

The background of the entire image is an aerial photograph of a rural landscape, characterized by a dense grid of green agricultural fields. Overlaid on this landscape are numerous semi-transparent circles and squares in various shades of green and yellow, creating a complex, abstract pattern. A solid magenta horizontal band runs across the middle of the image, serving as a backdrop for the title and subtitle.

MACRO:

A Metagramme Studio publication
by Matt Steel

A **pinhole camera** is a device that was known to the ancient Greeks and has been put to various uses ever since. A small hole punched in the wall of a box—or a room—creates an inverted image on a screen of whatever object the

camera faces. The pinhole camera, or camera obscura, was used in the Renaissance as a drawing aid. When the screen was replaced by a photographic film, it formed the basis for today's handheld cameras. *continued—*



Boulder, the goal is to use a large-scale camera obscura to obtain the first pictures of exosolar planets—worlds from beyond our solar system.

Now, a project funded by NASA's Institute for Advanced Concepts (NIAC) could launch the humble pinhole camera into the sky. Dubbed the New Worlds Imager (NWI) and led by Dr. Webster Cash of the University of Colorado at

fund studies of “revolutionary aeronautical and space concepts” that could form the basis of NASA missions in 10 to 40 years.

It sounds far-fetched, but that’s what the NIAC is for. Formed in 1998 and operated by the Universities Space Research Association, the NIAC exists to



HOW CAN A PERSON STAND APART FROM THE CROWD
IF THEY DON’T KNOW WHO THEY ARE?



HOW COULD COPERNICUS, GALILEO, AND NEWTON HAVE REVOLUTIONIZED SCIENCE
WITHOUT STUDYING THE COSMOS AS THE SUM OF ITS PARTS?

The basic building block of the New Worlds Imager is a pair of spacecraft, a starshade and a collector, that function together as a single pinhole camera. The starshade serves as the pinhole for the camera, though the entire shade will be a kilometer (0.6 miles) or more in diameter, with a hole about 10 meters (10 yards) across punched in the center. The collector holds a telescope with a primary mirror the same size as the pinhole: 10 meters.

Moon. Two starshade-collector pairs, their images combined in a central combiner spacecraft, form the New Worlds Imager.

To guarantee the best images, the starshade and collector need to be separated by about 200,000 km, or about half the distance from the Earth to the



TO RISE ABOVE THE NOISY CROWD,
WE HAVE TO STEP BACK.



WAY BACK.

If studies demonstrate its feasibility and NASA approves the mission, the New Worlds Imager could truly change our view of the universe. "I've always thought the most interesting things an astronomer could do would be to take

a picture of a black hole, and to take a picture of an exosolar planet," says Dr. Cash, grinning. "Our ability to look out to 10 parsecs (32.62 light-years, 185 trillion miles or 296 trillion km) means we have about 1,000 stars to search

for Earth-like planets, so we have a **good chance of finding one.**"

He goes on to explain that one of the main problems of looking for exosolar planets is that the star the planet orbits is very bright compared to the planet, and its light often drowns out light from the planet we want to see.



IN SPACE ALL IS QUIET,



PERSPECTIVE IS GAINED

making it bigger, Dr. Cash hopes to accomplish the same effect, but without the tight constraints on telescope and occulter quality that TPF has.

Terrestrial Planet Finder (TPF), a fully-funded NASA mission to search for planets orbiting nearby stars, will use a small occulter—a solid disk—to block out the light from the parent star. By placing a pinhole outside the telescope and

If NWI identified a system as possessing planets in the habitable zone—a band around a star in which planets are likely to have liquid water, and therefore possibly life—the Imager would pause its general survey to take a closer look at the planets it found. NWI’s spectrometer would analyze the planet’s atmosphere, looking for water vapor, carbon dioxide, and oxygen. “Did you know,” Dr. Cash remarks, “if all plant life on Earth were to die out, and you came



AND THE UNIVERSE BECOMES DISTILLED



INTO A COLLECTION
OF GLOBES, DUST AND VAPOR.

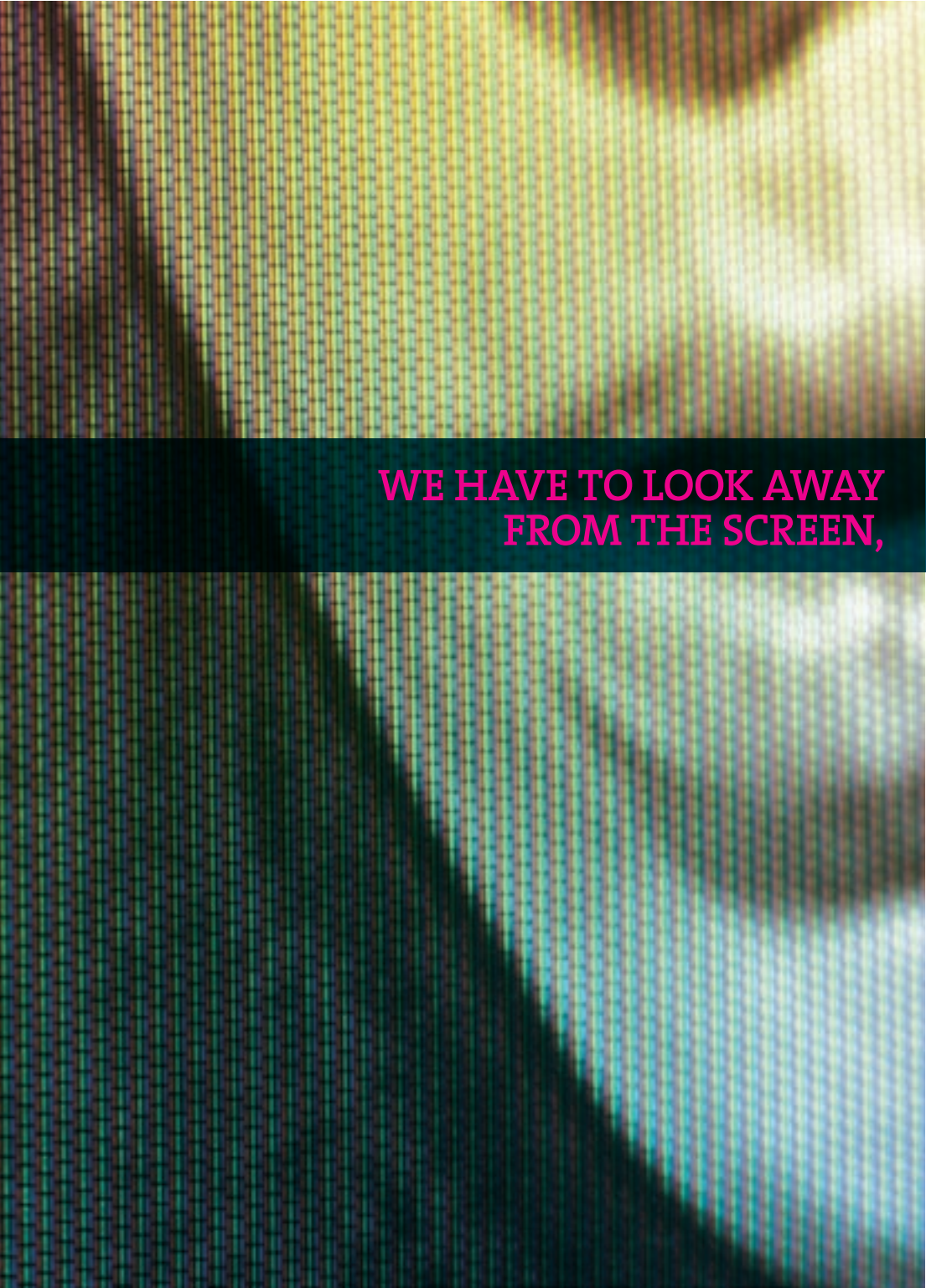
back a million years later, all the free (atmospheric) oxygen would be gone, absorbed back into the rocks?” Thus, if the NWI were to find both free oxygen and evidence of water on a planet, says Dr. Cash, “that planet would be a prime candidate for harboring plant life, or the alien equivalent of our plants.”

