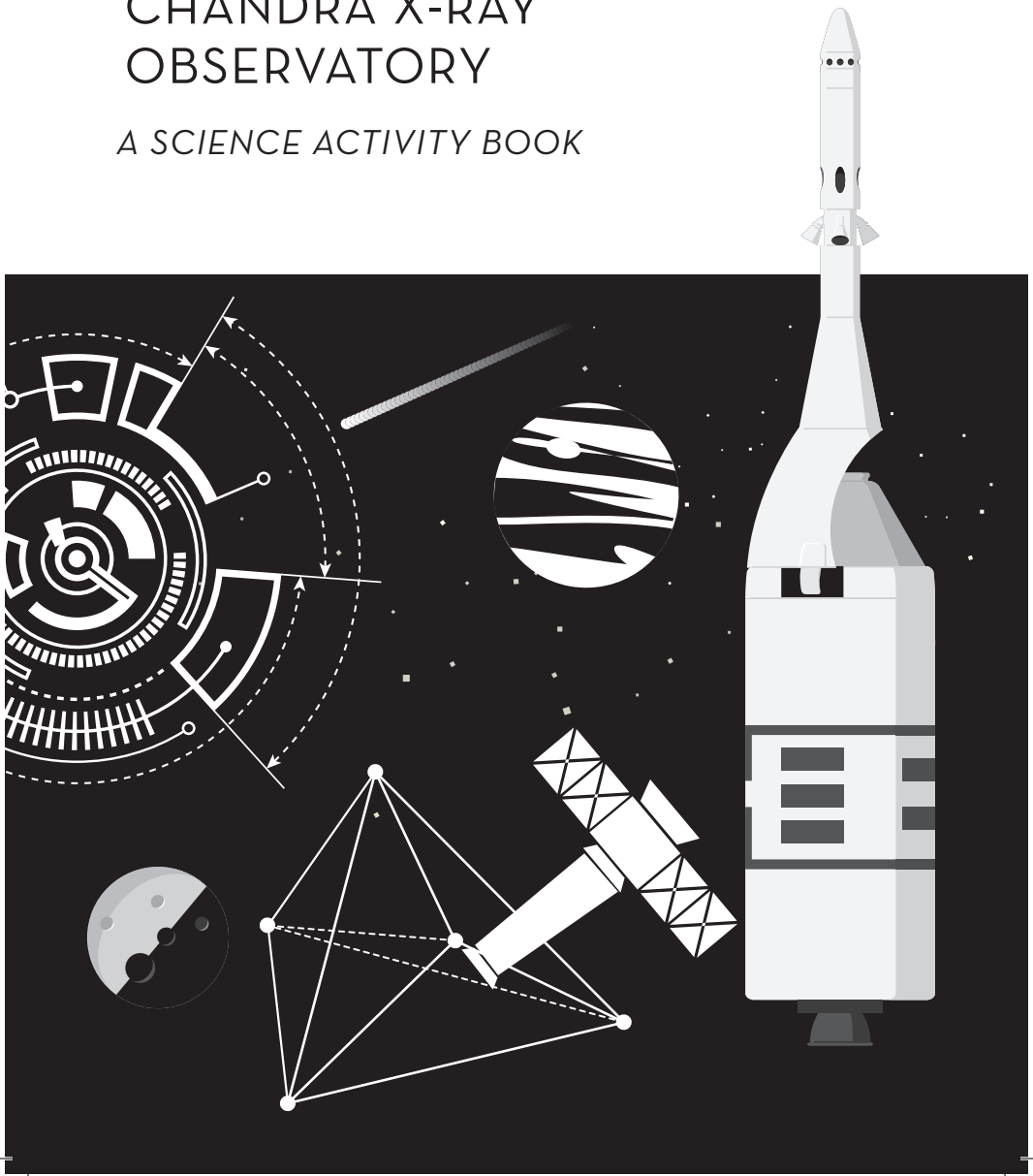
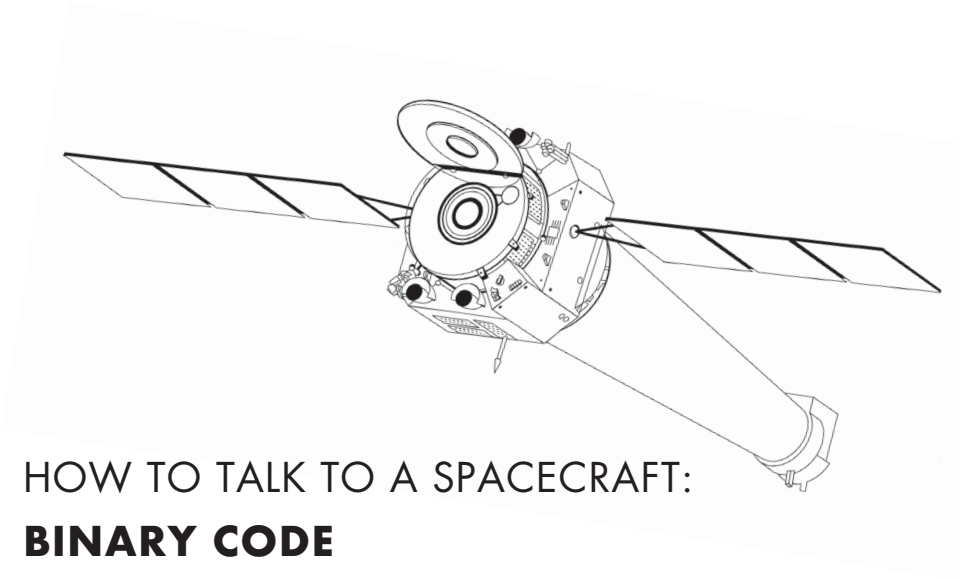
National Aeronautics and Space Administration

