ecule that prevents damage to DNA or cytoplasmic constituents. In plants, for example, UV light induces the transcription of genes that are involved in synthesis of UV-absorbing molecules such as flavonoids and phenylpropanoids[12]. Perhaps there is some evolutionary advantage to the UV-mediated induction of the same plant defence genes as those that are normally induced by insect and pathogen attack. A possible example would be if the intensity of UV-B were correlated with insect activity. Also, activation of signal-transduction pathways that regulate cell growth and division might have a beneficial effect on the survival of UV-damaged cells.

Finally, DNA repair is targeted to the transcribed strand of the genes that are undergoing transcription[1], so the induction of biologically important genes by the UV-response pathway will increase the speed at which lesions are excised from these genes. This should also have the effect of reducing the overall level of genome damage. Thus, one function of the UV response in eukaryotic cells could be to increase the rate of DNA repair through an increase in the transcriptional programme of the cell. □

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SUPERFLUIDS

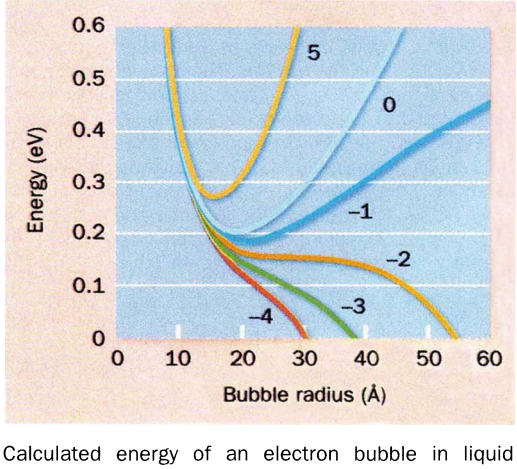
Exploding electron bubbles

Peter McClintock

ELECTRON bubbles, used in laboratories throughout the world for probing the unusual properties of liquid helium, can be made to explode by the application of negative pressure, according to investigations by Classen *et al.* published last month[1].

Helium is unique among liquids in that it can be cooled to arbitrarily low temperatures without solidifying — in principle, right down to zero kelvin. As it cools, the average speed of its atoms in random thermal motion decreases, and their de Broglie wavelengths (inversely proportional to momentum) correspondingly increase. When the waves of neighbouring atoms strongly overlap, their motion becomes correlated, and the liquid undergoes Bose–Einstein condensation[2] to a superfluid state with a whole set of exotic properties that have already kept physicists busy for more than half a century. For example, the superfluid flows without friction, exerts no drag on a moving object, tends to climb out of an open-topped container, and can only rotate at certain quantized angular velocities relative to the fixed stars.

This year's Nobel prize in physics went to David Lee, Douglas Osheroff and Robert Richardson for their 1972 discovery of superfluidity in ^{3}He, since when it has been intensively studied using nuclear magnetic resonance. Its isotopic sibling ^{4}He cannot be investigated in this way because its nucleus is non-magnetic.



Calculated energy of an electron bubble in liquid helium as a function of its radius, for pressures between 5 and –4 atmospheres[1]. No equilibrium bubble radius exists for pressures below –2 atmospheres, so they explode.

For this reason, electron bubbles — often misleadingly known as negative ions — have been widely used over the years to probe its superfluidity.

Their main features are well established[3], and can be understood in terms of the quantum-mechanical requirement that the lowest permitted kinetic energy of a particle depends on the volume it is confined in: make the volume smaller, and the so-called zero-point energy rises. This decidedly non-classical effect gets bigger as the mass of the particle decreases, and is especially pronounced for a very light particle such as an electron. Thus, an excess electron in liquid helium can decrease its energy by carving out a small spherical cavity for itself.

Enlargement of the bubble reduces the zero-point energy, but also involves doing work against surface tension and the external pressure. So there is a compromise (equilibrium) radius at which the total bubble energy is minimized. At zero pressure, this is about 19 Å, so rather than having a naked electron in liquid helium, one finds a mesoscopic, charged, spherical bubble of vacuum with an effective hydrodynamic mass equal to half the mass of displaced fluid (a few hundred helium atomic masses).