kilometers (60 miles) across, New Worlds Imager should be able to see clouds, continents, and oceans, giving us the first true pictures of a planet far from our own solar system. Not bad for the old pinhole camera.

Finally, the NWI would swing into imager mode, the two collector spacecraft executing a complicated dance around the combiner craft to build up an image of another world. With the ability to resolve distant objects about 100



TO GAIN PERSPECTIVE,



WE HAVE TO LOOK AWAY FROM THE SCREEN,

Why use the low-tech camera obscura to conduct such cutting-edge science? Dr. Cash has a simple answer: "A pinhole is a perfect lens," he says, "It creates

zero distortion in the wavefront, and has no dust or cleanliness issues."

With impeccable planning, a series of camps were set up and the expedition route pushed forward up the mountain. They pushed beyond the Swiss high point of the previous year to surmount the South Summit, at 28,750 feet, less

than 300 feet from the summit proper. Unfortunately, one of their oxygen sets was not functioning properly and, bitterly disappointed, they were forced to abort their attempt.

OUT THE WINDOW

AND THROUGH THE CLOUDS.

to drink what they could to prevent dehydration and their little cooker was started up to melt ice for water.

An additional high camp was set up above the South Col at 27,900 feet, where the pair spent a fitful night, waiting for dawn. Before first light on the 28th of May the long process of getting warmed up and ready began. It was important

Hillary's boots were frozen and he sought to thaw them out over the little flame. Way down in the darkness the lights of Tengboche Monastery could be seen, where they knew the monks would already be making offerings for their safety. By 6:30 a.m. they were dressed warmly in their down suits and crawled out into the new day, hoisted their oxygen sets onto their shoulders and started kicking steps towards the main ridge and the wash of sunlight.



WHEN YOU SEE THE BIG PICTURE,



YOU CAN TRULY KNOW YOURSELF.

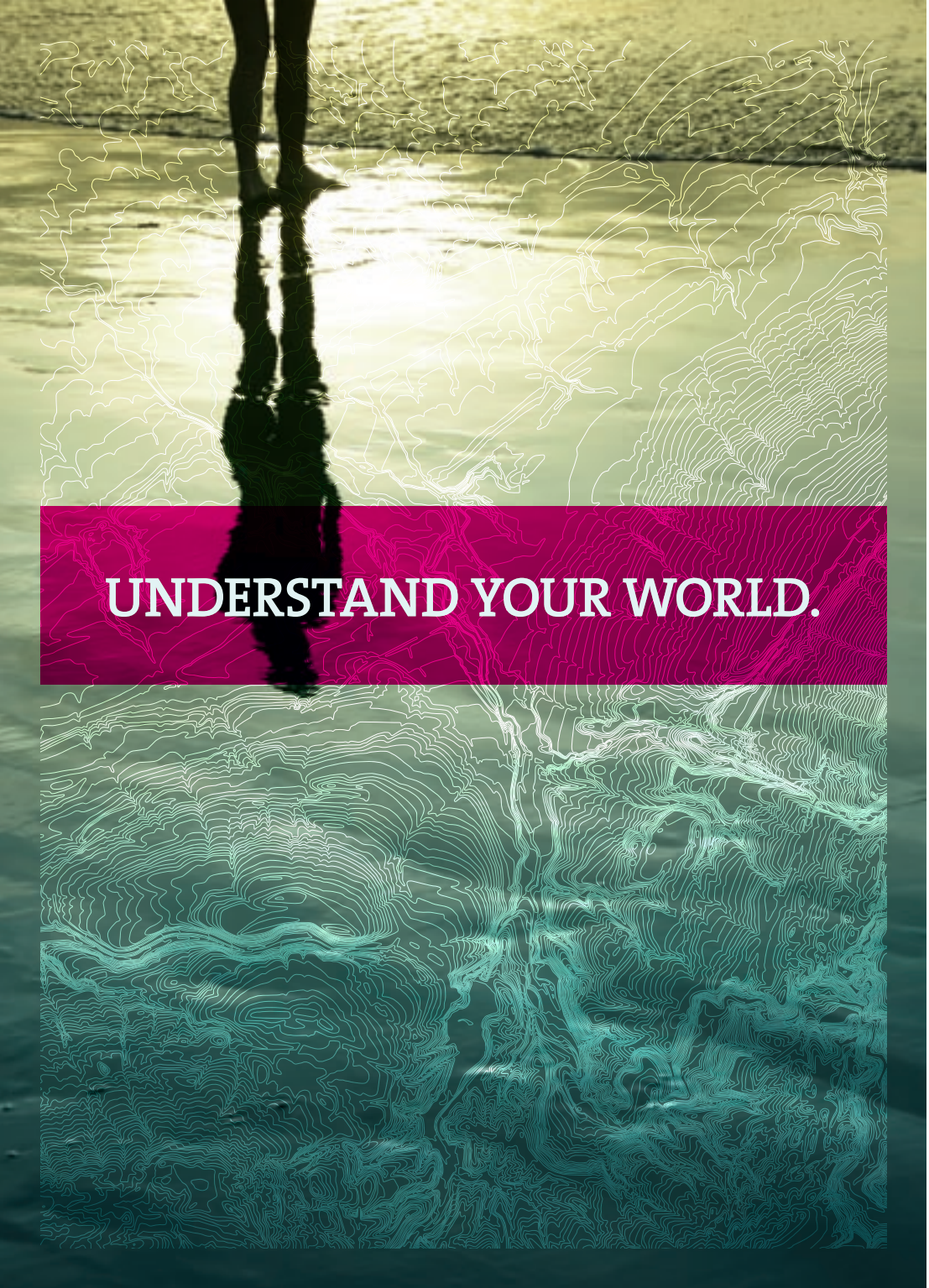
Snow conditions were not good and in places the southeast ridge narrowed to a knife-edge, but they plodded on slowly and gained the South Summit by 9 a.m. The looping ridge ahead was weighed down with heavy snow cornices overhanging the frightfully steep East, or Kangshung Face. They took stock of how much oxygen was remaining, and then Hillary led a tricky and difficult path, avoiding the cornices on one side and steep slopes on the other.