EXPLORING SPACE WITH NASA'S CHANDRA X-RAY OBSERVATORY

A SCIENCE ACTIVITY BOOK





HOW TO TALK TO A SPACECRAFT: **BINARY CODE**

Telescopes in space, such as NASA's Chandra X-ray Observatory, use binary code. Binary code is a system that uses two digits to represent things. You can think of each 1 and 0 like an "on" and "off" position of a switch. Binary code is a simple, effective way to talk to many kinds of electrical machines because with electricity, it's either on or off.

Our cell phones, computers, and other digital equipment all use a 256-letter alphabet of uppercase letters, lowercase letters, numbers, etc., if they are based in the English language. The characters are each assigned an 8-character binary equivalent. The location of each "1" represents that position's value, which is used to calculate the total value of the binary number. The positions of all eight characters then equal a fixed number value. The letter A for example is written as "01000001".

Binary code can be thought of as a foreign dialect that needs to be translated into a language that you can understand. Binary code is "spoken" in those sets of ones and zeros. If you know the code, or how to translate, you (or a computer) can "read" or understand.

Here is a chart of alphabet characters:

A	01000001	J	01001010	S	01010011
B	01000010	K	01001011	T	01010100
C	01000011	L	01001100	U	01010101
D	01000100	M	01001101	V	01010110
E	01000101	N	01001110	W	01010111
F	01000110	O	01001111	X	01011000
G	01000111	P	01010000	Y	01011001
H	01001000	Q	01010001	Z	01011010
I	01001001	R	01010010		

Use the chart above to write your name in code.

Can you tell what is written here below?

01000011 | 01001000 | 01000001 | 01001110

01000100 | 01010010 | 01000001

THE SCIENCE OF **FLYING**

Some paper planes fly better than others. Why is that? One important factor is is design. Other factors include paper, launch force/angle, and sometimes (if you're launching outside) even the weather!

What are the forces that enable a plane to fly? Force is something that pushes or pulls on something else. When you throw a paper plane in the air, you are giving the plane a push to move forward. That push is a type of force called thrust. While the plane is flying forward, air moving over and under the wings is providing an upward lift force on the plane. At the same time, air pushing back against the plane is slowing it down, creating a drag force. The weight of the paper plane also affects its flight, as gravity pulls it down toward Earth. All of these forces (thrust, lift, drag and gravity) affect how well a given paper plane's flight will go.

