Supplementary Videos

Supplementary Video 1, *associated with Figure 1*:
Phase contrast time-lapse acquisition of a sample keratocyte undergoing a persistent turn. Scale bar in bottom left indicates 10 microns. Time elapse in minutes is indicated on top right.

Supplementary Video 2, *associated with Figure 3*:
Time-lapse acquisition of a sample keratocyte showing both phase contrast images (*left*) and wide-field fluorescence of myosin-II regulatory light chain (*right*) in a turning cell. As the cell turns myosin accumulates on the outer wing of the turning cell. Scale bar in bottom right indicates 20 microns. Time elapsed in minutes is indicated on bottom right.

Supplementary Video 3, *associated with Figure 4*:
Phase contrast time-lapse acquisition of a turning cell (*left*) with wide-field fluorescence of actin-binding phalloidin speckles shown in the frame of reference of the cell (*center*) and substrate (*right*). Calculated flow field of the actin meshwork from the phalloidin speckles are overlaid on the fluorescent images. In the cell frame of view, actin flows asymmetrically towards the outer side. In the lab frame of view, there is increased centripetal flow on the outer-side of the cell. Scale bar in bottom right indicates 20 microns. Time elapse in minutes is indicated on top right.

Supplementary Video 4, *associated with Figure 7*:
Phase contrast time-lapse acquisition of a sample keratocyte crossing boundaries between high adhesion (*light regions*) and low adhesion (*dark regions*). When a differential in adhesion across the rear of the cell developed the cell would turn towards the side with higher adhesion to the substrate. Scale bar in bottom left indicates 10 microns. Time elapsed in minutes is indicated on top right.

Supplementary Video 5, *associated with Figure 7*:
Simulated behavior of a migrating keratocyte from the free-boundary model of cell migration, where the cell is exposed to fluctuating changes in adhesion strength without feedback between centripetal flow and actin filament strength. This produces cells that follow a wandering trajectory with mild shape and cytoskeletal asymmetries. Actin flow (*top left*), myosin distribution (*bottom left*), traction forces (*top right*) and adhesion strength to the substrate (*bottom right*) are presented for each time point in the simulation (*red clock*). Scale bar indicates 10 microns.

Supplementary Video 6, *associated with Figure 7*:
Simulated behavior of a migrating keratocyte from the free-boundary model of cell migration, where the cell is exposed to local increase in myosin contractility at region marked by blue circle for the first 8 minutes of the simulation as marked by blue dot by clock. Asymmetric myosin induces the cell to turn away from the side of increased contractility, matching experimental predictions. Actin flow (*top left*), myosin distribution (*bottom left*), traction forces (*top right*) and adhesion strength to the substrate (*bottom right*) are presented for each time point in the simulation (*red clock*). Scale bar indicates 10 microns.

Supplementary Video 7a, *associated with Figure 7*:
Simulated behavior of a migrating keratocyte from the free-boundary model of cell migration, where the cell migrates towards a boundary separating a high adhesion substrate (*left*) from a low adhesion substrate (*right*). As in experimental data the cell turns toward the side of high adhesion (*left*) when a differential in adhesion is created across the rear of the cell. Actin flow (*top left*), myosin distribution (*bottom left*), traction forces (*top right*) and adhesion strength to the substrate (*bottom right*) are presented for each time point in the simulation (*red clock*). Scale bar indicates 10 microns.

Supplementary Video 7b, *associated with Figure 7*:
Simulated behavior of a migrating keratocyte from the free-boundary model of cell migration, where the cell migrates towards a boundary separating a low adhesion substrate (*left*) from a high adhesion substrate (*right*). As in experimental data, the cell turns toward the side of high adhesion (*right*) when a differential in adhesion is created across the rear of the cell. Actin flow (*top left*), myosin distribution (*bottom left*),

traction forces (*top right*) and adhesion strength to the substrate (*bottom right*) are presented for each time point in the simulation (*red clock*). Scale bar indicates 10 microns.

Supplementary Video 8, *associated with Figure 7*:
Simulated behavior of a migrating keratocyte from the free-boundary model of cell migration, where the cell is exposed to local increase in protrusion at regions marked by red circles starting at the 2nd minute of simulation as marked by red dot by clock. Asymmetric protrusion deforms the shape and changes the direction of travel but does not induce the cell to turn. Actin flow (*top left*), myosin distribution (*bottom left*), traction forces (*top right*) and adhesion strength to the substrate (*bottom right*) are presented for each time point in the simulation (*red clock*). Scale bar indicates 10 microns.

Supplementary Video 9, *associated with Figure 7*:
Simulated behavior of a migrating keratocyte from the free-boundary model of cell migration, where the cell is exposed to fluctuating changes in adhesion strength that become locked in due to the feedback loops that define cell turning. This produces cells that follow a persistent trajectory with expected shape and cytoskeletal asymmetries. Actin flow (*top left*), myosin distribution (*bottom left*), traction forces (*top right*) and adhesion strength to the substrate (*bottom right*) are presented for each time point in the simulation (*red clock*). Scale bar indicates 10 microns.