manipulation (*14*), except that here the correlations arise thermodynamically.

In the second groundbreaking experiment, they demonstrate correlations in extended 1D systems. By raising the lattice along one direction, they convert the 2D lattice into an array of 1D systems (see the figure). The isolated 1D systems are sufficiently cooled to demonstrate antiferromagnetic spin correlations between neighboring spins. Remarkably, the correlations are observed to be symmetric, independent of which of a given spin's two neighbors are measured. This indicates that the adiabatically generated correlations extend beyond just two sites, a major achievement for cold-atom realization of magnetism.

The work here opens the door for a new set of challenges. Such low temperatures require careful understanding and control of all heating rates. This in itself can be an interesting area of research, because the mechanisms for heating can depend in detail on the many-body states (*15*). Also, because the adiabatic approach requires subsystems in which to dump entropy, it is not clear how far the technique can be pushed, or the best way to create cooling in other 2D lattice geometries. Nonetheless, the demonstration by Greif *et al*. of magnetic correlations in an extended cold-atom system provides optimism that these challenges can be overcome.

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PHYSICS

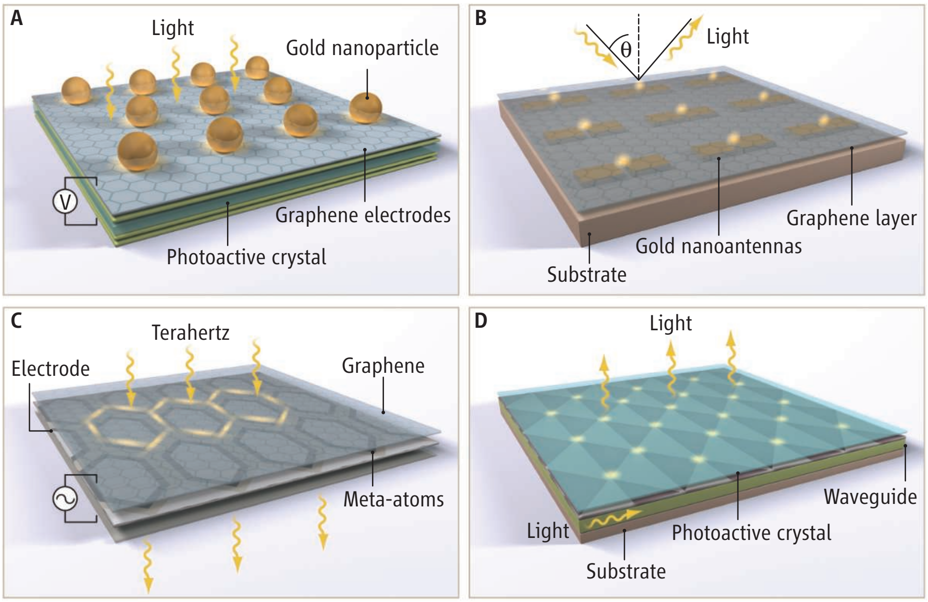
Two Two-Dimensional Materials Are Better than One

Combining 2D materials and 2D metasurfaces enables the fabrication of photonic devices based on extreme interactions between electrons and light.

Joachim M. Hamm and Ortwin Hess

Extraordinary electronic or optical properties can result when layered solids are realized as two-dimensional (2D) materials (single or few-layer sheets), as is the case when graphene is formed from graphite. Optical properties can also be enhanced by restructuring materials at subwavelength scales into metamaterials, such as enhancing the plasmonic properties of gold—the coupling of light to electrons—by forming nanoparticles. Combining these approaches can lead to devices with capabilities that are otherwise difficult to realize. For example, for photovoltaic devices or sensors, materials with high electronic conductivity could be optically thick (to efficiently absorb light) but dimensionally thin (to impart flexibility and light weight). On page 1311 of this issue, Britnell *et al*. (*1*) combined highly conductive graphene and optically active 2D transition metal dichalcogenides into a heterostructure that photoexcites electron-hole pairs within a band-gap material. These carriers were separated with a p-n junction and extracted as a photocurrent with transparent graphene electrodes (graphene), and the performance was enhanced with plasmonic gold nanoparticles.

How does the light-matter interaction become stronger by making a particular material to become 2D, e.g., by exfoliation of single layers and making it so thin that it effectively has no thickness relative to the wavelength of light? This surprising property is directly related to the presence of critical points that generate in 2D or 1D (but not in 3D) the so-called Van Hove singularities in the electronic structure. Britnell *et al*. report that for the photoactive transition metal dichalcogenides such as molybdenum



Uniting flat materials. Various ultraflat photonic devices that could be built through the combination of 2D electronic materials and 2D photonic metasurfaces are illustrated. (**A**) Ultrathin broadband photovoltaic devices could be realized by combining 2D materials and broadband light harvesting (*1*). (**B**) Label-free single-molecule detectors could be achieved by exploiting a diffractive coupling between plasmonic nanoantennas functionalized by a graphene layer (*10*). (**C**) A polarization-independent terahertz modulator could be made by using gate-tunable graphene embedded in a metamaterial structure (*11*). (**D**) Ultrafast and broadband metasurface emitters could be made by tailoring the 2D active material to operate in visible light or in the terahertz regime (*8*, *12*).

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disulfide (MoS_2), these singularities occur at visible frequencies and enhance the electronic density of states, i.e., the number of electrons per volume that participate in the absorption process at a given energy. Using this fundamental concept, a remarkably high quantum efficiency of up to 30% was achieved experimentally, in part by adding layers of hexagonal boron nitrate to provide homogenization of the doping levels.