After an hour's steady going they came to a steep rocky step, some forty feet high. They had known of this in advance from aerial photographs, but did not know whether it could be surmounted. Luckily, Hillary found a crack into

which he was able to partly jam his body and wriggle his way upwards. The obstacle is still called the Hillary Step today.



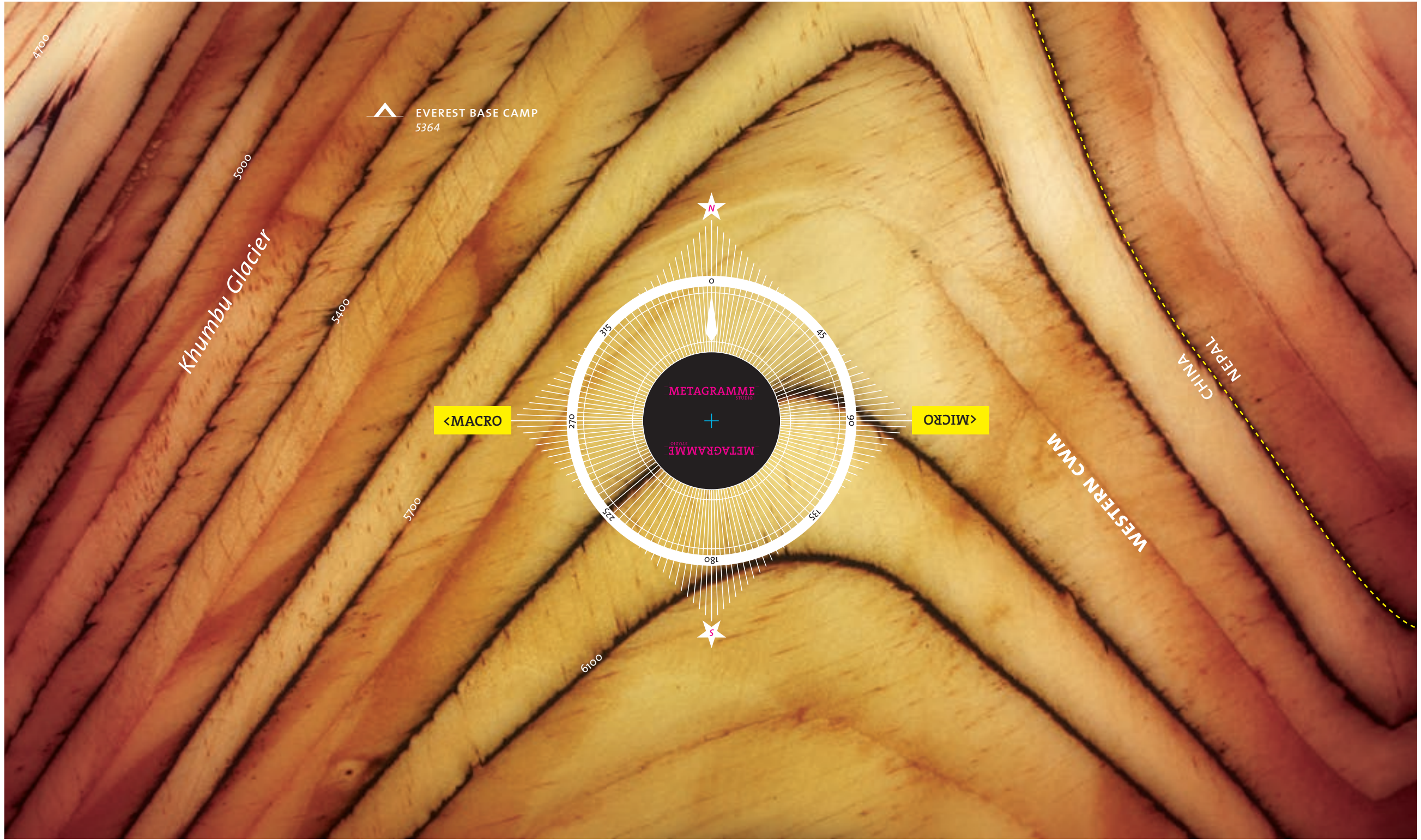
MOVE THE CROWD.



UNDERSTAND YOUR WORLD.

more whacks of the ice axe in the firm snow, and we stood on top, 'Hillary described later. It was 11.:30 a.m. and the highest point on earth had at last been trodden by man.

Tenzing followed up behind, and the pair continued their switchback progress along the summit ridge until finally they saw they had passed the last corner. Ahead of them lay only a snowy dome and the vast plateau of Tibet. A few



<MACRO

>MICRO

The background of the entire page is a microscopic view of a textured surface, possibly a liquid or a mineral, with a color gradient from dark teal on the left to light cyan on the right. A horizontal band of solid magenta color runs across the middle of the image, partially obscuring the background texture. The word "MICRO:" is printed in large, white, serif capital letters across the right side of this magenta band.

MICRO:

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For all the diversity of the world's five and a half billion people, full of creativity and contradictions, the machinery of every human mind and body is built and run with fewer than 100,000 kinds of protein molecules. And for each of

these proteins, we can imagine a single corresponding gene (though there is sometimes some redundancy) whose job it is to ensure an adequate and timely supply.

