LI-600

Porometer/Fluorometer

Rapid insights into stomatal conductance and chlorophyll *a* fluorescence

Keep Pace with Streamlined Productivity

The LI-600 Porometer/Fluorometer is a lightweight and handheld porometer and Pulse Amplitude Modulation (PAM) fluorometer device that can take a measurement in seconds. It delivers accurate, high-throughput measurements over the same leaf area. The compact, one-handed design makes it quick and convenient to take stomatal conductance and chlorophyll *a* fluorescence measurements —enabling you to analyze more plants in less time.

Two-in-One Measurements

The LI-600 functions as both a porometer and fluorometer. Get unique insight into a plant's overall physiology and performance by measuring stomatal conductance and chlorophyll *a* fluorescence at the same time on the same leaf area.

Portable Accuracy in Seconds

Expedite your high-throughput studies with the LI-600. Fast track your routine without sacrificing the quality of your measurements. Move quickly and efficiently from plant to plant, automatically or manually logging each data point as you go.

Comprehensive, Easy-to-Use Software

The LI-600 software makes it easy to set your experimental preferences, manage data files, and stream live data. Its comprehensive, intuitive interface simplifies your setup, giving you more time to collect data. Software is available for both Windows® and macOS® operating systems.

Auto vs. Manual Mode

With the LI-600, measurements can be logged with auto mode or manual mode. Both allow you the necessary flexibility that your data collection methods require.

Auto mode is automatic measurement logging that is based on user-definable parameters, which increases the repeatability of your measurement process. Manual mode is measurement logging that is done when the stability criteria meets user satisfaction.

Light- and Dark-Adapted Measurements

Depending on the nature of your research, the LI-600 can take both light- and dark-adapted measurements as needed.

Light-Adapted Measurements

For light-adapted leaves, the LI-600 measures the quantum yield of fluorescence (Φ_{PSII}), or the proportion of light absorbed by photosystem II used in biochemistry.

$$\Phi PS_{II} = \frac{F_m' - F_s}{F_m'}$$

F_m' is maximum fluorescence yield in a light-adapted leaf; F_s is steady-state fluorescence yield in a light-adapted leaf.

Dark-Adapted Measurements

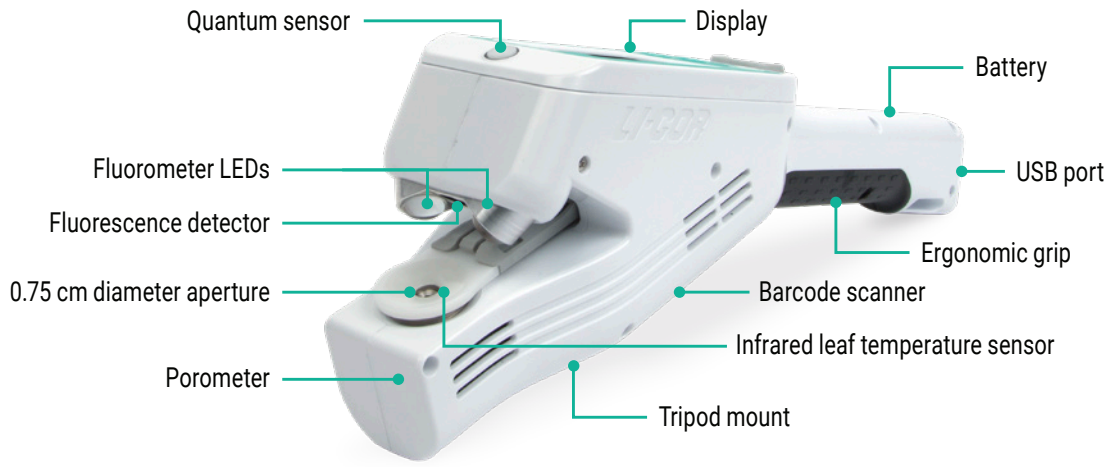
For dark-adapted leaves, the LI-600 measures maximum quantum yield (F_v/F_m), or the maximum proportion of absorbed light that can be used to drive photochemistry.

$$\frac{F_v}{F_m} = \frac{F_m - F_o}{F_m}$$

F_v is variable fluorescence yield in a dark-adapted leaf; F_m is maximum fluorescence yield in a dark-adapted leaf; F_o is minimum fluorescence yield in a dark-adapted leaf.

