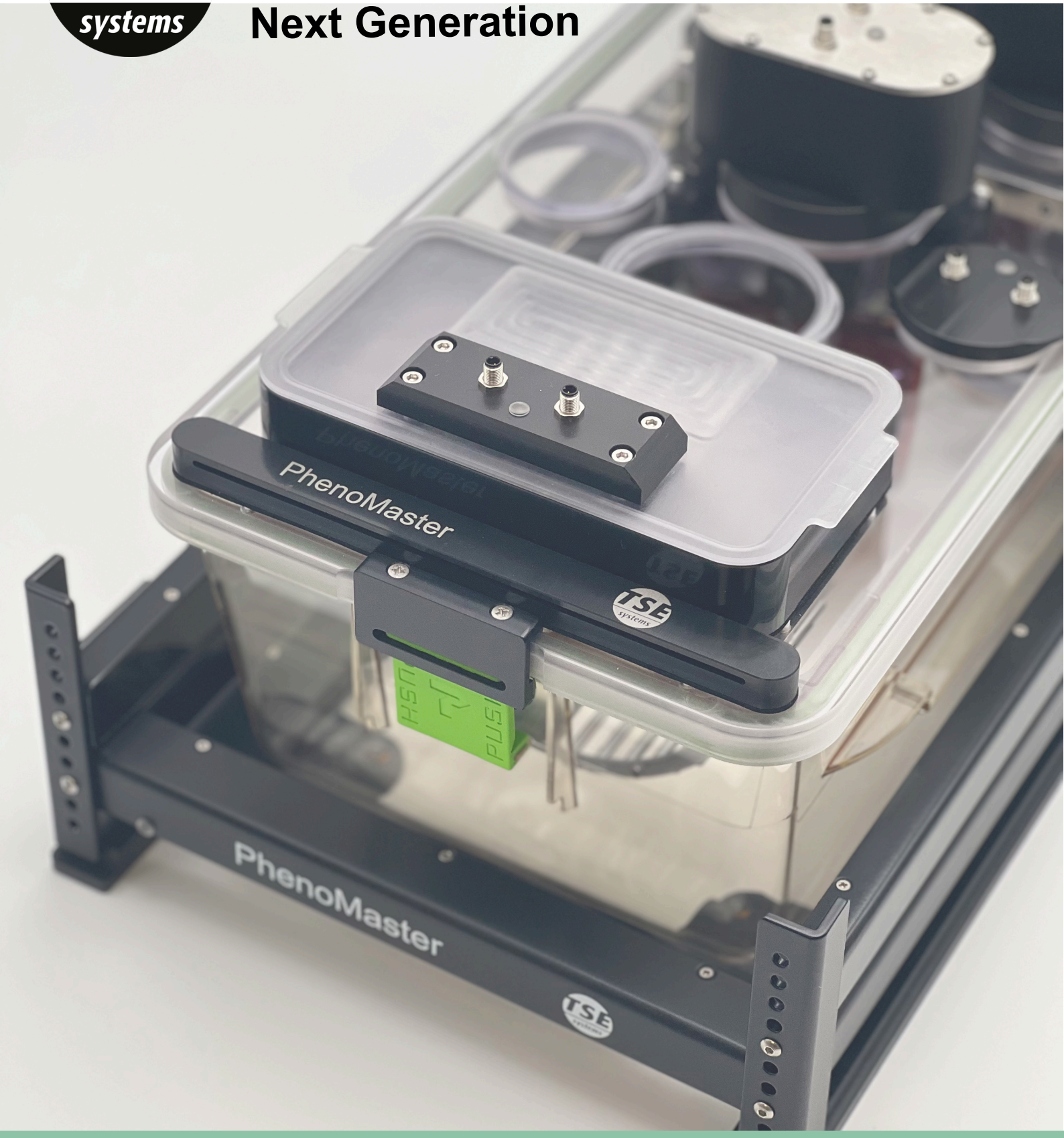
PhenoMaster

Next Generation



Advanced Multipurpose Platform for Rodent Metabolic, Behavioral and Physiological Studies

