of the waves. Consequently, a stronger wakefield requires a shorter proton bunch.

The main innovation in Adli and colleagues' work was, therefore, to make the length of the proton bunch as short as possible so that the bunch resonates with the plasma's internal clock, maximizing the amplitude of the wakefield. The authors achieved this feat using a feature of the plasma known as collective force. Although the electric force produced by each particle in the plasma is small, the collective force generated from all of the particles can be large, and becomes larger as the plasma density is increased[2]. The authors used this force to chop a long proton bunch into a series of shorter bunches. Because proton bunches are stiff (difficult to deform) at the extremely high particle energies present in the AWAKE experiment, this chopping was possible and effective only by using the plasma's collective force.

Adli *et al.* found that the wakefield produced by the short proton bunches could accelerate electrons to energies of up to 2 gigaelectronvolts in a plasma that is only about 10 metres in length. For comparison, at the European X-ray free-electron laser facility (European XFEL) in Germany, electrons are accelerated to energies of up to 17.5 gigaelectronvolts in an accelerator that is about 2 km long (see go.nature.com/2n6857t). In addition to providing compact acceleration, the authors' approach has a key advantage over standard accelerators and other wakefield accelerators. Because the proton bunches are stiff, they maintain their structure and speed. As a result, high-energy electrons can be produced in a single acceleration stage, as opposed to the complex multi-stage process that is needed in other accelerators.

Usually, the higher the energy of a particle beam, the longer it takes to stop (dump) the beam after use. The dumping of high-energy beams has become a serious issue because of the requirement of longer dumping lengths, which in turn increases the production of unwanted radioactive isotopes in the dense materials used for the dumping. The authors show that their accelerated electrons can form a beam of short electron bunches, which would encounter a large collective force if injected into an appropriately prepared plasma. Such a beam could therefore be stopped over a much shorter distance than conventional beams, inducing little radioactivity[5]. Overall, the authors' work represents a major step towards the development of future high-energy particle accelerators that use collective force. ■

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50 Years Ago

A campaign was opened last week for funds to refloat the Great Britain, one of the three major ships designed by Brunel. The object is to tow her back from the Falkland Islands to the Bristol shipyard … The Great Britain was the first ocean-going iron ship and the first to be driven by propeller … Brunel intended the ship to carry passengers of the Great Western Railway … to New York, but the Great Britain made only a few transatlantic voyages before running aground … Brunel managed to refloat the ship, which for the next 20 years carried emigrants to Australia … In 1875, the Great Britain's engines were removed and she was converted to sail, plying between Liverpool and San Francisco until put out of service by a fire near the Falkland Islands … Despite the ship's age, her structure is still sound enough to survive the journey back to Britain.
From *Nature* 21 September 1968

100 Years Ago

On the afternoon of Saturday, August 24 last, the allotment-holders of a small area in Hendon … were sheltering in their sheds during a heavy thundershower, when they observed that small fish were being rained to the ground. The fish were precipitated on three adjoining roads and on the allotment-gardens enclosed by the roads; the rain swept them from the roads into the gutters and from the roofs of the sheds … It is not easy to say how many fish fell, but … they were numerous … All the examples which came into my hands … prove to be the lesser sand-eel (*Ammodytes tobianus*) … The place where the sand-eels in question were deposited lies about one-quarter of a mile from the seashore … The only explanation … is that a shoal of sand-eels was drawn up by a waterspout.
From *Nature* 19 September 1918

CANCER

RETRACTED

T cells home in on brain tumours

Immunotherapies activate T cells to destroy tumours, but the approach has failed in some brain cancers. A strategy to improve migration of T cells across the blood–brain barrier could overcome this limitation. SEE ARTICLE P.331

MICHAEL PLATTEN

Therapies that activate immune cells called T cells to target tumours are an efficient way to combat many types of cancer[1]. But an aggressive brain cancer called glioblastoma has proved a particular challenge for immunotherapies[2]. The blood–brain barrier protects the brain against immune-cell infiltration to prevent the potentially life-threatening effects of brain inflammation. This phenomenon is beneficial in normal circumstances, but it prevents T cells from reaching glioblastomas, making the tumours immunologically 'cold'[3]. On page 331, Samaha and colleagues[4] report a way to trigger infiltration of T cells into the brains of mice, thus making glioblastomas vulnerable to immunotherapy.

In the disease encephalitis, brain inflammation occurs because T cells that are typically excluded from the brain migrate across the blood–brain barrier. This migration is a coordinated process that requires activated T cells circulating in the bloodstream to adhere to endothelial cells, which line blood vessels. Adhesion is mediated by the binding of ligand molecules on T cells to cell-adhesion molecules such as ALCAM, ICAM-1 and VCAM-1 on endothelial cells[5]. These cell-adhesion molecules are expressed at higher than normal levels in encephalitis[6]. Binding between ALCAM and the T-cell ligand CD6 halts the progress of activated T cells through blood vessels, allowing subsequent binding by ICAM-1 and VCAM-1.