

Cell & Tissue Research

Special Section – Muscle Physiology

WPI recently acquired the German company **Scientific Instruments Heidelberg**. This special section previews the SIH range of instruments for muscle physiology research 77-82



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Prices shown are in U.S. dollars. Actual charges will vary because of import duty, freight, and currency fluctuations. To obtain an exact quotation, contact your WPI office.



MUSCLE PHYSIOLOGY

WPI recently acquired the German company **Scientific Instruments Heidelberg** and now offers its entire line of muscle physiology products through WPI sales channels worldwide. Please contact your local WPI office or distributor for more information.

Modular Systems for All Your Muscle Studies

The SIH product line has solutions for cellular, tissue, and whole muscle studies, including skinned muscle fiber preparations and an instrument for long-term culture/preservation of intact muscle. All common myo-mechanical studies in muscle can be done, such as isometric and isotonic contractions, as well as eccentric contractions in skeletal muscle and after-loaded contractions in cardiac muscle. In addition, via optical techniques, sarcomere spacing, intracellular calcium, and myosin ATP-activity may be combined with the mechanical studies. Controlled, automated force-pCa studies are possible. These can be combined with measurement of membrane potential and oxygen tension/consumption.

The SI-H systems are modular in design and easily expandable wherever your research or applications may take you. The base system is formed by an indestructible, optical force transducer (KG series) and a temperature-controlled tissue cuvette system. These can be simple or sophisticated standalone systems. Or, they can be adapted to an inverted microscope for fiber or even single cell work. A linear motor expands the reach of mechanical studies, and optical components provide ultrastructure information on sarcomere spacing, calcium, or ATPase activity in the muscle fiber. Most components are sold separately so you can customize your existing system or build your own research setup.

SI-H Systems Offer Choices and Convenience



Intact muscle strips—The **muscle tester** is the all-round system of choice for all mechanical studies on intact muscle (skeletal, cardiac, or smooth) that do not require simultaneous optical measurements. The muscle tester does allow simultaneous recording of membrane potential and other invasive placement of electrodes or sensors in the bath. The system can come with a complete muscle data recording and analysis system (**DAQ**) or hardware to connect to your own data acquisition system (**MACP**).

Intact muscle strips and skinned muscle fibers—If you are planning to extend your research into the molecular mechanisms and biochemistry of force development on actin-myosin interaction or the study of ancillary proteins such as troponins or titin, then the **Muscle Research System MKB** is your choice. This is the most stable platform for advanced, high-end and low-force measurements. With the optional gradient system (**GRDM**) and calcium photometry, you can perform very accurate force-pCa curves in very small volumes down to 500 μ L. The cuvette system can also be cooled to allow accurate Q10 studies while better preserving the sarcomere ultrastructure.



If your research involves actual measurement of the ATPase activity via fluorescence or intracellular calcium in intact skeletal or cardiac muscle strips trabeculae or papillary muscle, the **Muscle Research System OPT** is the platform of choice. This system offers an optimized light path access and special cuvettes for high-end imaging and photometry in combination with the mechanical studies in both intact and skinned fibers. Both systems are stand-alone platforms with complete data acquisition and analysis (**DAQ**).



Muscle fibers on existing microscope systems—A special version of the muscle tester for intact and skinned fiber is available for placement on inverted microscopes. **FiberMIC**, a muscle tester with a small footprint, can be outfitted with or without a linear motor to do



all the possible mechanical tests in the standalone systems. The environment chamber of the muscle is controlled. There is also an option for laser-controlled fluid level to eliminate surface tension effects on the optical path and force measurement during sophisticated experiments. Since the optical path of the microscope is left unobstructed, researchers can continue to use their own hardware for advanced imaging applications on muscle preparations or fibers.

Long term culture of muscle fibers—The **Long-term Muscle Culture System** allows you to keep intact muscle fibers from skeletal or cardiac muscle alive and working for up to one week. The system allows all the mechanical tests and calcium imaging on the muscle in a sterile, gassed, closed, controlled environment. Protein exchange, viral transduction and RNA interference studies on muscle are now possible in a cost-effective system. Application specialists can help you discuss what can and has been done with this system.



Single muscle cell studies—The combination of the optical and very sensitive KG force transducers and a micro piezo nanomotor makes studies on single muscle cells possible. In the **Single Cell Muscle Tester**, a dual remote controlled microtweezer system with special biocompatible coating allows you to grasp cells and let them work just as you did with larger

fibers or cell clusters. The system is meant to be integrated on two micromanipulators and an (inverted) compound research microscope. On both sides the microtweezers or microplates with tip sizes down to 20 μ m are embedded in a pN sensitive transducer circuit and piezo-based nanomotor with 20 nm precision. External computer control allows you to design your length change protocols and measure optical responses such as confocal calcium or other live cell functional markers. Contact us for details and to discuss your application.

Accessories—For all of our systems the KG force transducers with different ranges are inter-exchangeable among all platform and amplifiers. All cuvette systems are heat controlled to 34-40°C or have a cooling option down to 5°C or any temperature in between.

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Basic Muscle Tester

The muscle tester is a convenient platform for all standard mechanical experiments on intact muscle preparations. The force transducer is one of the optical KG series with ranges from 0 to 2 N and sensitivities down to 1 μ N. The transducer comes with custom exchangeable tissue holders for general purpose or specific for skeletal, cardiac or smooth muscle with or without tendons attached. The bridge amplifier (**BAM21**) has integrated heat control for one of three possible perfusion cuvettes. The base system can be used for isometric force measurement with direct point stimulation of the muscle with a stimulator (**STIM**) through the transducer and mounting supports. Field stimulation is also possible. A very fast linear motor (**MOTTEST**) can be added to replace the standard micrometer and used in combination with one of the length control devices (**LCC**) to perform isotonic and eccentric contractions. Further tests that can be performed then include: after loaded contractions, slack test, quick stretch-release, force-velocity studies and vibration (sinusoidal/ muscle stiffness) studies. The muscle tester comes with a complete data acquisition and analysis package (**DAQ**) for muscle physiology and mechanics. Alternatively, a hardware control device (**MACP**) allows you to perform all tests while recording the data on your own data acquisition system. The muscle tester can also be equipped with a laser based detector of sarcomere spacing (**SARCSR** or **SARCCAM**).

BASIC SYSTEM FOR ISOMETRIC FORCE

MT-ORG-B	Muscle Tester	\$14,100
System includes: Base platform, Transducer holder, digital micrometer, Peristaltic pump, 1KG Force transducer, Mounting supports, BAM21 bridge amplifier, Binocular scope, Oxygenation/vacuum system, and choice of long cuvette, short cuvette or short cuvette with optical window (for laser)		

OPTIONAL COMPONENTS

AOSC	Anti-oscillation unit Eliminates resonance frequency from measurement	\$2025
STIM	Stimulator, standalone analog or digital control, +/- 45V, mono/bipolar	\$2228
STIM2	Stimulator, controlled by DAS software analog or digital control, +/- 45V, mono/bipolar	\$1580
FS	Electrode for field stimulation	\$338
MOTTEST	Linear motor with power amplifier	\$2025
LCU	Length control unit for slack test quick stretch/release, constant velocity	\$2025
COLU	Constant load unit, isotonic contractions	\$2025
ERG	Ergometer unit for after loaded contractions (e.g., heart muscle)	
VIBU	Vibration Unit (vibration, stiffness and sinusoidal studies)	\$2025
DAS	Data acquisition/analysis system (controls stimulator and all length devices)	\$5265
MACP	Motor Action Control Panel (motor control when using your own DAQ)	\$1755
SARCSR	Laser based sarcomere spacing, manual	\$3105
SARCCAM	Laser based sarcomere spacing with linear camera, electronic >250Hz	\$7290



**Modular
Flexible
Expandable**

Key Experiments

Isometric force

Isotonic force

Eccentric contractions

Constant load

Quick stretch release

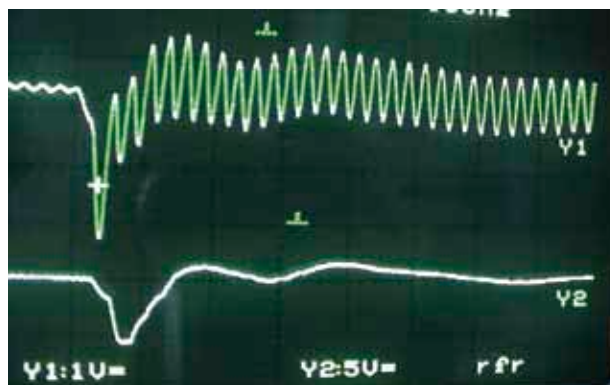
Constant velocity

Slack test

Sarcomere spacing (laser based)

MUSCLE TESTER SPECIFICATIONS

FORCE	0-5,10,50,100mN, 2N
MOTOR	7mm range, 200 μ m/s speed 1.5N pull Force indefinitely, 100N for 20ms
AMPLIFIER	dedicated to KG transducer, 1-10V output
MICROSCOPE	4.5-45x (specify objective) Binocular or Trinocular scope
STIMULATOR	0-45V mono/bipolar, ext trigger in/out, delay 5-500ms, stimulus duration 0.1-10ms, single pulse or train mode at 0.01-100Hz



Effect of the Anti-oscillation unit on force transducer output.

KG Optical Force Transducers

– lifetime warranty

- A force transducer series with a range and sensitivity from the pN to tens of newton range
- Nearly insensitive to temperature and light
- Extremely linear
- Virtually indestructible with normal use

Different transducer bodies can be exchanged and set and zeroed to the same bridge amplifier at the touch of a button. After a simple calibration with an appropriate weight, the system is ready for use.



TRANSDUCER SPECIFICATIONS

Unloaded transducer without tissue mounting device

	Range	Noise	Compliance	Resonance Frequency
KG2	0-2 N	250 μ N	0.15 μ m/mN	1.3 kHz
KG4	0-50 mN	15 μ N	0.5 nm/ μ N	1.2 kHz
KG4A	0-20 mN	4 μ N	1 nm/ μ N	1.2 kHz
KG7B	0-10 mN	1 μ N	1.5 nm/ μ N	550 Hz
KG7A	0-5 mN	0.4 μ N	5 nm/ μ N	500 Hz
KG7	0-5 mN	0.2 μ N	10 nm/ μ N	250 Hz
KG2A	0-0.5 N	300 μ N		
KGxx	contact us for specialty transducers with different ranges.			

KGXX	KG Series Force transducers	\$1147
MOTTEST	Linear motor with power amplifier	\$6950
BAM21	Bridge amplifier with heater controller	\$2349
AOSU	Anti-oscillation unit Eliminates resonance frequency from measurement.	\$2025

Mounting Supports include a choice of hooks, baskets, tweezers for general purpose, skeletal (with/without tendon), smooth muscle and cardiac muscle (papillary/trabeculae) fibers. Contact WPI for a list of current supports.

BAM21 SPECIFICATIONS

Bridge Amplifier

INPUT CONFIGURATION	Current to voltage converter
GAIN	1x,10x – Switch selectable
OUTPUT IMPEDANCE	100 Ω
POWER	12 VDC at 3 A (wall adaptor)
OUTPUT RANGE	0-10 V

Temperature Controller

SENSOR TYPE	RTD
TEMPERATURE RANGE	Ambient – 40 $^{\circ}$ C
ACCURACY	< 0.1 $^{\circ}$ C
ELEMENT CURRENT	0 – 2.4 A

SIH Linear Motor System

The SIH linear motor is a very fast, precise advanced system capable of generating strong force. It operates nearly friction free via induction movement. The unit is overload and spray water protected.



MOTTEST LINEAR MOTOR SPECIFICATIONS

MAXIMUM TRAVEL	7 mm
MAXIMUM SPEED	200 μ m/ms (0.2 m/s)
COMPLIANCE	20 μ m/N
POSITION SENSOR NOISE	< 1 μ m
FORCE	100 N for 20 ms, 5 N for 2 s, 1.5 N continuous.

