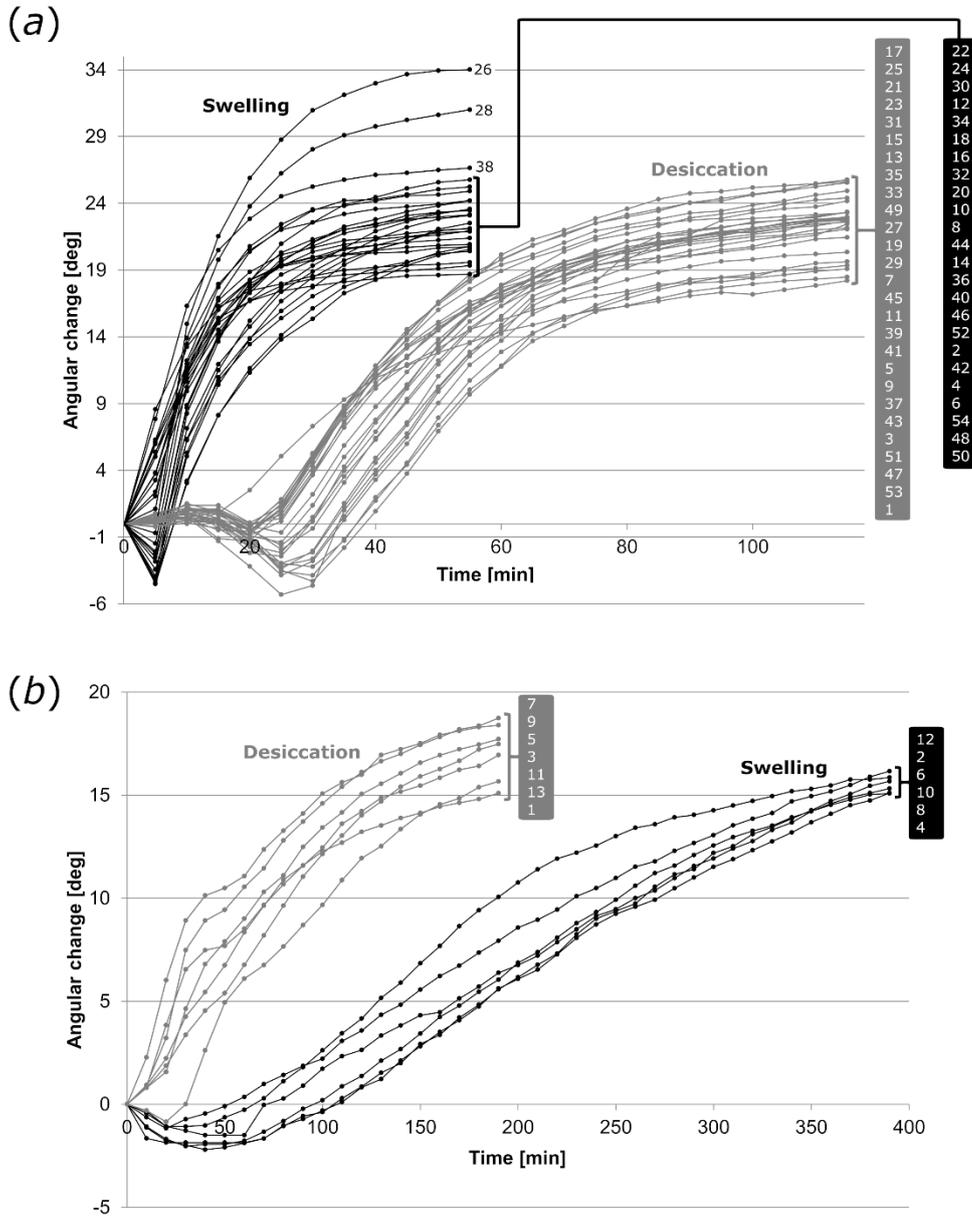


**4D pine scale: biomimetic 4D printed autonomous scale and flap structures capable of multi-phase movement**

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*Philosophical Transactions of the Royal Society A*



**Supplementary figure S1.** Repeated motions of natural and 4DP scales. Angular changes [deg] over time [min] are depicted for alternating swelling (black) and desiccation-driven movements (grey). The numbers situated next to the black curves and in the grey and black boxes on the right indicate the respective numbers of the successive movements. Each first recorded movement (1, grey box) was driven by desiccation in a drying oven after complete initial scale wetting, the second motion (2, black box) was due to swelling under water in an aquarium, and so on. (a) Repeated motion of a Bhutan pine (*P. wallichiana*) cone scale (54 movements in total: 27 by swelling, 27 by desiccation). (b) Repeated motion of a 4D printed scale (13 movements in total: six by swelling, seven by desiccation).