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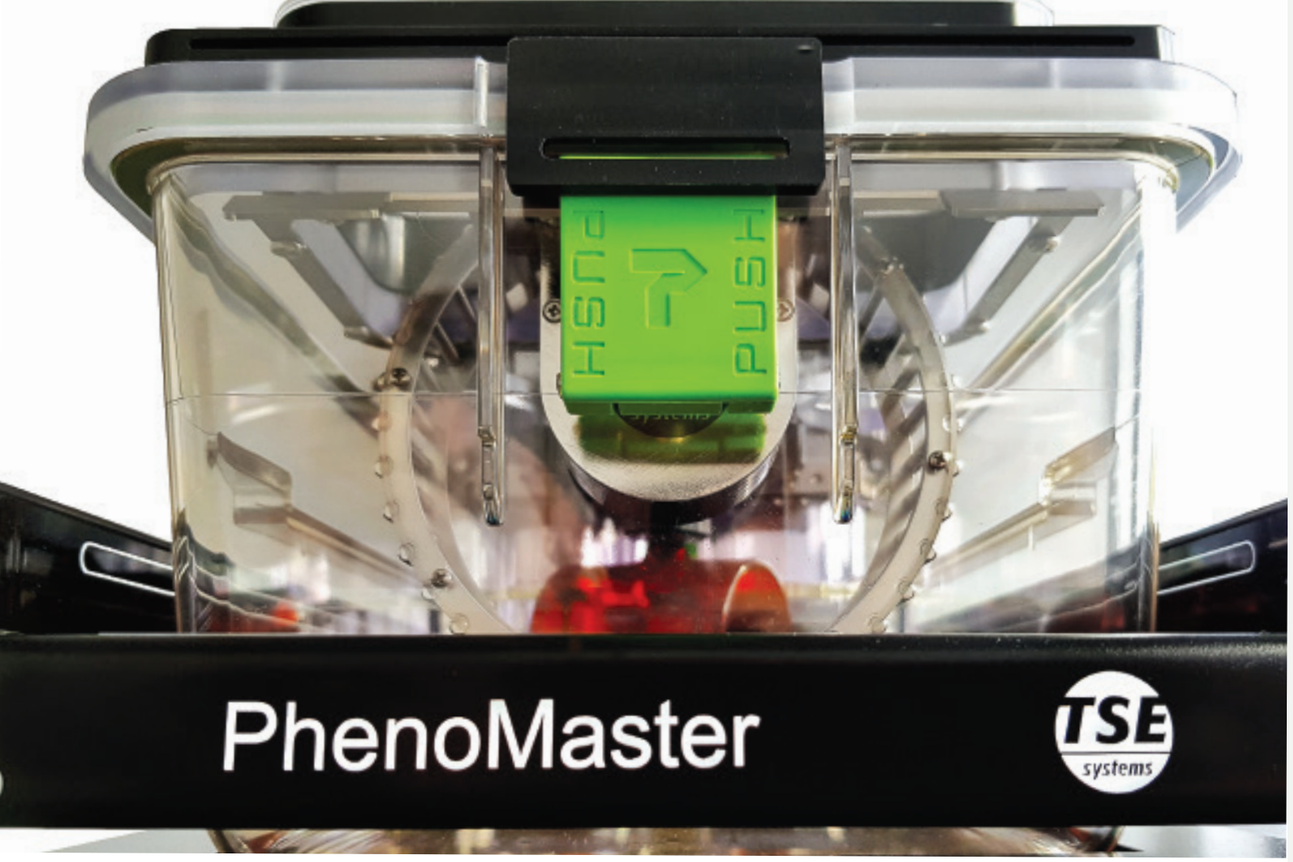


PhenoMaster Next Generation is a groundbreaking home cage system that revolutionizes metabolic, behavioral, and physiological research. Combining the core principles of precision, efficiency, and innovation, this multipurpose platform is unparalleled in accuracy and automation. With detailed data collection and sophisticated analysis, researchers can uncover even mild metabolic effects, leading to new scientific advances.

Designed to increase data throughput and accelerate progress, PhenoMaster allows researchers to perform a high quantity of experiments in less time than offered by other standardized approaches. The system's automated data collection and analysis reduces the need for human intervention, enabling the user to focus on more critical tasks. Additionally, the system's design prioritizes animal welfare and minimizes stressors, which can affect animals directly and indirectly, leading to increase data reliability and provide best ethical research practices.

400+
Systems installed worldwide

#1
Platform for rodent metabolic and behavioral phenotyping

2000+
Citations in scientific publications

At TSE Systems we believe previsioning the future is key to drive innovation. PhenoMaster is designed to stay ahead of the curve, offering unmatched flexibility through a combination of unique modules for your study requirements as they evolve over time.

The highest number of scalable modules that can't be found elsewhere.