LI-600 Features

The design of the LI-600 redefines what it means to be small but powerful. Access numerous intuitive features that help facilitate quick, accurate measurements—without surrendering any research capabilities.



Porometer

- Measures stomatal conductance in seconds
- Automatically matches the relative humidity (RH) sensors
- No desiccant required
- Photosynthetically Active Radiation (PAR) sensor

Fluorometer Module

- Measures chlorophyll *a* fluorescence
- Φ_{PSII} in light-adapted measurements
- F_v/F_m in dark-adapted measurements
- Optional 600-01F Fluorometer Upgrade Kit

Display

- Sunlight readable
- Stores up to four configurations
- Shows live measurement data

Barcode Scanner

- Scans barcodes for measurement organization
- For easy dataset postprocessing
- Optional for each configuration and measurement

Rechargeable Battery

- Rechargeable lithium ion battery
- Provides up to 8 hours of active use

USB Port

- Charges the instrument
- For configuration upload and data download

Tripod Mount

- Easily attaches a tripod to the instrument
- For live data streaming and educational purposes

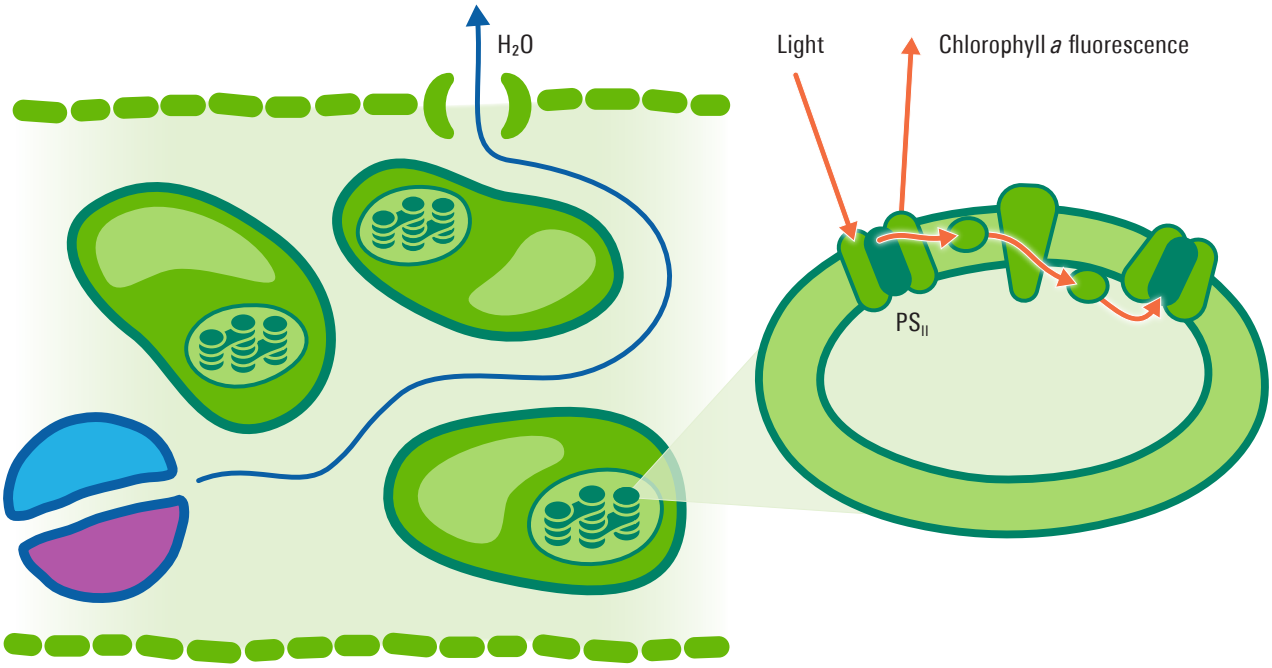
The Rationale Behind the LI-600

Why It Measures Stomatal Conductance

Stomatal conductance to water (g_{sw}) is a measure of the degree of stomatal openness and density. This measurement can be useful for phenotyping and indicates a plant's physiological response to its environmental condition.

