

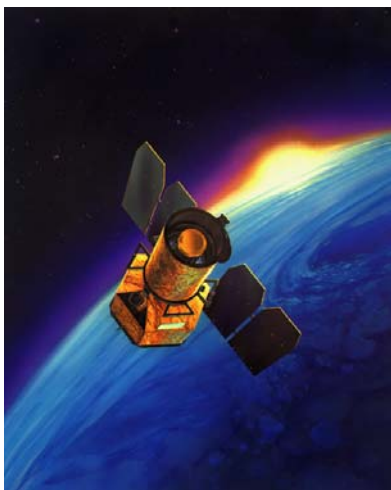
TELESCOPE AS TIME MACHINE

Read this article about NASA's latest high-tech space telescope.

Then, have fun doing one or both of the word puzzles that use the important words in the article.

A TELESCOPE FOR (ALMOST) ALL TIME

If all goes as planned, the National Aeronautics and Space Administration (NASA) has just launched a new space telescope that will see back in time 80% of the way to the Big Bang. The Big Bang is the colossal explosion that gave the universe its start around 12 billion years ago (give or take a few billion years). The Galaxy Evolution Explorer, or GALEX for short, is an Earth-orbiting telescope that is looking back 10 billion years to help scientists understand how galaxies like our Milky Way came to be and how they have changed over cosmic time. During its 29-month mission, GALEX will survey nearly the entire sky and gather galactic light that has been journeying toward us for nearly the entire history of the universe.



The Galaxy Evolution Explorer (GALEX) orbiting space telescope will look back in time 10 billion years.

GALAXIES 101

Galaxies are clusters of gas, dust, many different types of stars in all different phases of their life cycles, and various strange objects such as black holes. Our own Milky Way galaxy contains over 200 billion stars, and the entire universe probably contains over 100 billion galaxies. Galaxies come in a huge variety of shapes and sizes. Dwarf galaxies may contain as few as 10 million stars, while massive galaxies may have a trillion (that's a thousand billion) stars. Shapes of galaxies may be spiral, elliptical, or irregular.

Spiral galaxies have a large concentration of stars at the center, called the "bulge," and "arms" that extend outward. Viewed face on, they often look like giant pin-wheels. The spiral arms are rich in gas and dust needed to form new stars. Spiral galaxies that are sending out large amounts of blue and ultraviolet light (more about this kind of light later) tell scientists that a lot of new stars are forming. Our galaxy, the Milky Way, is an average-sized, spiral-shaped galaxy and is forming new stars at a rate of one star like our Sun every year.

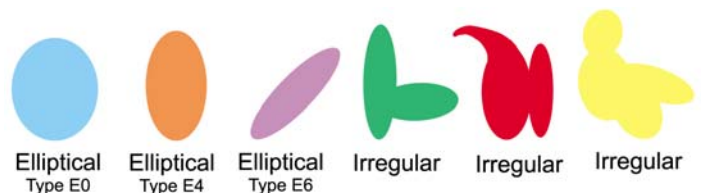


Some different types of spiral galaxies.

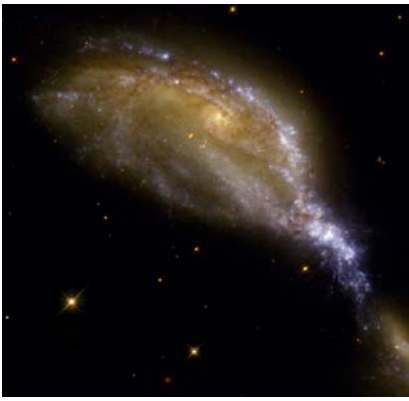


This magnificent spiral galaxy, photographed by the Hubble Space Telescope, is called NGC 4414. It is about 60 million light-years away.

Elliptical galaxies range from spherical to cigar-shaped. These galaxies don't contain much gas, so are rarely seen to be forming new stars. Their red color tells scientists that they contain mostly old stars. Irregular galaxies don't have much structure and are generally smaller than spiral or elliptical galaxies.



