HUGO SACHS ELEKTRONIK

a division of Harvard Bioscience, Inc.

Isolated Heart

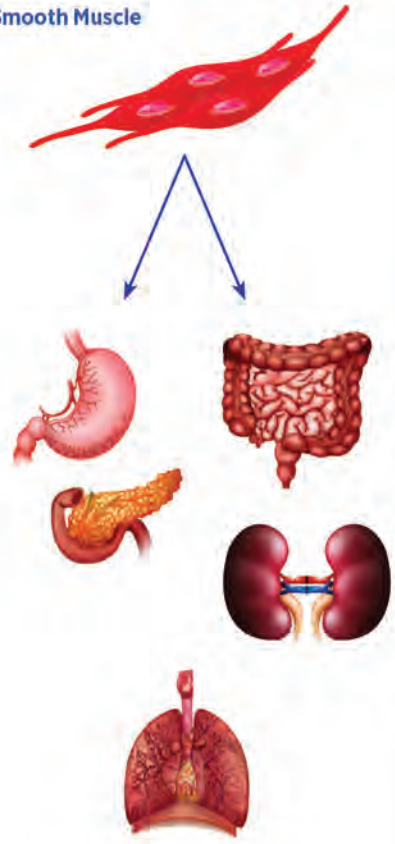
PERFUSION SYSTEMS

For Mouse to Small Pig Animal Models

www.hugo-sachs.de · www.harvardapparatus.com

PERFUSION & TISSUE BATH SYSTEMS OVERVIEW

Solutions for All Aspects of Animal Physiology Research

	Organs	Systems for Organs/Applications
Smooth Muscle 	**GASTROINTESTINAL TRACT** • Esophagus • Stomach • Liver/Pancreas • Intestine	• **Moist Chamber**—perfusion of liver, pancreas • **UP-100**—perfusion of liver ex vivo or in situ • **PBTO**—intraluminal intestine perfusion • **SCP**—perfusion of GI organs and tissues using peristaltic pump • **IPR**—perfusion of ileum peristaltic reflexes
	UROGENITAL TRACT • Kidney • Placenta	• **Moist Chamber**—perfusion of kidney, uterus • **UP-100**—perfusion of kidney ex vivo or in situ • **PBTO**—intraluminal vas deferens perfusion
	VASCULAR MUSCULATURE • Hind Quarter • Mesenteric Bed • Coronary Vasculature	• **Moist Chamber with Edema Balance**—simultaneous vascular and intraluminal perfusion • **UP-100**—perfusion of mesenteric bed, hindquarter, hind quarter ex vivo or in situ • **IH-SR, IH-5, IH-9**—isolated heart perfusion of small rodent, rabbit, small pig • **PBTO**—blood vessel perfusion
	BRONCHIAL MUSCULATURE • Lung	• **IPL-1, IPL-2, IPL-4, IPL-16**—isolated lung perfusion of mouse, rat, guinea pig, rabbit, pig • **PBTO**—intraluminal trachea perfusion • **PCLS**—precision cut lung slice chamber See our *Isolated Lung Brochure* for more information.
Cardiac 	**HEART** • Langendorff • Working Heart • Heart-Lung Preparation	• **UP-100, IH-SR, IH-5, IH-9**— isolated heart perfusion of small rodent, rabbit, small pig
Skeletal Muscle 	**SKELETAL MUSCULATURE** • Intact Limb • Hindquarter	• **UP-100**—perfusion of intact limb, hindquarter ex vivo or in situ
Nerve Bundle 	**NERVOUS SYSTEM** • Brain • Spinal Cord • Ganglion	See our *Tissue Baths & Perfusion Systems Selection Guide* for more information.
Tissue	**TISSUES**	See our *Tissue Baths & Perfusion Systems Selection Guide* for more information.

Isolated Heart

PERFUSION SYSTEMS

For Mouse to Small Pig Animal Models

Hugo Sachs Elektronik (HSE), part of the Harvard Bioscience family of companies, provides state-of-the-art, fully integrated physiology research systems, including perfusion and tissue bath systems for many organ and tissue types.

This catalog contains all the information you need to choose an optimal isolated perfused heart system for your research. To get started, select the basic system for your species model then add specific options to suit the particular needs of your study.

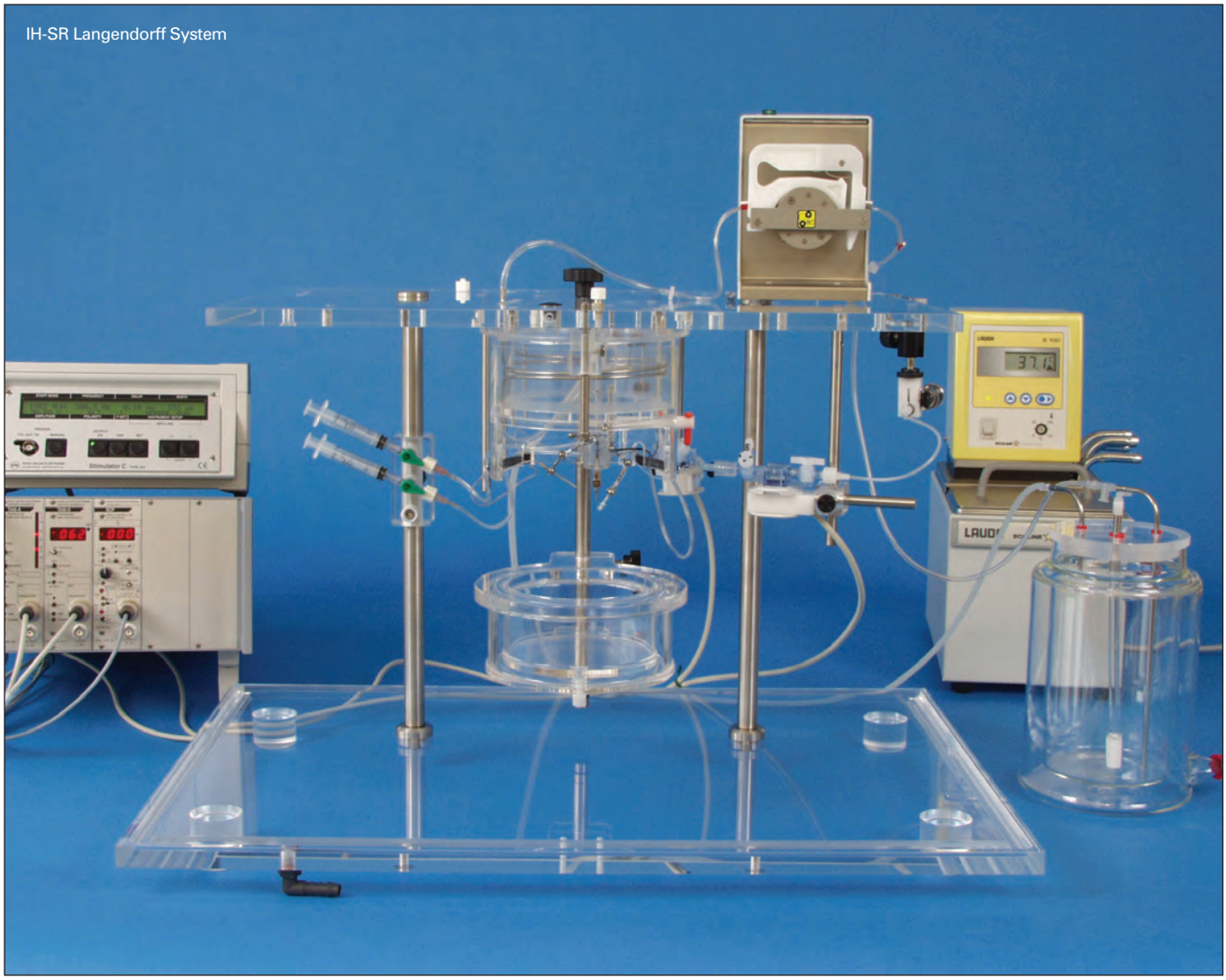
To ensure that your system is properly configured as a functional unit that meets your application needs, please complete our Checklist (see page 81) and then contact Technical Services at 800-547-6766 or via email at **support@hbiosci.com** before placing an order. In Europe, please call +49 7665 92000 or email **sales@hugo-sachs.de**. Our expert technical team of scientists and engineers is always ready to assist with system configuration, application support, and custom design requests.

HUGO SACHS ELEKTRONIK
a division of **Harvard Bioscience, Inc.**

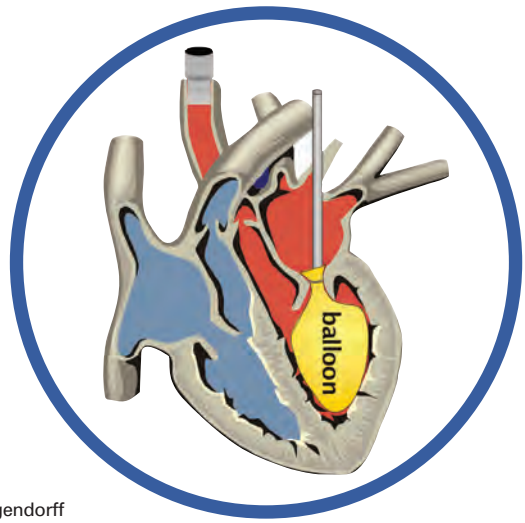
CONTENTS

Introduction to Isolated Heart Perfusion Systems

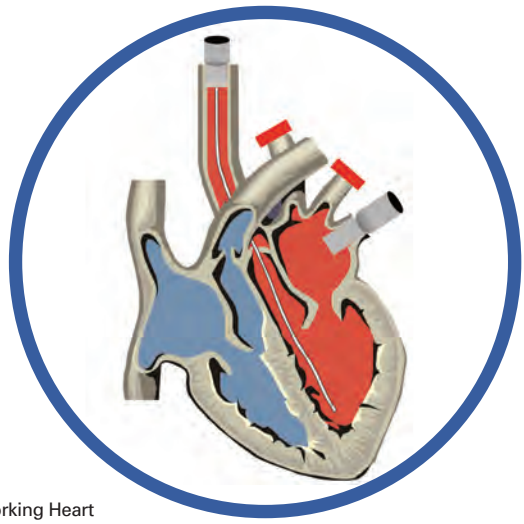
Hugo Sachs' IH series of isolated heart perfusion systems is the gold standard for cardiac physiology measurements in both retrograde heart perfusion (according to Langendorff) and working ejecting heart perfusion (according to Neely) modes. Our systems are modular in design, providing the flexibility to tailor a system to fit your research needs. Core systems can be supplemented with a comprehensive range of application-specific additions and options. Our product line is backed by an experienced technical support team of physiology specialists.



IH-SR Langendorff System



Langendorff System



Working Heart System

Unique Perfusion Technology

The IH series is unique due to its revolutionary Perspex®* construction, which simply cannot be matched. The use of Perspex instead of traditional glass allows our engineers to mill the perfusion pathway directly into the solid Perspex blocks. The result is what we call a solid state physiological perfusion circuit. This patented perfusion technology ensures a precisely repeatable non-turbulent perfusion pathway for the highest fidelity pressure and flow measurement. This, combined with the naturally excellent thermal properties of Perspex, creates a system that allows control, maintenance and monitoring of circulatory parameters in a way that is more physiologically relevant than any conventional perfusion system.

Langendorff System

The IH series ex vivo perfused heart systems always start as a Langendorff system. This means a configuration solely for retrograde perfusion down the aorta (toward the heart coronaries). In this mode, the aortic valve prevents the perfusate (nutrient solution) from entering the left ventricle, but the coronary arteries are perfused via the coronary ostia which are located just above the aortic valve, thus maintaining the viability of the heart muscle. Perfusate drains as effluate from the coronary circulation via the coronary sinus and pulmonary artery. It tends to drip from the apex of the heart making it easily available for collection. The IH system configured in this way provides an excellent platform for basic applications such as cardiomyocyte isolation as well as for physiological monitoring using the robust Langendorff setup where perfusions of several hours are typical.

Working Ejecting Heart System

The modular nature of the IH series allows for initial integration or later upgrade to a working (ejecting) heart perfusion pathway. This enables orthograde perfusion: entering the left atrium, flowing through the left ventricle and exiting the aorta. In this way, a more physiological assessment of ventricular contractility is possible as the left ventricle is now fully-ejecting and performing pressure-volume and acceleration work. In order to fully exploit this advantage, the IH series includes a specialized pathway which easily allows introduction of a pressure or pressure-volume catheter directly into the left ventricle via the aorta, rather than via apical puncture.

Biventricular Working Heart

The Biventricular Working Heart System allows for ex vivo studies of diseases characterized by pulmonary vascular dysfunction and right heart pathophysiology. The system employs unique flow resistance and compliance chambers to faithfully mimic the in vivo cardiac preloads and afterloads for both normal and diseased states. In addition to the ejecting left heart, which is now supplying perfusate to the coronaries and thus maintaining heart muscle viability, the right heart is also performing the low pressure ejection, whereby the perfusate enters the right atrium, flows into the right ventricle and exits through the pulmonary artery. Additional measurements of Right Ventricular Pressure or Right Ventricular Pressure-Volume can now be taken independently or simultaneously.

Langendorff and Working Heart illustrations are used with permission courtesy of SANOFI-AVENTIS, Germany.

* Perspex is a registered trademark of Perspex International.

Diagram of Hugo Sachs Isolated Heart Systems

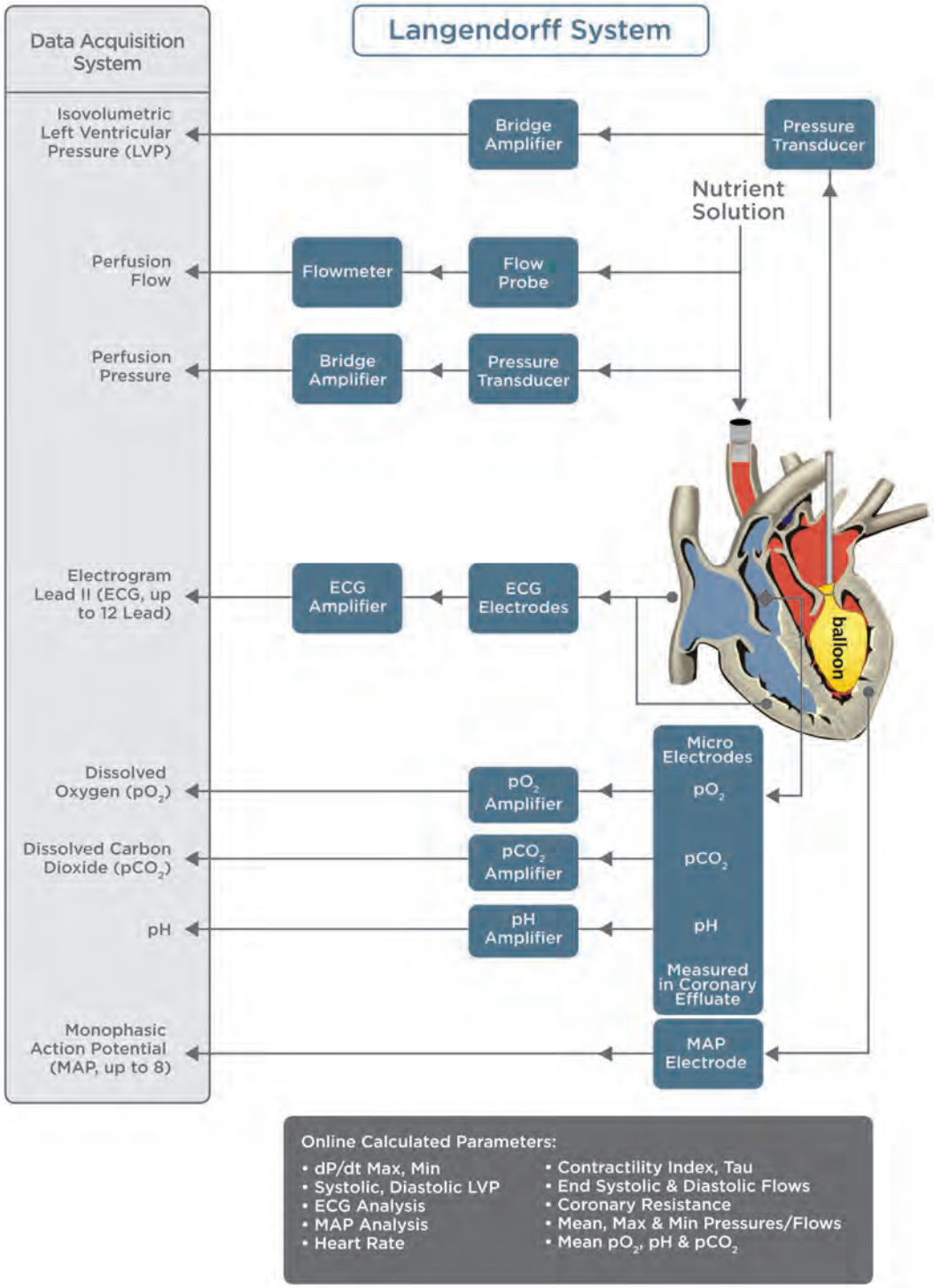
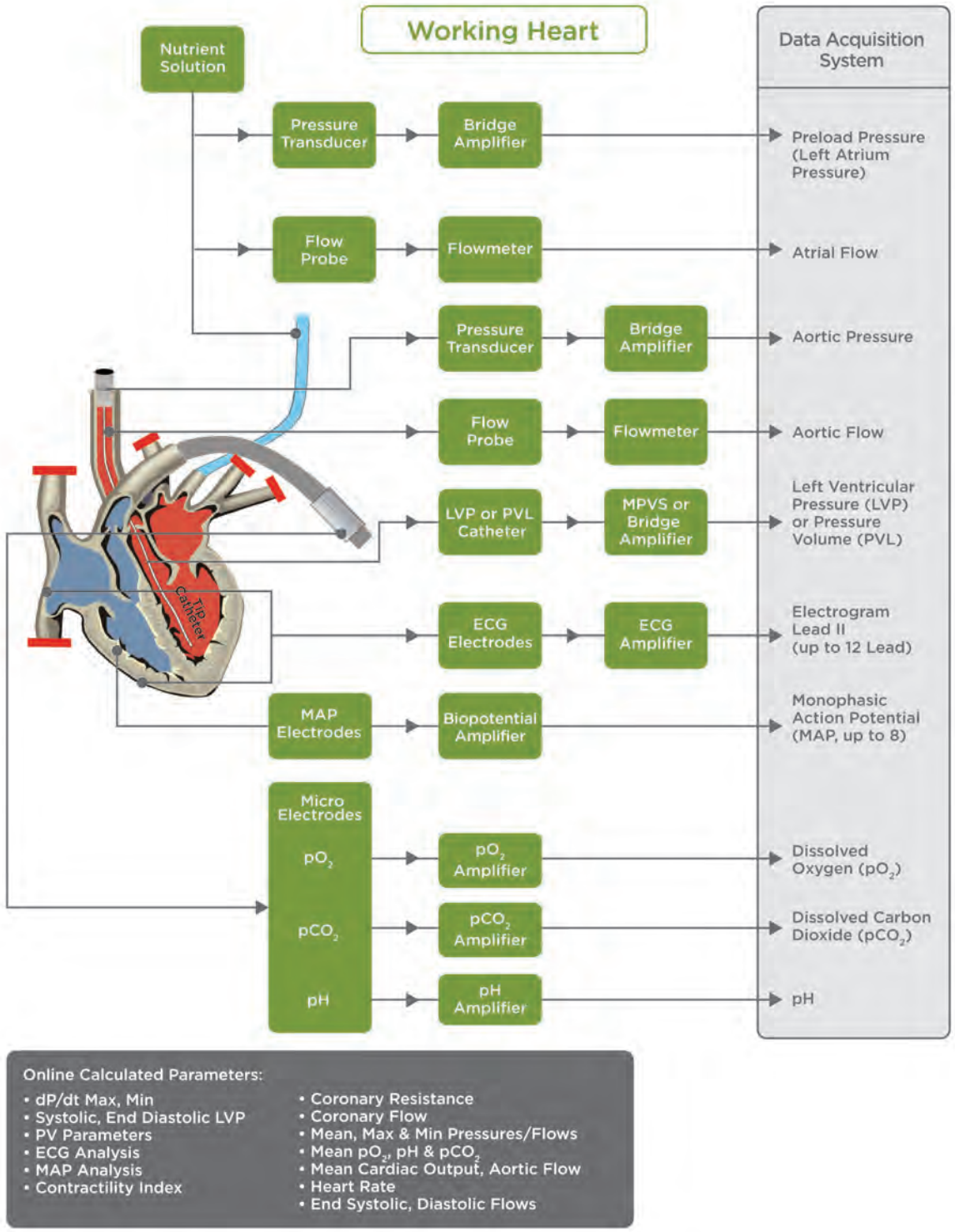


Diagram of Hugo Sachs Isolated Heart Systems



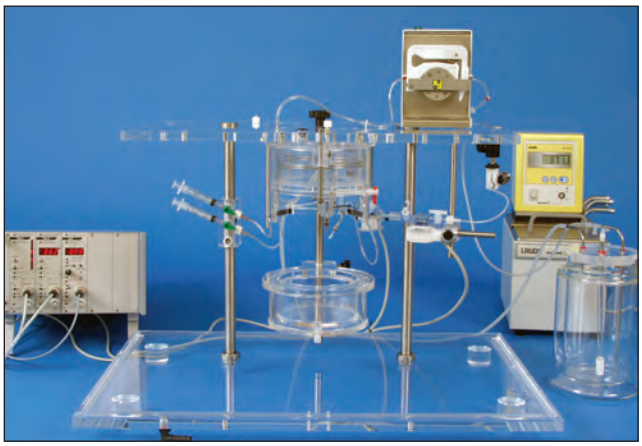
Langendorff Systems

UP-100IH Langendorff System

The UP-100IH Langendorff System is primarily for rat, guinea pig, and juvenile rabbit heart, though it can be used for mouse heart as well. It has a small footprint, making it ideal for multi-channel compound screening while still incorporating measurement of basic cardiac parameters such as LVP and ECG. It cannot be expanded to a Working Heart System.

IH-SR Langendorff System

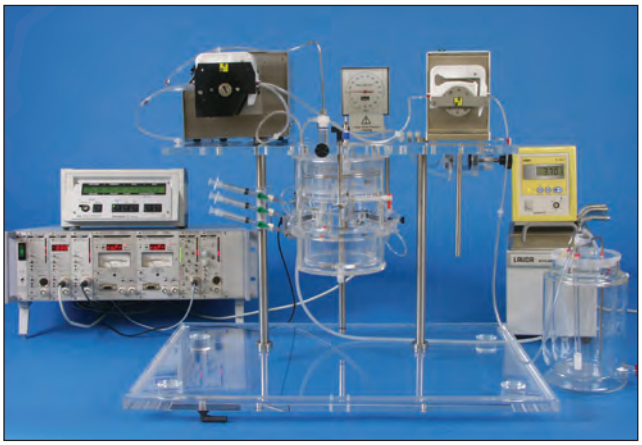
The IH-SR Langendorff System for small rodent models such as mouse, rat and guinea pig is designed to be used in the Langendorff retrograde perfusion mode. Because of the larger heart chamber this system is well-suited for studies that require single lead ECG with up to 3 MAP in addition to LVP, coronary flow, pacing, or any other combination of these parameters. The fully closing heart chamber allows for precise temperature control, making it the optimal choice for mouse heart perfusion. The Core Langendorff System can be easily upgraded to a working ejecting heart configuration any time later. This system can also be expanded/upgraded to a full biventricular working heart setup.



IH-5 Langendorff System

The IH-5 Langendorff System is designed for use with rat, guinea pig, and rabbit models in the Langendorff retrograde perfusion mode. Like the IH-SR, the IH-5 system does not utilize high water columns but creates a constant pressure perfusion setup using a pressure feedback pump controller, resulting in a compact system. The system is well-suited for studies that require single lead ECG with up to three MAP in addition to LVP, coronary flow and pacing or any other combination of these parameters. In addition to many other options, a special option is available for multi-lead ECG and multi-monophasic action potential recordings. The Core Langendorff System can be easily upgraded to a working ejecting heart configuration any time later. This system can also be expanded/upgraded to a full biventricular working heart setup.

Working Heart Systems

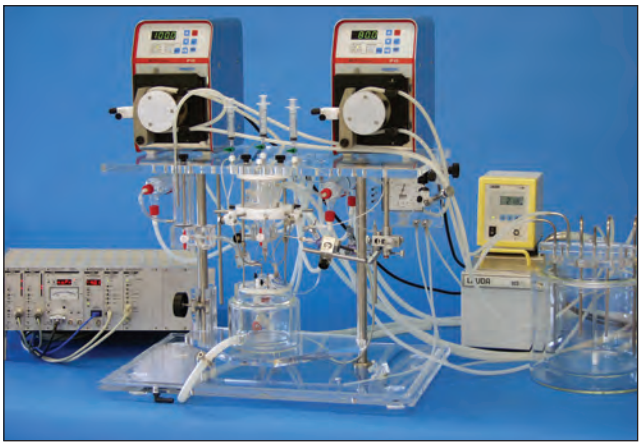


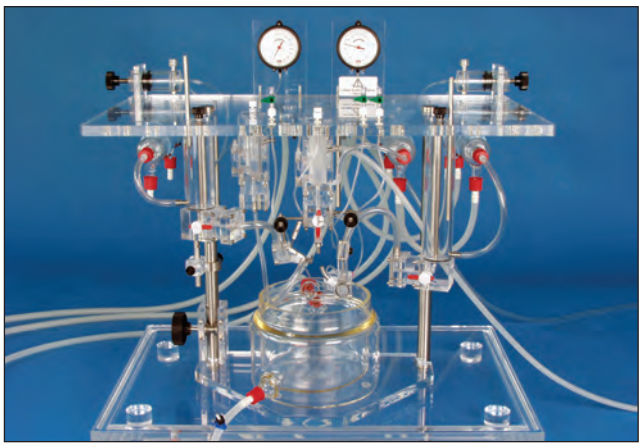
IH-SR Working Heart System

The working (ejecting) heart model is the ultimate ex vivo physiological model for mouse, rat and guinea pig hearts. The IH-SR Working Heart System allows you to take full advantage of this model with physiological simulation that cannot be matched in small rodent preparations. With the built-in patented physiological afterload system (Starling resistor), the need for the conventional water column is eliminated. The result is vastly improved arterial pressure evaluation without the risk of damage to heart valves.

IH-5 Working Heart System

The IH-5 Working Heart System provides a valuable tool for the researcher who wishes to study cardiac function and metabolism in rats, guinea pigs and rabbits. Because the heart is fully ejecting, a more comprehensive monitoring of functional parameters and the calculation of external heart work and mechanical efficiency are possible. The proprietary afterload system eliminates water column bouncing, reducing stress and damage to cardiac valves.



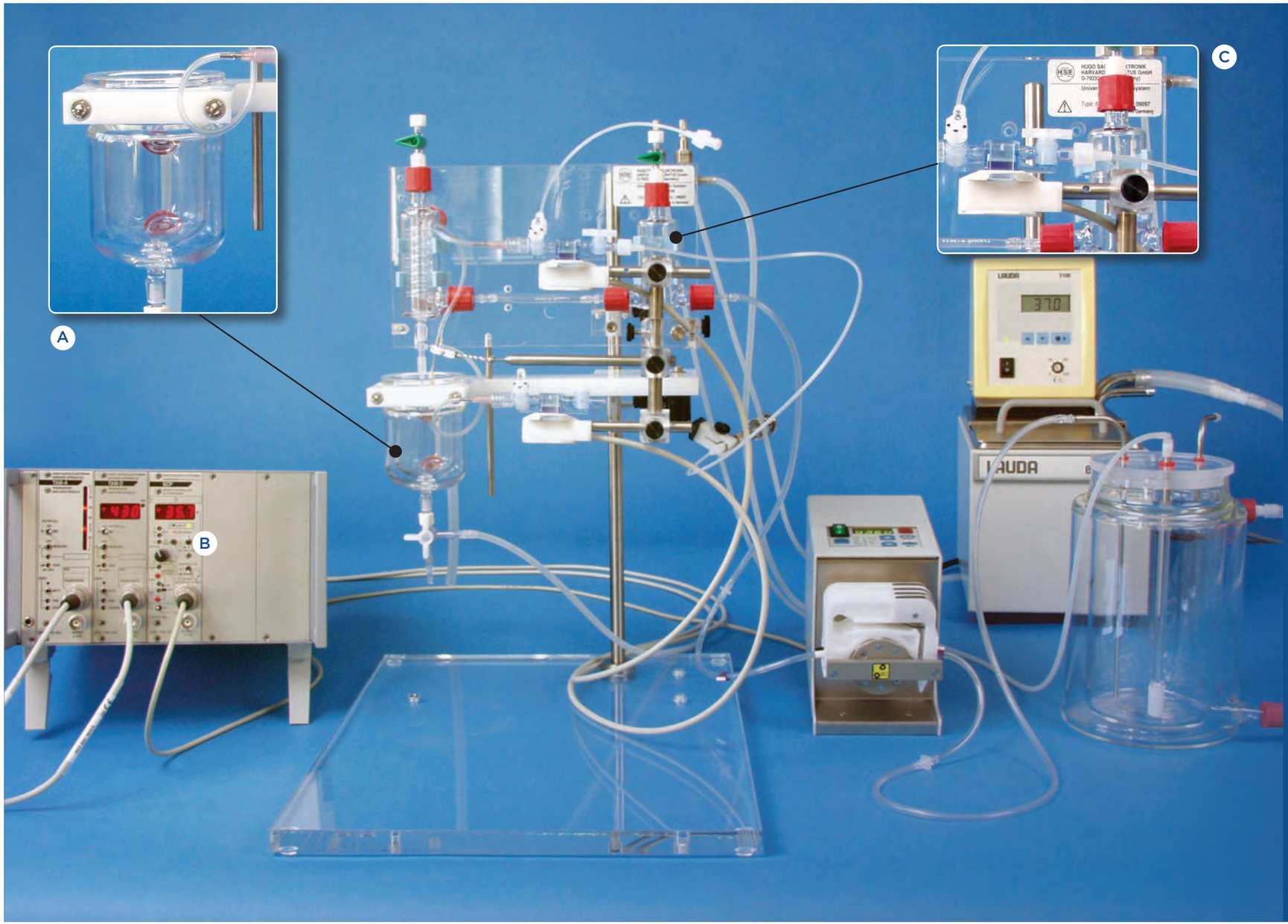


IH5-BI Biventricular Working Heart System

The Biventricular Working Heart System is the only ex vivo heart perfusion system in which both the right and left ventricle work as they do in vivo in the physiological environment. Due to our afterload membrane technology there is no need for high bouncing water columns and compliance tubing. This is accomplished by the use of our patented membrane flow resistance and compliance chambers to faithfully mimic the in vivo cardiac preloads and afterloads for both normal and diseased states in medium to large models (rat, guinea pig and rabbit).

The system is appropriate for studies requiring both the right and left heart to be ejecting and performing heart work in order to obtain a full set of meaningful data. Where previously this could only be accomplished with high fidelity in situ, the capability is available as an ex vivo preparation that is removed from the confounding influences of the central nervous system. The exclusive features of the system create a physiological isolated heart environment that closely resembles the actual resistance of the peripheral vasculature while allowing the entire heart to work as it does in vivo.

UP-100IH
Universal Perfusion System



UP-100IH UNIVERSAL PERFUSION SYSTEM FOR SMALL AND MEDIUM RODENTS

DESIGN FEATURES

- Most compact Langendorff design
- Versatile perfusion system can be used for in situ or ex vivo perfusion of heart, liver, kidney and other organs and tissues
- Small bench footprint allows setup of multiple systems for increased throughput

BASIC MEASURED PARAMETERS

- Aortic perfusion pressure
- Isovolumetric LVP (balloon method)

A HEART CHAMBER

- Small heart chamber for temperature maintenance
- Precision ball-joint system for secure positioning of electrodes
- Perfusion pressure measurement proximal to aorta

UPGRADEABLE FUNCTIONALITY

- ECG Lead II
- Pacing
- Direct or indirect coronary flow measurement
- Temperature measurement
- Metabolic monitoring
- Drug application
- Cell isolation option

B PLUGSYS MODULAR SYSTEM

- Compact amplifier system grows to fit your applications
- Low noise, analogy fidelity and control
- Analog signal output to virtually any data acquisition system

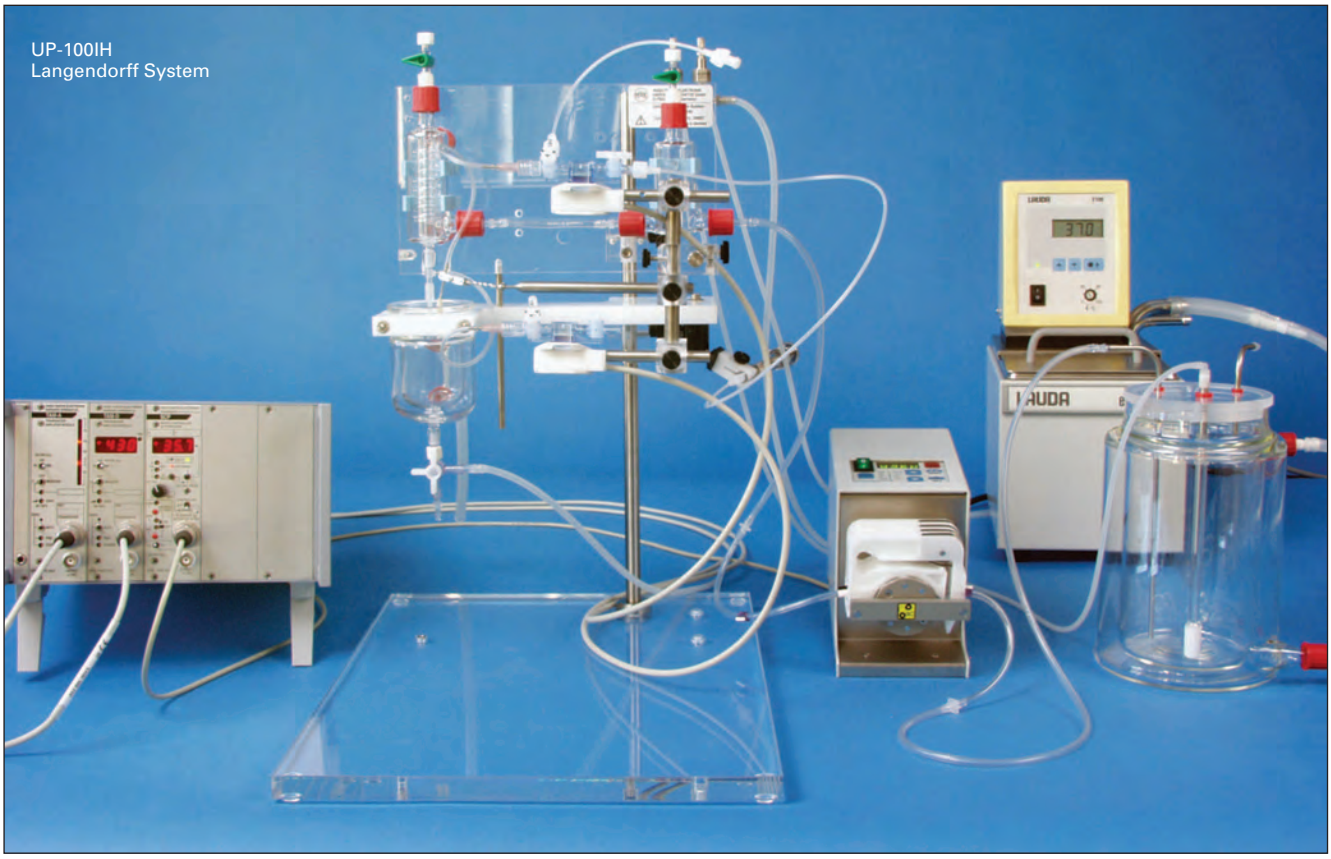
C PERFUSION PATH

- Compliance chamber for pressure pulse dampening of peristaltic pump
- Primary and secondary bubble traps protect against embolism; ensure vascular integrity
- System volume is <20 ml, reducing temperature loss and mixing of test components

web www.hugo-sachs.de web www.harvardapparatus.com email support@hbiosci.com

ISOLATED HEART PERFUSION SYSTEMS

UP-100IH Langendorff System



The UP-100IH is a universal perfusion system adapted for basic Langendorff perfusion studies primarily in rat, guinea pig and juvenile rabbit heart. It can be used for mouse heart as well. It is the preferred system for simple compound screening that requires basic measured parameters such as aortic pressure, left ventricular pressure (isovolumetric LVP) and ECG Lead II measurement.

There are two UP-100IH Core Systems to choose from. These complete system includes all the primary equipment you need to accomplish the basic Langendorff experiment, only requiring the addition of species-specific cannulae.

UP-100IH Core Systems

UP-100IH Basic Core System

The UP-100IH Basic Core System is the more common configuration. It allows you to measure aortic pressure and left ventricular pressure (LVP), as well as two to three additional parameters of your choice. Most researchers will also want to operate in a constant pressure perfusion mode and measure coronary flow, which is a simple addition to the basic system.

UP-100IH Advanced Core System

The UP-100IH Advanced Core System allows up to the full range of available measured parameters beyond the aortic pressure and left ventricular pressure (LVP) that are included in the Basic Core System. Measurements such as direct coronary flow, ECG lead II, temperature and metabolic parameters (pH, pO_2, pCO_2) can easily be added.

The only difference between the Basic and Advanced Core System is the PLUGSYS case included. The Basic System comes with a small PLUGYS amplifier housing, the Advanced comes with a full PLUGSYS case that can be mounted on a 19" rack. If the options you need require more than 10 slot units, you will need to choose the Advanced Core System.

UP-100IH UNIVERSAL PERFUSION SYSTEM FOR SMALL AND MEDIUM RODENTS

Advanced System Design

The UP-100IH has a small footprint and small system volume (<30 ml), making it ideal for multi-channel compound screening that can incorporate measurement of basic cardiac parameters such as LVP, ECG and coronary flow.

The modular system can be additionally equipped with ECG lead II measurement, pacing, direct or indirect flow measurement, temperature measurement, metabolic monitoring, drug addition, and cell isolation. The UP-100IH cannot be expanded to a working ejecting heart system.

Applications

- Drug compound screening
- Safety pharmacology and toxicology
- Study of myogene autoregulation with the addition of Direct Coronary Flow Measurement Option
- Testing with inotropic substances
- Testing of lusitrope substances
- Testing of vasoactive substances
- Cardiac rhythm tests
- Ischemia/hypoxia studies
- Cardioplegia studies
- Toxicology studies
- Biochemical tests

Features & Benefits

- Versatile perfusion system can be outfitted for in situ or ex vivo perfusion of heart, liver, kidney and other organs and tissues
- Constant pressure perfusion with no high water columns can be done using the SCP controller
- Small bench footprint allows set up of multiple systems for increased throughput
- Ideal economic choice for the cost-conscious physiology/pharmacology lab with the need to screen drugs for safety pharmacology and toxicology in multiple organs

Measured Signals and Calculated Parameters

The following signals are recorded as raw data in retrograde Langendorff perfusion:

- Isovolumetric left ventricular pressure (balloon method)
- Aortic (perfusion) pressure

The following parameters are calculated from the raw data (using a data acquisition system, e.g., ISOHEART):

- dLVP/dt, dLVP/dt Max., dLVP/dt Min., contractility index
- Systolic and diastolic LVP
- Heart rate
- Mean perfusion pressure
- Indirect coronary flow measurement and constant pressure perfusion, with the addition of the SCP module

Included Items

Included items are representative of a typical UP-100IH Core System. Individual components can be customized to your needs.