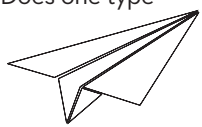
MAKE A PAPER AIRPLANE.

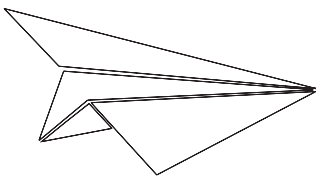
Create a "starting line" on the floor with tape, or by noting the tile square or other marker on the floor. Place your toe on the floor line and throw the paper plane. Did it fly very far?

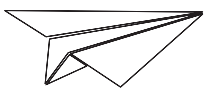
Throw the plane at 3 or 4 more times. Each time before you throw the plane, make sure it is still in good condition (that the folds and points are still sharp). When you toss it, place your toe on the line and try to launch the plane with a similar amount of force, including gripping it at the same spot. Did it go about the same distance each time?

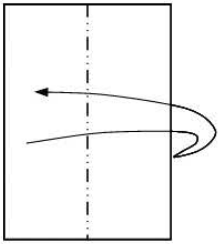
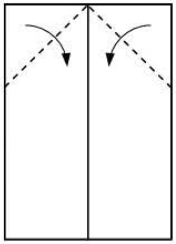
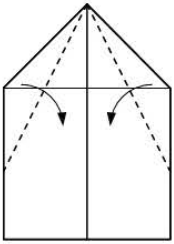
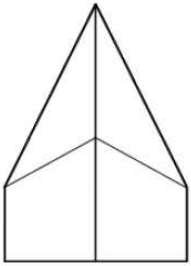
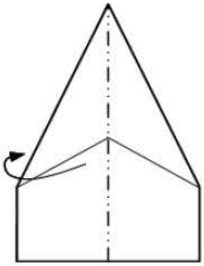
Make a new paper plane or even two planes that are different sizes and compare how well they fly. Do bigger planes fly farther?

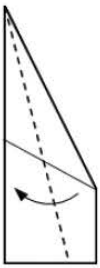
Try making paper planes out of different types of paper, such as printer paper, construction paper and newspaper. Use the same design for each. Does one type of paper seem to work best for making paper planes? Does one type work the worst?







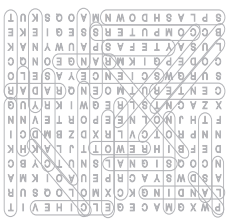


SPACE SCIENCE SEEK AND FIND

P W X G M A C E G E L C I H E V I T
L A N D I N G K C X M O L O Q S U R
A S D W S Y A C R P E U A O I K M A
N C O Q S I G N A L S N U T C Y B C
D E F B I H R E W O T T J L A K H K
N N P R O T C V L R X D Z B M D C I
F T H J N O L N E E P O R T E V N N
X Z A C N T S L R E G W I K R Y U G
C E N T E R U T M O E N Q R A D A R
S U R G W S C I E N C E Y A S E L O
C O D E P G I K M R A N G E O N Q C
L U S A Y T E F A S P A U W Y N A K
B C C O M P U T E R S S E G I E K E
S P L A S H D O W N M A O Q S K U T