Some different types of elliptical and irregular galaxies.



The shape of this formerly spiral galaxy, called NGC 6745, has been distorted as it collides with another galaxy.

BEYOND IMAGINATION'S LIMITS

So how is looking at far away galaxies like looking back in time? At 300,000 kilometers per second (186,000 miles per second), nothing travels faster than light. Even at this speed, though, it still takes time for light to get from one place to another. If you are looking at your girlfriend just across the classroom, you are seeing her as she was a tiny fraction of a second ago, rather than as she looks right now. It takes about 8 minutes for light from the Sun to reach Earth. The Voyager 1 spacecraft, which NASA launched back in 1977, is now the farthest human-made object from Earth. Even though this spacecraft is still inside our solar system, its signal, traveling at light speed, takes 12 hours to reach Earth!

So, if Voyager's signal takes that long to reach us, you can begin to imagine how long it takes light to reach us from far distant galaxies. What we are seeing of those galaxies is not how they look today, but how they looked when that now-very-old light left them, thousands or millions or billions of years ago.

DOES THE LIGHT SHOW ITS AGE?

How will scientists know how old the light is that GALEX is receiving?

Scientists know that the universe is expanding. Like a chocolate chip cake in the oven, space is the "cake batter" that keeps getting bigger and bigger, while the stars and galaxies are the "chocolate chips" that keep getting farther and farther apart. Like energy pulsing through the ocean, light energy travels in waves. As light waves travel through this expanding space, they get stretched out. The longer they spend traveling through space, the more stretched out they get. Because red light waves are longer than the light waves of other visible colors, scientists say that light coming from distant stars and galaxies is "red-shifted." The more red-shifted the light waves, the farther (and longer) they

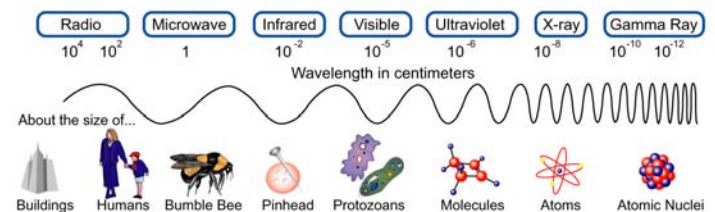
have traveled. GALEX is able to detect light that is extremely old, extremely red-shifted.

Like the Hubble Space Telescope that has given us so many awesome pictures of the universe, GALEX operates above Earth's atmosphere, so gathers light that cannot penetrate to telescopes on Earth's surface. While the Hubble is used by many astronomers around the world to study very particular, tiny regions of the sky, GALEX has its very specific mission to look at nearly the whole sky, a goodly piece at a time.

With the "all-sky survey" GALEX is making, scientists will be able to see how galaxies in the early universe (far, far away) are different from galaxies of more recent times (relatively nearby). Because distant galaxies appear to us as they were millions or even billions of years ago, we can study how they evolve. We see what they looked like when the universe was much younger, as galaxies were first forming. As we look at closer and closer galaxies we see how they change as they age, just as looking at babies, children, teenagers, and then adults can show how we humans change as we age.

MORE VIOLET THAN VIOLET?

GALEX is paying particular attention to how the universe looks in ultraviolet (UV) light. UV light waves are not visible to humans. The shortest light waves that humans can see are blue or violet. Ultraviolet waves, as their names implies, are shorter than violet waves. These shorter waves carry more energy than do visible light waves (or the light waves that are longer than those we can see, like infrared and radio waves). Most of the UV light from the Sun is absorbed or scattered by Earth's atmosphere, but what does get through to Earth's surface is what causes fair-skinned people to get sunburned.



GALEX detects ultraviolet objects in the sky that are more than a million times fainter than objects we can see in visible light from even the darkest locations on the ground.

