procollagen secretion[6,7]. TANGO1, however, does not make contact with SEC31 directly, nor is it found in fully formed vesicles, and so its possible connection to CUL3–KLHL12 is unclear.

Other questions remain. Does collagen become entirely encapsulated in a large COPII cage during vesicle formation (Fig. 1b), or does COPII somehow aid collagen export indirectly, without the need for a complete cage? And how does the addition of ubiquitin change the geometry of the COPII coat? Jin and colleagues' findings[2] might aid the development of a cell-free system for studying COPII-dependent packaging of collagen that would help to address these issues. Moreover, is SEC31 ubiquitination relevant to the packaging of other large secreted macromolecules, such as lipoproteins?

These questions are relevant to our understanding not only of the fundamental mechanisms of cellular secretion, but also of diseases in which secretion (particularly of collagen) is defective because of gene mutation[8]. Furthermore, manipulation of the CUL3–KLHL12 ubiquitination pathway might be used to increase collagen secretion from cells for applications in stem-cell culture, for growth of tissue components in regenerative medicine, or for perhaps for ameliorating age-related degeneration of connective tissue. ■

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ASTROPHYSICS

First results from Planck observatory

Early data from the Planck space satellite provide information about dust in distant galaxies, as well as in the Milky Way, and on the properties of gas in some of the largest clusters of galaxies in the Universe.

UROŠ SELJAK

Astronomers have long known[1] that most of the stars in the Universe are born in messy environments containing dusty clouds. Young stars in such dust-enshrouded regions are not visible to optical telescopes; thus, multi-wavelength studies, from the radio to the X-ray regime, are used to better understand how stars form in our Galaxy. But for more distant galaxies, including some of the first galaxies in the Universe, such dusty expanses are essentially invisible across most wavelengths. One exception is the wavelengths in the far-infrared and microwave regimes, which are roughly 1,000 times longer than those of visible light. Stars heat up the dust surrounding them to temperatures of roughly 20 kelvin — much lower than that of the stars themselves, but nevertheless high enough for the dust to radiate microwave and far-infrared light. This warm-dust signature, called the cosmic infrared background, has now been observed[2] by a large team of astronomers working with data from the Planck space observatory. The results are part of a series of studies that form a collection of 26 papers, published by the Planck team in *Astronomy & Astrophysics* (see go.nature.com/au8vap).

The Planck satellite's measurement of the cosmic infrared background[2] improves on previous measurements, including data[3] obtained by Herschel, a twin observatory to Planck launched by the European Space Agency aboard the same rocket in 2009. The rocket carried them to the Earth–Sun Lagrangian point L2 (1.5 million kilometres from Earth in the opposite direction from the Sun), where the satellites can be stationary relative to both the Sun and Earth, allowing for shielding from the Sun's radiation.

Planck detects microwave light in several wavelength bands in which the warm-dust emission can be observed (Fig. 1). Because the Universe is expanding and the wavelength of light stretches with the expansion, the light that we observe has a longer wavelength than it