Scalable Design

- Indirect Calorimetry
- Feeding, Drinking, Body Weight
- XYZ Activity Frame
- Microbiome Activity Monitoring
- Running Wheel
- Climate Chamber
- Automated Access Control

Unique Features

- Operant Wall
- ISO-cages and Isolators
- Weight Lifting
- Stable Isotope Tracing
- Urine and Feces Collection
- Implantable Telemetry
- Wireless Optogenetics

Flexibility Through Modularity

Smart Cage Architecture

Available for Mice and Rats

Weight Sensors
High-precision sensors, capturing micro events: feeding, drinking and body weight. With onboard 32-bit digitization, linearization, for precise measurement at the highest sampling rate.

Individual Cage Controller
Allows digital communication with the central acquisition computer. For easy changes, expansion of the cage numbers, and quick upgrades.

Cage Lid
Made of transparent components to maximize light influx in the cage and help maintain the animal's normal circadian rhythms. All modules are fixed to the lid for an optimal air-flow through the cage.

Climate Board
Continuously monitors the temperature, ambient pressure, and humidity in the home cage. Can additionally be used to quantify water balance.

Body Weight
Red tubular housing invites animals to rest and sleep. Acts as a cage enrichment and improves animal welfare.

Access Control
An automated door restricts access to food and/or water based on time, amount, or average consumption of individuals and/or control group.



Infrared Activity Frame
5mm physical resolution (1.25mm spatial resolution) for finest locomotor activity analysis at 100Hz sampling rate.

Food Containers
With SpillProtect technology. Available in different configurations for a broad variety of food types.

Running Wheel
Module for activity and exercise monitoring. Available in different configurations: for voluntary, workload and motor skill running, including enable/disable function.

Supportive Frame
For fast cage cleaning and easy handling during experiments.

User Benefits Come First In Our Design Process

- 30% more in-cage living space
- Highest animal welfare compliance
- Single Ethernet cable connection
- Sensor data on-board digitalization
- Quick and easy maintenance
- Fast and affordable upgrade and extension

Maximize Your Research Output With Our Powerful Add-Ons

- Operant behavior wall
- Counterbalance arm for swivel connection
- TTL module for integrated external device control
- Variety of customized cage lids
- Special feeder for high-fat diet
- InfraMot activity sensor

Metabolism

Indirect calorimetry measures the animal's oxygen consumption and carbon dioxide production to calculate all key metabolic parameters, including energy expenditure (EE) or the respiratory exchange ratio (RER) for the esitimation of substrate utilization (fat vs. carbohydrate utilization).

Indirect Calorimetry

PhenoMaster continuously captures and stores high-definition raw data individually for every cage throughout your experiment, hereby setting the highest standard in metabolic research and comprehensive phenotyping. Real-time monitoring and displaying of ongoing experiments in graph, table, and numerical form come to life through synchronized data acquisition and analysis for all modules.

Measure as Fast as You Want

Multiplexed CaloSys

Multiplex calorimetry: one or multiple gas sensor pairs are shared between two or more cages with a seamless upgrade to continuous mode.

High-Speed CaloSys

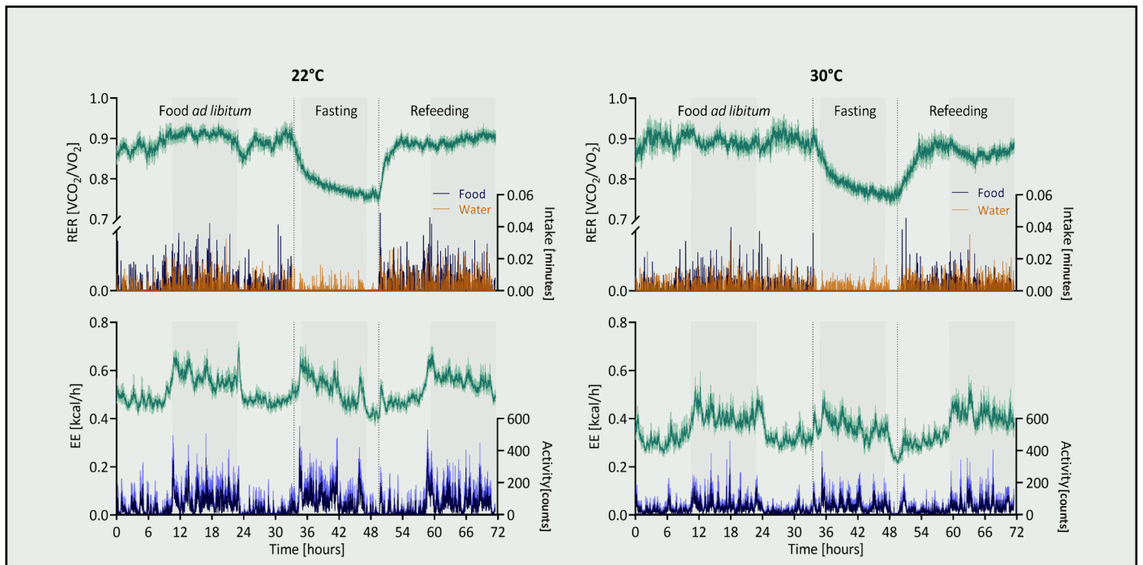
High-precision and fast sampling gas sensor pairs with extended lifespan for flawless metabolic studies.

