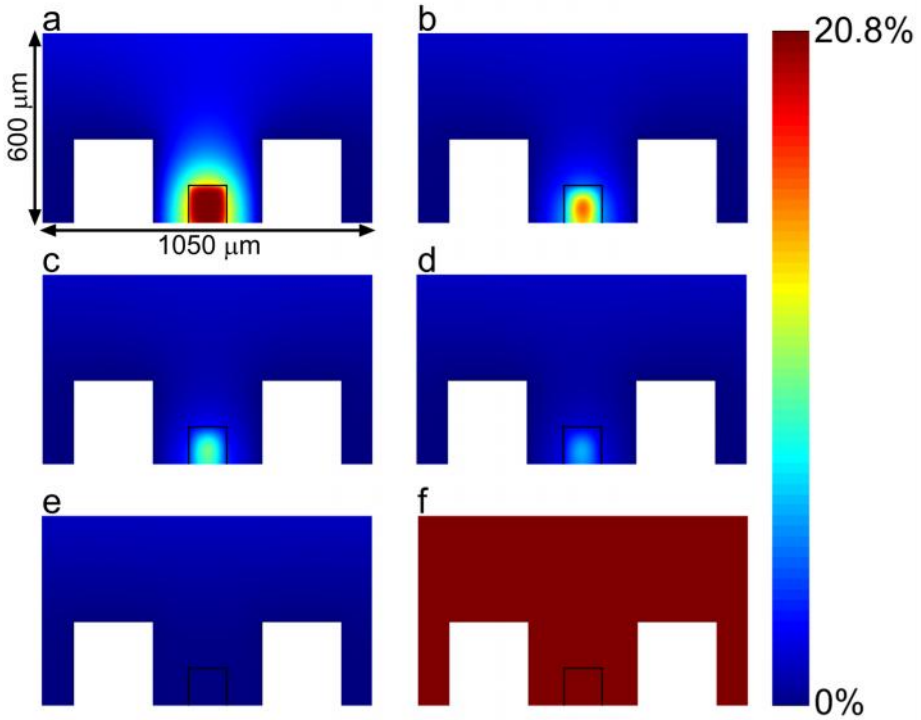

Figure S-1. Comsol simulations of [O_2] profiles at 1.05 mm wide cross-sections of the PDMS chip, corresponding to one period of the gas exchanger channel network. The bottom 0.6 mm of the 6 mm tall computational domain (corresponding to the 6 mm thickness of the PDMS chip) is shown. The computational domain includes a single 120×120 µm liquid-filled channel, with boundaries highlighted by black lines at the bottom center, and also accounts for two 250×265 µm gas channels, which are represented by while rectangles protruding into the computational domain at the bottom left and bottom right. The boundary conditions are insulation at the bottom (corresponding to the cover glass) and on the sides (corresponding to a periodic [O_2] profile in an exchanger with many folds in the channels) and [O_2] = 20.8% at the top of the domain (top surface of the PDMS chip). The boundary conditions at the walls of the gas channels (rectangles at the bottom right and bottom left) are [O_2] = 0 for gas channels ventilated with N_2 and [O_2] = 20.8% for gas channels ventilated with air. The simulations use 1000 $\mu m^2/s$ and 2000 $\mu m^2/s$ for the diffusion coefficients of O_2 in PDMS and the liquid-filled channel and 10.4 and 1.3 mM/atm for the respective solubilities of O_2. (a) – (d) show [O_2] profiles at consecutive locations along the liquid-filled channel perfused at mean flow velocity of 52 mm/s with water, which is initially fully aerated, with [O_2] = 20.8%. The simulations account for the laminar profile of flow velocity in the channel (with zero velocity at the walls and maximal velocity at the center). (a) shows the [O_2] profile at 1 mm from the entrance, with mean [O_2] = 20.3%. As water moves along the channel, the effective mean value of [O_2] decays to 11.8% in (b), 7.2% in (c) and 4.4% in (d), which, respectively, correspond to 31, 61, and 91 mm from the entrance. The effective mean value of [O_2] is calculated as an average across the channel weighted with the local flow velocity, thus accounting for contributions of different streamlines into the total volumetric flux. (e) and (f) are cross-channel distribution with no flow in the channel and the gas channels ventilated with N_2 and air respectively. It is worth noting that the amount of O_2 removed from the PDMS and liquid-filled channel between (a), where the liquid-filled channel has [O_2] = 20.8%, and (e), where the liquid-filled channel has [O_2] = 0.15%, is much smaller than the difference in the amount of O_2 between (f) and (e), especially if one accounts for ~8 times higher solubility of O_2 in PDMS as compared to water.

