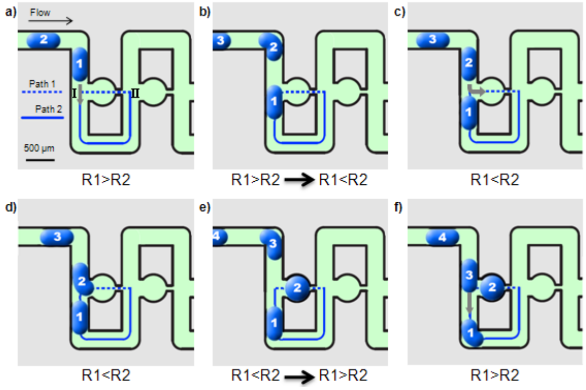
Supplementary Information

Part 1

The droplets are captured and immobilized by the change of flow resistance along the microchannels, which results from the movement of the constricted droplets. As the presence of surfactant in the oil, the interfacial tension of water-oil is greatly reduced, so the surface tension effects of moving droplets were neglected in the following resistance calculation. [1, 2] The principle of the droplet trapping process is shown in Supplementary Fig. 1. As shown in the figure, there are two flow paths from junction Ⅰ to Ⅱ which are named as Path 1 (the straight channel) and Path 2 (the square channel), and the flow resistances along them are defined as R1 and R2, respectively.



Supplementary Fig. 1 Principle of the droplets captured in the traps array. The successive generated droplets are numbered sequentially. The two paths from junction Ⅰ to Ⅱ are named as path 1 and path 2, and the flow resistances along them are defined as R1 and R2, respectively. Process for trapping one droplet is described as following: a-b) R1>R2, droplet 1 at junction Ⅰ will flow into path 2; c-e) R2>R1, droplet 2 at junction Ⅰ will flow into path 1 and be trapped; f) R1>R2, droplet 3 at junction Ⅰ will flow into path 2 and enter the next trapping process.

As shown in Fig. 2a, when Path 1 and Path 2 are both filled with oil, the equation described by Zimmermann[3] is used. The flow resistance of rectangular micro-channels is a geometric term with a Fourier series and can be approximated by a linear term

$$R_F = \left[\frac{1}{12}\left(1+\frac{5}{6}\alpha\right)\frac{abR_H^2}{L}\right]^{-1}$$

Here R_F is the total flow resistance of the flow path, L is the length of the microchannel, a and b are the depth and width of the microchannel respectively, α is either $\frac{a}{b}$ or $\frac{b}{a}$ such that $0 \le \alpha \le 1$, and R_H is the hydraulic radius of the microchannel,

$$R_H = \frac{2A}{P} = \frac{ab}{a+b}$$

with P being the perimeter and A the area of the cross section of the microchannel. In our calculation, the minor losses due to bends, widening and narrowing, etc. are ignored. So

$$\frac{R1}{R2} = \left(\frac{L_1}{L_2}\right)\cdot\left(\frac{a_1+b_1}{a_2+b_2}\right)^2\cdot\left(\frac{a_2}{a_1}\right)^3\cdot\left(\frac{b_2}{b_1}\right)^3\cdot\left(\frac{1+\frac{5}{6}\alpha_2}{1+\frac{5}{6}\alpha_1}\right)$$

For Path 1, L_1 is assumed to be the length of the narrow channel to simplify analysis. This is valid because most of the pressure drop occurs along the narrow channel. The dimensions and flow resistances of Path 1 and Path 2 are listed below:

	L	a	b	α	R1/R2
Path 1	90	185	45	0.24	29.7
Path 2	255	185	300	0.62	

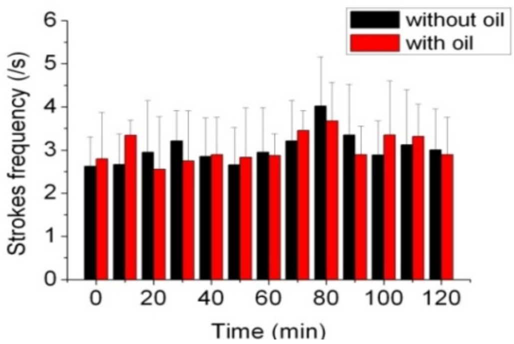
From the table, we can conclude that when Path 1 and Path 2 are both filled with oil, the flow resistance along Path 1 is higher than that of Path 2, namely, R1>R2. Thus, droplet 1 reaching junction I will be driven into Path 2 (Fig. 2b).