UP-100IH Core System, Basic, (73-4385) and Advanced (73-4387), 230 V include:		UP-100IH Core System, Basic, (73-4384) and Advanced (73-4386), 115 V include:	
Item #	**Product Name**	**Item #**	**Product Name**
73-4228	Universal Perfusion System (UP-100) Base Unit	**73-4228**	Universal Perfusion System (UP-100) Base Unit
73-2070	Heart Chamber (Size 3 Rodents) including Holder	**73-2070**	Heart Chamber (Size 3 Rodents) including Holder
73-0720	Parts for Adaptation of the UP-100 for Retrograde Langendorff Heart Perfusion	**73-0720**	Parts for Adaptation of the UP-100 for Retrograde Langendorff Heart Perfusion
73-4544	TC120 Thermocirculator, with 5 L stainless steel bath and lid, 220 V	**73-4545**	TC120 Thermocirculator, with 5 L stainless steel bath and lid, 120 V
73-2448	REGLO Analog 2-Channel Peristaltic Pump, 230 VAC, 50 Hz	**73-2952**	REGLO Analog 2-Channel Peristaltic Pump, 115 VAC, 50 Hz
73-2068	Windkessel for Absorption of Pulsation Caused by Peristaltic Pump	**73-2068**	Windkessel for Absorption of Pulsation Caused by Peristaltic Pump
73-1521	PLUGSYS Case, Type 601 (Basic Core System)	**73-1521**	PLUGSYS Case, Type 601 (Basic Core System)
73-0045	PLUGSYS Case, Type 603 (Advanced Core System)	**73-0045**	PLUGSYS Case, Type 603 (Advanced Core System)
73-3862	Blood Pressure Transducers (APT300), 2 included	**73-3862**	Blood Pressure Transducers (APT300), 2 included
73-1973	PLUGSYS Transducer Amplifier Module (TAM-D)	**73-1973**	PLUGSYS Transducer Amplifier Module (TAM-D)
73-0065	PLUGSYS Transducer Amplifier Module (TAM-A)	**73-0065**	PLUGSYS Transducer Amplifier Module (TAM-A)
73-3869	Rod to hold APT300, length 75 mm	**73-3869**	Rod to hold APT300, length 75 mm
73-0566	Perspex Block Clamp to mount APT300 onto rod	**73-0566**	Perspex Block Clamp to mount APT300 onto rod

The Base Unit (73-4228) includes:

Plexiglas stand, heat exchanger with built-in bubble trap, holder for pressure transducer and tubing for thermocirculator and perfusion circuit. (System volume = 30 ml). Cannulae not included.

Parts for Adaptation for Retrograde Langendorff Heart Perfusion (73-0720) include:

Aortic cannulae (four different diameters), adapter for Luer cannulae with side port for pressure measurement, modification of holder for perfusion pressure measurement, rod and adaptation for LVP measurement.

Additional Requirement for a Functional Langendorff Unit

A UP100-IH functional unit requires the addition of species-specific cannulae. See table below.

Addition for Mouse Hearts (73-4388) includes:		Addition for Rat/Guinea Pig Hearts (73-4389) includes:	
Item #	**Product Name**	**Item #**	**Product Name**
73-2798	Aortic Cannula with Luer Taper for Mouse to UP100-IH, PSCI or EasyCell, OD 1.0 mm	**N/A**	All required cannulae are included in 73-0720
73-0126	3-Stop Tygon® E-Lab Tubing, 1.22 mm ID, 12/pack, Red/Grey	**73-0155**	3-Stop Tygon® E-Lab Tubing, 2.79 mm ID, 12/pack, Purple/White
73-3438	Jacketed Glass Reservoir for Buffer Solution with Frit, 1 L	**73-3440**	Jacketed Glass Reservoir for Buffer Solution with Frit, 2 L
73-3456	Tube Set for Jacketed Buffer Reservoir with Fluid Line Shutoff Valves	**73-3456**	Tube Set for Jacketed Buffer Reservoir with Fluid Line Shutoff Valves
73-0331	Universal Mini Balloon Kit for Isovolumetric LVP for Mouse Hearts	**73-3560**	Universal Balloon Kit V.2 for Rat/Guinea Pig Hearts, with 10 Latex Balloons
73-2787	Mouse/Neonatal Rat Ventricular Balloon Assembly Kit for LVP Measurements		

For a functional unit, both core systems require the addition of a species-specific option.

Ordering Information

Item #	Description
73-4385	UP-100IH Basic Core System, 230 V
73-4384	UP-100IH Basic Core System, 115 V
73-4387	UP-100IH Advanced Core System, 230 V
73-4386	UP-100IH Advanced Core System, 115 V
73-4388	Additions to UP-100IH Core System for Mouse Hearts
73-4389	Additions to UP-100IH Core System for Rat/Guinea Pig Hearts

Specialized Applications & Options

Constant Pressure or Constant Flow Perfusion

Constant pressure or constant flow perfusion is achieved by the optional addition of an SCP controller which modulates the flow generated by the perfusion pump based on a perfusion pressure feedback loop. The controller also provides an accurate, low-cost way to indirectly measure coronary flow. *See page 44.*

Coronary Flow Measurement

The UP-100IH can be adapted for direct real-time coronary flow measurement with ultrasonic transit time technology. This allows measurement of fast flow changes, e.g. studying the myogene autoregulation (reactive hyperemia). Alternatively coronary flow can be measured indirectly by controlling the pump speed of a peristaltic pump with the SCP controller. *See page 44.*

Coronary Effluate Collection

For cannulating rat, guinea pig or small rabbit pulmonary artery for effluate sampling from a UP-100IH System. Used to sample the effluate of the pulmonary artery (effluate from the coronaries) for further analysis or for continuous pO_2, pH and pCO_2 measurements. *See page 48.*

Perfusate Oxygenation

For oxygenation of buffers supplemented with albumin, fatty acids, washed erythrocytes or other foaming solutions. Normal oxygenation is done by bubbling in the reservoir. Foaming solutions cannot be bubbled and need a fiber oxygenator. *See page 50.*

Cell Isolation Upgrade

For isolating cardiomyocytes in a UP-100IH System following a physiology experiment or for occasional cardiomyocyte isolation in addition to the standard Langendorff experiment. This option forms a separate perfusion loop to avoid collagenase coming into the normal perfusion circuit. *See page 53.*

Applications for Other Organs

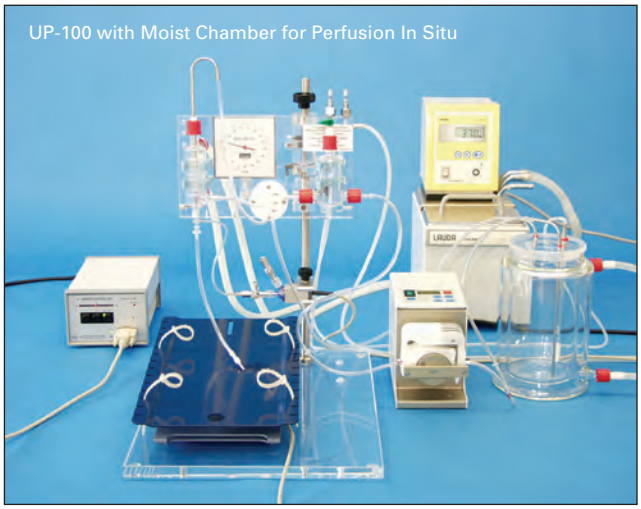
The standard UP-100 Universal Perfusion System is a multi-purpose system utilized when different types of organs, such as liver, rabbit ear, heart, kidney, rat hind limb, and mesenteric bed, must be perfused either ex vivo or in situ under constant flow or constant perfusion. It is easily adapted for different applications using additions or extensions to the base unit.

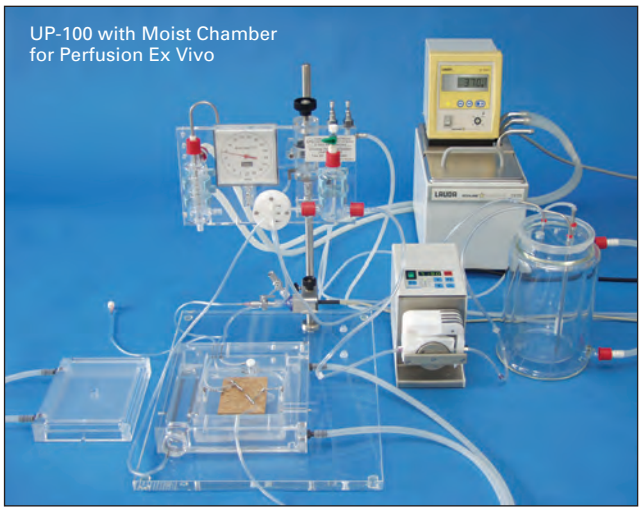
Applications

- Ex vivo perfusion of liver, kidney, mesenteric bed (with the addition of a moist chamber to maintain optimal physiological conditions)
- Test of vasodilative drugs
- Studying metabolic processes
- Neural vascular tone
- Organ preservation for transplant
- In situ perfusion of liver, kidney, mesenteric bed, hind limb, hindquarter (with the addition of an operating table)

System Extensions for Perfusion In Situ

For in situ perfusion of organs such as liver and kidney, or for perfusion of regional vascular systems like hindquarter, an operating table can be placed on the main Plexiglas plate below the UP-100 mounting platform. The compact arrangement allows the connection line between organ and heat exchanger to remain short to ensure consistent perfusate temperature.


UP-100 with Moist Chamber for Perfusion In Situ


UP-100 with Moist Chamber for Perfusion Ex Vivo

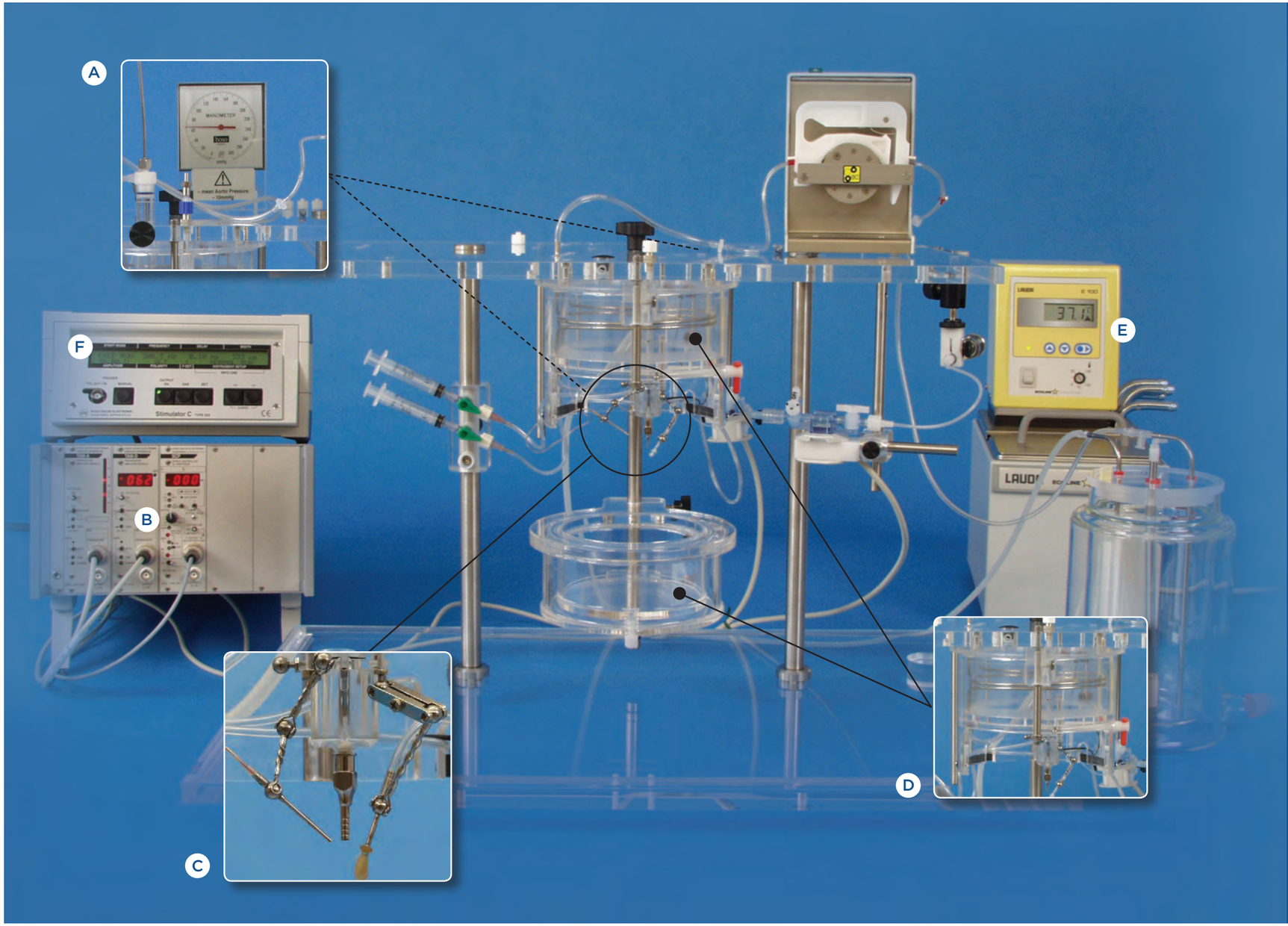
IH-SR Langendorff System

DESIGN FEATURES

- Compact design optimized for mouse, rat and guinea pig hearts
- Constant pressure or constant flow perfusion in one unit
- Modular design to integrate more applications in the future
- Unique aortic block and heart chamber allows unsurpassed physiological simulation
- Small flow resistance and low dead space volume for highly reproducible and accurate results
- Low volume drug injection pathway is ideal for compound screening

BASIC MEASURED PARAMETERS

- Perfusion pressure
- Coronary flow
- Isovolumetric LVP



A STARLING RESISTOR OPTION

- Equip your Langendorff system with the optional Starling resistor instead of the SCP Controller option to facilitate a later upgrade to a working heart setup
- Provides constant pressure perfusion of the heart in Langendorff mode and acts as an afterload system in the working heart mode.

B PLUGSYS MODULAR SYSTEM

- Compact amplifier system grows to fit your applications
- Wide range of measurement capabilities
- Low noise, analogy fidelity and control
- Analog signal output to virtually any data acquisition system

C AORTIC BLOCK

- Very low flow resistance
- Small dead space volume
- Integrated bubble trap and shut-off stopcock
- Highly stable attachment point for the heart, probes and electrodes
- Solid state perfusion circuit for stable pressure and flow control

D HEART CHAMBER

- Closes fully for superior temperature control
- Spacious enough for a range of physiological measurement probes and electrodes
- Opens and swings completely out of the way for easy adjustment of heart and probes
- Removable for easy cleaning

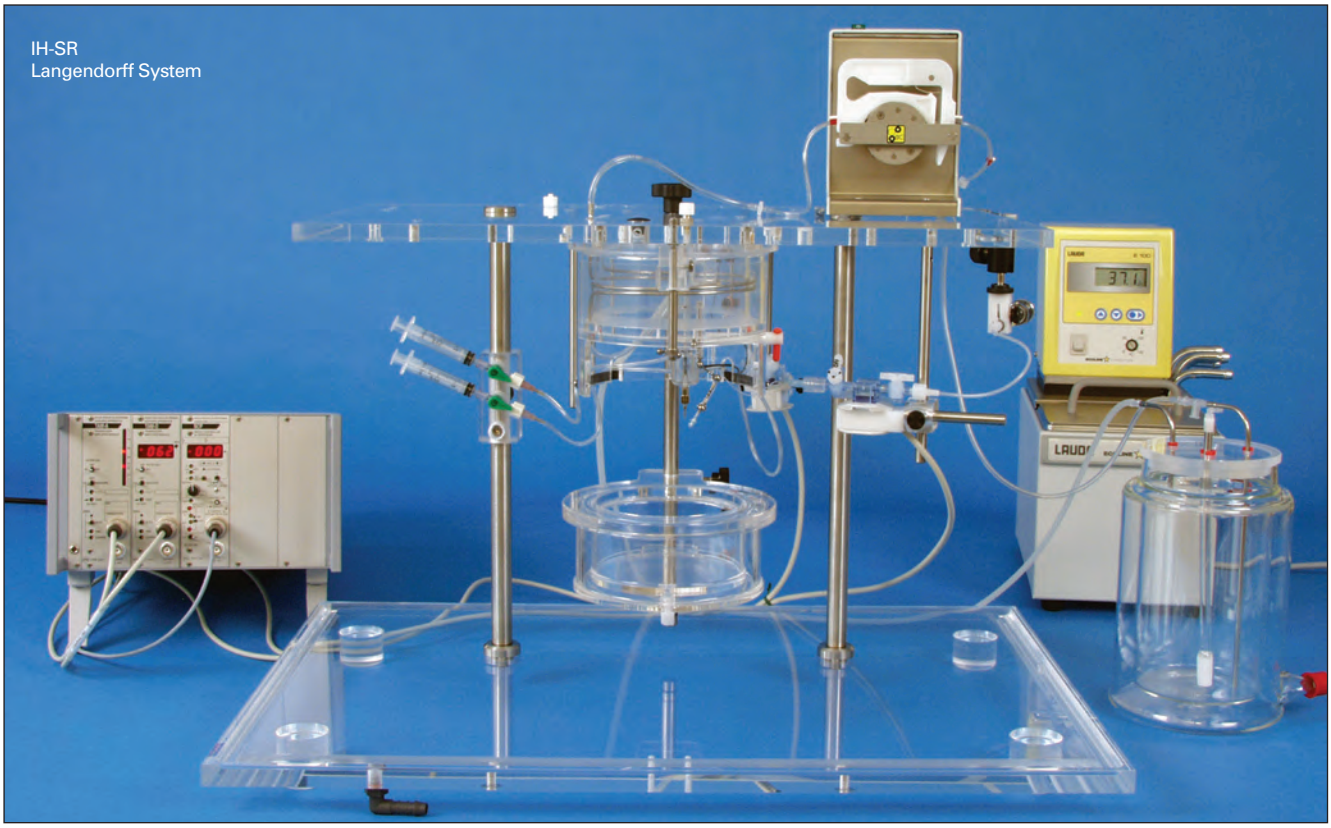
E PERFUSATE SUPPLY & PERIPHERAL EQUIPMENT

- Unique double-walled glass reservoir with aeration pathway
- Peristaltic pump with feedback control
- Thermocirculator
- Electrical stimulator for pacing

F ELECTRICAL STIMULATOR FOR PACING

web www.hugo-sachs.de web www.harvardapparatus.com email support@hbiosci.com

IH-SR Langendorff System


IH-SR
Langendorff System

The IH-SR Langendorff Core System is the starting point for all isolated perfused heart experiments on small rodents such as mouse, rat and guinea pig in the Langendorff retrograde perfusion mode.

The Core System contains all the primary equipment you need to accomplish the basic Langendorff experiment. A fully functional IH-SR Langendorff System additionally requires the selection of core system options and other components including:

- Method of constant pressure perfusion
- Species-specific additions (cannulae, buffer reservoirs and balloons)
- Desired data acquisition system

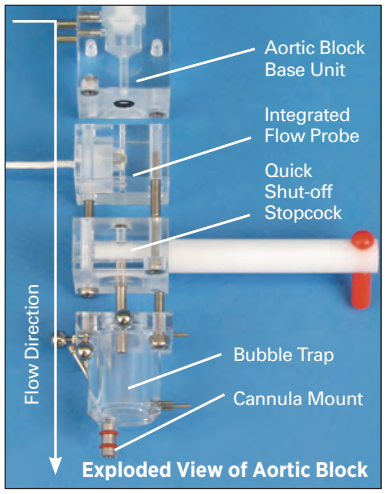
The IH-SR Langendorff Core System can be upgraded to a fully ejecting working heart system (according to Neely), accommodating aortic flows up to 60 ml/min. (See page 20.) Other options enable additional measurement and application-specific capabilities.

Advanced System Design

Advanced design provides ease-of-use and exceptional stability of measurements while maintaining the flexibility to upgrade to more advanced capabilities.

IH series systems do not use high water-columns to achieve a constant pressure and rely on instead other safer methods (Starling resistor or feedback-based perfusion controller) that keep every portion of your system within easy reach.

The aortic block is fully enclosed in the water-jacketed upper and lower IH-SR heart chamber and precision milled from thermally stable Perspex. This design allows for precise temperature control and stability, making it the optimal choice for mouse heart perfusion. Because of its larger heart chamber, this system is well-suited for applications that require ECG and MAP recordings in addition to LVP and pacing.



IH-SR ISOLATED HEART PERFUSION SYSTEMS FOR SMALL RODENTS

Applications

- Study of myogene autoregulation (add the Direct Coronary Flow Measurement Option. See p. 44-45.)
- Testing inotropic substances
- Testing of lusitrope substances
- Testing of vasoactive substances
- Cardiac rhythm tests
- Ischemia/hypoxia studies
- Refractory period studies
- Ischemia/reperfusion injury studies
- Cardioplegia studies
- Cardiac preconditioning
- Cardiovascular screening performance
- Electrophysiology studies
- Phenotyping of transgenic animals
- Drug compound screening
- Toxicology studies
- Biochemical tests

Features & Benefits

- Langendorff and optional working heart perfusion in a single system
- Compact design with no high water columns—optimized individually for mouse, rat or guinea pig
- Constant pressure or constant flow perfusion in one unit—easily switch between the two modes without changes in tubing setup
- Suitable for hearts from hypertensive rats (perfusion pressures up to 300 mmHg are possible)
- Unique integrated small volume aortic block with built-in bubble trap (immediately above the aortic cannula) and Windkessel
- Large fully-heated, closed heart chamber—important to maintain heart temperature
- Natural physiological environment for the isolated heart
- Hearts are kept alive for hours in a very stable physiologic environment
- All electrodes, catheters and probes are fully enclosed in the unique closed jacketed chamber—easy, direct access to the heart and to maintain physiological conditions while performing the experiments
- Low dead space volume—fluid injection pathway directly on top of the aortic cannula into aortic stream
- Different cannula sizes available—all metal, no fragile glass cannulae
- Cannula resistance—optimized according to Hagen-Poiseuilles physical law
- Proprietary mini holders—allow easy and stress-free positioning of electrodes, catheters and probes

Measured Signals and Calculated Parameters

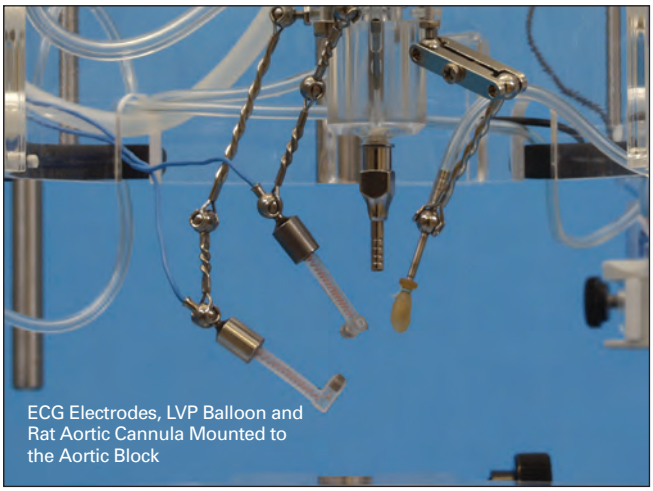
The following signals are recorded as raw data in retrograde Langendorff perfusion:

- Isovolumetric left ventricular pressure (LVP) with balloon method
- Aortic (perfusion) pressure
- Coronary flow*

The following parameters are calculated from the raw data (using ISOHEART data acquisition software):

- dLVP/dt, dLVP/dt Max, dLVP/dt Min, contractility index
- Systolic and diastolic LVP
- Heart rate
- Mean perfusion pressure
- Mean perfusion flow*
- Coronary resistance*

** This parameter is based on indirect flow measurement with the SCP controller or direct ultrasonic flow measurement with the TTFM-2 flowmeter and suitable flow probe. See page 44-45.*



ECG Electrodes, LVP Balloon and Rat Aortic Cannula Mounted to the Aortic Block

Included Items

Included items are representative of a typical IH-SR Core System. Individual components can be customized to your needs.

IH-SR Core System, Basic, 230 V (73-4343) includes:		IH-SR Core System, Basic, 115 V (73-4344) includes:	
Item #	**Product Name**	**Item #**	**Product Name**
73-4991	IH-SR Base Unit for Small Rodent Hearts	**73-4991**	IH-SR Base Unit for Small Rodent Hearts
73-4544	TC120 Thermocirculator, complete with 5 L stainless steel bath and lid, 220 V	**73-4545**	TC120 Thermocirculator, complete with 5 L stainless steel bath and lid, 120 V
73-2448	REGLO Analog 2-Channel Peristaltic Pump, 230 VAC, 50 Hz	**73-2952**	REGLO Analog 2-Channel Peristaltic Pump, 115 VAC, 50 Hz
73-0045	PLUGSYS Case, Type 603	**73-0045**	PLUGSYS Case, Type 603
73-1793	PLUGSYS Transducer Amplifier Module (TAM-D)	**73-1793**	PLUGSYS Transducer Amplifier Module (TAM-D)
73-0045	PLUGSYS Case, Type 603	**73-0045**	PLUGSYS Case, Type 603
73-0065	PLUGSYS Transducer Amplifier Module (TAM-A) (Does not include balloon kit)	**73-0065**	PLUGSYS Transducer Amplifier Module (TAM-A) (Does not include balloon kit)
73-3862	Blood Pressure Transducers (APT300), 2 included	**73-3862**	Blood Pressure Transducers (APT300), 2 included
73-3869	Rod to hold APT300, length 75 mm	**73-3869**	Rod to hold APT300, length 75 mm
73-0566	Perspex Block Clamp to mount APT300 onto rod	**73-0566**	Perspex Block Clamp to mount APT300 onto rod

The IH-SR Base Unit (73-4991) includes:

Plexiglas stand, aortic block with aorta link unit with Windkessel, heat exchanger, jacketed heart chamber, two needle valve for adjusting gas flow, holder for APT300 transducer for perfusion pressure and tubing.

Additional Requirements for a Functional Langendorff Unit

An IH-SR functional Langendorff unit requires the addition of core options to the selected Core System (either 73-4343 or 73-4344). Specifically, the Core System requires the addition of:

- Perfusion pressure controller (SCP module or Starling resistor)
- Species-specific addition (includes cannulae and balloons)

The core option and species-specific addition you select depend on:

- If you want a Langendorff Only configuration or a Working Heart-Ready Langendorff configuration.
  - The Langendorff Only configuration can easily be modified to a Langendorff Working Heart-Ready configuration in the future.
  - Researchers who know they will be upgrading to a working heart system in the future often start with the Langendorff Working Heart-Ready configuration.
- The species to be studied, i.e., mouse or rat/guinea pig

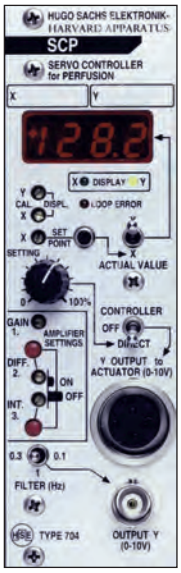
Core System Options

Langendorff Only Configuration	Langendorff Working Heart-Ready Configuration*
SCP PLUGSYS Servo Controller Module (73-2806) for constant pressure perfusion and flow control	Starling Resistor for IH-SR (73-4346) for perfusion pressure control in Langendorff mode or afterload control in working heart mode
Species-Specific Addition (choose one or both) • Mouse Hearts (73-4019) • Rat/Guinea Pig Hearts (73-4020)	Species-Specific Addition (choose one or both) • Mouse Hearts (73-4019) • Rat/Guinea Pig Hearts (73-4020)

**Coronary flow measurement in this case is only possible by using an ultrasound transit time TTFM-2 flowmeter with flow probe.*

Perfusion Pressure Controllers

PLUGSYS Servo Controller for Perfusion (SCP) Module (73-2806)



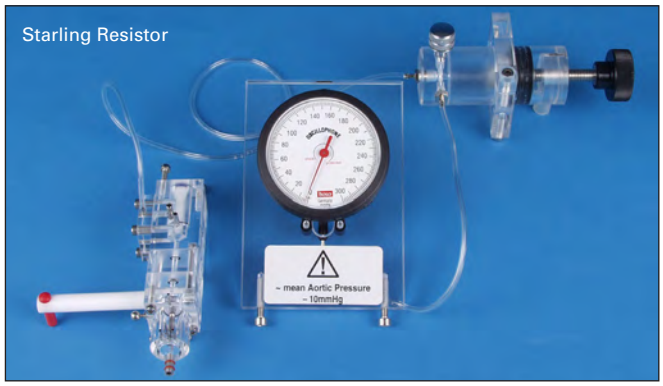
PLUGSYS SCP Module

The SCP constant pressure/flow controller maintains perfusion either at constant pressure or at constant flow using a peristaltic pump. It provides accurate control of perfusion flow rate or pressure, even at very low flow rates. The SCP controller modulates the flow generated by the perfusion pump based on a perfusion pressure feedback loop. The controller also provides an accurate, low-cost way to indirectly measure coronary flow. The SCP calculates flow rate from pump speed, eliminating the need for an expensive flowmeter. It is required for Langendorff Only configurations.

Additional measured signals and calculated parameters:

- Indirect coronary flow measurement
- Calculation of coronary resistance

Starling Resistor for Perfusion Pressure Control (73-4346)



The perfusion pressure controller with Starling resistor provides constant pressure perfusion of the heart in Langendorff mode and acts as an afterload system in the working heart mode. It uses a Teflon membrane flow resistor, manometer and pressure syringe to create a pressure-controlled valve in the aortic block. It is required for a Langendorff Working Heart-Ready configuration.

If coronary flow measurement is required, the use of the PLUGSYS ultrasonic transit time flow measurement module (TTFM-2) and flow probe (See pages 44-45) will be required, as the SCP controller cannot make that measurement.

Additional measured signals/calculated parameters:

- Coronary flow data (Add Flow Measurement Option, pages 44 - 45.)

The Starling Resistor includes:

- Aortic block base unit with flange-mounted adjustable flow resistance
- Pressure syringe with mounting bracket
- Manometer

Species-Specific Additions

(Purchase Separately)

Addition to IH-SR Core System for Mouse Hearts (73-4019) includes:		Addition to IH-SR Core System for Rat/Guinea Pig Hearts (73-4020) includes:	
Item #	**Product Name**	**Item #**	**Product Name**
73-2816	Aortic Cannula for Mouse Heart to IH-SR, OD 1.0 mm	**73-2814**	Aortic Cannula for Rat Heart to IH-SR, OD 2.3 mm
		73-2862	Aortic Cannula for Rat/ Guinea Pig Heart to IH-SR, OD 3.0 mm
73-0126	3-Stop Tygon® E-Lab Tubing, 1.22 mm ID, 12/pack, Red/Grey	**73-0155**	3-Stop Tygon® E-Lab Tubing, 2.79 mm ID, 12/pack, Purple/ White
73-3456	Tube Set for Jacketed Buffer Reservoir with Fluid Line Shutoff Valves	**73-3456**	Tube Set for Jacketed Buffer Reservoir with Fluid Line Shutoff Valves
73-3438	Jacketed Glass Reservoir for Buffer Solution with Frit, 1 L	**73-3440**	Jacketed Glass Reservoir for Buffer Solution with Frit, 2 L
73-0143	Mini Balloon Kit for Mouse Heart for IH-SR	**73-3560**	Balloon Kit for Rat Heart for IH-SR
73-2787	Mouse/Neonatal Rat Balloon Assembly Kit		

Ordering Information

Item #	Description
73-4343	IH-SR Core System for Isolated Small Rodent Heart, 230 VAC
73-4344	IH-SR Core System for Isolated Small Rodent Heart, 115 VAC
73-2806	PLUGSYS Servo Controller for Perfusion (SCP)*
73-4346	Perfusion Pressure Control with Starling Resistor for IH-SR
73-4019	Additions to IH-SR Basic System for Mouse Hearts
73-4020	Additions to IH-SR Basic System for Rat Hearts

**Module requires 2 PLUGSYS slots.*

Additional Components

ISOHEART Data Acquisition Software and Associated Hardware

Provides real-time evaluation of a wide range of signals and classical cardiovascular parameters. *See page 66.*

Note: Ponemah Data Acquisition & Analysis Software from DSI, a Harvard Bioscience Company is also suitable. *See page 66.*

Thermocirculator

Used to warm and maintain temperature of the perfusate. *See pages 58-59.*

Buffer Reservoirs

Used in conjunction with a peristaltic pump to deliver warmed perfusate to the target organ and to aerate the perfusate with O2 and CO2. *See page 60.*

Peristaltic Pump

Used to deliver warmed perfusate to the target organ in the heart chamber. *See pages 61-62.*

Specialized Applications & Upgrades

Coronary Flow Measurement

Coronary Flow measurement can be accomplished in an IH-SR unit using two methods. *See pages 44-45.*

- Indirect measurement by controlling the pump sped of a peristaltic pump (SCP controller)
- Direct measurement with Ultrasonic Transit Time Technique (TTFM-2 module)

Coronary Effluate Collection

Pulmonary artery cannulae, preparation dish and effluate funnel for collection of effluate from the coronaries for metabolic studies, further analysis, or for continuous pO_2, pH, or pCO_2 measurements. *See page 48-49.*

Perfusate Oxygenation of Foaming Media

For oxygenation of buffer solution supplemented with albumin, fatty acids, washed erythrocytes, or other foaming additives. *See page 50.*

Perfusate Filtration

For filtration of recirculated perfusate. *See page 50.*

Temperature Measurement

Measure perfusate temperature in any isolated perfused organ system. Since the system is well thermostated, temperature measurement is only necessary when specific temperature studies with special temperature protocols are being performed, e.g. cooling or transplantation studies. *See page 51.*

Perfusion Solution Monitoring

Permits precise continuous or intermittent measurement in liquid media or perfusate of three key parameters: pO_2, pH and pCO_2. *See page 51.*

Drug Addition

For accurate drug addition using a syringe pump. Additional option for flow controlled drug addition, where flow is measured (or calculated) and a drug must be added in a certain ratio. *See page 52.*

Cell Isolation Upgrade

Add this upgrade to a functional IH-SR System for cell isolation/cell extraction applications. *See page 53.*

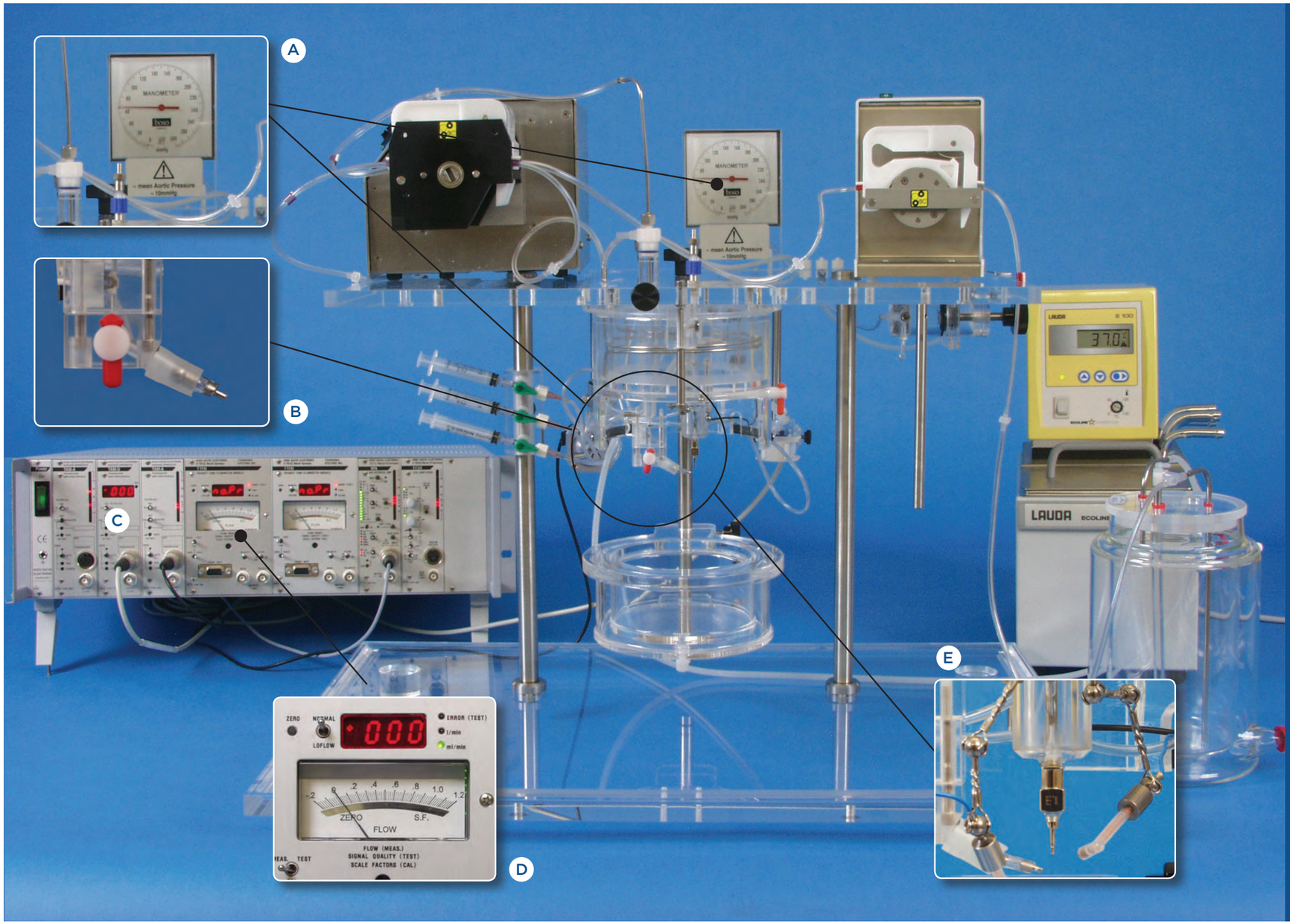
Pacing

For addition of pacing to functional IH-SR or IH-5 Langendorff and Working Heart Systems. For small rodent hearts (mouse, rat and guinea pig). *See page 53.*

Single-Lead ECG and MAP Measurement

For single-lead ECG and MAP on functional IH-SR Systems, one ECG lead can be measured in combination with MAP electrodes. *See page 54-55.*

IH-SR
Working Heart System



DESIGN FEATURES

- Allows assessment of external heart work under adjustable load
- Unsurpassed physiological environment
- Optimized for mouse, rat or guinea pig hearts
- Compact, small bench footprint and vertical clearance (not high water columns required)
- Optional continuous measurement of metabolic parameters, e.g. pH, pO_2, pCO_2
- Low volume drug injection pathway
- Reduced line resistance engineered to exceed species flow for optimal atrial filling
- Low flow resistance and dead space volume for highly accurate and reproducible results
- Rapid and easy switching between working heart and Langendorff modes

A STARLING RESISTOR OPTION

- Equip your Langendorff system with the optional Starling resistor instead of the SCP Controller option to facilitate a later upgrade to a working heart setup
- Provides constant pressure perfusion of the heart in Langendorff mode and acts as an afterload system in the working heart mode.