Electron bubbles of this kind have been used to measure the quantum of circulation[4], that is, the liquid's allowed increments of rotational motion, which take physical form as quantized vortex lines. They have also provided techniques for imaging the vortex lines photographically[5], for measuring the Landau critical velocity at which superfluidity breaks down[6], and for demonstrating that vortex creation occurs through a form of macroscopic quantum tunnelling[7] closely analogous to processes recently observed in magnetic systems (see ref. 8 for a brief review).

What Classen *et al.* have now done is to take this familiar probe, subject it to negative pressure, and see what happens. Their experimental technique involves the use of focused ultrasound, which causes the pressure on the bubble to rise and fall cyclically above and below ambient pressure. For large enough amplitudes, the pressure minima can become negative.

What should happen to an electron bubble near the focus of the ultrasound, where the pressure swings are largest? The figure plots the calculated bubble energy as a function of radius for several pressures[1]. Above a critical pressure of about –2 atmospheres, a minimum exists in the energy at some radius, determining the equilibrium state of the bubble. For lower pressures, however, there is evidently no minimum, and one can conclude that there is then no stable configuration for the bubble. So if the pressure minima induced by the ultrasound go below –2 atmospheres, the bubble will start to expand without limit; in other words, to explode. In this set-up, disaster is prevented by the high-pressure part of the cycle, which recompresses the bubble and restores its stability.

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Erratum

In the article 'Tangle disentanglement' in the 10 October issue (**383**, 476–477; 1996), ref. 1 was cited as from *Mol. Psychol.* The correct title of the journal is *Molecular Psychiatry.*

Classen and colleagues used a β-emitting radioactive source to inject electrons into the liquid helium, and looked for exploding bubbles by shining a laser through the liquid. Electron bubbles are normally far too small to scatter light, but in their vastly expanded exploded state they can be expected to scatter it effectively. In the event, the authors were able not only to confirm the existence of the exploding bubbles, but also to determine the probability of explosions as a function of the ultrasound amplitude, and show that it fits expectations.

It would not surprise me if exploding electron bubbles came in useful for something — perhaps non-destructive imaging of an electron cloud, to watch where they go in the helium? But essentially this is good basic science. Although there are some unexpected features of the results that need further investigation — notably phenomena observed below 1 K, possibly caused by bubbles getting stuck on quantized vortices — the work demonstrates convincingly that the normally placid electron bubble can sometimes explode. □

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DEVELOPMENTAL BIOLOGY

High hops of transgenic frogs

J. M. W. Slack

THOSE of us who work in developmental biology, and use the frog *Xenopus laevis* as our experimental organism, are used to being stopped in the corridor and told that *Xenopus* are useless because "They have no genetics". Other model organisms such as *Drosophila*, mouse, zebrafish and *Caenorhabditis elegans* have been chosen mainly because they are suitable for genetic experiments, whereas frogs are used because their embryos are large and appropriate for micromanipulation. *Xenopus* do, of course, have genes. But they are not suitable for mutagenesis or breeding experiments because of their long generation time, and because they have two similar copies of each chromosome, having apparently undergone a genome duplication about 30 million years ago.

Now, however, one of the most important techniques available to those who work with mice or *Drosophila* has also become applicable to frogs. This is transgenesis, or the introduction into the organism of genes engineered in the laboratory. The new methods are described in *Development* by Kroll and Amaya[1]: and given the high level of conservation of developmental mechanisms between different animal groups, their application should tell us more not only about frogs but about animal development generally.

Transgenic mice are made routinely by injecting DNA into a pronucleus of the fertilized egg, and similar experiments have been performed with frogs for many years[2]. The trouble is that only a minority of cells in the embryo express the transgene. The reasons for this 'mosaic' expression are not fully understood, but it effectively limits DNA-based experiments to three types — use of reporter genes to study the tissue specificity of modified promoters[3], or to probe the intracellular regulatory environment in different regions of the embryo[4]; or overexpression of secreted factors that can affect not only the cells in which the gene is active but also surrounding tissues[5].