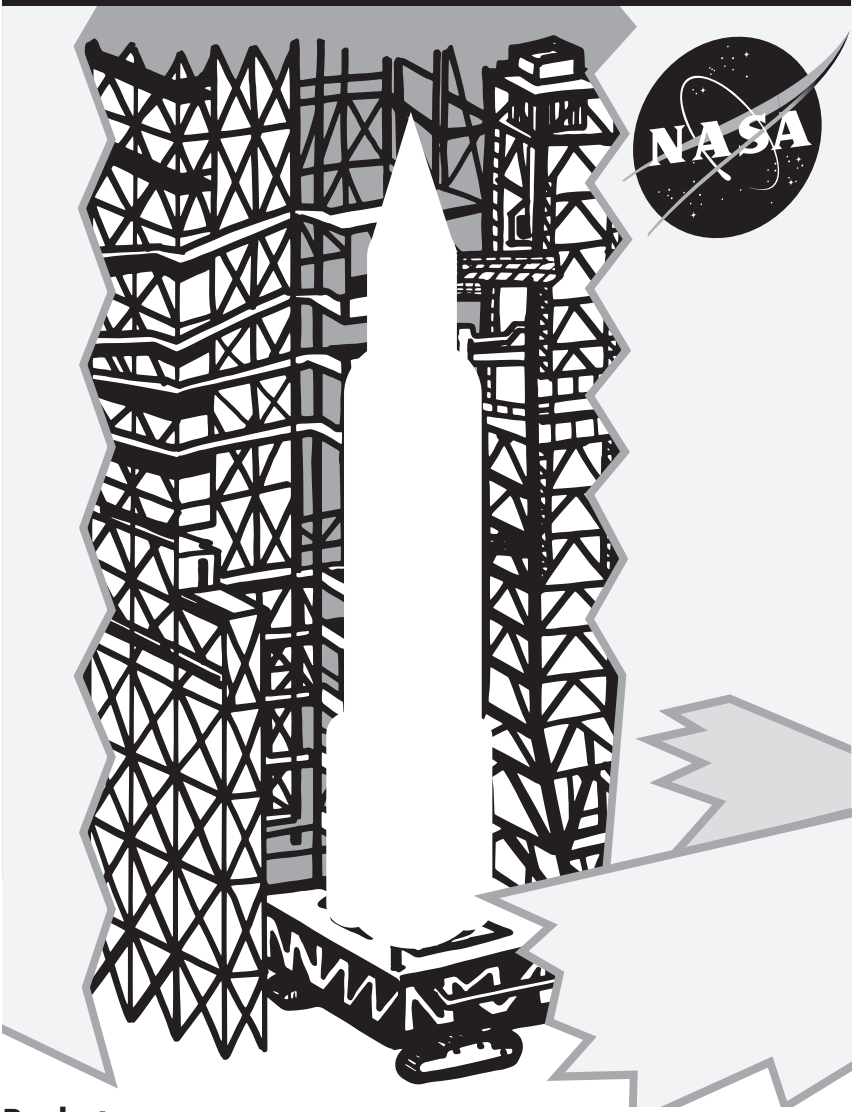
ASCENT
BOOSTER
BUDGET
CAMERAS
CAPSULE
CENTER
COMPUTERS
CONTROL
COUNTDOWN
CRAWLER
DATA
EXPLORE
KENNEDY
LANDING
LAUNCH
MISSION
NASA
PAD
PLAN
RADAR
RANGE
ROCKET
SAFETY
SCIENCE
SIGNAL
SPACE
SPLASHDOWN
TOWER
TRACKING
VEHICLE

SOLUTION



Visit **go.nasa.gov/groundsystems**, for more information.