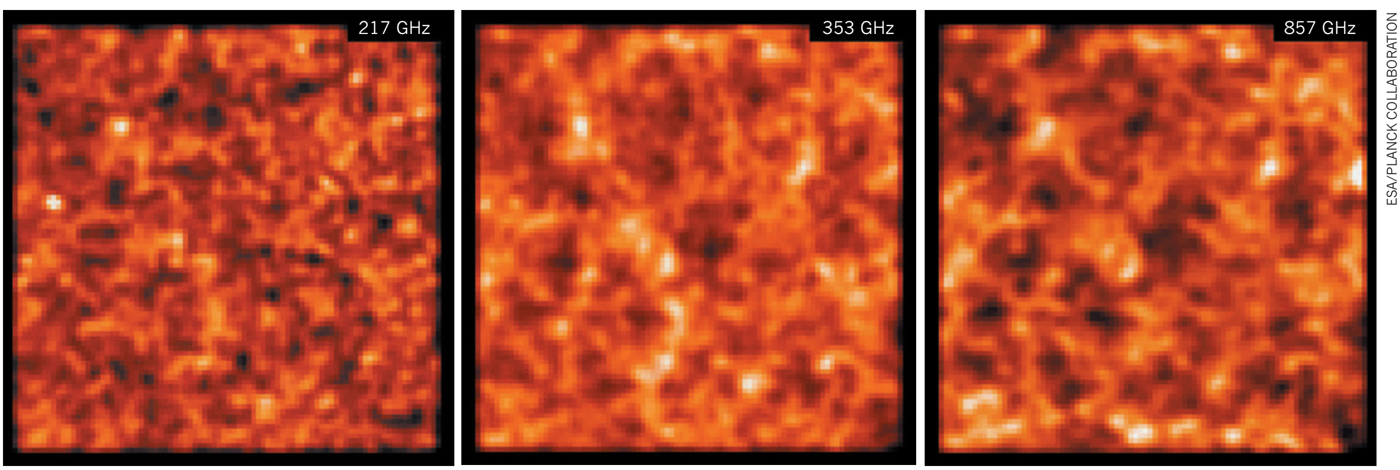

Figure 1 | The cosmic infrared background. The images show the anisotropies, or irregularities, of the cosmic infrared background in three of the frequency channels (217 gigahertz, 353 GHz and 857 GHz) probed by the Planck observatory[2] over a 26° × 26° patch of the sky. The anisotropies are visible as globular structures and correspond to dusty galaxies clumped together on large scales. As we move across frequency channels, different epochs of cosmic time become visible: observations at 217 GHz offer a glimpse of some of the oldest galaxies in the Universe, which formed when the Universe was less than 2 billion years old.

FLUID MECHANICS

Mist opportunities


C. DUPRAT & S. PROTIÈRE

From the fixative properties of hairsprays to the stickiness of filaments on beetles' feet, the wetting of flexible fibres with droplets of liquid is a universal phenomenon — but one we know surprisingly little about. On page 510 of this issue, Duprat *et al*. formulate rules to describe how mists of droplets interact with flexible fibre arrays (C. Duprat, S. Protière, A. Y. Beebe & H. A. Stone *Nature* **482,** 510–513; 2012).

The researchers began with the simplest possible model: the interactions of water droplets with a pair of closely aligned, flexible glass fibres that were clamped at one end but free to bend at the other. They observed that a droplet deposited close to the clamped ends adopts one of three forms: it could remain as a tight, spherical bridge between the filaments, or, depending on the conditions, it could either partially or completely spread along the fibres, in the latter case causing them to coalesce.

On further investigation, Duprat *et al*. found that six physical parameters control droplet shape and spreading; they include fibre geometry, the distance between the fibres, and the fibres' mechanical properties. The authors also identified a critical droplet volume above which fibres do not coalesce, and a second critical volume at which droplet capture by fibres is maximized.

The team went on to explore the wetting of a natural fibre array by spraying a goose feather with oil droplets and observing the effects on the barbules (filaments projecting from each barb of a feather). They found that their theoretical model held up — small droplets spread along the barbules and caused barbule clumping, whereas larger droplets did not spread and could be easily dislodged — despite the roughness of the feather's barbules and the chemical affinity between the droplet and the barbules' surfaces.

Duprat and colleagues' discoveries suggest that the mechanical properties and spatial organization of biological fibre arrays may have evolved to optimize interactions with liquid droplets, and so enhance functions such as adhesion, dew collection and self-cleaning. The work also offers opportunities for improving the performance of technological wetting systems — for example, droplet volumes in sprays could be engineered to fine-tune their wetting interactions with relevant fibres. **Rosamund Daw**

had at its source. This means that, for the same dust temperature, observing the dust emission at the longer wavelengths corresponds to observing an epoch when the Universe was smaller, and hence younger. By measuring the dust at different wavelengths, Planck can track the emission from star-forming galaxies as a function of cosmic time. Planck's observations[2] suggest that most of the emission in the longer-wavelength bands comes from galaxies that formed at a time when the Universe was less than 2 billion years old (the age of the Universe today is approximately 14 billion years).