SIH Bridge Amplifier

BAM21, the SIH bridge amplifier has integrated heat control.



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Muscle Research System MKB

The standard muscle research system is primarily designed for intact living muscle preparations. It combines the versatility of the KG transducer series with a solid platform for mechanical and combined optical measurements on intact muscle. The system can also be used for skinned preparations, thus providing one platform that spans nearly the entire muscle physiology field. It can be equipped with photometers, a laser diode and a linear motor. A range of perfusion cuvettes and temperature control options provide a wide range of possible applications.



KEY FEATURES

- ***Mechanically stable platform for advanced mechanical & optical muscle studies***
- ***Complete turnkey system***
- ***Modular design***
- ***Corrosion-free design (stainless steel, anodized aluminium, plastic)***

Complete SI-H systems are assembled from a large variety of custom components and made to order. Call our staff physiologist to discuss the many options for your experimental needs.

KEY EXPERIMENTS

- Measure intact muscle responses to electrical stimulation or tetanus. Measure myomechanical properties of contracting and relaxing muscle strips. An ergometer (**ERG**) can be used to perform after-loaded contractions in heart muscle and to perform eccentric contractions.
- Twitch amplitude and kinetics analysis, time to peak, (50%) relaxation velocities, starting curve, diastolic force development can be monitored with Muscledata software.
- A linear motor plus control units can be adapted to measure mechanical muscle properties such as slack-test, isotonic release, constant velocity release, stretch release, vibration and after-loaded contractions (intact muscle) background information.
- A gradient maker (**GRDM**) can be fitted for automated force-pCA studies background information.
- Simultaneous measurement of the sarcomere length is possible by laser diode diffraction. This can be combined with calcium measurement.



Muscle Research System OPT

The Muscle research system OPT is primarily designed for advanced optical measurements on intact and skinned muscle fibers under good mechanical control. The system has a greater mechanical stability and can be equipped with photometers, laser diode, linear motors and very sensitive force transducers. It can also be used for intact muscle studies. It is recommended that this system be placed on a vibration isolation table or very stable platform.

KEY FEATURES

- **Mechanically very stable platform for advanced muscle studies**
- **Complete turnkey system**
- **Modular design**

KEY EXPERIMENTS

- Measure muscle ATPactivity in thin muscle strips (or single skeletal muscle cells). The time resolution of the ATPase determination depends on the muscle and is within 5 to 20s.
- A linear motor (MOTTEST) plus control units can be adapted to measure mechanical muscle properties such as slack-test, isotonic release, constant velocity release, stretch release, and vibration.
- A gradient maker (GRDM) can be adapted for automated force-pCA studies.
- Simultaneous measurement of the Sarcomere length is possible by laser diode diffraction. This can be combined with calcium measurement.

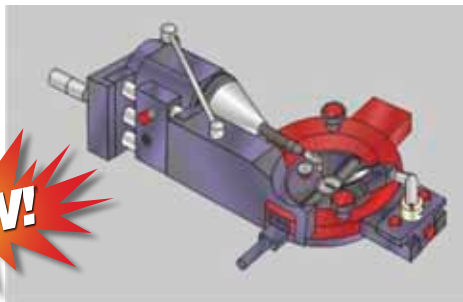
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FiberMIC

The FiberMIC muscle research system is primarily designed to be placed on an existing inverted microscope from ZEISS or OLYMPUS so it can be combined with optical recordings of your choosing. Its primary use is intact living muscle preparations but it can also be used for skinned fibers. It combines the versatility of the KG transducer series with a small compact footprint perfusion cuvette system and optical windows. Because the system can also be used for skinned preparations, it provides one platform that spans a wide range of muscle physiology experiments. The microscope can be equipped with our photometers and the system comes standard with our linear motor. The perfusion cuvette is temperature controlled.



KEY FEATURES

- **Mechanically stable platform for combining advanced mechanical & optical muscle studies**
- **Complete turnkey system with data recording & analysis available. Data can be combined with calcium or sarcomere measurements from the microscope system.**
- **Cuvette system of your choice can be closed or open for easy access**
- **Heat control between 30-42°C**
- **Linear motor for muscle length perturbation studies**

KEY EXPERIMENTS / MUSCLE Parameters

- Measure intact muscle responses to electrical stimulation or tetanus. Measure myomechanical properties of contracting and relaxing muscle strips. An ergometer can be used to perform after-loaded contractions in heart muscle and to perform eccentric contractions.
- Twitch amplitude and kinetics analysis, time to peak, (50%) relaxation velocities, starting curve, diastolic force development can be monitored with Muscledata software.
- A linear motor plus control units can be adapted to measure mechanical muscle properties such as slack-test, isotonic release, constant velocity release, stretch release, vibration, eccentric and after-loaded contractions (intact muscle).

ACCESSORIES

Stimulator & Tetanizer for intact muscle stimulation

Photometer for the microscope to allow intracellular calcium studies (or use your own imaging system)

Laser controlled perfusion system for highly accurate low force measurements

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Single Cell Muscle Tester

The Micro-Tweezer single-cell muscle tester features two remote controlled Micro-Tweezer with 20-50 μm flat or pointed tips. The tips are coated with a proprietary tissue compatible glue to hold the cell. One tweezer is embedded in a KG force transducer with 0-5 mN range and 200 pN sensitivity. The other tweezer is part of a piezo based nanomotor with a travel of 200 μm and 20 nm precision. The amplifier controller has a built-in anti-resonance circuit for enhanced sensitivity and reduced noise. The system is mounted on a course/fine micromanipulator and built onto an inverted research microscope.



Two Micro-Tweezers, nanomotors, force transducers and front panel of the control box. Complete system also includes two coarse manipulators.

Micro-Tweezer

- 20 μm tipped jaws
- Remote control open/close
- Flexible mounting on existing micromanipulators

Nanomotor

- Piezo-based movement
- 20nm precision, 200 μm travel
- Remote control via analog input

Force Transducer

- KG series type 7A
- 0-5mN, 200pN resolution
- Integrated anti-resonance circuit



Single muscle fiber held between two Micro-Tweezers

Trans Epithelial Electric Resistance (TEER) Measurements

During the last two decades TEER measurements have become universally established as the most convenient, reliable and non-destructive method to evaluate and monitor the growth of epithelial tissue cultures *in vitro*. The confluence of the cellular monolayer is quickly determined by a sharp increase in TEER. Recently there has been a significant surge of interest in introducing a combined

electrode for resistance measurements in the Millipore 96-well PAMPA (parallel artificial membrane permeability assay) plate.

TEER measurement technology, which was first introduced by WPI in the mid-1980's, has since been perfected and expanded to include a range of TEER related manual and automatic instrumentation.

EVOM²TM

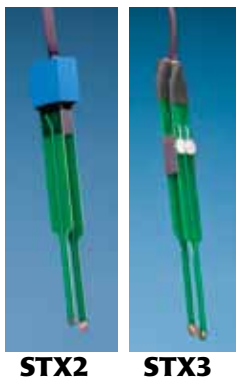
Epithelial Voltohmmeter

- **Manual TEER measurements of epithelial cells in 6-, 12-, and 24-well plates**
- **Electrically isolated meter that plugs into a standard outlet for continual readout without push buttons**
- **Compatible with Endohm chambers**
- **STX2 manual electrodes and test electrode included with every meter**



The EVOM was the first instrument designed specifically to perform routine Trans Epithelial Electrical Resistance (TEER) measurement in tissue culture research. EVOM2 is the next generation, redesigned for ease of use. The EVOM2 not only qualitatively measures cell monolayer health, but also quantitatively measures cellular confluence. The unique electronic circuit of the EVOM2 and the included STX2 electrode detect the confluence of the cellular monolayer. When combined with WPI's Endohm chamber, the EVOM2 can also be used to perform more accurate quantitative measurements or lower resistance measurements like trans endothelial electrical resistance measurements.

The isolated power source of the EVOM2 was specifically designed to avoid adverse effects on tissue and the formation of electrode metal deposits, even when it is plugged into a standard wall outlet. Now, the EVOM2 is always on when you need it. In addition, its rechargeable battery allows up to 10 hours of mobile use. The four and a half digit readout provides a range of 1-9,999 Ω. The included test electrode lets you calibrate the resistance



measurements for an accurate reading every time, and the voltage meter never needs calibration. An analog BNC output is standard with the EVOM2, providing an output port for recording data or remote display of the EVOM2 output.

EVOM2 comes complete with the popular STX2 "chopstick" electrodes, 4 mm wide and 1 mm thick. Each stick of the electrode pair contains a silver/silver-chloride pellet for measuring voltage and a silver electrode for passing current. The small size of each electrode is designed to facilitate placement of the electrodes into a variety of standard cell culture wells.

EVOM2 SPECIFICATIONS

MEMBRANE VOLTAGE RANGE	±200 mV
RESOLUTION	0.1 mV
RESISTANCE RANGE	0 to 9999 Ω
RESISTANCE RESOLUTION	1 Ω
AC SQUARE WAVE CURRENT	±10 μA nominal at 12.5 Hz
POWER	Internal rechargeable 6V NiMH 2200 mAh battery with external 12 VDC supply for recharging
NOMINAL BATTERY RUN TIME	10 hours
BNC OUTPUT	1-10 V (1 mV/ohm)
DIMENSIONS	19 x 11 x 6 cm (7.25" x 4.25" x 2.30")
WEIGHT	1.4 kg (3 lb)
ELECTRODE CONNECTION	RJ-11 connector (telephone style)
TEST RESISTOR	External
ENVIRONMENTAL RANGE	10-38°C (50-100°F) 0-90% non-condensing relative humidity

EVOM2 Epithelial Tissue Voltohmmeter (includes STX2 electrode set)

REPLACEMENTS AND ACCESSORIES

- STX2** Replacement "Chopstick" Electrode Set
- STX3** Adjustable Tip Spread "Chopstick" Electrode Set
- 3993** Electrode Adapter (for electrodes with 2 mm pins)
- 503540** 4-Way Switchbox & Interface Cable
- 91736** Replacement Battery, Rechargeable NiMH

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TEER measurements in High Throughput

STX100

Series Electrodes

- **Designed for 24-well HTS plate (Corning Costar and BD Falcon) and with 96-well plates (Millipore and BD Falcon)**
- **Improved accuracy down to 5 Ohm**
- **Sterilized with EtO, alcohol or bactericide**

With the development of a High Throughput Screening (HTS) protocol for faster drug discovery, a new line of cell culture filter plates have been introduced by several major cell culture insert manufacturers. These HTS plates normally have either 24 or 96 individual cell culture inserts "bonded" together as one plate so that it can be handled by a robot apparatus. In response to these developments, WPI has developed an automatic REMS system and a manual electrode, STX100, for TEER measurements using HTS plates.

STX100's design is based on the same reliable design principle as the universally used STX2 electrode, with several important modifications. The size of the electrode tip has been reduced to 1.5 mm to facilitate positioning through the narrower slit of the HTS plate. The STX100 electrode itself is constructed using a stronger material for higher durability and maximum usage applications. The bottom section of the electrode is shaped to fit neatly into the "keyhole" shaped filter well. This enables the STX100 electrode to produce increased accuracy and reproducibility of TEER readings ($\pm 5\Omega$) compared to the standard STX2. Several versions of STX100 are available, designed to fit the Corning Costar 24-well HTS plate, the Falcon 24 well HTS plate, and the

Millipore Multiscreen CaCo 96-well plate. Measurement can be directly performed when the HTS plate is in either a common or divided tray, reducing the possibility of contamination as well as mechanical damage to the cultured cells.

