the kinetics of crystalline cellulose hydrolysis by cellulases has been investig-
gated intensively so far, the mechanism of crystalline cellulose degradation
still contains many mysteries. The main reason for the difficulty to understand
the mechanism is the lack of analytical methods to monitor the enzymatic re-
action at a solid/liquid interface. We here use high-speed atomic force micro-
copy (HS-AFM) to reveal how the enzyme molecules behave on the substrate.
When glycoside hydrolase family 7 celllobiohydrolase from Trichoderma rees-
sei (TrCel7A) was incubated with crystalline cellulose, many enzyme mole-
cules moved unidirectionally on the cellulose surface with the velocity of
7.2 ± 3.9nm/sec but at some point the movement of individual molecules
was halted, leading to appearance of traffic jams of enzyme molecules. The
present results suggest that solving the traffic jams of productively bound cel-
lulose is a key to enhance the hydrolytic activity of cellulases on crystalline

2979-Pos Board B749
Towards Tracking Moving Single Molecules in Atomic Force Microscopy
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The atomic force microscope (AFM) is an invaluable tool for observing bio-
logical systems, due in part to its incomparable resolution as well as its ability
to observe systems in their physiological environments and to measure me-
chanical properties directly. Its slow imaging rate, however, greatly reduces
its applicability in recording fast-changing mechanisms. Such studies are of
critical importance. For example, investigating the dynamics of protein motors
and other macromolecules is essential for understanding and treating a variety
of genetic diseases. Motivated by this, we are developing an approach to AFM
centering on tracking rather than imaging. The scheme is primarily designed
to follow the motion of a single macromolecule moving along a biopolymer.
In approaching this problem, we consider that the presence of the moving
macromolecule on its track results in a change in the apparent width of the track.
Based on this, we have developed a high-speed width detector that rap-
idly determines the width by detecting the two edges of the sample during a
fast scan. As a result, the motion of these single macromolecules is derived
directly from tracking rather than a sequence of images. Such an approach
promises a much higher temporal resolution than is achievable in time-lapse

2980-Pos Board B750
Encased Cantilevers and Alternative Scan Algorithms for Ultra-Gantle
High Speed Atomic Force Microscopy
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Live cells and many biological samples readily deform under the minimum
force required to perform an AFM measurement precluding imaging at high
temporal and spatial resolution. We reduced the force noise of the measurement
by building a protective encasement around the cantilever. This keeps the can-
tilever dry reducing the fluid viscosity and damping but allows the tip to
probe the sample in solution. Encased cantilevers have exceptionally high res-
onance frequency, Q factor, and detection sensitivity and low force noise en-
abling gentle high speed imaging. Present raster scan techniques are poorly
matched to the instrument limitations of Atomic Force Microscopy making
data collection slow. We have used advanced image processing tools
such as inpainting to recover high-resolution images from sparse quickly
collected images to improve temporal resolution without applying more
force or increasing bandwidth. We are also using spiral scanning to in-
crease temporal resolution by allowing higher tip velocities without
distortion. Inpainting or interpolation is used to quickly create images from
the nongrided data.