Continuous CaloSys

Each cage has its own gas sensors with **1 second** time resolution for continuous recording.



Generate and Synchronize True Raw Data



Impact of housing temperature, fasting-refeeding challenge and activity on energy homeostasis, and metabolic adaptations in mice.

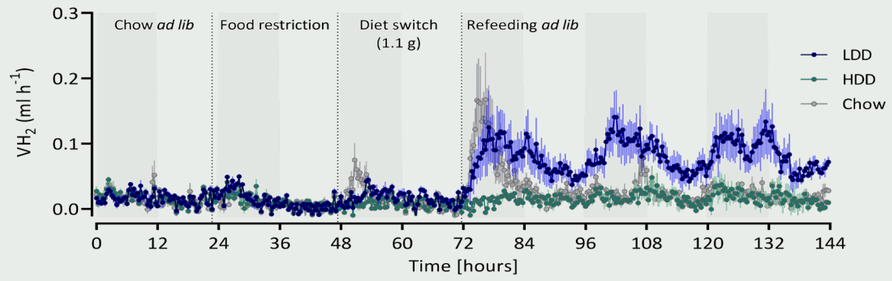
- All gas sensors are maintenance-free, and can be easily and quickly auto-calibrated.
- Programmable mass-flow controllers (MFC) for each cage create optimize cage flow rates to account for different animal sizes, weights, species.
- System incorporates lab environmental monitor for documentation of environmental parameters that may affect the experiment: CO_2, temperature, humidity, barometric pressure, room light, sound and human activity (in-room motion).
- System can be configured in PULL or PUSH mode to specify the direction of air flow throughout the system: PUSH mode enables hypoxia studies, germ-free experiments with IsoCages, and exposure to defined gas sources.
  PULL mode serves as the standard functionality for PhenoMaster with optimized usage within a climate chamber.
- The combination of different sensors types detects changes in the low ppm range at user adjustable flow rates between 0.15-5l/minute.

Microbiome Activity Monitoring

CH_4, H_2 gas sensors

Microbial activity of gut microbes

H_2 evolution reflects adaptation to dietary carbohydrates



Mice fed with low digestible diet produced more hydrogen than their counterparts, while at ad libitum consumption of high digestible diet hydrogen levels left unchanged.

TSE Systems pioneered indirect calorimetry measurements with highly specific gas analyzers to monitor the activity and contribution of the host microbiome. These sensors allow for real-time detection of gas production during microbial fermentation of dietary substrates in the gut, providing valuable insights into the activity of the microbiota.

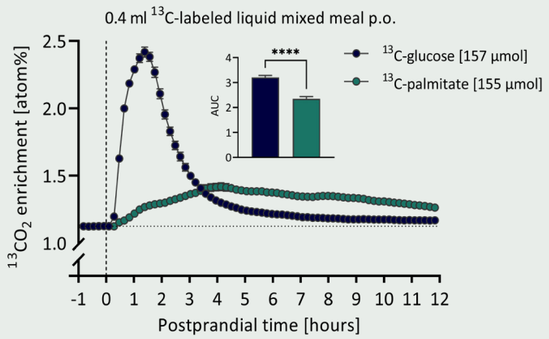
For Truly Flawless Studies

Stable Isotope Tracing

$^{13}C/^{12}C$ gas sensor for advanced substrate utilization studies using labeled **^{13}C-Glu, ^{13}C-Fru, ^{13}C-Gal, ^{13}C-FAs**

TSE Systems is the first to offer researchers the combined power of $^{13}C/^{12}C$ sensor for stable isotope tracing and indirect calorimetry. This cutting-edge tool facilitates the investigation of metabolic pathways and evaluation of intervention effects such as drugs or dietary changes.
For drug development, our new gas analyzer can evaluate the substance's pharmacokinetics and pharmacodynamics in rodents, providing critical information for optimizing dosing regimens. Our $^{13}C/^{12}C$ sensor has been introduced in cancer research to investigate tumor metabolism and the effect evaluation of respective treatments.