What is so special about UV in studying stars and galaxies? The youngest stars are the brightest and hottest stars, and they produce a lot of UV light. By precisely measuring the brightness of the UV light coming from a galaxy, scientists can tell how fast that galaxy is churning

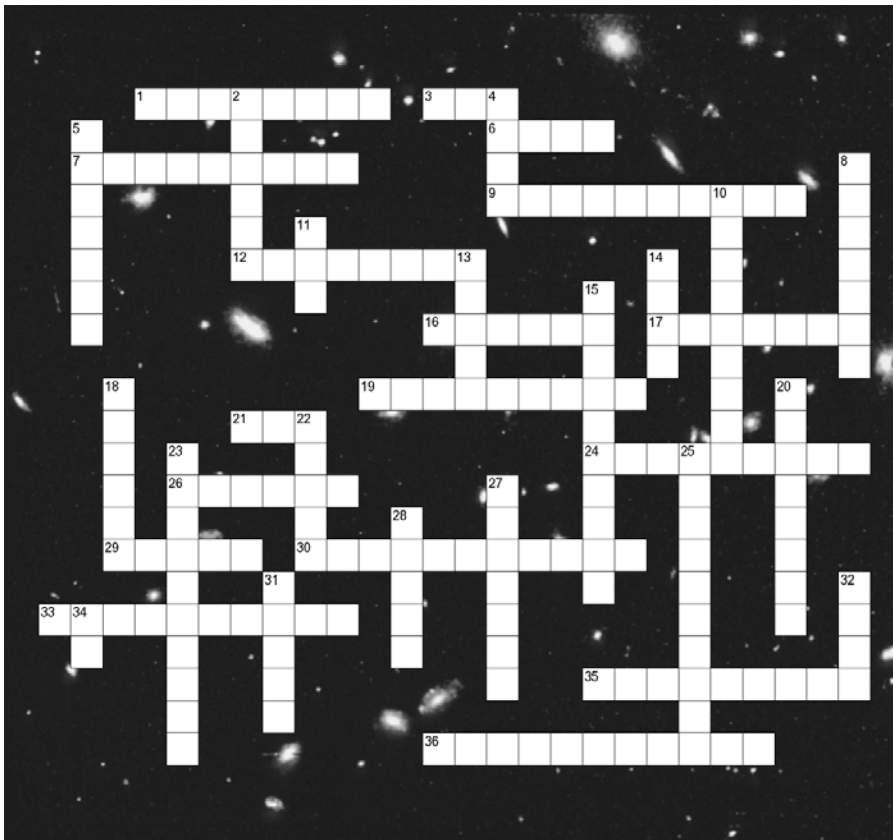
out new stars. GALEX's UV surveys will help scientists measure not only star formation rates, but many other characteristics of galaxies, such as luminosity (brightness), shape, gas content, how galaxies cluster together, and how such properties change over cosmic time.

We may not be able to actually place ourselves into the past, but remember: Space is time and time is space. So to look far back in time, all you need is a good telescope!

GALACTIC PUZZLES

Now, test your galactic IQ by solving one or both of these word puzzles. But don't cheat! If you do both puzzles, do the crossword first.

EXPLORING THE GALAXIES



Across

- 1 All there is
- 3 Nearby star
- 6 Common to human, octopus, and some galaxies
- 7 Viewer into the past
- 9 The blanket above us
- 12 Our galactic home
- 16 Another eye in the sky

DISCUSSION

The starship *Cosmographer* receives a distress signal. Zorp, the communication officer, announces it is coming from an ally's damaged ship four light years away. How might Zorp know the distance to the source of the signal? Should the crew just drop everything and rush to the aid of the ship in distress? Why or why not? What would have to be different from our current understanding of science for the *Cosmographer* to get to the damaged ship on time to save its crew?