The light-matter interaction was further increased by manipulating the local optical density of states. Britnell *et al*. show that depositing gold nanoparticles on the surface of the 2D heterostructure further enhanced the photogeneration of electron-hole pairs by a factor of 10. The nanoplasmonic particles form a broadband light-harvesting metamaterial (*2*) that concentrates field energy (or bundles optical modes) in "hotspots" under the particles. Additional generation of carriers takes place where these hotspots overlap with the photoactive layer.

These results not only demonstrate that the simultaneous design of the electronic and the optical density of states is the key to an extreme control of light-matter interaction but also provide a glimpse of how future nanophotonic devices can benefit from the combination of two 2D materials: heterostructures of 2D atomic crystals ("electronic metamaterials") to control the electronic wave functions and nanostructured metasurfaces (*3*–*5*) to control the light field. This principle, which we call the "United Flatlands" (*6*, *7*) opens up many opportunities for the next generation of active 2D metamaterials (*8*) with quantum gain (*9*) and ultraflat photonic devices, such as solar cells, light-emitting diodes, nanolasers, and optical sensors. The figure showcases some of the most striking possibilities. With the potential to break many performance and size limitations of bulk materials, particularly with respect to speed, energy efficiency, and area-footprint, the marriage of electronic and optical 2D (meta-) materials heralds a quantum leap in photonic device technology.

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CELL BIOLOGY

Rapid Aging Rescue?

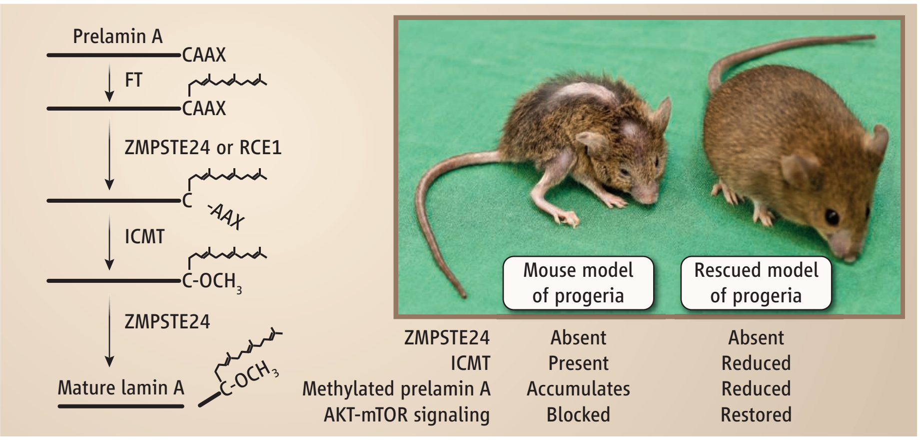
Reducing methylation of the protein lamin A may provide a therapeutic target for Hutchinson-Gilford progeria syndrome.

Thomas E. Johnson

Hutchinson-Gilford progeria syndrome (HGPS) is a rare dominant genetic disorder that mimics premature, rapid aging. Patients fail to thrive, and death occurs at an average age of 13 years, usually from myocardial infarction or stroke. Spontaneous HGPS-generating mutations occur at the rate of about 1 in 4 to 8 million births. *LMNA*, the gene harboring the HGPS mutations, encodes prelamin A (*1*). This precursor matures to lamin A, a structural component of the nuclear envelope. On page 1330 of this issue, Ibrahim *et al*. (*2*) show that methylated prelamin A, an intermediate form in the protein's maturation pathway, is associated with progeria symptoms in a mouse model of the disease. The methylated form blocks a signaling pathway that promotes cell proliferation, survival, and tissue growth. Reducing this methylation pharmacologically could be an effective therapeutic approach for treating progeroid disorders.

LMNA generates four peptides as the result of alternative splicing of its corresponding messenger RNA (mRNA). The two major protein products are prelamins A and C. Lamin A is a 664–amino acid protein that results from a variety of chemical and enzymatic processes (see the figure). The addition of a farnesyl group to prelamin A by farnesyltransferase is followed by removal of three amino acids from the distal end of the protein by either Ras-converting enzyme (RCE1) or the zinc metallopeptidase STE24 (ZMPSTE24) (*3*). Methylation of the remaining terminal cysteine is carried out by isoprenylcysteine carboxyl methyltransferase (ICMT), and a final clipping of the protein by ZMPSTE24 to generate mature lamin A. The final cleavage step is altered in HGPS, producing a truncated form of prelamin A, often referred to as progerin.

Elucidating the synthesis of lamin A has an intriguing history. Initially, a mutation that causes HGPS was localized to chromosome 1q by genetic mapping. Three different mutations were then identified in 23 individuals diagnosed with the disorder (*1*, *4*).



Signs of aging, reversed. Prelamin A is processed to lamin A, a constituent of the nuclear membrane. Mice lacking the gene encoding ZMPSTE24 show signs of accelerated aging that are characteristic of the Hutchinson-Guilford progeria syndrome. If there is reduced expression of ICMT as well in these mice, many aspects of aging are reversed. The rescued mice produced less methylated prelamin A and showed an increase in growth promoting signaling (the AKT-mTOR pathway). FT, farnesyltransferase; mTOR, mammalian target of rapamycin.

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