B LEFT ATRIAL BLOCK

- Built-in stopcock for rapid control of atrioventricular flow
- Integrated bubble trap and syringe for drug addition in working heart perfusion mode
- Optional integration of ultrasonic flow probe for atrial flow measurement

C PLUGSYS MODULAR SYSTEM

- Compact amplifier system grows to fit your applications
- Wide range of measurement capabilities
- Low noise, analogy fidelity and control
- Analog signal output to virtually any data acquisition system

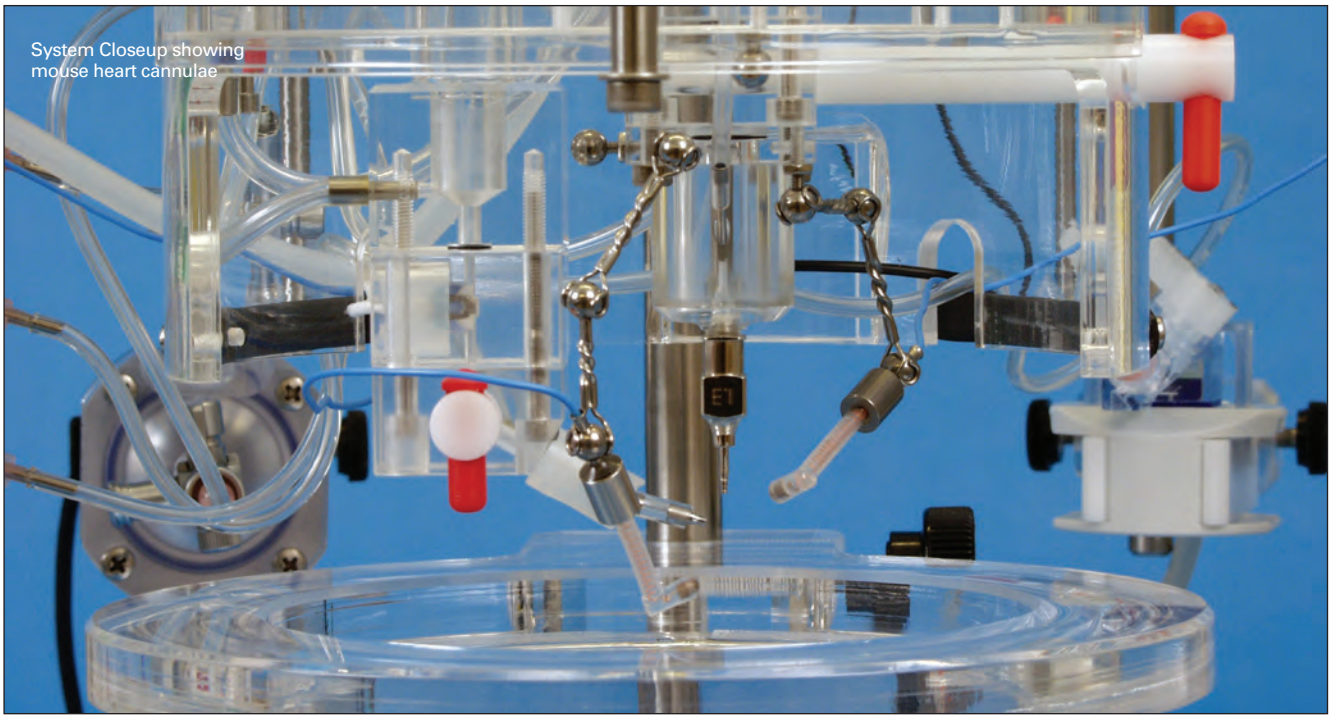
D FLOW MEASUREMENT

- Phasic real-time direct flow measurements
  - Aortic flow
  - Atrial flow
  - Coronary flow (calculated from atrial – aortic flow or measured via cannulation of the pulmonary artery)
- Fully integrated flow probes
- Solid-state physiological perfusion circuit ensures non-turbulent laminar flow

E AORTIC BLOCK

- Unique physiological afterload system (Starling resistor)
- Adjustable afterload resistor (Starling resistor) built in to the aortic block for setting peripheral resistance in the working heart preparation
  - 0 to 300 mmHg adjustment range
  - Precise control of cardiac afterload to simulate hypo-, normo-, or hypertensive states
  - Improved arterial pressure evaluation without risk of damage to heart valves
- Simulates natural physiological environment
- Built-in Windkessel to simulate aortic compliance
- Integrated pathway for insertion of a pressure or pressure-volume catheter

IH-SR Working Heart System


System Closeup showing mouse heart cannulae

The IH-SR Langendorff System can be upgraded to a fully-ejecting working heart system (according to Neely) for physiological cardiovascular studies, e.g. cardiac function and metabolism. The upgrade allows rapid and easy switching between working heart and Langendorff modes.

To upgrade our IH-SR Langendorff Core System to an IH-SR Working Heart System, add a Working Heart Upgrade and species-specific atrial cannulae. To measure flow, a TTFM-2 flowmeter and species-suitable flow probe are also required.

Applications

- Real-time measurement of atrial and aortic flow (add species-appropriate flow probes and PLUGSYS TTFM-2 Flowmeter module.)
- Isovolumetric left ventricular pressure (LVP) measurement (add the LVP Measurement Option. See page 46.)
- Pressure-volume measurement (add the Pressure-Volume Loop (PVL) Measurement Option.)
- High atrial pressure-induced disease state simulation (add the Increased Preload Pressure Option.)

Features & Benefits

- Fully-ejecting working heart model for physiological cardiovascular studies, e.g. cardiac function and metabolism
- Allows rapid and easy switching between Working Heart (Ejecting Heart) and Langendorff modes
- Optimized atrial cannulating conditions—true aortic flow and pressure signals (no bouncing induced by a water column afterload)
- Short atrial fill time (low flow resistance)—optimal ventricle filling
- Low resistance and dead space volume
- Minimal temperature and oxygen loss
- Unique vascular afterload system using the Starling membrane resistor—optimal vascular system simulation including compliance simulation by Windkessel
- Physiological atrial and arterial pressure waveform—avoids non-physiological pressure wave; no dynamic pressure effects or altered coronary flow
- Ready constant preload system—preload pressure independent of the atrial flow; no stress on mitral valve
- Low aortic cannula flow resistance—optional insertion of a FISO or Millar transducer for LVP or a Millar transducer for LVP/Volume measurement
- No liquid pressure column as afterload—less stress on aortic valves
- All electrodes, catheters and probes are fully enclosed in the unique closed jacketed chamber—easy, direct access to the heart and to maintain physiological conditions while performing the experiments.

Measured Signals and Calculated Parameters

All parameters of standard Langendorff can be measured. In addition, the following signals can be recorded:

- Preload (left atrial preload/ventricular filling pressure)
- Afterload (determining the diastolic and systolic aortic pressure)
- Intracardial left ventricular pressure or pressure-volume loops
- Atrial, aortic and coronary flow (calculated from atrial and aortic flow

Included Items

Working Heart Upgrade, 230 V (73-4347) includes:		Working Heart Upgrade, 115 V (73-4349) includes:	
Item #	Product Name	Item #	Product Name
73-2818	Working Heart Option to IH-SR Core System	**73-2818**	Working Heart Option to IH-SR Core System
72-6432	Ecoline VC-MS/CA8-6, 230 VAC	**72-6433**	Ecoline VC-MS/CA8-6, 115 VAC
73-1838	3-Stop Tygon® E-Lab Tubing, 2.54 mm ID, 12/pack, Purple/Orange	**73-1838**	3-Stop Tygon® E-Lab Tubing, 2.54 mm ID, 12/pack, Purple/Orange
73-1839	3-Stop Tygon® E-Lab Tubing, 3.17 mm ID, 12/pack, Black/White	**73-1839**	3-Stop Tygon® E-Lab Tubing, 3.17 mm ID, 12/pack, Black/White
73-0020	Blood Pressure Transducer P75 for PLUGSYS Module	**73-0020**	Blood Pressure Transducer P75 for PLUGSYS Module
73-0065	PLUGSYS Transducer Amplifier Module (TAM-A)	**73-0065**	PLUGSYS Transducer Amplifier Module (TAM-A)
73-3440	Jacketed Reservoir for Buffer Solution with Frit, 2 L	**73-3440**	Jacketed Reservoir for Buffer Solution with Frit, 2 L
73-3456	Tube Set for Jacketed Buffer Reservoir with Fluid Line Shutoff Valves	**73-3456**	Tube Set for Jacketed Buffer Reservoir with Fluid Line Shutoff Valves

Working Heart Option (73-2818) includes:

Left atrium cannulating system consisting of preload reservoir (capacity 2 to 7 ml), movable atrium connection adapter, and holder for P75 pressure transducer for preload measurement. Atrial cannulae must be ordered separately.

Atrial Cannulae (Required, Purchase Separately)

Complete the Working Heart upgrade by choosing the appropriate species-specific addition:

- 73-4033 Working Heart Left Atrial Cannula for Mouse Heart, 1.3 mm OD
- 73-4034 Working Heart Left Atrial Cannula for Rat and Guinea Pig Heart, 2.3 mm OD

Ordering Information

Item #	Description
73-4343	IH-SR Core System for Isolated Small Rodent Heart, 230 VAC
73-4344	IH-SR Core System for Isolated Small Rodent Heart, 115 VAC
73-2806	PLUGSYS Servo Controller for Perfusion (SCP)*
73-4346	Perfusion Pressure Control with Starling Resistor for IH-SR
73-4019	Additions to IH-SR Basic System for Mouse Hearts
73-4020	Additions to IH-SR Basic System for Rat Hearts
73-4033	Working Heart Left Atrial Cannula for Mouse Heart, 1.3 mm OD
73-4034	Working Heart Left Atrial Cannula for Rat and Guinea Pig Heart, 2.3 mm OD

Specialized Applications & Upgrades

Left Atrial and Aortic Flow Measurement

Left atrial and aortic flow measurement in IH-SR Working heart mode is performed with PLUGSYS Ultrasonic Transit Time Technique (TTFM-2 module). *See page 45.*

Intracardial Left Ventricular Pressure (LVP) Measurement

Easily allows introduction of a tip pressure catheter directly into the left ventricle via the adapter port and the aorta, rather than via apical puncture. *See page 46.*

Pressure-Volume Loop (PVL) Measurement

Easily allows introduction of a pressure-volume loop catheter directly into the left ventricle via an adapter port and the aorta. *See page 47.*

Increased Preload Pressure

To create left atrial preload pressures higher than 1h1 mmHg. *See pages 48.*

Coronary Effluate Collection

Pulmonary artery cannulae, preparation dish and effluate funnel for collection of effluate from the coronaries for metabolic studies, further analysis, or for continuous pO_2, pH, or pCO_2 measurements. *See pages 48-49.*

Perfusate Oxygenation of Foaming Media

For oxygenation of buffer solution supplemented with albumin, fatty acids, washed erythrocytes, or other foaming additives. *See page 50.*

Perfusate Filtration

For filtration of recirculated perfusate. *See page 50.*

Temperature Measurement

Measure perfusate temperature in any isolated perfused organ system. Since the system is well thermostated, temperature measurement is only necessary when specific temperature studies with special temperature protocols are being performed, e.g. cooling or transplantation studies. *See page 51.*

Perfusion Solution Monitoring

Permits precise continuous or intermittent measurements in liquid media or perfusate of three key parameters: pO_2, pH and pCO_2. *See pages 51-52.*

Drug Addition

For accurate drug addition using a syringe pump. Additional option for flow controlled drug addition, where flow is measured (or calculated) and a drug must be added in a certain ratio. *See page 52.*

Cell Isolation Upgrade

Add this upgrade to a functional IH-SR System for cell isolation/cell extraction applications. *See page 53.*

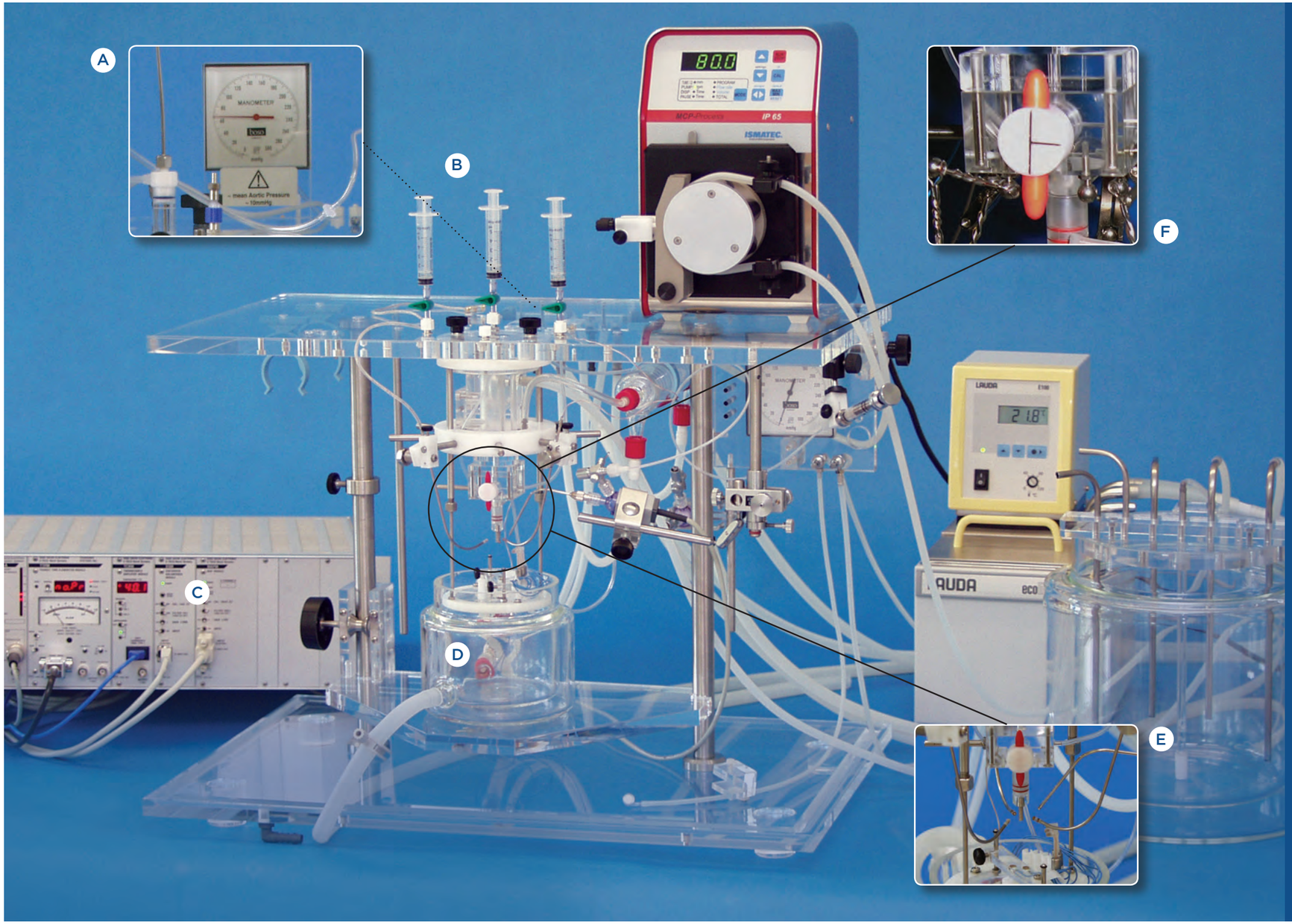
Pacing

For addition of pacing to functional IH-SR or IH-5 Langendorff and Working Heart Systems. For small rodent hearts (mouse, rat and guinea pig). *See page 53.*

Single-Lead ECG and MAP Measurement

For single-lead ECG and MAP on functional IH-SR Systems, one ECG lead can be measured in combination with MAP electrodes. *See pages 54-55.*

IH-5
Langendorff System



IH-5 ISOLATED HEART PERFUSION SYSTEMS FOR RAT, GUINEA PIG & RABBIT

DESIGN FEATURES

- Suitable for hearts from hypertensive animals with perfusion pressures up to 300 mmHg
- Compact system with no high wall-installed water columns
- Constant pressure and constant flow perfusion in one unit
- Modular system is fully upgradable and expandable at any time
- Large 6 L perfusate reservoir accommodates enough perfusate for rabbit Langendorff and working heart requirements (2 L available for smaller species).

BASIC MEASURED PARAMETERS

- Perfusion (aortic) pressure
- Coronary flow
- Isovolumetric LVP

A STARLING RESISTOR OPTION

- Equip your Langendorff system with the optional Starling resistor instead of the SCP Controller option to facilitate a later upgrade to a working heart setup
- Provides constant pressure perfusion of the heart in Langendorff mode and acts as an afterload system in the working heart mode.

B CONVENIENT ACCESS PORTS

- Drug injection pathway built directly into aortic perfusate stream
- Integrated stopcock allows switching between primary and secondary perfusate (such as cardioplegia solution)
- Secondary port for either drug injection or insertion of catheter type probes (e.g. temperature)

C PLUGSYS MODULAR SYSTEM

- Compact amplifier system grows to fit your applications
- Wide range of measurement capabilities
- Low noise, analogy fidelity and control
- Analog signal output to virtually any data acquisition system

D HEART CHAMBER AND PLATFORM

- Large chamber accommodates a range of physiological probes and electrodes
- Knob conveniently raises and lowers elevator platform
- Fully surrounds heart and lower aortic block for temperature stability

E ELECTROPHYSIOLOGY & SAFETY PHARMCOLOGY OPTIONS

- Single- or multi-lead ECG analysis (up to 12)
- ECG mapping
- Epicardial monophasic action potentials (up to 8)
- Endocardial monophasic action potential

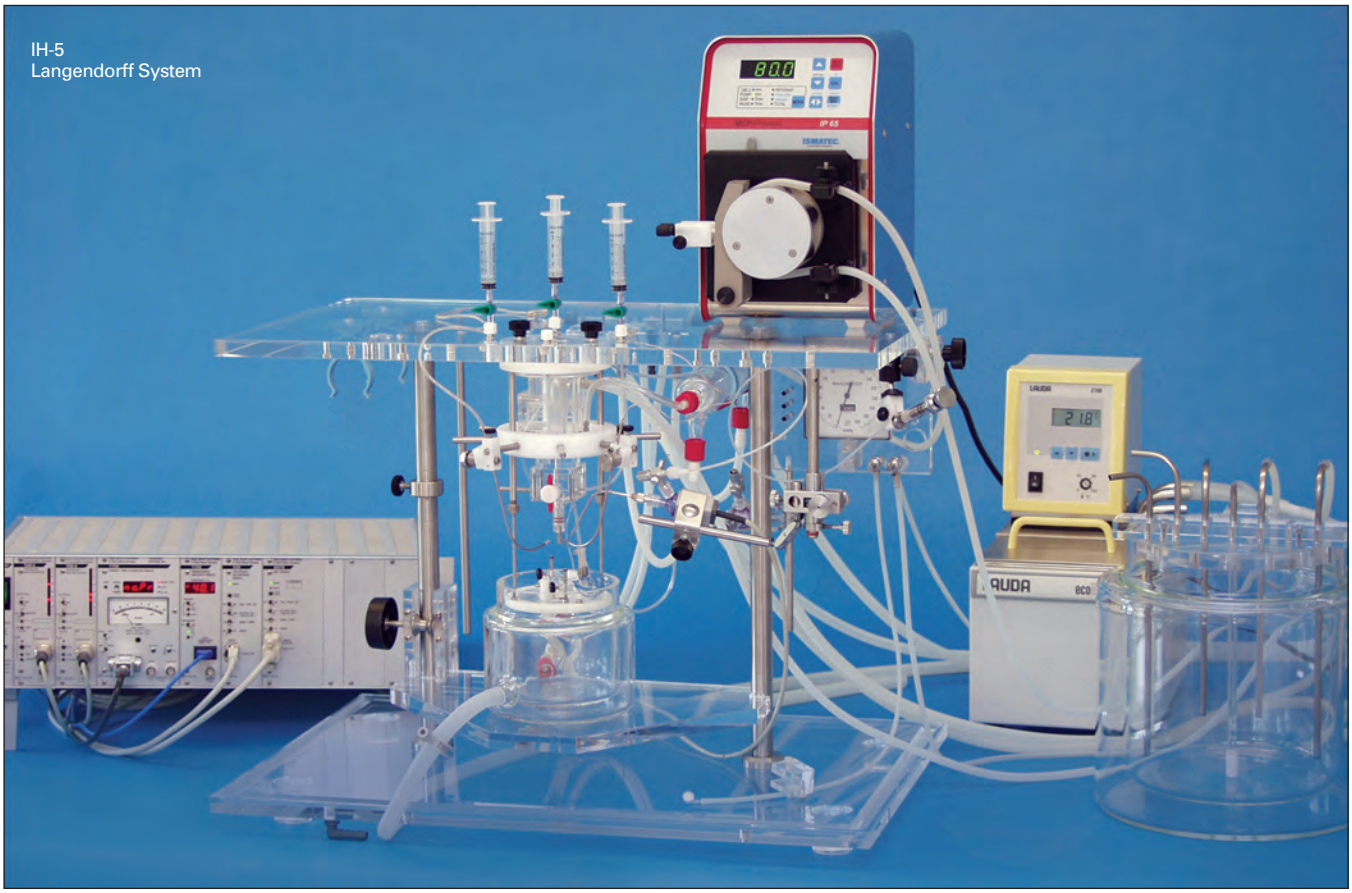
F AORTIC BLOCK

- Low flow resistance engineered for increased flow up to 500 ml/min
- Unique small volume aortic block with built-in bubble trap and Windkessel
  - Reproduces in situ elastic properties of the aorta
  - Adjustable air volume in Windkessel for optimal pulsation dampening
- Solid-state perfusion technology mimics in vivo perfusion and prevents measurement artifact
- Highly stable attachment point for the heart, probes and electrodes
- Unique proprietary aortic cannulae in stainless steel, multiple sizes

ISOLATED HEART PERFUSION SYSTEMS

web www.hugo-sachs.de web www.harvardapparatus.com email support@hbiosci.com

IH-5 Langendorff System



The IH-5 Langendorff Core System is the starting point for all isolated perfused heart experiments for medium-sized rodents (rat, guinea pig and rabbit) in the Langendorff retrograde perfusion mode.

The Core System contains all the primary equipment to accomplish the basic Langendorff experiment. A fully functional IH-5 Langendorff System requires the addition of core system options and other components including:

- Method of constant pressure perfusion
- Species-specific additions (cannulae, buffer reservoirs and balloons)
- Heart chamber
- Desired data acquisition system

The modular nature of the IH-5 allows the system to evolve along with your research. Our Langendorff System can easily be upgraded to a full working ejecting heart according to Neely (See page 30), accommodating aortic flows up to 500 ml/min or to a biventricular system where both sides of the heart eject fluid as in vivo. (See page 38.) Other options add additional measurement and application capabilities, such as multi-channel ECG and MAP cardiac electrophysiology applications.

Advanced System Design

The IH-5 utilizes the architecture of the ground-breaking IH-SR to set the standard for isolated heart perfusion in rabbits, adult guinea pigs, or adult rats. Engineered for the increased flow produced by these species (up to 500 mL/min), the IH-5 offers ultimate perfusion stability and real physiological conditions for longer, more relevant recordings with fewer artifacts. This compact platform has been optimized to create in situ-like perfusion features, delivering a considerably higher sensitivity for various experimental manipulation while maintaining the advantages of an ex vivo preparation. Like the IH-SR, the IH-5 System does not utilize high water columns but creates a constant pressure perfusion setup using a pressure feedback pump controller, resulting in a compact system fully within your reach.

If the aortic block with the Starling resistor (working heart ready) is used for Langendorff applications, the aortic perfusion pressure is defined by the setting of the membrane pressure in the Starling resistor. By setting a defined threshold pressure at the Starling resistor, the system works under constant pressure. By increasing the threshold pressure to a super-maximal pressure (300 mmHg), the system works under constant flow. The complete aortic block mounted on a compact acrylic stand.

The IH-5 utilizes convenient switches that allow you to easily change from constant flow to constant pressure perfusion, Langendorff to working heart, and between two different perfusion solutions.

IH-5 ISOLATED HEART PERFUSION SYSTEMS FOR RAT, GUINEA PIG & RABBIT

Applications

- Study of myogene autoregulation with the addition of the Flow Measurement Option (See page 44-45.)
- Testing inotropic substances
- Testing of lusitrope substances
- Testing of vasoactive substances
- Cardiac rhythm tests
- Ischemia/hypoxia studies
- Refractory period studies
- Ischemia/reperfusion injury studies
- Cardioplegia studies
- Cardiac preconditioning
- Cardiovascular screening performance
- Electrophysiology studies
- Phenotyping of transgenic animals
- Drug compound screening
- Toxicology studies
- Biochemical tests

Features & Benefits

- Compact design, no high water columns—optimized individually for rabbit, rat or guinea pig
- Easily upgraded to a working (ejecting) heart system or biventricular working heart system—special flow resistance and compliance chamber closely mimics the in vivo afterload
- Constant pressure or constant flow perfusion in one unit—easily switch between the two modes without changes in tubing setup
- Suitable for hearts from hypertensive animals—perfusion pressures up to 300 mmHg are possible
- Unique integrated small volume aortic block with built-in bubble trap and Windkessel chamber
- Natural physiological environment for isolated heart with large heated chamber
- Continuous measurement of heart mechanics (contractility), bioelectrical signals (ECG, MAP) and perfusate characteristics (pCO_2, pO_2, pH)
- Unique cannula design, available in different sizes, all metal, no fragile glass cannulae
- Cannula resistance is optimized according to Hagen-Poiseuilles Physical Law
- Proprietary mini holders allow easy and stress-free access to hold electrodes and catheters in position
- Drug injection pathway built directly into aortic perfusate stream

Measured Signals and Calculated Parameters

The following signals are recorded as raw data in retrograde Langendorff perfusion:

- Isovolumetric left ventricular pressure (LVP) with balloon
- Aortic (perfusion) pressure
- Coronary flow*

The following parameters are calculated from the raw data (using ISOHEART Data Acquisition Software):

- dLVP/dt, dLVP/dt Max, dLVP/dt Min, Contractility Index
- Systolic and Diastolic LVP
- Heart Rate
- Mean Perfusion Pressure
- Mean Perfusion Flow*
- Coronary Resistance*

** This parameter is based on indirect flow measurement with SCP or direct ultrasound flow measurement with the TTFM-2 flowmeter and suitable flow probe. See page 44-45.*

Included Items

Included items are representative of a typical IH-5 Core System. Individual components can be customized to your needs.

IH-5 Core System, Basic, 230 V (73-4398) includes:		IH-5 Core System, Basic, 115 V (73-4397) includes:	
Item #	**Product Name**	**Item #**	**Product Name**
73-4996	IH-5 Base Unit	**73-4996**	IH-5 Base Unit
73-4544	TC120 Thermocirculator, with 5 L stainless steel bath and lid, 220 V	**73-4545**	TC120 Thermocirculator, with 5 L stainless steel bath and lid, 120 V
70-7001	Harvard Peristaltic Pump P230	**70-7001**	Harvard Peristaltic Pump P230
73-0045	PLUGSYS Case, Type 603	**73-0045**	PLUGSYS Case, Type 603
73-1793	PLUGSYS Transducer Amplifier Module (TAM-D)	**73-1793**	PLUGSYS Transducer Amplifier Module (TAM-D)
73-3862	Blood Pressure Transducers (APT300), 2 included	**73-3862**	Blood Pressure Transducers (APT300), 2 included
73-1973	PLUGSYS Transducer Amplifier Module (TAM-D)	**73-1973**	PLUGSYS Transducer Amplifier Module (TAM-D)
73-0065	PLUGSYS Transducer Amplifier Module (TAM-A)	**73-0065**	PLUGSYS Transducer Amplifier Module (TAM-A)
73-3862	Rod to hold APT300, length 75 mm	**73-3862**	Rod to hold APT300, length 75 mm
73-3871	Holder for APT300 Transducer for IH-5	**73-3871**	Holder for APT300 Transducer for IH-5

The IH-5 Base Unit (73-4996) includes:

Plexiglas stand, aortic block with aorta link unit with Windkessel, heat exchanger, jacketed heart chamber, two needle valves for adjusting gas flow, holder for transducer for perfusion pressure, tubing. Aortic cannula and buffer reservoir must be ordered separately. Buffer reservoirs (required) must be purchased separately. See page 60.

Additional Requirements for a Functional Langendorff Unit

An IH-5 Langendorff functional unit requires the addition of core options to the selected Core System (either 73-4397 or 73-4398). Specifically, the Core System requires the addition of:

- Perfusion pressure controller (SCP module or Starling resistor)
- Species-specific addition (includes cannulae and balloons)
- Application-appropriate heart chamber

The core option and species-specific addition you select depend on:

- If you want a Langendorff Only configuration or a Working Heart-Ready Langendorff configuration.
  - The Langendorff Only configuration can easily be modified to a Langendorff Working Heart-Ready configuration in the future.
  - Researchers who know they will be upgrading to a working heart system in the future often start with the Langendorff Working Heart-Ready configuration.
- The species to be studied, i.e., rat, guinea pig or rabbit.

Core System Options

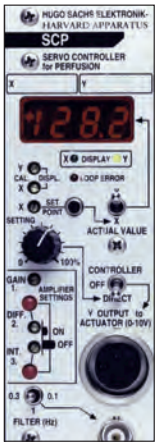
Langendorff Only Configuration	Langendorff Working Heart-Ready Configuration*
SCP PLUGSYS Servo Controller Module (73-2806) for constant pressure perfusion and flow control	Starling Resistor (73-4435) for perfusion pressure control and afterload control in working heart
Species-Specific Addition (choose one or both) • Rat/Guinea Pig Hearts (73-4399) • Rabbit Hearts (73-4400)	Species-Specific Addition (choose one or both) • Rat/Guinea Pig Hearts (73-4399) • Rabbit Hearts (73-4400)
Heart Chamber (choose one) • 73-4401 for Cardiovascular Studies • 73-4402 for Electrophysiology Studies**	Heart Chamber (choose one) • 73-4401 for Cardiovascular Studies • 73-4402 for Electrophysiology Studies**

**Coronary flow measurement in this case is only possible by using an ultrasound transit time TTFM-2 flowmeter with flow probe.*

*** Choose this option if you intend to use the multi-ECG ring and/or circular MAP ring, as it requires a larger heart chamber.*

Perfusion Pressure Controllers

PLUGSYS Servo Controller for Perfusion (SCP) Module (73-2806)



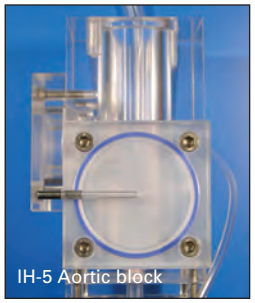
SCP Controller

The SCP constant pressure/flow controller maintains perfusion either at constant pressure or at constant flow using a peristaltic pump. The SCP controller modulates the flow generated by the perfusion pump based on a perfusion pressure feedback loop. The controller also provides an accurate, low-cost way to indirectly measure coronary flow. It provides accurate control of perfusion flow rate or pressure, even at very low flow rates. The SCP calculates flow rate from pump speed, eliminating the need for an expensive flowmeter. It is required for Langendorff Only configurations.

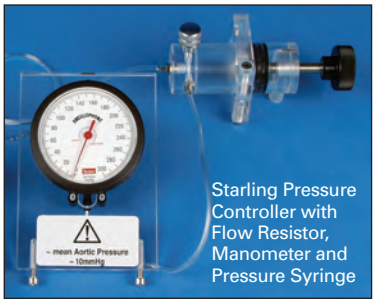
Additional measured signals and calculated parameters:

- Indirect coronary flow measurement
- Calculation of coronary resistance

Starling Resistor for Perfusion Pressure Control (73-4435)



IH-5 Aortic block



Starling Pressure Controller with Flow Resistor, Manometer and Pressure Syringe

The perfusion pressure controller with Starling resistor provides constant pressure perfusion of the heart in Langendorff mode and acts as an afterload system in the working heart mode. It uses a Teflon membrane flow resistor, manometer and pressure syringe to create a pressure-controlled valve in the aortic block. It is required for a Langendorff Working Heart-Ready configuration.

If coronary flow measurement is required, the use of the PLUGSYS ultrasonic transit time flow measurement module (TTFM-2) and flow probe will be required, as the SCP controller cannot make that measurement (See pages 44-45.)

Additional measured signals/calculated parameters:

- Coronary flow data (Add species-specific Flow Measurement Option. See pages 44-45.)

The Starling Resistor includes:

- Aortic block base unit with flange-mounted adjustable flow resistance
- Pressure syringe with mounting bracket
- Manometer

Species-Specific Additions

(Purchase Separately)

Addition to IH-5 Core System for Rat and Guinea Pig Hearts (73-4399) includes:		Addition to IH-SR Core System for Rat/Guinea Pig Hearts (73-4020) includes:	
Item #	**Product Name**	**Item #**	**Product Name**
73-3072	Aortic Cannula for Rat/ Guinea Pig Heart to IH-5, set of 2, OD 3.0 and 2.5 mm	**73-0719**	Aortic Cannula for Rabbit Heart to IH-5, OD 2.3 mm, set of 3, OD 3.0, 4.0 and 5.0 mm
73-1860	2-Stop Tygon® E-Lab Tubing, 2.06 mm ID, 12/ pack, Purple/Purple	**73-1863**	2-Stop Tygon® E-Lab Tubing, 2.79 mm ID, 12/pack, Purple/ White
73-3441	Jacketed Glass Reservoir for Buffer Solution, with Frit and Bottom Drain, 2 L	**73-0322**	Jacketed Glass Reservoir for Buffer Solution, with Frit, 6 L
73-4463	Balloon Kit for Rat/Guinea Pig Hearts for IH-5	**73-0323**	Balloon Kit for Rabbit Hearts for IH-5

Ordering Information

Item #	Description
73-4398	IH-5 Core System for Isolated Rat, Guinea Pig or Rabbit Heart, 230 VAC
73-4397	IH-5 Core System for Isolated Rat, Guinea Pig or Rabbit Heart, 115 VAC
73-2806	PLUGSYS Servo Controller for Perfusion (SCP)*
73-4435	Perfusion Pressure Control with Starling Resistor for IH-5
73-4399	Additions to the IH-5 Core System for Rat/Guinea Pig Hearts
73-4400	Additions to the IH-5 Core System for Rabbit Hearts
73-4401	Heart Chamber for IH-5 Core System for Cardiovascular Studies
73-4402	Heart Chamber for IH-5 Core System for Electrophysiology

**Module requires 2 PLUGSYS slots.*

Additional Components

ISOHEART Data Acquisition Software and Associated Hardware

Provides real-time evaluation of a wide range of signals and classical cardiovascular parameters. *See page 66.*

Note: Ponemah Data Acquisition & Analysis Software from DSI, a Harvard Bioscience Company is also suitable. See page 66.

Thermocirculator

Used to warm and maintain temperature of the perfusate. *See pages 58-59.*

Buffer Reservoirs

Used in conjunction with a peristaltic pump to deliver warmed perfusate to the target organ and to aerate the perfusate with O_2 and CO_2. *See page 60.*

Peristaltic Pump

Used to deliver warmed perfusate to the target organ in the heart chamber. *See pages 61-62.*

Specialized Applications & Upgrades

Coronary Flow Measurement

Coronary flow measurement can be accomplished in an IH-5 unit using two methods. *See pages 44-45.*

- Indirect measurement by controlling the pump sped of a peristaltic pump (SCP controller)
- Direct measurement with Ultrasonic Transit Time Technique (TTFM-2 module)

Coronary Effluate Collection

Pulmonary artery cannulae, preparation dish and effluate funnel for collection of effluate from the coronaries for metabolic studies, further analysis, or for continuous pO2, pH, or pCO2 measurements. *See pages 48-49.*

Perfusate Oxygenation of Foaming Media

For oxygenation of buffer solution supplemented with albumin, fatty acids, washed erythrocytes, or other foaming additives. *See page 50.*

Perfusate Filtration

For filtration of recirculated perfusate. *See page 50.*

Temperature Measurement

Measure perfusate temperature in any isolated perfused organ system. Since the system is well thermostated, temperature measurement is only necessary when specific temperature studies with special temperature protocols, e.g. cooling or transplantation studies, are being performed. *See page 51.*

Perfusion Solution Monitoring

Permits precise continuous or intermittent measurement in liquid media or perfusate of three key parameters: pO2, pH and pCO2. *See page 51-52.*

Drug Addition

For accurate drug addition using a syringe pump. Additional option for flow controlled drug addition, where flow is measured (or calculated) and a drug must be added in a certain ratio. *See page 52.*

Cell Isolation Upgrade

Add this upgrade to a functional IH-5 system for cell isolation/cell extraction applications. *See page 53.*

Pacing

For addition of pacing to functional IH-SR or IH-5 Langendorff and Working Heart systems. For small rodent hearts (mouse, rat and guinea pig). *See page 53.*

Single-Lead ECG and MAP Measurement

For single-lead ECG and MAP on functional IH-SR or IH-5 systems, one ECG lead can be measured in combination with MAP electrodes. *See pages 54-55.*

Multi-Lead ECG and MAP Measurement

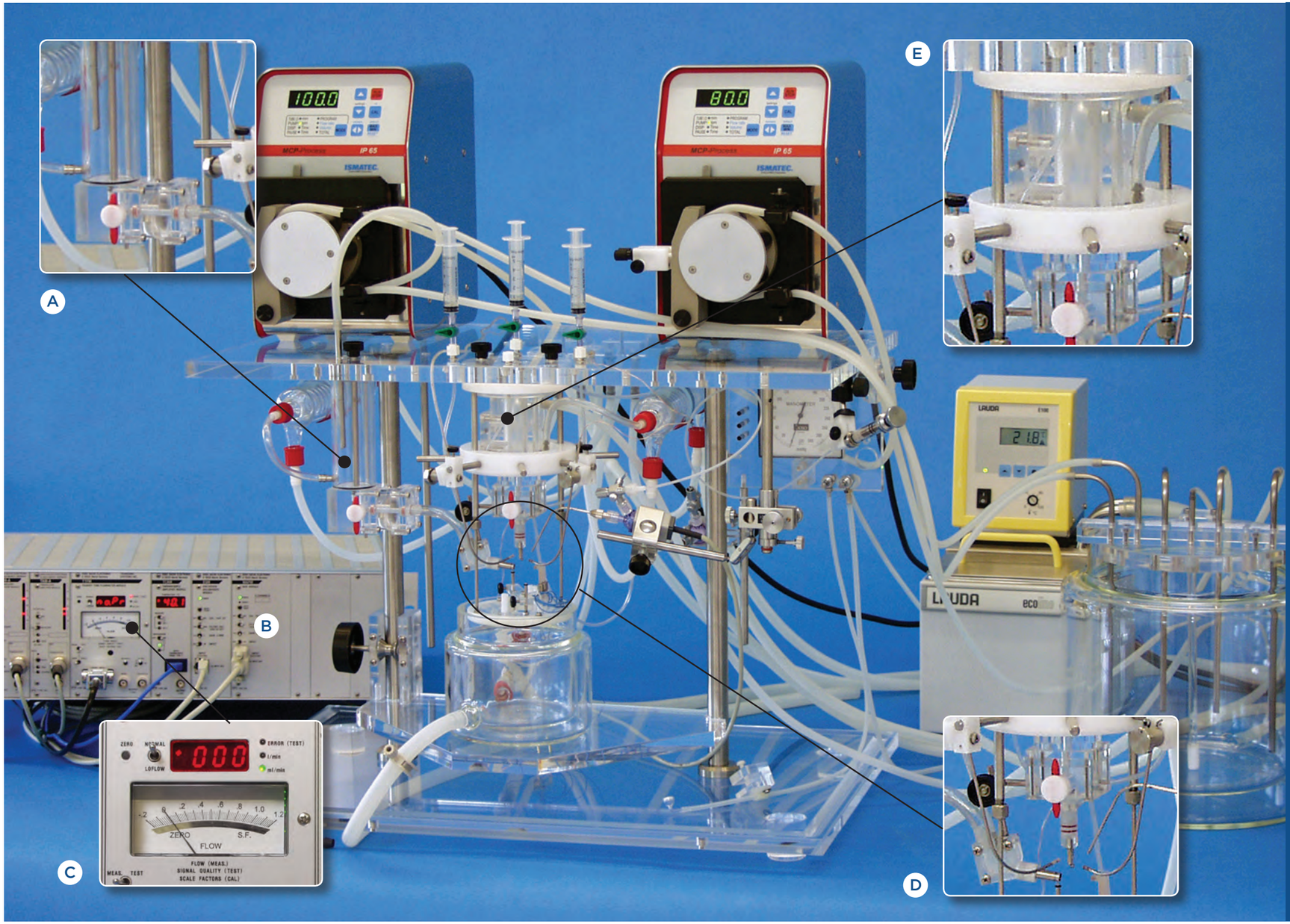
For multi-lead ECG and MAP measurements on functional IH-5 Langendorff or working heart systems, up to 12 ECG leads are combined with up to 8 MAP electrodes for measurement on rat, guinea pig or rabbit hearts. *See pages 55-57.*

IH-5
Working Heart System

IH-5 ISOLATED HEART PERFUSION SYSTEMS FOR RAT, GUINEA PIG & RABBIT

DESIGN FEATURES

- Allows assessment of external heart work under adjustable load
- Unsurpassed physiological environment
- Compact, smaller bench footprint and vertical clearance (no high water columns required)
- Optional continuous measurement of metabolic parameters, e.g. pH, pO_2, pCO_2
- Low volume drug injection pathway
- Reduced line resistance engineered to exceed species flow for optimal atrial filling
- Low flow resistance and dead space volume for highly accurate and reproducible results
- Lamina flow lines to improve accuracy of flow measurement
- Rapid and easy switching between working heart and Langendorff modes



A PRELOAD RESERVOIR

- Preload pressure adjustment
  - Constant level fluid column height corresponds to preload pressure
- Built-in stopcock for rapid control or atrio-ventricular flow
- Optional integrated ultrasonic flow probe for cardiac output measurement

B PLUGSYS MODULAR SYSTEM

- Compact amplifier system grows to fit your applications
- Wide range of measurement capabilities
- Low noise, analogy fidelity and control
- Analog signal output to virtually any data acquisition system

C FLOW MEASUREMENT

- Phasic real-time direct flow measurements
  - Aortic flow
  - Atrial flow
  - Coronary flow (calculated from atrial – aortic flow or measured via cannulation of the pulmonary artery)
- Fully integrated flow probes
- Solid-state physiological perfusion circuit ensures non-turbulent laminar flow

D ATRIAL CANNULA BLOCK

- Integrated bubble trap and syringe for containing and removing any air bubbles that may be swept into atrium head
- Preload pressure is measured by transducer connected to the atrial block
- Atrial filling is optimized by the inclusion of an elastic diaphragm connected to atmospheric pressure

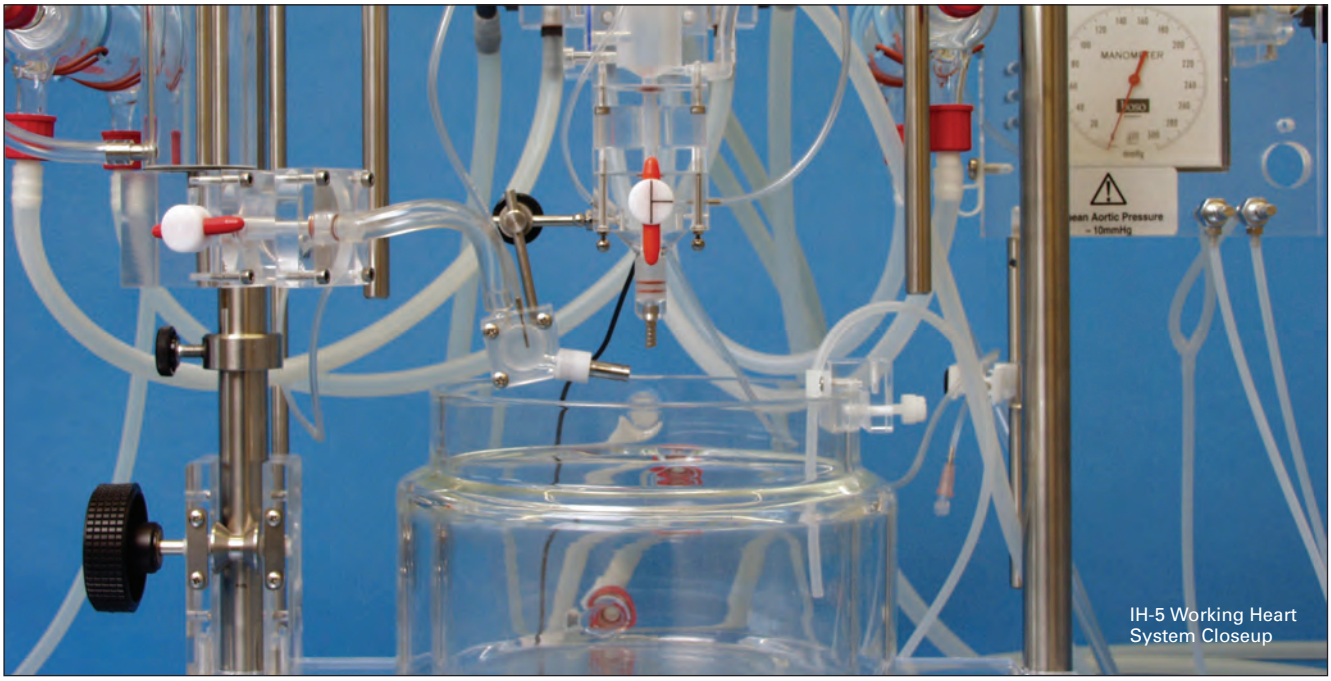
E AORTIC BLOCK

- Adjustable afterload resistor (Starling resistor) built in to the aortic block for setting peripheral resistance in the working heart preparation
  - 0 to 300 mmHg adjustment range
  - Precise control of cardiac afterload to simulate hypo-, normo-, or hypertensive states
  - Improved arterial pressure evaluation without risk of damage to heart valves
- Oscillation dampening system improves dynamic characteristics of the system by mimicking peripheral compliance, allowing near physiological pressure waveforms
- Integrated pathway for insertion of a pressure or pressure-volume catheter into the LV
- Simulates natural physiological environment
- Built-in Windkessel to simulate aortic compliance
- Integrated pathway for insertion of a pressure or pressure-volume catheter

ISOLATED HEART PERFUSION SYSTEMS

web www.hugo-sachs.de web www.harvardapparatus.com email support@hbiosci.com

IH-5
Working Heart System



IH-5 Working Heart System Closeup

The IH-5 Langendorff System can be upgraded to a fully-ejecting working heart model for physiological cardiovascular studies, e.g. cardiac function and metabolism. The upgrade allows rapid and easy switching between Working Heart (Ejecting Heart) and Langendorff modes.

