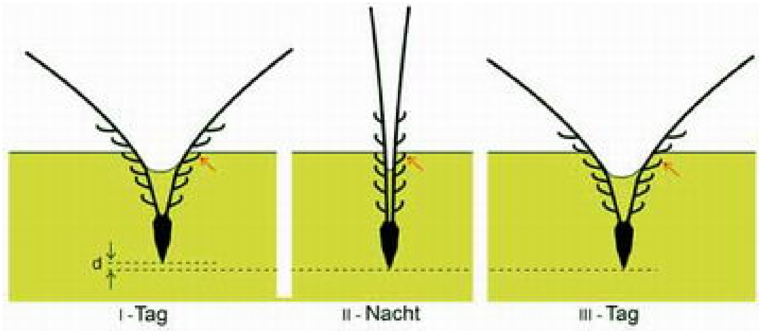
Wild wheat shows its muscles



A seed drill: I The seed and part of the awn in the soil (the red arrow is pointing to a silica hair). II When humidity rises during the night, the awns become erect and push the grain into the soil, because the hairs prevent any movement out of the soil. III As the airs dries the next day, the awns bend apart again. This tensions the drill that will push the seed further into the ground during the following night. Image: Planck Institute of Colloids and Interfaces

A grain of wild wheat has everything required for plant propagation - even tools for drilling into the soil. It uses its two awns for this: in the dry daytime air, these bristles bend outwards. At night, dampened by the dew, they straighten. Over several days, this movement, similar to the swimming strokes of a frog, pushes the grain into the soil.

This discovery was made by scientists from the Max Planck Institute of Colloids and Interfaces. The fine, barb-like silica hairs on the outside of the awn ensure that the seed can only move downwards. A similar mechanism could use fluctuating humidity levels to drive micromachines (*Science*, 11 May 2007).

The awns of the wild wheat are both steering mechanism and engine at the same time. They guide a ripe grain to the earth with the pointed end downwards by providing it with the correct balance as it falls. Once the grain is sticking in the earth, the two bristles transform themselves into a drill and drive the grain into the tilth. This action is powered solely by the air which in the habitat of the wild wheat plant is dry during the day and damp during the night. However, domesticated wheat has lost the ability to perform this trick

During the day when it is dry, the two awns bend outwards; in the dampness of the night, they bend towards each other. This is because the cap of the awn, the side facing towards the other awn, reacts to humidity in a different way from the side facing outwards, the ridge. This is due to the construction of its cellulose fibres, which biologists call fibrils. In the cap, the cellulose fibrils are all parallel to the awn. In the lower section of the ridge of the awn, they are arranged randomly. That not only makes the ridge ten times as rigid as the cap, but also makes the awn into a simple drill. Under damp conditions, all the fibrils swell widthways. This means however that the awn cap only swells on the side where all the fibres are arranged lengthways. The ridge of the awn on the other hand stretches as some of the fibres are also at right angles to the bristle, thus making the whole awn stand up.

Rivka Elbaum, a scientist who was involved in the project and who is a Humboldt fellow at the Max Planck Institute of Colloids and Interfaces explains: "The mechanism is similar to that with which pine cones open. The central area of the ridge functions like a muscle, bending and straightening the awns." However, on its own, the muscle is not sufficient to allow the grains to burrow into the soil. That only happens with the help of the fine silica hairs on their outer side. The hairs act as barbs which we can also feel. If you run your finger along the awn away from the grain, the awn feels smooth; towards the grain, the barbs offer tangible resistance.

These tiny silica hairs prevent the awns from pushing themselves out of the soil when the bristles straighten during the night. They can only move into the earth and thus push the grain a little deeper every night. The scientists discovered this by wrapping a grain of wheat and the lower section of its awns in a cloth. The silica hairs caught on the cloth. When the researchers alternately raised and lowered the humidity, the grain moved a little deeper into the cloth with every cycle.

"Wild wheat uses this mechanism to disperse itself," says Professor Peter Fratzl, Director at the Max Planck Institute in Potsdam and Head of the Research Group. The seed uses its swimming movements to propel itself across the ground, as well as into the soil. "We have already built simple machines and muscles modelled on the awn mechanism to convert variations in humidity to movement." Fratzl sees this as a potential contribution to the use of renewable energy. "I’m fascinated by the possibility of converting solar energy to movement in this way." After all, it is the heat of the sun that dries the air which the dew dampens during the night.

Citation: Rivka Elbaum, Liron Zaltzman, Ingo Burgert, Peter Fratzl, The Role of Wheat Awns in the Seed Dispersal Unit, *Science*, 11 May 2007

Source: Max Planck Institute of Colloids and Interfaces