0.4 ml ^{13}C-labeled liquid mixed meal p.o.



Data Acquisition and Analysis

The PhenoMaster comprises a powerful, flexible and user-friendly software controlling all hardware modules. Intuitive navigation as well as its large selection of configuration options make it easy to create and fine-tune your experiments. Synchronized data acquisition and analysis of all cages and user-defined modules allows real-time monitoring of your ongoing experiments that can be easily displayed in graph, table, and numerical form. Standardized output formats and the new TSE Analytics package provide user-friendly tools for data distribution tests, user-defined data binning and normalization, statistical analysis, and publishable graphical data presentation and reports.

All hardware modules are captured in the single main menu.

Multiple modules communicate and interact according to user-defined rules.

NEW standardized output and export formats including CaLR.

NEW TSE Analytics package with statistical analysis for parametric and non-parametric analysis such as ANOVA or ANCOVA.

All sensors raw data are always stored for each module (e.g., status of each light beam at every point, O_2 or CO_2 values for each cage and time point).

Various integrated alarm functions based on user-defined threshold in a cage (CO_2, food and drink consumption level) accessible any time remotely.



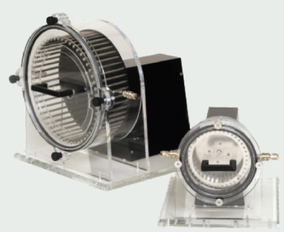
Indirect Calorimetry

Our CaloSys Professional Unit is fully compatible with the world's largest choice of home cage and other enclosures such as:



CaloTreadmill

Computerized-air-tight system for exercise calorimetry, compatible with telemetric cardiovascular recording. User-defined speed profiles with acceleration/phases, stepless adjustable incline/decline, air puff, or electric shock.



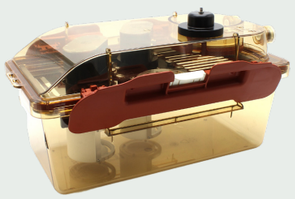
CaloWheel

Air-tight motorized forced exercise calorimetry wheel with computerized speed control for various user-designed running protocols.



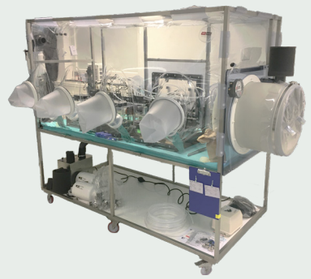
Metabolic PhenoCage

With improved urine and feces separation, quantification and storage in standard laboratory tubes. The freezing unit preserves sensitive metabolites for further analysis.



IsoCage

Special cage contains HEPA filter allowing filtered air flow into or out of the cage. Ideal solution for gut microbiome studies in combination with our special gas sensor.



Isolators

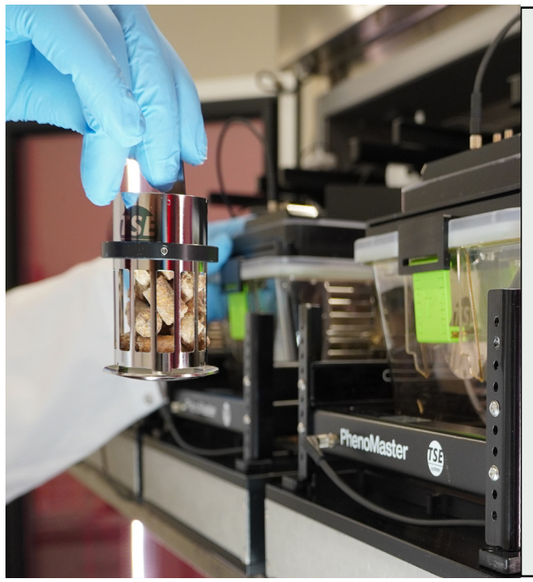
For safe investigation of germ-free or immunocompro-mised animals. Provides lab environment protection from pathogens during the use of infected animals.



Climate Chamber

For thermoneutrality and temperature challenge experiments.
Stable and reliable control of temperature, humidity, and lighting. Available in three sizes.

