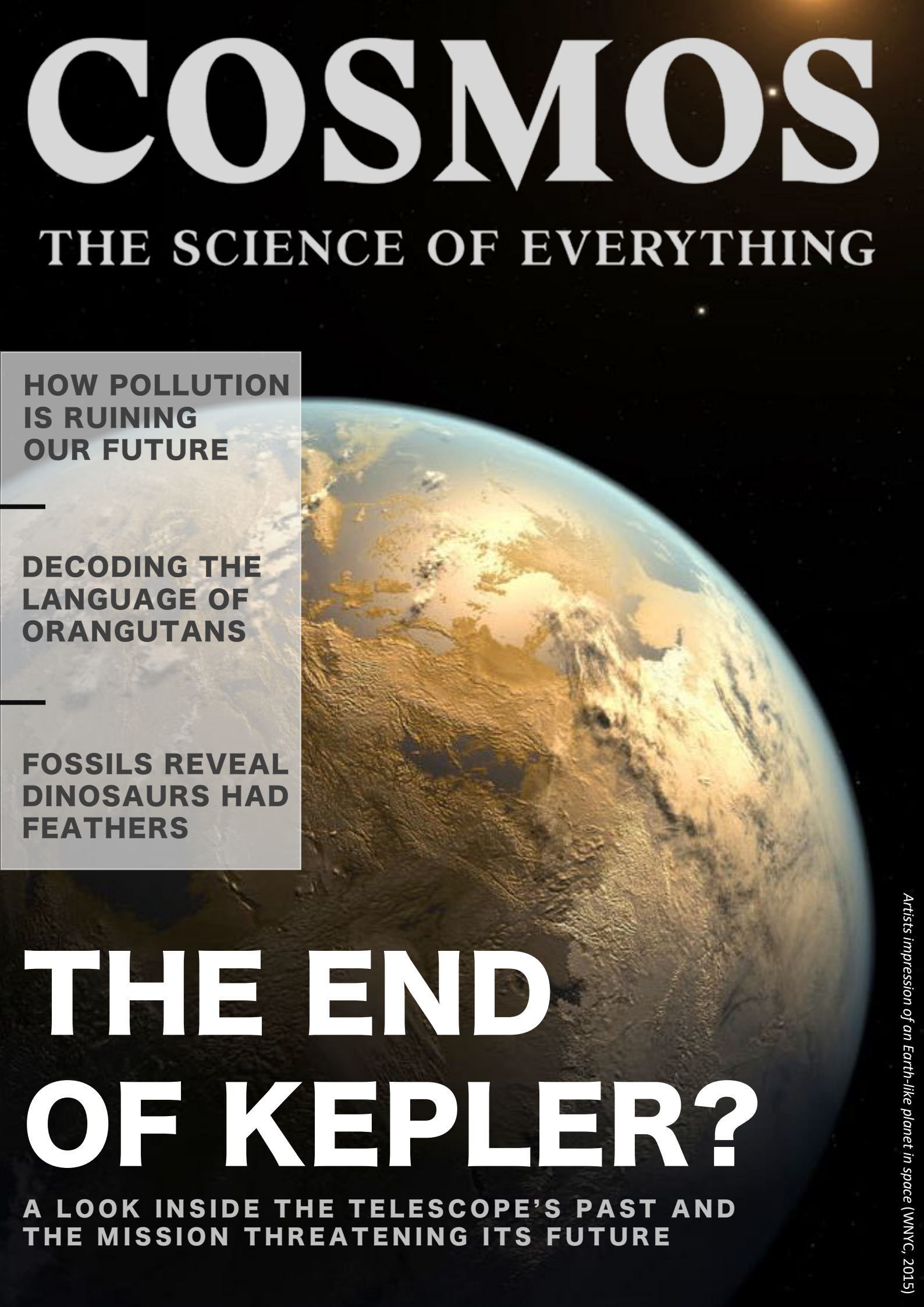
COSMOS

THE SCIENCE OF EVERYTHING

HOW POLLUTION IS RUINING OUR FUTURE

DECODING THE LANGUAGE OF ORANGUTANS

FOSSILS REVEAL DINOSAURS HAD FEATHERS



THE END OF KEPLER?

A LOOK INSIDE THE TELESCOPE'S PAST AND THE MISSION THREATENING ITS FUTURE

Artists impression of an Earth-like planet in space (WNYC, 2015)

“FASTER BETTER CHEAPER”

Like many of us, NASA asked the question, “Is anyone out there?”. Unlike most of us, NASA had the resources to take the first step in answering this question. They named this first step ‘Kepler’, a space telescope tasked with discovery of exoplanets. As the Transiting Exoplanet Survey Satellite (TESS) – Kepler’s successor – prepares for launch in April 2018, now is the time to look back at Kepler, its successes, its failures, and what it has given humanity. On March 7, 2009 Kepler was launched from Cape Canaveral in a Delta II Rocket. The construction and operation of Kepler was initially the responsibility of NASA’s Jet Propulsion Laboratory (JPL), although the telescope is now managed by Ball Aerospace and the University of Colorado, and has been since December of 2009.

