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Enhancement of Absorption by Micro-Mixing induced by Villi Motion YANXING WANG, JAMES BRASSEUR, GINO BANCO, Penn State Univ — Motions of surface villi create microscale flows that can couple with lumen-scale eddies to enhance absorption at the epithelium of the small intestine. Using a multigrid strategy within the lattice-Boltzmann framework, we model a macro-scale cavity flow with microscale "villi" in pendular motion on the lower surface and evaluate the couplings between macro and micro-scale fluid motions, scalar mixing, and uptake of passive scalar at the villi surface. We study the influences of pendular frequency, villous length, and villous groupings on absorption rate. The basic mechanism underlying the enhancement of absorption rate by a villous-induced "micro-mixing layer" (MML) is the microscale "pumping" of low concentration fluid from between groups of villi coupled with the return of high concentration fluid into the villi groups from the macroscale flow. The MML couples with the macrosacle eddies through a diffusion layer that separates micro and macro mixed layers. The absorption rate increases with frequency of villi oscillation due to enhanced vertical pumping. We discover a critical villus length above which absorption rate increases significantly. The absorption is influenced by villus groupings in a complex way due to the interference between vertical and horizontal geometry vs. MML scales. We conclude that optimized villi motility can enhance absorption and may underlie an explanation for the existence of villi in the gut. [Supported by NSF]

James Brasseur
Penn State Univ

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