STX100C	STX100 for Corning Costar HTS Transwell-24
STX100F	STX100 for Falcon HTS Multiwell Insert System
STX100M	STX100 for Millipore Multiscreen™ CaCo 96-Well Plate
STX100C96	STX100 for Corning HTS 96-Well Plate

OPTIONAL ACCESSORIES

13685	Modular Cable, 7 ft
13347	Chart Recorder Adapter
2851	Standard BNC Cable, 5'2"
500184	Standard BNC Cable, 10 ft (3m)

CaliCell™

Cell culture cups with synthetic membrane for testing STX electrodes, Endohm and Ussing chambers

It takes a long time and a lot of work to grow a batch of cells, so you will want to make certain that your test apparatus is functioning properly. The CaliCell™ provides a quick and positive way to test STX electrodes, EVOMs, Endohm, and Ussing chamber.

The CaliCell™ is a major improvement in TEER electrode calibration. Its membrane makes use of our unique electric current constriction technology to produce resistance readings comparable to those obtained with real cell cultures. The CaliCell™ does not have to be refrigerated, and can be cleaned and sterilized with alcohol. Readings will not drift over time as long as the unit is kept in good physical condition.

CALICELL-12	12 mm Calibration Cell for Endohm-6/Endohm-12
CALICELL-24	24 mm Calibration Cell for Endohm-24



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Screening (HTS) cell culture filter plates

Multi-96

Resistance measurement with 96-well PAMPA (parallel artificial membrane permeability assay) plates

Non-cell based 96-well PAMPA assays have been designed for predictive drug candidate testing. To ensure that the donor/acceptor fluxes are not due to porous or unstable hexadecane layers, the stability of the hexadecane membrane can be tested at the end of the incubation period by electrical resistance measurements. To conduct the measurement a PAMPA plate is transferred to MULTI-96. Like the other Endohm models (designed for individual cell culture cups), the base of MULTI-96 is a fluid-filled receptacle for the PAMPA plates, also serving as the bottom half of the electrode pair. Inserting the top electrode into each well allows the user to obtain the resistance of the synthetic membrane layer of that well. MULTI-96 provides a stable and reproducible reading of tissue culture resistance. **EVOM2** is recommended for use with MULTI-96.



MULTI-96 Endohm for Millipore MultiScreen 96-well PAMPA plate

Endohm™

For TEER measurement of endothelial cell cultures in individual cups

- **Compatible with EVOM2**
- **Improved accuracy of 1-2 Ohm**
- **Accommodates 6mm, 12mm, 24mm cups and Costar Snapwell cup**
- **Sterilized with EtO, alcohol or a bactericide**

Using WPI's EVOM2 resistance meter, Endohm chambers provide reproducible resistance measurements of endothelial tissue in culture cups. Transfer cups from their culture wells to the Endohm chamber for measurement rather than using hand-held electrodes. The chamber and the cap each contain a pair of concentric electrodes: a voltage-sensing silver/silver chloride pellet in the center plus an annular current electrode. The height of the top electrode can be adjusted to fit cell culture cups of different manufacture. Endohm's symmetrically apposing circular disc electrodes, situated above and beneath the membrane, allow a more uniform current density to flow across the membrane than with **STX2** electrodes. The background resistance of a blank insert is reduced from 150 Ω (when using WPI's hand-held STX2 electrodes) to less than 5 Ω . With

Endohm's fixed electrode geometry, variation of readings on a given sample is reduced from 10-30 Ω with STX2 electrodes (depending on the experience of the user) to 1-2. Compared with other resistance measurement methods, Endohm with EVOM2 offers a much more convenient and economic solution to "leaky tissue" measurement. Because of the uniform density of the AC square wave current from EVOM2, errors owing to electrode polarization or membrane capacitance are largely eliminated. Endohm together with EVOM2 offers the most accurate and economical endothelial ohmmeter now available. To date, cups from Costar, Millipore, ICN Biomedicals, and Falcon have been tested. Endohm chambers may be sterilized with EtO, alcohol or a bactericide (also see: Cidex, Microsurgery section); not autoclavable.



Also for use with Millicell ERS-2

ENDOHM-6	Endohm for 6 mm culture cup (24 wells per plate)
ENDOHM-12	Endohm for 12 mm culture cup (12 wells per plate)
ENDOHM-24SNAP	Endohm for 24 mm & Costar Snapwell™ cup (6 wells per plate)
	<i>Requires EVOM2, EVOM or EVOMX to operate</i>
53330-01	Replacement Endohm Cable

Prices shown are in U.S. dollars. Actual charges will vary because of import duty, freight, and currency fluctuations. To obtain an exact quotation, contact your WPI office.

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Automated TEER Measuring System



The **REMS AutoSampler** automates measurements of electrical resistance of transepithelial, transendothelial or Caco-2 cell membranes being grown to confluence on microporous filters of high throughput screening (HTS) 24- and 96-well microplates. It is a PC-controlled, tissue resistance measurement system that offers reproducibility, accuracy, flexibility and ease-of-operation for this kind of measurement. Automated measurement of tissue resistance in cell culture microplates provides the important advantages of speed, precision, decreased opportunity for contamination and the instant availability of measured resistance data on a computer. These measurements are useful in applications such as drug bioavailability studies and studies on the mechanisms of drug transport.

The main components of the REMS AutoSampler include: the robotic sampler that moves the electrode over each well of the microplate, the electrode which is located on the robotic arm, a base plate for the 24- and 96-well tray, a Windows-based data acquisition card, the REMS interface unit and the REMS software to operate the system on a Windows-based computer.

The REMS AutoSampler automates TEER measurements previously made with WPI's **EVOM** Epithelial Voltohmmeter. Automated tissue resistance measurements up to 20 k can

be performed on 24- or 96-well HTS microplates. Microplates presently supported include the Corning Costar HTS Transwell-24, Falcon HTS Multiwell insert systems, and Millipore Multiscreen™ CaCo 96-well plate.

The REMS AutoSampler is designed to facilitate integration with other robotic systems. Special locating bars are installed on the REMS base platform that allow other system robots to place an HTS tray into a precise location on the REMS base.

The REMS AutoSampler will automatically measure and record tissue resistance from a user-specified matrix of culture wells on the microplate. According to the specified sequence, the robotic arm moves over the identified wells taking TEER measurements. By means of a x-y-z locating system, the electrode-containing arm is positioned precisely and reproducibly over each well. The ability of the REMS AutoSampler to reproducibly and precisely locate the electrode results in highly reproducible TEER measurements. TEER measurements are stored in the computer as the electrode moves from one well to the next. The Windows-based software provides user-friendly features to acquire, display and store the tissue resistance measurements.

The REMS electrode is very compact and robust in design. Each of two rod-shaped probes, 1.5 mm in diameter, consists

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of a pair of electrodes: one electrode for injecting current and the other for measuring the voltage. The use of two pairs of electrodes eliminates the error caused by the electrode-liquid interface. To take a measurement, the robot inserts one probe into the center of the filter well and the other into the opening slot of the 24- or 96-well plate. The use of AC current to measure resistance provides several advantages over DC current, including:

- Absence of offset voltages on measurements;
- There is a zero net current being passed through the membrane and therefore it is not adversely affected by a current charge;
- No electrochemical deposition of electrode metal.

The REMS AutoSampler also features a rinse and calibration check station. If occasional rinsing of the REMS electrode is required it may be sent to a rinse station by pressing the rinse station button on the menu bar.

REMS AUTOSAMPLER SPECIFICATIONS

MEMBRANE RESISTANCE RANGE	0 to 2000 Ω and 0 to 20 k Ω
AC SQUARE WAVE CURRENT	+/- 20 μ A @ 12.5 Hz
ELECTRODE POSITIONING	Resolution in X, Y and Z: +/- 1 mm
ELECTRODE PERFORMANCE	Repeatability in X, Y and Z: +/- 0.25 mm
ELECTRODE ARM SPEED	X- and Y-axis: 250 mm/sec Z-axis: 247.3 mm/sec
TYPICAL MEASUREMENT TIME 24-WELL	1 min, 10 sec
SCAN PATTERN	Choice of any well pattern sampling
LINE VOLTAGE	User specified: 100/120 V or 220/240 V
DIMENSIONS	53.5 x 43.7 x 37.1 cm (21 $\frac{3}{32}$ x 17 $\frac{3}{16}$ x 14 $\frac{5}{16}$ in.)
WEIGHT	24 kg (52 lb)

REMS Automated Tissue Resistance Measuring System

Includes robot sampler, data acquisition board, base plate, software with Windows XP and Vista, and electrode for either 24-well plate (Corning Costar HTS Transwell-24 or Falcon HTS Multiwell) or 96-well plate (Millipore Multiscreen CaCo) – SPECIFY WHEN ORDERING.

ACCESSORIES

REMS-24	Replacement REMS STX Electrode for 24-well HTS Plate
REMS-96	Replacement REMS STX Electrode for MilliporeTM 96-well Plate

Contact WPI for detailed information.

Give your HTS system the ability to perform REMS TEER measurements



WPI's REMS TEER measurement system is also available in a fully customizable package that does not include the robot. The REMS-KIT is designed to enable manufacturers and users of robotic and HTS systems to incorporate TEER measurement capability into their own automated protocols. Essentially the REMS-KIT provides the same TEER measuring system as the REMS but without the robot positioner. Control over TEER measurement is accomplished using the DDE protocol. Virtually any Windows-compatible programming language that uses the DDE protocol (including LabView and Visual Basic) can be used. The REMS-KIT is designed for use with Corning Costar HTS Transwell-24, Falcon HTS Multiwell Insert System and Millipore Multiscreen™ CaCo 96-well plates. The system includes the following components:

- REMS TEER electrode with 5-ft cable
- Dummy TEER electrode for training robot
- REMS TEER measurement electrode interface unit
- Windows PCI A/D data acquisition card
- Interface software using the DDE protocol
- Instruction Manual

REMS KIT SPECIFICATIONS

Resistance range 0 to 20 k Ohms
Time for each measurement 1 to 2.5 seconds

Minimum Configuration: Pentium processor (90 MHz) running on Windows 95 or Windows 98 and having at least 16 Mb of RAM. 10 Mbytes of free disk space.

REMS KIT includes one electrode which fits either the Corning Costar 24-well microplate, the Falcon 24-well microplate, or the Millipore Multiscreen CaCo 96-well microplate.

REMS-KIT REMS Kit for Corning Costar HTS Transwell-24 or Falcon HTS Multiwell Insert System

BioTester 5000

Biaxial Test System for Biomaterials

BioTester 5000 offers you a complete system for testing small biological specimens and analyzing the test results. Skin, ligaments, blood vessels, heart valves, sclera, membranes, scaffolds – BioTester can examine any planar biological or replacement tissue. Easy-to-use, yet powerful, image tracking and analysis software delivers synchronized data, image and video management. Data can be exported to spreadsheets or analysis software.