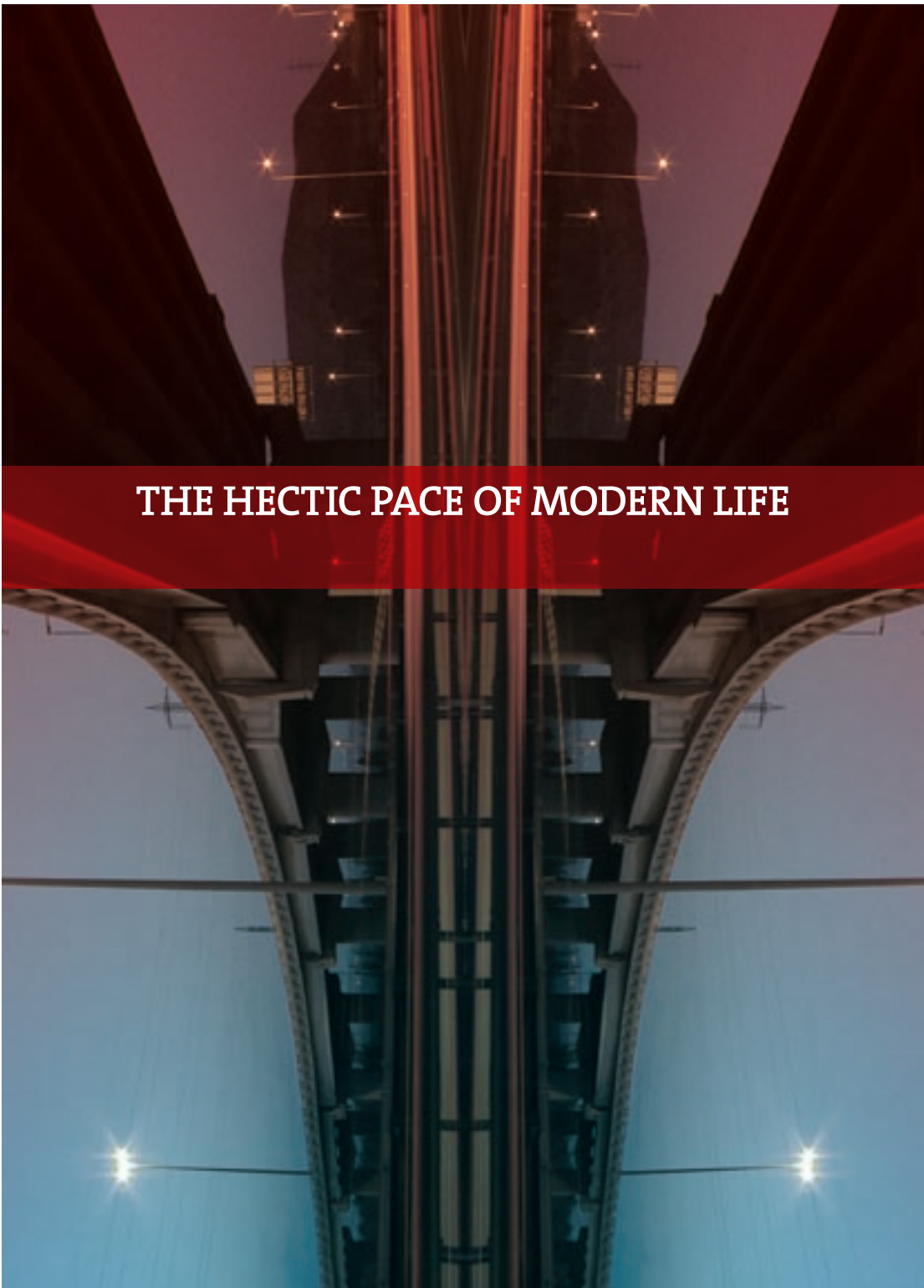
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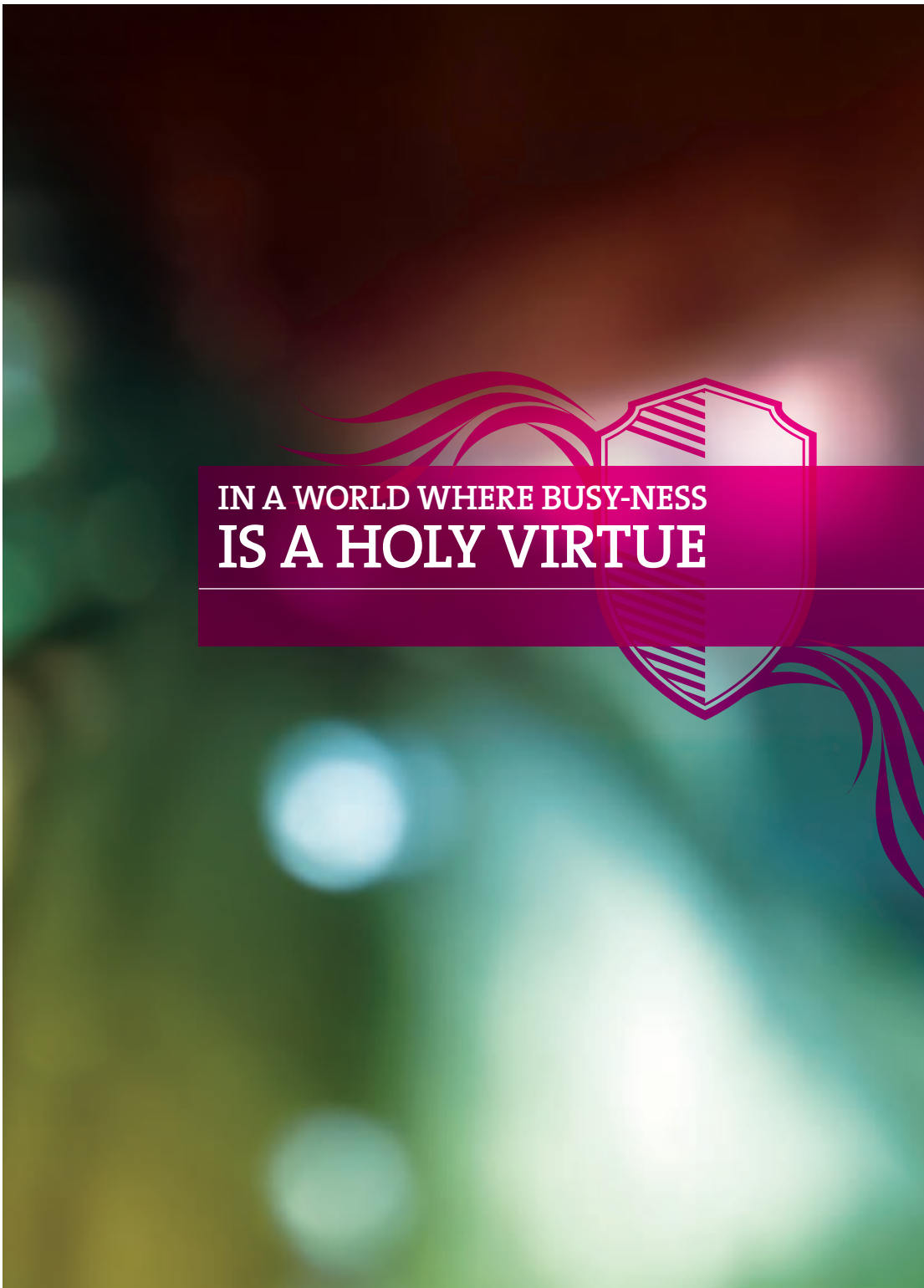
In a material sense, then, all of the subtlety of our species, all of our art and science, is ultimately accounted for by a surprisingly small set of discrete genetic instructions. More surprising still, the differences between two unrelated individuals, between the man next door and Mozart, may reflect a mere handful of differences in their genomic recipes—perhaps one altered word in five hundred.

We are far more alike than we are different. At the same time, there is room for near-infinite variety.

It is no overstatement to say that to decode our 30,000 genes in some fundamental way would be an epochal step toward unraveling the manifold mysteries of life.