DESIGN YOUR OWN **ROCKET**



Rocket name _____

Commander _____

Payload _____

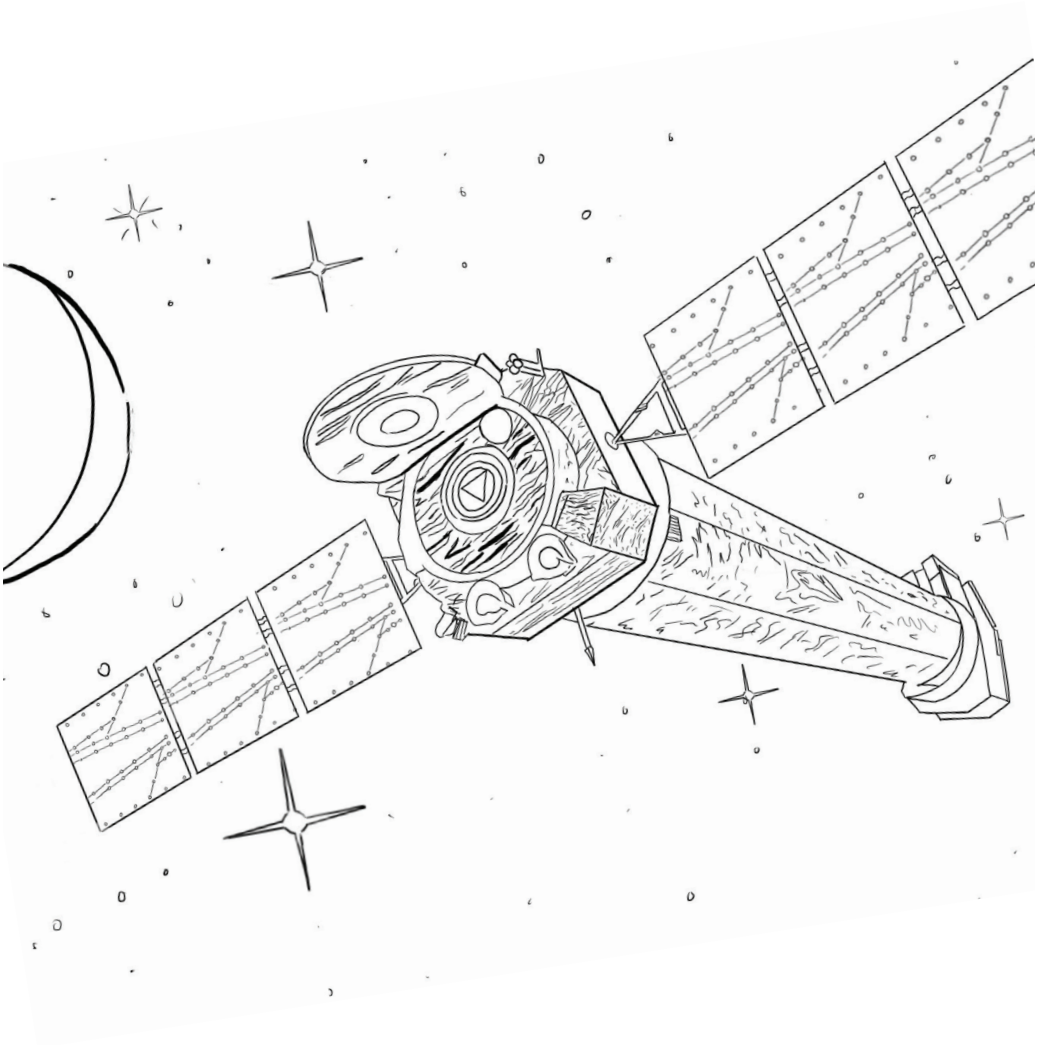
Destination _____

Astronaut Cady Coleman, STS-93, Mission Specialist

U.S. Air Force Colonel, chemist and astronaut Cady Coleman (b. 1960) helped deploy NASA's Chandra X-ray Observatory into space in 1999 and has since spent about 180 days aboard the International Space Station. Coleman cites that it wasn't until she was in college when astronaut Sally Ride came to talk that she first became interested in being an astronaut.

Astronaut Eileen Collins, STS-93, Space Shuttle Commander

When Eileen Collins (b.1956) joined the Air Force Reserve Office Training Corp (ROTC), women were not allowed to be pilots. but, luckily that changed in 1976 while she was working on her degree in math and economics. After spending over a decade at the Air Force, Collins was selected to the astronaut corps in 1990. She became the first woman to command a NASA shuttle mission, when she commanded STS-93 to launch Chandra.



Chandra X-Ray Observatory

Chandra's powerful and unique X-ray eyes have contributed to a revolution in our understanding of the cosmos. An X-ray telescope is the only way astronomers can observe the hot regions of the Universe. X-ray telescopes allow us to image matter swirling as close as 90 kilometers from the event horizon of a stellar black hole or to track the expansion of a hot gas bubble produced by an exploding star. Chandra, which was launched by the Space Shuttle on July 23, 1999, is helping scientists to better understand the hot, turbulent regions of space and answer fundamental questions about the origin, evolution, and destiny of the Universe.