It has not been possible to produce consistent changes in the anatomy of the embryo by the overexpression of genes whose products are retained within the cell, for example receptors, kinases or transcription factors, because too few of the cells in the body are transformed. Many groups have used RNA-based overexpression which does not suffer from this problem, but injected messenger RNA is translated from the time of injection and this effectively limits studies to the earliest stages of development because later events are often obscured by interference from earlier ones.

Another potential route to transgenesis is nuclear transplantation. This was first successfully performed in 1952 by Briggs and King[6], who showed that blastula nuclei could be transplanted into enucleated eggs of another frog species, *Rana pipiens,* and could support development up to adulthood. Subsequent work, mainly using *Xenopus*, showed that, although nuclei from progressively later stages supported development less well than did blastula nuclei, it was possible to obtain a few well-differentiated tadpoles even using nuclei from fully differentiated cells grown in primary culture[7]. Building on this, transgenes have been introduced into *Xenopus* cell lines and the nuclei used for the transplantations[8,9]. But although the transgenes could be expressed throughout the embryo, the cell nuclei could not support normal development. This is probably because *Xenopus* tissue culture is not a highly developed technology and all existing cell lines have abnormal karyotypes. When the host nucleus was left in place, survival was better but expression of the transgene then tended to be mosaic.

Kroll and Amaya[1] have circumvented the problem of aneuploidy by the simple expedient of introducing the transgene into sperm instead of tissue culture cells (Fig. 1). Using green fluorescent protein as a marker, the authors show that their embryos express the transgene in all cells while the same gene on injected DNA is expressed only in a minority of cells. When tadpoles were reared to 1–2 months of age, the transgenes were still

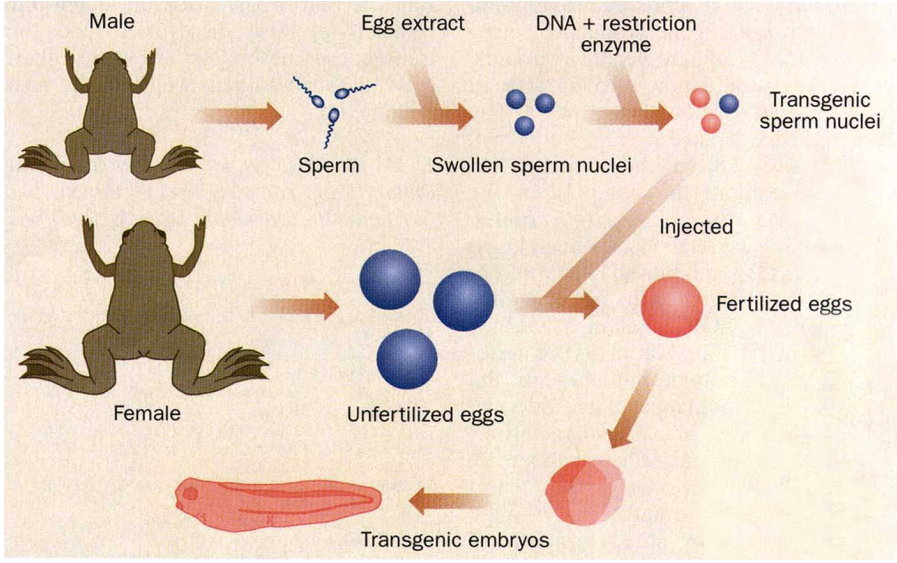

FIG. 1 The new procedure for making transgenic *Xenopus*, developed by Kroll and Amaya[1]. Sperm nuclei are treated with an egg extract to swell them and decondense the chromatin. The transgene is then added along with a restriction enzyme to make complementary breaks in the sperm DNA. The sperm nuclei are injected into unfertilized eggs, obtained from females by injection of chorionic gonadotrophin. Although eggs can be activated to begin development merely by pricking, if no sperm, or more than one sperm, has been injected, then the cleavages are aberrant and development soon ceases.