THE HECTIC PACE OF MODERN LIFE

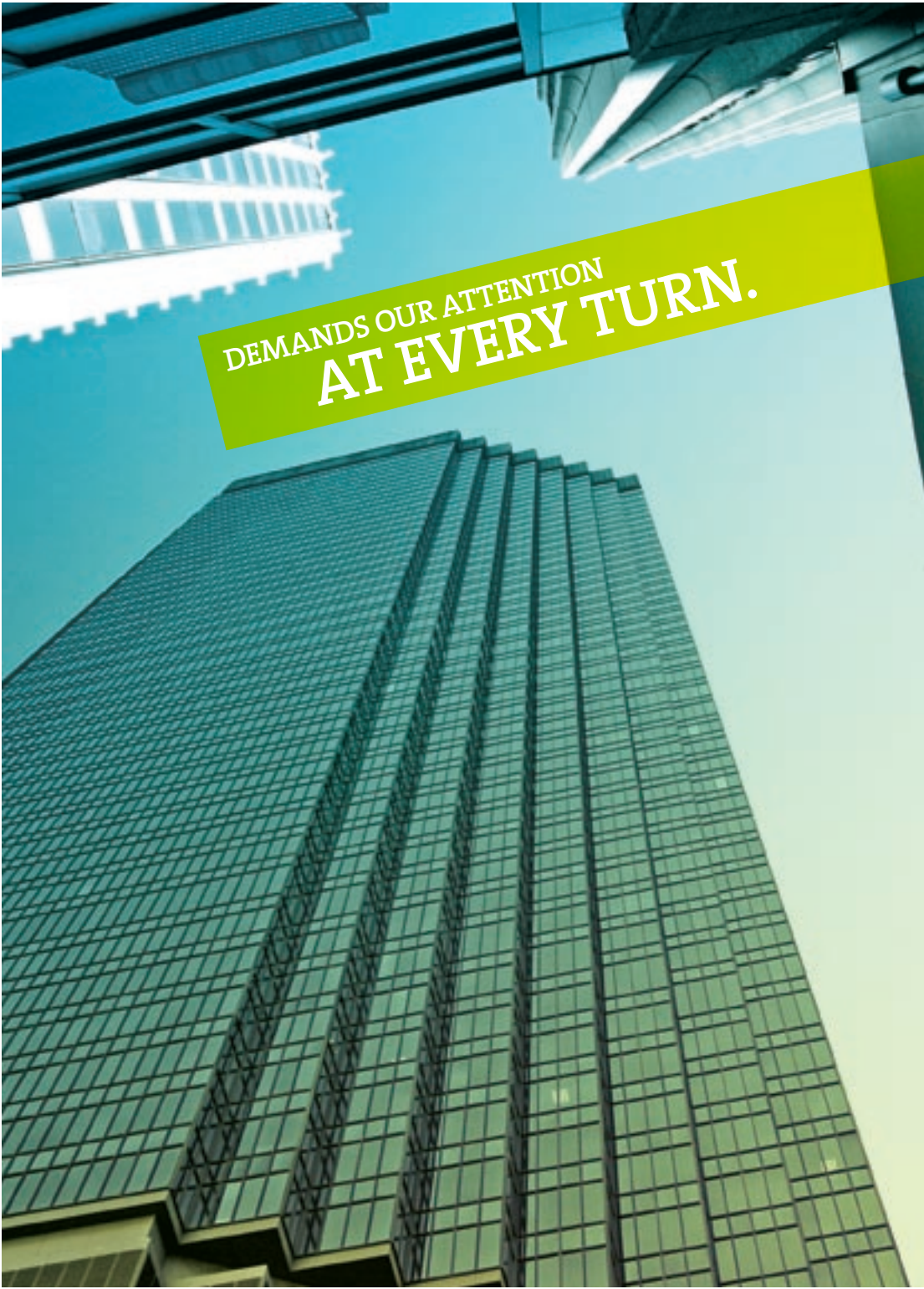


IN A WORLD WHERE BUSY-NESS IS A HOLY VIRTUE

ferent kinds of genome maps, the variety of which is suggested in Genomic geography. One type, a genetic linkage map, is based on careful analyses of human inheritance patterns.

One of the central goals of the Human Genome Project is to produce a detailed "map" of the human genome. But, just as there are topographic maps and political maps of the United States, so there are dif-

It indicates for each chromosome the whereabouts of genes or other “heritable markers,” with distances measured in centimorgans, a measure of recombination frequency. During the formation of sperm and egg cells, a process of genetic recombination—or “crossing over”—occurs in which pieces of genetic material are swapped between paired chromosomes. This process of chromosomal scrambling accounts for the differences invariably seen



DEMANDS OUR ATTENTION
AT EVERY TURN.



IT CAN BE DIFFICULT
TO SEE THE TREES

even in siblings (apart from identical twins). Logically, the closer two genes are to each other on a single chromosome, the less likely they are to get split up during genetic recombination. When they are close enough that the chances of being separated are only one in a hundred, they are said to be separated by a distance of one centimorgan.

pin down the relative positions of these genetic markers. By the end of 1994, a comprehensive map was available that included more than 5800 such markers, including genes implicated in cystic fibrosis, myotonic dystrophy,

The role of human pedigrees now becomes clear. By studying family trees and tracing the inheritance of diseases and physical traits, or even unique segments of DNA identifiable only in the laboratory, geneticists can begin to



FOR THE FOREST.



IF ALL OF US COULD SEE

Huntington disease, Tay-Sachs disease, several cancers, and many other maladies. The average gap between markers was about 0.7 centimorgan.

Whereas the issues raised by modern genome research are among the most challenging we face, they are not unprecedented. Issues of privacy, knotty questions of how knowledge is to be commercialized, problems of dealing

balance that must be sought. Accordingly, further study is needed, as well as continuing efforts to promote public awareness and understanding, as we strive to define policies for the intelligent use of the profound knowledge

with probabilistic risks, and the imperatives of education have all been confronted before. As usual, defensible perspectives and reasonable arguments, even precious rights, exist on opposing sides of every issue. It is a

THE TEXTURE, DETAIL, PURE FORM,
AND VISUAL CLUES

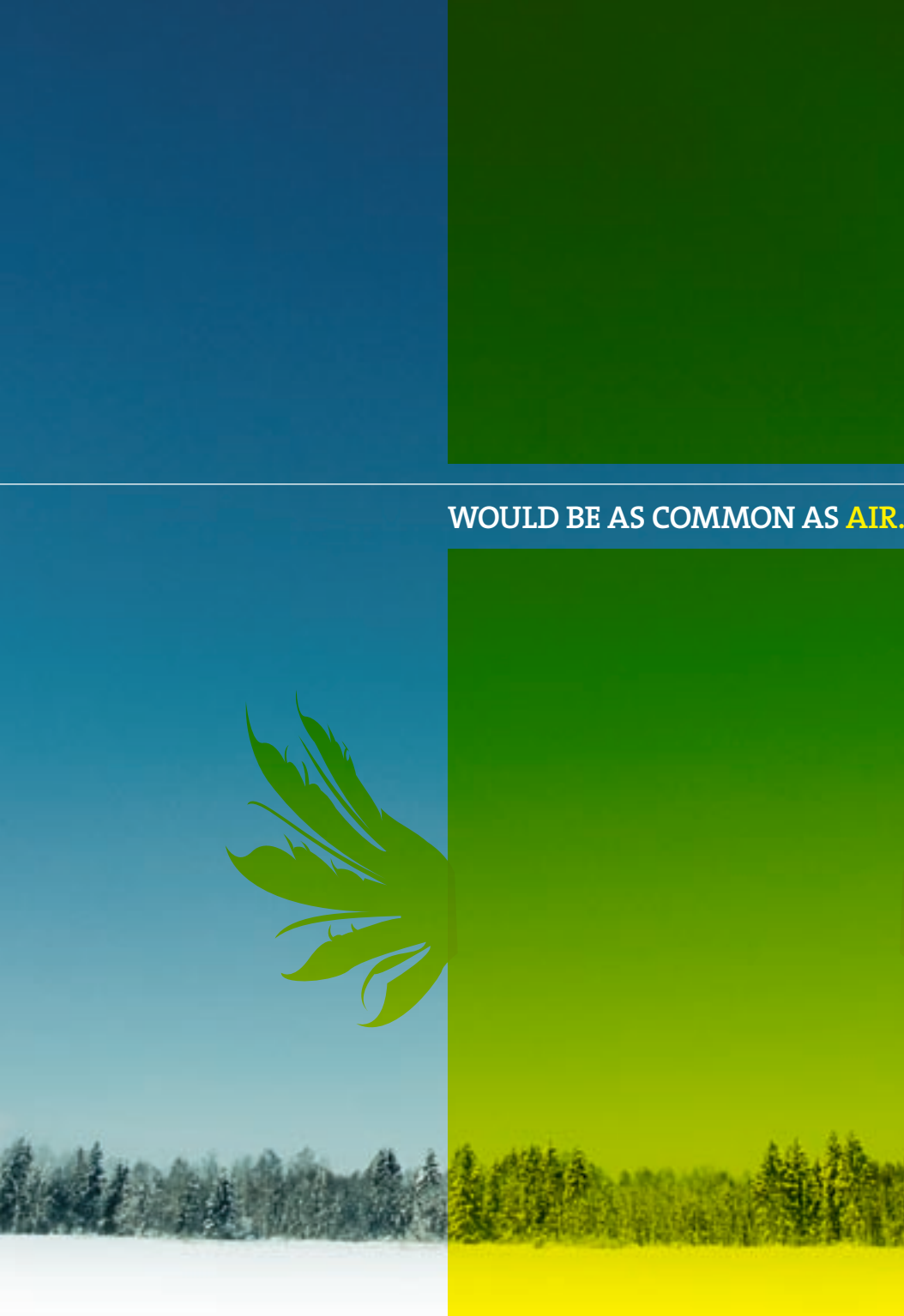
we seek to uncover about ourselves.