To upgrade an IH-5 Langendorff Core System to an IH-5 Working Heart System, add a Working Heart Upgrade and one of the species-specific atrial cannulae. To measure flow, a TTFM-2 flowmeter and species-suitable flow probe are also required.

Applications

- Real-time measurement of atrial and aortic flow (add species-appropriate flow probes and PLUGSYS TTFM-2 Flowmeter module. See pages 44-45.)
- Intracardial left ventricular pressure (LVP) measurement (add the LVP Measurement Option. See page 46.)
- Pressure-volume measurement (add the Pressure-Volume Loop (PVL) Measurement Option. See page 47.)
- High atrial pressure-induced disease state simulation (add the Increased Preload Pressure Option. See page 48.)

Features & Benefits

- Fully-ejecting working heart model for physiological cardiovascular studies, e.g. cardiac function and metabolism
- Allows rapid and easy switching between Working Heart (Ejecting Heart) and Langendorff modes
- Optimized atrial cannulating conditions—true aortic flow and pressure signals (no bouncing afterload induced by a water column)
- Short atrial fill time (low flow resistance)—optimal ventricle filling
- Low resistance and dead space volume
- Minimal temperature and oxygen loss
- Unique vascular afterload system using the Starling membrane—optimal vascular simulation, including compliance by Windkessel
- Physiological atrial and arterial pressure waveform—avoids non-physiological pressure wave; no dynamic pressure effects or altered coronary flow
- Ready constant preload system—preload pressure independent of the atrial flow; no stress on mitral valve
- Low aortic cannula flow resistance—optional insertion of a FISO or Millar transducer for LVP or a Millar transducer for PVL measurement
- No liquid pressure column as afterload—less stress on aortic valves
- All electrodes, catheters and probes are fully enclosed in the unique closed jacketed chamber—easy, direct access to the heart and to maintain physiological conditions while performing the experiments

Measured Signals and Calculated Parameters

All parameters of standard Langendorff can be measured. In addition, the following signals can be recorded:

- Preload (left atrial preload/ventricular filling pressure)
- Afterload (determining the diastolic and systolic aortic pressure)
- Intracardial left ventricular pressure or pressure-volume loops
- Atrial, aortic and coronary flow (calculated from atrial and aortic flow)

Included Items

Working Heart Upgrade, 230 V (73-4412) includes:		Working Heart Upgrade, 115 V (73-4411) includes:	
Item #	**Product Name**	**Item #**	**Product Name**
73-3064	Working Heart Option to IH-5 Core System	**73-3064**	Working Heart Option to IH-5 Core System
73-0020	Blood Pressure Transducer P75 for PLUGSYS Module	**73-0020**	Blood Pressure Transducer P75 for PLUGSYS Module
73-0065	PLUGSYS Transducer Amplifier Module (TAM-A)	**73-0065**	PLUGSYS Transducer Amplifier Module (TAM-A)
73-0116	Peristaltic Pump MCP-SB2, 230 V	**73-0115**	Peristaltic Pump MCP-SB2, 115 V

Working Heart Option (73-3064) includes:

Left atrium cannulating system with preload reservoir and preheating coil, movable atrium connection adapter and holder for P75 (preload pressure).

Atrial Cannulae (Required, Purchase Separately)

Complete the Working Heart upgrade by choosing the appropriate species-specific addition:

- 73-4413 Working Heart Left Atrial Cannula for Rat/Guinea Pig Hearts, 2.3 mm OD (IH5-WH-RPG)
- 73-4414 Working Heart Left Atrial Cannula for Rabbit Hearts, 6.0 mm OD (IH5-WH-RAB)

Ordering Information

Item #	Description
73-4412	Working Heart Upgrade to IH-5 Core System, 230 V
73-4411	Working Heart Upgrade to IH-5 Core System, 115 V
73-4413	Working Heart Left Atrial Cannula for Rat/Guinea Pig Hearts, 2.3 mm OD
73-4414	Working Heart Left Atrial Cannula for Rabbit Hearts, 6.0 mm OD

Specialized Applications & Upgrades

Left Atrial and Aortic Flow Measurement

Left atrial and aortic flow direct measurement in IH-SR Working heart mode is performed with Ultrasonic Transit Time Technique (PLUGSYS TTFM-2 module). *See pages 44-45.*

Intracardial Left Ventricular Pressure (LVP) Measurement

Easily allows introduction of a tip pressure catheter directly into the left ventricle via the adapter port and the aorta, rather than via apical puncture. *See page 46.*

Pressure-Volume Loop (PVL) Measurement

Easily allows introduction of a pressure-volume loop catheter directly into the left ventricle via an adapter port and the aorta. *See page 47.*

Increased Preload Pressure

To create left atrial preload pressures higher than 11 mmHg. *See page 48.*

Coronary Effluate Collection

Pulmonary artery cannulae, preparation dish and effluate funnel for collection of effluate from the coronaries for metabolic studies, further analysis, or for continuous pO_2, pH, or pCO_2 measurements. *See pages 48-49.*

Perfusate Oxygenation of Foaming Media

For oxygenation of buffer solution supplemented with albumin, fatty acids, washed erythrocytes, or other foaming additives. *See page 50.*

Perfusate Filtration

For filtration of recirculated perfusate. *See page 50.*

Temperature Measurement

Measure perfusate temperature in any isolated perfused organ system. Since the system is well thermostated, temperature measurement is only necessary when specific temperature protocols are being performed, e.g. cooling or transplantation studies. *See page 51.*

Perfusion Solution Monitoring

Permits precise continuous or intermittent measurement in liquid media or perfusate of three key parameters: pO_2, pH and pCO_2. *See pages 51-52.*

Drug Addition

For accurate drug addition using a syringe pump. Additional option for flow controlled drug addition, where flow is measured (or calculated) and a drug must be added in a certain ratio. *See page 52.*

Cell Isolation Upgrade

Add this upgrade to a functional IH-5 system for cell isolation/cell extraction applications. *See page 53.*

Pacing

For addition of pacing to functional IH-SR or IH-5 Langendorff and Working Heart systems. For small rodent hearts (mouse, rat and guinea pig). *See page 53.*

Single-Lead ECG and MAP Measurement

For single-lead ECG and MAP on functional IH-SR systems, one ECG lead can be measured in combination with MAP electrodes. *See pages 44-45.*

Multi-Lead ECG and MAP Measurement

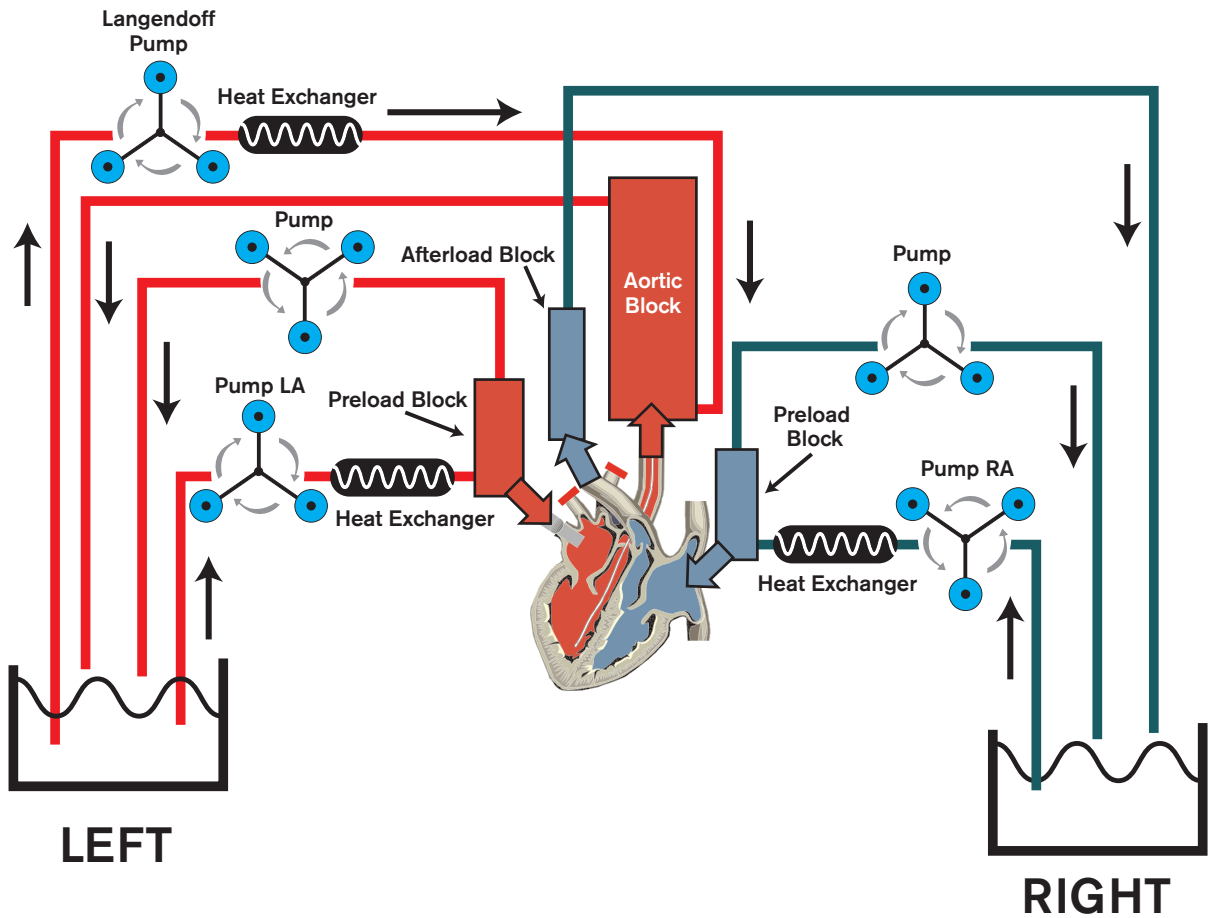
For multi-lead ECG and MAP measurements on functional IH-5 Langendorff or working heart systems, up to 12 ECG leads are combined with up to 8 MAP electrodes for measurement on rat, guinea pig or rabbit hearts. *See pages 55-57.*

IH5-BI Biventricular Working Heart System for Large Rodents

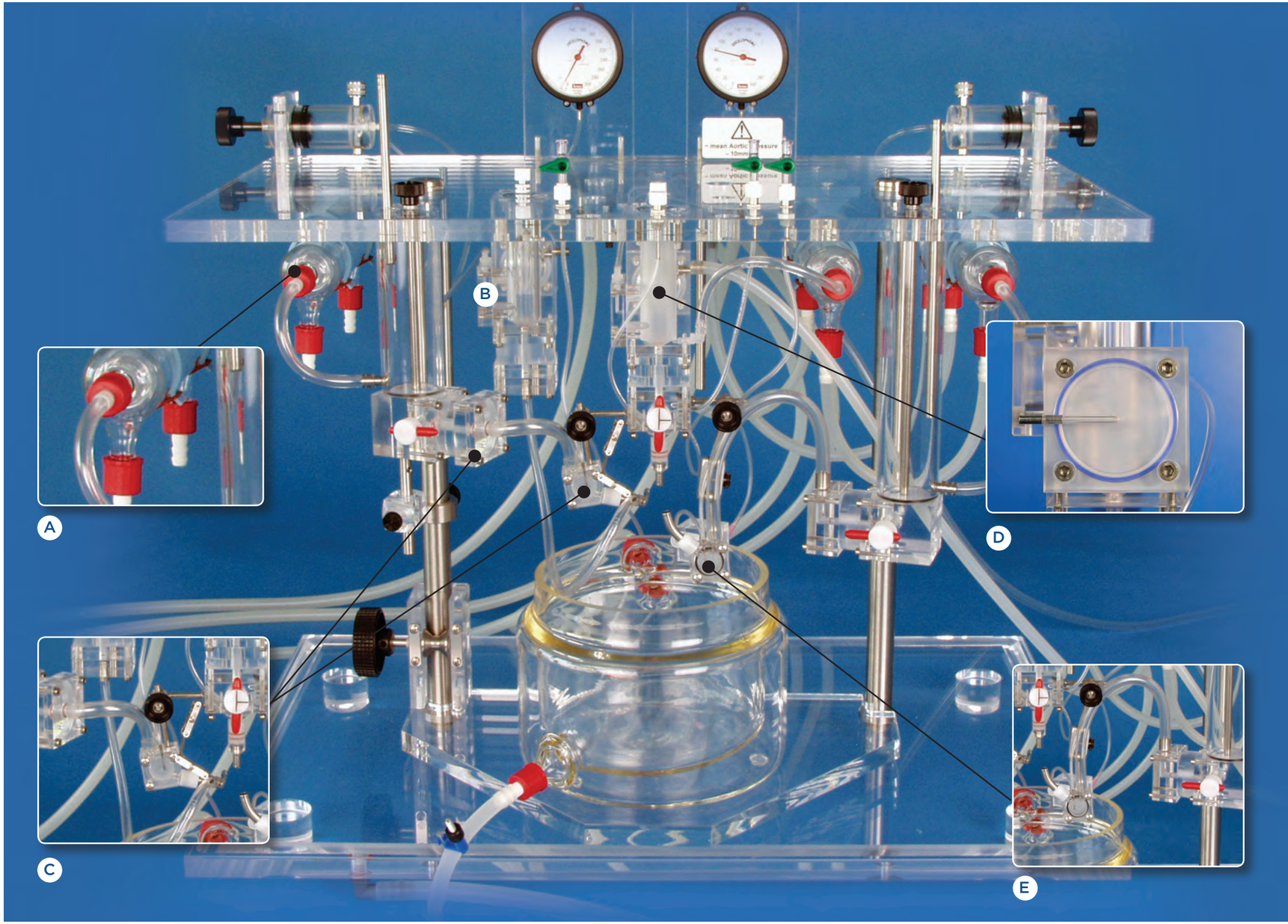
Differences between Working (Ejecting) Heart and Biventricular Working Heart

In normal Langendorff and working (ejecting) heart studies (according to Neely), measurements are done only on the left ventricle. The right side of the heart is nourished via the coronaries but does not fill with and eject fluid. Right heart diseases are under increasing scrutiny as the effects of chronic pulmonary conditions have been discovered to create distinct right heart pathophysiology. Additionally, advances in cardiac electrophysiology have characterized spiral patterns and complex electrical waves of activity which underlie arrhythmic conditions, the study of which may be more relevant in a fully biventricular ejecting heart model. Ex vivo perfusion of heart isolated from diseased models with Right Ventricular Hypertrophy (RVH) following prolonged partial pulmonary ligation is also possible, allowing the same studies that have been done previously on normal hearts to be replicated on RVH hearts.

Our Biventricular Working Heart System is based on the IH-5 working heart platform but has an added, decoupled perfusion circuit for the right heart. The preload pressure of the right heart is, like the left heart, achieved with a water column, only this time set to the lower pressures of the right atrium (<5 mmHg). The patented afterload system is used both in the aortic block to simulate peripheral resistance and in the right ventricular afterload block to simulate lung resistance. Both afterloads can be set by the researcher over a wide range covering normal, hypotensive and hypertensive pressures.



IH5-BI
Biventricular Working Heart System



DESIGN FEATURES

- Assessment of external heart work under adjustable load of right and left ventricle
- Reduced line resistance engineered to exceed species flor for optimal atrial filling
- Rapid and easy switching between biventricular, left working heart and Langendorff modes
- Compact, smaller bench footprint and vertical clearance (no high water column required)
- Low flow resistance and dead space volume for highly reproducible and accurate results
- Low volume drug injection pathway
- Solid state perfusion technology
- Proprietary patented afterload system to eliminate

A TEMPERATURE CONTROL

- Perfusate is re-warmed in heat exchangers located proximally to the cannulae to minimize heat loss through tubing
- Large jacketed heart chamber fully encloses the right and left atrium blocks

B RIGHT VENTRICULAR AFTERLOAD

- Adjustable right ventricular afterload pressure is set by knob on pressure gauge
- Patented membrane resistor simulates lung resistance
- Allows study of pulmonary artery hypertension

C LEFT ATRIAL BLOCK

- Preload pressure adjustment
  - Constant level fluid column height corresponds to preload pressure
  - Preload pressure is measured by transducer connected to the atrial block
- Built-in stopcock for rapid control of atrioventricular flow
- Optional integrated ultrasonic flow probe for cardiac output measurement
- Integrated bubble trap and syringe for drug addition in working heart perfusion mode
- Atrial filling is optimized by the inclusion of an elastic diaphragm connected to atmospheric pressure

D AORTIC BLOCK

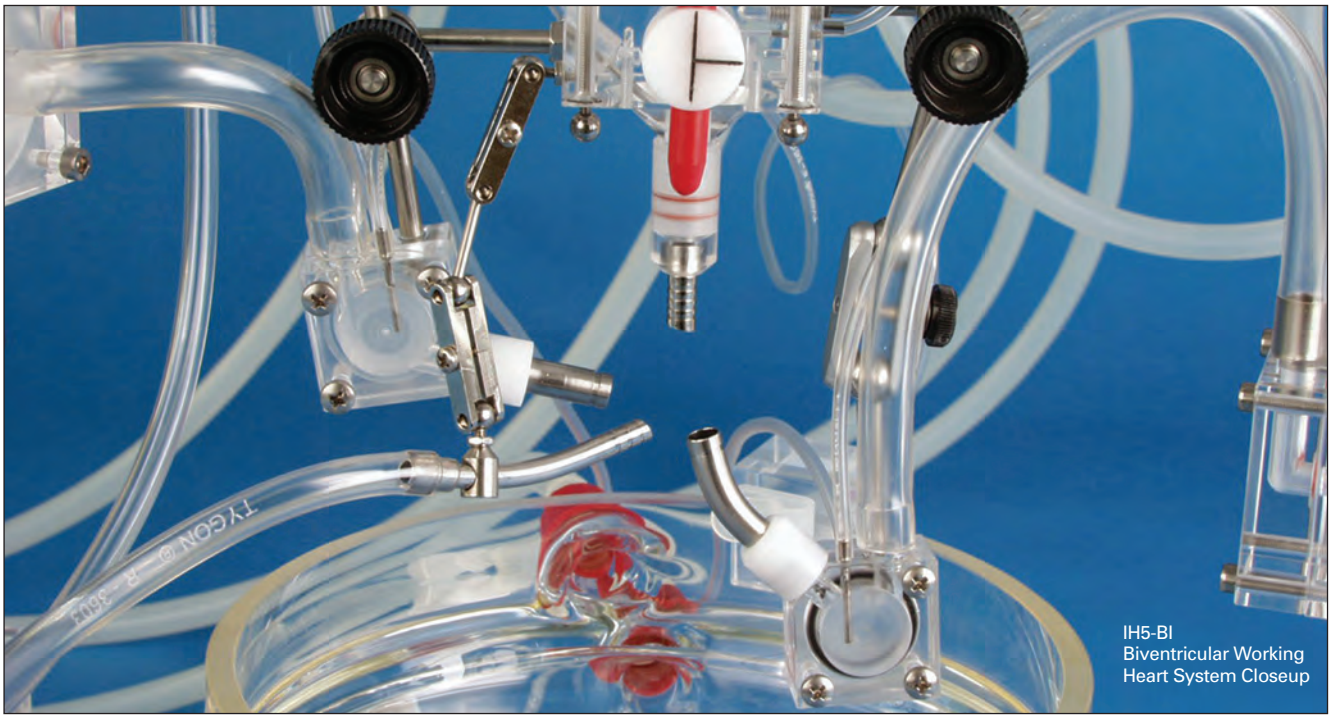
- Adjustable afterload resistor (Starling resistor) built in to the aortic block for setting peripheral resistance in the working heart preparation
  - 0 to 300 mmHg adjustment range
  - Precise control of cardiac afterload to simulate hypo-, normo-, or hypertensive states
  - Improved arterial pressure evaluation without risk of damage to heart valves
- Oscillation dampening system improves dynamic characteristics of the system by mimicking peripheral compliance, allowing near physiological pressure waveforms
- Integrated pathway for insertion of a pressure or pressure-volume catheter into the LV

E RIGHT ATRIAL BLOCK

- Preload pressure adjustment
  - Constant level fluid column height corresponds to right atrial preload pressure
  - Preload pressure is measured by transducer connected to the atrial block
- Built-in stopcock for rapid control of atrioventricular flow
- Optional integrated ultrasonic flow probe for flow measurement in the right side of the heart
- Atrial filling is optimized by the inclusion of an elastic diaphragm connected to atmospheric pressure

web www.hugo-sachs.de web www.harvardapparatus.com email support@hbiosci.com

IH5-BI Biventricular Working Heart System



IH5-BI
Biventricular Working
Heart System Closeup

The IH-5 Langendorff system can be upgraded to the Biventricular Working Heart System (IH5-BI). For use with rat, guinea pig and rabbit hearts, it is a valuable tool for the researcher who wants to study whole heart cardiac function.

The complete system contains all the primary equipment you need to accomplish the basic biventricular working heart experiment, only requiring the addition of species-specific cannulae. Many options are available for the IH5-BI system to extend its capabilities. (See IH-5.)

Advanced System Design

The IH5-BI System utilizes patented flow resistance and compliance chambers to faithfully mimic the in vivo cardiac preloads and afterloads for both normal and diseased states in medium to large rodent models. The exclusive features of the system create a physiological isolated heart environment that closely resembles the actual resistance of the peripheral vasculature while allowing the entire heart to work as it does in vivo.

This IH5-BI allows for in-depth ex vivo studies of the effects of pulmonary artery hypertension (PAH), hypertrophy (RVH), COPD, ARCV, emphysema and a variety of other diseases characterized by pulmonary vascular dysfunction and right heart pathophysiology. It allows measurement of a wide range of cardiovascular parameters with unsurpassed fidelity, such as single ECG Lead II and single epicardial monophasic action potential (MAP). Integration of high fidelity pressure-volume catheters for right and left ventricle pressure-volume loop measurement is also available.

Applications

- All applications listed for the standard IH-5 Working Heart System (See page 32.)
- Calcium homeostasis
- Drug effects on right heart electrophysiology and contractility
- Ischemia/reperfusion effects on right heart
- Effects of right ventricular hypertrophy on cardiac function

Features & Benefits

- Combines the advantages of an isolated organ preparation with in situ-like perfusion features
- Allows assessment of external heart work under adjustable load for both right and left heart
- Allows a more comprehensive monitoring of functional parameters, the calculation of the external heart work and mechanical efficiency, and the highest sensitivity for various experimental manipulation in ex vivo isolated heart preparations
- Allows rapid and easy switching between biventricular working heart, left working heart and Langendorff modes

IH5-BI BIVENTRICULAR WORKING HEART SYSTEM FOR LARGE RODENTS

Measured Signals and Calculated Parameters

The following signals can be recorded:

- Left atrial preload pressure (left ventricular filling pressure)
- Right atrial preload pressure (right ventricular filling pressure)
- Afterload pressure (aortic pressure for calculation of systolic and diastolic pressure)
- Right ventricular afterload (pulmonary artery pressure)
- Left ventricular pressure or pressure volume loop
- Right ventricular pressure or pressure volume loop
- Cardiac output (Left atrial flow), aortic, right atrial flow
- Coronary flow (subtraction of aortic flow from CO or by subtraction of right atrial flow from pulmonary artery flow)

Included Items

Included items are representative of a typical IH5-BI Core System. Individual components can be customized to your needs.

IH5-BI Core System, Basic, 230 V (73-4420) includes:		IH5-BI Core System, Basic, 115 V (73-4419) includes:	
Item #	**Product Name**	**Item #**	**Product Name**
73-4238	Base Unit for Biventricular Working Heart	**73-4238**	Base Unit for Biventricular Working Heart
73-3611	Heart Chamber, Jacketed Glass Vessel, ID = 145 mm, with Bottom Drain	**73-3611**	Heart Chamber, Jacketed Glass Vessel, ID = 145 mm, with Bottom Drain
73-4544	TC120 Thermocirculator, with 5 L stainless steel bath and lid, 220 V	**73-4545**	TC120 Thermocirculator, with 5 L stainless steel bath and lid, 120 V
73-0116	Peristaltic Pump MCP-SB2, 230 VAC	**73-0115**	Peristaltic Pump MCP-SB2, 115 VAC
73-6432	Ecoline Peristaltic Pump, VC-MS/CA8-6, 8 Channels, 230 VAC, 50 Hz	**73-6433**	Ecoline Peristaltic Pump, VC-MS/CA8-6, 8 Channels, 115 VAC, 60 Hz
73-0155	3-Stop Tygon® E-Lab Tubing, 2.79 mm ID, 12/pack, Purple/White	**73-0155**	3-Stop Tygon® E-Lab Tubing, 2.79 mm ID, 12/pack, Purple/White
73-0322	Jacketed Glass Reservoir for Buffer Solution, with Frit, 6 L	**73-0322**	Jacketed Glass Reservoir for Buffer Solution, with Frit, 6 L
73-0045	PLUGSYS Case, Type 603	**73-0045**	PLUGSYS Case, Type 603
73-3862	Blood Pressure Transducer (APT300)	**73-3862**	Blood Pressure Transducer (APT300)
73-0020	Blood Pressure Transducer (P75) for PLUGSYS Module	**73-0020**	Blood Pressure Transducer (P75) for PLUGSYS Module
73-0065	PLUGSYS Transducer Amplifier Module (TAM-A), 2 included	**73-0065**	PLUGSYS Transducer Amplifier Module (TAM-A), 2 included

The IH5-BI Base Unit (73-4238) includes:

Plexiglass stand, aorta link unit with Windkessel, adjustable artificial flow resistance for adjusting the aortic afterload pressure (with pressure gauge), preheating coil for Langendorff mode, holder for pressure transducers (aortic/perfusion pressure), tubing for in situ preparation with adapter. Also included are a left atrium cannulating system with preload reservoir and preheating coil, movable atrium connection adapter and holder for P75 (preload pressure), a column for right atrium cannulation, movable right atrium connection adapter, holder for P75 (right atrium pressure), and a right ventricle afterload system (simulates Lung resistance).

All cannulae must be ordered separately depending on your animal model. See below.

Species-Specific Additions (Required, Purchase Separately)

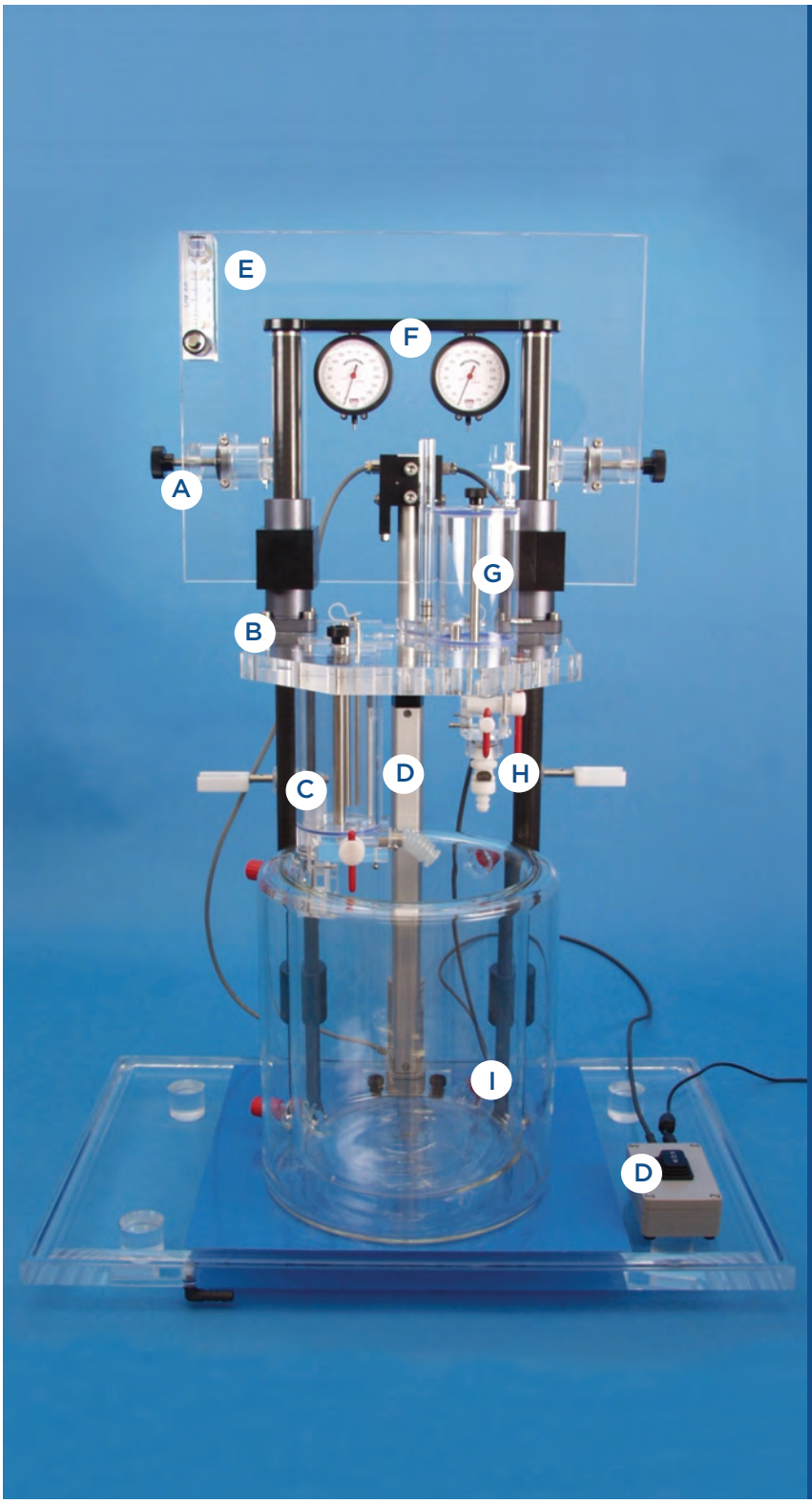
For a functional unit the IH5-BI Core Systems require one of these species-specific cannula sets:

Rat/Guinea Pig Biventricular Cannula Set (73-4450) includes:	Rabbit Biventricular Cannula Set (73-4451) includes:
• Aortic Cannula Set for rat/guinea pig hearts, 2.5 mm OD and 3.0 mm OD	• Aortic Cannula for rabbit hearts, 3.0, 4.0 and 5.0 mm OD
• Left Atrium Cannula, 2.3 mm OD	• Left Atrium Cannula, 2.3 mm OD
• Right Atrium Cannula, 2.3 mm OD	• Right Atrium Cannula, 2.3 mm OD
• Pulmonary Artery Cannula Set, 2.5 mm OD plus Mini-Ball Joint Mounting Kit	• Pulmonary Artery Cannula Set, 2.5 mm OD plus Mini-Ball Joint Mounting Kit

Ordering Information

Item #	Description
73-4420	IH5-BI Core Biventricular Working Heart System, 230 V
73-4419	IH5-BI Core Biventricular Working Heart System, 115 V
73-4450	Rat/Guinea Pig Biventricular Cannula Set
73-4451	Rabbit Biventricular Cannula Set

IH-9
Working Heart System



A LARGE THREADED SPINDLE SYRINGES

- Sets preload pressure in working heart perfusions (left)
- Sets aortic pressure in retrograde Langendoff perfusion or afterload pressure in ejecting working heart (right)
- Included patented membrane allows pressurization of the setup so that high water columns are not needed

B MOVEABLE CHAMBER LID

- Includes attached aortic block, Windkessel and, for working heart, preload reservoir

C PRELOAD PRESSURE RESERVOIR

- For left atrium perfusion in working heart mode only
- Controlled by manometer

D ELECTRICAL-DRIVEN LIFT

- Moves lid up and down using switch
- Complete lid with attached heart is lowered into the main chamber to maintain temperature of the heart

E GAS FLOWMETER (CARBOGEN OR O_2)

- Adjusts gas flow from gas tank to oxygenator

F MANOMETERS

- Indicates aortic pressure in retrograde Langendoff perfusion or afterload pressure in ejecting working heart (right)
- Indicates preload pressure in preload reservoir (left)

G LARGE WINDKESSEL

- Acts as bubble trap and damping reservoir in retrograde Langendorff perfusion
- Mimics aortic compliance in ejecting working heart perfusions

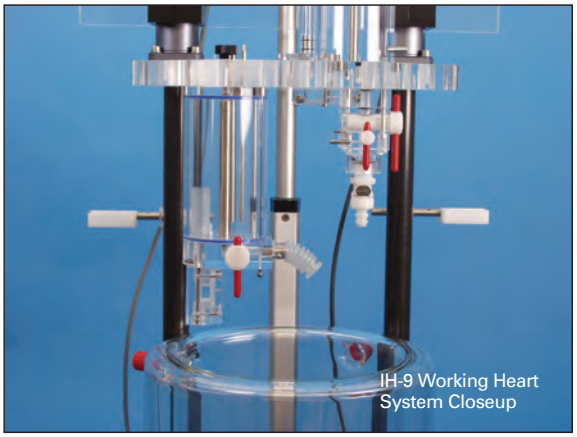
H UNIQUE AORTIC BLOCK

- Includes stopcock and ports for measurements, drug addition and sampling

I HEART CHAMBER

- Large jacketed 6 L heart chamber
- Acts as reservoir to keep blood or perfusion solution volume as LOW as possible

IH-9 Langendorff and Working Heart Systems


IH-9 Working Heart System Closeup

The IH-9 system is a tabletop isolated heart perfusion system developed for small pigs with a body weight up to about 20 kg. It can also be used for rabbit or mini pig models. The IH-9 offers ultimate perfusion stability and real physiological conditions for longer, more relevant recordings with fewer artifacts.

The modular nature of the IH-9 allows the system to evolve along with your research. Our Langendorff system can easily be upgraded to full working heart system. Both Langendorff and working heart modes allow a choice of measurement capabilities with dedicated packages available for specialized applications, such as measurement and analysis of multiple ECG and MAP signals. Perfusion of such larger hearts also creates the opportunity for detailed study of cardioplegia solutions and reperfusion after cardioplegia. Infarct studies with reperfusion and many other studies similar as on smaller hearts are possible. See application list on the right.

Advanced System Design

The IH-9 utilizes the proven architecture and functional principle of our smaller IH-5 system but is engineered for the increased flow produced by these larger species. The system can be operated in any one of the three modes: retrograde Langendorff perfusion under constant pressure , retrograde Langendorff perfusion under constant flow, and real ejecting working heart. The IH-9 allows standard hemodynamic as well as ischemia-reperfusion studies using saline or erythrocyte-containing perfusion solutions or real blood (heparinized). Saline perfusions will not be optimal as the O_2 transport in saline solution is not sufficient enough for these large organs.

The key part of the system is the unique aortic block, which is mounted on the cover of the heart chamber. In the working heart setup, the preload reservoir is also mounted on the bottom of the cover and consequently in the heart chamber. All other components are mounted on the main heart cover chamber, except for the pumps, the oxygenator, the thermostatic circulator and the PLUGSYS amplifier system.

The large Windkessel acts as bubble trap and damping reservoir in retrograde Langendorff perfusion and mimics the compliance of the aorta in ejecting working heart perfusions. Special attention has been made to ensure that all critical connecting tubing are short, thus avoiding any cooling to ambient temperature through a temperature gradient and any system generated flow resistances.

A large threaded spindle syringes on the right sets aortic pressure in retrograde Langendorff perfusion or the afterload pressure in ejecting working heart. The second threaded spindle syringe on the left side sets the preload pressure (left atrium pressure) in working ejecting heart perfusions. The patented membrane system where these syringes are connected avoids high bouncing water columns. Thus the measured pressure waves mimic in vivo pressures situation as near as possible.