Chandra Word Search

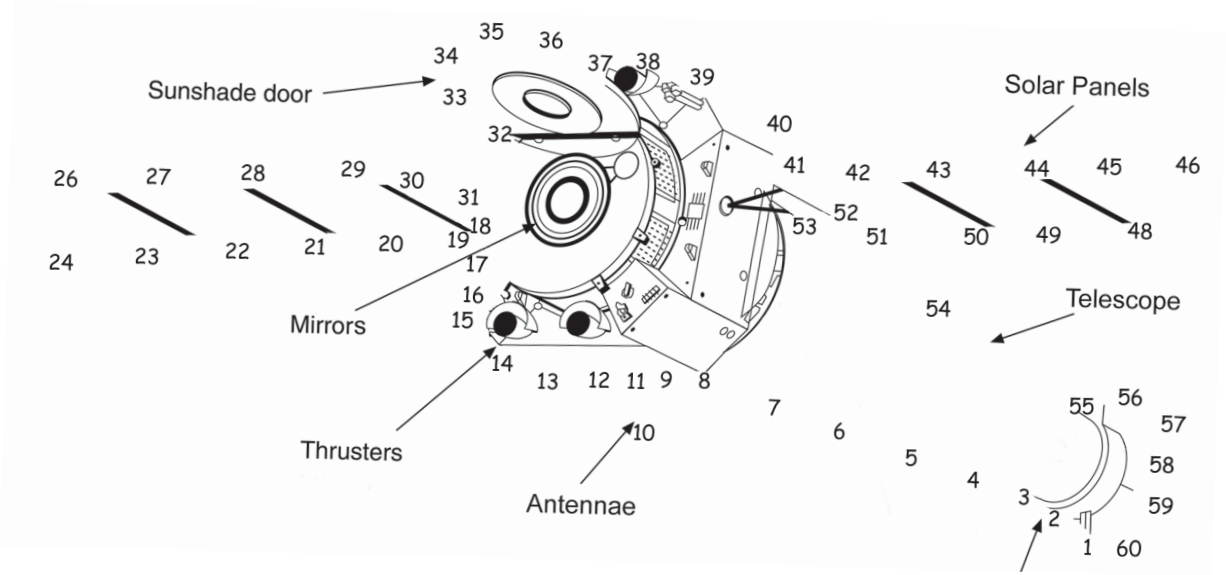
A B Z M H X X I W E
C L G I T V A U C Y
X A B R G D A A U X
R C J R N W P N A A
A K J O E S I T R L
Y H E R L V N N D A
S O J S E Y A E N G
X L F R V S E N A Y
K E S R A T S A H O
H E W F W J E V C U

Find the words hidden in this puzzle. Words may be hidden horizontally, vertically, forward, or backward.