Food, Liquid and Body Weight



- High-precision weighing sensors, capturing micro-feeding events
- Easy handling, space-saving, available in multiple configurations, including special high-fat feeder
- Validated SpillProtect and LeakProtect technology for feeders and bottle
- Multiple sensor configuration: up to four in cage for mice discrimination studies: e.g., two diets, water, and body weight (free combination)
- Cutting-edge body weight tube design for premium animal welfare

Automated Access Control

An automated access control module provides the possibility to restrict food and/or liquid access based on time, amount, or averaged consumption of a control group or an individual. Standard TWO access controls can be used simultaneously in every cage.

PhenoMaster is the only system that offers access-controls that are interchangeable between the feeders(s) and drinking bottle(s), providing higher flexibility for study designs.

Combine food or drink access control with other modules to expand your research applications

- Paired/Yoked feeding
- Cognitive testing
- Running for reward
- Motivation testing
- Circadian rhythms
- Meal pattern analysis

Most Versatile and Flexible

Imagine the Possibilities

Behavior and Exercise

ActiMot provides the finest resolution in infrared activity frames for evaluation of spontaneous voluntary activity in the home cage during long-term experiments under stress-free conditions. With a high spatial and temporal resolution, granted by ultra-dense and extra-fast light-beam sensors, the activity frame enables a comprehensive analysis of animal movement.
Our module offers the most precise XYZ activity frame resolution in the market and allows detailed behavioral analysis associated with the spontaneous “life in the cage”, including rearing/jumping.

ActiMot Activity Frame

More than **100 parameters** calculated from raw data

Output speed, latencies, **rearing/ jumping** and more

Regions of interest allow precise **zone-specific analysis**

Unique sensor spacing of 5mm in mouse frame (1.25mm digital resolution)

100Hz sampling rate **ultra-fast movement detection**

Differentiate between activity and resting periods - **vital for metabolic data**



Running Wheel

PhenoMaster Running Wheel is the best choice for exercise study needs and home cage enrichment, significantly improving animal welfare and offering much more than just as simple “turning.”



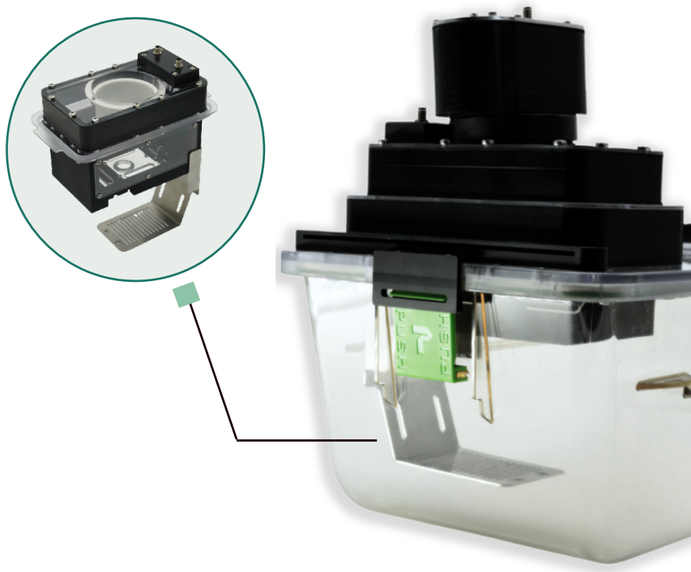
- **Time and distance-controlled** running with enable/disable function.
- In combination with PhenoMaster Indirect Calorimetry, wheel activity and inactivity is being **synchronized with key metabolic parameters.**
- **Workload module** with adjustable resistance allows investigation of different mechanical loads on exercise, muscle physiology, and metabolism in advanced cardiometabolic studies.
- Programmed **Progressive Exercise** and learning routines.
- A **Motor Skill Wheel** with variable distance between bars enables reliable detection of motor skill deficits and learning much earlier than in standard tests.

