

# Cell-Based Perfusion Assays, Using the ibidi Pump System

Cultivation of Cells Under Flow for Simulation of Blood Vessels



## Applications:

- Defined shear stress, in long-term cell culture (e.g. endothelium, kidney, or biofilm)
- Live cell imaging and immunofluorescence for analyzing shear stress response
- Mimicking shear stress conditions in microcapillary, venous, and arterial flow
- Rolling and adhesion of suspended cells on substrates

### ✓ Ideal simulation of all physiological conditions

Continuous unidirectional, oscillating, and pulsatile flow

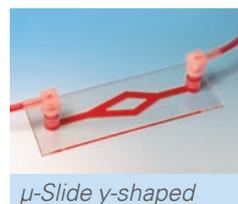
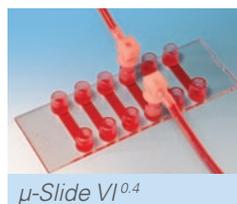
### ✓ Fully integrated solution, also for microscopy

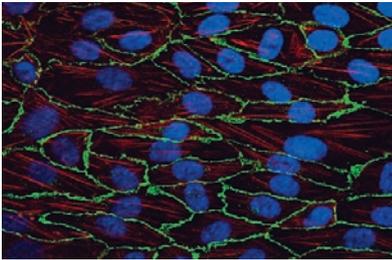
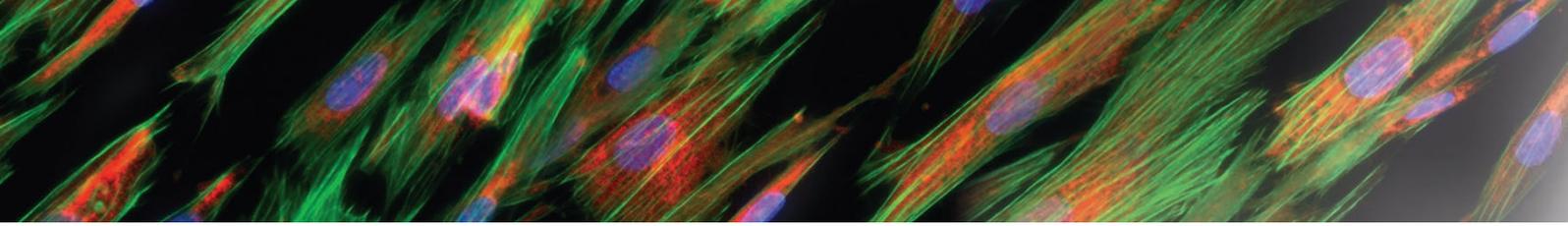
Compatible with ibidi Heating Systems, all incubators, and incubated microscopes

### ✓ Complete setup under sterile circular conditions

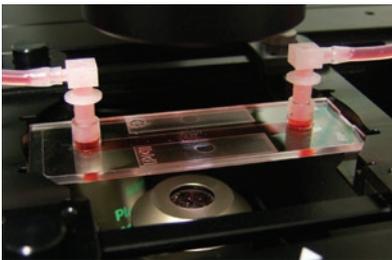
Minimal mechanical stress, minimal amount of medium and supplement

Equipment for researchers working with cell-based perfusion assays:





Human umbilical vein endothelial cells (HUVEC) cultured under flow conditions in  $\mu$ -Slide 1<sup>0.4</sup> Luer  
 blue: nucleus (DAPI)  
 green: VE-catherins (Alexa 488 conjugated antibody)  
 red: actin cytoskeleton (Cy5 conjugated antibody)  
 (Courtesy S. Zahler, Munich, Germany)



### Technical Details

- Up to four parallel Fluidic Units per ibidi Pump
- Flow characteristics: unidirectional and continuous flow, oscillating flow for simulating turbulent flow, and pulsatile flow
- Flow rate: 0.03 – 35 ml/min
- Shear stress: 0.3 – 150 dyn/cm<sup>2</sup>
- Working volume: 2.5/12 ml
- Suitable for all  $\mu$ -Slides with Luer adapters
- Compatible with all incubators
- Software-controlled flow rates and shear stress

### Cultivation under flow conditions

*In vivo*, several adherent cell types are exposed to mechanical shear stress, equal to what is found in blood vessels. This mechanical stimulus has a great impact on the physiological behavior and adhesion properties of cells. Cultivation of endothelial cells, under perfusion, reflects their natural environment far better than doing so under static conditions.