Chandra
Space
Xrays
Mirrors
NASA
Universe
Wavelength
Star
Galaxy
Blackhole

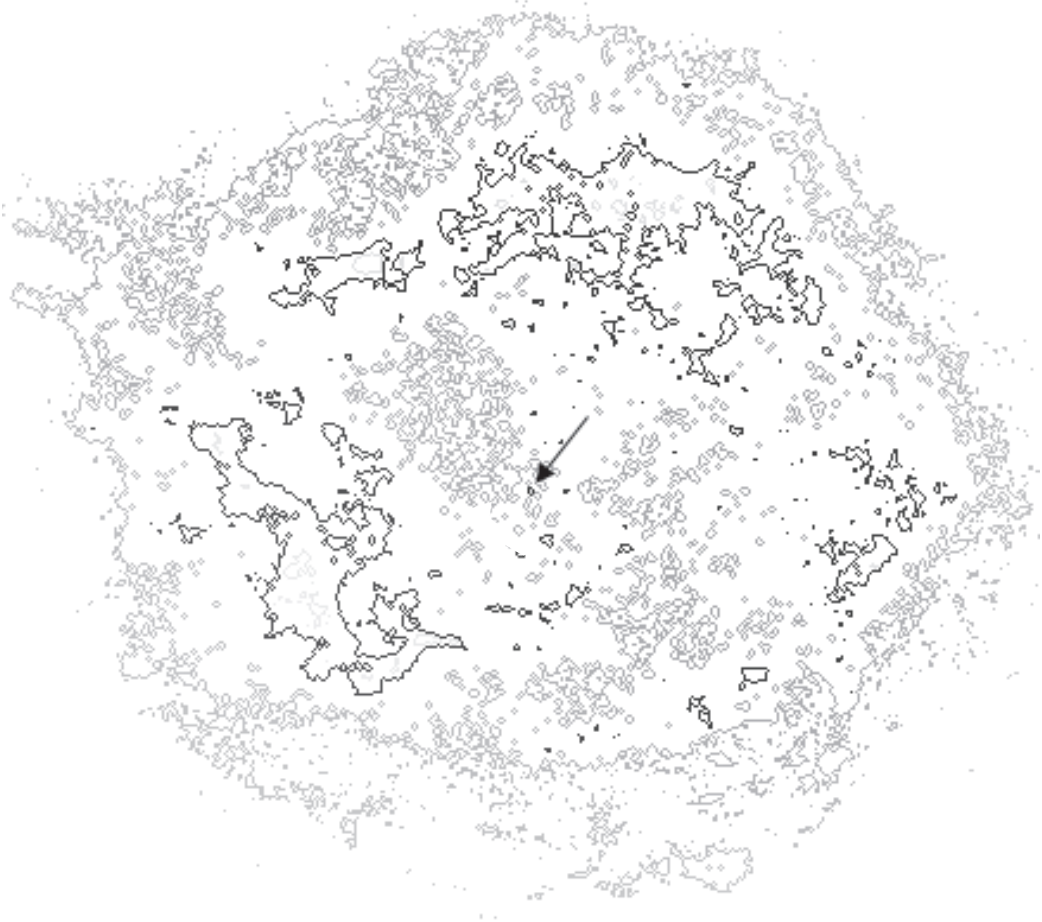
The Spacecraft

The Chandra X-ray Observatory has three major parts: (1) the X-ray telescope, whose mirrors focus X-rays from celestial objects; (2) the science instruments which record the X-rays so that X-ray images can be produced and analyzed; and (3) the spacecraft, which provides the environment necessary for the telescope and the instruments to work. The mirrors on Chandra are the largest, most precisely shaped and aligned, and smoothest mirrors ever constructed. The images Chandra makes are twenty-five times sharper than the best previous X-ray telescope.



Supernova Cassiopeia A

Chandra's First Light



Cassiopeia A (Cas A) was a massive star that used up all of its fuel and exploded. The scattered, glowing remains from the explosion are called a supernova remnant. Cas A's explosion produced a cloud of very hot (50 million degree) gas that is still expanding. Chandra's sharp focus allowed scientists to identify a dot in the center (see arrow) that is the hot, superdense neutron star formed as a result of the star's collapse and explosion. Cas A was Chandra's official "First Light" image, taken about 1 week after the doors and covers over Chandra's mirrors and detectors were opened.

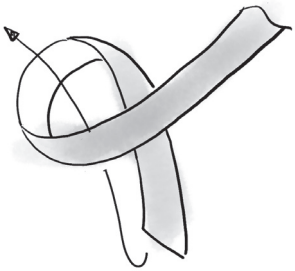
Origami is an ancient Japanese style of paper folding

Not only is it a decorative art form, origami provides solutions to many problems in modern science and engineering. For example, origami-inspired techniques are used to unfold stents in clogged arteries, release airbags during automobile collisions, and even unfurl the large mirror for the soon-to-be-launched James Webb Space Telescope.