The Power of Innovation

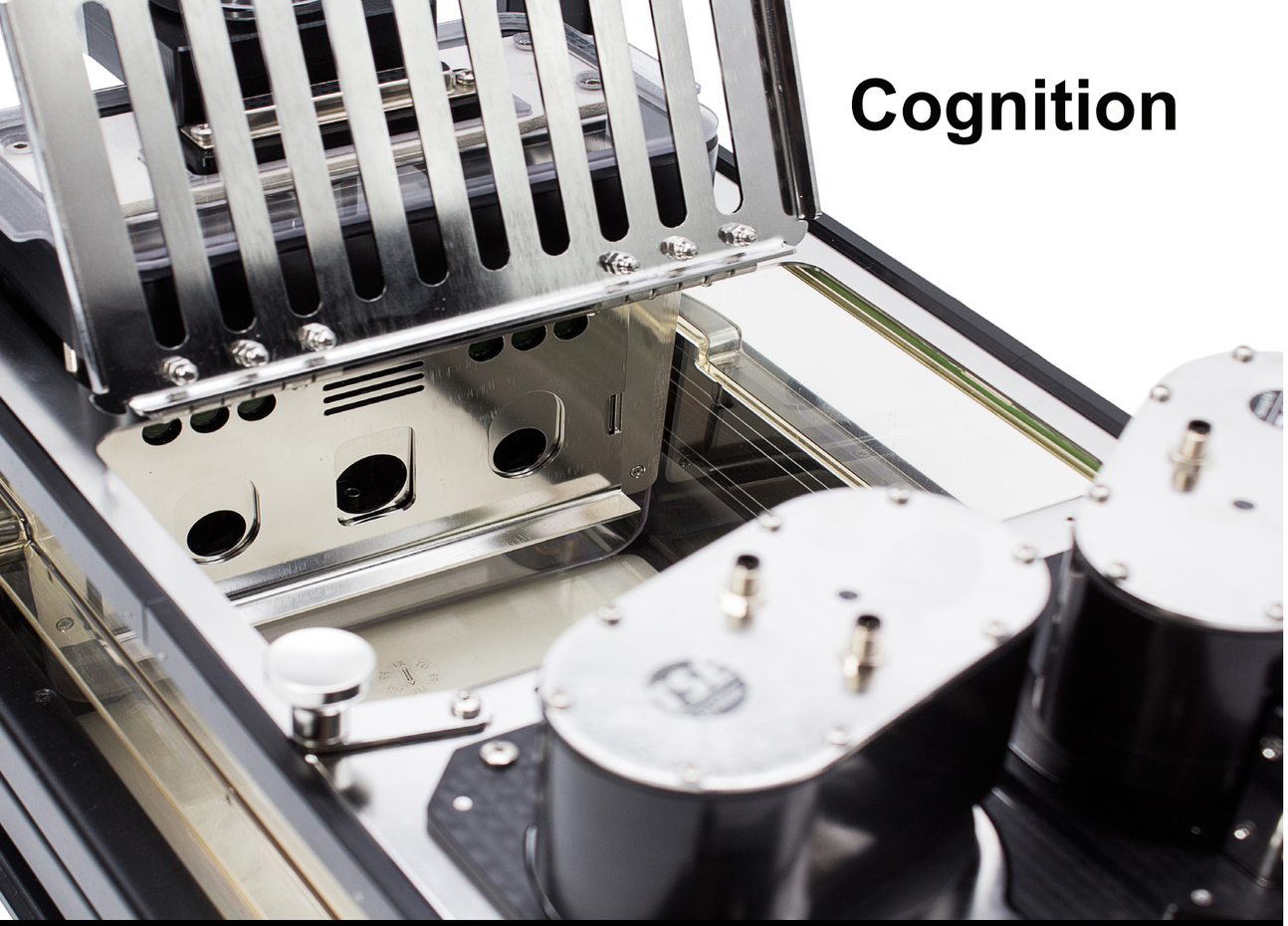
The First Industrial Weightlifting Module* for Voluntary Resistance Exercise

Introducing our **LATEST INNOVATION** to eliminate the need for invasive and stressful resistance training methods traditionally employed in small laboratory animals outside their home cage enclosures. Animals are encouraged to perform a hindleg extension to reach the food feeder hidden beneath a hinge with user-set resistance (% body weight). Our weightlifting module is directly placed in the PhenoMaster home cage.

Trainings can be performed either in single bouts, over short-term or long-term allowing investigation of the effects on muscle fiber composition changes and metabolic adaptations.
The module allows analysis of the molecular mechanisms underlying resistance exercise, alone or combined with endurance training, to increase translational reliability of your data by simulating common exercise methods used for humans.



*Mouse version coming soon



Cognition

Physiology

Smart Tools for Smart Research

Operant Wall

The only home cage integrated operant wall enabling a fully automated operant conditioning experiment during metabolic monitoring. No human interference, reduced stress levels, shortened testing periods, long-term self-motivated learning, customized experiments and many more significant advantages.