- Quick and easy sample mounting
- High Resolution (integrated) CCD camera
- Image tracking and analysis software included
- Precision measurement of small samples
- Simple USB interface for quick connection
- User-friendly, comprehensive software
- Real-time data analysis



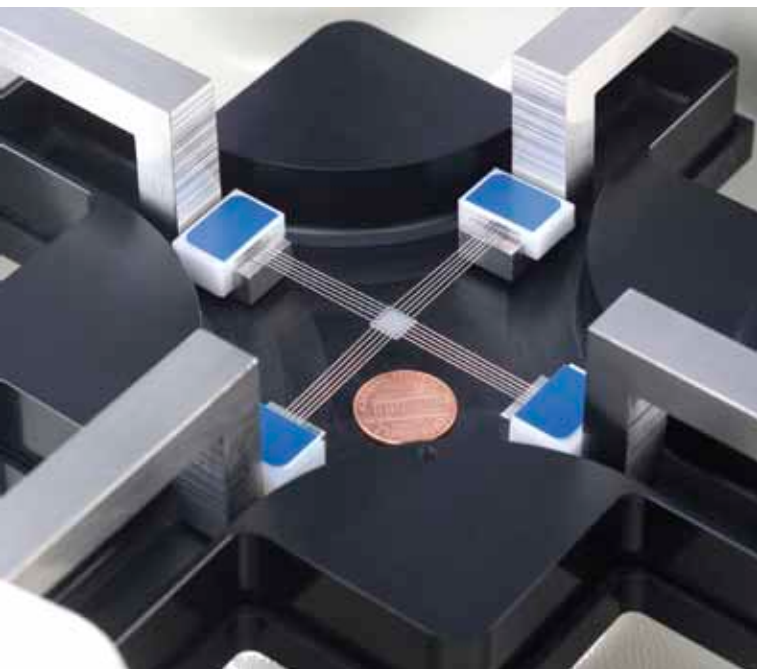
BIOTESTER 5000 SPECIFICATIONS

FORCE CAPACITY	500, 100, 2500, 5000 mN, 10 N, 23 N
FORCE RESOLUTION	>0.02% of full scale
FORCE ACCURACY	0.2% of full scale
SPATIAL RESOLUTION (ACTUATOR)	>0.1 μm
SPATIAL ACCURACY (ACTUATOR)	10 μm
SPATIAL RESOLUTION (IMAGE ANALYSIS)	$\frac{1}{8}$ pixel
FORCE DATA RATE	≤ 100 Hz
IMAGE RATE	1280x960 - 15 Hz
	1024x768 - 30 Hz
	640x480 - 60 Hz
DEFORMATION RATE	≤ 100 mm/s
	(17 mm/s optional)

CS-BIOTESTER5000 Biaxial Biomaterial Tester

Prices shown are in U.S. dollars. Actual charges will vary because of import duty, freight, and currency fluctuations. To obtain an exact quotation, contact your WPI office.

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Sample Mounting

Unique tungsten BioRakes easily pierce the toughest and most delicate soft tissue samples. They provide distributed attachment sites across the geometry of the sample for uniform attachment and deformation across the sample edges. The sharp rakes will not damage fragile samples.

Testing

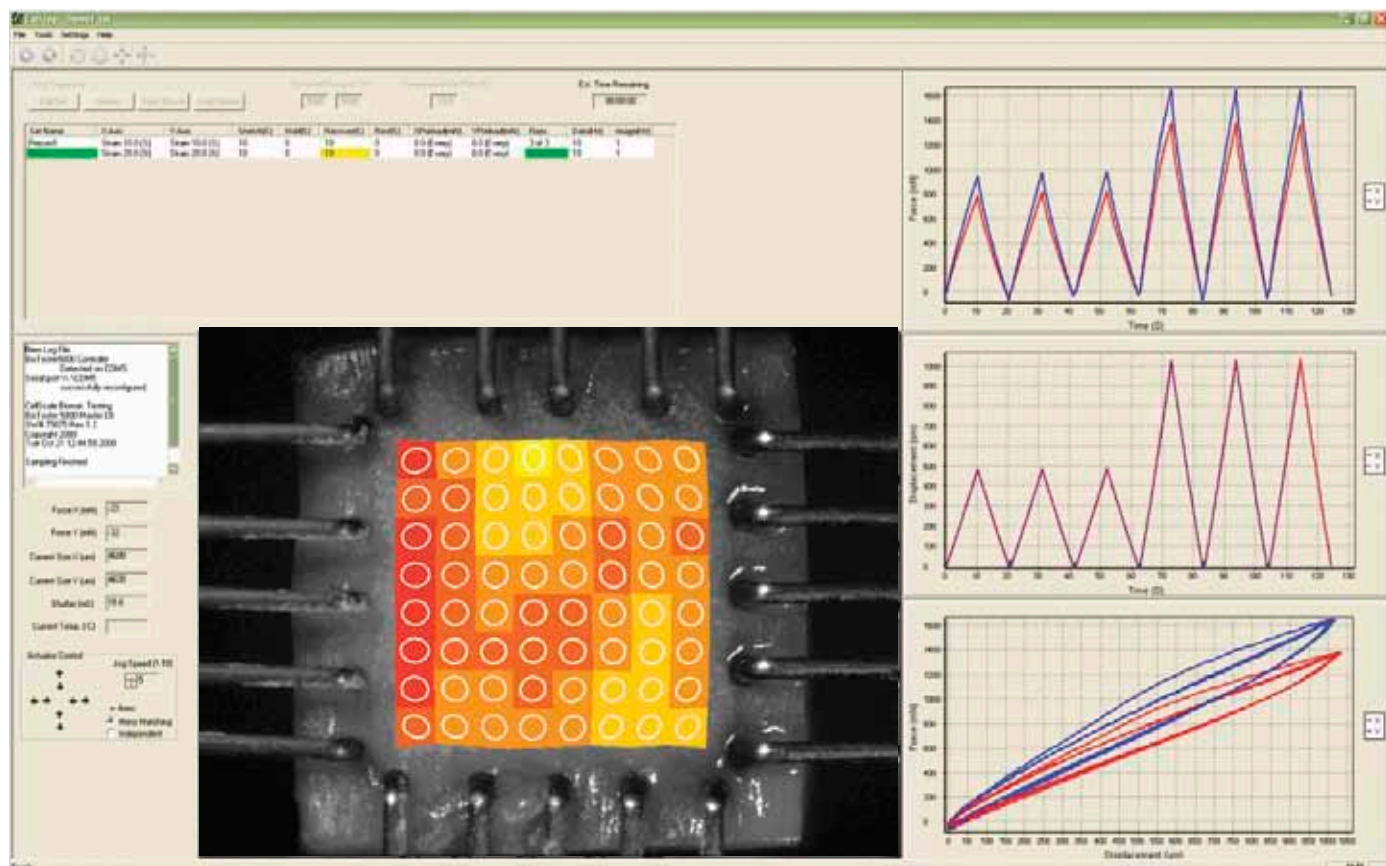
BioTester 5000 is easy to operate. To conduct a test:

1. Choose a template or set up a protocol.
2. Use the BioRakes to attach the specimen to the automatically positioned tungsten rakes.
3. Click **Start Test**.

Software

The software features a user-friendly interface with live data graphing and imaging. The menu-driven setup offers a virtually limitless number of test stages and duration combinations. Previously used tests and templates can be easily edited for quick test designs. Live test status and data graphing provides real-time data monitoring. Analysis data can be easily exported to spreadsheets or other scientific modeling software.

Image analysis software is provided with the BioTester5000 to deliver synchronized data, image and video management. Image features are easily tracked and synchronized to measured data and export to spreadsheets or other scientific analysis software. Images are available as JPG or AVI files for presentation and import into other image processing applications.



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Myobath II

Multi-Channel Tissue Bath System

System Overview

For more than 100 years pharmacologists and physiologists have been studying cardiac and smooth muscle in tissue baths. WPI's multi-channel isolated tissue bath system was developed over a period of several years in collaboration with top cardiovascular research scientists. The result is a feature packed, cost-effective system for the *in vitro* study of vascular and non-vascular smooth muscle. Tissue holders are also available for cardiac muscle and other tissue preparations.

The Myobath is available in 2-, 4- and 8-channel configurations. Its modular design allows up to four individually mounted baths to be studied simultaneously. Multiple systems can be linked together if more bath setups are required. The convenient compact bench-top design of Myobath II enables the system to be readily located even in tight quarters. WPI's Custom tailored systems are sold complete with every hook, every hanger and all of the tubing and fittings you need to get right to work. We provide well documented, clear assembly/operation instructions and free telephone support in case you encounter a problem.



SYSTEMS

MYOBATHII-2 Myobath II, 2-channel (choose 2 each – baths, positioners, tissue holders – from tables on following pages)

MYOBATHII-4 Myobath II, 4-channel (choose 4 each – baths, positioners, tissue holders – from tables on following pages)

MYOBATHII-8 Myobath II, 8-channel (choose 8 each – baths, positioners, tissue holders – from tables on following pages)

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Stands and clamps

The skeleton of WPI's tissue bath system is constructed of a system of bases, rods and clamps. The modular design allows systems of almost any number of baths to be created and, systems can be expanded at a later date. The base system is comprised of a weighted base, four steel rods, a stabilizing bar and a jacketed 1-liter perfusate reservoir with stand and support.



Tissue Bath

WPI offers five different tissue baths: 2 mL, 5 mL, 10 mL, 25 mL, and 50 mL. This range is sufficient to cover a broad variety of applications including those involving smaller vessels and tissues from mice or other small animals.

Each tissue bath has 6 ports. The baths are jacketed to maintain the temperature of the perfusate in the center well. The jacket has an inlet and an outlet. A separate inlet with a ceramic frit is used to aerate the perfusate. The frit is designed to produce smaller bubbles that are less prone to strike the tissue or supporting hangers hard enough to cause a perturbation in the force signal. The bath is also provided with a drain port at the bottom of the chamber, an overflow port and a fill port positioned at the top. The overflow insures that perfusate delivered into the bath will not overflow the chamber and contaminate the work surface. It is also critical for automated fill and drain operations using the optional valve bank and valve controller.

Tissue Baths

	Volume (mL)	ID (mm)	Depth (mm)	Real Volume (mL)
47262	2	12.1	33.65	3.87
47263	5	15.7	39.7	7.68
47264	10	20	42	13.19
47265	25	26	49	26.00
47266	50	32	66	53.05

Micrometer Positioner/Tensioner

The optional Micrometer Transducer Positioner (#47700) can be used to precisely tension tissues and keep track of the exact position or extension of the tissue.



POSITIONERS

47700 Micrometer Positioner/Tensioner



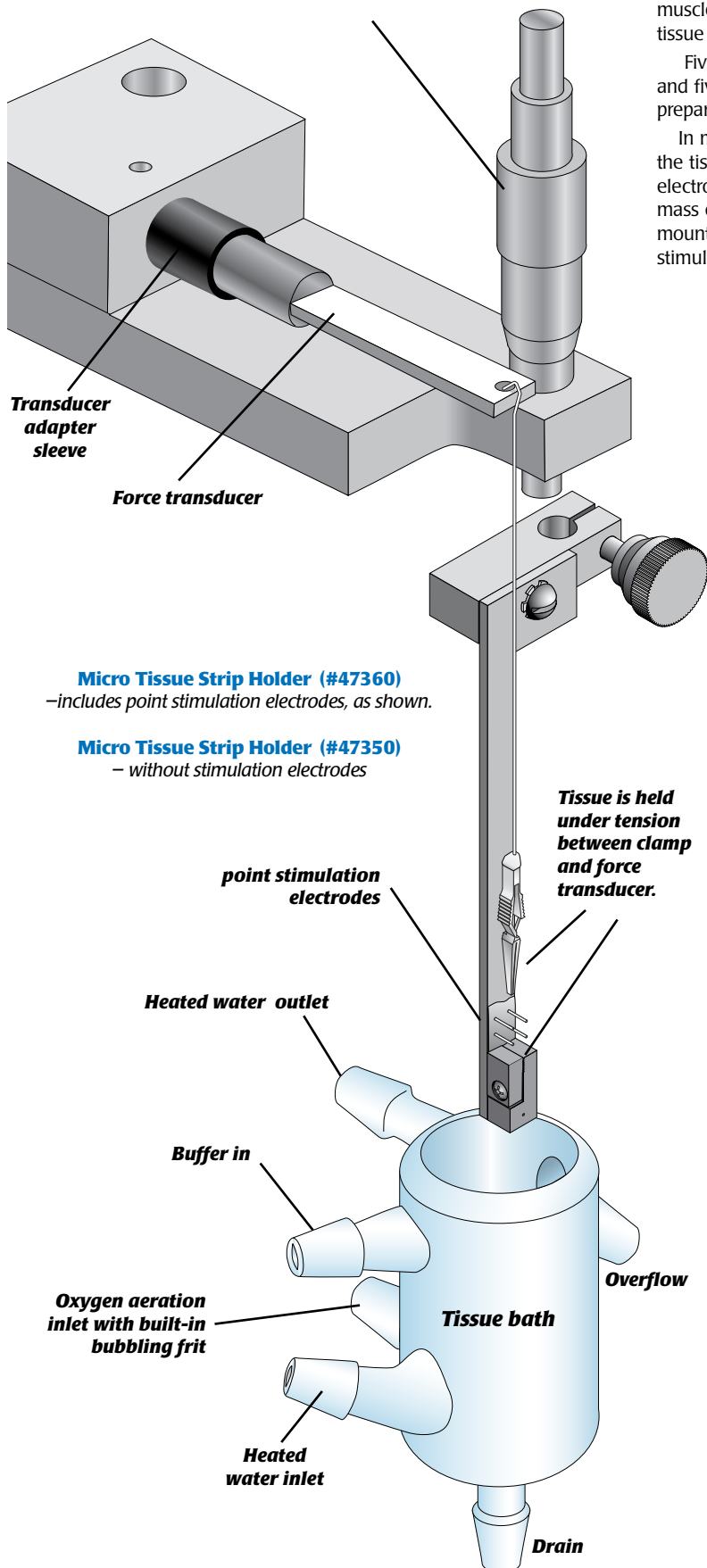
Aeration

A 6-channel aeration manifold, designed to regulate the flow of O₂/CO₂ mixtures, is mounted on the top of the center stainless steel post. Four regulators (needle valves) are used to regulate the flow of O₂/CO₂ to each individual tissue bath. The remaining two regulators are used to supply O₂/CO₂ to the buffer reservoir and dissection dish. The buffer reservoir holds warmed, oxygenated buffer solution to fill the tissue baths. The tissue baths and the buffer reservoir are jacketed and require a heating and circulating pump to maintain the desired temperature (e.g., WPI #500787).

