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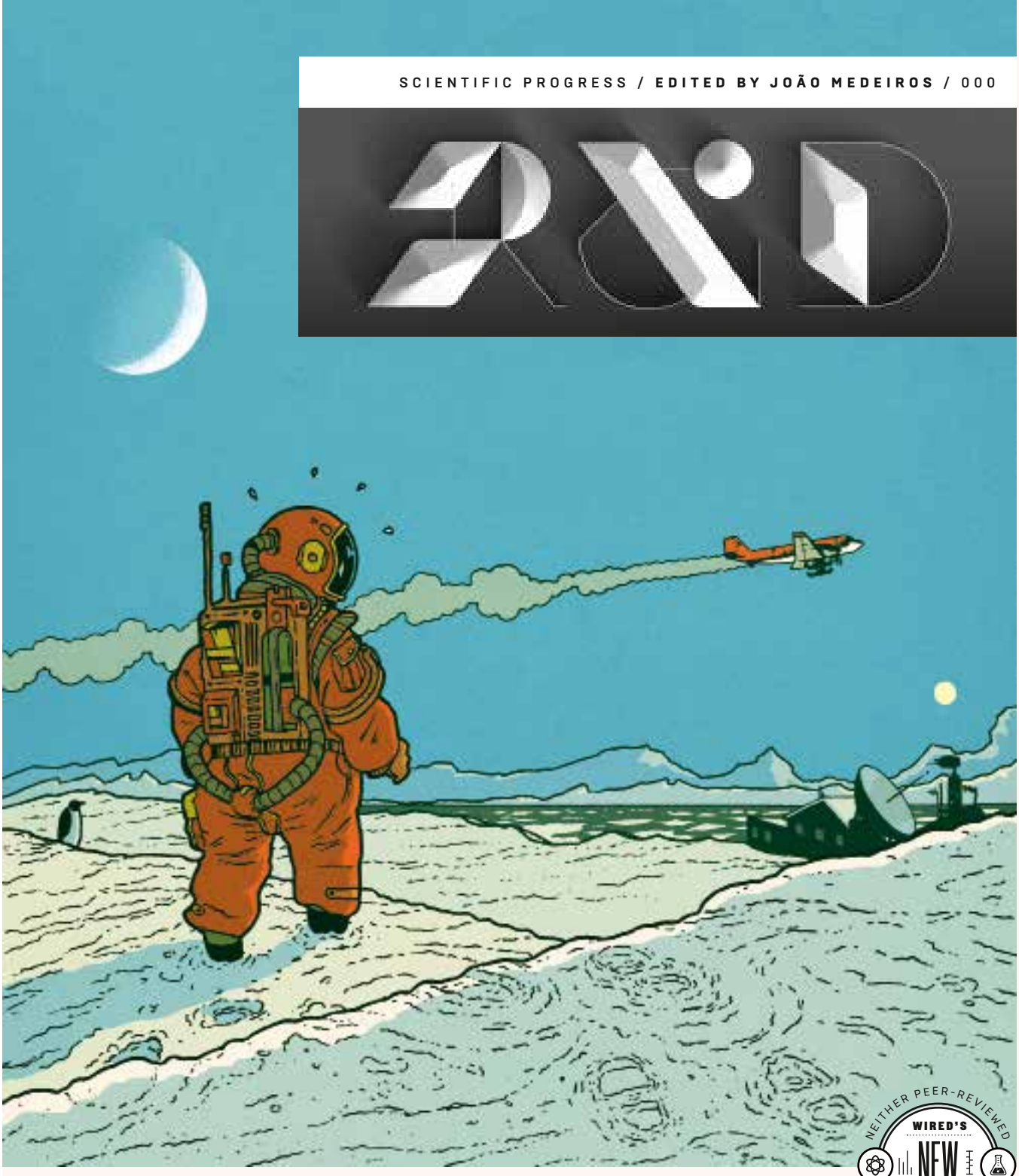

NEITHER PEER-REVIEWED WIRED'S NEW SCIENCE SECTION NOR REPLICABLE*

* BUT WITH FOOTNOTES. ILLUSTRATION: ROBERT G FRESSON

OFF-PLANET PSYCHOLOGY

THE INNER-SPACE EXPLORER

Alexander Kumar is helping scientists prepare for life on Mars – by observing their psychological decline in the loneliest place on Earth. By Nayanah Siva

IN FEBRUARY 2012, A VINTAGE DC-3 BALSER AEROPLANE TOOK OFF FROM AN ICY RUNWAY IN ANTARCTICA, NOT to return for nine months. The drone of the plane's engines faded into the cold winter sky, leaving a crew of 13 behind on the ice, including meteorologists, glaciologists, climatologists and astronomers. They were at the coldest point on Earth, where temperatures drop to -80° Celsius, and winter consists of three months of darkness. Their destination: a French-Italian research lab, Concordia Station, which would be home to them for a year. >

To one of the scientists, British medical doctor and explorer Alexander Kumar, each breath felt like the air was being ripped from his lungs[1]. Sixteen thousand kilometres from home, he trudged to the station with his new housemates, wondering what might to get him first: the severe cold and hypoxic conditions, or the deep isolation? But that was the point of his "White Mars" study for the European Space Agency (ESA).