To achieve this measurement, the Planck team performed[2] a sophisticated software analysis called component separation. This was required because these wavelength bands contain radiation from many other sources, mostly the Milky Way, but also the cosmic microwave background (CMB, relic radiation from the early Universe glowing at 2.7 K). The strengths of these sources vary differently as a function of wavelength. By combining Planck's nine wavelength bands with additional external measurements, the team was able to separate the cosmic-infrared-background component from the other sources of radiation. The authors found[2] a broad agreement in results between different areas in the sky, which had been specially chosen for having low radiation from our Galaxy, suggesting that the component separation was successful.

The emission from the Milky Way is not just a contaminant of the cosmic infrared background; it also contains some surprises of its own. One of these relates to the 'anomalous microwave emission' at centimetre wavelengths. This has been known about for a few years, but its origin has been controversial. In particular, although this radiation has been observed[4] to correlate with the emission from small dust grains in the Galaxy, simple models of thermal emission from dust could not explain its wavelength dependence. However, if the dust particles are spinning at high rates, they can radiate at a wavelength that relates to their spinning frequency and size. In this spinning-dust model, the emission occurs over a relatively narrow range of wavelengths that happens to coincide with the longest-wavelength band of the Planck observatory. Planck's observations of emission from the Milky Way provide[5] strong support for the spinning-dust model.

Not all of the results from Planck are related to dust radiation. Light propagating through hot gas can be scattered off electrons zooming around these high-temperature regions. The result of this process, named the Sunyaev–Zeldovich (SZ) effect after the two Russian scientists who first proposed[6] it, is that longer-wavelength light is shifted to shorter wavelengths. When viewed against the background provided by the CMB radiation, this effect leads to a dark hole at longer wavelengths at the position of a gas clump on the sky. Similarly, it causes a bright peak of light at shorter wavelengths at the same position.

With Planck's many wavelength bands, both of these features can be observed, leading to a convincing detection of the SZ effect. The sources most likely to provide a detectable SZ signal are the most massive galaxy clusters, which contain huge amounts of some of the hottest gas in the Universe. The Planck team found[7] nearly 200 cluster candidates with this technique, of which about 20 were previously unknown. Most of these have subsequently been confirmed as real clusters by follow-up studies, including X-ray observations[8] with the XMM-Newton satellite. Combined analysis of these data provides detailed information about the gas density and temperature distribution in the clusters, resulting in a better understanding of the processes that led to their formation.

These new results[7] demonstrate that it is possible to find clusters of galaxies with the SZ technique even for surveys looking at the entire sky, in contrast to previous SZ detections — by the South Pole Telescope[9] and Atacama Cosmology Telescope[10] — that searched smaller patches of the sky. Ultimately, the SZ method will allow clusters to be observed at a much larger distance from Earth than is possible with other methods, such as X-ray emission. One exciting application of the SZ approach would be to probe the growth of the largest (and thus rarest) structures at early times. Such observations would provide a measurement of the different components that make up the Universe and of the size of the initial density fluctuations that eventually grew to become galaxies and galaxy clusters.

The early results from Planck demonstrate that the observatory is working flawlessly, and provide a first glimpse of its scientific potential. However, the best is yet to come. The main mission of Planck is to map the CMB radiation and its polarization with unprecedented precision. This measurement will provide a window onto the early Universe and offer clues as to what created the first seeds of structure. Planck may also detect the relic gravity waves from the Big Bang through the observations of CMB polarization. The task is complicated by the relative faintness of the CMB compared with other sources of radiation, such as dust emission, in most of the wavelength bands. Careful separation of components is thus needed to isolate the CMB signal, a task that has proved challenging and is the main reason that these early results do not include any primary CMB data. These CMB results are expected to be announced in early 2013. Given the spectacular instrument performance of Planck shown by its early findings[2,5,7], the cosmology community is eagerly awaiting more results. ■

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MATERIALS SCIENCE

Cell environments programmed with light

A combination of two light-induced reactions has been used to attach peptides to a polymeric gel, and then to detach them from it. This feat opens up opportunities for studying the effects of signalling molecules on cell behaviour *in vitro*.