### ibidi $\mu$ -Slides for easy flow applications in a channel

ibidi consumables can be used in static and perfusion cell cultures. Many of the  $\mu$ -Slides were especially designed to perform flow assays. Additionally, their optical quality makes them compatible with any inverted microscope technique. They are ideal for performing perfusion assays directly on the microscope, or inside the incubator.

### The ibidi perfusion system perfectly reflects the natural environment of cells under flow conditions

The ibidi Pump System consists of two main components: The **ibidi Pump** (a computer controlled air pump) and the **Fluidic Unit** (two cell media reservoirs, with slide holder and tubes). By using this “split” approach, the closed flow setup can be assembled separately and transferred to the microscope after cell cultivation, without compromising the sterility of the system. The open architecture with the Luer connectors allows the use of any kind of flow devices. The **PumpControl software** controls the pressure, and subsequently the shear stress acting on the cells. The system is a fully integrated solution. By hosting the Fluidic Unit in the incubator, it is still possible to run perfusion assays directly on the microscope.



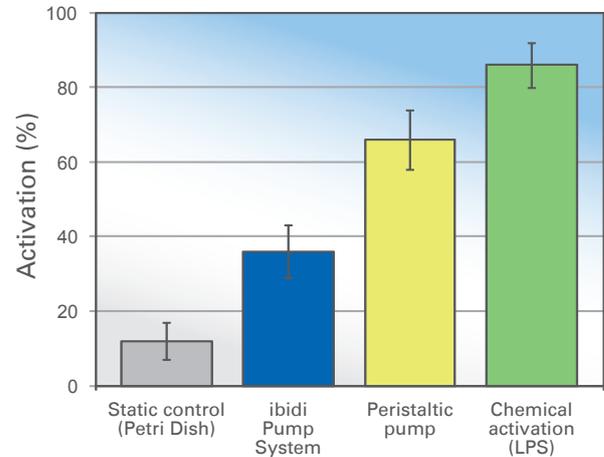
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## Cultivation of Cells Under Flow for Simulation of Blood Vessels

### ibidi Pump System generates minimal mechanical stress

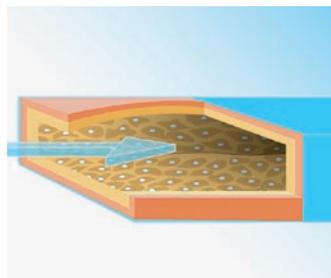
The graph shows the degree of activation of suspended dendritic cells, in different pump systems, under identical flow rate and shear stress. In peristaltic pumps, tubes and suspended cells are mechanically squeezed. This technique leads to increased nonspecific activation of cells. The ibidi Pump System works with air pressure and reduces mechanical stress to a minimum. The nonspecific activation of suspension cells is suppressed.