Stimulus elements include: house light, stimulus lights, sound/ noise generator and speaker	Faster habituation and better learning
Response elements include: nose pokes units, levers (optionally retractable), running wheel	Less human interference, reduced workload
Reinforcement elements include dispenser for dustless precision pellets or liquid dispenser	Continuous testing within long-term experiments across light and dark phases
Various combination options with other modules extend the functionality	Saves animals, costs and space

Wireless Implantable Telemetry

Stellar Telemetry allows either scheduled or continuous monitoring of physiological parameters in complex cage environments and simultaneously of metabolic and behavioral measurements in PhenoMaster system.



A single receiver enables data recording at group-housed animals in any environment. (Up to 5 meters transmission range).

- Pressure, Heart Rate, ECG, EEG, EMG, EOG (Dual) Temperature and (3D) Activity
- Transducer-tipped solid-state pressure sensor for blood pressure monitoring
- Wireless remote programming of implants
- Smart implants for 22g-3500g+ animal with a built-in memory card for remote data collection storage
- Core body or localized brown adipose tissue temperature

Wireless Optogenetics

NeuroLux provides time **precise light stimulation** while allowing real-time neural activity recording. This technology supports researchers in their journey to a better understanding of intricate brain functionalities by allowing them to gain insights into complex neurological disorders and behavior. The **wireless and battery-free** device design ensures high flexibility at the same time offers a greater convenience, as well as freedom of the animal movement. NeuroLux is compatible with a wide range of methods (photometry, multi-arrey recordings), enabling researchers to customize their approach depending on their needs.



Unilateral



Bilateral



Spinal

Advanced software and algorithms support high-resolution data analysis, which is vital for studying the neural basis of behavior and neurological disorders. Finally, by being fully compatible with PhenoMaster, NeuroLux is a state-of-art tool for researchers studying central/peripheral neurosystem, define organ function or gut-brain axis.



Selected Publications

• Lund, J., Breum, A. W., Gil, C., Falk, S., Sass, F., Isidor, M. S., ... & Clemmensen, C. (2023). The anorectic and thermogenic effects of pharmacological lactate in male mice are confounded by treatment osmolarity and co-administered counterions. Nature Metabolism, 1-22.

• Park, E. J., Kim, H. S., Lee, D. H., Kim, S. M., Yoon, J. S., Lee, J. M., ... & Lee, C. W. (2023). Ssu72 phosphatase is essential for thermogenic adaptation by regulating cytosolic translation. Nature Communications, 14(1), 1097.

• Liskiewicz, D., Zhang, Q., Barthem, C. S., Jastroch, M., Liskiewicz, A., Khajavi, N., ... & Müller, T. D. (2023). Neuronal loss of TRPM8 leads to obesity and glucose intolerance in male mice. Molecular Metabolism, 101714.

• Zani, F., Blagih, J., Gruber, T., Buck, M. D., Jones, N., Hennequart, M., ... & Vousden, K. H. (2023). The dietary sweetener sucralose is a negative modulator of T cell-mediated responses. Nature, 1-7.

• Kentistou, K. A., Luan, J. A., Wittemans, L. B., Hambly, C., Klaric, L., Kutalik, Z., ... & Morton, N. M. (2023). Large scale phenotype imputation and in vivo functional validation implicate ADAMTS14 as an adiposity gene. Nature Communications, 14(1), 307.

• González-García, I., García-Clavé, E., Cebrian-Serrano, A., Le Thuc, O., Contreras, R. E., Xu, Y., ... & García-Cáceres, C. (2023). Estradiol regulates leptin sensitivity to control feeding via hypothalamic Cited1. Cell Metabolism, 35(3), 438-455.

• R iva, M., Moriceau, S., Morabito, A., Dossi, E., Sanchez-Bellot, C., Azzam, P., ... & Pierani, A. (2023). Aberrant survival of hippocampal Cajal-Retzius cells leads to memory deficits, gamma rhythmopathies and susceptibility to seizures in adult mice. Nature Communications, 14(1), 1531.

• Verlande, A., Chun, S. K., Song, W. A., Oettler, D., Knot, H. J., & Masri, S. (2022). Exogenous detection of 13C-glucose metabolism in tumor and diet-induced obesity models. Frontiers in Physiology, 2108.

• Hoces, D., Lan, J., Sun, W., Geiser, T., Stäubli, M. L., Cappio Barazzone, E., ... & Slack, E. (2022). Metabolic reconstitution of germ-free mice by a gnotobiotic microbiota varies over the circadian cycle. PLoS biology, 20(9), e3001743.



Our system comes with all-in-one warranty and excellent technical support service

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