As shown in Fig. 2c, after droplet 1 flows into Path 2, as it is large enough to rub against the walls with a friction, R2 will increase significantly and exceed R1. In this case, the droplet 2 reaching junction I will be driven into Path 1 (Fig. 2d), blocked by the narrow channel and immobilized in the circular trap (Fig. 2e).

Once droplet 2 is trapped in Path 1, R1 will become much higher than R2, and droplet 3 will be driven into Path 2 and enters the next trapping process following droplet 1 (see Fig. 2f).

Part 2

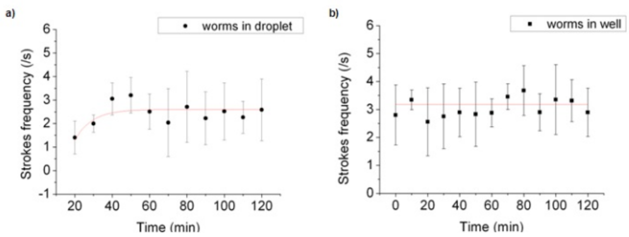
In order to test the toxicity of n-hexadecane as the continuous phase to worms, a worm suspension of synchronized L1 N2 worms with a density of 1 worms /uL were added into six wells (100 uL /well) of a 96-well plate, and then 50 uL n-hexadecane was carefully added into three wells among them, thus, in half of the wells, worm suspension was under the coverage of a n-hexadecane oil layer. The real-time movement of about 20 worms in each well (with and without oil) were recorded by a high-resolution CCD camera mounted onto a stereozoom microscope in a format of 15fps@800×600. The recording was carried out for 15-20 seconds of 2 hours with intervals of 10 minutes. It was found that the worms moved actively in wells both with and without oil in the test period of time. From Supporting Figure 1, there is no significant difference between the stroke frequencies of worms incubated with and without n-hexadecane, indicating that n-hexadecane is nontoxic to worms in the test period of time.



Supplementary Fig. 2 Strokes frequency of N2 worms as a function of incubation time with and without the coverage of n-hexadecane oil layer.

Part 3

In order to characterize the effects of the droplet microenvironment (like limited supply of oxygen and nutrition) on the individual N2 worms, the real-time movements of six worms (selected randomly, the number of selected worms was limited by the resolution and sensor size of our CCD camera) within droplets were recorded and investigated after encapsulation for 120 minutes. In the meantime, certain numbers of worms in the same stage were added into 96-well plates for comparison. It was found that the worms moved actively both in droplets and well-plates format in the test period of time. The averaged stroke frequency was 2.6/s in droplets as compared to 3.1/s in well-plates (shown in Supporting Figure 2). There was no significant difference in terms of movement between the droplet and well-plate environment in the test period of time, indicating that the processes of droplet generation and capture cause no significant damage to the worms. The slight change of them may be due to the difference between droplet and well-plate environment (in droplet, individual worms are less effected by the others), and the stroke frequency of worms in droplets increases at the beginning of culturing maybe caused by the disturbing of the microenvironment in encapsulating and trapping processes.



Supplementary Fig. 3 Strokes frequency of N2 worms as a function of incubation time. a) in droplet; b) in well.

1. H.-C. Chang, in *The MEMS Handbook*, ed. M. Gadelhak, CRC Press, 2001, pp. 305-317.
2. J. Ratulowski and H.-C. Chang, *Phys. Fluids A*, 1989, **1**, 1642-1655.
3. M. Zimmermann, H. Schmid, P. Hunziker and E. Delamarche, *Lab Chip*, 2007, **7**, 119-125.