Activation of suspended dendritic cells after 24h

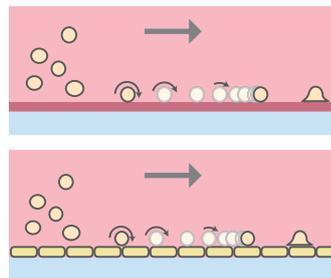


### Types of Assays

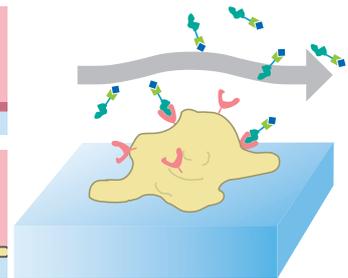
#### Cells Under Shear Stress



#### Adhesion Assays



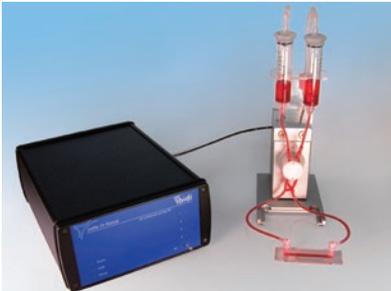
#### Stop Flow Experiments



Application	Endothelial cells under flow:	Blood cells to protein surfaces:	Defined liquid exchange:
	<ul style="list-style-type: none"> <li>Influence of shear stress on endothelial cells</li> <li>Preparing cells while mimicking <i>in vivo</i> perfusion conditions</li> <li>Formation of plaques on endothelium</li> <li>Biofilm formation of microorganisms</li> <li>Antibody stainings</li> </ul>	<ul style="list-style-type: none"> <li>Rolling and adhesion of suspended cells such as platelets, leukocytes, monocytes on substrates, such as adhesion proteins or confluent cell monolayers</li> </ul>	<ul style="list-style-type: none"> <li>Defined medium exchange for optimal feeding</li> <li>Online drug delivery</li> <li>Live stainings</li> <li>Ca<sup>2+</sup>-imaging</li> </ul>
Recommended Pumps	<ul style="list-style-type: none"> <li>ibidi Pump System</li> </ul>	<ul style="list-style-type: none"> <li>ibidi Pump System</li> <li>Syringe pumps</li> <li>Peristaltic pump</li> </ul>	<ul style="list-style-type: none"> <li>Manual liquid delivery</li> <li>Syringe pumps</li> <li>Peristaltic pump</li> </ul>
Duration	Hours, up to several weeks	Minutes to hours	Minutes to hours
Experimental Environment	Incubation conditions	Room temperature or incubation conditions	Room temperature or incubation conditions

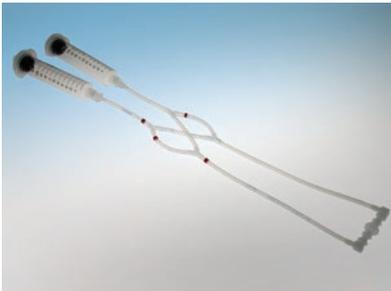
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## Ordering Information



### ibidi Pump System

ibidi Pump System, consisting of ibidi Pump, Fluidic Unit, Perfusion Set, notebook, PumpControl software	10902
ibidi Pump: accuracy: +/- 1 mbar, pressure range: -100 to +100 mbar; including control software and 4 Fluidic Unit control ports	10905
Fluidic Unit: pinch valve for dual tubing, stable aluminium housing, exchangeable reservoir holders	10903
Notebook: ready to use, pre-configured Windows system, PumpControl software	10908
Cell Culture Incubator: small volume system (14l), especially suited for separated setups, like ECIS measurements, or setups with up to two Fluidic Units	10991



### Accessories for ibidi Pump System

Perfusion Set, 15 cm, ID 0.5 mm, 2 ml (3 units) YELLOW	10965
Perfusion Set, 15 cm, ID 0.8 mm, 10 ml (3 units) BLUE	10961
Perfusion Set, 15 cm, ID 1.6 mm, 10 ml (3 units) RED	10962
Perfusion Set, 50 cm, ID 0.5 mm, 2 ml (3 units) BLACK	10966
Perfusion Set, 50 cm, ID 0.8 mm, 10 ml (3 units) WHITE	10963
Perfusion Set, 50 cm, ID 1.6 mm, 10 ml (3 units) YELLOW/GREEN	10908
Reservoir Set, 10 ml, sterile (10 units)	10971
Reservoir Set, 2 ml, sterile (10 units)	10972

The ibidi Pump System is optimized for use with all ibidi channel slides. For detailed ordering information on the whole line of ibidi  $\mu$ -Slides, please go to: [www.ibidi.com](http://www.ibidi.com).

## Selected publications using the ibidi Pump System:

N. Cockcroft, O. Oke, F. Cunningham, E. Bishop, I. M. Fearon, R. Zantl and M. D. Gaça, *An In Vitro Perfusion System to Examine the Responses of Endothelial Cells to Simulated Flow and Inflammatory Stimulation*. ATLA, 2009.

B. Fuchs, U. Budde, A. Schulz, C. M. Kessler, C. Fisseau and C. Kannicht, *Flow-based measurements of von Willebrand factor (VWF) function: Binding to collagen and platelet adhesion under physiological shear rate*. Thrombosis Research, 2009.

F. Kotsis, R. Nitschke, M. Doerken, G. Walz and E. W. Kuehn, *Flow modulates centriole movements in tubular epithelial cells*. Pflügers Archiv European Journal of Physiology, 2008.

C. Schulz, E. Heiss, F. Gaertner, M. Orban, M.-L. v. Bruehl, P. Schramm and S. Massberg, *Novel Methods for Assessment of Platelet and Leukocyte Function Under Flow – Application of Epifluorescence and Two-Photon Microscopy in a Small Volume Flow Chamber Model*. The Open Biology Journal, 2009.

D. Wilson and B. Hube, *Hgc1 Mediates Dynamic Candida albicans-Endothelium Adhesion Events during Circulation*. Eukaryot. Cell, 2010.