- 17 Light gets under your skin
- 19 The youngest and the _____
- 21 Like air out in space
- 24 Amoeba-like galaxy
- 26 Pinwheel galaxy
- 29 From where we stand
- 30 Our closest celestial family
- 33 How much it shines
- 35 Much stranger than that of Alice's rabbit
- 36 More than blue

Down

- 2 True nothingness
- 4 Space agency of the U.S.
- 5 Make longer
- 8 What started the whole thing
- 10 Opposite of contracting
- 11 A red star is this
- 13 A blue star is this
- 14 Raw material for new stars
- 15 Light made longer
- 18 Change over time
- 20 Age of the universe, times about 12 years
- 22 Great balls of fire
- 23 Star student
- 25 Egg-shaped galaxy
- 27 The farthest artifact
- 28 Surveying the galaxies
- 31 Speediest traveler
- 32 Pulse of energy
- 34 Lots made where stars are born, abbreviation

Puzzle solution on Page 5.

The words in the list on the left are hidden in the jumble of letters. Words may be frontwards, backwards, upside-down, or diagonal. When you find a word, draw a box around it and cross it off the list.

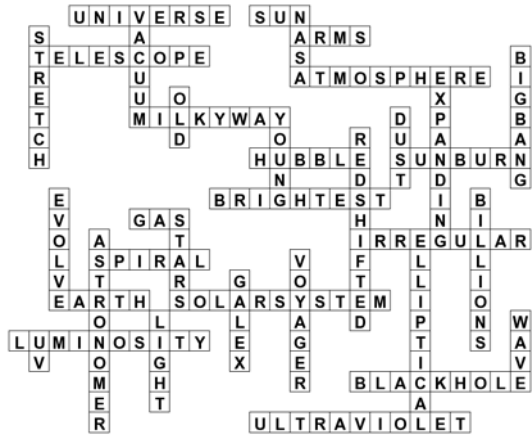
GALEX Words	
ASTRONOMER	
ATMOSPHERE	
BIGBANG	
BILLIONS	
BLACKHOLE	A M W W F J V G K C G A L A X I E S U X
BRIGHTEST	Q P V X Y H X H R O B M U U C A V G I W
DUST	Z U R E M O N O R T S A N L V S C I R X
EARTH	V Y D A X V X M H H G T A W N T B Y D I
ELLIPTICAL	B K L H B A N G Q Z U R R I K A B L V K
EVOLVE	I I C D U S T A W B I B F E K R T V U S
EXPANDING	F S L S J T F L P P A I B H T S Y H M S
GALAXIES	B P Q L B D I E S S R A I L R C X N U S
GALEX	T E S J I I P X A S A N Y B E P H P Y S
GAS	E V N R V O Y A G E R G O T D S M B R A
HUBBLE	L O L T I M N E J T L A X I S K I B F T
IRREGULAR	E L I S C D S S G Q R S I O H J L I Z M
LIGHT	S V G T E L O I V A R T L U I K K G V O
LUMINOSITY	C E H N D B R I G H T E S T F K Y B S S
MILKYWAY	O X T S Y T I S O N I M U L T G W A H P
NASA	P E V A W L A C I T P I L L E O A N O H
REDSHIFTED	E A R T H E X P A N D I N G D Q Y G M E
SOLARSYSTEM	C E S R E V I N U Z R A L U G E R R I R
SPIRAL	L M E T S Y S R A L O S U R M P A U M E
STARS	U G M V N B L A C K H O L E Y O U N G F
STRETCH	
SUN	
TELESCOPE	
ULTRAVIOLET	
UNIVERSE	
VACUUM	
VOYAGER	
WAVE	
YOUNG	



This article was written by Diane Fisher, writer and designer of The Space Place website at spaceplace.nasa.gov. The article was provided through the courtesy of the Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, under a contract with the National Aeronautics and Space Administration.

Puzzle solution on Page 5.

Solution to Space Place Crossword



Solution to Space Place Wordfind