The large 6 L heart chamber also acts as reservoir to keep blood or perfusion solution volume as small as possible. Perfusate that contains erythrocytes is oxygenated by a special membrane oxygenator. The connection to the heart is made through interchangeable aortic cannulae and atrial cannulae in the working heart extension.

The entire setup is on a platform with an electrical-driven lift that moves the platform up and down. The complete platform with the attached heart can be lowered with the lift so that the heart hangs in the heated jacketed heart chamber to get better temperature conditions for the heart.

The system can accommodate hearts with aorta diameters from 5 to 12 mm. For retrograde perfusion, perfusion pressure may be up to 300 mmHg and perfusion flow up to 500 ml/min. In working heart mode, the special flow resistance and compliance chamber closely mimics the in vivo afterload. Aortic flow up to 1,500 ml/min is possible.

Applications

- Study of myogene autoregulation with the addition of ultrasonic flow measurement (TTFM-2 and suitable flow probe)
- Testing inotropic substances
- Testing of lusitrope substances
- Testing of vasoactive substances
- Cardiac rhythm tests
- Ischemia/hypoxia studies
- Refractory period studies
- Ischemia/reperfusion injury studies
- Cardioplegia studies
- Cardiac preconditioning
- Cardiovascular screening performance
- Electrophysiology studies (ECG, Monophasic Action Potentials)
- Phenotyping of transgenic animals
- Drug compound screening
- Toxicology studies
- Biochemical tests
- Heart transplantation models
- In-depth hemodynamic applications including study of cardiac flow, LVP and pressure-volume relationships

In addition, in working heart mode:

- Real-time measurement of aortic and atrial flow
- Intracardial left ventricular pressure (LVP) measurement
- Pressure-volume measurement
- High atrial pressure-induced disease state simulation

IH-9 ISOLATED PERFUSED HEART SYSTEMS FOR MINI AND SMALL PIG

Features & Benefits

Langendorff Mode

- Low flow resistance and dead space volume, minimize perfusion artifacts
- Compact system does not require high water columns
- Suitable for hearts from hypertensive animals (perfusion pressure up to 300 mmHg is possible)
- Constant pressure or constant flow in one unit
- Unique integrated aortic block
  - Bubble trap located immediately above the aortic cannula
  - Integrated flow probe option for accurate real-time flow measurement
  - Integrated stopcock to control perfusion flow and simulate ischemic conditions
- Drug injection pathway built directly into aortic perfusate stream
- Temperature and oxygen loss minimal
- Easily upgraded to a working heart system
- Modular system grows with your applications
- System specific electrodes and holders for precise measurements
- All electrodes, catheters etc. are placed around the heart to have easy and direct access

Working Heart Mode (in addition to all Langendorff features)

- Optimized atrium cannulating conditions
- Easy to switch from the Langendorff mode to the working heart mode and back
- Physiological flow resistance and minimal dead space volume
- Short atrial fill time (low flow resistance) resulting in optimal ventricle filling
- Built in port for insertion of a catheter transducer for left ventricular pressure or pressure-volume measurement
- Mimic physiologic atrial and arterial pressure and flow patterns
- Compact aortic block
  - Exclusive patented Membrane Afterload System and compliance chamber, mimic physiological cardiac afterload and avoid damage to heart valves that occurs with water column-based systems
  - Integrated flow probe option for accurate real-time aortic flow measurement
- Real constant preload system
  - Mimics physiologic atrial pressure patterns
  - Reduced stress on mitral valve caused by the pump
  - Preload pressure independent of the atrial flow
- Real time coronary flow measurement (option)
  - Coronary flow can be measured directly by cannulation of the pulmonary artery

Measured Signals and Calculated Parameters

The following signals are recorded as raw data in retrograde Langendorff perfusion:

- Isovolumetric left ventricular pressure (LVP) with balloon
- Aortic (perfusion) pressure
- Coronary flow*

The following parameters are calculated from the raw data (using ISOHEART Data Acquisition Software:

- dLVP/dt, dLVP/dt Max, dLVP/dt Min, Contractility Index
- Systolic and Diastolic LVP
- Heart Rate
- Mean Perfusion Pressure
- Mean Perfusion Flow*
- Coronary Resistance*

** This parameter is based on indirect flow measurement with SCP or direct ultrasound flow measurement with the TTFM-2 flowmeter and suitable flow probe.*

In working heart mode, all parameters of standard Langendorff can be measured. In addition, the following signals can be recorded:

- Preload (left atrial preload / ventricular filling pressure)
- Afterload (determining the diastolic and systolic aortic pressure)
- Intracardial left ventricular pressure or pressure-volume loops
- Aortic flow
- Coronary flow measured by cannulation of the pulmonary artery with an ultrasound flow probe and TTFM-2 flowmeter module

Required Core Items
(Purchase Separately)

Each IH-9 system is quoted to meet the specific requirements of the researcher. The table below is representative of components that are required to build a core Langendorff retrograde perfusion system to work under constant pressure or constant flow. All items are purchased separately. Additional components required for a fully functional system. Add the Working Heart Option to upgrade to a working heart system.

IH-9 Tabletop Langendorff System, 230 V		IH-9 Tabletop Langendorff System, 115 V	
Item #	**Product Name**	**Item #**	**Product Name**
73-4965	Base Unit for IH-9T, Tabletop Version	**73-4965**	Base Unit for IH-9T, Tabletop Version
73-0125	Lauda Thermocirculator, Type E-103, 230 V/50 Hz, 3 L Bath Volume, Temperature Range 20 to 150°C	**73-2802**	Lauda Thermocirculator, Type E-103, 115 V/60 Hz, 3 L Bath Volume, Temperature Range 20 to 150°C
73-0045	PLUGSYS Case, Type 603	**73-0045**	PLUGSYS Case, Type 603
73-3862	Blood Pressure Transducers (APT300), 2 included	**73-3862**	Blood Pressure Transducers (APT300), 2 included
73-0065	PLUGSYS Transducer Amplifier Module (TAM-A) (Does not include balloon kit)	**73-0065**	PLUGSYS Transducer Amplifier Module (TAM-A) (Does not include balloon kit)
73-0326	MCP Pump Drive, 230 VAC	**73-0329**	MCP Pump Drive, 115 VAC
73-2470	For hemolysis-free pumping: Centrifugal Pump Drive (BVP-ZX), 230 VAC, 50/60 Hz	**73-2963**	For hemolysis-free pumping: Centrifugal Pump Drive (BVP-ZX), 115 VAC, 50/60 Hz
73-2807	Centrifugal Pump Head (BP-80)	**73-2807**	Centrifugal Pump Head (BP-80)
Core System Options			
73-4966	Working Heart Option	**73-4966**	Working Heart Option

The IH-9 Base Unit (73-4965), tabletop version, includes:

Plexiglas stand, aortic block with Windkessel and bubble trap, adjustable artificial flow resistance for adjusting the aortic pressure with pressure gauge and manometer, jacketed heart chamber (volume 5 L) with electrical lift, filter, tubing and connections, set of aortic cannulae (OD = 5 to 12 mm*). Expandable to working heart. Note: The heart chamber acts as reservoir.

The Working Heart Option (73-4966) includes:

Left atrium cannulating system consisting of preload reservoir (capacity 0.3 L), movable atrium connection adapter, set of left atrial cannulae (OD = 5 to 12 mm*), aortic flow rate up to 1.5 l/min. Additional components required to complete a setup. Please inquire.

**Replacement cannulae can be purchased separately.*

Additional Components
(Purchase Separately)

Oxygenator

An oxygenator is necessary for oxygenating and warming the perfusion solution (blood). Hugo-Sachs does not supply an oxygenator suitable for the IH-9 system. Researchers can readily use available clinical oxygenators, such as the Medtronic Affinity NT Oxygenator.

Amplifier

An amplifier system is required for the various pressures and flow, ECG and MAP measurement, etc. See PLUGSYS Modules and Housings on pages 64-65.

ISOHEART Data Acquisition Software and Associated Hardware

Provides real-time evaluation of a wide range of signals and classical cardiovascular parameters. Option available for flow proportional drug addition using a syringe pump.See page 66.

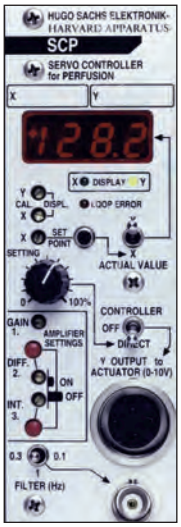
Note: Ponemah Data Acquisition & Analysis Software from DSI, a Harvard Bioscience Company is also suitable. See page 66.

Specialized Applications & Upgrades

Please contact technical support for assistance in adding specialized applications or to upgrade an IH-9 Langendorff system to a working heart.

- Working Heart Option
- Cardioplegia Option
- Direct Coronary and Aortic Flow Measurement
- Intracardial Left Ventricular Pressure (LVP) Measurement
- Pressure-Volume (PV) Loop Measurement (requires PoNeMah or PowerLab hardware and software)
- Increased Preload Pressure
- Perfusate Oxygenation of Foaming Media
- Temperature Measurement
- Perfusion Solution Monitoring
- Coronary Effluate Collection
- Drug Addition
- Perfusate Filtration
- Pacing
- Single-Lead ECG and MAP Measurement
- Multi-Lead ECG and MAP Measurement

Flow Measurement Option



PLUGSYS SCP Module

PLUGSYS TTFM-2 Module

Coronary flow measurement can be accomplished in functional UP100-IH, IH-SR and IH-5 systems in retrograde Langendorff mode either indirectly or directly.

In a retrograde Langendorff perfusion coronary flow can be measured in two ways:

- Indirect measurement by controlling the speed of a peristaltic pump with the SCP controller
- Direct measurement using the ultrasonic transit time technique with the PLUGSYS TTFM-2 module

In working heart mode, flow can only be measured directly with the ultrasonic transit time technique and suitable flow probes. Both flow into the left atrium and flow out of the aorta (the volume ejected per minute by the aorta) are measured. Coronary flow is then calculated from the difference between the two (the atrial flow minus the aortic flow).

Indirect Coronary Flow Measurement using Constant Pressure/Flow Control

If you work in Langendorff mode, the PLUGSYS Servo Controller Module (SCP) is used in combination with a peristaltic pump to perfuse the heart in constant pressure mode. Besides regulating the pressure, the SCP module calculates the coronary flow from the peristaltic pump's head speed (indirect flow measurement).

The PLUGSYS TAM-D module amplifies the measured perfusion pressure signal, sends it to the SCP and outputs it to the data acquisition system. Both the peristaltic pump and the TAM-D are included in the IH-SR and IH-5 Core Systems. SCP must be purchased separately.

Features and Benefits

- Allows perfusion under constant pressure or constant flow (direct switchable)
- Provides accurate control of perfusion pressure or flow, even at very low flow rates
- Flexible perfusion circuit setup adjusts to suit individual perfusion conditions
- Indirect coronary flow measurement from pump speed

Direct Coronary Flow Measurement with Ultrasonic Transit Time Flowmeter

The Ultrasonic Transit Time Flowmeter (PLUGSYS TTFM-2) module provides real and accurate transit time flow measurement in ml/min for direct coronary flow measurement in retrograde Langendorff mode. In working heart mode, it measures flow into the atrium and flow out of the aorta, then calculates coronary flow from the difference between the two.

Applications

- Accurate real time coronary flow measurement on drug studies in Langendorff mode
- Studies on coronary resistance changes (pre and post ischemia)
- Myogene autoregulation (reactive hyperemia)
- Measuring left atrium flow and aortic flow in Working Heart mode

Features & Benefits

- Accurate ultrasonic transit time direct flow measurement
- Unique integration of flow probe into perfusion path
- Laminar flow lines improve accuracy of flow measurement
- Thermal properties of Perspex adapter reduce temperature loss
- Increased system flexibility by allowing the study of Myogene Autoregulation (Reactive Hyperemia)
- Indirect flow measurement can typically follow increasing flow rates but often lags behind decreasing flow rates

Flow Measurement Option (continued)

Species-Specific Flow Probes and Adapters for Direct Coronary Flow Measurement (Required, Purchase Separately)

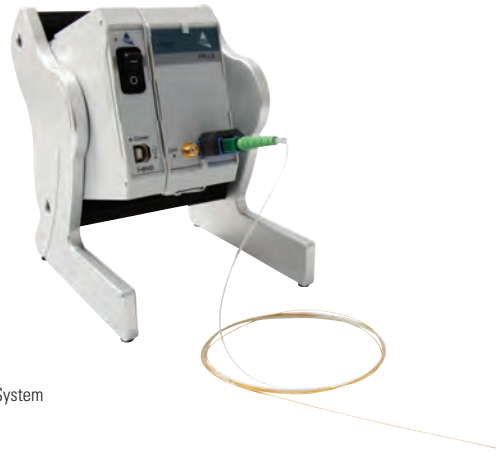
The table below specifies the flow probe and adapter to be used with the TTFM-2, by species and type of measurement, for each type of isolated heart system (IH-SR, IH-5 or UP-100IH). It is extremely important to order the correct probe and adapter pair. Please contact technical support for assistance.

Type of IH-SR Measurement/Species	Required Probe and Adapter
Direct Flow Measurement for Mouse Application: Coronary flow measurement in retrograde Langendorff mode or aortic flow measurement in working heart.	**73-4668** MA1PRB Flow Probe for TTFM-2** **73-3554** Adapter for 73-4668 1RB Flow Probe for IH-SR (flow probe is embedded into this adapter).
Direct Flow Measurement for Rat Application: Coronary flow measurement in retrograde Langendorff mode or aortic flow measurement in working heart.	**73-4644** MA2PSB Flow Probe for TTFM-2** **73-2819** Adapter for 73-4644 2SB Flow Probe for IH-SR (flow probe is embedded into this adapter)
Cardiac Output Measurement*, Working Heart for Mouse Application: Flow measurement into left atrium in working heart mode	**73-4668** MA1PRB Flow Probe for TTFM-2** **73-3554** Adapter for 73-4668 1RB Flow Probe for IH-SR (flow probe is embedded into this adapter)
Cardiac Output Measurement*, Working Heart for Rat Application: Flow measurement into left atrium in working heart mode	**73-4647** MA2.5PSB Flow Probe for TTFM-2** **73-2820** Adapter for 73-4647 2.5SB Flow Probe for IH-SR (flow probe is embedded into this adapter)
Type of IH-5 Measurement/Species	**Required Probe and Adapter**
Direct Flow Measurement for Rat and Guinea Pig Application: Coronary flow measurement in retrograde Langendorff mode or aortic flow measurement in working heart.	**73-4647** MA2.5PSB Flow Probe for TTFM-2** **73-3071** Adapter for 73-4647 F2.5SB Flow Probe for IH-5
Direct Flow Measurement for Rabbit Application: Coronary flow measurement in retrograde Langendorff mode or aortic flow measurement in working heart.	**73-4652** MA4PSB Flow Probe for TTFM-2** **73-3069** Adapter for 73-4652 4SB Flow Probe for IH-5
Cardiac Output Measurement*, Working Heart for Rat and Guinea Pig Application: Flow measurement into left atrium in working heart mode	**73-4647** MA2.5PSB Flow Probe for TTFM-2** **73-3071** Adapter 73-4647 2.5SB Flow Probe 2.5SB for IH-5
Cardiac Output Measurement*, Working Heart for Rabbit Application: Flow measurement into left atrium in working heart mode	**73-4652** MA4PSB Flow Probe for TTFM-2** **73-3069** Adapter for 73-4652 4SB Flow Probe for IH-5

Ordering Information

Item #	Description
73-2806	Servo Controller for Perfusion (SCP)
73-4617	Transit Time Flowmeter Module (TTFM-2)
73-4668	MA1PRB Flow probe for TTFM-2 Module
73-3554	Adapter for 73-4668 1RB Flow Probe for IH-SR
73-4644	MA2PSB Flow probe for TTFM-2 Module
73-2819	Adapter for 73-4644 2SB Flow Probe for IH-SR
73-4647	MA2.5PSB Flow Probe for TTFM-2 Module
73-2820	Adapter for 73-4647 2.5SB Flow Probe for IH-SR
73-4652	MA4PSB Flow Probe for TTFM-2
73-3071	Adapter for 73-4647 F2.5SB Flow Probe for IH-5
73-3069	Adapter for 73-4652 4SB Flow Probe for IH-5
73-4670	MA1.5 PRB Flow probe for TTFM-2 Module
73-2993	Adapter for 73-4670 1.5RB Flow Probe for UP-100IH
73-2935	Holder for Block Flow Probes for UP-100 Systems

Intracardial Left Ventricular Pressure Measurement Option



FISO System

Intracardial LVP measurement can be added to an IH-SR or IH-5 Working Heart System. The IH series includes a specialized pathway which easily allows introduction of a tip pressure catheter directly into the left ventricle via the adapter port and the aorta, rather than via apical puncture.

LVP can be measured in two ways: with a Millar tip catheter or with a FISO fiber optic catheter.

Intracardial LVP Measurement with Millar Tip Catheter

All items (except the TAM-A amplifier) required for intracardial LVP measurement using a Millar catheter are included in the options below (73-4037 and 73-4038). The tip pressure catheter is connected using a dedicated connecting cable to a PLUGSYS TAM-A Transducer Amplifier Module, which is purchased separately. See page 64. Additional catheter sizes are available for rat and guinea pig for IH-5. Please contact technical support for help in choosing the correct catheter.

Included Items

LVP Measurement in Mouse Working Heart (73-4037) includes:		LVP Measurement in Rat/ Guinea Pig Working Heart (73-4038) includes:	
Item #	**Product Name**	**Item #**	**Product Name**
72-9781	Millar Ultra-Miniature Pressure Catheter for Mouse, Polyimide, Straight Tip, Low Profile, 1.0 F, 20 cm Length*	**72-9775**	Millar Ultra-Miniature Pressure Catheter for Rat, Nylon, Straight Tip, Low Profile, 2.0 F, 140 cm Length*
73-4193	Adapter for inserting tip catheter into left ventricle via aortic cannula (Touhy Borst Adapter)	**73-4193**	Adapter for inserting tip catheter into left ventricle via aortic cannula (Touhy Borst Adapter)
72-9843	Cable Interface with Low Profile Connector to PLUGSYS TAM Amplifier	**72-9843**	Cable Interface with Low Profile Connector to PLUGSYS TAM Amplifier

Intracardial LVP Measurement with Fiber Optic FISO Tip Catheter

For this method of intracardial LVP measurement, all required items must be purchased separately. The FISO optical fiber tip pressure catheter is connected to the FISO signal conditioner which is installed in the Evolution chassis. (Additional conditioners and sensors can be added at a later date.)

Required Items (Order Separately)

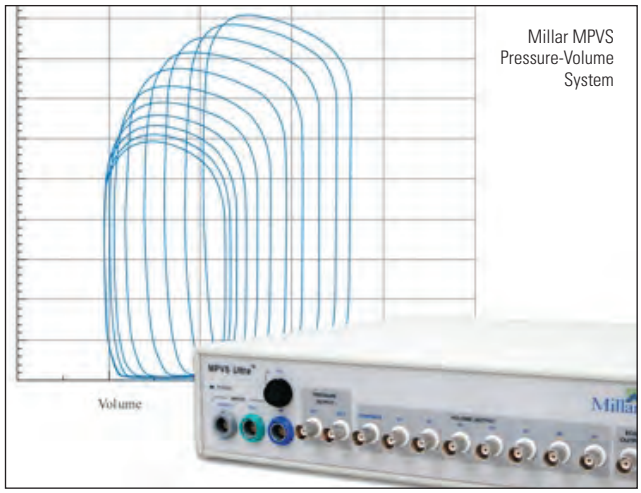
LVP Measurement in Mouse Working Heart requires the following items:		LVP Measurement in Rat/ Guinea Pig Working Heart requires the following items:	
Item #	**Product Name**	**Item #**	**Product Name**
75-0700	FISO Evolution Series EVO-2 Benchtop Chassis, 24 VDC, 70 W, for Mounting up to 2 FISO Signal Conditioners. USB communication, (Evolution software included)	**75-0700**	FISO Evolution Series EVO-2 Benchtop Chassis, 24 VDC, 70 W, for Mounting up to 2 FISO Signal Conditioners. USB communication, (Evolution software included)
75-0704	FISO FPI-LS Signal Conditioner, Single Channel, up to 15 kHz Sampling Rate through Analog Output	**75-0704**	FISO FPI-LS Signal Conditioner, Single Channel, up to 15 kHz Sampling Rate through Analog Output
75-0706	FISO-LS Fiber Optic Pressure Catheter, Standard, 0.9 F, 1.2 M Length, +/- 300 mmHg	**75-0707**	FISO-LS Fiber Optic Pressure Catheter, Standard, 2 F, 1.7 M Length, +/- 300 mmHg
73-4193	Adapter for inserting tip catheter into left ventricle via aortic cannula (Touhy Borst Adapter)	**73-4193**	Adapter for inserting tip catheter into left ventricle via aortic cannula (Touhy Borst Adapter)

Ordering Information

Item #	Description
73-4037	Intracardial Left Ventricular Pressure (LVP) Measurement Option in Mouse Working Heart
73-4038	Intracardial Left Ventricular Pressure (LVP) Measurement Option in Rat/Guinea Pig Working Heart
75-0700	FISO Evolution Series EVO-2 Benchtop Chassis, 24 VDC, 70 W
75-0704	FISO FPI-LS Signal Conditioner, Single Channel
75-0706	FISO-LS Fiber Optic Pressure Catheter, Standard, 0.9 F, 1.2 M Length, +/- 300 mmHg
75-0707	FISO-LS Fiber Optic Pressure Catheter, Standard, 2 F, 1.7 M Length, +/- 300 mmHg
73-4193	Touhy Borst Adapter

Note: If you plan to work with multiple species, please do not order both Options (73-4037 and 73-4038), as you will then receive duplicate items unnecessarily. Please contact us and we will quote only the additional items you will need.

Pressure-Volume Loop (PVL) Measurement Option



Millar MPVS Pressure-Volume System

The IH series includes a specialized pathway which easily allows introduction of a pressure-volume loop catheter directly into the left ventricle via an adapter port and the aorta for pressure-volume loop measurement in IH-SR and IH-5 Working Heart Systems.

The pressure-volume loop catheter is connected to MPVS Ultra Pressure Volume Hardware. All options also require the PowerLab Data Acquisition System. See page 67.

Required Items (Order Separately)

PVL Measurement in IH-SR Mouse Working Heart	
Item #	**Product Name**
72-9739	Millar Ultra Single Segment Pressure-Volume Unit (MPVS) with Control Software
72-9835	Ultra Cable Pack 4 ft (CEC-4E PV Cable, PEC-4D)
72-9728	BNC Cable Pack-PowerLab (10 BNC-BNC 9 in, 1 BNC-BNC 1 ft, 2 BNC-BNC 3 ft)
72-9735	Mouse Calibration Cuvette
72-9740 or 72-9738	Millar Ultra-Miniature Pressure-Volume Catheter for Mouse, 1.0 Fr or Millar Ultra-Miniature Pressure-Volume Catheter for Mouse, 1.4 Fr

PVL Measurement in IH-SR and IH-5 Rat Working Heart	
Item #	**Product Name**
72-9739	Millar Ultra Single Segment Pressure-Volume Unit (MPVS) with Control Software
72-9835	Ultra Cable Pack 4 ft (CEC-4E PV Cable, PEC-4D)
72-9728	BNC Cable Pack-PowerLab (10 BNC-BNC 9 in, 1 BNC-BNC 1 ft, 2 BNC-BNC 3 ft)
72-9822	Rat Large Volume Calibration Cuvette
72-9745	Millar Ultra-Miniature Pressure-Volume Catheter for Rat, 2.0 Fr

PVL Measurement in IH-5 Rabbit and Guinea Pig Working Heart*	
Item #	**Product Name**
72-9724	Millar Ultra Multi-Segment Pressure Volume Control Unit
72-9835	Ultra Cable Pack 4 ft (CEC-4E PV Cable, PEC-4D)
72-9728	BNC Cable Pack-PowerLab (10 BNC-BNC 9 in, 1 BNC-BNC 1 ft, 2 BNC-BNC 3 ft)
72-9822	Rat Large Volume Calibration Cuvette
72-9745	Millar Ultra-Miniature Pressure-Volume Catheter for Rat, 2.0 Fr

** Larger hearts, such as guinea pig and rabbit, require the MPVS Multi-Segment Pressure Volume Control Unit.*

Choosing the Right PV Catheter for IH-5 PVL Measurement Using Larger Hearts

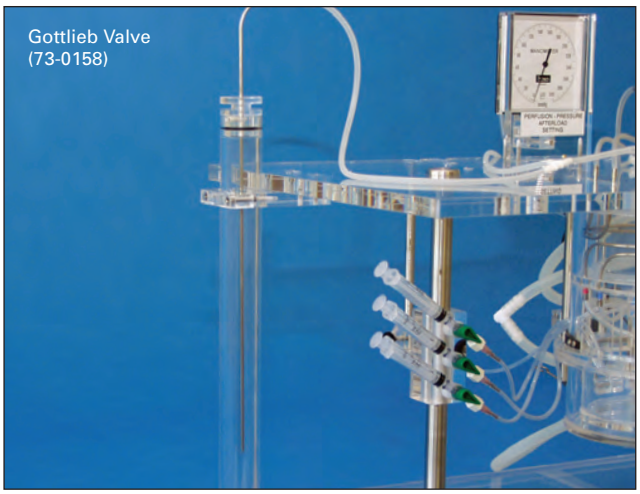
Larger hearts often require multi-segment catheters for accurate volume measurement. The minimum size of these catheters is 3 Fr. The IH-5 System can accommodate catheters up to 3 Fr via the dedicated access path; however, for larger hearts it is recommended to use the apical puncture method instead. Since the larger pressure volume catheters have multiple conductance electrodes arrayed at regular intervals, they require the use of the MPVS Multi-Segment Pressure Volume Control Unit. Additionally, due to the variance in the sizes of the left ventricles of larger hearts, the catheters are not pre-packaged with the hardware and the software, and need to be purchased separately.

Choosing the correct PV Catheter requires the knowledge of ventricle size of the rat, guinea pig, or rabbit heart with which you are working. Remove the heart from a typical subject (or from the largest and smallest subjects if you are using a range) you will likely be using for experiments. Cut the heart longitudinally from the aortic valve to the apex of the left ventricle and measure the distance between these two points. Once you know this distance, you will be able to choose the appropriate PV catheter from the options below. **Please contact our technical team for assistance to ensure you are choosing the correct catheter.**

Ordering Information

Item #	Description
72-9739	Millar Ultra Single Segment Unit with Control Software
72-9724	Millar Ultra Multi-Segment Pressure Volume Control Unit with Control Software
72-9738	72-9738 Millar Ultra-Miniature Pressure-Volume Catheter for Mouse, Single Segment, 1.4 Fr, 4 Electrodes, 4.5 mm Spacing, Non-repairable, 3.5 cm Length
72-9740	Millar Ultra-Miniature Pressure-Volume Catheter for Mouse, Single Segment, 1.0 Fr, 4 Electrodes, 3.0 mm Spacing, Non-repairable, 3.25 cm Length
72-9745	Millar Ultra-Miniature Pressure-Volume Catheter for Rat, Single Segment, 2.0 Fr, 4 Electrodes, 6.0 mm Spacing, Non-repairable, 12.5 cm Length
72-9752	Millar Pressure-Volume Catheter for Rabbit/Cat, Multi Segment, 3 Fr, 10 Electrodes, 3.0 mm Spacing, 10.5 cm Length
72-9753	Millar Pressure-Volume Catheter for Rabbit/Cat, Multi Segment, 3 Fr, 10 Electrodes, 4.5 mm Spacing, 10.5 cm Length
72-9754	Millar Pressure-Volume Catheter for Rabbit, Multi Segment, 3 Fr, 10 Electrodes, 2.5 mm Spacing, 12.0 cm Length
72-9835	Ultra Cable Pack 4 ft (CEC-4E PV Cable, PEC-4D)r
72-9728	BNC Cable Pack-PowerLab (10 BNC-BNC 9 in, 1 BNC-BNC 1 ft, 2 BNC-BNC 3 ft)
72-9735	Mouse Calibration Cuvette
73-4193	Touhy Borst Adapter

Increased Preload Pressure Option


Gottlieb Valve
(73-0158)

Choose this option when you need to create left atrial preload pressures that are greater than 11 mmHg in an IH-SR Working Heart System.

The addition of the Gottlieb Valve allows you to create preload pressures outside of the standard physiological range in order to simulate a disease state. Preload pressure can be increased up to 30 mmHg.

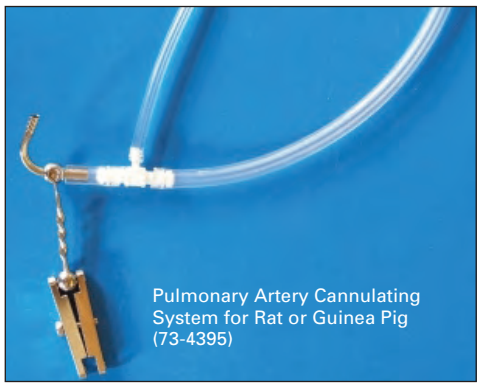
Ordering Information

Item #	Description
73-0158	Gottlieb Valve for Increased Preload Pressure in Working Heart (IHSR-GOTT)

Coronary Effluate Collection Option

These cannulating systems are used to sample coronary effluate for further analysis on your own equipment, for metabolic studies, or for pO_2, pH, and pCO_2 measurements.

On rat, guinea pig and rabbit hearts the coronary effluate is sampled via cannulation through the pulmonary artery. On mouse hearts the pulmonary artery cannot be cannulated, therefore a small polyethylene catheter is placed directly into the right ventricle.


Pulmonary Artery Cannulating System for Rat or Guinea Pig (73-4395)


Right Ventricle Cannulating System for Mouse (73-4396)


Ball Joints and Pulmonary Artery Cannulating System for Rat/ Guinea Pig Hearts (73-0206)

Coronary Effluate Collection Option
(continued)

Included Items

Cannulating System for Rat or Guinea Pig Pulmonary Artery on IH-SR or IH-5 (73-4395) includes bent cannula for pulmonary artery, mini ball joint holder, link for higher loading capacity, mini ball and Tygon® tubing

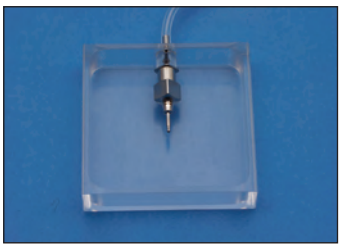
Cannulating System for Rat or Guinea Pig Pulmonary Artery on UP100-IH (73-4394) includes 73-4395 items plus stand with block clamp and bar with mini ball for mounting on stand.

Cannulating System for Rabbit Pulmonary Artery on IH-5, O.D. 4.0 mm (73-0517) includes 4 mm OD bent cannula with holder and perspex block clamp.

Cannulating System for Mouse Right Ventricle on IH-SR (73-4396) includes two mini holders, mini ball with thread, ball to hold PE catheter and PE tubing.

Not Included (Purchase Separately)

Small Preparation Dish



The small preparation dish is used as a tool for isolated mouse heart cannulation, ideal to fix the mouse heart on the aortic cannula under a microscope.

The preparation dish is placed on ice and filled with 4°C cold perfusion solution in order to keep metabolic function and ischemia low. It is designed with a very thin base so that when placed on an ice bath the perfusate in the dish will be dramatically cooled resulting in cardioprotective hypothermia. There are prep dishes available for cannula with Luer taper and with IH-SR taper.

The 73-0129 prep dish´s aortic cannula connector is designed to only accommodate the IH-SR mouse cannula. The mouse cannula is held stable in the dish while the heart is mounted. An inlet port on the dish serves as the attachment point for a syringe filled with cold buffer that is used to fill the tube and the cannula bubble free and to carefully flush the blood from the heart. Over-pressurizing the heart is prevented by a pressure relief port just prior to the aortic cannula.

Once the heart is secured onto the cannula with suture and flushed, it can be removed from the preparation dish and mounted onto the perfusion system.

Effluate Collection Funnel

The effluate collection funnel fits into lower lid of the heart chamber in an IH-SR system. It is used to collect effluate, which drops down from the isolated heart into this funnel.

Ordering Information

Item #	Description
73-4395	Cannulating System for Rat or Guinea Pig Pulmonary Artery for IH-SR or IH-5 systems*
73-4394	Cannulating System for Rat, Guinea Pig or Small Rabbit Pulmonary Artery for UP-100IH*
73-0206	Cannulating Option for Rat or Guinea Pig Pulmonary Artery for IH-5, OD = 2.5 mm
73-0517	Cannulating Option for Rabbit Pulmonary Artery for IH-5 , OD = 4.0 mm
73-4396	Cannulating System for Mouse Right Ventricle for IH-SR
73-0129	Small Preparation Dish for Mouse Hearts on IH-SR with link for IH-SR cannula
73-4327	Small Preparation Dish for Mouse Hearts with male taper for conical Luer cannula and straight taper for IH-SR cannulae
73-4464	Small Preparation Dish for Mouse Hearts with male taper for conical Luer cannula. Used for UP100IH, PSCI, Easycell
73-3329	Effluate Collection Funnel for Isolated Heart System IH-SR

**Rat and guinea pig only. Cannot be used with mouse heart due to the small size of the pulmonary artery.*

Perfusate Oxygenation Option

Add this option if you are using buffer supplemented with albumin, fatty acids, washed erythrocytes, or other foaming additives that result in foaming solutions. It allows you to adapt the fiber oxygenator types D150 and DP07HE for use with the IH-SR, IH-5, UP-100IH or any other system.

Features of Fiber Oxygenators

- MediSulfone membrane material
- Priming volume 18 ml (D150) or 49 ml (DP07HE)
- Active oxygenating surface area 0.22 m^2 (D150) or 0.7 m^2 (DP07HE)
- Can be used 3 to 10 times after careful cleaning

Oxygenating System Option for IH-SR and UP-100IH (73-4449) includes:

Item #	Product Name
73-3762	Fiber Oxygenator Type D150, pkg. of 5
73-3061	Holder for Oxygenators
73-3759	Mounting Kit for D150 Fiber Oxygenator
73-3765	Connection Kit for D150 or DP07HE Fiber Oxygenator (containing five sets of tubing connectors)

Oxygenating System Option for IH-5 (73-4348) includes:

Item #	Product Name
73-4995	Fiber Oxygenator Type DP07HE, pkg. of 5
73-3061	Holder for Oxygenators
73-3760	Mounting Kit for DP07HE Fiber Oxygenator
73-3765	Connection Kit for D150 or DP07HE Fiber Oxygenator (containing five sets of tubing connectors)

Ordering Information

Item #	Description
73-4449	Oxygenating System Option for IH-SR and UP-100IH
73-4348	Oxygenating System Option for IH-5

Perfusate Filtration Option

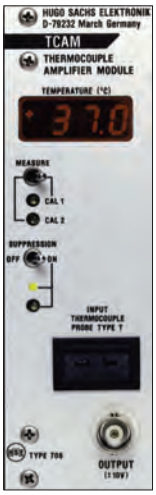
This option enables filtration of recirculated perfusate in any isolated organ system. Includes:

- In-line holder for disc particle filter, diameter = 47 mm
- Polypropylene particle filter, 45 µm, diameter = 47 mm (pack of 100)
- Filters with other pore sizes are available:

Ordering Information

Item #	Description
73-4423	Addition of Filtration of Recirculated Perfusate. Includes 73-2091 Inline Filter Holder and 73-2093 Polypropylene Particle Filter 45 µm
73-2091	Inline Holder for Disc Particle Filters, D = 47 mm
73-2093	Polypropylene Particle Filters, 45 µm, D = 47 mm, pkg. of 100
73-2047	Polypropylene Particle Filters, 25 µm, D=47mm, pkg. of 100
73-4956	Nylon Particle Filters, 1 µm, D = 47 µm, pkg. of 100

Temperature Measurement Option



Left: PLUGSYS TCAM Module for Temperature Measurement Option. Above: Copper Constantin Thermocouple Probe with Touhy Borst Adapter

Perfusate temperature can be measured in one of two ways: with the PLUGSYS Thermocouple Amplifier Module (TCAM) or using a handheld thermometer with a digital readout. The perfusate temperature is measured by inserting a thermocouple probe directly into the perfusion line (into the tubing.) Since all IH systems are accurately thermostated, temperature measurement is only necessary on studies using different temperatures, e.g. transplantation studies.

- Temperature Measurement with TCAM (73-1792) provides an analog output to record temperature changes with any DAQ system.
- Temperature Measurement with a handheld thermometer (73-4945) provides measurement on a digital display.

Choose either of the options above and add:

- Copper Constantan Thermocouple Flexible Implantable Probe (52-1732)
- Extension Cable for Thermocouples, 6 ft L (73-1911)
- Tuohy Borst Adapter for inserting tip catheter, small temperature probe or PE catheter into left ventricle via aortic cannula (73-4193)

Ordering Information

Item #	Description
73-1792	PLUGSYS Thermocouple Amplifier Module (TCAM)
73-4945	Handheld Thermometer for Thermocouple Probes
52-1732	Copper Constantan Thermocouple Flexible Implantable Probe, 0.6 mm Tip Diameter
73-1911	Extension Cable for Thermocouple Probes, 6 feet long (ca. 1.80 m)
73-4193	Tuohy Borst Adapter

Perfusion Solution Monitoring

This addition permits precise continuous monitoring and measurement of three key parameters, pO_2, pH and pCO_2, in liquid media or perfusate. Monitoring is accomplished using ion-sensitive, chemosensor-based, flow-through electrodes. The electrodes require a dedicated pulsation-free peristaltic pump to deliver a constant flow of perfusate through the electrode at flow rates in the range of 0.5 to 2 ml/min.

Because of the high impedance of these sensors, screening or shielding of the measuring circuit is required to protect against electrostatic discharges and other electrical disturbances.

Continuous measuring pH, pO_2 and pCO_2 of the perfusion solution in an isolated organ system allows the user to control these parameters over the course of the experiment. It is especially important to monitor these parameters throughout the course of drug studies as any change in these values indicates a significant effect of the drug being tested.

Applications

- Measurement of organ O_2 consumption, CO_2 production and/or pH changes

Features & Benefits

- Enables continuous measurement of pH, pO_2, and pCO_2 in perfusate
- Smooth side stream flow through electrodes with use of peristaltic pump
- Noise-free design (when used with the Shielding Case)
- Measure parameters in the reservoir (pre-organ) and in the effluent (post-organ) allowing measurement of O_2 exchange, CO_2 production and pH change

Perfusion Solution Monitoring (continued)

System Components (Purchase Separately)

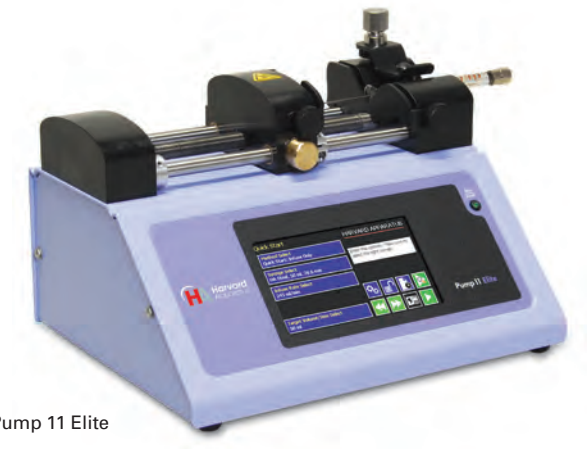
- Shielding Case and Mounting Plate
- Electrodes, associated amplifiers, adapters and related components*
- Dedicated peristaltic pump (such as REGLO Analog Pump 73-0114 or 73-0113) and appropriate pump tubing (73-0206)

**Various microelectrodes and associated components are available. Not all options listed. Please contact us to discuss your application so that we can assist you with the best possible solution.*

Ordering Information

Item #	Description
Shielding Cases	
73-4195	Microelectrode Shielding Case for Three Electrodes (pH, pO_2, pCO_2)
73-0207	Mounting Plate for Three-Electrode Shielding Case
73-4196	Microelectrode Shielding Case for Single Electrode (pO_2 or pCO_2)
73-3000	Mounting Base for Single Electrode Shielding Case
Sensors for pO_2 Measurement	
73-4189	Mini Flow-Through Oxygen Electrode, 1/16" Fittings, for use with OPPM
66-0100	O_2 Flow Through Electrode, 1/16" Fittings for O_2 Adapter
Sensors for pCO_2 Measurement	
73-4191	CO_2 Flow Through Electrode, 1/16" Fittings
Sensors for pH Measurement	
73-4190	pH Flow Through Electrode, 1/16" Fittings
73-4197	pH Mini Flow Through Electrode Set, 1/16" fittings. Includes: flow through electrode, solid state reference system and cable to pHMM
73-2998	Leak Free pH Flow Through Reference Electrode Set for Millivolt Adapter and pHMM Module
Amplifiers & Adapters	
73-0210	PLUGSYS Oxygen Partial Pressure Module (OPPM)
73-0212	PLUGSYS Electrometer Module (EMM)
73-0215	PLUGSYS pH Measurement Module (pHMM)
75-1672	O_2 Adapter 100, Lemo to ADI DIN
75-1672	Millivolt Adapter, Lemo to ADI DIN (for pCO_2 or pH electrodes)

Drug Addition Option



Pump 11 Elite

These options for drug addition can be added to any isolated organ system where flow is measured or calculated and a drug must be added in a certain ratio.