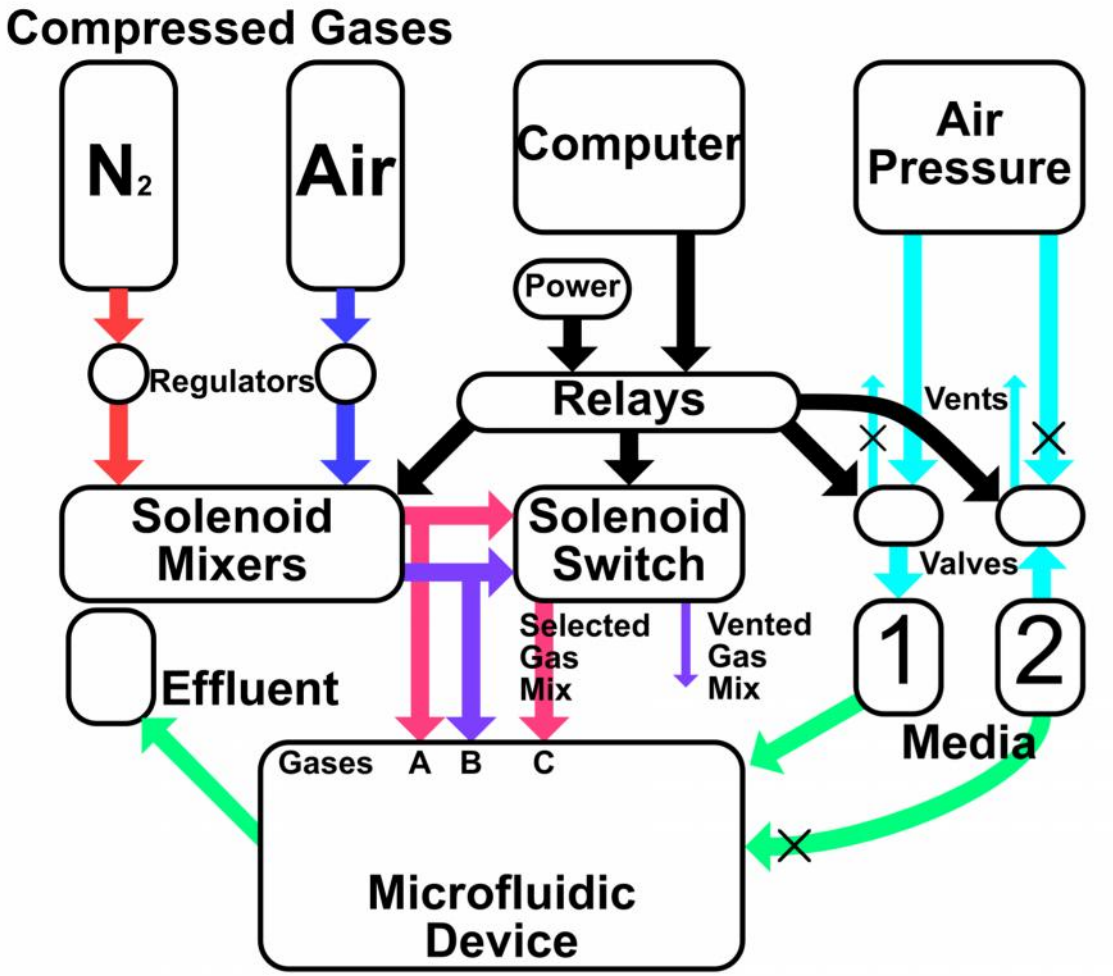

Figure S-2. Schematic diagram of the microfluidic experimental system with arrows representing flows of N_2 and air gasses (red and blue), mixed gasses fed to exchanger 1 (pink) and 2 (purple), air pressure (light blue), media (light green), and electrical power and signals (black). The system is shown with exchanger 1 active and exchanger 2 passive (fast flow of the medium through gas exchanger 1 towards the imaging region and slow backflow through gas exchanger 2). In this state a solenoid valve switch (the assembly of two solenoid valves) vents gas mixture B and feeds gas mixture A (selected gas mix) into gas inlet C (the auxiliary channel inlet). As a result, the gas mixture supplied to gas inlet C (and the auxiliary gas channel) is the same as the gas mixture supplied to the active exchanger (exchanger 1, port A of the microfluidic device).

Supplementary Movie 1. A 7-day zebrafish larva in the imaging region of the microfluidic device during an experimental trial with **strong** hypoxia. At 50 sec in the trial, the larva was exposed to three 50 sec long intervals of hypoxic medium, with $[O_2] \approx 1.8\%$ around it, with two 50 sec intervals of aerated medium ($[O_2] = 20.8\%$) in between. The top line of subtitles shows the cumulative time of the trial; the middle line shows the present $[O_2]$ in the medium and the time at this $[O_2]$; the bottom line shows the current rate of pectoral fin beats averaged over a 2 sec interval. The field of view is ~1.8x1.35 mm. Note that the frame rate is 4-times the original speed.

Supplementary Movie 2. A 7-day zebrafish larva (the same animal as in Supplementary Movie 1) in the imaging region of the microfluidic device during a **control** experimental trial. In this trial, both gas exchangers were ventilated with air, but the exchanger feeding the imaging region was switched every 50 sec, starting at 50 sec through the trial. The top line of subtitles shows the cumulative time of the trial; the middle line shows the present $[O_2]$ in the medium and the time since the most recent switching; the bottom line shows the current rate of pectoral fin beats averaged over a 2 sec interval. The field of view is ~1.8x1.35 mm. Note that the frame rate is 4-times the original speed.