IN THE WORLD THAT SURROUNDS US,

The Age of Discovery was an era when European civilization reached out to the Far East and thus filled many of the voids in its map of the world. But in a larger sense, we have never ceased from our exploration and discovery.

Science has been unstinting over the ages in its efforts to complete our intellectual picture of the universe. In this century, our explorations have extended from the subatomic to the cosmic, as we have mapped the heavens

to their farthest reaches and charted the properties of the most fleeting elementary particles. Nor have we neglected to look inward, seeking, as it were, to define the topography of the human body. Beginning with the first modern

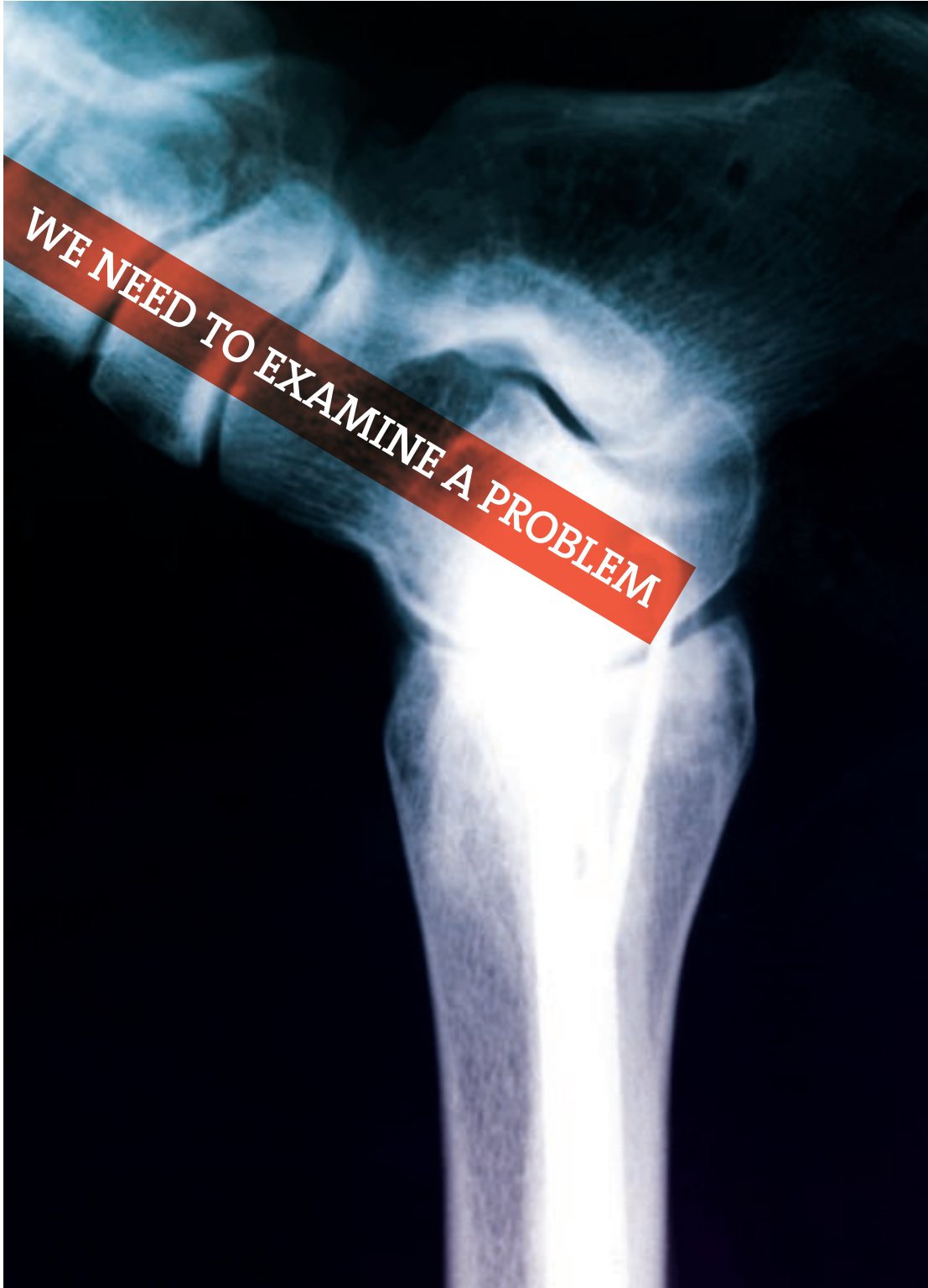


voyage that will bring us to a profound understanding of human biology.

