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NATURE

50 Years Ago

Medical geography could soon benefit considerably from computer graphics … Medical geography is concerned with variations in the incidence of disease in different areas and the link with possible causes connected with elements of the physical, biological and sociocultural environment. As such it is a topic in which maps should be valuable, but they are often of little use because of the time taken for such lengthy and repetitive processes as the calculation and statistical testing of attack rates, fatality rates, standardized mortality ratios and other disease indices. And it takes a long time to represent these indices in cartographic form. Computer graphics — the construction of maps and diagrams using the electronic computer — could have considerable potential in medical geography. They may, by the speed, efficiency and reliability of processing and mapping medical data, lead to a more effective use of maps.
From *Nature* 30 August 1969

100 Years Ago

The Medical Research Committee has issued a report … on the influence of alcohol on manual work and neuromuscular co-ordination. Accuracy and speed in typewriting and in using an adding machine, and accuracy in hitting spots on a target, were used as tests, and both pure alcohol and alcohol in the form of wine and spirit were employed. There was no distinct difference between the two forms of alcohol, and when very dilute (5 per cent.) the effect was about three-fourths as great as when taken strong (37–40 per cent.) for the same amount of alcohol … The degree of effect depended largely on whether the alcohol was taken on an empty stomach or with food; on an average it was twice as toxic under the former condition.
From *Nature* 28 August 1919

CONDENSED-MATTER PHYSICS

Superconductivity seen in a nickel oxide

Magnetism alone was thought to be responsible for superconductivity in copper oxides. The finding of superconductivity in a non-magnetic compound that is structurally similar to these copper oxides challenges this view. SEE LETTER P.624

GEORGE A. SAWATZKY

In 1986, scientists unexpectedly discovered that a lanthanum barium copper oxide, $La_{1.85}Ba_{0.15}CuO_4$, becomes a superconductor (has zero electrical resistance) below a relatively high temperature[1] of 35 kelvin. This result triggered one of the most intense experimental and theoretical research efforts in condensed-matter physics. Soon afterwards, many other copper oxides (cuprates) were found to superconduct at temperatures[2] of up to 133.5 K. However, after more than 30 years, there is no consensus regarding the underlying mechanism of cuprate superconductivity. On page 624, Li *et al.*[3] report that a neodymium strontium nickel oxide, $Nd_{0.8}Sr_{0.2}NiO_2$, superconducts below 9–15 K. This material has a similar crystal structure to that of the cuprate superconductors, suggesting that the authors' discovery could lead to a better understanding of superconductivity in these systems.

Superconductivity can occur in a metallic material if the usual repulsive interaction between electrons turns into an attractive one. In this scenario, the response of surrounding atoms to the charge and spin (magnetic moment) of electrons indirectly leads to electron pairing. At a low enough temperature, these paired electrons condense to form a superfluid (a state of matter that flows without friction), which exhibits zero electrical resistance[4]. The key to understanding superconductivity in a given material is to identify the mechanism that provides the 'pairing glue'.

In the conventional mechanism, the spatial displacement of atoms close to an electron forms an attractive region for another electron[4]. An analogy is that of two heavy balls on a spring mattress, whereby the indentation in the mattress made by one of the balls produces an attractive region for the other ball. However, some theoretical work has suggested that this effect is too small to account for the high-temperature superconductivity of the cuprates.

Researchers have therefore considered that the spins of moving electrons might cause deviations in the magnetic order (the ordered pattern of atomic spins) in the cuprates. With respect to the mattress analogy, these deviations represent mattress indentations, and the strong interactions between the spins of neighbouring Cu^{2+} ions represent the mattress springs. To understand how this mechanism works, consider the cuprate superconductor $La_{1.85}Ba_{0.15}CuO_4$, which is obtained from the compound La_2CuO_4 by replacing some lanthanum atoms with barium.

In La_2CuO_4, the electrons of a particular Cu^{2+} ion are prevented from moving by their strong repulsion to the electrons of surrounding Cu^{2+} ions. As a result, the material is an electrical insulator[5]. Each Cu^{2+} ion has an odd number of electrons and a net spin of 1/2. The ions have strong antiferromagnetic order, which means that the spins of neighbouring ions point in opposite directions.

When lanthanum in La_2CuO_4 is partially replaced with barium, electron vacancies called holes are introduced into the system in a process known as doping. These holes migrate to the planes of CuO_2 in the material. If their density is low enough, they act as freely moving charge carriers, resulting in metallic behaviour. The combination of a Cu^{2+} ion and a doped hole has an even number of electrons and a net spin of 0, which causes a severe disturbance in the spin directions of surrounding

Cu^{2+} ions. It is this change in the magnetic background associated with hole doping that leads to pairing.

Over the past 30 years or so, researchers have looked for superconductivity in other compounds that have planes containing spin-1/2 ions. Examples of such compounds are $LaNiO_2$ and $NdNiO_2$, which comprise alternating planes of lanthanum or neodymium and NiO_2. Ni^{1+} ions in these materials could have the same role in inducing superconductivity as do Cu^{2+} ions in $La_{1.85}Ba_{0.15}CuO_4$. Several groups have prepared $LaNiO_2$ and $NdNiO_2$ in both powder and thin-film form (see, for example, refs 6–8). However, no superconductivity (but also no sign of magnetic order) has been found.