Why It Measures Chlorophyll *a* Fluorescence

Chlorophyll *a* fluorescence measurements can provide information about the leaf's quantum efficiency, electron transport rate (ETR), and non-photochemical quenching (NPQ)—along with other reactions that collectively protect a leaf when it absorbs excessive light energy.



Why It Measures Both Simultaneously

You can measure stomatal conductance and chlorophyll *a* fluorescence using the same conditions, time, and leaf area with the LI-600. These combined measurements present a more complete picture of a plant's physiological state than either technique could provide on its own.

The Science Behind the LI-600

How It Measures Stomatal Conductance

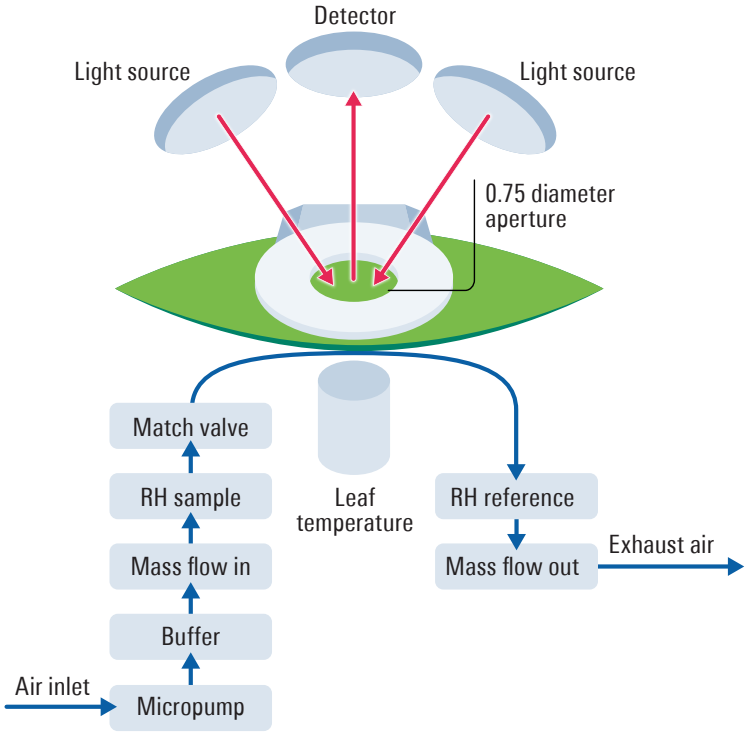
The LI-600 uses an open flow-through differential measurement for quantifying transpiration (E) and stomatal conductance that enhances its measurement process. First, E is quantified by measuring the flow rate and water vapor mole fraction of air that enters and leaves the chamber. Meanwhile, total conductance to water vapor (g_{tw}) is computed as a function of E and vapor pressures in the leaf and cuvette. Boundary layer conductance is computed as a function of flow rate and cuvette geometry. Finally, stomatal conductance to water (g_{sw}) is computed as a function of g_{tw} and the boundary layer conductance to water vapor (g_{bw}).

LI-600 Measurement Flow Path Advantages

- Flow rates that quickly flush through the small chamber volume and result in rapid stabilization for quick measurements
- A differential measurement that is close to ambient conditions
- Minimally disturbed light, CO_2, and H_2O during the measurement that eliminate the need for desiccant chambers or corrections for large diffusion gradients
- Automatic matching that accounts for drift between the reference and sample sensors

How It Measures Chlorophyll *a* Fluorescence

Measurements of chlorophyll *a* fluorescence provide insights into photosynthesis, and, when combined with stomatal conductance, results in a more complete picture of the overall plant physiology and health. In addition to rectangular flashes, the LI-600 supports multiphase flashes (MPF), which can prevent underestimation of F_m' (Loriaux et al., 2013) and thereby reduce bias in numerous fluorescence parameters.