Less widely known as ‘Discovery 10,’ Kepler is a part of NASA’s Discovery program, with the motto “Faster, Better, Cheaper.” Led by William Borucki of NASA Ames, Kepler was tasked with “determining the diversity and structure of planetary systems.” (Gould, 2017). This included “surveying our region of the Milky Way to discover hundreds of Earth-sized planets in or near the habitable zone, determining the fraction of stars that are home to such planets, the distribution of planetary sizes, the frequency of planet sizes in multiple-planet systems, determine planet reflectivity, sizes, masses and densities, identifying additional members of discovered planetary systems, and determining the properties of the stars that harboured these planets.” (Gould, 2017).

Kepler was the first telescope of its kind, sent to discover possible life-bearing planets; and so a mission as new as this required new technology. Built by JPL, Kepler had one data-collecting scientific instrument on board, a CCD array as part of the Schmidt telescope

Artistic impression of Kepler operating as part of K2 (NASA Ames, 2014)

SEARCHING THE SKY

A TRIP DOWN MEMORY LANE AND INTO THE FUTURE

An article written by Annalise Lennon

Light reflects off Kepler's primary mirror onto the CCD array, where it is slightly unfocused, a technique discovered to be better for photometry (the measure of light). Photometry requires accurate measures of brightness instead of sharp images - the reasoning behind the unfocused state. Kepler utilises this CCD array to collect measurements on light being emitted from stars for months at a time. If a planet orbits in front of the target star, there will be a drop in brightness, which can also be used to detect the planet size and orbital distance.

Despite the carefully engineered focus of the CCD, Kepler's photometric precision was less than originally anticipated, at an accuracy of 29 parts per million (ppm), rather than the expected 20ppm. This problem was caused by larger than expected levels of instrument noise. However, work is taking place to better understand and calibrate instruments to block out the noise – an improvement that will help TESS in its mission. Early 2013 was when the real issues began to hit. Two of Kepler's four rotation wheels to keep its field of view steady broke, leaving the telescope in an unstable state and unable to collect accurate data, but engineers rose to the challenge. A great scientific achievement, it was discovered that sunlight could be used to guide the telescope. Photons from the sun place pressure on the spacecraft, equal amounts on the top and bottom, keeping it stable enough to collect data, but not in the same field of view as the initial Kepler mission anticipated.

K2 is Kepler's second chance. Split into 12 'campaigns,' Kepler is studying 12 patches of sky, rotating between them at a rate of 4.5 changes a year, avoiding direct sunlight into the telescope. K2 gave Kepler the chance to complete all six original goals set for the mission, proving that space exploration could be done "Faster, Better, Cheaper" as the founder of the Discovery Program had said. The primary goal to "explore the structure and diversity of extrasolar planetary systems" (Gould, 2017) was achieved through observation of a large sample of stars. The original Kepler mission found 4,496 candidate exoplanets, 2,316 confirmed exoplanets and 30 exoplanets with a volume less than 2 Earths within the habitable zone. Likewise, K2 discovered 741 candidate exoplanets and 307 confirmed exoplanets. These discoveries, however, were not without controversy.

Throughout the course of the mission, many of the public became convinced the scientists were withholding information. The key scientific data was withheld in favour of giving the team of scientists a few-month extension on the publishing of their data. This frustrated many people, as they wanted the data immediately. Our team at Cosmos believe that the choice was smart, as extra time to analyse the data meant less false hope and more accurate analysis, and most reputable scientists didn't feel the need to raise the issue either.

The sheer volume of discoveries made by the Kepler mission meant it was inevitable that it would make it into the mainstream news. Many of Kepler's discoveries did so, and in a vastly more positive light than the previous controversies would lead you to believe. In December 2010, Kepler data was added to a citizen science project known as Planet Hunters on zooniverse.org. Projects such as these give the public an opportunity to engage in science, and approx. 300,000 people tried their hand at analysing the data. This raised excitement over scientific discovery and hype over the mission. April 2017 saw the launch of a similar program for K2, labelled Exoplanet Explorers, where the system K2-128 was discovered on the second day, speeding up the rate at which astrophysicists could analyse the data with the help of 19,000 hands. The quicker analysis of scientific data has led to a rapid rise in the popularity of similar citizen science projects over the last five to ten years and is what makes these programs so appealing to scientists, such as the Kepler team. However, there will always be those who believe our money is wasted in space, and we have more pressing problems to worry over on Earth before turning outwards. Luckily for Kepler, these were the minority and the public were keen to support discoveries.

Kepler was such a successful mission, it is being followed up with the launch of TESS later this year. The scientific data, new techniques, and mission life that was achieved from such a low-budget mission is blazing a trail for the future of space exploration, a future that the wider public will want to be a part of. Kepler wasn't without flaws, but the mission as a whole is considered to be a great success. With the standards set high, it is safe to say that TESS has a lot to live up to from launch in April 2018, and our team here at Cosmos is sure to be watching.

Fly high, TESS.

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