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Micrometer allows fine adjustment (0.01-mm) of tension on tissue sample.



Micro Tissue Strip Holder (#47360)
– includes point stimulation electrodes, as shown.

Micro Tissue Strip Holder (#47350)
– without stimulation electrodes

Tissue is held under tension between clamp and force transducer.

point stimulation electrodes

Heated water outlet

Buffer in

Oxygen aeration inlet with built-in bubbling frit

Heated water inlet

Tissue bath

Overflow

Drain

Tissue Holders

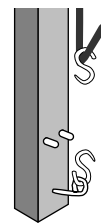
The devices that actually hold tissue for experimentation in a tissue bath are critical to success. They need to be robust, appropriately sized and well thought out in terms of the attachment to the tissue. Since many different sizes and types of tissue can be used in the study of smooth muscle, variety is also critical. WPI offers 10 different application specific tissue support devices.

Five types of tissue holders are available for 10-50 mL organ baths and five types of Miniature Tissue Holders are available for smaller tissue preparations.

In many applications it is desirable to deliver electrical stimulation to the tissue. WPI offers a series of tissue holders with built in stimulation electrodes. Connection to the stimulation device is accomplished with low mass connectors and wire. These ultimately connect to BNC connectors mounted in the stabilizing part of the frame. Connections to isolators or stimulators can then be made with standard coaxial cables.

Atria Holder with Stimulation (#47250)

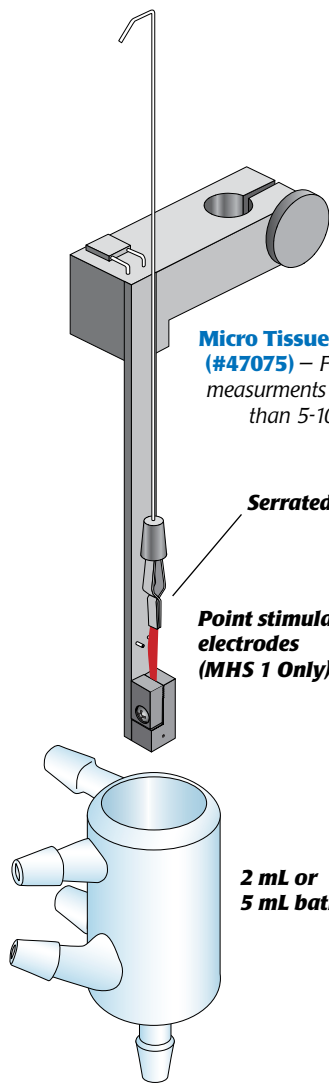
The AS holder is used for mounting atrial muscle preparations. This holder is equipped with stimulation electrodes. The tissue is mounted onto the two S-shaped hooks (made from 30 gauge needles). The S-hooks measure 2 mm in diameter on both ends with a sharp tip on one end where tissue is pieced. The two point stimulation platinum (Pt) electrodes on the holder are 2.54 mm (0.1 in.) apart.



Vascular Holder with Stimulation (#47050)

The VS holder uses the same tissue-mounting mechanism as the V holder, but has two 5 mm flexible platinum stimulation electrodes, which can be positioned around the tissue. The VS holder can only be used in the 25 mL or 50 mL baths.



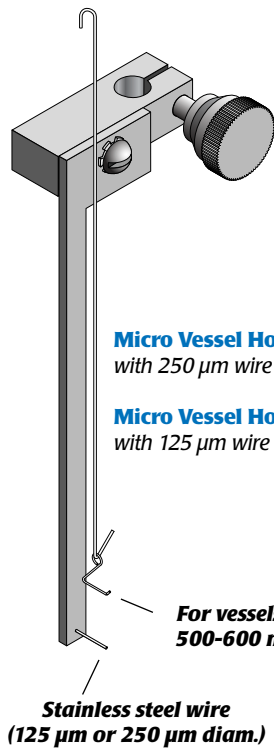


Micro Tissue Holder (#47075) – For force measurements smaller than 5-10 g

Serrated clamp

Point stimulation electrodes (MHS 1 Only)

2 mL or 5 mL baths

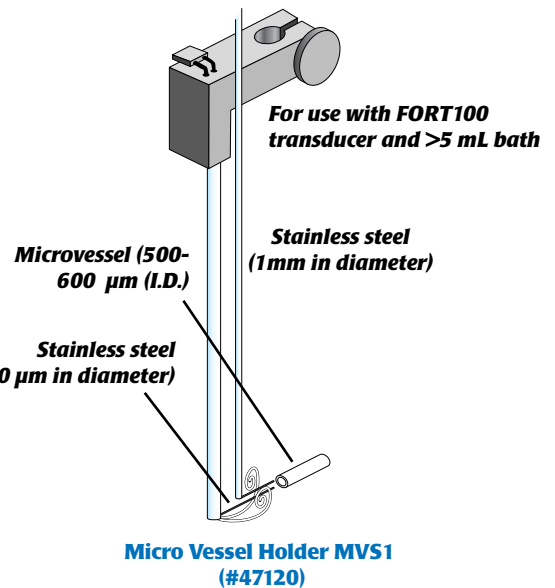


Micro Vessel Holder (#47330) with 250 µm wire

Micro Vessel Holder (#47310) with 125 µm wire

For vessels as small as 500-600 microns (I.D.)

Stainless steel wire (125 µm or 250 µm diam.)



For use with FORT100 transducer and >5 mL bath

Stainless steel (1mm in diameter)

Microvessel (500-600 µm (I.D.))

Stainless steel (250 µm in diameter)

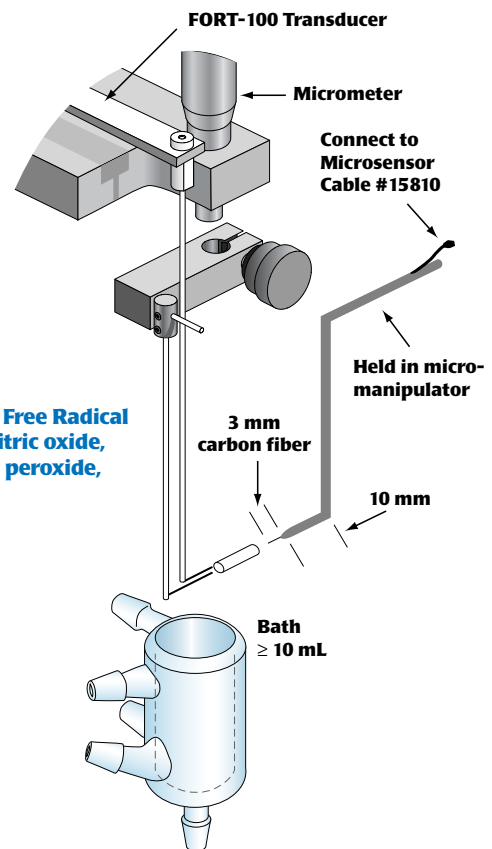
Micro Vessel Holder MVS1 (#47120)

Micro Tissue Holders

With the wide use of transgenic mice in studies of this kind, the need for tissue support mechanisms capable of handling the extremely small size of vessels and muscle strips harvested from small animals is paramount. WPI offers five micro-tissue holders for use with micro tissue strips, micro vessels and other tissues where the force measurements are less than 10 g.

Micro tissue holders are designed to be used with the 2 mL and 5 mL volume tissue baths and FORT 25 transducer. Microtissue Holders #47350 and #47360 are designed for muscle strips as small as 0.5 mm in width and 5 mm in length. The muscle strip is held between two miniature vessel clips with a clamping pressure of 60 grams. These holders are most suitable for measuring isometric force of less than 5-10 grams. #47360 differs from #47350 only in that it has an in-built stimulation circuit and electrodes.

Micro Vessel Holders #47330, #47120 and #47130 require a tissue bath larger than 5 mL and the use of FORT 25 or comparable transducer. These holders are designed for studying tension in vascular rings. When used with the micrometer driven tensioner/positioner they can also be used for measuring the lumen diameter of vessel preparations. The #47330 and #47120 can be used for micro vessel preparations as small as 500-600 microns (ID). #47130 is designed for larger vessels (> 2 mm ID). #47120 and #47130 feature specially designed spiral stimulation electrodes fabricated from 250-micron diameter platinum wire. The two-and-a-half turns of each spiral electrode span appropriately 4-5 mm. The positions of the spiral electrodes can be adjusted with respect to the tissue placement, a feature that is very useful in controlling stimulus intensity.



L-Shaped Free Radical Sensor (nitric oxide, hydrogen peroxide, oxygen)

FORT-100 Transducer

Micrometer

Connect to Microsensor Cable #15810

Held in micro-manipulator

3 mm carbon fiber

10 mm

Bath ≥ 10 mL

HOLDERS & HOOKS

47050	Vascular Hook with Stimulation Style VS
47250	Atria Holder with Stimulation Style AS
47330	Micro Vessel Holder
47120	Micro Vessel Holder with stimulation – Style MVS1
47350	Micro Tissue Strip Holder Style MH1
47360	Micro Tissue Strip Holder with Stimulation – Style MHS1
47125-6	Transducer Hook for use with 47330 Tissue Holder
47126-12	Triangular Tissue Hook, pack of 12
47034-24	S-shaped Tissue Hook, pack of 24



Transducers

FORT25, FORT10g

The rigid-lever force transducers transform applied force into proportional voltage. Using balanced strain gauges, FORT transducers produce linear output voltage vs. applied force input with very little deflection. The MYOBATH II system is designed to use together with WPI's force transducers, including the **FORT100** (100 g full scale), **FORT25** (25g full scale), and **FORT10g** (10g full scale). These transducers can be directly connected to either the 4-channel **Transbridge™** amplifier or the more advanced 8-channel **Bridge8** amplifier. Bridge8 is the preferred amplifier for small vessel applications because it provides additional noise filtration (0.03-10Hz). In this way, the noise produced by increased sensitivity of the FORT10g or FORT25 transducer can be significantly attenuated.

FORT10-100

The FORT10-100 is a high sensitivity dual-range research grade force transducer designed to measure forces in the 0.005 to 10 gram and 0 to 100 gram ranges. FORT10-100 exhibits excellent isometric properties. In addition, its unique optical technology makes it resistant to drift and offers intrinsically low noise characteristics. FORT10-100's on-board amplifiers reduce gain and adjustment requirements on recording amplifiers to which it may be connected.