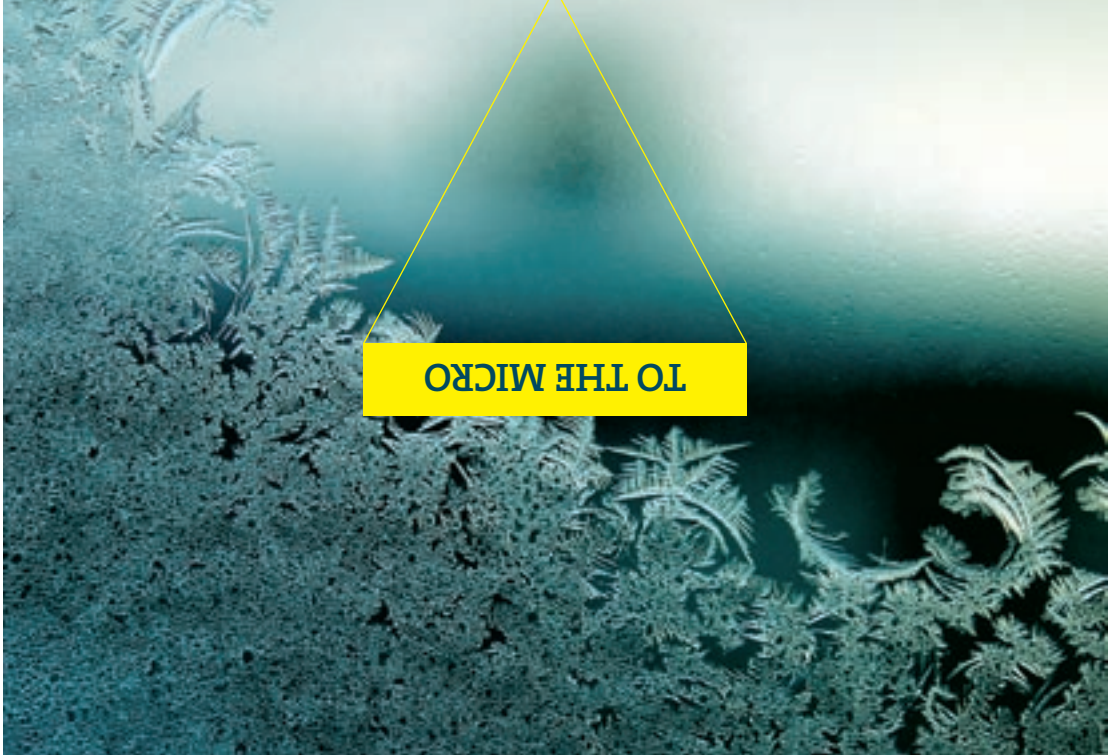
anatomical studies in the sixteenth century, we have added dramatically to our picture of human anatomy, physiology, and biochemistry. The Human Genome Project is thus the next stage in an epic voyage of discovery—a

In an important way, though, the genome project is very different from many of our exploratory adventures. It is spurred by a conviction of practical value, a certainty that human benefits will follow in the wake of success. The prod-

uct of the Human Genome Project will be an enormously rich biological database, the key to tracking down every human gene — and thus to unveiling, and eventually to subverting, the causes of thousands of human diseases.



WE NEED TO EXAMINE A PROBLEM



TO THE MICRO



FROM THE MACRO

It has further been said that the Human Genome Project is guaranteed to succeed: Its goal is nothing more assuming than a sequence of three billion characters. And we have a very good idea of how to read those characters.

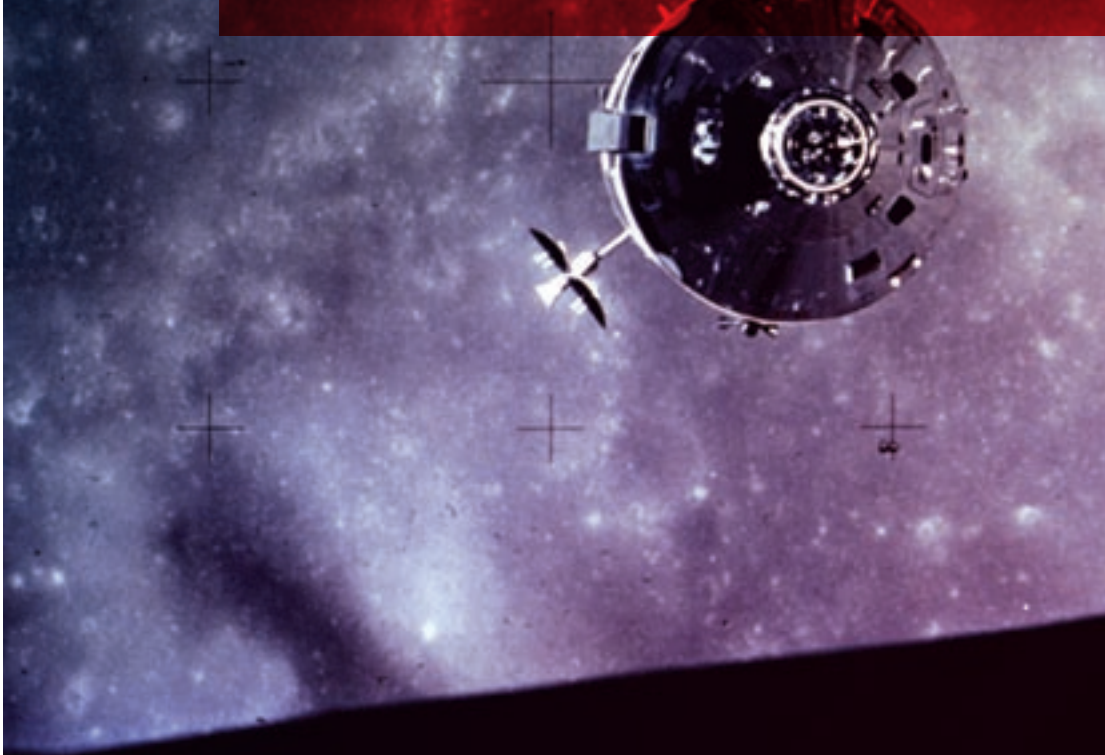
The sequence of our genome will ultimately allow us to unlock the secrets of life's processes, the biochemical underpinnings of our senses and our memory, our development and our aging, our similarities and our differences.

Unlike perilous voyages or searches for unknown subatomic particles, this venture is assured of its goal. But beyond a detailed picture of human DNA, no one can predict the form success will take. The genome project itself offers

no promises of cancer cures or quick fixes for Alzheimer's disease, no detailed understanding of genius or schizophrenia. But if we are ever to uncover the mysteries of carcinogenesis, if we are ever to know how biochemistry



IN ORDER TO CREATE SYSTEMS
AND TRANSLATE MEANING.