"You can go mad there. People go off the charts," Kumar says. He splits his time between the University of Leicester, where he undertakes clinical and research work in infectious diseases, and the University of Fribourg, Switzerland, where he is completing his PhD on extreme physiology and psychology.

We hear of the physiological challenges of space travel: bone loss, altered cardiac rhythms, decompression illness, changes in vision. But a lingering worry for space agencies has been astronauts' mental health, which has been known to impact the success of missions. It is rumoured that at least three Russian space missions were terminated due to psychological and interpersonal issues among the crew[2].

Kumar wants to understand how far human physiology and psychology can be pushed under such extreme conditions, in preparation for a future manned mission to Mars. "Physiology we know about – it's easy to predict the effects," he says. "Psychology is fascinating because it's largely unpredictable." According to Kumar, ten per cent of people who winter in Antarctica will develop serious psychiatric problems. His experiments at Concordia built on previous ESA work, which found that despite all the screening, training and preparedness for a mission, the isolation and extreme conditions deeply impacted cognition. Effects include dysfunctional responses to stress, fatigue, lack of energy, conflicts and tensions, perceived loss of control, and decrements in attention and cognitive function[3]. "It is extremely difficult to predict who will not do well there," says Kumar. Choosing people who are good at coping with stress does not seem to make a difference. The symptoms impact anyone and everyone – even Kumar. "You never know what monsters sleep undisturbed in the unexplored corners of your mind," he says.

Choosing people who are good at coping with stress does not seem to make a difference

It's possible to quantify and measure these psychological factors. Some of Kumar's experiments required testing blood, urine and saliva, and wiring the crew up to electroencephalogram machines to assess brain activity as they performed tasks, such as playing brain-teaser games. By doing so, he was able to chart the decline of the crew's mental wellbeing. Effects included difficulty and slowness in concentration, and short-term memory problems.[4] "People do become cognitively impaired during the Antarctic winter, and we would also expect this on a nine-month flight to Mars," Kumar says. "By the time the crew get there, they will have to perform one of the most technologically difficult landings in aviation, space and human history."

In addition, Kumar points to a recent study where actual structural changes in the brain were reported in those who wintered in Antarctica. In a Nasa-sponsored study undertaken at the German Neumayer Antarctic station, Mathias Basner from the University of Pennsylvania and his team performed MRI scans of crew members before, during and after their mission. Surprisingly, they found physical loss of volume to the hippocampus in the brain, which is essential in both memory formation and visual and spatial orientation. "One of the biggest issues people complain about during the winter is specific memory difficulty," Kumar says. The next stage is to perform MRI scans on the current crew at Concordia, due to leave in November and December 2015[5].

Another aspect that was profoundly affected was sleep. Kumar tracked his team's circadian rhythms by measuring levels of cortisol and melatonin in urine and saliva over 24-hour periods. He also noticed a distortion in the crew's perception of time, and assessed oxygen levels and sleep patterns. Nightmares were commonplace, but Kumar says this could be explained with physiology. The altered day-cycle, months of darkness, sensory deprivation and a hypoxic environment all contributed. At times, the crew members' oxygen saturation was dangerously low during sleep, at levels below 83 per cent, compared with 95-100 per cent for someone living at typical altitude. Taking less oxygen may be accompanied by hypercarboxemia, where the level of carbon dioxide in the body is removed less quickly due to the lowered respiratory rate and gas exchange[6]. This rise in CO_2 can impact blood pH and cerebral blood flow, which affects sleep and dreams.

Kumar has been surprised by findings that quantitatively showed that the detrimental effects of isolation may be more than that of physiological factors such as hypoxia. Psychological stress may impact the brain as much as, if not more than, physiological. As he wrote on his *New York Times* blog: "Living in isolation, exacerbated by sensory deprivation, I have often woken feeling exhausted, like I had already lived the day ahead, having spent the night on a nerve-racking, adrenaline-fuelled rocking horse adventure in a desert or jungle, surviving one of Antarctica's many conjured nightmares."