Grass/Narco/Kent/Harvard

WPI positioners, baths, amplifiers, and data systems are completely compatible with sensors from Grass, Narco, Kent and Harvard.

Amplifiers



Transbridge

All of the transducers above can be directly connected to the 4-channel Transbridge™ amplifier. This basic device offers 4 channels of variable gain transducer conditioning. Each channel has x1 x10 x100 and x1000 gain and offset control. Bandwidth is fixed at 1kHz.

Bridge 8/IsoDam Rack



Bridge8 is the preferred amplifier system for microvessel applications because it provides additional signal filtration (0.03-10Hz). In this way, the noise produced by more sensitive transducers such as the fort 25 can be significantly attenuated.

Data Systems

Hardware – Lab-Trax

Although the WPI tissue bath can be configured to work with any data acquisition system, WPI's **Lab-Trax** is the preferred recording platform. Each channel in the Lab-Trax contains its own 24-bit analog-to-digital converter, an independent stimulator output and a built-in variable gain bridge amplifier. In addition, 8 programmable digital outputs are provided. These are easily configured and are used to control the automated filling and draining of individual baths. By combining all



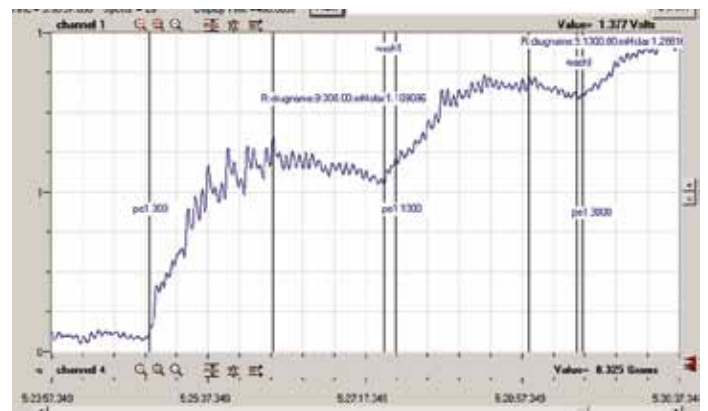
of these functions into a 4- or 8-channel device, cost goes down and performance goes up. The low-profile box fits virtually anywhere and because all functions are integrated into the same instrument, system noise is low – and best of all, the wiring hookup is reduced to plugging in transducers and power. The bundled **Data-Trax** software includes dose response software that can manage multiple runs, calculate ED-50 and draw Schild plots.

Software – Data-Trax

Although the bundled Data-Trax software can be seen as a general purpose digital chart recorder, there are many features that make recording and analysis of isolated tissue bath data easier and less time consuming.

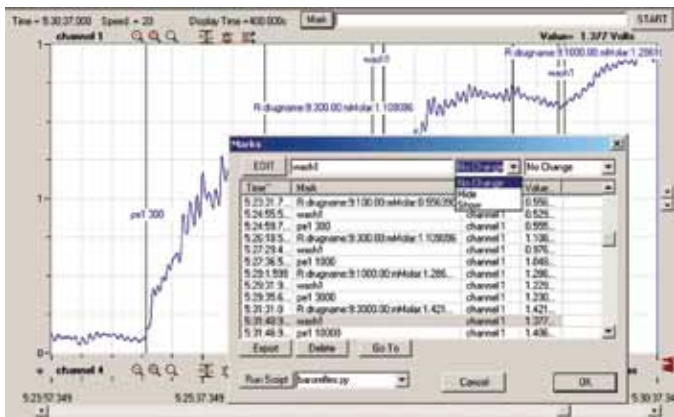
The Data-Trax software allows you to easily convert voltage to real units, such as grams or mmHg. The display allows you to toggle between a preferred y-axis scaling (between 0 and 6 grams, for example) and the “best view” as determined by the AutoScale feature. Alternately, you can zoom-in or zoom-out by factors of two with a single mouse click. In a similar fashion, x-axis scaling can be expanded or compressed by factors of two with a single click. Where multiple channels are being viewed simultaneously the user can define additional “Views” of the data. For example in addition to the main or default display showing all channels, the user might create additional views, each showing only a few channels to allow a better online presentation of the data

While recording, you can mark your data with text messages. These marks are searchable, and appear in the field of data to which they apply. Marks are time locked to the record and can be used to “Go To” any marked region of the data. They are also used post recording by the DOSE RESPONSE software to calculate ED50 values and Draw Schild plots.

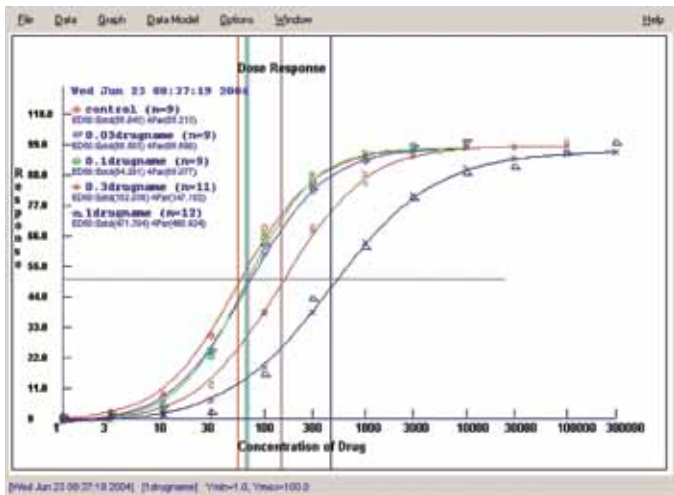


Record dose response.

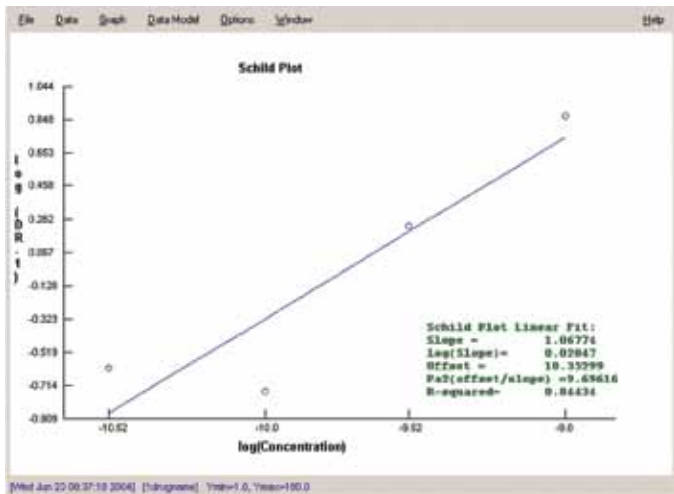
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Automark and extract maximum response values.



Use a custom script to build dose response graphs ...



... and Schild plots.

Data-Trax also controls the built in stimulator in The WPI-118 and T-series recorders. Pulse protocols can be created in advance, stored and delivered automatically or on command. Pulse durations, frequencies and amplitudes can be changed as the protocol is being delivered. The software also offers full control of digital I/O lines that can be used to count events, or control devices in the lab environment such as valves or injectors. Using WPI's AUTODRAIN together with the Data-Trax protocol generator, the entire process of draining, filling, and drug delivery can be automated.

ABE

The dose response software provided is based on ABE, an open source freeware Module written by Gordon Webster. The package as provided has been modified to accept Data Trax formatted data and provide a smooth transition from recording to analysis

ABE is written in Python 2.2 and uses the Tkinter graphic library to generate a friendly graphical user interface (GUI) for manipulating and visualizing the data.

For the data modeling, ABE uses the nonlinear regression routines from the Scientific Python (SciPy) and Numeric libraries as well as the polyfit function from Raymond Hettingers Public Domain Matfunc module for computing the fitted polynomial coefficients from the supplied data. Functions for computing the derivatives of the fitted polynomials, solving polynomial roots and estimating the initial parameters for the nonlinear regression were added by the author and are included in the body of the main Abe module. In addition to the libraries of the standard Python distribution therefore, only the SciPy, Numeric and Matfunc modules need to be included in the Python path for ABE to be run. These are provided on the Data-Trax install disk

Options

Heating Circulator

Ideal for controlling temperatures of external systems. This heating circulator features a polyphenyleneoxide (PPO) construction with a powerful 17 liter per minute flow rate pump for optimum heat exchange with a 12 mm hose. The working temperature range is 25-100°C. A tap water cooling coil (with a working temperature range of 20-100°C) is fitted as a standard feature. The unit comes with a stainless steel cover. The 115 V model is equipped with a 1200-watt heater and the 230 V model comes with a 2000-watt heater.

The bath has a volume of 5 liters and an opening of 13 x 17 x 16 cm. The overall dimensions of the unit are 16 x 33 x 36 cm. Shipping weight: 22 lb (10 kg).

Menu-driven control module allows easy temperature setting, correction and display. Temperature accuracy of $\pm 0.02^\circ\text{C}$.

Heated bath inflow and outflow

Fluid ports for external cooling

Stainless steel bath cover

Bath made from polyphenylene oxide (PPO)



500787	Haake DC10-P5/U Circulating Bath (115 V)
500788	Haake DC10-P5/U Circulating Bath (230 V)
500789	Haake DC10-P5/U Circulating Bath (100 V)

Ussing System

For electrophysiological investigation of epithelial transport

- **Direct connect low-resistance electrodes**
- **Simplified operation, easy to control temperature and clean after use**
- **Luer type leak-free attachment of tubing and electrodes**
- **Recessed electrode ports to avoid air bubble formation**
- **Secure membrane holding by sharp stainless steel pins or O-ring**
- **Specialized chamber adapts cell culture insert (Costar Snapwell) for monolayer cell culture**
- **Chambers with rectangular openings for tubular tissues from small animals**

WPI's Ussing System offers researchers a quick, effective means of making low-resistance electrical connections to the Ussing chamber without need of long agar bridges or Calomel half-cells. Ag/AgCl half-cells screw into short tubes which plug firmly into place in the chamber's luer ports. These direct-connect electrodes eliminate the inconvenience and expense of Calomel half-cells in open liquids. The System includes one Ussing Chamber (eight sizes available), Support Stand, Electrode Kit, Glass Circulation Reservoir (two sizes available), and a Tubing start-up kit (25 feet of 0.375-in. tubing, 10 feet of 0.156-in. tubing, plus four male luer fittings, two compressor clamps, one Y-connector, and one clip). Sixteen possible system configurations are listed at right. Components are also available separately. (Preamplifier in photo not included.)

Ussing Chambers

WPI's classical Ussing Chambers are well established perfusion chambers that are easy to operate, easy to control temperature, and easy to clean after use. Hundreds of them are used daily by scientists in the field. Ussing Chambers are machined from solid acrylic with eight entry ports for fluid lines, electrodes, or agar bridges. For easy, leak-free attachment of tubing and electrodes, all eight ports are luer type. The four ports for voltage and current electrodes are recessed to prevent formation of air bubbles in the chamber. The fluid compartments in each side of the chamber are separated by the epithelial membrane being studied. Sharp stainless steel pins on one side of the chamber hold the membrane in position and mate with holes in the opposite chamber interface. (In the CHM4, tissue is held by an O-ring instead of pins.)

The CHM5 chamber adapts the Costar Snapwell, a cell culture insert for monolayer cell culture, into WPI's "classical" epithelial voltage clamp system. Until now, classical Ussing Chambers have not been widely used for monolayer cell culture inserts because most inserts have a very deep profile, limiting good fluid perfusion at the surface of the membrane — and limiting voltage electrodes from measuring the potential close to the surface of the membrane. CHM5 solves these problems: Perfusion fluid is introduced into the chamber at an angle so that it will flow directly to the surface of the membrane. The voltage electrode is also inserted into the chamber at an angle so as to reduce the distance between the surface of the membrane and the electrode.



Complete Ussing System includes stand, glass reservoir, electrodes, Ussing chamber and tubing (EVC3 preamp and ringstand clamp not included—see page 14).

