Table S1: Physical, Chemical, and Biological Parameters. Default simulation parameters are used in all simulations unless otherwise stated.

Parameter	Symbol	Value	Units	Description	Ref.
Simulation Physical Properties					
Simulation Dimensions		300 x 100 x 300	μm	Radial and azimuthal periodic boundary conditions. Zero-gradient boundary conditions elsewhere	
Parcel Dimensions		5 x 20 x 5	μm	Fluid parcel size	
Simulation Volume	V	9 (10)^6	μm^3		
Simulation Radius from HARV	r	(10)^5	μm	Maximum distance of simulation box to radius of rotation	
Fluid Density	ρ_f	1.00	$\frac{pg}{\mu m^3}$	Density of media	[54]
Fluid Kinematic Viscosity	ν	0.9	$\frac{\mu m^2}{\mu s}$	Constant viscosity of media	[54]
HARV Rotation Rate		10	R.P.M.		
Gravitational Field Strength	g	9.81 (10)$^{-6}$	$\frac{pg}{\mu s^2}$		
Integration Timesteps:			μs		
Particle Timestep	dt	150-250	μs		
Fluid Timestep	dt	150-250	μs		
Chemical Timestep	dt	150-250	μs	Higher diffusion requires a smaller timestep	
Biological Timestep	dt	150-250	μs		
Temperature	T	310.15	K	Constant	[20]

Simulation Chemical Properties					
Mass Transfer Coefficient	h_s	variable	$\frac{\mu m}{\mu s}$		
Methionine Diffusivity	$D_{e,m}$	Low: 3.1 $(10)^{-4}$ Mid: 5.0 $(10)^{-4}$ High:7.6 $(10)^{-4}$	$\frac{\mu m^2}{\mu s}$	Fick's Law diffusion constant	[51, 55]
Acetate Diffusivity	$D_{e,a}$	Low: 4.9 $(10)^{-4}$ Mid: 5.0 $(10)^{-4}$ High:12. $(10)^{-4}$ ^{4}	$\frac{\mu m^2}{\mu s}$	Fick's Law diffusion constant	[51, 55]
Bulk Media Diffusivity	$D_{e,l}$	Low: 2.1 $(10)^{-4}$ Mid: 5.0 $(10)^{-4}$ High:5.1 $(10)^{-4}$	$\frac{\mu m^2}{\mu s}$	Fick's Law diffusion constant	[56]
Starting Methionine Quantity		0.00001/Y_{ES}	$\frac{pg}{\mu m^3}$	To kickstart metabolism, total Simulation Starting Quantity Distributed Equally among all Cells, in terms of Biomass Equivalents of *E*.	
Starting Acetate Quantity		0.00001/Y_{SS}	$\frac{pg}{\mu m^3}$	Starting Quantity in terms of Biomass Equivalents of *S*.	
Acetate Coefficient of Solutal Specific Gravity	β_1	0.85		Linearly interpolated coefficient that converts acetate concentration (cell equilvalent) to fluid density	[57]
Methionine Coefficient of Solutal Specific Gravity	β_2	0.003		Linearly interpolated coefficient that converts methionine concentration (cell equilvalent) to fluid density	[58]
Bulk Media Coefficient of Solutal Specific Gravity	β_3	0.39		Linearly interpolated coefficient that converts lactose concentration (cell equilvalent) to fluid density	[59]
Bacterial Cell Physical/Mechanical Properties					
Cell size	*d*	1.12	pg	Diameter, based on effective volume of a rod shaped *E. coli*	[60]

Cell Volumetric density	ρ_s	1.08	$\frac{pg}{\mu m^3}$	Needed for Bouyancy	[60]
Young's Modulus of Elasticity	E	50,000	$\frac{pg}{\mu m \mu s^2}$	Required LIGGGHTS® parameter	[46]
Coefficient of Restitution	e	0.05		Minimum Required LIGGGHTS® collision parameter	
Poisson Ratio	ν	0.4		Required LIGGGHTS® parameter	[46]
Surface Energy Intensity	γ	0	$\frac{pg}{\mu s^2}$	Cell – cell Adhesion Energy	
Coefficient of Friction	μ_f	0		Cell – cell Sliding Friction Coefficient	
***E. coli* Biological Properties**					
Population Density		1.11 (10)$^{-10}$	$\frac{cells}{\mu m^3}$	Starting Density of Coculture	[20]
Maximal growth-rate	$\mu_{max,E}$	1.82 (10)$^{-11}$	μs^{-1}	Monod Kinetic Maximal Growth Rate	[29, 61]
Biomass Yield (Methionine)	Y_{ES}	70.2	$\frac{pg}{pg}$	Biomass/Methionine Mass	[17, 48]
Biomass Yield (Lactose)	Y_{ES}	1.5	$\frac{pg}{pg}$	Biomass/Lactose Mass	[61, 62]
Product Yield	Y_{PS}	31.9	$\frac{pg}{pg}$	Acetate/Methionine Mass	[29, 63]
Half-saturation constant	K_S	variable	$\frac{pg}{\mu m^3}$	Monod Kinetic Substrate Concentration of Half-maximal Growth Rate	[48]
***S. enterica* Biological Properties**					
Population Density		1.11 (10) $^{-10}$	$\frac{cells}{\mu m^3}$	Starting Density of Coculture	[20]
Maximal growth-rate	$\mu_{max,S}$	9.09 (10)$^{-12}$	μs^{-1}	Monod Kinetic Maximal Growth Rate	[61]
Biomass Yield	Y_{SS}		$\frac{pg}{pg}$	Biomass/Acetate Mass	[61]