How It Enhances Your Research

By taking both stomatal conductance and chlorophyll *a* fluorescence measurements together, you can learn more about a plant's performance, stress, and internal reactions. Understanding these processes is important to many research applications—including genetic screening, agronomy, plant physiology, ecology, climate change research, and stress tolerance.

Loriaux, S.D., et al. (2013). Closing in on maximum yield of chlorophyll fluorescence using a single multiphase flash of sub-saturating intensity. Plant Cell Environ 36:1755-1770.

Fast Track Your Routines

The LI-600 takes measurements in seconds. As a pragmatic tool for high-throughput studies, it enables you to swiftly process numerous plants without compromising on precision or accuracy along the way.

- Achieves conductance stability in seconds
- Measures a wide range of plant species
- Complements mass screening initiatives

Watch the LI-600 complete six measurements in 60 seconds at www.licor.com/600speed

Multiple Measurements in a Minute

The LI-600 is capable of taking multiple measurements in a single minute, expediting your research and saving you time in the field.

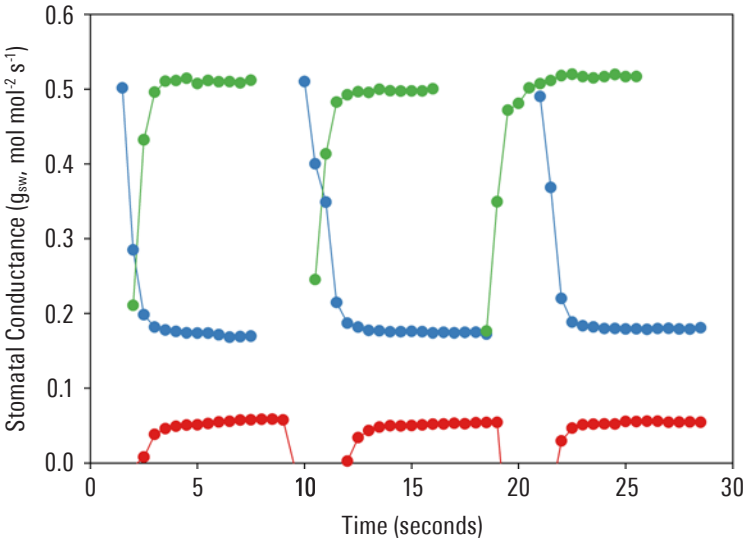
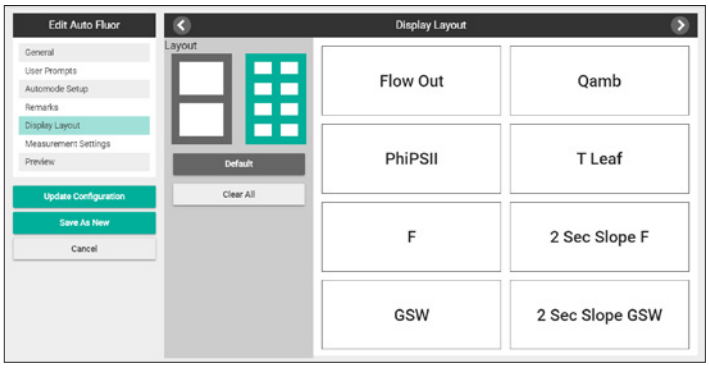


Figure 1: Three time series of measurements taken at different times of day on three adjacent leaves of three plants. The series are overlaid to show that the instrument can complete measurements in 6 to 9 seconds at a range of g_{sw} values. Data points when not clamped between leaves not shown for clarity. Measurements are one-side stomatal conductance (g_{sw}) made on three adjacent leaves (orange is soy shortly after sunrise; g_{sw} = 0.055, blue is soy near midday; g_{sw} = 0.17, and green is tobacco at midday; g_{sw} = 0.51). Data are the 2 Hz measurements from the LI-600.