Two small chambers with rectangular openings are designed for tubular tissue from small animals such as the mouse intestinal tract membrane (CHM6) and rat intestinal tract membrane (CHM7). The rectangular opening more closely matches the shape of the tissue than would a circular opening, significantly increasing the membrane area available for testing. The larger membrane area increases the transport rate of low permeability chemicals; it also reduces the electrical resistance of the system for easier current clamping.

Optional Drains

Drains may be added to Ussing chambers to allow quick and complete evacuation of radioactive or toxic substances. To have drains added at the time of order, add a "D" to the part number (such as "USS1LD"); \$100 will be added to the cost of the chamber or system you order.

Cartridge Electrodes

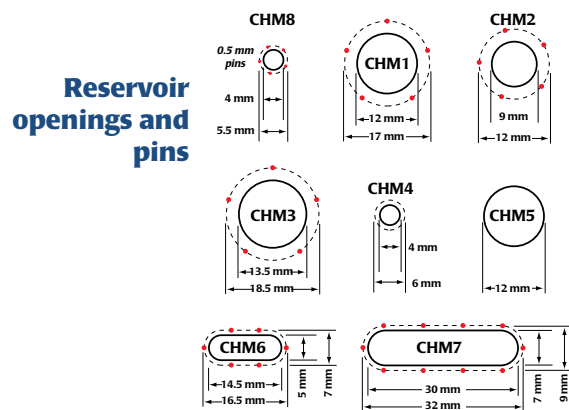
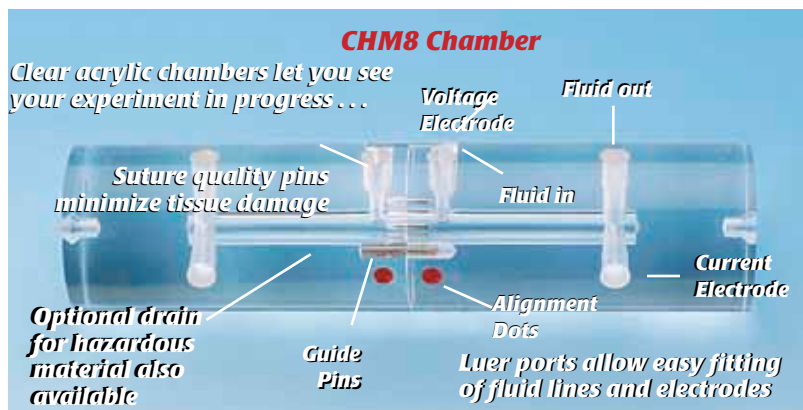
The Electrode Kit contains four voltage/current electrodes, plus four luer-tipped cartridges. Electrodes are threaded and screw securely into the end of each cartridge. The luer tip then plugs securely into the luer openings of the chamber. The cable from each electrode terminates with a 2 mm pin which may be plugged into voltage/current clamps such as WPI's DVC1000 or EVC-4000.



EKV and EKC Cartridge Electrodes

The miniature electrode-gel cartridge is a small plastic tube with a male luer tip identical to those at the tip of hypodermic syringes. The tube may be filled with different gel materials; agar is commonly used but other gel materials may also be satisfactory.

Prices shown are in U.S. dollars. Actual charges will vary because of import duty, freight, and currency fluctuations. To obtain an exact quotation, contact your WPI office.



	CHM1 (Medium)	CHM2 (Small)	CHM3 (Large)	CHM4 (Extra Small)	CHM5 (Snap)	CHM6 (Rect., Small)	CHM7 (Rect., Large)	CHM8 (Extra Small)
Reservoir Opening	12 mm	9 mm	13.5 mm	4 mm	12 mm	5 x 14.5 mm	7 x 30 mm	4 mm
Half-Chamber Volume	1.0 mL	0.75 mL	1.2 mL	0.5 mL	1.7 mL	0.8 mL	5.5 mL	0.5 mL
Pin Circle Diameter	17 mm	12 mm	18.5 mm	6 mm*	N/A	7 x 16.5 mm	9 x 32 mm	5.5 mm

Assembled chambers are 101.6 mm (4 in.) long. *O-ring diam.



Circulation Reservoirs

Hand-blown borosilicate glass, with jacketed chambers for temperature control. Available in two sizes — #5210 holds 20 mL per side, and #5362 (at left) holds 10 mL per side (useful when expensive chemicals are involved). Reservoir condenser caps prevent air bubbles and turbulence in fluid reservoirs.

Water Bath

The Haake DC10-P5/U Constant Temperature Water Bath (see page 73) has been tested at WPI and found to be ideal for WPI's Ussing system. It can provide simultaneous warming for up to 16 systems. Menu-driven control module allows easy temperature setting, correction and display, with temperature accuracy of ± 0.02°C.



USSING SYSTEMS, LARGE RESERVOIR

USS1L	Medium Chamber, Stand, Reservoir, Electrodes, Tubing
USS2L	Small Chamber, Stand, Reservoir, Electrodes, Tubing
USS3L	Large Chamber, Stand, Reservoir, Electrodes, Tubing
USS4L	Extra Small Chamber, Stand, Reservoir, Electrodes, Tubing
USS5L	Snap Chamber, Stand, Reservoir, Electrodes, Tubing
USS6L	Small Rectangular Chamber, Stand, Reservoir, Electrodes, Tubing
USS7L	Large Rectangular Chamber, Stand, Reservoir, Electrodes, Tubing
USS8L	Extra Small Chamber, Stand, Reservoir, Electrodes, Tubing

USSING SYSTEMS, SMALL RESERVOIR

USS1S	Medium Chamber, Stand, Reservoir, Electrodes, Tubing
USS2S	Small Chamber, Stand, Reservoir, Electrodes, Tubing
USS3S	Large Chamber, Stand, Reservoir, Electrodes, Tubing
USS4S	Extra Small Chamber, Stand, Reservoir, Electrodes, Tubing
USS5S	Snap Chamber, Stand, Reservoir, Electrodes, Tubing
USS6S	Small Rectangular Chamber, Stand, Reservoir, Electrodes, Tubing
USS7S	Large Rectangular Chamber, Stand, Reservoir, Electrodes, Tubing
USS8S	Extra Small Chamber, Stand, Reservoir, Electrodes, Tubing

* Add EVC4000 at reduced price when buying Ussing System with equivalent number of channels

EVC4000-1	1-Channel Voltage Clamp & Preamps
EVC4000-2	2-Channel Voltage Clamp & Preamps
EVC4000-3	3-Channel Voltage Clamp & Preamps
EVC4000-4	4-Channel Voltage Clamp & Preamps

System components also available separately:

xxxxD	Drain option (add "D" to part number of chamber or system)
CHM1	Medium Chamber
CHM2	Small Chamber
CHM3	Large Chamber
CHM4	Extra Small Chamber with O-Ring Seal
CHM5	Snap Chamber (fits Costar Snapwell cups)
CHM6	Small Rectangular Chamber
CHM7	Large Rectangular Chamber
CHM8	Extra Small Chamber with Mounting Pins
EK1	Ussing Electrode Kit (2 voltage, 2 current)
EKC	Extra Ussing Current Electrode (red) (each)
EKV	Extra Ussing Voltage Electrode (blue) (each)
5210	Large Glass Circulation Reservoir, (20 mL per side)
5233	Replacement Condenser for 5210
5362	Small Glass Circulation Reservoir, (10 mL per side)
5361	Replacement Condenser for 5362
3955	EKV Cartridges, 35 mm (pkg of 12)
3960	EKC Cartridges, 58 mm (pkg of 12)
3669	Tubing Kit (flexible hose and luer fittings)
3579-20	Replacement luer fittings for tubing connections (pkg of 20)
5153	Support Stand

Prices shown are in U.S. dollars. Actual charges will vary because of import duty, freight, and currency fluctuations. To obtain an exact quotation, contact your WPI office.

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Vibroslice™

An economical, easy-to-use precision microtome for preparing live tissue sections for physiological, pharmacological and biochemical research

Blade speed up to 4500 rpm

Sensitive parts sealed to avoid damage from spillage

Removable molded top cover for easy maintenance

Advance speed as low as 0.07 mm/sec

Blade angle variable through 90 degrees from horizontal to vertical



NVSL (manual)



Model NVSL offers a manual advance for positioning the specimen holder and bath chamber. Sample positioning on Model NVSLM1 is motorized. Other features include independent, removable specimen holder and bath chamber, variable advance speed and hands-free operation via a footswitch.



NVSLM1 (motorized)



NVSL & NVSLM1 SPECIFICATIONS

SECTION THICKNESS	
MINIMUM	20 µm (fixed tissue) 50 µm (fresh tissue)
MAXIMUM	700 µm
STEP SIZE	5 µm
CHAMBER	
DIMENSIONS	2 ¹ / ₈ × 3 ¹ / ₄ × 1 ¹ / ₄ in. (55 × 82 × 31 mm)
VOLUME	8.5 cu. in. (140 mL)
BATH	
ADVANCE SPEED	0.07 to 1.6 mm/s (NVSLM1) (continuously variable)
REVERSE SPEED	4 mm/s (NVSLM1)
VIBRATION	
SPEED	60 to 4500 rpm
AMPLITUDE	1 mm (approx.)
POWER	95-135 V, 50/60 Hz, or 220-240 V, 50/60 Hz
SHIPPING WEIGHT	19 lb (8.6 kg)

Vibroslice uses a vibrating blade to slice tissues without the trauma produced by other methods. Live brain or other tissues can be cut into slices 50- to 700-microns thick. Fixed tissues can be cut down to 20-micron slices (these need not be embedded or frozen). Particularly useful for improving the access for certain histological reagents (e.g., during processing for horseradish peroxidase).

The blade has a lateral displacement of about 1 mm, and its oscillating frequency may be varied between 60 and 4500 rpm. This allows you to achieve clean cuts in tissues of different mechanical consistencies.

SYS-NVSL	Manual Vibroslice
SYS-NVSLM1	Motorized Vibroslice

Specify line voltage

OPTIONAL ACCESSORIES

VSLM1H	Spare Specimen Holder
VSLM1C	Spare Bath Chamber
5450	Replacement Belts for NVSL (2)
5451	Replacement Belts for NVSLM1 (4)
BLADES	Blades, Single Edge (100)
7600	Temperature Controller, Standard Power
7600S	Temperature Controller, High Performance
503566	Footswitch for NVSLM1

See adhesives, in Lab Supplies section. See Cidex, in Microsurgery section.

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Tissue Bath Coolers for Vibroslice



thermoelectric elements in the base of the tissue bath. These act as energy transfer units so that heat is drawn off through the heat exchanger and removed by tap water flow. The unit uses P.I.D. (proportional integral derivative) temperature control to take the bath temperature to within 0.5°C at the point of measurement. The temperature feedback thermistor is located in the bath floor and software calculates an offset automatically.

Immediate cooling of the tissue prevents anoxia by lowering the oxygen demand. Once removed from the animal tissue should be immediately place in cooled saline or sucrose buffer before mounting in the tissue bath. (See adhesives, pages 154-156.)

Once removed from the animal, tissue must be immediately cooled to lower the oxygen demand and prevent anoxia. Holding the tissue close to 4°C must continue throughout the slicing procedure. This can be done with passive cooling where a known amount of ice is used to maintain the cooled a.c.s.f. or with an electronically controlled Tissue Bath Cooler.

The control unit supplies power to the Peltier

7600	Controller & Standard Tissue Bath Cooler (A)
7600S	Controller & Autoclavable Tissue Bath Cooler (B)

MODEL 7600 SPECIFICATIONS

DISPLAY RESOLUTION:	0.1 °C
TEMP. ACCURACY:	+/- 1 °C
TEMPERATURE RANGE:	+8°C to 0°C <i>(Note that the actual temperatures achievable will be dependent upon the solutions used and local temperature conditions)</i>
VOLTAGE REQUIREMENTS:	230V 50Hz or 115V 60Hz
POWER RATING:	60W
INLET FUSE RATING:	2A



- Large, stable base
- Hardened blades for long service
- Ambidextrous configuration

Rodent Guillotine

The small animal guillotine has been completely redesigned for ease of use and extra added safety features. The blades are drawn together by magnetic force to ensure a clean and precise cut through very strong bones and skin.