Enter Li and colleagues. The authors grew a thin film of $NdNiO_2$ and then hole-doped this film by replacing some Nd^{3+} ions with Sr^{2+} ions. They found that the resulting material, $Nd_{0.8}Sr_{0.2}NiO_2$, superconducts at temperatures of up to 15 K. After some 30 years of trying, scientists have finally found a non-cuprate compound that has a cuprate-like structure and that exhibits superconductivity at surprisingly high temperatures. But, unlike in the cuprates, there is no sign of magnetic order in $NdNiO_2$ down to a temperature[8] of 1.7 K. The authors' discovery might therefore indicate that magnetism is not exclusively responsible for cuprate superconductivity.

However, this conclusion is based on the assumption that the cuprates and hole-doped $NdNiO_2$ have similar electronic structures. There are three reasons why this assumption might not be valid. First, in the cuprates, the holes reside mainly in the 2*p* electron orbitals of oxygen atoms. The spins of these holes couple antiferromagnetically to the spins of neighbouring Cu^{2+} ions, producing a net spin of 0. By contrast, in hole-doped $NdNiO_2$, the holes reside mostly in Ni^{1+} ions and result in Ni^{2+} ions that, in conventional oxides, have a spin of 1 (ref. 9). But perhaps the situation here is different from that of conventional oxides. X-ray spectroscopy could determine whether this is the case, if good enough samples are available.

Second, the antiferromagnetic coupling between spins might be substantially stronger in the cuprates than in $NdNiO_2$. This difference would be consistent with the absence of magnetic order in $NdNiO_2$. And third, a theoretical study[10] suggests that 5*d* electron orbitals of lanthanum atoms in $LaNiO_2$ and of neodymium atoms in $NdNiO_2$ are involved in electrical transport. If confirmed, this result could change the picture completely. In particular, local spins would be affected by being coupled to delocalized conducting electrons, as in compounds called Kondo systems[11]. Such systems exhibit a minimum in a plot of resistivity against temperature, which is observed by Li *et al.* for $NdNiO_2$.

There are therefore many issues to address before it can be concluded that the electronic structures of the cuprates and of hole-doped $NdNiO_2$ are similar. Future work should check that the nickel ions in $NdNiO_2$ are Ni^{1+} ions, determine the local symmetry and spin of the hole-doped states and explore how the temperature at which the material becomes superconducting varies with hole doping. The chemical composition of the material also needs to be verified, because unwanted hydrides or hydroxides might have formed. Nevertheless, Li and colleagues' work could become a game changer for our understanding of superconductivity in cuprates and cuprate-like systems, perhaps leading to new high-temperature superconductors. ■

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REGENERATIVE BIOLOGY

What makes flatworms go to pieces

Flatworms called planarians can break off fragments of themselves that regenerate to form new, complete worms. The molecular cues that regulate the frequency of such fission events have been revealed. **See Letter p.655**

THOMAS W. HOLSTEIN

Understanding how tissues and organs can regenerate requires an appreciation of the mechanisms and factors that organize cells and tissues, both in space and through time. Planarian flatworms are a widely used model for studying such pattern formation because pieces of these animals that are cut off can regrow missing body parts and form complete worms. Planarians also have a self-scission behaviour called fission — they stretch and contract their tail tissue, which leads to detachment of parts of their posterior body that then grow into clones. Whether or not fission occurs depends on the size of the parent worm, but the underlying molecular and cellular processes have not been well understood. On page 655, Arnold *et al.*[1] establish a method to reliably induce fission in the planarian *Schmidtea mediterranea*, and show that cell-signalling pathways involving the proteins Wnt and transforming growth factor-β (TGF-β) are key regulators of this process.

Wnt signalling has a decisive role in development and cell differentiation and is involved in many diseases[2]. The Wnt proteins are highly diverse, are found only in animals and are usually attached to a lipid chain and secreted by cells. They bind to receptor proteins of different families to activate various downstream cell-signalling cascades that regulate the levels of cytoplasmic factors — molecules that control gene expression and, thus, cell function[2,3]. Although our knowledge of the influence of Wnt signalling on tissue-pattern formation has advanced greatly in the past few years, how such patterning might be linked to specific tissue functions is still unknown.

Previous studies[4–6] in planarians have characterized a molecular framework in which self-organized gradients of Wnt proteins regulate patterning along the length of the animal (that is, along the anterior–posterior axis), and in which a gradient of TGF-β regulates patterning from its topside to its underside (along the dorsal–ventral axis). It has been suggested[7] that planarian fission is regulated by gradients in metabolic activity, molecular positional cues or neurohormone molecules along the anterior–posterior body axis. One study indicated that fission might be inhibited by the front part of the nervous system[7], and another examined the biomechanical forces and tissue properties that enable it to occur[8].

Unlike regeneration, which can be induced experimentally by cutting planarian worms into pieces, fission has been difficult to induce reliably, limiting studies on this process. However, Arnold *et al.* found that transferring worms to cultures in which food was limited and water was stagnant induced fissioning in worms longer than about 4 or 5 millimetres