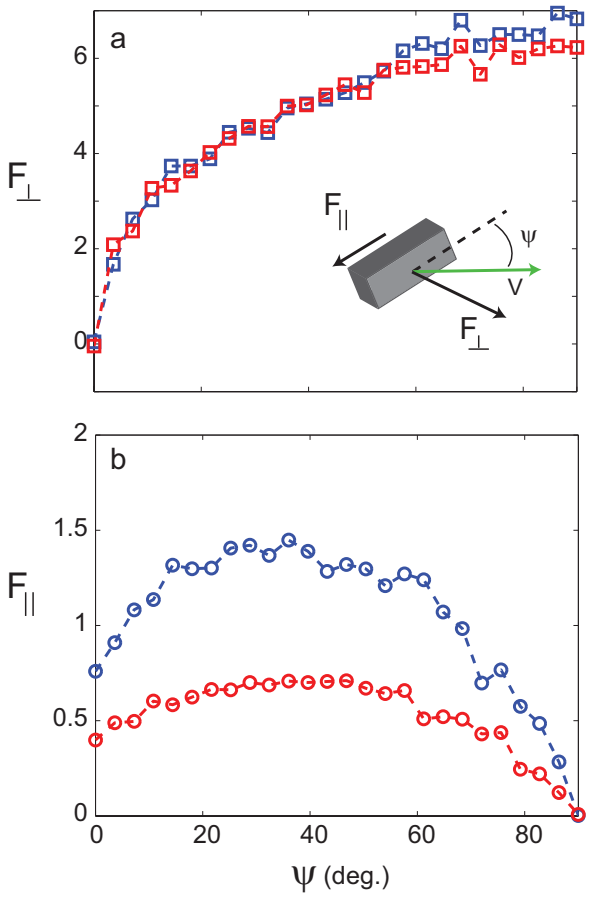

Figure S1: (a) Perpendicular and (b) parallel forces on a square cross-section rod (width & height = 16 mm, length = 40 mm) dragged through 3 mm glass closely packed particles in simulation as a function of the angle,ψ, between the velocity direction and the rod axis. The blue markers correspond to forces on a rod with body-grain coefficient of friction of 0.27 and the red markers correspond to a body-grain friction of 0.13. Courtesy of Yang Ding.

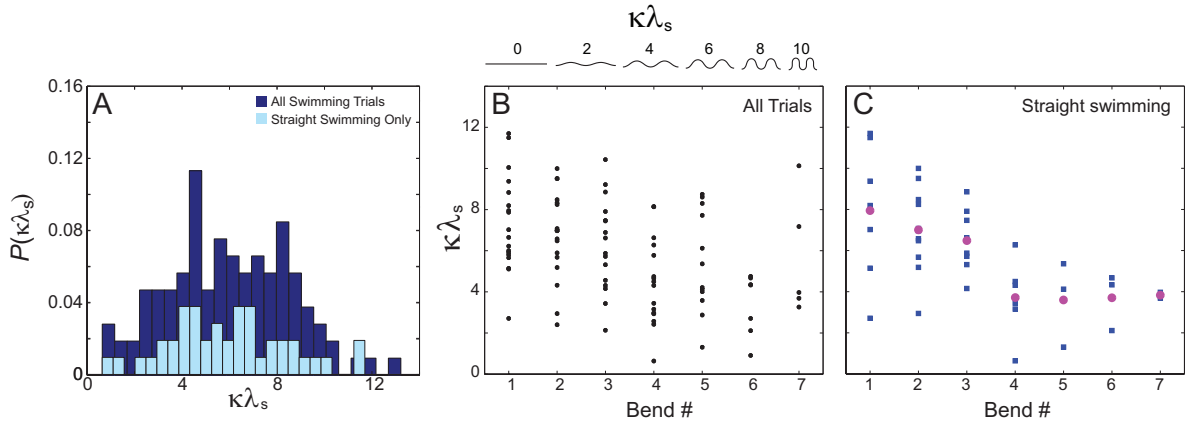

Figure S2: The local relative curvature, $\kappa\lambda_s$, during straight and turning snake swimming. (A) Distribution of $\kappa\lambda_s$ for all trials (dark bars) and for 'straight' swimming (light blue bars) in which the average body moves along a linear trajectory. In this analysis, each local curvature measured within a trial and across trials is considered an independent datum. (B) $\kappa\lambda_s$ and corresponding bend number for all trials (both turning and straight). Bend number corresponds to the number of half wave lengths along the body after the animal has entered the medium (i.e. bend number 1 is the first half wave visible in X-ray in which that portion of the body is buried). Because the animal is moving deeper into the media, higher bend number corresponds to that portion of the body having a deeper burial depth. (C) $\kappa\lambda_s$ vs. bend number during straight swimming *only*. Magenta circles show the average $\kappa\lambda_s$ at each bend for straight swimming. The maximum $\kappa\lambda_s$ decreased for straight swimming while the minimum stayed approximately constant with increasing bend number.

Movie 1. (A) Shovel-nosed snake (*Chionactis occipitalis*) burying into dry granular media composed of 0.3 mm diameter glass particles. (B) Video with panels showing shovel-nosed snake burial and swimming, from left to right: Visible light (left panel), x-ray with overlay with B-Spline fit to the body midline (mid panel) derived from tracked markers (right panel). All video played real time.

Table S1: Means and $\pm$ s.d. for kinematic parameters.

Measured Parameters	symbol	*C. chionactis*			*S. scincus*		
		CP	LP	T-test	CP	LP	T-test
Relative curvature*	$\overline{\kappa\lambda_s}$	6.2 ± 1.3	6.0 ± 1.3	$P > 0.84$	7.4 ± 1.3	7.5 ± 0.8	$P > 0.75$
Undulation number	$\overline{\xi}$	3.50 ± 0.52	3.53 ± 0.85	$P > 0.93$	1.04 ± 0.14	0.99 ± 0.06	$P > 0.13$
Average slip angle	$\overline{\beta_s}$	6.0 ± 1.1	6.9 ± 1.6	$P > 0.2$	21.9 ± 4.0	21.2 ± 3.5	$P > 0.51$
Undulation Efficiency	η_u	0.60 ± 0.06	0.57 ± 0.09	$P > 0.48$	0.28 ± 0.05	0.27 ± 0.08	$P > 0.63$

*Relative curvature was averaged across all bends visible along the body.
The mean and s.d. represent across trial values