MATTHIAS P. LUTOLF

The ability to use light to precisely control the activity of cells has transformed the way many experiments in biology are performed. In particular, optogenetic techniques — in which light is used to manipulate cells that have been genetically engineered to be light responsive — have revolutionized neuroscience by providing a completely new way to modulate cell signalling, even in live animals[1]. Writing in *Angewandte Chemie*, DeForest and Anseth[2] report that light can be used to dynamically manipulate not only the intrinsic cellular regulatory machinery, but also the external microenvironment of a cell. Specifically, they showcase a class of 'optobiomaterial' whose biochemical properties can be changed to influence cellular activity simply by having different sources of light shone on it.

Far from being intrinsically determined, cell behaviour such as proliferation, differentiation and migration are tightly regulated by spatio-temporally complex signals originating from the surrounding milieu (the extracellular matrix, ECM). For instance, the microenvironments (known as niches) surrounding rare adult stem cells in human tissues regulate stem-cell behaviour using a combination of local cell–cell interactions, ECM-derived signals and soluble signalling molecules. Together, these niche signals are crucial for ensuring lifelong maintenance of stem-cell function[3]. An understanding of how stem cells respond to signals from their extracellular environment is therefore essential, especially for realizing the therapeutic potential of stem cells.

Biologists have a variety of *in vitro* model systems at hand to study such complex cell–ECM interactions, and this enables them to uncover cell-signalling mechanisms in near-physiological, three-dimensional contexts. These models have been generated from crosslinked networks of protein components of the ECM such as collagen, or from ECM glycoproteins (polypeptides that have sugars attached) such as laminin. They have provided vital insight into extrinsic cell regulation, and in some cases have even made possible the formation of entire tissues from single stem cells *in vitro*[4]. Unfortunately, these biomatrices tend to suffer from uncontrollable batch-to-batch variability and are unable to modulate the availability of extrinsic signalling molecules — and thus cell function — controllably in space and time.

To recreate the dynamics of cellular microenvironments in three dimensions, researchers have sought strategies in materials chemistry that permit the biophysical and biochemical properties of matrices to be selectively modulated in a tailor-made fashion. Most approaches rely on well-characterized, crosslinked, synthetic polymers known as hydrogels that have ECM-like biophysical properties.

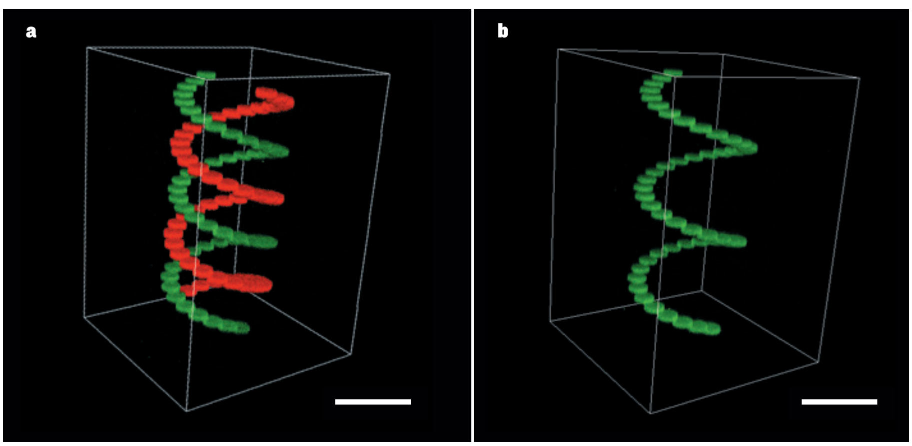

Figure 1 | Reversible gel patterning. DeForest and Anseth[2] have prepared hydrogels — water-absorbent polymeric networks — to which biologically active molecules can be attached and then removed using two light-induced reactions. By focusing light on specific regions of the gel, the authors precisely controlled the points of attachment. **a**, In this three-dimensional section of a hydrogel, fluorescently labelled peptides are bound in a double-helix pattern that was traced out using focused, visible laser light. False colour has been used to aid visualization. **b**, Subsequent irradiation of the red part of the helix with ultraviolet light has caused the peptides in that region to detach. Scale bars, 200 micrometres. (Images reproduced from ref. 2.)