		0.46			
Product Yield	Y_{PS}	0.058	$\frac{\text{pg}}{\text{pg}}$	Methionine/Acetate Mass	[29, 61]
Half-saturation constant	K_S	variable	$\frac{\text{pg}}{\mu\text{m}^3}$	Monod Kinetic Substrate Concentration of Half Maximal Growth Rate	[48]
Non-dimensional Numbers					
Reynolds Number	Re	$\frac{u_f d}{\nu}$		Ratio of Inertial to Viscous Forces	
Schmidt Number	Sc	$\frac{\nu}{D_m}$		Ratio of Momentum Diffusivity to Mass Diffusivity	
Sherwood Number	Sh	$\frac{h}{D_m/d}$		Ratio of Convective to Diffusive Mass Transport	

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Table S2: Simulation Details and Results. Simulation input files can be found in File S1.

File Names	Spatial Structure & Diffusivity	Population Size & E:S Ratio	Notes	Steady % Growth Rate
3.1.1a-c	Manually Placed, Intermediate Diffusion	2 cells, 1 E : 1 S	0.01_starting metabolites a. (1 μm distance) b. (50 μm distance) c. (218 μm distance)	 4.7 4.6 4.4
3.1.1d, 3.1.1e/3.1.2a/3.1.3f	Manually Placed, High Diffusion	3 cells, 2:1	0.00001_starting metabolites d. (207 μm distance) e. (1 μm distance)	 0.8 4.9
3.1.2b-c,	Randomly Distributed High Diffusion	b. 2000 cells 1.86:1 c. 283 cells 1.86:1		27.2 29.4
3.1.2c2, 3.1.2e	Spherical gaussian distributed High Diffusion	C2. 283 cells 1.86:1 E. 100 cells 1.86:1		27.8 24.5
3.1.2d/3.1.3a/3.2.3e 3.1.3b-e	Tightly packed Sphere, High diffusion	1:86:1 a. 2000 cells b. 1000 cells c. 500 cells d. 283 cells e. 99 cells f. See above		35.4 29.3 28.8 26 23.4

3.1.3g/3.2.3c 3.1.3h-l	Tightly packed Sphere, Low diffusion	1:86:1	29.4
		g. 2000 cells	29.0
		h. 1000 cells	28.6
		i. 500 cells	27.8
		j. 283 cells	24.5
		k. 99 cells	6.6
		l. 3 cells	
3.1.4a/3.2.3a 3.1.4b	Intermediate diffusion a. Gaussian Distributed Sphere b. Randomly distributed	2000 cells, 44 E : 1 S 0.00000001 starting metabolites 190% λ_E and 333% λ_S Measured S. Growth	50 ~0
3.2.1/3.2.3b		Same conditions as 3.1.4a plus RWV hydrodynamics	7.6
3.2.2a-b	Gaussian Distributed Spheres Intermediate diffusion	2000 cells, 18 E : 1 S 0.00001 starting metabolites 190% λ_E and 333% λ_S Measured S. Growth (218 μm distance) a. Microgravity b. RWV	not steady (Figure 8b) not steady (Figure 8b)

3.2.3c-g	Tightly packed spheres, c-e. Low Diffusion f-g. High Diffusion	2000 cells, 1.86 E : 1 S	b. RWV Liquid colony c. RWV Solid colony d. Microgravity e. RWV Solid Colony f. Microgravity λ_E and λ_S varies	Growth depends on product yield (Figure 9)
3.3.1a-b	Intermediate Diffusion a. Flat cylindrical on floor b. Spherical on floor	2000 cells, 44 E : 1 S	1g Gravity	Not steady state (Figure 8b)