The authors went on to demonstrate that their technique could be used to make multi-junction lateral heterostructures for compounds known as TMD ternary alloys (which contain one type of metal, but a mixture of sulfur and selenium atoms). To do this, the authors used a powdered mixture of $MoSe_2$ and WS_2, or of MoS_2 and WSe_2 (rather than a mixture of MoS_2 and WS_2, or of $MoSe_2$ and WSe_2, as in their first experiments). This produced high-quality, 2D lateral heterostructures consisting of domains containing the alloys $MoS_{2(1-x)}Se_{2x}$ or $WS_{2(1-x)}Se_{2x}$ (where x is a number less than 1). The optical and electrical properties of such heterostructures could now be fine-tuned by altering the alloy composition[10].

The authors conducted preliminary electrical characterizations of single-junction heterostructures produced using their method. They observed that planar p–n junctions that formed at the boundaries of electron-doped MoX_2 (made by adding a small amount of electrons to MoX_2) and hole-doped WX_2 (formed by removing a few electrons from WX_2) show good rectification behaviour, which is a further indication of the high quality of the heterostructures. They also observed photodiode behaviour — the generation of a substantial current when the junction area was illuminated by light. Having the ability to build such tiny p–n diodes and photodiodes holds great potential for future efforts to miniaturize electronic and optoelectronic devices.

Sahoo and co-authors' method opens up a promising route for the synthesis of high-quality lateral heterostructures. Insights into the thermodynamics and chemistry operating at the atomic scale in this process are now needed to develop the ability to prepare heterostructures involving any desired combination of TMDs. Moreover, research must be performed to work out why interfaces that switch from MoX_2 to WX_2 are not as sharp as those in which WX_2 switches to MoX_2, and to optimize the production of sharper MoX_2–WX_2 interfaces.

It will also be important to explore variations of the technique that might allow the growth of lateral heterostructures between MX_2 and other exotic 2D materials, including those that have metallic, semi-metallic or superconducting properties[1,2], to make new types of device. The availability of complex TMD heterostructures — including those that have several junctions in series — should also allow the exploration of fundamental physics, such as the mechanism by which charge transfer occurs at interfaces. Lastly, Sahoo and co-workers' technique will enable the development of proof-of-concept prototype devices, to advance our knowledge of the viability and scope of 2D technologies. ■

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EVOLUTIONARY DEVELOPMENTAL BIOLOGY

More than one way to a central nervous system

Have the molecular mechanisms that are linked to the developmental organization of centralized nervous systems evolved once or multiple times? Evidence from nine animal species points to the latter. SEE ARTICLE P.45

CAROLINE B. ALBERTIN & CLIFTON W. RAGSDALE

Animal nervous systems come in many shapes and sizes, ranging from a handful of neurons to large, complex brains. A key question has been whether the centralized nervous systems found in many bilaterally symmetrical animals (bilaterians), which include vertebrates and insects, share a common evolutionary origin, or evolved more than once. At a superficial level, both flies and vertebrates boast a brain connected to a single nerve cord that extends into the trunk. In addition, molecular data indicate that key regulatory genes are deployed similarly during nervous-system development in vertebrates, flies[1] and another bilaterian, a segmented worm