disruptiveness index should not be embraced uncritically. Because it relies on citations to articles, it can be calculated only after enough time has passed since publication for citations to accumulate. This limits the applicability of the index in areas in which citations build up slowly, or its use as a tool for evaluating the impact of recent policies. Moreover, Wu and colleagues' article leaves open the question of mechanisms: why would small teams be more likely to perform disruptive work? How much overlap is there between the skills, backgrounds and experience of the members of small teams and those of large teams? Are differences in talent between collaborators more or less pronounced in small scientific teams than in large collaborations? These questions await further examination. ■

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NUCLEAR PHYSICS

Origin of neutron and proton changes in nuclei

The structure of a neutron or a proton is modified when the particle is bound in an atomic nucleus. Experimental data suggest an explanation for this phenomenon that could have broad implications for nuclear physics. SEE LETTER P.354

GERALD FELDMAN

In 1983, it was discovered that the internal structure of a nucleon — a proton or a neutron — depends on its environment[1]. That is, the structure of a nucleon in empty space is different from its structure when it is embedded inside an atomic nucleus. However, despite vigorous theoretical and experimental work, the cause of this modification has remained unknown. On page 354, the CLAS Collaboration[2] presents evidence that sheds light on this long-standing issue.

The advent of nuclear physics dates back to the days of Ernest Rutherford, whose experiments in the early 1900s on the scattering of α-particles (helium nuclei) by matter revealed a compact, dense core at the centre of atoms[3]. Since then, physicists have been working to understand the structure of the atomic nucleus and the dynamics of its component parts. Similarly, since the revelation in the late 1960s that nucleons themselves have internal constituents called quarks[4,5], extensive work has focused on studying this deeper underlying structure.

For decades, it was generally thought that nucleons in nuclei were structurally independent of each other and were essentially influenced by the average nuclear field produced by their mutual interactions. However, a lingering question had been whether nucleons were modified when inside a nucleus; that is, whether their structure was different from that of a free nucleon. In 1983, a startling discovery by the European Muon Collaboration (EMC) at the particle-physics laboratory CERN near Geneva, Switzerland, provided evidence for such a nucleon modification[1]. The modification, known as the EMC effect, manifested itself as a variation in the momentum distribution of quarks inside the nucleons embedded in nuclei. This result was verified by subsequent experiments at the SLAC National Accelerator Laboratory in Menlo Park, California[6,7], and at the Thomas Jefferson National Accelerator Facility (Jefferson Lab) in Newport News, Virginia[8].

Although the existence of the EMC effect is now firmly established, its cause has been elusive. Current thinking offers two possible explanations. The first is that all nucleons in a nucleus are modified to some extent because of the average nuclear field. The second is that most nucleons are not modified, but that specific ones are substantially altered by interacting in what are called short-range correlated (SRC) pairs over brief time periods (Fig. 1). The current paper provides definitive evidence in favour of the second explanation.

The EMC effect is measured in experiments in which electrons are scattered from a system of particles, such as a nucleus or a nucleon. The electron energies are selected so that the quantum-mechanical waves associated with the electrons have a wavelength that matches the dimensions of the system of interest. To study the interior of a nucleus, energies of 1–2 GeV (billion electronvolts) are needed. To probe the structure of a smaller system, such as a nucleon, higher energies (smaller wavelengths) are required, in a process called deep inelastic scattering (DIS). This process was central to the discovery of the quark substructure of nucleons[4,5], which resulted in the 1990 Nobel Prize in Physics[9].

In DIS experiments, the rate at which scattering occurs is described by a quantity called the scattering cross-section. The magnitude of the EMC effect is determined by plotting the ratio of the per-nucleon cross-section for a given nucleus to that for the

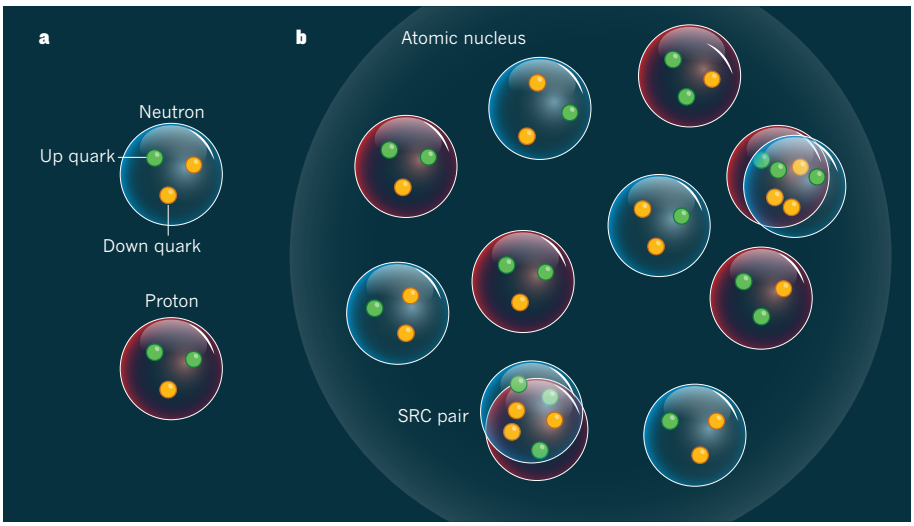

Figure 1 | Modified protons and neutrons in nuclei. **a**, Nucleons — neutrons and protons — are composed of elementary particles called quarks. Neutrons contain one 'up' quark and two 'down' quarks, whereas protons contain two up quarks and one down quark. **b**, In atomic nuclei, nucleons can briefly interact in what are known as short-range correlated (SRC) pairs. The CLAS Collaboration[2] reports evidence that these interactions alter the internal structure of the nucleons inside the nucleus.

hydrogen isotope deuterium as a function of the momentum of the quark that is struck by the electron. If there were no nucleon modification, this ratio would have a constant value of 1. The fact that this ratio decreases as a function of momentum for a given nucleus indicates that individual nucleons in the nucleus are somehow modified. Moreover, the fact that this decrease occurs more rapidly if the mass of the nucleus is increased suggests that the EMC effect is enhanced for heavier nuclei.