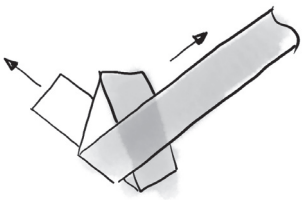
In astrophysics, there are instances where the expansion and unpacking of origami demonstrates what scientists witness. Take the death of stars. When a star about 10 to 15 times more massive than our Sun runs out of nuclear fuel, it will collapse onto itself and then create a giant explosion. This energetic event, known as a supernova, hurls the outer layers of the star into space, creating an elegant tapestry of energy and stellar debris.

NASA's Chandra X-ray Observatory has looked at many of these explosions and the debris fields they leave behind (called "supernova remnants".)

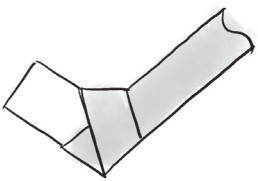
Use a long narrow strip of paper to create your star like the strip on the right.



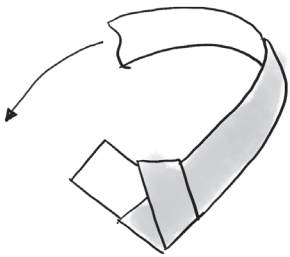
1 Make a loop at one end of the paper. Weave the short end of the paper through the loop.



2 Tighten knot and press flat.

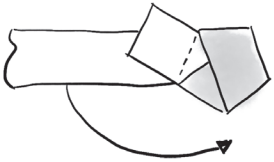


3 Fold short-end of paper down towards center of star. If it is too long, tear off a small piece.

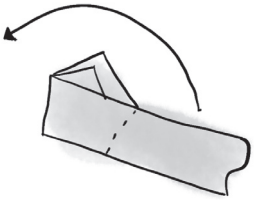


4 Fold long-end of paper up. Make sure edges line up right on top of one another.

see next page for directions 5-8

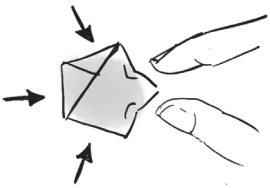


5 Flip paper around so long-end of paper is pointing down again.

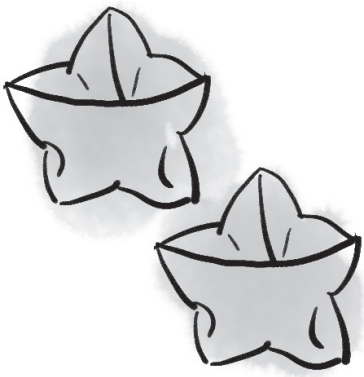


6 Fold long-end of paper up and to the left. Make sure edges line up one on top of the other.

7 Flip paper around again so long-end of paper is pointing down.



8 Pinch the sides and puff out your star! Be careful here, too, to avoid ripping your star.



In 2019, NASA's Chandra X-ray Observatory celebrates its 20th year in space exploring the Universe. In these past two decades, Chandra has made profound discoveries and contributed invaluable information about the cosmos and the wondrous objects within it.

Chandra is part of a rich legacy of telescopes. Its X-ray lineage stretches back to the Space Age when scientists and engineers pioneered instruments that were sent above the Earth's atmosphere. This allowed astronomers to observe X-rays from cosmic objects for the first time. Each decade has brought new innovations and new capabilities, culminating in Chandra's launch aboard the Space Shuttle Columbia in 1999.

Chandra also has strong astronomical family ties across the electromagnetic spectrum. As part of NASA's "Great Observatories" program, Chandra was designed and built to observe X-rays alongside the Hubble Space Telescope in ultraviolet, visible and infrared light, the Spitzer Space Telescope in infrared light, and the Compton Gamma-ray Observatory in gamma rays.

Today, the quest to explore the Universe is both multiwavelength andmultimessenger in nature, with many of the very significant and exciting discoveries requiring information from different types of light as well as gravitational waves and particle physics. In its 20 years of operation, Chandra and X-ray astronomy as a whole have played a pivotal role in uncovering and solving the mysteries of the Universe. We look forward to what the next years may bring.

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