When the authors superimposed an available structure of a pMHC bound to a TCRβ heterodimer onto their TCR structure, the TCRαβ heterodimers were similar in both structures. This is unsurprising, because force application is probably the major cause of structural changes driving TCR subunit rearrangements, and these structures were obtained in the absence of force, and thus capture a compact state of the TCRαβ heterodimer. The force-based TCR–pMHC recognition process differs from typical receptor–ligand interactions such as antibody–antigen interactions, which are force-independent. Harnessing energy for mechanosensing from cellular motions could explain how, unlike in force-independent interactions, TCRs can discriminate so sensitively between very similar antigens, differing by just one amino acid.

It has been suggested that the subunit rearrangements that occur when force is applied to the TCR might foster CD3 dimer dissociation, starting with CD3ζζ, and that this contributes to T-cell activation1. The authors’ structure confirms that CD3ζζ dissociation would indeed cause changes to the TCR structure in the transmembrane region.

Dong and colleagues' work provides a basis for future studies. Could structures of other αβ-type TCRs of defined antigen specificities, with or without the relevant pMHC, be obtained? Might it be possible to obtain high-resolution structures of the transmembrane segments of a TCR in a natural lipid-membrane environment to visualize the cytoplasmic tails of TCR proteins? Could conformations of the TCR complex under the application of force be imaged if new structural-analysis methods are developed?

Given the importance of the TCR for understanding immune-cell function and the use of T cells in immunotherapy to tackle cancer, information about TCR structure might bring improvements in TCR design for medical purposes. Dong and colleagues’ work is an urgent summons to immunologists interested in tumour biology and to others to consider bio-forces when assessing T cells in vitro to gauge the potential of their TCRs in vivo. Great opportunities lie ahead to make more progress in developing high-quality TCRs for clinical use.

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that metallic hydrogen might exhibit many exotic phenomena, such as high-temperature superconductivity\(^*\) (electrical conduction without resistance) or superfluidity\(^*\) (fluid flow without friction).

Over the past few decades, multiple solid phases of hydrogen have been identified by increasing the pressure to well above that at the centre of Earth. These experiments make use of devices called diamond anvil cells, in which a hydrogen sample is placed in a thin-foil gasket, which is in turn screwed between two diamonds to achieve extreme pressures in the centre of the sample.

The main approaches for analysing the compressed samples involve studying how the constituent molecules absorb infrared light (infrared spectroscopy), or observing how they scatter light (Raman spectroscopy). Such methods provide insights into the molecular structure. They have revealed that, as pressure increases, hydrogen transitions from a gaseous solid to a liquid and then to a solid phase. This phase transition occurs at a pressure of about 1.9 million times standard atmospheric pressure.

Because of these difficulties, X-ray diffraction studies of hydrogen had so far reached pressures of up to only 190 gigapascals\(^*\) (about 1.9 million times standard atmospheric pressure). This is about half the pressure that is needed to study some of the element's most exotic phases, such as the mixed phase. Ji and co-workers have addressed these challenges in a tour de force, carrying out more than a hundred experiments over a period of five years at pressures of up to 254 GPa. To increase the signal arising from hydrogen compared with that from its surroundings, the gaskets used were made of elements lighter than tungsten and rhenium. The authors also designed the experiments to yield useful data in the short time available before the inevitable diamond failure.

The results provide evidence of the long-range structure of molecular hydrogen across three high-pressure solid phases.

**The results provide evidence of the long-range structure of molecular hydrogen across three high-pressure solid phases.**

Unfortunately, using this technique to study high-pressure hydrogen has, up to now, proved extremely challenging. A major difficulty is that the ability of X-rays to scatter off electrons decreases as the mass of the atoms that make up the material decreases. Hydrogen, being the lightest element, therefore gives rise to particularly weak signals. As a result, it is hard to distinguish between the X-rays scattered by the electrons in the hydrogen sample and those scattered by the surrounding gasket, which is typically made from heavy elements (such as tungsten or rhenium). A further challenge is that the diamonds that are used to pressurize the sample break easily when exposed to X-rays, leading to loss of pressure.

**Figure 1 | Structure of hydrogen under extreme pressure.** Ji et al.\(^*\) demonstrate that the molecules in three high-pressure solid phases of hydrogen adopt a hexagonal close-packed structure. The drawing is a snapshot of where the two constantly moving protons in each molecule might be located. It also shows the charge density of the two electrons in each molecule, averaged over many snapshots.

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**Correction**

In the News & Views ‘Gerrymandering in social networks’ by Carl T. Bergstrom and Joseph B. Bak-Coleman (Nature 573, 40–41; 2019), Figure 1c incorrectly stated the numbers of blue and orange nodes that influence each participant in the blue part of the diagram. This has been corrected in the online version of the article.