The CLAS Collaboration has used electron-scattering data taken at Jefferson Lab to establish a relationship between the size of the EMC effect and the number of neutron–proton SRC pairs in a given nucleus. A key feature of the work is the extraction of a mathematical function that includes the effect of SRC pairs on the scattering cross-section and that is shown to be independent of the nucleus. This universality provides strong confirmation of the correlation between the EMC effect and neutron–proton SRC pairs. The results indicate that the nucleon modification is a dynamical effect that arises from local density variations, as opposed to being a static, bulk property of the medium in which all nucleons are modified by the average nuclear field.

The authors have focused on neutron–proton SRC pairs for a particular reason: it turns out that these pairs are more common than their neutron–neutron or proton–proton counterparts. In this sense, the nucleons are isophobic; that is, similar nucleons are less likely to pair up than are dissimilar nucleons. Therefore, owing to the asymmetry in the numbers of neutrons and protons in medium-mass and heavy nuclei, the probability of protons forming neutron–proton SRC pairs increases roughly as the ratio of neutrons to protons, whereas the probability of neutrons doing this tends to plateau[10]. The CLAS Collaboration has used this specific feature to solidify its conclusions by demonstrating a clear difference between the per-proton and per-neutron EMC effects for asymmetric nuclei heavier than carbon. The fact that this distinction emerges directly from the data provides further support for the authors' interpretation that the nucleon modification arises from the formation of SRC pairs.

"A lingering question had been whether protons and neutrons were modified when inside a nucleus."

One implication of the present study is that information deduced about free neutrons from DIS experiments on deuterium or heavier nuclei needs to be corrected for the EMC effect to account for the modification of the neutrons in the nuclear medium. Another consequence concerns current and future experiments in which neutrinos or their antiparticles (antineutrinos) are scattered from asymmetric nuclei. Because protons and neutrons have different quark compositions, and because protons are more strongly affected by the in-medium modification than are neutrons, neutrino and antineutrino scattering cross-sections can show variations that could erroneously be attributed to an effect of some exotic physics — such as deficiencies in the standard model of particle physics, or possible mechanisms for understanding the asymmetry between matter and antimatter in the Universe. Before any such claim can be made, the differences in the EMC effect for protons and neutrons would have to be taken into account. ■

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CANCER

Tumours use a metabolic twist to make lipids

To survive and divide, cancer cells need a constant supply of lipid molecules called monounsaturated fatty acids. Tumours can achieve this by an unsuspected route that harnesses a metabolic pathway also used in hair follicles. SEE LETTER P.403

MARTEINN THOR SNAEBJORNSSON & ALMUT SCHULZE

Abnormal cellular metabolism is a hallmark of cancer cells, from alterations in the pathways that use glucose to aberrant activation of lipid metabolism. Lipids are a highly complex class of molecule with many cellular functions[1], one of the most important of which is to provide the building blocks for the synthesis of cellular lipid membranes. Most tissues in the adult body rely on lipids obtained from the diet or those made in the liver, but many cancer cells instead activate lipid-synthesis pathways to support their rapid proliferation[2]. This difference between normal and cancerous cells suggests a possible tumour-cell vulnerability that might be exploited therapeutically. Indeed, preventing the synthesis or modification of fatty acids (the building blocks for lipids) can reduce tumour growth in several animal models of cancer[2], although this approach has not been successful in the clinic yet. Vriens *et al.*[3] report results on page 403 that might indicate a way forward.

One reason that anticancer strategies targeting lipid metabolism have been ineffective in the clinic could be that alternative pathways compensate for the pathway that is blocked by a given drug. Vriens and colleagues have identified one such compensatory pathway in cancer cells that enables the cells to make monounsaturated fatty acids if the pathway that they normally use is blocked. This alternative pathway is known to act in oil-producing sebaceous glands in human hair follicles, and the authors' discovery has revealed that cancer cells can also harness this pathway to meet their metabolic demands.

The enzyme stearoyl-CoA desaturase (SCD) catalyses the formation of a specific double bond in palmitate, a saturated fatty acid (a fatty acid without a double bond), and this type of desaturation reaction is needed in the pathway that generates the monounsaturated fatty acids palmitoleate and oleate. These fatty acids are key building blocks for the phospholipids that are components of cellular membranes. The authors investigated the effect of an SCD inhibitor on human cancer cells grown *in vitro*. They found that some of the types of cancer cell tested were highly sensitive to SCD inhibition, and either stopped dividing or died, whereas others were insensitive and continued to divide. This was unexpected, because the predicted outcome of SCD inhibition would be the accumulation of saturated fatty acids that are toxic to cells at high concentrations[4].

Vriens *et al.* found that cancer cells that are insensitive to SCD inhibition contain high levels of sapienate, a type of a monounsaturated fatty acid that is usually produced in the sebaceous gland. Sapienate is produced[5] from palmitate by an enzyme called FADS2 (Fig. 1). FADS2 is also required[6] in mammalian tissues for the processing of omega-3 and omega-6 essential fatty acids, which are those obtained from the diet.

The authors report that, relative to its expression in normal tissue, FADS2 expression is elevated in samples from human liver