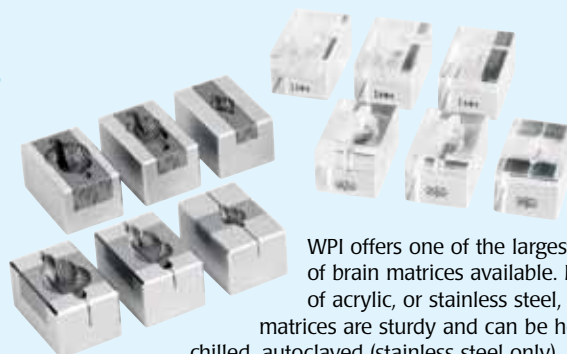
There is a large base for stability, long handle for extra leverage, spring action so the blades can not fall down unexpectedly, hardened stainless blades for endurance, simplified construction for easy maintenance. The fluoropolymer coated surface on the base makes cleaning easy.

The guillotine is considered one of the most humane methods to dispense with a subject.

DCAP	Guillotine for Rodents and other small animals (opening 1.5 x 1.5 in.)
DCAP-M	Guillotine for large rodents and other medium animals (opening 2.5 x 2.5 in.)
DCAP-L	Guillotine for larger animals (opening 4 x 4 in.)

Rodent Brain Matrices

RBMA-200C	Adult mouse, coronal slices, acrylic
RBMA-200S	Adult mouse, sagittal slices, acrylic
RBMA-300C	Rat, 175-300g, coronal slices, acrylic
RBMA-300S	Rat, 175-300g, sagittal slices, acrylic
RBMA-600C	Rat, 300g-600g, coronal slices, acrylic
RBMA-600S	Rat, 300g-600g, sagittal slices, acrylic
RBMS-200C	Adult mouse, coronal slices, stainless steel
RBMS-200S	Adult mouse, sagittal slices, stainless steel
RBMS-300C	Rat, 175-300g, coronal slices, stainless steel
RBMS-300S	Rat, 175-300g, sagittal slices, stainless steel
RBMS-600C	Rat, 300g-600g, coronal slices, stainless steel
RBMS-600S	Rat, 300g-600g, sagittal slices, stainless steel
BLADES	Single-Edge Blades (pkg of 100)



WPI offers one of the largest selections of brain matrices available. Made of acrylic, or stainless steel, these matrices are sturdy and can be heated, chilled, autoclaved (stainless steel only), scrubbed — and stand up to rigorous daily use. Coronal matrices have the additional feature of a mid-line sagittal cut to facilitate splitting of the left and right hemispheres. Sections can be as fine as 1-mm. The olfactory/spinal/notch is cut into each matrix.

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FluoroDish™

Cover-glass bottom for observing and growing cells in imaging related research

- **Optical quality glass bottom for better imaging quality (RI=1.525)**
- **Low sample volume for expensive chemicals**
- **Lowest access angle for micropipette**
- **Low toxicity adhesive for embryo research**



WPI's **FluoroDish™** tissue culture dishes are now available in a larger range of sizes and coatings. These polycarbonate dishes provide exceptional imaging quality for many applications requiring the use of inverted microscopes such as high resolution image analysis, microinjection and electrophysical recording of fluorescent-tagged cells. Taking advantage of WPI's extensive experience with low toxicity adhesives, FluoroDish uses a specially formulated adhesive that is optically clear, durable and with extremely low toxicity. Tests by an independent laboratory have shown that the 96-hour surviving rate of embryos is 100% when kept in FluoroDish, substantially better than some other brands. The bottom glass has superior UV transmission (30% transmission at 300 nm, compared to less than 7% for the most popular German glass). Stringent quality control ensures that glass thickness stays within the 0.17 ±0.01 mm range.

Conventional plastic dishes and chambers limit the utility of the inverted scope for many applications because the thick plastic bottom requires a long working distance objective available only in lower magnifications. Each WPI dish has a flat (0.17 mm thick) optical quality glass bottom, allowing the use of a much shorter objective working distance, larger numerical aperture (NA), and a higher magnification (up to 100x). The larger NA and higher magnification provide superior quality imaging for both classical and fluorescence microscopy. Higher effective NA yields

brighter images for fluorescence and higher resolution in Image Analysis. The glass bottom permits the use of immersion objectives with medium such as water, glycerin or oil for the highest magnification possible. To optimize heat-exchange, WPI's glass-bottom dish is designed to be flush (flat) with the microscope stage or heating unit, therefore eliminating the air gap that exists with modified plastic dishes in which a glass cover slip has been inserted.

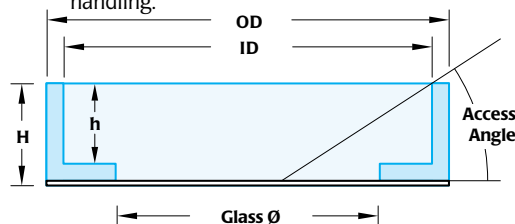
Three different sizes of FluoroDish are offered, one type of 50 mm diameter dish and two types of 35 mm diameter dishes. An inner well is created within the dish by the glass bottom and the tissue culture grade polystyrene which forms the sides of the dish. All WPI dishes have the advantages of low toxicity and good UV transmission bottom glass. They are individually packed and gamma sterilized.

The 35 mm dish has outside dimensions similar to that of a Corning 35 mm dish and has ø23.5 mm glass window (**FD35**) or ø10 mm glass window (**FD3510**). Most heaters and perfusion adapters designed for the Corning 35 mm dish will also fit this dish. The 23.5 mm glass window dish is available uncoated, poly-D-lysine-coated, or collagen-coated. Certain types of cell lines

(e.g., PC3 and HEK) adhere well to the uncoated glass bottom dish. The poly-D-lysine coating has been reported to improve the adhesion of neuron cells, and type I rat tail collagen has been reported to improve the adhesion of muscle cells. The users can also apply to the uncoated dish any special coating that is best for their cell line.

The 10 mm glass window dish (**FD3510**) has low sidewall for easy microelectrode access and low solution volume. The low microelectrode access angle is the lowest among all of 35 mm dishes on the market (very close that of a 50 mm dish). The dish needs only 100 ~ 200 mL to cover the bottom well, an important feature when using expensive drugs and chemicals.

The 50 mm dish (**FD50**) has a large growth area (35 mm well diameter), a low access angle for microelectrodes, and grips for easy handling.



Part Number	ID (mm)	OD (mm)	Glass Ø (mm)	height (inside)	Height (outside)	Access Angle
FD35	33	35.5	23.5	7.8	9	29°
FD3510	10	35.5	10	1.5	4.65	17°
FD5040	47.5	49.82	35	7.25	7.4	17°

● Choose from poly-D-lysine or collagen coated, or uncoated

FD35-100	FluoroDish Sterile Culture Dish, clear wall, 35 mm, 23 mm well, box of 100
FD35COL-100	FluoroDish Sterile Culture Dish, Collagen Coated, clear wall, 35 mm, 23 mm well, box of 100
FD35PDL-100	FluoroDish Sterile Culture Dish, Poly-D-Lysine Coated, clear wall, 35 mm, 23 mm well, box of 100
FD3510-100	FluoroDish Sterile Culture Dish, clear wall, 35 mm, 10 mm well, low sidewall, box of 100
FD5040-100	FluoroDish Sterile Culture Dish, clear wall, 50 mm, 35 mm well, box of 100

Prices shown are in U.S. dollars. Actual charges will vary because of import duty, freight, and currency fluctuations. To obtain an exact quotation, contact your WPI office.

MPS-2 Multichannel Perfusion System

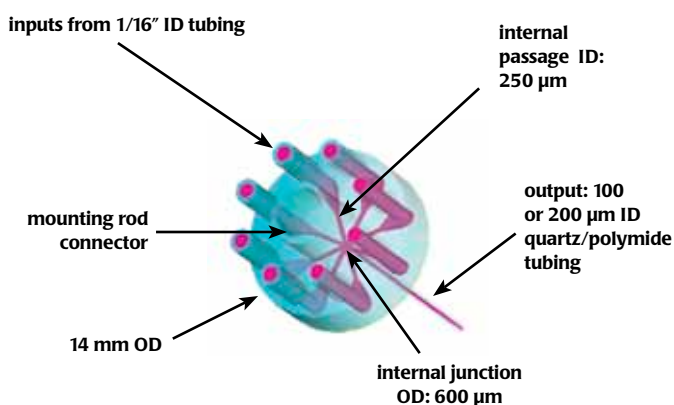
for single ion channel and
whole-cell solution exchange



MPS-2 is a programmable 8-channel perfusion system designed for single channel and whole-cell patch preparations. Offering the best combination of performance and value, the MPS-2 incorporates the same high quality solenoid valves found on similar but much more expensive systems. Unlike other perfusion systems on the market, which often compromise performance to fit every possible application, the MPS-2 is the only perfusion system designed and optimized specifically for single-channel and whole-cell patch perfusion applications.

The system can be controlled manually via membrane switches on the front panel or through a PC. Two different manual control modes are offered. One controls each channel independently and the other mode allows the user to assign a master channel that will keep the system flow when all other channels are switched off. User-friendly graphic timing software is included,

- **Manual or Programmable PC control with user-friendly GUI interface**
- **Fast LAFF solenoid valve**
- **Color-coded polyurethane tubing for easy identification**
- **Super low dead volume (<80 nL) micromanifold**
- **Economically priced**



Micromanifold closeup: Fluid-filled passages are shown in magenta.

and the programmed perfusion sequence can be started by computer, a patch clamp amplifier or other external trigger, or manually by the user

The perfusion fluid flows through specially designed color-coded polyurethane ribbon style tubing. The color-coding allows the user to easily trace each channel for diagnostic checks or set up and the ribbon style of tubing keeps the system very neat and organized. Unlike PVC based tubing, polyurethane tubing contains no plasticizer, which can cause contamination. The tubing ribbon is designed as an economical disposable item, which is often critical when cleanness is needed.

The most unique feature of the MPS-2 is its perfusion micromanifold. Using the latest microfluidic techniques, the injection molded micromanifold provides the least flow resistance and dead volume of any product on the market. The flow channel inner diameter is approximately 1.0 mm, except

for the last 5 mm before the junction point. This design allows a fast flow rate without using a pressured system. The maximum flow rates are 1 and 16 microliter per second for the 15 mm long 100 micrometers and 200 micrometers ID tips, respectively. Small channels and a unique design at the merging point further reduce the chance of cross contamination. Dead volume is less than 80 nL.

MPS-2 Multichannel Perfusion System & Control Software

REPLACEMENT PARTS

502109-15 Color-coded Polyurethane Tubing, 1/16" ID x 8 Channels, 15 ft

502110 Micromanifold, 100 micrometers ID tip, 2 pcs/pk

502125 Micromanifold, 200 micrometers ID tip, 2 pcs/pk

Specify line voltage and Micromanifold tip OD when ordering.

MPS-2 SPECIFICATIONS

Channels	8
Valve Response Time	2 ms
Valve Control	Serial Port, TTL, and Manual
Syringe Reservoir Volume	10 mL
Manifold	8 to 1
Tip ID	200 micron and 100 micron.
Maximum Flow Rates (gravity fed)	100 micrometers ID tip, 60 microliters/min. (equivalent linear speed: 12.7 cm/sec) 200 micrometers ID tip, 960 microliters/min. (equivalent linear speed: 51 cm/sec)
Dead Volume	< 80 nL excluding the single outlet tubing

Prices shown are in U.S. dollars. Actual charges will vary because of import duty, freight, and currency fluctuations. To obtain an exact quotation, contact your WPI office.

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