eggs but no sperm, failed to live longer in response to ancestral COMPASS inactivation. The simplest interpretation of this result is that a COMPASS-dependent process occurs in germ cells to control lifespan, and that the flux of germ cells is important for its effects. However, an alternative possibility is that a functional germ line modulates other aspects of worm physiology. For example, it is known that *C. elegans* germ cells undergoing division control fat metabolism in the intestine, and that increased fat metabolism can extend life[8]. A similar non-autonomous effect may account for the germline dependence of COMPASS.

A question central to all transgenerational studies is how transient alterations in the environment or mutation can lead to long-term, multi-generational consequences. One attractive candidate mechanism has been methylation of DNA, a chemical modification that is associated with gene silencing. Most parental DNA methylation is removed in newly fertilized eggs, but some genes may retain methylated DNA over multiple generations, to serve as a transgenerational cue. This effect has been seen in mice, in which a region of DNA that controls coat colour can escape erasure of parental DNA methylation during embryonic development; the remaining degree of DNA methylation produces a range of fur colours[6]. But DNA methylation cannot be the only mechanism for transgenerational signalling, because *C. elegans* lacks DNA methylation altogether. Instead, Greer and colleagues' work[3] implicates histone modifications — specifically, methylation of histone H3 at a particular amino acid (the H3K4me modification).

A crucial issue is whether H3K4me itself is the inherited cue, or whether the modification in parental cells leads to downstream events that generate an epigenetic signal. Previous studies have shown that H3K4me is established in the mother's germ line and inherited by the fertilized egg, where it is retained for at least the first few cell divisions[9]. One possibility, therefore, is that maintenance or interpretation of embryonic histone modifications affects adult worm longevity days later. Greer *et al.*[3] show that their *C. elegans* COMPASS mutants lack H3K4me, and that restoration of H3K4me correlates with a shorter life, suggesting that this histone modification is crucial for controlling longevity. But COMPASS can also function beyond individual genes, to influence the organization of chromosomes — in *C. elegans*, members of COMPASS associate with the dosage-compensation machinery, a complex of proteins that both controls the structure of the X chromosome and attenuates the expression of thousands of X-linked genes[10]. Taken together, the evidence suggests that COMPASS may mediate transgenerational signalling directly, by controlling how genes and chromosomes are organized within cells.

An alternative explanation is that COMPASS and H3K4me activate gene expression, and that the resulting RNA or protein is inherited, rather than the H3K4me mark itself. Greer *et al.* identified genes that were misexpressed — that is, genes that were expressed when they shouldn't have been, and those that weren't expressed when they should have been — in COMPASS mutants, and found that many of the genes coded for proteins associated with longevity, growth or development. In line with the observed transgenerational effects[3], these genes remained misexpressed in the F_4 generation but reverted to normal expression levels in F_5, and the expression of many of the genes was dependent on a functional germ line. An intriguing possibility is that the resulting RNAs are expressed in germline cells, where they could be placed in nascent oocytes (immature egg cells) and passed to the next generation. Although Greer *et al.* focused on messenger RNAs, small, non-coding RNAs (such as siRNAs, miRNAs and piRNAs) are also found in the *C. elegans* germ line and are probably inherited by the embryo. Small RNAs have regulatory roles in silencing gene expression, and could thereby shorten lifespan. Perhaps parental COMPASS is important for producing these non-coding RNAs.

One or a combination of the above explanations may account for the role of COMPASS in lifespan regulation, and it will be fascinating to learn how COMPASS induces transgenerational effects. Future studies will also be able to address whether COMPASS responds to environmental cues such as food, which would link the complex to the types of transgenerational influence that have been described in other animals. Finally, Greer and colleagues' study focused on the role of mothers, but in invertebrates it is clear that both mothers and fathers can signal to their descendants. It will be exciting to learn if COMPASS-dependent cues pass not only through the mother, but also through the father. ■

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QUANTUM PHYSICS

Shaking photons out of the vacuum

The dynamical Casimir effect — the generation of photons out of the quantum vacuum induced by an accelerated body — has been experimentally demonstrated using a superconducting circuit that simulates a moving mirror. SEE LETTER P.376

DIEGO A. R. DALVIT

Quantum theory predicts that the vacuum of space is a roiling bath of virtual particles that continuously appear and disappear. These vacuum fluctuations produce measurable phenomena, such as the Casimir effect[1], which arises from the pressure that virtual photons exert on stationary bodies. In 1970, Gerald Moore[2] theorized that bodies in accelerated motion would produce real photons out of quantum vacuum fluctuations — the dynamical Casimir effect. In this issue (page 376), Wilson *et al.*[3] report the first experimental demonstration of the dynamical Casimir effect, using a superconducting circuit that simulates an oscillating mirror.

Accelerated bodies modify quantum vacuum fluctuations, causing emission of photon pairs from the vacuum[4] and dissipation of the bodies' motional energy. The power dissipated in the motion of the body is equal to the total radiated electromagnetic power, as expected according to the law of energy conservation. In its original form, the dynamical Casimir effect was predicted to occur when a single mechanical mirror undergoes accelerated motion in the vacuum. It was then extended to configurations in which the photon production rate is enhanced; for example, in cavities formed by two parallel mirrors, where the position of one of them oscillates with time.

A serious problem for detecting the dynamical Casimir effect induced by moving mechanical systems is that the dissipated energy and the associated radiation are negligibly small. Among other requirements, motions at nearly the speed of light are necessary. Because of these difficulties, several analogous systems have been proposed for observing the effect, the first being a nonlinear optical medium whose refractive index is rapidly changed with time[5].