Computer Software Features

Create a Configuration

- Add prompts and remarks
- Choose stability criteria and measurement settings
- Preview the configuration
- Directly upload and remove configurations



Data Management

- Download and evaluate data
- Clear data from the instrument

Live View

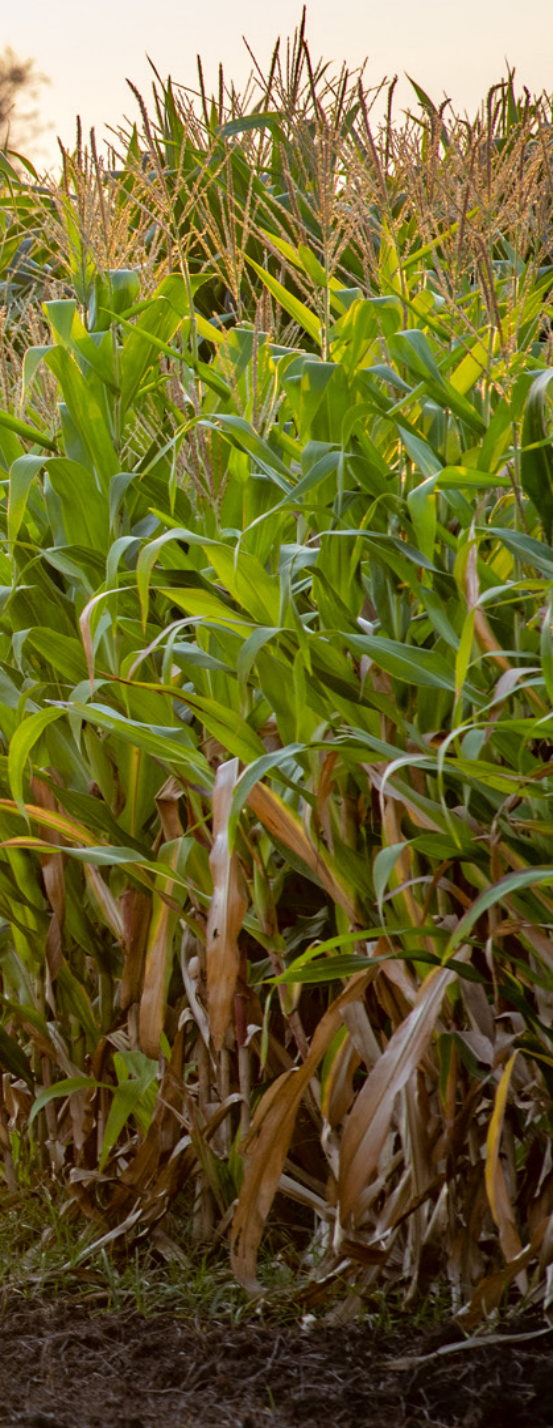
- Take measurements in real time
- Select variables and view graphs in real time
- Ideal for educational settings

The LI-600 and LI-6800

Maximize your research capabilities by pairing the LI-600 with the LI-6800 Portable Photosynthesis System. First screen your plants with the LI-600 to establish stomatal conductance and chlorophyll *a* fluorescence; both measurements will help pinpoint which plants to study in detail.

You can then expand on your findings under controlled conditions with the LI-6800. Its environmental controls allow you to maintain parameters—from leaf temperature and light conditions to carbon dioxide and water vapor deficit—that can help answer your research questions. For intricate studies with several areas of interest, the LI-6800 has a wide variety of interchangeable chambers, allowing the instrument to adapt as your studies evolve.

Together, the LI-600 and LI-6800 optimize your time and capture a more comprehensive dataset from your plants.



Ordering Information

LI-600PF Porometer/Fluorometer

The LI-600PF includes the porometer and fluorometer for stomatal conductance and chlorophyll *a* fluorescence measurements.

Includes a carrying case, wrist strap, battery charger, USB cable, spares kit, manual, and quick start guide.

LI-600P Porometer

The LI-600P includes the porometer for stomatal conductance measurements.

Includes a carrying case, wrist strap, battery charger, USB cable, spares kit, manual, and quick start guide.