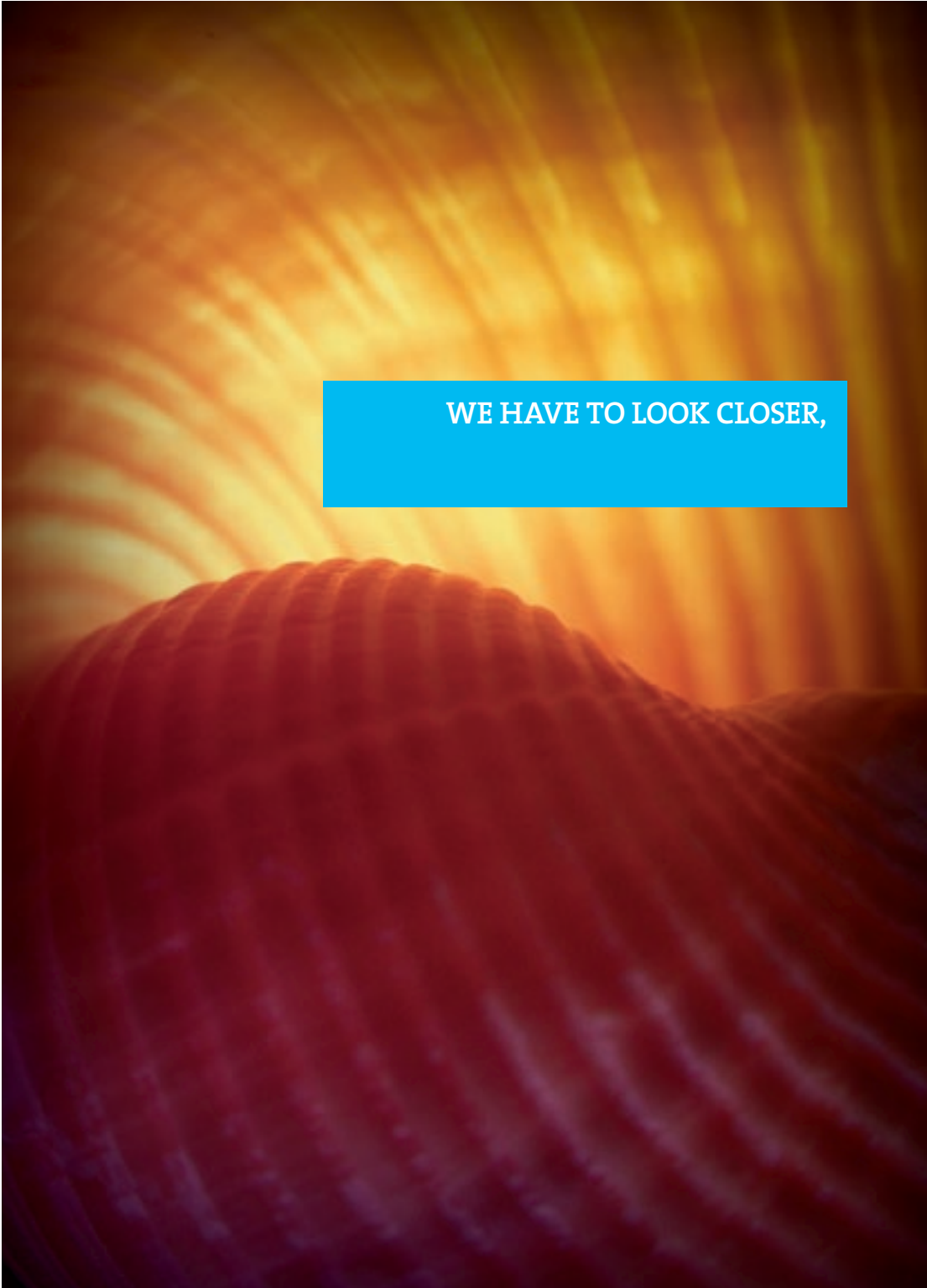
TO UNDERSTAND THE BIG PICTURE,

contributes to mental illness and dementia, if we ever hope to really understand the processes of growth and development, we must first have a detailed map of the genetic landscape. That's what the Human Genome Project promises. In a way, it's a rather prosaic step, but what lies beyond is breathtaking.

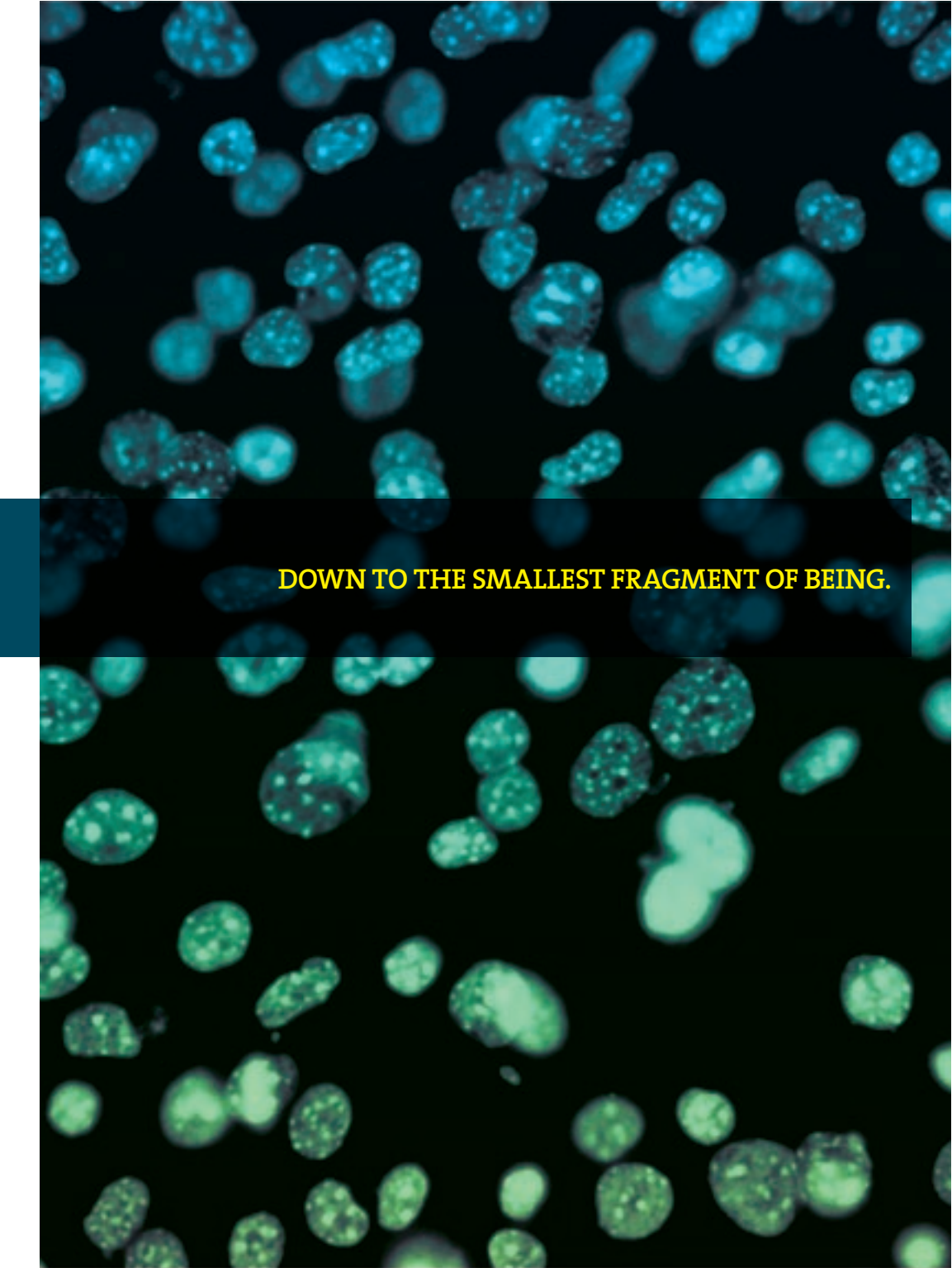
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WE HAVE TO LOOK CLOSER,



DOWN TO THE SMALLEST FRAGMENT OF BEING.

This book is dedicated to Siri Nadler for inspiring me, and to Gregg Stein for firing me.
The typeface used in this book is Thesis, by Luc(as) DeGroot, 1994.
Printing by Top Graphics, Hazelwood, MO.
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