In one experiment being pursued[6], the moving mirror is simulated by a semiconducting, layered wall whose conductivity is periodically modulated by an external laser; this set-up closely resembles an actual oscillating mirror. Wilson and colleagues' experiment[3] is based on another proposal[7], and consists of a waveguide terminated at one end by a superconducting quantum interference device (SQUID) — a very sensitive magnetometer. In this approach, a time-dependent magnetic flux threading through the SQUID modifies the electromagnetic field in the waveguide, just as if the SQUID had been replaced by a moving mirror. Because there is no massive body in motion, the effective velocity of the fictitious mirror can be made a substantial fraction of the speed of light.

Even without the dynamical Casimir effect, photons can exist at any finite temperature, and these must be distinguished from motion-induced photons generated from the vacuum. By cooling their apparatus to very low temperatures (less than about 50 millikelvin), Wilson *et al.* prepared their system as close as possible to the vacuum state — the number of thermal photons remaining in such a cold environment is very small. To produce dynamical Casimir photons, the authors 'pumped' the system with a time-varying magnetic flux through the SQUID. They then measured the intensity and frequency of the generated radiation at the open end of the waveguide, as a function of the strength and frequency of the pump field.

Wilson *et al.* detected motion-induced radiation whose broadband microwave energy spectrum was symmetrical at around half the frequency of the oscillating fictitious mirror. The measured spectrum is consistent with that of dynamical Casimir photons, which are generated in pairs whose frequencies add up to the mirror's oscillation frequency. What's more, they found that the measured photon intensity versus pump strength compares reasonably well with theoretical predictions. In addition to observing the creation of real photons, Wilson and colleagues measured photon correlations in the output port of their system. To do this, they split the output photon signal into two separate analysis chains and detected specific correlations. Such correlations are a signature of the quantum nature of the photon-generation process and are another hallmark of the dynamical Casimir effect.

A potential problem with these measurements is that photons might be generated by spurious processes that could mimic the dynamical Casimir effect. Wilson and colleagues considered, and ruled out, a number of such systematic effects. For example, nonlinearities in the electromagnetic properties of the waveguide's substrate and/or in the SQUID electronics could conceivably generate photons in the output port by means of a process known as parametric down-conversion. But the authors emphasize that the pump-power levels used in their experiment are much lower than those needed for such nonlinear processes to occur. Even in the absence of spurious nonlinear mechanisms, motion-induced photons could be seeded, not by quantum vacuum fluctuations, but by uncontrolled noise in the apparatus (for example, thermal noise). However, the authors measured the output photon flux at two temperatures (50 and 250 mK) and were able to verify that the signals are dominated by quantum, and not thermal, fluctuations.

Wilson and colleagues' breakthrough demonstration of the dynamical Casimir effect, together with other ongoing experimental and theoretical efforts, will strongly impact on fundamental physics. They will enable table-top demonstrations of particle creation in an expanding Universe and of black-hole evaporation, among others. ■

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GEOPHYSICS

Earth's longest fossil rift-valley system

The origins of the Gamburtsev mountain range, which is hidden beneath Antarctic ice, are a long-standing mystery. Detailed geophysical data from the area form the basis of a comprehensive model that solves the mystery. SEE LETTER P.388

JOHN VEEVERS

One-tenth of Earth's crust is masked by the East Antarctic Ice Sheet, and constitutes one of the least understood parts of the planet. Recent work[1,2] reveals that, far from having a flat surface like its former neighbour Australia, this part of the crust is cut into mountain ranges and valleys. The largest of the ranges, the Gamburtsev Subglacial Mountains, is similar in size and shape to the European Alps, but buried beneath kilometres of ice. Its high elevation and jagged topography are intriguing: how could such a topography, which is characteristic of recently formed and uplifted tectonic features, have formed in the interior of an ancient, geologically moribund continent? On page 388 of this issue, Ferraccioli *et al.*[2] present geophysical data that indicate the existence of a 2,500-kilometre-long rift-valley system surrounding an area of anomalously thick crust that is coextensive with the Gamburtsevs, and suggest a model to explain its formation.

The authors' model postulates that the collision of continents about 1 billion years ago produced a high, mountainous topography on thickened crust (see Fig. 4 of the paper[2]). This uplift collapsed under its own weight and was worn away by erosion, whereas the underlying crustal base (known as the root) remained intact. Successive rifting — a process in which a portion of Earth's crust is pulled apart — about 250 million years (Myr) ago, and then again about 100 Myr ago, led to the formation of an extensive rift-valley system with uplifted flanks. The uplifted regions were incised, first by rivers and then (from 34 Myr to 14 Myr ago) by glaciers, to create the steep peaks and valleys of the Gamburtsevs[1]. The youthful topography of the Gamburtsevs was then literally frozen by the growth of the East Antarctic Ice Sheet.

This understanding has come after 60 years of land-based and airborne geophysical surveys. Ice drapes the Gamburtsevs to form the Dome Argus plateau, the highest (4,093 metres) and possibly coldest place in Antarctica. A detailed overland radar survey[1] of the base of the ice at Dome Argus was the first to reveal the underlying alpine topography. An airborne survey of the entire Gamburtsevs, collected as part of Antarctica's Gamburtsev Province Project, now provides details of the mountain range's rugged surface, and constrains speculation about its deep geological structure, as Ferraccioli *et al.*[2] report.

The airborne survey covered a strip