There are two options:

- **Perfusion drug addition with syringe pump**: allows drug addition at a set flow rate without software control.
- **Perfusion flow-controlled drug addition with syringe pump:** allows a drug addition proportional to the measured flow in order to maintain a stable drug concentration at any flow rate under constant pressure. Requires HSE software to read and calculate the flow to control the syringe pump flow.

Drug Addition Option (73-4041) includes:		Flow-Controlled Drug Addition Option (73-4042) includes:	
Item #	**Product Name**	**Item #**	**Product Name**
70-4504	Pump 11 Elite Infusion/ Withdrawal Programmable Single Syringe	**70-4504**	Pump 11 Elite Infusion/ Withdrawal Programmable Single Syringe
73-4193	Tuohy Borst Adapter	**73-4193**	Tuohy Borst Adapter
73-4624	Luer Cannula, 0.51 mm, L = 25 mm 25G, pkg. of 5	**73-4624**	Luer Cannula, 0.51 mm, L = 25 mm 25G, pkg. of 5
72-0191	Non-Sterile Polyethylene Tubing, 3 m, 0.40 x 0.80 cm Polye 140	**72-0191**	Non-Sterile Polyethylene Tubing, 3 m, 0.40 x 0.80 cm Polye 140
		73-3819	HSE DAQ Flow-Controlled Drug Addition Software

For either option, a syringe with Luer taper must be purchased separately.

Ordering Information

Item #	Description
73-4041	Drug Addition Option
73-4042	Flow Controlled Drug Addition Option*

Cell Isolation Upgrade

These upgrades are for cell isolation/cell extraction applications with the UP-100IH or IH-SR Systems.

Included Items

UP-100IH Upgrade, 230 VAC, (73-4393) includes:		UP-100IH Upgrade, 115 VAC (73-4392) includes:	
Item #	**Product Name**	**Item #**	**Product Name**
72-1973	Magnetic stirrer, 230 VAC	**72-1972**	Magnetic stirrer, 115 VAC
73-3496	Enzyme Solution Reservoir, Duran glass, 100 ml volume with cover (in case of cell harvesting. Used for protease solution.	**73-3496**	Enzyme Solution Reservoir, Duran glass, 100 ml volume with cover (in case of cell harvesting. Used for protease solution.
72-2693	3-way Stopcock (200 PSI) FLL/ FLL Male, Luer slip (Pack of 25)	**72-2693**	3-way Stopcock (200 PSI) FLL/ FLL Male, Luer slip (Pack of 25)
72-8327	1-Way Stopcock (Pack of 25)	**72-8327**	1-Way Stopcock (Pack of 25)
73-1866	Tygon® Tubing, OD = 2.86, ID = 1.14 (R43010), 1 meter	**73-1866**	Tygon® Tubing, OD = 2.86, ID = 1.14 (R43010), 1 meter
73-0155	3-Stop Tygon® E-Lab Tubing, 2.79 mm ID, 12/pack, Purple/White	**73-0155**	3-Stop Tygon® E-Lab Tubing, 2.79 mm ID, 12/pack, Purple/White
IH-SR Upgrade, 230 VAC (73-3981) includes all items supplied with 73-4393 plus:		**IH-SR Upgrade, 115 VAC (73-4354) includes all items supplied with 73-4392 plus:**	
72-3329	Effluate Funnel for Isolated Heart System IH-SR	**72-1972**	Effluate Funnel for Isolated Heart System IH-SR
00-1442	Heat Exchanger with Bubble Trap for Cell Harvesting, 230 V	**73001442**	Heat Exchanger with Bubble Trap for Cell Harvesting, 115 V

Ordering Information

Item #	Description
73-4393	Cell Isolation/Extraction Upgrade for UP-100IH, 230 V
73-4392	Cell Isolation/Extraction Upgrade for UP-100IH, 115 V
73-3981	Cell Isolation/Extraction Upgrade for IH-SR, 230 V
73-4354	Cell Isolation/Extraction Upgrade for IH-SR, 115 V

Pacing Option

The pacing option provides electrical stimulation to isolated small rodent hearts in functional IH-SR or IH-5 Langendorff or Working Heart Systems to ensure a stable or constant heart rate. Pacing is useful when studying, for example, cardiac contractile function. This option is also useful for the study of specific stimulation patterns, allowing stimulation to be switched on and off as required.

The Stimulator C is a compact, highly stable square wave pulse stimulator that features precise digital timing control. A large LCD display (2 lines at 40 characters) and minimum of controls make setup and operation easy. All relevant stimulation parameters are shown on the display providing a rapid view of the current settings. Several stimulation modes are possible, e.g., repetitive, single, triggered, tetanic.

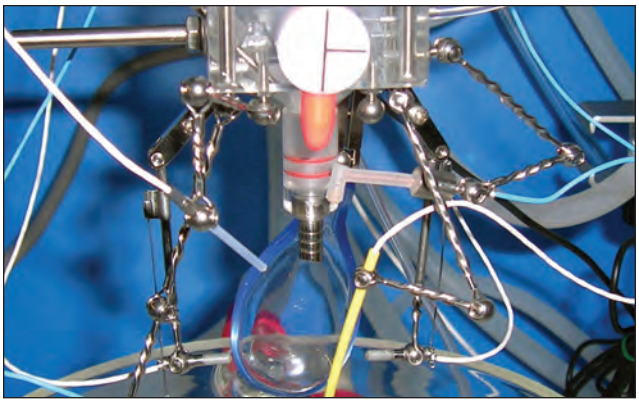
IH-SR Pacing Option, 115 V, for Small Rodents (73-4345) includes:		IH-SR Pacing Option, 230 V, for Small Rodents (73-4024) includes:	
Item #	**Product Name**	**Item #**	**Product Name**
73-3716	Stimulator C, 115 V	**73-3713**	Stimulator C, 230 V
73-0160	Small Coaxial Stimulation Electrode Set	**73-0160**	Small Coaxial Stimulation Electrode Set

IH-5 Pacing Option, 115 V, for Rabbit, Guinea Pig and Rat (73-4452) includes:		IH-5 Pacing Option, 230 V, for Rabbit, Guinea Pig and Rat (73-4436) includes:	
Item #	**Product Name**	**Item #**	**Product Name**
73-3716	Stimulator C, 115 V	**73-3713**	Stimulator C, 230 V
73-0219	Coaxial Stimulation Electrode Set	**73-0219**	Coaxial Stimulation Electrode Set

Ordering Information

Item #	Description
73-4024	Pacing Option for IH-SR, 230 V
73-4345	Pacing Option for IH-SR, 115 V
73-4436	Pacing Option for IH-5, 230 V
73-4452	Pacing Option for IH-5, 115 V

Single-Lead ECG and MAP Measurement Options



Single-Lead ECG and MAP Measurement

For single-lead ECG and MAP measurements on functional IH-SR or IH-5 Langendorff or Working Heart Systems, one ECG lead can be combined with one or more MAP electrodes.

The Monophasic Action Potential (MAP) electrodes work based on the principle of Franz et al* whereby firm, stable contact of the MAP electrode results in a high-quality MAP. MAP recording has been utilized in cardiac physiology for decades as it allows regional assessment of the electrophysiological state of the intact heart.

** Franz MR, Burkhoff D, Spurgeon H, Weisfeldt ML, Lakatta EG (1986). In vitro validation of a new cardiac catheter technique for recording monophasic action potentials. Eur Heart J, 7: 34-41.*

Applications

MAP recording is essential to researchers who study:

- Atrial fibrillation
- Arrhythmias
- Anti-arrhythmic drugs
- Ischemia
- Depolarization and repolarization cycles
- Activation time
- Mechanisms of action of various drugs

Features & Benefits

- Mini monophasic action potential electrodes for epicardial and endocardial recording, with dedicated holders
- Precision MAP electrodes with dedicated holders allow easy positioning on the heart
- Small electrodes allow multiple ECG and MAP signals to be recorded even on mouse hearts
- Mini ECG electrodes with dedicated holders
- Flexible ECG electrodes follow the heartbeat, dedicated holders allow easy positioning on the heart

Configurations

Item #	Measurement	Species	Included Items
73-4025	Single Epicardial MAP on IH-SR	Mouse	Micro MAP-Tip electrode (73-3840) Link for Higher Load Capacity, for Two Arms with 5 mm Mini Balls (73-0564) MAP Opposite Holder to Maintain Mouse Heart in Position (73-3858) Connection Cable for MAP Electrode to BPA Amplifier (73-0152) PLUGSYS Biopotential Amplifier (BPA) Module (73-0153)
73-4026	Single Epicardial MAP on IH-SR	Rat, Guinea Pig	Mini MAP-Tip electrode (73-0150) Holder for MAP Electrode for IH-SR System (73-0151) MAP Opposite Holder to Maintain Rat or Guinea Pig Heart in Position (73-2989) Connection Cable for MAP Electrode to BPA Amplifier (73-0152) PLUGSYS Biopotential Amplifier (BPA) Module (73-0153)
73-4421	Single Epicardial MAP on IH-5	Rat, Guinea Pig, Rabbit	Mini MAP-Tip Electrode (73-0150) Holder for MAP Electrode (73-0151) Link for Higher Load (73-0564) Mini Ball Joint Holder (73-0563) MAP Opposite Holder (73-3755) Connection Cable for MAP Electrode to BPA Amplifier (73-0152) PLUGSYS Biopotential Amplifier (BPA) Module (73-0153)
73-4027	Single Endocardial MAP on IH-SR or IH-5	Rat, Guinea Pig, Rabbit	Intracardial MAP-Tip electrode with Holders (73-3715) Connection Cable for MAP Electrode to BPA Amplifier (73-0152) PLUGSYS Biopotential Amplifier (BPA) Module (73-0153)
73-4422	ECG Lead II on IH-SR or IH-5	Mouse to Rabbit	Two Contact ECG Electrodes (73-0200) Four Mini Ball Joint Holders (73-0177) Two Mini Ball Joint Holders (73-0174) Two Mini Ball Joint Holders (73-0175) ECG Cable to ECGA Module (73-0148) ECGA Amplifier Module (73-0149)

MAP Electrodes

The MAP electrodes required for each application, species and system are included in the options above.

- Micro MAP-Tip Electrode (73-3840) for single epicardial MAP on IH-SR with mouse heart includes the electrode, spring wire and pack of sponges, as well a 2 mm male connector. The MAP electrode opposite holder (73-3858) needs to be attached with a certain pressure to the heart on the opposite side to hold the heart in position.

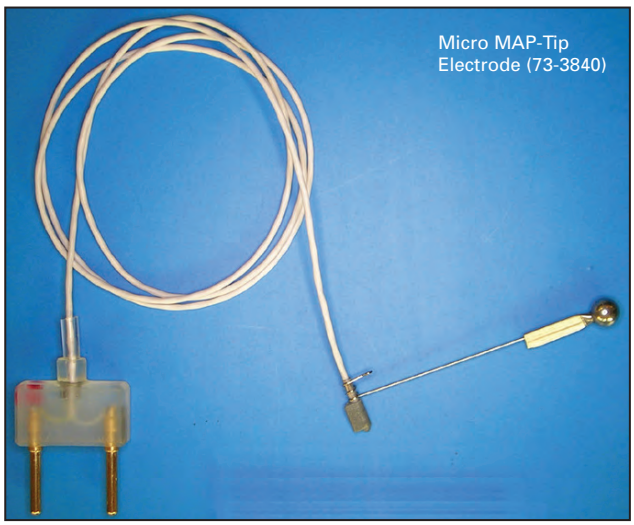
Single-Lead ECG and MAP Measurement Options (continued)

- Mini MAP-Tip Electrode (73-0150) for single epicardial MAP on IH-SR (rat, guinea pig heart) or IH-5 (rat, guinea pig, rabbit heart) comes with two male connectors and includes one pack of sponges. This electrode must be used with the spring holder (73-0151), sold separately. The MAP electrode opposite holder (73-2989) holds the rat or guinea pig heart in place at a certain pressure.
- MAP Electrode for Intracardial MAP (73-3715) for endocardial MAP on IH-SR or IH-5 (rat, guinea pig, rabbit heart) includes necessary holders.

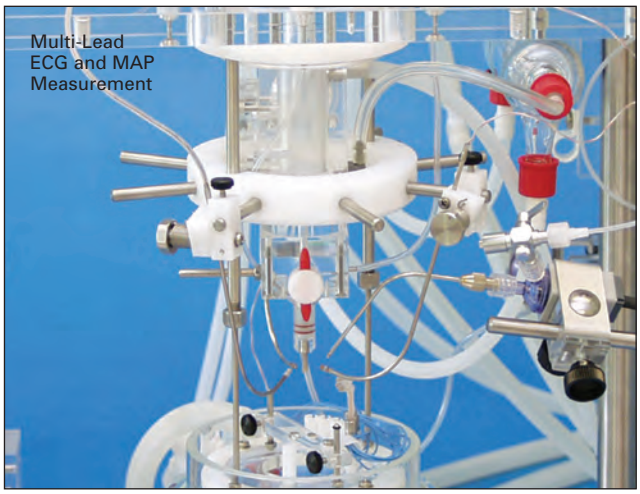
For more details about these packages, please contact Technical Support.

Ordering Information

Item #	Description
73-4025	Measurement of Single Epicardial Monophasic Action Potential on Mouse Heart Option
73-4026	Measurement of Single Epicardial Monophasic Action Potential on Rat Heart Option
73-4421	Measurement of Single Epicardial Monophasic Action Potential on Rat, Guinea Pig or Rabbit Heart Option
73-4027	Measurement of Single Endocardial Monophasic Action Potential on Rat Heart Option
73-4422	Measurement of ECG Lead II on Any IH System Option
73-0150	Mini MAP-Tip Electrode for Rat, Guinea Pig and Rabbit (requires 73-0151)
73-0151	Holder for MAP Electrode for IH-SR System
73-2910	Sponges for MAP Epicardial Probe
73-2989	MAP Electrode Opposite Holder to Maintain Rat or Guinea Pig Heart in Position on IH-SR
73-3715	Intracardial MAP-Tip electrode with Holders for Rat, Guinea Pig and Rabbit
73-3755	MAP Opposite Holder for IH-5 System
73-3840	Micro Map-Tip Electrode for Mouse
73-3858	MAP Electrode Opposite Holder to Maintain Mouse Heart in Position on IH-SR
73-0200	Contact ECG Electrode, Silver Chloride Pellet
73-0174	Mini Ball Joint Holder, Eye-Eye, 23 mm long, pkg. of 1
73-0177	Mini Ball Joint Holder, Eye-Ball, 25 mm long, pkg. of 1


Micro MAP-Tip Electrode (73-3840)

Multi-Lead ECG and MAP Measurement


Multi-Lead ECG and MAP Measurement

For multi-lead ECG and MAP measurements on functional IH-5 Langendorff or Working Heart Systems, up to 12 ECG leads can be combined with up to 8 MAP electrodes.

The Monophasic Action Potential (MAP) electrodes work based on the principle of Franz et al whereby firm, stable contact of the MAP electrode results in a high-quality MAP. For electrophysiology studies, up to 12 ECG leads can be combined with up to 8 MAPS on a functional IH-5 System. These options are particularly suited for safety pharmacology laboratories.

- 6-lead ECG measurements are accomplished using Einthoven Goldberger leads and the PLUGSYS Einthoven Goldberger (EGM) module.
- 12-lead ECG measurements are accomplished using a combination of Einthoven Goldberger leads and Wilson leads with the PLUGSYS Einthoven Goldberger (EGM) and Wilson (WLA) modules. 12-leads ECGs are required for drug studies.
- MAP measurements use MAP electrodes with the PLUGSYS Monophasic Action Potential (MAPM) module.
- Input boxes with circular MAP holders are available for configurations that require them.

Applications

MAP recording is essential to researchers who study:

- Cardiac mapping
- Dispersion of ventricular repolarization
- Arrhythmias characterization of regional ischemia using MAP
- Activation time and similar applications

Multi-Lead ECG and MAP Measurement
(continued)

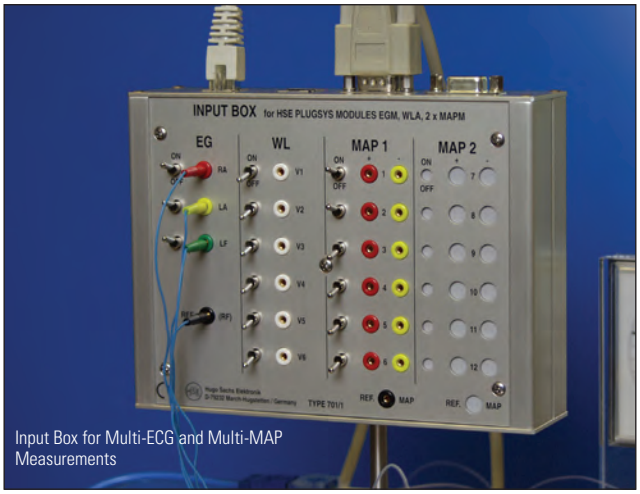
You can make up to 12 ECG measurements alone or up to 12 ECG combined with up to 8 MAP measurements on a functional IH-5 System. Simply choose a combination of the following ECG and MAP options that suit your application. Measurements of 6 to 8 MAP, with or without ECG, require an Input Box.

Configurations

Item #	Measurement	Included Items
73-4405	6-Lead ECG (6 Einthoven-Goldberger)	6-Lead ECG Electrode Insert (73-3636) PLUGSYS Einthoven Goldberger (EGM) Module (73-1778) 6-fold Output Module for EGM, WLA, or MAPM (73-3827) Input Box for up to 12 ECG Channel (73-1789) Requires 6 available data acquisition input channels.
73-4406	12-Lead ECG (6 Einthoven-Goldberger and 6 Wilson)	12-Lead ECG Electrode Insert (73-0550) PLUGSYS Einthoven Goldberger (EGM) Module (73-1778) PLUGSYS Wilson Lead Amplifier (WLA) Module (73-1779) Two 6-fold Output Modules for EGM, WLA, or MAPM (73-3827) Requires 12 available data acquisition input channels.
73-4407	Multi-MAP for 6 MAP	Six MAP Electrodes, J-form (73-0409) PLUGSYS Monophasic Action Potential (MAPM, 6-channel) Module (73-1780) Circular Holder for 8 MAP Electrodes (73-0551)* Requires 6 available data acquisition channels and an input box.
73-4408	Multi-MAP for 3 MAP	Three MAP Electrodes, J-form (73-0409) PLUGSYS Monophasic Action Potential (MAPM, 3-channel) Module (73-3080) 6-fold Output Module for EGM, WLA, or MAPM (73-3827) Requires 3 available data acquisition channels and an input box.

** The circular holder holds up to 8 MAP electrodes and fits only to the IH-5 System. The J-form MAP electrodes are installed on the circular holder.*

Input Boxes for Multi-ECG and Multi-MAP Measurements on IH-5



Input Box for Multi-ECG and Multi-MAP Measurements

Input Boxes for multi-ECG and multi-MAP measurements for use with the PLUGSYS EGM, WLA and MAPM modules. Multi-lead MAP and ECG options available with circular MAP holder included.

If you already have a circular MAP holder or the necessary input box, items can be also purchased separately. If you are just setting up for multi-lead ECG and/or MAP measurements, the input boxes in the table below are recommended.

Configurations

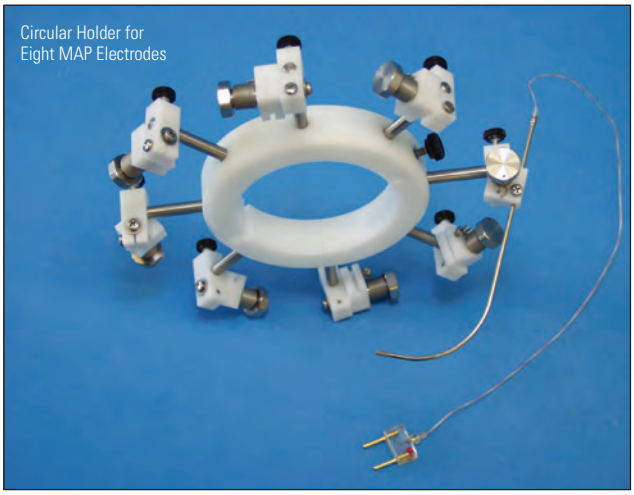
Item #	Input Box	Includes	Compatible Item #
73-1789	Up to 12 ECG (No MAP)	Provides 4 labeled and color-coded 2 mm input sockets for EINTHOVEN Leads (I, II, III, avL, avR, aVF) and 6 labeled 2 mm input sockets for WILSON chest leads (V1-V6), cables to EGM and WLA modules are included.	73-4405 73-4406
73-4438	Up to 6 MAP	Includes Input Box for one MAPM Module for 6 differential MAP inputs (73-1787),Circular Map Holder* (73-0551) and MAPM connection cable	73-4407 74-4408
73-4439	Up to 12 MAP	Includes Input Box for two MAPM Modules (73-1788) for 12 (2 x 6) differential MAP inputs, Circular Map Holder (73-0551) and MAPM connection cables	73-4407 74-4408
73-4440	Up to 12 ECG, up to 6 MAP	Includes Input Box for EGM, WLA and one MAPM Modules for 4 + 6 ECG and 6 differential MAP inputs (73-1790), Circular Map Holder (73-0551) and connection cables to EGM, WLA and MAPM modules	73-4406 73-4407
73-4441	Up to 12 ECG, up to 12 MAP	Includes Input Box for EGM, WML and two MAPM Modules for 4 + 6 ECG and 12 (2 x 6) differential MAP inputs (73-1791), Circular Map Holder (73-0551) and connection cables to EGM, WLA and MAPM modules	73-4406 73-4407 73-4408

Multi-Lead ECG and MAP Measurement

(continued)

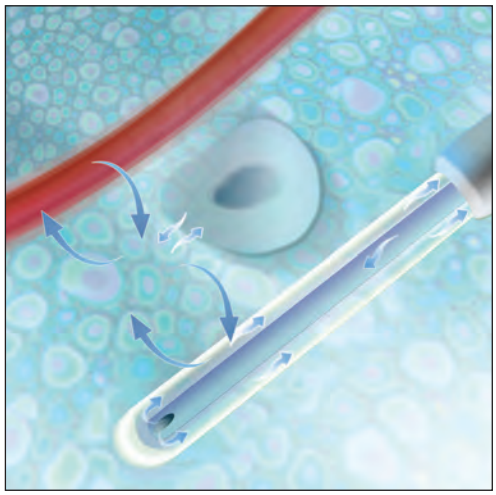
Ordering Information

Item #	Description
73-1789	Input Box for up to 12 ECG Channels (no MAP), for PLUGSYS EGM and WLA Modules, with Connection Cables
73-4438	Input Box for up to 6 MAP Channels for PLUGSYS MAPM Module, with Circular MAP Holder and Connection Cables
73-4439	Input Box for up to 12 MAP Channels for PLUGSYS MAPM Module, with Circular MAP Holder and Connection Cables
73-4440	Input Box for up to 12 Lead ECG and 6 MAP Channels, for PLUGSYS EGM, WLA and MAPM Modules, includes Circular MAP Holder and Connection Cables
73-4441	Input Box for up to 12 Lead ECG 12 MAP Channels, for PLUGSYS EGM, WLA and MAPM Modules, includes Circular MAP Holder and Connection Cables
73-1787	Input Box for up to 6 MAP Channels, for PLUGSYS MAPM Modules, with Connection Cables
73-1790	Input Box for up to 12 ECG and 6 MAP Channels, for PLUGSYS EGM, WLA and MAPM Modules, with Connection Cables
73-1791	Input Box for 12 ECG and 12 MAP Channels, for PLUGSYS EGM, WLA and MAPM Modules, with Connection Cables
73-0551	Circular Holder for 8 MAP Electrodes for IH-5 MAP
73-4405	6-Lead Einthoven Goldberger (EGM) ECG Set for IH-5
73-4406	6-Lead Einthoven Goldberger (EGM) and 6-Lead Wilson (WLA) ECG Set for IH-5
73-4407	Multi-MAP Addition Set for 6 MAP for IH-5
73-4408	Multi-MAP Addition Set for 3 MAP for IH-5



Circular Holder for Eight MAP Electrodes

Cardiac Microdialysis



Microdialysis can be used to explore tissue chemistry in the myocardium.

Before a molecule from the blood can enter a cell, in an organ, or vice versa, it must first traverse the extracellular space. This crucial compartment for chemical communication between the cells is experimentally inaccessible by conventional methods of bioanalytical chemistry.

The Microdialysis Probe mimics the function of a blood vessel. The probe is constantly perfused with a physiological solution at a low flow-rate. Once the probe is implanted into the tissue, endogenous substances are filtered by diffusion out of the extracellular fluid into the perfusion medium. By reversing the process the probe can be used to locally infuse exogenous compounds, nutrients and drugs. Samples are collected and then analyzed.

A standard microdialysis setup includes physiological solution, syringes and syringe pump, tubing, connectors, microdialysis probe and collecting vials. Different techniques could be used for analyzing the collected samples. There are also Microdialysis Analyzers available on the market.

Ordering Information

Item #	Description
8003100	CMA 402 Pump with Accessory Kit
8010771	CMA 7 Microdialysis Probe, 1 mm, pkg. of 3*
P000034	Perfusion Fluid T1, 5 mL, pkg. of 10
8409501	FEP tubing, 1 meter, pkg. of 10
3409500	Tubing Adapter, pkg. of 10
7431100	Vials Plastic, 300 µL, pkg. of 1000
7431101	Caps, Plastic, pkg. of 1000

Lauda Thermocirculators

E-103 Thermocirculator

RE-207 Thermocirculator

Lauda Bath/Immersion Thermostats (E-103)

Economical, high quality stainless steel baths that provide temperature-controlled circulating water from 20°C to 150°C.

Features & Benefits

- User-friendly menu guidance, operation with three keys
- Over-temperature cut off
- Visual alarm
- High-powered, speed-selectable, five-speed pump with electronic control heats the thermocirculator up quickly
- Can be switched between internal and external circulation

Lauda Low-Temp Thermostats (RE 207)

Powerful, low-temperature thermostats with microprocessor technology. Environmentally-friendly and energy-saving refrigeration system.

Features & Benefits

- Clear 2-line LCD display with numbers and symbols
- Parallel display of actual and set temperature
- Messages for the various operating states in plain language
- Audible alarm for low level and over temperature
- Facility for remote fault indication through floating contact

Ordering Information

Item #	Description
73-2481	Lauda Low Temperature Thermostatic Circulator RE 207, 6 L Bath Volume, 230 VAC/ 50Hz, Temperature Range -35 to + 200°C
73-0125	Lauda Thermostatic Circulator, Type E-103, 230 V/50 Hz, 3 L Bath Volume, Temperature Range 20 to 150°C
73-2802	Lauda Thermostatic Circulator, Type E-103, 115 V/60 Hz, 3 L Bath Volume, Temperature Range 20 to 150°C
73-2968	Tube Set for Lauda Thermocirculators

LT ecocool Refrigerated / Heating Circulating Baths

LT ecocool Circulating Baths

Powerful cooling and heating in an eco-friendly bath. Up to 80% energy savings compared to standard compressor units. The two models offered come as complete kits with hosing, clips and connectors.

Features & Benefits

- Temperature range -20°C to 100°C or -25°C to 150°C (model dependent)
- Active cooling through whole temperature range
- Thermostat and chiller work simultaneously, eliminating the danger of overheating or freezing
- Single front switch for user convenience

Ordering Information

Item #	Description
75-0310	LT ecocool 100, 120 V, -20 to 100ºC
75-0311	LT ecocool 100, 230 V, -20 to 100ºC
75-0312	LT ecocool 150, 120 V, -25 to 150ºC
75-0313	LT ecocool 150, 230 V, -25 to 150ºC

TC120 Series Heated Circulating Bath

TC120 Thermocirculator with Stainless Steel Bath

This easily programmable thermocirculator allow for high precision temperature control from 0 to 120°C. The powerful pump makes these circulators ideal for both routine and sensitive procedures.

Features & Benefits

- Digital control unit with four digit display
- Rotor dial for simple temperature setting
- Low liquid protection
- Over temperature cut out
- Integral pump with max flow rate 16 L/min
- Visual alarm

Operation at Low Temperatures

An Accessory Cooling System is required for controlled operation at or below ambient temperature. The minimum working temperature without an Accessory Cooling System depends on the size of the bath. The small baths, P5 and ST5, have a minimum working temperature of approximately 10°C above ambient without a lid and 15°C above ambient with a lid. Other bath sizes can be used at a temperature of 5°C above ambient.

These TC120 Thermocirculators are supplied complete with the thermocirculator itself, stainless steel or plastic bath and lid.

Ordering Information

Item #	Description
73-4544	TC120 Thermocirculator, complete with 5 L stainless steel bath and lid, 220 V
72-4945	TC120 Thermocirculator, complete with 5 L stainless steel bath and lid, 120 V
72-4924	TC120 Thermocirculator, complete with 5 L plastic bath and lid, 120 V
72-4921	TC120 Thermocirculator, complete with 5 L plastic bath and lid, 220 V

Fiber Oxygenators

D150 Fiber Oxygenator

Stand Alone Oxygenator Holder, with Needle Valve (73-3058)

The fiber (or membrane) oxygenator is an alternative to glass frit or bulb oxygenators. This oxygenator is used for blood, blood/perfusate mix, or perfusate that contains protein (to prevent foaming).

Oxygenator holders are available separately. Mounting rods or stand are not included. Mounting kits are specific for either the D150 or DP07HE oxygenator. They include two ring clamps to hold the oxygenator, tubing adapters, silicone and Tygon® tubing.

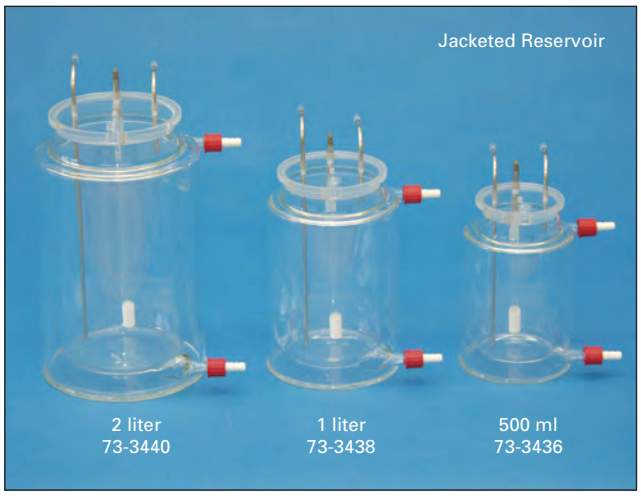
Features

- Hollow fiber oxygenator in two sizes D150 or DP07HE
- MediSulfone® membrane material
- 18/49 ml total priming volume
- 0.22/0.7 m^2 active oxygenating surface area
- Can be used 3 to 10 times
- Selection of different holders available

Ordering Information

Item #	Description
73-3757	Fiber (Membrane) Oxygenator Type D150, pkg. of 1
73-3762	Fiber (Membrane) Oxygenator Type D150, pkg. of 5
73-4993	Fiber (Membrane) Oxygenator Type DP07HE, pkg. of 1
73-4995	Fiber (Membrane) Oxygenator Type DP07HE, pkg. of 5
73-3061	Holder for Oxygenators for UP-100 and IH-SR
73-3057	Holder for Oxygenators for PSCI
73-3058	Stand Alone Holder for Fiber (Membrane) Oxygenators with Needle Valve
73-3759	Mounting Kit for D150 Fiber Oxygenator on Holder
73-3760	Mounting Kit for DP07HE or DP07HE Fiber Oxygenators on Holder
73-3765	Connection Kit for Fiber Oxygenator: Consisting of 5 sets of tubing connectors for perfusate and gas to the oxygenator

Jacketed Glass Perfusate Reservoirs



These jacketed glass reservoirs are used in conjunction with a peristaltic pump to deliver warmed and aerated (oxygenated) perfusate to the target organ. They interface with a thermocirculator to stabilize the temperature of the reservoir through ports that accept 5 mm ID tubing.

These reservoirs are available in multiple sizes and styles:

- Standard and sealed styles: the peristaltic pump is connected to the longer stainless steel tube via a Luer connector and tubing.
- Bottom drain type: the perfusate outlet is the drain port, which can be connected to 5 mm ID tubing or via a Luer adapter to the stopcock (included with the reservoirs with bottom drain).
- All styles: a return flow can be connected to the short stainless steel tube with the included Luer to barded tubing connector.

Each reservoir is supplied with a frit to aerate the perfusate. Tubing sets for interfacing with a thermocirculator must be purchased separately.

Ordering Information

Item #	Description
Jacketed Glass Reservoirs	
73-0322	Jacketed Glass Reservoir for Buffer Solution, with Frit, 6.0 L
73-3440	Jacketed Glass Reservoir for Buffer Solution, with Frit, 2.0 L
73-3438	Jacketed Glass Reservoir for Buffer Solution, with Frit, 1.0 L
73-3436	Jacketed Glass Reservoir for Buffer Solution, with Frit, 0.5 L
73-3496	Jacketed Glass Reservoir for Enzyme Solution, with Cover, 100 ml
Jacketed Glass Reservoirs with Bottom Drain	
73-3441	Jacketed Reservoir for Buffer Solution with Frit and Bottom Drain, 2.0 L
73-3439	Jacketed Reservoir for Buffer Solution with Frit and Bottom Drain, 1.0 L
73-3437	Jacketed Reservoir for Buffer Solution with Frit and Bottom Drain, 0.5 L
Seal jacketed, autoclaveable Reservoirs	
73-4734	Sealed Jacketed Glass Reservoir with Autoclavable Lid, 2.0 L, with Tubing Oxygenator
73-4808	Sealed Jacketed Glass Reservoir with Autoclavable Lid, 220 ml, (no tubing)
73-4954	Sealed Jacketed Glass Reservoir with Autoclavable Lid, 2 L (no tubing)
73-4952	Sealed Jacketed Glass Reservoir with Autoclavable Lid, 220 ml (no tubing)
Accessories & Replacement Parts	
73-3566	Frit for 2.0 L Jacketed Buffer Reservoir
73-3565	Frit for 1.0 L Jacketed Buffer Reservoir
73-3564	Frit for 0.5 L Jacketed Buffer Reservoir
73-3455	Tube Set for Jacketed Buffer Reservoir
73-3456	Tube Set for Jacketed Buffer Reservoir with Fluid Line Shutoff Valves
73T17140	Return Tube for Glass Reservoir, stainless steel, D = 4 x 0.25 mm, L = 70 mm
73T17141	Suction Tube for 0.5 L Glass Reservoir, stainless steel, D = 4 x 0.25 mm, L = 190 mm
73T17142	Suction Tube for 1.0 L Glass Reservoir, stainless steel, D = 4 x 0.25 mm, L = 220 mm

REGLO Analog & Digital Peristaltic Pumps

REGLO Digital Peristaltic Pump

The REGLO peristaltic pump is available in either analog or digital models. The analog pump has a variable speed drive with start/stop, speed, and direction functions. The digital version features a dispense mode with variable flow rates and also dispenses by volume or time intervals. The digital readout facilitates programming.

Features

- Included snap-on MS/CA Click 'n' Go Cassettes makes these pumps very easy to use
- Flow rate can be displayed in ml/min

While the REGLO digital is suitable for constant flow perfusion, the analog is necessary when utilizing the SCP module for constant pressure perfusion.

Ordering Information

Item #	Description
73-0113	REGLO Analog Peristaltic Pump, 4-channel MS-4/8, 115 VAC, 60 Hz
73-0114	REGLO Analog Peristaltic Pump, 4-channel MS-4/8, 230 VAC, 50 Hz
73-2915	REGLO Digital Peristaltic Pump, 4-channel MS-4/8, 115 VAC, 60 Hz
73-0100	REGLO Digital Peristaltic Pump, 4-channel MS-4/8, 230 VAC, 50 Hz

3-Stop Collared Tubing		
Item #	**AME#**	**Description**
73-1828	12	3-Stop Collared Tygon® E-Lab Tubing,1.09 mm ID, max flow 7.2 ml/min, pkg. of 12
73-0126	14	3-stop Collared Tygon® E-Lab Tubing, 1.22 mm ID, max flow 8.8 ml/min, pkg. of 12
73-1831	16	3-stop Collared Tygon® E-Lab Tubing, 1.42 mm ID, max flow 8.8 ml/min, pkg. of 12
73-1836	21	3-stop Collared Tygon® E-Lab Tubing, 2.06 mm ID, max flow 11 ml/min, pkg. of 12
73-1838	23	3-stop Collared Tygon® E-Lab Tubing, 2.54 mm ID, max flow 27 ml/min, pkg. of 12
73-1839	25	3-stop Collared Tygon® E-Lab Tubing, 3.10 mm ID, max flow 35 ml/min, pkg. of 12

Harvard Apparatus Peristaltic Pump

Harvard Apparatus Peristaltic Pump with P-70 motor drive

The Harvard Apparatus Peristaltic Pump provides unparalleled accuracy, reproducibility, and ease of use over a broad range of flow rates. It consists of a control unit, a motor drive, a tubing cassette and some sample tubing. The P70 drive allows for flow rates of 1 µm/min to 70 ml/min, depending on tubing size used.

Features

- Ability to separate the motor drive from the controller to facilitate use and save space in incubators and fume hoods
- Easy to calibrate just by sampling a small amount of fluid over time.
- Analog input for speed control

All settings can easily be saved as user-generated methods in the pump's memory. The method can be easily recalled and run very quickly, saving researchers valuable time.

The pump will automatically rotate at the proper rpm for the tube selection and flow rate chosen. To further increase the accuracy, Harvard Peristaltic Pumps offer a rapid calibration routine to further optimize flow accuracy by entering a measured volume of fluid collected.

Note: Connecting this pump to the SCP pressure controller requires a special cable (73-4619) which must be ordered separately.

Ordering Information

Item #	Description
70-7000	Harvard Apapratus Peristaltic Pump with P-70 Motor Drive
70-2215	Footswitch
72-0604	Replacement Cartridge/Cassette for P-70
3-Stop Collared Tubing	
72-0643	3-stop Collared Silicone Tubing, 1.29 mm ID, max flow 14.96 ml/min, pkg. of 6
72-0649	3-stop Collared Silicone Tubing, 2.05 mm ID, max flow 37.79 ml/min, pkg. of 6
72-0651	3-stop Collared Silicone Tubing, 2.54 mm ID, max flow 58.02 ml/min, pkg. of 6
72-0652	3-stop Collared Silicone Tubing, 2.79 mm ID, max flow 70.00 ml/min, pkg. of 6

Ecoline Microprocessor Controlled Peristaltic Pumps

Ecoline Peristaltic Pump

The Ecoline pumps are economical and compact and offer a wider flow rate range than both the Harvard Peristaltic Pump and the REGLO Analog and Digital Pumps. They are ideal for complex pumping applications such as recirculating organ perfusion system.

The Ecoline pumps accept 3-stop collared tubing and utilize the MS/CA Click 'n' Go Cassettes.

Features & Benefits

- MS/CA Click 'n Go Cassettes included
- Analog interface

Note: Connecting this pump to the SCP pressure controller requires a special cable (73-4964) which must be ordered separately.