600-01F Fluorometer Upgrade Kit

The 600-01F Fluorometer Upgrade Kit adds the fluorometer module to the LI-600P (porometer only) model for chlorophyll *a* fluorescence measurements.

Specifications

Measurement time:
Porometer: 5 to 15 seconds typically, depending on species, leaf surface characteristics, and leaf conditions
Fluorometer: 1 second
Operating conditions:
Temperature: 0 to 50 °C
Pressure: 50 to 110 kPa
Humidity: 0 to 85%; non-condensing
Weight: 0.68 kg (porometer only); 0.73 kg with fluorometer
Dimensions: 32.4 cm × 16.9 cm × 6.2 cm (L × W × H)
Display:
Dimensions: 6.8 cm diagonally
Resolution: 400 × 200 pixels; sunlight readable monochrome
Keypad: 5-button membrane pad
Battery:
Built-in Li-ion
Operating hours: 8 hours typically
Capacity: 5200 mAh
Recharging time: 3.5 hours typically; 2 hours with Qualcomm® Quick Charge™ 2.0 or 3.0
Data storage: 128 MB
USB specifications: Communication/charging interface: Micro-B Qualcomm® Quick Charge™ 2.0 or 3.0 for rapid charging
Universal charging adapter:
Input: 90 to 264 VAC; 50 to 60 Hz
Output: 5 VDC; 1 Amp
Configuration software: Windows® and macOS® applications
Data files: Plain text data compatible with any spreadsheet application or data analysis program
Output: .CSV format
Barcode scanner: 1-D and 2-D, including Code 39, Code 128, PDF417, 100% UPC, Data Matrix, QR Code
Photosynthetically Active Radiation (PAR) measurement:
Units: Photosynthetic Photon Flux Density (PPDF); µmol s^{-1} m^{-2}
Calibration Accuracy: ±10% of reading; traceable to NIST
Cosine correction: Cosine corrected up to 60° angle of incidence

Porometer

Aperture: 0.75 cm diameter
Flow rates:
Low: 75 µmol s^{-1}
Medium: 115 µmol s^{-1}
High: 150 µmol s^{-1} *
RH sensor accuracy: ±2% RH
Reference temperature: ±0.2 °C
Leaf temperature sensor accuracy: ±0.5 °C
Inlet flow measurement: ±1% of reading from 75 µmol s^{-1} to 150 µmol s^{-1}
Exhaust flow measurement: ±5% of full scale up to 150 µmol s^{-1}
Parameters computed:
g_{sw} mol m^{-2} s^{-1}; g_{bw} mol m^{-2} s^{-1}; g_{tw} mol m^{-2} s^{-1}; E mmol m^{-2} s^{-1}
VP_{cham} kPa; VP_{ref} kPa; VP_{leaf} kPa; VPD_{leaf} kPa
H_2O_{ref} mmol mol^{-1}; H_2O_{samp} mmol mol^{-1}; H_2O_{leaf} mmol mol^{-1}

Fluorometer

Flash types: User configurable Rectangular and Multi-phase Flash™ (MPF)
Measuring light peak wavelengths: 625 nm
Peak light intensity: 0 to 10,000 µmol m^{-2} s^{-1}
Flash intensity: 0 to 7500 µmol m^{-2} s^{-1}
Parameters computed:
F_o, F_m, F_v, F_v/F_m, F_s, F_m', Φ_{PSII}, ETR

**High flow may not be achievable at higher altitude*
Specifications subject to change without notice

LI-COR Biosciences
4647 Superior Street
Lincoln, Nebraska 68504
Phone: +1-402-467-3576
Toll free: 800-447-3576
envsales@licor.com
envsupport@licor.com
www.licor.com/env

LI-COR GmbH, Germany
Siemensstraße 25A
61352 Bad Homburg
Germany
Phone: +49 (0) 6172 17 17 771
envsales-gmbh@licor.com
envsupport-eu@licor.com

LI-COR Ltd., United Kingdom
St.John's Innovation Centre
Cowley Road
Cambridge
CB4 0WS
United Kingdom
Phone: +44 (0) 1223 422102
envsales-UK@licor.com
envsupport-eu@licor.com

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