1. alexanderkumar.com/dr-kumar-i-presume
2. thespacereview.com/article/2683/1
3. researchgate.net/publication/275517326
4. scientistatwork.blogs.nytimes.com/2012/09/06/lost-in-time-in-the-antarctic-ice-age
5. radionz.co.nz/national/programmes/ourchangingworld/audio/201777175/mars-mission-a-mental-journey
6. scientistatwork.blogs.nytimes.com/2012/08/06/in-antarctica-dreaming-of-mars

SETI'S SEARCH FOR LIFE

Each month we illustrate today's pioneering projects.
This issue: ***how scientists at the Search for Extra Terrestrial Intelligence (SETI) are seeking evidence of a massive alien megastructure built around a star showing unusual light fluctuations***

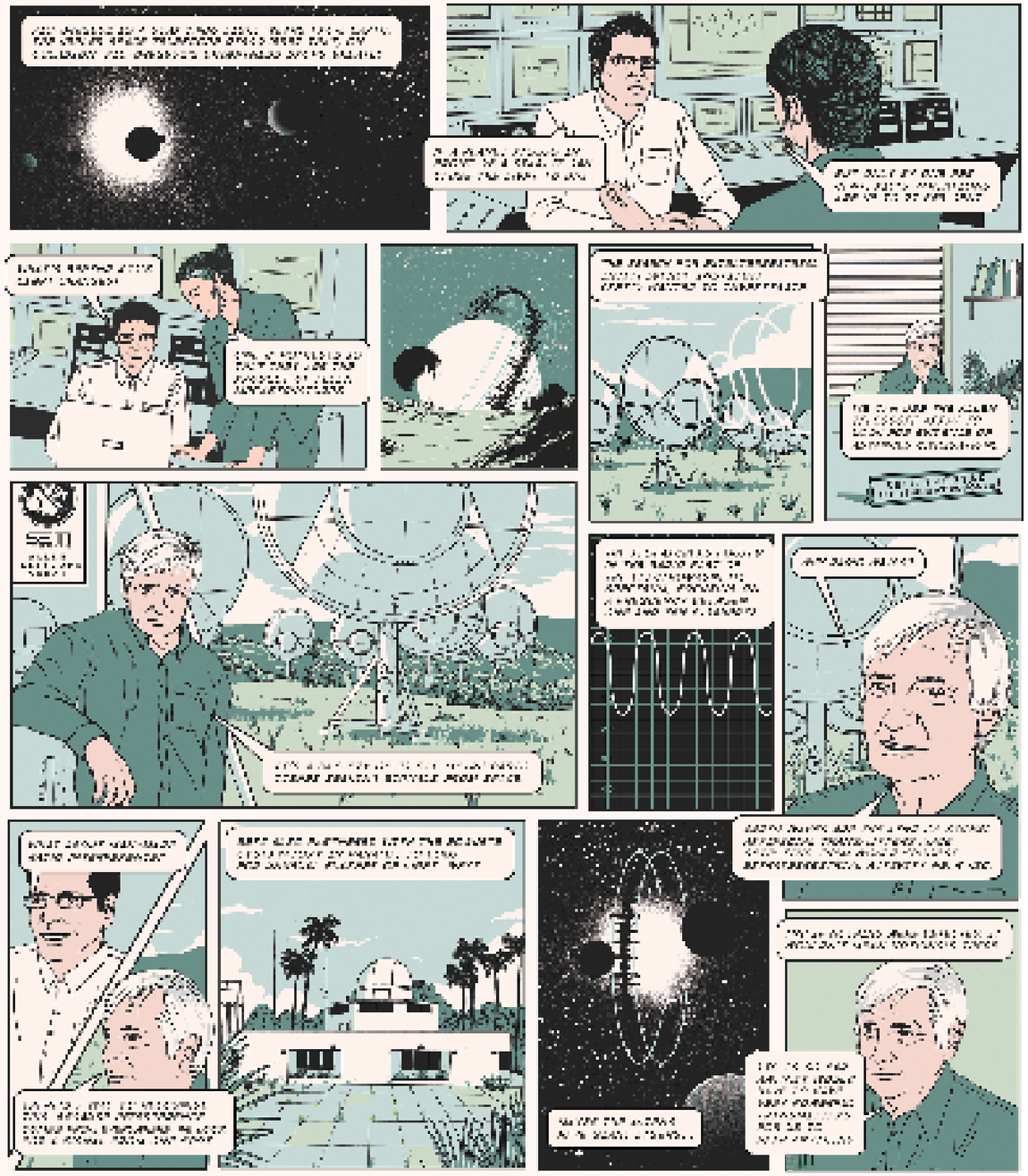

ILLUSTRATION: JOSEPH WILLIAM