Ordering Information

Item #	Description
72-6434	Ecoline Peristaltic Pump, VC-MS/CA4-12, 4 Channels, 230 VAC, 50 Hz
72-6435	Ecoline Peristaltic Pump, VC-MS/CA4-12, 4 Channels, 115 VAC, 60 Hz
72-6432	Ecoline Peristaltic Pump, VC-MS/CA8-6, 8 Channels, 230 VAC, 50 Hz
72-6433	Ecoline Peristaltic Pump, VC-MS/CA8-6, 8 Channels, 115 VAC, 60 Hz

3-Stop Collared Tubing		
Item #	**AME#**	**Description**
73-1828	12	3-Stop Collared Tygon® E-Lab Tubing,1.09 mm ID, max flow 7.2 ml/min, pkg. of 12
73-0126	14	3-stop Collared Tygon® E-Lab Tubing, 1.22 mm ID, max flow 8.8 ml/min, pkg. of 12
73-1831	16	3-stop Collared Tygon® E-Lab Tubing, 1.42 mm ID, max flow 8.8 ml/min, pkg. of 12
73-1836	21	3-stop Collared Tygon® E-Lab Tubing, 2.06 mm ID, max flow 11 ml/min, pkg. of 12
73-1838	23	3-stop Collared Tygon® E-Lab Tubing, 2.54 mm ID, max flow 27 ml/min, pkg. of 12
73-1839	25	3-stop Collared Tygon® E-Lab Tubing, 3.10 mm ID, max flow 35 ml/min, pkg. of 12

Centrifugal Pump

Centrifugal Blood Pump

The centrifugal pump is specifically designed for pumping blood and/or erythrocyte suspension solutions in the physiological or pharmacological laboratory. It consists of the pump drive BVP-ZX and a centrifugal pump head which can be replaced without tools. Pump heads are hermetically sealed. The coupling to the motor of the pump drive is carried out via magnetic force; there is no axle.

Features & Benefits

- Low hemolysis
- Flow rates up to 16 L/min
- No or only low pulsation
- Smooth run, producing only low noise
- Pump heads interchangeable without tool
- Speed setting by a digital switch in 0.1% steps
- "Max Speed" button for quick fill or ventilate
- Robust construction for long life time
- Analog interface for remote control, e.g. via SCP pressure controller

The pump speed is set using a 3-digit potentiometer switch (000 to 999) or via an analog interface. The drive is very robust and suitable for continuous speed selection operation.

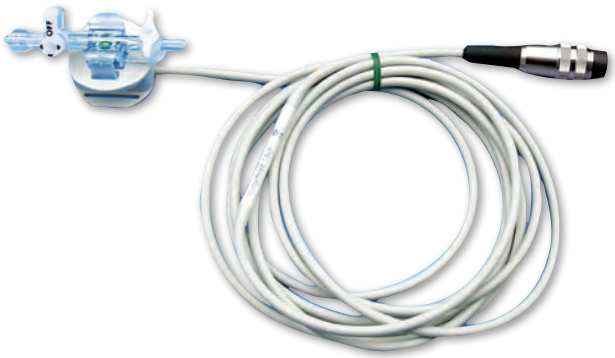
The pump drive and pump heads must be purchased separately. The pump heads are interchangeable and do not require tools to change.

Ordering Information*

Item #	Description
73-2963	Centrifugal Pump Drive (BVP-ZX), 115 VAC, 50/60 Hz
73-2470	Centrifugal Pump Drive (BVP-ZX), 230 VAC
73-2807	Centrifugal Blood Pump Head (BP-80)

**Communication cable from pump to SCP, included with SCP module.*

Blood Pressure Transducer (APT300)



APT300 Pressure Transducer

The APT300 Transducer is an inexpensive pressure transducer which can be used to measure arterial blood pressures in all species, even on mice with a high heart rate. This transducer is typically used for arterial pressure measurement in vivo, perfusion pressures in isolated perfused organs such as heart or kidney, Isovolumetric Left Ventricular (using a balloon) pressures in isolated hearts from mice up to rabbits or pigs.

Features & Benefits

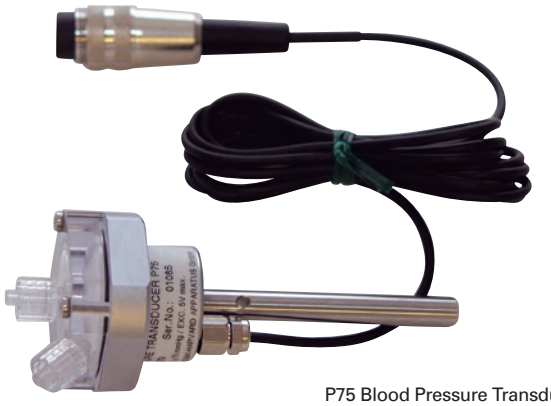
- Inexpensive, reliable and accurate
- Low volume displacement
- Suitable for virtually all arterial pressure applications
- Easy to fill
- Stopcocks Included
- Simple holder for rod mounting

The APT300 Transducer consists of a contact plate with cable and the exchangeable transducer head, which can easily be replaced. Contact plates with cables for different amplifiers are available. Please visit www.harvardapparatus.com for detailed specifications.

Ordering Information

Item #	Description
73-3862	APT300 Pressure Transducer for PLUGSYS Module
73-3866	APT300 Pressure Transducer for ADInstruments
73-3860	Replacement Cable with Contact Plate for PLUGSYS TAM Amplifier
73-3861	Replacement Transducer Head for APT300 Transducer
73-3868	Holder for APT300 Transducer, 8 mm Rod, Length 160 mm
73-3869	Holder for APT300 Transducer, 8 mm Rod, Length 75 mm
73-0566	Plexiglass Block Clamp for mounting Mini-Ball Bar onto Lab Stand
73-0500	Lab Stand with Triangular Base Plate, 30 cm Rod Length (one block clamp included)
73-4479	Manual Pressure Calibrator, Range 0 to 300 mmHg

Venous Pressure Transducer (P75)



P75 Blood Pressure Transducer

This rugged low pressure transducer is highly sensitive for research and surgical applications involving liquids or gases.

- For low pressure applications with liquids and gases +/-75 mmHg
- Excellent sensitivity and baseline stability
- Robust construction with a removable Macrolon® dome, easy to fill, bubble free
- Transducer is a metal housing with ceramic pressure sensor giving the P75 excellent resistance to a variety of media

The P75 has a removable Macrolon® dome with a pressure connection and a vent connection at the side, so that it can be filled free of air bubbles. The dome connections have male Luer tapers so that either of the 1-way or 3-way supplied stopcocks can be attached. The transducer has a metal housing. The actual pressure sensor inside is made from ceramic and therefore has excellent resistance to different media.

The transducer's rugged construction can withstand pressure overloads up to 4000 mmHg without damage. It works together with any DC bridge amplifier (e.g., PLUGSYS TAM–A). Please visit www.harvardapparatus.com for detailed specifications and accessories.

Ordering Information

Item #	Description
73-0020	Blood Pressure Transducer P75 for PLUGSYS Module
73-3738	Blood Pressure Transducer P75 for ADInstruments Bridge Amp
73-0025	Replacement Dome for P75

PLUGSYS Modules & Housings

PLUGSYS TAM-A and TAM-D Modules

PLUGSYS Minicase Type 609

PLUGSYS is a flexible measuring and control system for amplifying, capturing, monitoring and recording physiological data. Its modular structure permits multi-application platform use in areas such as hemodynamics, pulmonary studies, isolated organ studies, biopotentials and combination studies.

A wide range of available modules (bridge amplifiers, ECG, EEG, EMG amplifiers, flowmeters etc. can easily be interconnected and interfaced to PC data acquisition and other recording systems. All PLUGSYS modules fit directly into slots in a PLUGSYS main frame. In addition to being a conventional modular analog measuring system, the PLUGYSYS includes specific interface modules and application software for data acquisition and analysis. For more details about PLUGSYS, please visit **www.harvardapparatus.com**.

PLUGSYS Modules for IPL Systems

Transducer Amplifier Modules (TAM-A and TAM-D)

Universal DC bridge amplifiers used to amplify physiological signals such as blood pressure, contraction force or contraction displacement.

- **TAM-A (analog):** The TAM-A is equipped with an analog LED bar graph signal indicator and is best suited for applications which require the monitoring of dynamic signals, e.g. pulsatile blood pressures, respiratory airflow, airway pressures, contraction force or contraction displacement on tissue studies.
- **TAM-D (digital display):** The TAM-D has a digital numeric display and is best suited for applications with slowly changing low pulsatile signals, e.g. constant blood pressures, perfusion pressures, slow isometric or isotonic contractions, intracranial pressure or venous blood pressures.

Servo Controller for Perfusion Module (SCP)
A PID pressure controller intended for perfusion control of isolated organ perfusions using a peristaltic pump. It works together with PLUGSYS bridge amplifiers TAM-A and TAM-D. It can operate in constant flow perfusion mode, in which the SCP controls the pump speed, or constant pressure mode,

PLUGSYS Housing Type 601 with Five PLUGSYS Modules

PLUGSYS Housing Type 603

in which the speed of the pump is automatically adjusted to maintain a constant pressure. It also calculates the flow rate from the pump speed (indirect flow measurement).

pH Measurement Module (pHMM)
Used to continuously measure pH with pH glass electrodes, primarily in biological fluids such as perfusate for isolated perfused organs.

Oxygen Partial Pressure Module (OPPM)
Used to measure oxygen concentrations with CLARK-style electrodes in biological fluids of isolated perfused organs

Electrometer Module (EMM)
Used to measure CO_2 concentration or ion concentrations in biological fluids such as perfusate for isolated perfused organs, using appropriate electrodes

Thermocouple Amplifier Module (TCAM)
Use to measure temperature accurately and record temperature continuously with thermocouple probes

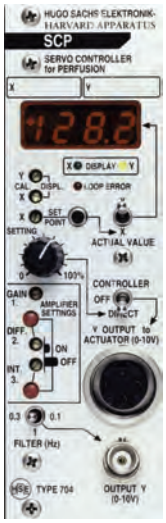
Transit Time Flowmeter Module (TTFM-2)
An ultrasonic transit time flowmeter module used to measure blood flow in vivo or flow rates of any perfusion solution in isolated organ systems (direct flow measurement). It incorporates a complete 1-channel Transonic® ultrasonic transit time flowmeter. It can be used either with HSE in-line flow probes or perivascular probes.

Monophasic Action Potential Module (MAPM), 3-Channel or 6-Channel
Used for capturing and amplifying monophasic action potentials (MAPs). Connects to special MPA electrodes. This module incorporates isolated input amplifiers in order to avoid hum interference.

Einthoven Goldberger Module (EGM)
Used for capturing and amplifying ECG signals after Einthoven and Goldberger lead configuration, 6-lead ECG. It connects to 4 electrodes. This module has isolated input amplifiers in order to avoid hum interference.

Electrocardiogram Amplifier Module (ECGA)
Amplifies ECG signals up to 1,000 beats per minute. This module incorporates a floating input circuit used to avoid hum and grounding problems.

PLUGSYS MODULES & HOUSINGS



Servo Controller for Perfusion (SCP)

Einthoven Goldberger Module (EGM)

Wilson Lead Amplifier Module (WLA)

Wilson Lead Amplifier Module (WLA)
Used for capturing and amplifying unipolar ECG chest lead potentials after Wilson lead configuration. Up to 6 chest electrodes (V1 to V6) can be connected. Requires EGM module.

Biopotential Amplifier Module (BPA)
A non-isolated amplifier used to amplify ECG, EMG, EEC, and ENG biopotentials

Thermocouple Amplifier Module (TCAM)

Oxygen Partial Pressure Module (OPPM)

pH Measurement Module (pHMM)

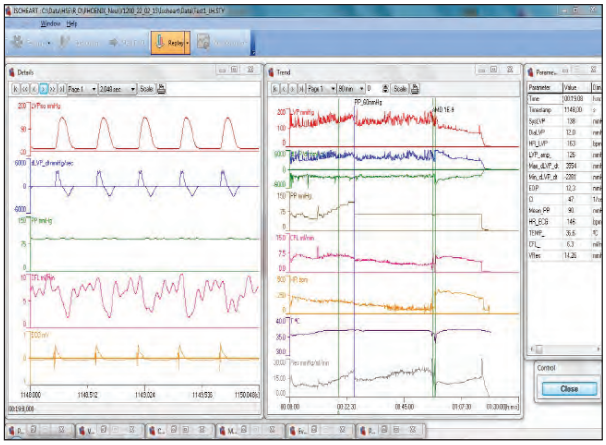
PLUGSYS TTFM-2 Module

Ordering Information

Item #	Description	PLUGSYS Slots Required
73-0065	Transducer Amplifier Module, Analog (TAM-A)	2
73-1793	Transducer Amplifier Module, Digital (TAM-D)	2
73-2806	Servo Controller for Perfusion (SCP)	2
73-0215	pH Measurement Module (pHMM)	2
73-0210	Oxygen Partial Pressure Module (OPPM)	2
73-0212	Electrometer Module (EMM)	2
73-1792	Thermocouple Amplifier Module (TCAM)	2
73-4617	Transit Time Flowmeter Module (TTFM-2)	5
73-1780	Monophasic Action Potential Module (MAPM-6), 6 channel	3
73-3080	Monophasic Action Potential Module (MAPM-3), 3 channel	3
73-1778	Einthoven Goldberger Module (EGM)	2
73-1779	Wilson Lead Amplifier Module (WLA)	2
73-0153	Biopotential Amplifier Module (BPA)	2
73-0149	Electrocardiogram Amplifer Module (ECGA)	2
73-1521	PLUGSYS Case, Type 601, ready to use, 10 slot units	N/A
73-0045	PLUGSYS Case, Type 603, ready to use, 20 slot units	N/A

**Supplied custom wired and configured. Please inquire.*

ISOHEART Data Acquisition Software



ISOHEART Screenshot

ISOHEART Data Acquisition Software can be adapted to virtually any isolated heart system. Acquisition can cover signals such as left ventricular pressure, aortic pressure, aortic flow, atrial pressure, atrial flow, coronary flow, pO_2, pCO_2, pH, temperature, etc.

Various parameters can be derived from these signals, e.g. systolic, diastolic and mean pressures, heart rate, +/-dLVP/dt contractility index CI, minimal, maximal, and mean flows, etc.

Easy to Use

- Choose available signals to acquire and display.
- Choose from possible parameters to evaluate and display.
- Enter experimental protocol.
- Calibrate. (Calibration can be taken from previous experiment.)
- Start data acquisition.
- Offers data reduction and evaluation.

Functionality

All acquired signals and all calculated parameters can be displayed in two graphic windows (Detail and Trend) according to the settings of the user. Complete raw data of experiment are stored on hard disk and can be replayed any time later after the experiment. Data reduction tools are included. Graphic selection of trend data points is possible for easy data reduction.

ISOHEART software is available in a basic version which includes the minimal necessary algorithms. Optional software modules are available to upgrade to a more complex system that includes all the available algorithms.

ISOHEART software can acquire a maximum of 8 or 16 channels (depending on hardware used: 73-3330 (16 ch), 73-4817 (8 ch), 73-4818 (16 ch), i.e. up to 16 different raw signals can be handled.

Ordering Information

Item #	Description
73-4792	ISOHEART Data Acquisition Software for Isolated Heart Studies for Windows
73-0237	LVP Advanced Software Module. Evaluated parameters Taulog, Time to peak, Relaxation time RT50 and RT10, Contractility Index
73-2715	Monophasic Action Potential (MAP) Software Module. Calculates: MaxV, MinV, Amplitude, Rate, dV/dtmax, dV/dtmin, APD90 (duration at 10% of MAP amplitude), APD75, APD50, APD25, APDx
73-3330	Data Acquisition Hardware, USB Universal Stand Alone Version, 16 Channels
73-4817	USB-C Data Acquisition Module for PLUGSYS, 8 Channels
73-4818	USB-C Data Acquisition Module for PLUGSYS, 16 Channels

Ponemah Data Acquisition & Analysis Software

Ponemah is a complete physiologic data acquisition and analysis software platform used to confidently collect, accurately analyze, and quickly summarize study data. Version available for GLP labs.

Available from DSI, a Harvard Bioscience Company.

Visit **www.datasci.com/products/software/ponemah.**

Powerlab Data Acquisition System

PowerLab System

PowerLab® is a complete data analysis and data acquisition system used with LabChart™ software offering comprehensive data recording, display and analysis features for a wide variety of research applications.

LabChart™ is suitable for research on any species—from primates to mice to flies. The software provides the capability to continuously record and display up to 16 channels of data, perform online or offline calculations, display numerous analysis windows, and automatically extract data. Quick and easy setup of experimental parameters, powerful computation and analysis features are just the beginning.

Configuring and recording parameters, such as range and filters, take seconds, with all of the information, including settings, calibration and computed values, saved in a single file. Parameters of interest are easily extracted to an internal spreadsheet and can be exported for further analysis or graphing.

Multiple modules are available to expand on the capability of the standard LabChart™ software. All modules are available for individual purchase (for use with the latest LabChart™ software) or as part of LabChart™ Pro. Modules includes ECG, blood pressure, cardiac output, dose response and more.

Ordering Information

Item #	Description
PowerLab® with LabChart	
77-0239	PowerLab® 4/35, 4 Channels with LabChart™ Software
77-0241	PowerLab® 8/35, 8 Channels with LabChart™ Software
77-0243	PowerLab® 16/35, 16 Channels with LabChart™ Software
PowerLab® with LabChart Pro	
77-0240	PowerLab® 4/35, 4 Channels with LabChart™ Pro Software
77-0242	PowerLab® 8/35, 8 Channels with LabChart™ Pro Software
77-0244	PowerLab® 16/35, 16 Channels with LabChart™ Pro Software

Barbed Connector Kits


Barbed Connectors, Kynar® (Small Kit)

These kits allow you to customize or expand the functionality and species range of your perfusion system. Many researchers add a compound of interest to a second or even a third reservoir rather than use a syringe pump for drug additions. Also common is the use of the system for multiple species, which requires that different tube sets be adapted to the existing tubing.

These barbed connector kits come in three different size ranges:

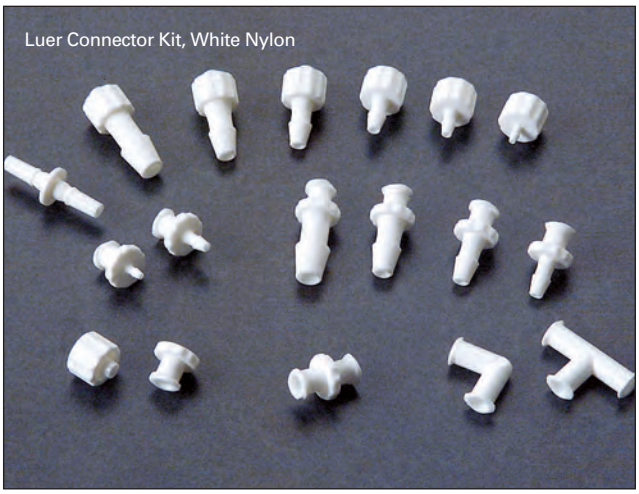
- Small fittings for 1/16-, 3/32- and 1/8-inch ID tubing (10 pieces of each component)
- Medium fittings for 1/4-, 5/16-, 3/8-inch ID tubing (10 pieces of each component)
- Large fittings 1/2- and 5/8-inch ID tubing (5 pieces of each component)

Kit components include tube to tube connectors, tube to tube reducing adapters, Y-, T- and L-connectors, Y-, T- and L-reducing adapters and tubing plugs. Connectors join tubing of similar size while reducing adapters join tubing of different sizes. Nylon and Kynar® connectors can be autoclaved at 121°C.

Ordering Information

Item #	Description
72-1409	Barbed Connector Kit, Small, Nylon
72-1410	Barbed Connector Kit, Small, Polypropylene
72-1411	Barbed Connector Kit, Small, Kynar®
72-1412	Barbed Connector Kit, Medium, Nylon
72-1413	Barbed Connector Kit, Medium, Polypropylene
72-1414	Barbed Connector Kit, Medium, Kynar®
72-1415	Barbed Connector Kit, Large, Nylon
72-1416	Barbed Connector Kit, Large, Polypropylene
72-1417	Barbed Connector Kit, Large, Kynar®

Luer to Tube Connector Kits


Luer Connector Kit, White Nylon

The Luer connection kits contain a selection of Luer fittings to interconnect Luer connectors (e.g. syringes, stopcocks and needles) with one another and with tubing.

Fittings include:

- Luer to barb connectors, Male Luer Lock (MLL) and Female Luer Lock (FLL) to barbed connector sizes 1/16-, 3/32-, 1/8-, 5/32-, 3/16- and 1/4-inch ID
- Luer to Luer connectors: MLT (Male Luer Taper) to MLT, RMLL (Rotating Male Luer Lock) to RMLL, FLL to FLL, FLL to FLL elbow, 3 x FLL 'T' connector, FLL to MLT and both MLL and FLL caps.

Each kit is supplied in a convenient box. All kit components are also sold separately with convenient bin reorder part numbers located inside each kit lid. The Male Luer Taper kit contains various MLT fittings to barbed connectors as well as MLT to MLT fittings. The kit also contains color coded rotating Luer lock rings that securely snap onto the MLT side of each connector.

Ordering Information

Item #	Description
72-1406	Luer Connector Kit, White Nylon, 10 pieces of each type
72-2738	Male Luer Taper Kit, White Nylon, 10 pieces of each type

Note: White nylon fittings can be autoclaved at 121°C.

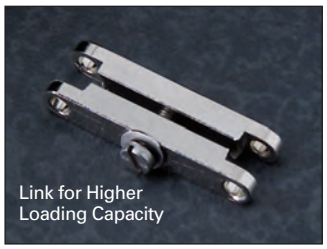
Luer Stopcock Kit

The Luer Stopcock Kit includes a collection of 1-, 3- and 4-way stopcocks. Fittings include MLL (Male Luer lock), FLL (Female Luer Lock), MLT (Male Luer Taper), and barbed tubing connectors. The 4-way stopcocks have three ports but four fluid path configurations. Some stopcocks have high pressure capabilities.

Ordering Information

Item #	Description
72-1664	Luer Stopcock Kit , includes 1-. 3- and 4-way MLL and FLL (non-rotating and rotating) and Male Luer Slips

Mini Ball Joint Holders



Mini ball joint holders are linking elements ideal for use inside small organ chambers where space is extremely limited, such as those used for mouse hearts. They are also useful for mounting small flow probes in open chest experiments in mice or rats, and mounting cannulas on isolated hearts.

All holder elements are made from stainless steel. The special design of the ball joint ensures minimum size and permits perfectly smooth operation without any trace of spring-back. Mini holders remain rigid while carrying weights up to a few grams and are suitable for supporting tubing and small components.

High Load Link (73-0564) provides very stable positioning with a high a mount of tension when used with Mini Ball Joint Holders. They receive 5 mm Mini Balls for length extension and increased positioning possibilities.

Ordering Information

Item #	Description
73-0174	Mini Ball Joint Holder, Eye-Eye, 23 mm long, pkg. of 1
73-0175	Mini Ball Joint Holder, Eye-Eye, 42 mm long, pkg. of 1
73-0176	Mini Ball Joint Holder, Eye-Ball, 18 mm long, pkg. of 1
73-0177	Mini Ball Joint Holder, Eye-Ball, 23 mm long, pkg. of 1
73-3321	Mini Ball Joint Holder, Eye-Ball, 35 mm long, pkg. of 1
73-0563	Mini Ball Joint Holder, Ball-Ball, 18 mm long, pkg. of 1
73-0564	Link for Higher Loading Capacity, for Two Arms with 5 mm Mini Balls, pkg. of 1
73-0562	Bar with Ball for Mounting on a Stand, D = 8 mm, L = 140 mm, Ball Size = 5 mm
73-0566	Plexiglass Block Clamp for mounting 73-0562 Bar onto Stand
53-2012W	Closed Connector, White

Latex Balloons

Mouse/Neonatal Rat
Balloon Assembly Kit

Latex Balloons

Latex Balloons are used for measuring isovolumetric contractile forces in the left ventricle of isolated perfused hearts. They are available in several different sizes to be used with hearts from small rats up to rabbits.

Latex balloons are not suitable for mouse hearts due to the rigidity of the latex material and the high heart rate of mouse hearts. A technique using cling-film allows you to create small balloons which can be used for such small hearts. The Mouse/Neonatal Rat Ventricular Balloon Assembly Kit (73-2787) consists of a stand with two holders and crocodile clamps, hex screwdriver modified for balloon forming, syringe, scissor, cling wrap and PE tubing.

Ordering Information

Item #	Description
Rat/Guinea Pig	
73-3478	Rat/Guinea Pig Balloons, 100 to 200 g, Size 3, pkg. of 10
73-3479	Rat/Guinea Pig Balloons, 300 to 400 g, Size 4, pkg. of 10
73-3480	Rat/Guinea Pig Balloons, 500 g, Size 5, pkg. of 10
73-3481	Rat/Guinea Pig Balloons, 700 g, Size 6, pkg. of 10
Large Guinea Pig/Rabbit	
73-3482	Large Guinea Pig/Rabbit Balloons, 1.0 kg, Size 7, pkg. of 10
73-3483	Large Guinea Pig/Rabbit, 1.2 kg, Size 8, pkg. of 10
73-3484	Large Guinea Pig/Rabbit, 1.5 kg, Size 9, pkg. of 10
Rabbit/Cat	
73-3485	Rabbit/Cat Balloons, 1.7 kg, Size 10, pkg. of 10
73-3486	Rabbit/Cat Balloons, 2.2 kg, Size 12, pkg. of 10
73-3489	Rabbit/Cat Balloons, 3.0 kg, Size 14, pkg. of 10
Mouse/Neonatal Rat	
73-2787	Mouse/Neonatal Rat Balloon Assembly Kit

Magnetic Stirrers

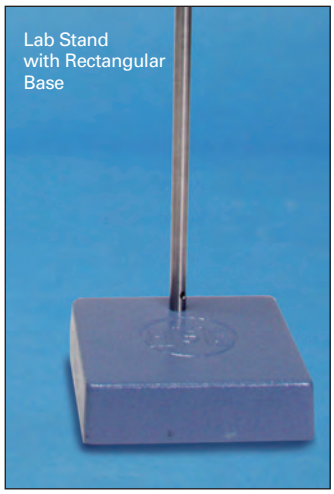
These compact, lightweight magnetic mini-stirrers incorporate electronic controls that allow the user to regulate the speed with greater precision.

Ordering Information

Item #	Description
72-1972	Magnetic stirrer, 120 x 120 x 45 mm, 115 VAC
72-1973	Magnetic stirrer, 120 x 120 x 45 mm, 230 VAC
72-1977	Micro Stir Bar, 10 pcs, for 72-1972, 72-1973 and 72-1972

Laboratory Stands


Lab Stand with Triangular Base


Lab Stand with Rectangular Base

These rugged laboratory stands have a stainless steel upright rod and heavy base plate. The stainless steel rod is threaded and may be removed from the base if desired. The stand with triangular base is supplied with an acrylate block clamp.

Ordering Information

Item #	Description
73-0499	Lab Stand with Rectangular Base Plate
73-0500	Lab Stand with Triangular Base Plate with 300 mm Rod
73-4140	Lab Stand with Triangular Base Plate with 160 mm Rod
73-0566	Plexiglass Block Clamp for mounting 73-0562 Bar onto Stand
53-2012W	Closed Connector, White*

Specifications		
	Stand with Triangular Base	Stand with Rectangular Base
Rod Mounting	Center	End
Base Plate Dimensions	130 x 130 x 130 mm	150 x 150 x 50 mm
Rod Diameter	8 mm	12 mm
Rod Length	300 or 160 mm	510 mm
Weight	1.6 kg	6.75 kg

** Closed Connector also available in Red. For ordering, use "R" in place of "W"*

Surgical Kits


Rat/Guinea Pig Isolated Heart Surgical Kit

These isolated heart surgical kits were assembled to include the most commonly used tools for isolating a mouse, rat or guinea pig heart. Our precise, high quality surgical tools are made from certified surgical grade German steel. View our full line at https://www.harvardapparatus.com/surgical/surgical-instruments-tools.html.

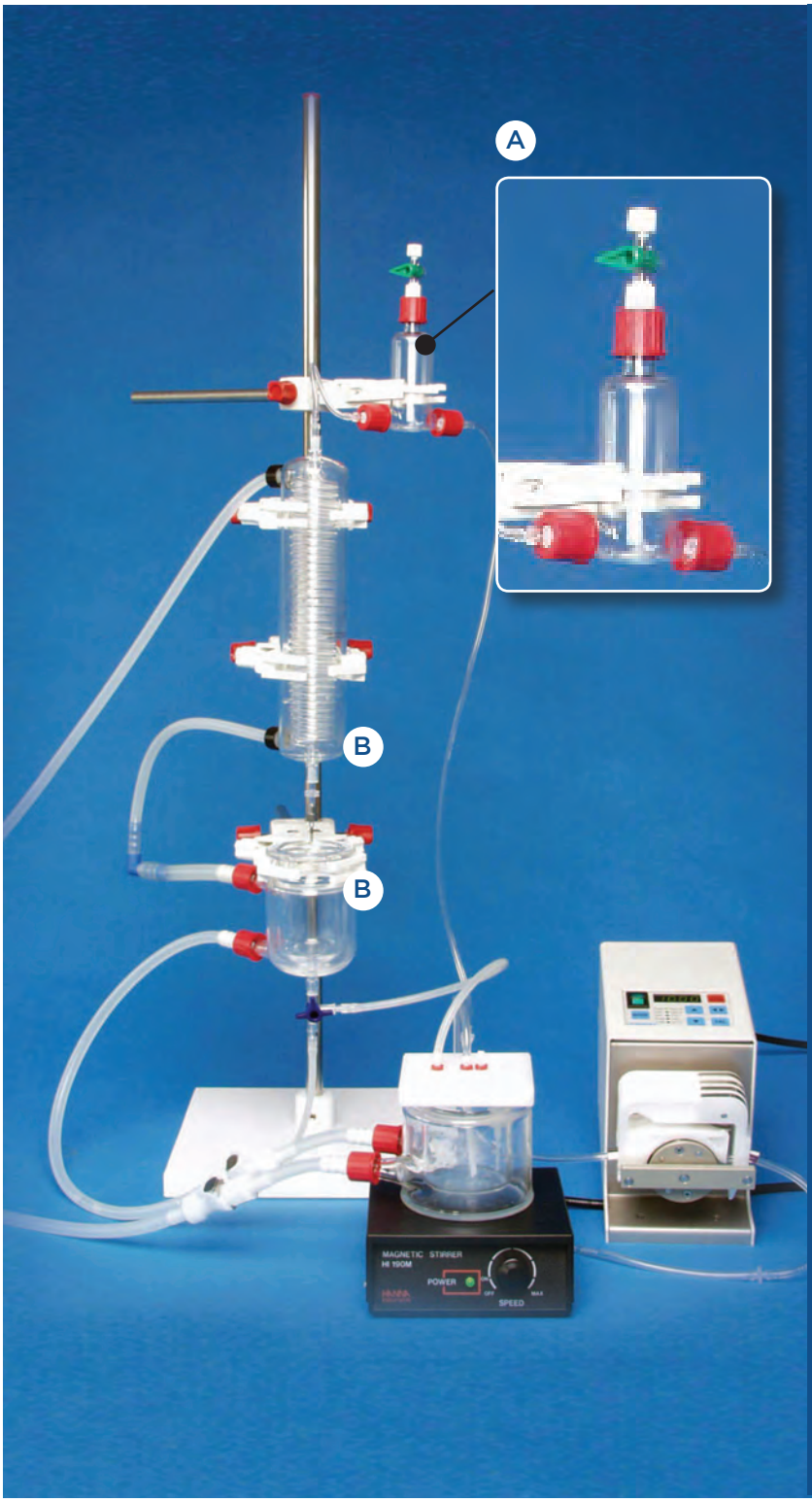
Ordering Information

Item #	Description
72-8998	**Rat/Guinea Pig Isolated Heart Surgical Kit** • Suture without Needle, Silk Black Braid, 4-0, 100 yards • Operating Scissors, 13.0 cm, Sharp/Sharp, Straight • Dressing Forceps, 13.0 cm, Straight, Slender • Castroviejo-Mini Eye Scissors Spring Action, 11.0 cm, Right Angled • Graefe Iris Forceps, Serrated, 10.0 cm, Strongly Curved, Points 0.3 mm, pkg. of 2 • Halsted Mosquito Hemostatic Forceps, 12.5 cm, Straight, pkg. of 2 • Dieffenbach Vessel Clip, 35 mm, Straight
72-8999	**Mouse Isolated Heart Surgical Kit** • Suture without Needle, Silk Black Braid, 5-0, 100 yards • Graefe Iris Forceps, Serrated, 10.0 cm, Straight, Points 0.7 mm • Eye Scissors, 11.5 cm, Straight, Special Cut • Jeweler's Forceps, 11.0 cm, No. 5, Angled, pkg. of 2 • Vessel Clip, 4 mm Jaw Length, 0.75 mm Jaw Width, Locking Pressure 125 g • Applying Forceps for Vessel Clip • Vannas Eye Scissors, Spring Action Model Tübingen, 8.5 cm, Straight

EasyCell Simple Cell Extraction System

DESIGN FEATURES

- Simple constant flow perfusion system designed for cardiomyocyte isolation from small rodent hearts
- Can be adapted for other small rodent organs in situ or ex vivo
- Easy to set up, operate and maintain
- Wetted parts can be disinfected with 70% ethanol or autoclaved for sterilization



A PULSATION DAMPENING

- Air vessel/compliance chamber dampens perfusion pressure pulsation generated by the peristaltic pump
- Serves as a primary bubble trap to prevent air emboli from causing regional ischemia, increasing potential cell yield

B TEMPERATURE CONTROL

- Water-jacketed heat exchanger and heart chamber for maintenance of physiological temperature

EasyCell System for Cardiomyocyte Isolation

The EasyCell system has been specifically developed to isolate primary cells from hearts ranging from mouse to guinea pig. The system is supplied complete with everything you need for basic cardiomyocyte isolation. Perfusion pressure monitoring can easily be added to aid in choosing an appropriate physiological perfusion pump flow setting. The system can also be configured for either in situ or ex vivo organ perfusion with the addition of an operating table or moist chamber and appropriate cannulae.

Applications

- Cardiomyocyte isolation from small rodent hearts
- Can be adapted for other small rodent organs in situ or ex vivo
- Basic research or student lab use

Features & Benefits

- Simple constant flow perfusion system
- Easy to set up, operate and maintain
- Temperature control—water-jacketed heat exchanger and heart chamber for maintenance of physiological temperature
- Pulsation Dampening—air vessel/compliance chamber dampens perfusion pressure pulsation generated by the peristaltic pump. Serves as primary bubble trap to prevent air emboli from causing regional ischemia, thus increasing potential cell yield
- Wetted parts can be disinfected with 70% ethanol or autoclaved for sterilization

Operation

The EasyCell System is simple to setup, operate and maintain. Its compact design has a minimal footprint, conserving valuable bench space.

The heart is first perfused with a warmed, aerated standard perfusion buffer for blanching/clearing the heart of blood and then with a warmed, aerated protease (collagenase) solution for tissue disintegration. Unlike the PSCI system, the clearing buffer and collagenase share the same perfusion line, slightly delaying the delivery of the collagenase after switching over from the clearing buffer. The transition from clearing buffer to collagenase is accomplished by either moving the suction tube or turning a stopcock (not included) to switch between the two reservoirs.

The EasyCell system has a single perfusion pathway that is fully compatible with ethanol for disinfection. The wetted components of the perfusion circuit can be flushed with a 70% ethanol solution for sterilization purposes should the cells need to be incubated for a number of hours following isolation rather than for immediate use.

Included Items

Included items are representative of a typical EasyCell System. Individual components can be customized to your needs.

230 V EasyCell System (73-4431) includes:		115 V EasyCell System (73-4430) includes	
Item #	**Product Name**	**Item #**	**Product Name**
73-3756	Easy Setup for Cell Extraction by Organ Disintegration, consisting of Base Stand with Clamps, Bubble Trap/ Windkessel, Heating Coil, Protease Reservoir	**73-3756**	Easy Setup for Cell Extraction by Organ Disintegration, consisting of Base Stand with Clamps, Bubble Trap/ Windkessel, Heating Coil, Protease Reservoir
73-3761	Heart Chamber (ID 40 mm x 60 mm deep, Length 110 mm, OD 60 mm) with Mounting Clamp	**73-3761**	Heart Chamber (ID 40 mm x 60 mm deep, Length 110 mm, OD 60 mm) with Mounting Clamp
73-4544	TC120 Thermocirculator, with 5 L stainless steel bath and lid, 220 V	**73-4545**	TC120 Thermocirculator, with 5 L stainless steel bath and lid, 120 V
73-3438	Jacketed Glass Reservoir for Buffer Solution with Frit, 1 L	**73-3438**	Jacketed Glass Reservoir for Buffer Solution with Frit, 1 L
73-3456	Tube Set for Jacketed Buffer Reservoir with Fluid Line Shutoff Valve	**73-3456**	Tube Set for Jacketed Buffer Reservoir with Fluid Line Shutoff Valve
73-0100	REGLO Digital 4-Channel Peristaltic Pump, 230 VAC, 50 Hz	**70-7000**	Harvard P70 Peristaltic Pump
73-0155	3-Stop Tygon® E-Lab Tubing, 2.79 mm ID, 12/pack, Purple/ White	**72-0668**	3-Stop Tygon® E-Lab Tubing, 2.29 mm ID, 12/pack, Purple/ Black
73-0126	3-Stop Tygon® E-Lab Tubing, 1.22 mm ID, 12/pack, Red/Grey	**72-0662**	3-Stop Tygon® E-Lab Tubing, 1.14 mm ID, 12/pack, Red/Red
72-1973	Magnetic Stirrer, 230 VAC	**72-1972**	Magnetic Stirrer, 115 VAC
73-2798	Aortic Cannula with Luer Taper for Mouse, OD 1.0 mm	**73-2798**	Aortic Cannula with Luer Taper for Mouse, OD 1.0 mm
73-2868	Aortic Metal Cannula with Luer Taper for Small Rat, OD 2.0 mm	**73-2868**	Aortic Metal Cannula with Luer Taper for Small Rat, OD 2.0 mm
73-2871	Aortic Metal Cannula with Luer Taper for Rat/Guinea Pig, OD 3.0 mm	**73-2871**	Aortic Metal Cannula with Luer Taper for Rat/Guinea Pig, OD 3.0 mm

Addition for perfusion pressure measurement to EasyCell (Purchase Separately): Add PLUGSYS Minicase, Type 609 (73-1523); PLUGSYS TAM-D (73-1793); APT300 Pressure Transducer (73-3862), holder for pressure transducer (73-3869), and closed connector, white (53-2012W)

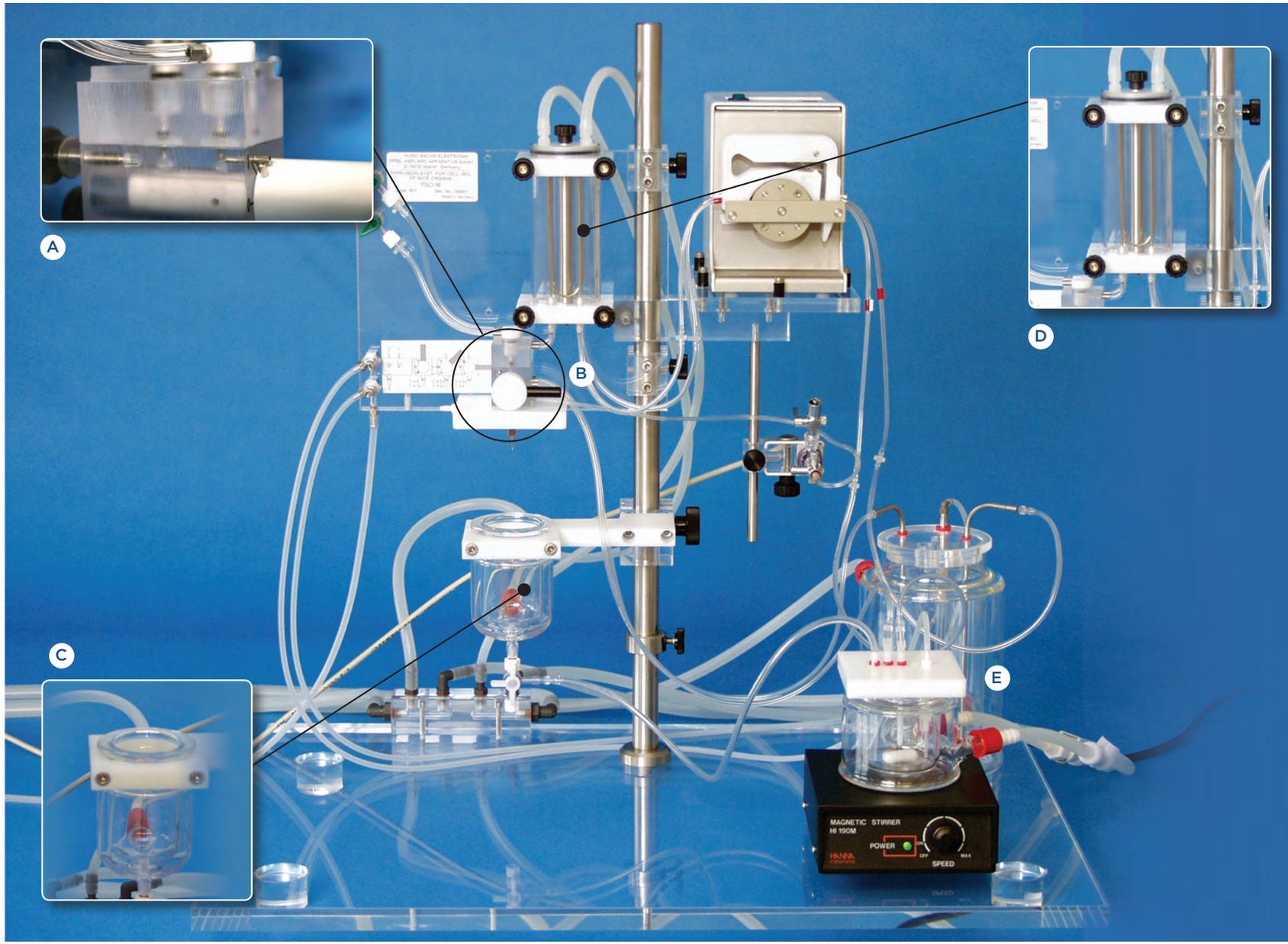
Ordering Information

Item #	Description
74-4431	EasyCell Basic Constant Flow Cardiomyocyte Isolation System for Small Rodents (230 V)
74-4230	EasyCell Basic Constant Flow Cardiomyocyte Isolation System for Small Rodents (115 V)

PSCI
Perfusion System for Cell Isolation

DESIGN FEATURES

- Dual perfusion system for blood cell flushing and enzymatic digestion
- Compatible with disinfection using ethanol
- Low priming volume conserves collagenase and minimizes temperature loss through tubing (<3 ml for mouse system, <5 ml for rat system)
- Integrated platform for peristaltic pump minimizes system footprint and conserves bench space
- Multi-purpose system can be fitted for use with other organs (e.g. in situ or ex vivo hepatocyte isolation from rat or mouse liver)water-column bouncing and resulting valve damage
- Laminar flow lines to improve accuracy of flow measurementswater-column bouncing and resulting valve damage
- Laminar flow lines to improve accuracy of flow measurements



A PERFUSION HUB

- Solid state perfusion circuit ensures thermal stability, laminar flow and minimal system volume
- Bubble traps for each perfusate stream to prevent air emboli from causing regional ischemia, maximizing cell yield

B PRECISION-MILLED CHANGEOVER STOPCOCK

- Integrated stopcock with independent, non-overlapping fluid paths for minimal mixing of clearing buffer and enzymatic buffers
- Three stopcock positions for recirculation of both perfusates, clearing buffer delivery with recirculation of collagenase, and collagenase delivery with recirculation of clearing buffer
- Allows study of pulmonary artery hypertension

C ENCLOSED HEART CHAMBER

- Heart chamber lid integrated into base of perfusion hub for superior temperature control and to isolate heart from contamination
- Low-flow gas inlet ensures positive pressure within the heart chamber, protecting against bacterial contamination

D DUAL HEAT EXCHANGER

- Thin-walled stainless steel heat exchanger provides quick heating with minimal volume
- Exchangeable heat exchanger allowsallows switchover between mouse and rat heat exchangers to optimize priming volumes for the two species

E COLLAGENASE RESERVOIR

- Custom-designed small volume (100 ml) reservoir with positive pressure gas supply to maintain sterility of collagenase
- Fully autoclavable components
- Dedicated return lines for
  - Recirculating unused perfusate from hub
  - Recirculating used perfusate
  - Capturing released cardiomyocytes

PSCI PERFUSION SYSTEM FOR CELL ISOLATION

CARDIOMYOCYTE ISOLATION SYSTEMS

PSCI
Perfusion System for Cell Isolation


PSCI Perfusion System for Cardiomyocyte Isolation

The Perfusion System for Cell Isolation (PSCI) is designed for harvesting individual cells from isolated organs such as mouse, rat or guinea pig heart, liver and other organs.

This system is specially adapted for harvesting individual cardiomyocytes from mouse, rat or guinea pig hearts. The base units are equipped with a heart chamber. The isolated heart hangs on the aorta and is perfused retrograde in order to perfuse the coronaries.

Applications

- Cardiomyocyte isolation (enzymatic digestion)

Features & Benefits

- Dual perfusion system for blood cell flushing and enzymatic digestion
- Compatible with disinfection using ethanol
- Low pressure gas flow in heart chamber and reservoir prevent bacterial contamination
- Low priming volume conserves collagenase and minimizes temperature loss through tubing (<3 ml for mouse system, <5 mL for rat system)
- Integrated platform for peristaltic pump minimizes system footprint and reduces system volume
- Multi-purpose system can be fitted for use with other organs (e.g. in situ or ex vivo hepatocyte isolation from rat or mouse liver)

Operation

The PSCI works such that individual cells are released from the tissue stucture through perfusion with enzyme solution and are then flushed out.

For cardiomyocyte isolation, a jacketed heart chamber is mounted on a slide which is clamped to the vertical column. A slow gas flow into this chamber ensures a positive pressure inside the heart chamber at all times, thus preventing ingress of bacteria from the surroundings during operation.

The cardiomyocytes are collected in the collagenase reservoir to which the dissected left ventricle can be added for further dissociation, allowing an increased total cell yield.

The apparatus is so designed that the individual steps required for preparing the cells can proceed as simply and clearly as possible. With two separate perfusion circuits, the organ can be switched between clearing buffer for removal of blood cells and collagenase buffer for organ digestion by means of a custom, precision-milled changeover stopcock.

Using the standard configuration, perfusion takes place under constant-flow conditions which you set on the peristaltic pump. The limits of the apparatus are a flow rate of about 50 or 100 ml/min depending on the configuration (mouse vs. rat/guinea pig).

Common additions to the PSCI include perfusion pressure measurement and constant pressure perfusion. These options allow for optimized perfusion of the heart, further maximizing cell yield and viability by ensuring non-damaging physiological perfusion conditions.

The components wetted by the perfusion solutions are made from alcohol-resistant materials so that the apparatus can be filled with ethanol for sterilization/disinfection should your experiment require prolonged incubation time where bacterial contamination would be problematic.

Included Items

Included items are representative of a typical PSCI Core System. Individual components can be customized to your needs.

PSCI Core System for Mouse Cardiomyocyte Isolation, 230 V (73-4425) includes:		PSCI Core System for Mouse Cardiomyocyte Isolation, 115 V (73-4424) includes:	
Item #	**Product Name**	**Item #**	**Product Name**
73-3638	Base Unit for Cell Isolation from Mouse Heart	**73-3638**	Base Unit for Cell Isolation from Mouse Heart
73-4544	TC120 Thermocirculator, with 5 L stainless steel bath and lid, 220 V	**73-4545**	TC120 Thermocirculator, with 5 L stainless steel bath and lid, 120 V
73-3436	Jacketed Glass Reservoir for Buffer Solution, with Frit, 0.5 L	**73-3436**	Jacketed Glass Reservoir for Buffer Solution, with Frit, 0.5 L
73-3456	Tube Set for Jacketed Buffer Reservoir with Fluid Line Shutoff Valve	**73-3456**	Tube Set for Jacketed Buffer Reservoir with Fluid Line Shutoff Valve
73-2448	REGLO Analog 2-Channel Peristaltic Pump, 230 VAC, 50 Hz	**73-2952**	REGLO Analog 2-Channel Peristaltic Pump, 115 VAC, 50 Hz
73-0126	3-Stop Tygon® E-Lab Tubing, 0.95 mm ID, 12/pack, White/Black	**73-0126**	3-Stop Tygon® E-Lab Tubing, 0.95 mm ID, 12/pack, White/Black
72-1973	Magnetic Stirrer, 230 VAC	**72-1972**	Magnetic Stirrer, 115 VAC

PSCI Core System for Rat/Guinea Pig Cardiomyocyte Isolation, 230 V (73-4427) includes:		PSCI Core System for Rat/Guinea Pig Cardiomyocyte Isolation, 115 V (73-4426) includes:	
Item #	**Product Name**	**Item #**	**Product Name**
73-3672	Base Unit for Cell Isolation from Rat or Guinea Pig Heart	**73-3672**	Base Unit for Cell Isolation from Rat or Guinea Pig Heart
73-4544	TC120 Thermocirculator, with 5 L stainless steel bath and lid, 220 V	**73-4545**	TC120 Thermocirculator, with 5 L stainless steel bath and lid, 120 V
73-3438	Jacketed Glass Reservoir for Buffer Solution, with Frit, 0.5 L	**73-3438**	Jacketed Glass Reservoir for Buffer Solution, with Frit, 0.5 L
73-3456	Tube Set for Jacketed Buffer Reservoir with Fluid Line Shutoff Valve	**73-3456**	Tube Set for Jacketed Buffer Reservoir with Fluid Line Shutoff Valve
73-2448	REGLO Analog 2-Channel Peristaltic Pump, 230 VAC, 50 Hz	**73-2952**	REGLO Analog 2-Channel Peristaltic Pump, 115 VAC, 50 Hz
72-1973	Magnetic stirrer, 230 VAC	**72-1972**	Magnetic stirrer, 115 VAC
73-1839	3-Stop Tygon® E-Lab Tubing, 3.17 mm ID, 12/pack, Black/White	**73-1839**	3-Stop Tygon® E-Lab Tubing, 3.17 mm ID, 12/pack, Black/White
73-2870	Aortic Cannula with Luer Taper for Rat to UP100-IH, PSCI or EasyCell, OD 2.5 mm	**73-2870**	Aortic Cannula with Luer Taper for Rat to UP100-IH, PSCI or EasyCell, OD 2.5 mm
73-2871	Aortic Cannula with Luer Taper for Rat/Guinea Pig to UP100-IH, PSCI or EasyCell, OD 3.0 mm	**73-2871**	Aortic Cannula with Luer Taper for Rat/Guinea Pig to UP100-IH, PSCI or EasyCell, OD 3.0 mm

The Basic Units include:

Plexiglass stand, double heat exchanger, switching valve, heart chamber, aortic metal cannula with Luer taper OD 1.0 mm for mouse (73-2798) or 2.0 mm for rat (73-2868), protease reservoir and holder for pressure transducer.

Addition for perfusion pressure measurement to PSCI (Purchase Separately):

Add PLUGSYS Minicase, Type 609 (73-1523); PLUGSYS TAM-D (73-1793); APT300 Pressure Transducer (73-3862

Addition for constant pressure perfusion to PSCI (Purchase Separately):

In addition to above, add SCP Servo Controller for Perfusion (73-2806)

Ordering Information

Item #	Description
74-4425	PSCI Core System for Mouse Cardiomyocyte Isolation, 230 V
74-4224	PSCI Core System for Mouse Cardiomyocyte Isolation, 115 V
73-4427	PSCI Core System for Rat/Guinea Pig Cardiomyocyte Isolation, 230 V
73-4426	PSCI Core System for Rat/Guinea Pig Cardiomyocyte Isolation, 115 V
73-3638	PSCI Base Unit Only for Cell Isolation from Mouse Heart
73-3672	PSCI Base Unit Only for Cell Isolation from Rat or Guinea Pig Heart

REFERENCES

Isolated Heart Published Papers using HSE systems

UP-100IH

Gabrielová E, Bartošíková L Nečas J, and Modrianský M. (2019). Cardioprotective effect of 2,3-dehydrosilybin preconditioning in isolated rat heart. *Fitoterapia*. 132:12-21.

Gabrielova E, Zholobenko A, Bartosikova L, Necas J and Modriansky M. (2015). Silymarin Constituent 2,3-Dehydrosilybin Triggers Reserpine-Sensitive Positive Inotropic Effect in Perfused Rat Heart. *PLoS One*. 10(9):E0139208.

Liehn EA, et al. (2011). Double-Edged Role of the CXCL12/CXCR4 Axis in Experimental Myocardial Infarction. *J Am Coll of Cardiol*. 58(23):2415–2423.

Bartosikova L, Necas J, Bartosik T, Frana P, Pavlik M. (2008). Changes in biomechanical parameters during heart perfusion and after midazolam premedication--experimental pilot study. *Biomed Pap Med Fac Univ Palacky Olomouc Czech Repub*. 152(1):79-82.

Carreira RS, Monteiro P, Kowaltowski AJ, Gonçalves LM, Providência LA. (2008). Nicorandil protects cardiac mitochondria against permeability transition induced by ischemia-reperfusion. *J Bioenerg Biomembr*. 40(2):95-102.

Matafome P, et al. (2008). Therapeutic association of atorvastatin and insulin in cardiac ischemia: study in a model of type 2 diabetes with hyperlipidemia. *Pharmacol Res*. 58(3-4):208-14.

Monteiro P, Duarte AI, Moreno A, Gonçalves LM, Providência LA. (2003). Carvedilol improves energy production during acute global myocardial ischaemia. *Eur J Pharmacol*. 482(1-3):245-53.

IH-SR Langendorff

Boening A, Assling-Simon L, Heep M, Boengler K, Niemann B, Grieshaber P. (2018). Buckberg's blood cardioplegia for protection of adult and senile myocardium in a rat in vitro model of acute myocardial infarction. *Exp Gerontol*. 104:98-104.

Kaese S, et al. (2017). Electrophysiological alterations in a murine model of chronic coxsackievirus B3 myocarditis. *PLoS One*. Jun 23;12(6):e0180029.

Paelestik KB, et al. (2017). Effects of hypoglycemia on myocardial susceptibility to ischemia-reperfusion injury and preconditioning in hearts from rats with and without type 2 diabetes. *Cardiovas Diabetol*. 16(1):1-10.

Li, D., Wu, J., Bai, Y., Zhao, X., Liu, L. (2014). Isolation and Culture of Adult Mouse Cardiomyocytes for Cell Signaling and in vitro Cardiac Hypertrophy. *J. Vis. Exp*. (87), e51357, doi:10.3791/51357.

Schrammel A, et al. (2014). Endothelial dysfunction in adipose triglyceride lipase deficiency. *Biochim Biphy Acta*. Jun;1841(6),906-917.

Soltysinska E, et al. (2014). KCNMA1 Encoded Cardiac BK Channels Afford Protection against Ischemia-Reperfusion Injury. *PLoS One*. 9(7):e103402.

Oral H, et al. (2013). CXC chemokine KC fails to induce neutrophil infiltration and neoangiogenesis in a mouse model of myocardial infarction. *J Mol Cell Cardiol*. Jul;60:1-7.

Caillier B, et al. (2012). Metabolic syndrome potentiates the cardiac action potential-prolonging action of drugs: A possible 'anti-proarrhythmic' role for amlodipine. *Pharmacol Res*. Mar;65(3):320-327.

Kaddar N, Vigneault P, Pilote S, Patoine D, Simard C, Drolet B. (2012). Tizanidine (Zanaflex): A Muscle Relaxant That May Prolong the QT Interval by Blocking IKr. *J Cardiovasc Pharmacol Ther*. Mar;17(1):102-109.

Andersen AD, et al. (2011). The cardioprotective effect of brief acidic reperfusion after ischemia in perfused rat hearts is not mimicked by inhibition of the Na(+)/H(+) exchanger NHE1. *Cell Physiol Biochem*. 28(1):13-24.

Clements RT, Feng J, Cordeiro B, Bianchi C, Sellke FW. (2011). p38 MAPK-dependent small HSP27 and aB-crystallin phosphorylation in regulation of myocardial function following cardioplegic arrest. *Am J Physiol Heart Circ Physiol*. 300(5), H1669-77.

Clements RT, Cordeiro B, Feng J, Bianchi C, Sellke FW. (2011). Rottlerin increases cardiac contractile performance and coronary perfusion through BKCa++ channel activation after cold cardioplegic arrest in isolated hearts. *Circulation*. 124(11 Suppl):S55-61.

da Rosa Araujo AS, et al. (2010). Increased resistance to hydrogen peroxide-induced cardiac contracture is associated with decreased myocardial oxidative stress in hypothyroid rats. *Cell Biochem Funct*. 28(1):38-44.

Løfgren B, et al. (2010). Amino acid transamination is crucial for ischaemic cardioprotection in normal and preconditioned isolated rat hearts—focus on L-glutamate. *Exp Physiol*. 95(1):140-52.

Reil JC, et al. (2010). Cardiac Rac1 overexpression in mice creates a substrate for atrial arrhythmias characterized by structural remodeling. *Cardiovasc Res*. 87(3):485-93.

Khabbaz KR, Feng J, Boodhwani M, Clements RT, Bianchi C, Sellke FW. (2008). Nonischemic myocardial acidosis adversely affects microvascular and myocardial function and triggers apoptosis during cardioplegia. *J Thorac Cardiovasc Surg*. 135(1):139-46.

Oh KS, Han W, Wang MH, Lee BH. (2007). The effects of chronic treatment with Morus bombycis KOIDZUMI in spontaneously hypertensive rats. *Biol Pharm Bull*. 30(7):1278-83.

Trask AJ, Averill DB, Ganten D, Chappell MC, Ferrario CM. (2007). Primary role of angiotensin-converting enzyme-2 in cardiac production of angiotensin-(1-7) in transgenic Ren-2 hypertensive rats. *Am J Physiol Heart Circ Physiol*. 292(6):H3019-24.

Iwata K, Matsuno K, Nishinaka T, Persson C, Yabe-Nishimura C. (2006). Aldose reductase inhibitors improve myocardial reperfusion injury in mice by a dual mechanism. *J Pharmacol Sci*. 102(1):37-46.

Béguin PC, Joyeux-Faure M, Godin-Ribuot D, Lévy P, Ribuot C. (2005). Acute intermittent hypoxia improves rat myocardium tolerance to ischemia. *J Appl Physiol*. 99(3):1064-9.

Joyeux-Faure M, et al. (2005). Chronic intermittent hypoxia increases infarction in the isolated rat heart. *J Appl Physiol*. 98(5):1691-6.

Merx MW, et al. (2005). Myocardial stiffness, cardiac remodeling, and diastolic dysfunction in calcification-prone fetuin-A-deficient mice. *J Am Soc Nephrol*. 16(11):3357-64.

Tokarska-Schlattner M, Zaugg M, da Silva R, Lucchinetti E, Schaub MC, Wallimann T, Schlattner U. (2005). Acute toxicity of doxorubicin on isolated perfused heart: response of kinases regulating energy supply. *Am J Physiol Heart Circ Physiol*. 289(1):H37-47.

Georget M, et al. (2003). Cyclic AMP compartmentation due to increased cAMP-phosphodiesterase activity in transgenic mice with a cardiac-directed expression of the human adenylyl cyclase type 8 (AC8). *FASEB J*. 17(11):1380-91.

Fioretto JR, Querioz SS, Padovani CR, Matsubara LS, Okoshi K, Matsubara BB. (2002). Ventricular remodeling and diastolic myocardial dysfunction in rats submitted to protein-calorie malnutrition. *Am J Physiol Heart Circ Physiol*. 282(4):H1327-33.

Joyeux M, Arnaud C, Godin-Ribuot D, Demenge P, Lamontagne D, Ribuot C.

REFERENCES

(2002). Endocannabinoids are implicated in the infarct size-reducing effect conferred by heat stress preconditioning in isolated rat hearts. *Cardiovasc Res.* 55(3):619-25.

Merx MW, Flögel U, Stumpe T, Gödecke A, Decking UK, Schrader J. (2001). Myoglobin facilitates oxygen diffusion. *FASEB J.* 15(6):1077-9.

Pinto YM, et al. (2000). Increased kallikrein expression protects against cardiac ischemia. *FASEB J.*14(13):1861-3.

Wascher TC, Wölkart G, Russell JC, Brunner F. (2000). Delayed insulin transport across endothelium in insulin-resistant JCR:LA-cp rats. *Diabetes.* 49(5):803-9.

Potenza M, et. al. Insulin resistance in spontaneously hypertensive rats is associated with endothelial dysfunction characterized by imbalance between NO and ET-1 production. *Am. J. Physiol.* 2005 Mar; 289:H813–H822.

Hauet T, Mothes D, Goujon J, Carretier M, Eugene M. Protective effect of polythylene glycol against prolonged cold ischemia and reperfusion injury: Study in the isolated perfused rat kidney. *J. Pharmacol. Exp. Ther.* 2001 Jun; 3:297:946–952.

IH-SR Working Heart

Bozeat ND, et al. (2011). Activation of volume regulated chloride channels protects myocardium from ischemia/reperfusion damage in second-window ischemic preconditioning. *Cell Physiol Biochem.* 28(6):1265-78.

Lenski M, Kazakov A, Marx N, Böhm M, Laufs U. (2011). Effects of DPP-4 inhibition on cardiac metabolism and function in mice. *J Mol Cell Cardiol.* 51(6):906-18.

Liu J, et al. (2011). PPARß/d activation in adult hearts facilitates mitochondrial function and protects cardiac performance under pressure-overload condition. Hypertension, 57(2):223-30. *NIHMSID #* 265863.

Luo J, et al. (2010). Conditional PPARčknockout from cardiomyocytes of adult mice disturbs myocardial fatty acid utilization. *Amer J of Transl Res.* 3(1):61-72.

Reil JC, et al. (2010). Cardiac Rac1 overexpression in mice creates a substrate for atrial arrhythmias characterized by structural remodeling. *Cardiovasc Res.* 87(3):485-93.

Panek AN, et al. (2009). Connective tissue growth factor overexpression in cardiomyocytes promotes cardiac hypertrophy and protection against pressure overload. *PLoS One,* 4(8):e6743.

Merx MW, et al. (2005). Statin treatment after onset of sepsis in a murine model improves survival. *Circulation.* 112(1):117-24.

Chen H, et al. (2004). Targeted inactivation of cystic fibrosis transmembrane conductance regulator chloride channel gene prevents ischemic preconditioning in isolated mouse heart. *Circulation.* 110(6):700-4.

Cheng L, et al. (2004). Cardiomyocyte-restricted peroxisome proliferator-activated receptor-delta deletion perturbs myocardial fatty acid oxidation and leads to cardiomyopathy. *Nat Med.* 10(11):1245-50.

Itter G, Jung W, Juretschke P, Schoelkens BA, Linz W, (2004). A model of chronic heart failure in spontaneous hypertensive rats (SHR). *Lab Anim.* 38(2):138-48.

Müller OJ, et al. (2003). Transgenic rat hearts overexpressing SERCA2a show improved contractility under baseline conditions and pressure overload. *Cardiovasc Res.* 59(2):380-9.

Karck M, et al. (2001). Myocardial protection by ischemic preconditioning and delta-opioid receptor activation in the isolated working rat heart. *J Thorac Cardiovasc Surg.* 122(5):986-92.

Ruetten H, Badorff C, Ihling C, Zeiher AM, Dimmeler S. (2001). Inhibition of caspase-3 improves contractile recovery of stunned myocardium, independent of apoptosis-inhibitory effects. *J Am Coll Cardiol.* 38(7):2063-70.

Frey N, et al. (2000). Transgenic rat hearts expressing a human cardiac troponin T deletion reveal diastolic dysfunction and ventricular arrhythmias. *Cardiovasc Res.* 47(2):254-64.

IH-5 Langendorff

Christoph J, Schröder-Schetelig J and Luther S. (2017). Electromechanical optical mapping. *Prog Biophys Mol Biol.* 130(Pt B):150-169.

Andersen A, Povlsen JA, Johnsen J, Jespersen NR, Bøtker HE, Nielsen-Kudsk JE. (2016). SGC–cGMP–PKG pathway stimulation protects the healthy but not the failing right ventricle of rats against ischemia and reperfusion injury. *Int J Cardiol.* Nov 15;223:674-680.

Lang CN, et al. (2016). Electro-mechanical dysfunction in long QT syndrome: Role for arrhythmogenic risk prediction and modulation by sex and sex hormones. *Prog Biophys Mol Biol.* 120(1-3):255-269.

Ziupa D, et al. (2014). Pronounced Effects of HERG-Blockers E-4031 and Erythromycin on APD, Spatial APD Dispersion and Triangulation in Transgenic Long-QT Type 1 Rabbits. *PLoS One.* Sept 22;9(9): e107210.

Odening KE, et al. (2013). Spatial correlation of action potential duration and diastolic dysfunction in transgenic and drug-induced LQT2 rabbits. *Heart Rhythm.* 10(10):1533-1541.

Osadchii OE. (2013). Quinidine elicits proarrhythmic changes in ventricular repolarization and refractoriness in guinea-pig. *Can J Physiol Pharmcol.* 91(4):306-315.

Qu Y, et al. (2013). Itraconazole decreases left ventricular contractility in isolated rabbit heart: Mechanism of action. *Toxicol Appl Pharmacol*, 268(2):113-122.

Zausig, YA, et al. (2013). The impact of crystalloidal and colloidal infusion preparations on coronary vascular integrity, interstitial oedema and cardiac performance in isolated hearts. *Crit Care.* 17(5): R203. doi: 10.1186/cc12898.

Osadchili, O. (2012). Effects of ventricular pacing protocol on electrical restitution assessments in guineaČpig heart. *Exp Physio.* 97(7): 807-821. doi: 10.1113/expphysiol.2012.065219. Epub 2012 Mar 23.

Bentzen BH, et al. (2011). Pharmacological activation of Kv11.1 in transgenic long QT-1 rabbits. *J Cardiovasc Pharmacol.* 57(2):223-30.

Biermann J, et al. (2011). Nicorandil normalizes prolonged repolarisation in the first transgenic rabbit model with Long-QT syndrome 1 both in vitro and in vivo. *Eur J Pharmacol.* 650(1):309-16.

Laursen M, Grunnet M, Olesen SP, Jespersen T, Mow T. (2011). Keeping the rhythm—pro-arrhythmic investigations in isolated Göttingen minipig hearts. *J Pharmacol Toxicol Methods.* 64(2):134-44.

Laursen M, Olesen SP, Grunnet M, Mow T, Jespersen T. (2011). Characterization of cardiac repolarization in the Göttingen minipig. *J Pharmacol Toxicol Methods.* 63(2):186-95.

Guo L, Dong Z, Guthrie H. (2009). Validation of Guinea pig Langendorff heart model for assessing potential cardiovascular liability of drug candidates. *J Pharmacol Toxicol Methods.* 60(2):130-51.

Milberg P, et al. (2008). Inhibition of the Na+/Ca2+ exchanger suppresses torsades de pointes in an intact heart model of long QT syndrome-2 and long QT syndrome-3. *Heart Rhythm.* 5(10):1444-52.

Hansen RS, Olesen SP, Grunnet M. (2007). Pharmacological activation of rapid delayed rectifier potassium current suppresses bradycardia-induced triggered activity in the isolated guinea pig heart. *J Pharmacol Exp Ther.* 321(3):996-1002.

REFERENCES

Favory R, Lancel S, Tissier S, Mathieu D, Decoster B, Nevière R. (2006). Myocardial dysfunction and potential cardiac hypoxia in rats induced by carbon monoxide inhalation. *Am J Respir Crit Care Med.* 174(3):320-5.

Milberg P, et al. (2005). Verapamil prevents torsade de pointes by reduction of transmural dispersion of repolarization and suppression of early afterdepolarizations in an intact heart model of LQT3. *Basic Res Cardiol.* 100(4):365-71.

Milberg P, et al. (2005). Transmural dispersion of repolarization as a key factor of arrhythmogenicity in a novel intact heart model of LQT3. *Cardiovasc Res.* 65(2):397-404.

Kim HD, (2003). Infarct size-limiting effect of calcium preconditioning in rabbit hearts. *J Korean Med Sci.* 18(3):337-43.

Eckardt L, Breithardt G, Haverkamp W. (2002). Electrophysiologic characterization of the antipsychotic drug sertindole in a rabbit heart model of torsade de pointes: low torsadogenic potential despite QT prolongation. *J Pharmacol Exp Ther.* 300(1):64-71.

Kjølbye AL, Holstein-Rathlou NH, Petersen JS. (2002). Anti-arrhythmic peptide N-3-(4-hydroxyphenyl)propionyl Pro-Hyp-Gly-Ala-Gly-OH reduces dispersion of action potential duration during ischemia/reperfusion in rabbit hearts. *J Cardiovasc Pharmacol.* 40(5):770-9.

Milberg P, et al. (2002). Divergent proarrhythmic potential of macrolide antibiotics despite similar QT prolongation: fast phase 3 repolarization prevents early afterdepolarizations and torsade de pointes. *J Pharmacol Exp Ther.* 303(1):218-25.

Ebel D, Schlack W, Comfère T, Preckel B, Thämer V. (1999). Effect of propofol on reperfusion injury after regional ischaemia in the isolated rat heart. *Br J Anaesth.* 83(6):903-8.

Kim H, et al. (1998). Evidence of protein kinase C translocation by ischemic preconditioning in global ischemia model. *J Korean Med Sci.* 13(5):473-82.

IH-5 Working Heart

Wiedemann D, et al. (2010). The fibrin-derived peptide Bbeta (15-42) significantly attenuates ischemia-reperfusion injury in a cardiac transplant model. *Transplantation.* 89(7):824-9.

Trescher K, et al. (2009). Improved myocardial protection in the failing heart by selective endothelin-A receptor blockade. *J Thorac Cardiovasc Surg.* 137(4):1005-11, 1011e1.

Vogt S, Troitzsch D, Abdul-Khaliq H, Moosdorf R. (2007). Heat stress attenuates ATP-depletion and pH-decrease during cardioplegic arrest. *J Surg Res.* 139(2):176-81.

Semsroth S, et al. (2005). S-nitroso human serum albumin attenuates ischemia/reperfusion injury after cardioplegic arrest in isolated rabbit hearts. *J Heart Lung Transplant.* 24(12):2226-34. Epub 2005 Nov 17.

Kröner A. (2002). Diltiazem during reperfusion preserves high energy phosphates by protection of mitochondrial integrity. *Eur J Cardiothorac Surg.* 21(2):224-31.

Podesser BK, et al. (2002). Optimizing ischemia/reperfusion in the failing rat heart--improved myocardial protection with acute ACE inhibition. *Circulation.* 106(12 Suppl 1):I277-83.

Vogt S, Troitzsch D, Abdul-Khaliq H, Böttcher W, Lange PE, Moosdorf R. (2000). Improved myocardial preservation with short hyperthermia prior to cold cardioplegic ischemia in immature rabbit hearts. *Eur J Cardiothorac Surg.* 18(2):233-40.

Rosada B, Wagner SM, Kuschkowitz F, Buddensiek M, Laczkovics AM, Stegmann TJ. (1999). Monitoring the Function of the Heart Using the Monophasic Action Potential – Investigation in the Langendorff Perfused Rabbit Heart. *Progress in Biomed Res.* 202-206.

Biventricular Working Heart

Asfour H, Wengrowski AM, Jaimes R, Swift LM, Kay MW. (2012). NADH Fluorescence Imaging of Isolated Biventricular Working Rabbit Hearts. *J Vis Exp.* (65). pii: 4115. doi: 10.3791/4115.

Garrott KE. (2017). Adapting Novel Techniques to Elevate Physiological Relevance to Study Heart Failure and Oxygenation in the Isolated Heart. The George Washington University ProQuest Dissertations Publishing. 10264753.

Other

Boknik P, et al, (2018). Phenotyping of Mice with Heart Specific Overexpression of A 2A -Adenosine Receptors: Evidence for Cardioprotective Effects of A 2A -Adenosine Receptors. *Front Pharmacol.* 9:13.

Lourenço MAM, et al. (2018). Lipid damage is the best marker of oxidative injury during the cardiac remodeling process induced by tobacco smoke. *BMC Pharmacol Toxicol.* 19:74.

Boengler K, et al. (2017). Lack of Contribution of p66shc and Its Mitochondrial Translocation to Ischemia-Reperfusion Injury and Cardioprotection by Ischemic Preconditioning. *Front Physiol.* Oct 5;8:733.

Frommeyer G, et al. (2017). Experimental evidence for a severe proarrhythmic potential of levosimendan. *Int J Cardiol.* 228:583-587.

Gomes HL, et al. (2016). Cardiovascular effects of Sp-CTx, a cytolysin from the scorpionfish (Scorpaena plumieri) venom. *Toxicon.* 118(C):141-148.

Skarsfeldt M, et al. (2016). Pharmacological inhibition of I K 1 by PA 6 in isolated rat hearts affects ventricular repolarization and refractoriness. *Physiol Rep.* 4(8). pii: e12734.

Axelsen LN, et al. (2015). Diet-induced pre-diabetes slows cardiac conductance and promotes arrhythmogenesis. *Cardiovasc Diabetol.* 14(1):87.

Wolff G, Truse R, Decking U and Mohanraj R. (2015). Extracellular Adenosine Formation by Ecto-5′-Nucleotidase (CD73) Is No Essential Trigger for Early Phase Ischemic Preconditioning. *PLoS One.* 10(8):e0135086.

Milberg P, et al. (2013). Sodium channel block by ranolazine in an experimental model of stretch-related atrial fibrillation: Prolongation of interatrial conduction time and increase in post-repolarization refractoriness. Europace. 15(5):761-769.

Cardiac Microdialysis

Løfgren B, et al. (2010) Amino acid transamination is crucial for ischaemic cardioprotection in normal and preconditioned isolated rat hearts – focus on L-glutamate. *Exp Physiol* 95(2):140-152.

Kitagawa H, Yamazaki T, Akiyama T, Sugimachi M, Sunagawa K, Mori H. (2005). Microdialysis separately monitors myocardial interstitial myoglobin during ischemia and reperfusion. *Am J Physiol Heart Circ Physio.* 289(2):H924–H930.

Van Wylen DG, Schmit TJ, Lasley RD, Gingell RL, Mentzer RM Jr. (1992). Cardiac microdialysis in isolated rat hearts: interstitial purine metabolites during ischemia. *Am J Phyiol.* Jun:262(6 Pt 2):H1945-1938.

Configure Your Ideal Isolated Heart Perfusion System

To ensure that your system is properly configured as a functional unit that meets your application needs, please complete our Checklist and then contact Technical Services at 800-547-6766 or or via email at support@hbiosci.com before placing an order. In Europe, please call +49 7665 92000 or email at sales@hugo-sachs.de.

Which species are you going to study? (Check all that apply.)

- ❑ Mouse
- ❑ Rabbit
- ❑ Rat
- ❑ Mini Pig
- ❑ Guinea Pig
- ❑ Small Pig

If others please specify:

_____

What perfusion mode will you require? (Check all that apply.)

- ❑ Cardiomyocyte isolation only
- ❑ Retrograde perfusion according to Langendorff
- ❑ Later upgrade to a working ejecting heart system
- ❑ Ejecting, working heart according to Neely (left heart only)
- ❑ Ejecting, bi-ventricular working heart (right heart and left heart perfusion) only on rat and rabbit hearts

Which perfusion solutions do you intend to use? (Check all that apply.):

- ❑ Krebs-Henseleit Solution
- ❑ Erythrocyte-containing solution
- ❑ Blood
- ❑ Recirculating

If others please specify:

_____

Which parameters would you like to measure? (Check all that apply.)

Langendorff System

- ❑ Perfusion pressure/aortic pressure
- ❑ Left ventricular pressure (LVP) with balloon method
- ❑ Coronary flow

Working Heart System

- ❑ Preload pressure
- ❑ Aortic pressure (afterload pressure)
- ❑ LVP with pressure catheter
- ❑ LVP pressure volume loop
- ❑ Atrial flow (cardiac output)
- ❑ Coronary flow
- ❑ Aortic flow
- ❑ Preload (diastolic) pressures >11cm$H_2$0 (Gottlieb valve add-on)

Perfusion Solution Monitoring

- ❑ Temperature
- ❑ pO_2
- ❑ pH

Electrical Stimulation

- ❑ Pacing

Single Lead ECG and MAP

- ❑ Multi-lead ECG mapping with 32 or 64 electrodes
- ❑ Single-lead ECG
- ❑ Single epicardial monophasic action potential (MAP)
- ❑ Single endocardial monophasic action potential (MAP)

Multi-lead ECG and Multiple Epicardial MAP*

- ❑ 12-lead (6 Einthoven-Goldberger and 6 Wilson leads)
- ❑ 6-lead (6 Einthoven-Goldberger leads)
- ❑ Multi-monophasic MAP (only on larger hearts)

How many MAP Electrodes?

_____

**Only on rat and larger hearts, IH-5 system*

What type of computer will you be using for data acquisition?

- ❑ Desktop
- ❑ Laptop

NOTES

Harvard Apparatus Worldwide

United States

Harvard Apparatus
84 October Hill Road
Holliston, Massachusetts 01746, USA
Tel: **+1 508 893 8999**
Toll Free: **+1 800 272 2775 (US Only)**
Fax: **+1 508 429 5732**
support@hbiosci.com
www.harvardapparatus.com

Canada

Harvard Apparatus Canada
6010 Vanden Abeele
Saint-Laurent, Quebec, H4S 1R9, Canada
Tel: **+1 514 335 0792**
Toll Free: **+1 800 361 1905 (Canada only)**
Fax: **+1 514 335 3482**
sales@harvardapparatus.ca
www.harvardapparatus.ca

France

Harvard Apparatus, S.A.R.L.
6 Avenue des Andes
Miniparc - Building 8
91952 Les Ulis Cedex, France
Tel: **+33 1 64 46 00 85**
Fax: **+33 1 64 46 94 38**
info@harvardapparatus.fr
www.harvardapparatus.fr

Germany

Hugo Sachs Elektronik /
Harvard Apparatus, GmbH
Gruenstrasse 1
D-79232 March-Hugstetten, Germany
Tel: **+49 0 7665 9200-0**
Fax: **+49 0 7665 9200-90**
info@hugo-sachs.de
www.hugo-sachs.de

Spain

Panlab, S.L. / Harvard Apparatus
C/Energia, 112
08940 Cornellà, Barcelona, Spain
Tel: **+34 934 750 697 (International Sales)**
+34 934 190 709 (Sales in Spain)
Fax: **+34 934 750 699**
info@panlab.com
www.panlab.com

Sweden

CMA Microdialysis AB / Harvard Apparatus
Torshamnsgatan 30A
SE-164 40 Kista, Sweden
Tel: **+46 8 470 10 00**
cma@microdialysis.se
www.microdialysis.se

United Kingdom

Biochrom Limited / Harvard Apparatus UK
East Wing, Building 1020
Cambourne Business Park, Cambourne
Cambridge, CB23 6DW, United Kingdom
Tel: **+44 1732 864001**
Fax: **+44 1732 863356**
sales@harvardapparatus.co.uk
www.harvardapparatus.co.uk

China

Harvard Apparatus China
Room 1902E
19F, Building B
Zhong Shan Plaza
1065 West Zhong Shan Road
Changning District
Shanghai, China 200051
Tel: **+86 21 2230 5128**
china@harvardapparatus.com

Worldwide

Harvard Apparatus solutions are available from a wide network of distribution partners. Please contact us or visit **www.harvardapparatus.com** to find a distributor near you.

Divisions of Harvard Bioscience, Inc.

Note: Products in this catalog are for Research Use Only. They are not for use on humans unless proper investigational device regulations have been followed. Harvard is a registered trademark of Harvard University. The marks Harvard Apparatus and Harvard Bioscience are being used pursuant to a license agreement between Harvard University and Harvard Bioscience, Inc.

HUGO SACHS ELEKTRONIK

a division of Harvard Bioscience, Inc.

Isolated Heart

PERFUSION SYSTEMS

For Mouse to Small Pig Animal Models