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LCpro T
Quick Start Guide
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Analysing the carbon cycle

LCpro T

Intelligent Photosynthesis System

QUICK START GUIDE



Contents

Introduction	3
Overview	3
Included with your LCpro T	4
Additional chamber options	5
LCpro T layout and external functions	6
LCpro T battery compartment	8
Plant Leaf Chamber	9
Using your LCpro T for the first time	10
Connecting things up*	10
Using a stable air supply	10
Switching ON.....	13
Switching OFF.....	14
The assembled system	14
The Main Menu Structure.....	15
Main Menu 1.....	15
Main Menu 2.....	15
Main Menu 3.....	16
Menu 1 Structure Flow Chart.....	17
Menu 2 and 3 Structure Flow Chart.....	18
Setting the date and time	19
Before taking measurements on a leaf:.....	19

Changing the leaf chamber parameters	20
Leaf chamber settings:	20
Setting the flow rate	21
Setting Light, Q or PAR (irradiance) levels	22
Recording Data.....	23
When will the LCpro T record measurements?	23
What is recorded?	24
Where is data recorded?	25
Create a data 'log' file	25
Stop a data 'log' file	26
Access a saved data 'log' file.....	26
How to review data.....	26
How to download data	26
Deleting data files	27
Controlling the leaf chamber climate	27
Setting up	27
Single level control.....	28
Automatic climate sequence	28
Create a climate sequence file.....	29
Editing total PAR or %RGB in a sequence file	31
Saving a climate sequence file	32
Using a climate sequence file	32
Interpreting data file Q values	33
Plotting a graph.....	34

Introduction

Welcome to your new LCpro T. Reading this quick start guide as you set up and try out your LCpro T will enable you to follow the comprehensive, technical manual to use and maintain your LCpro T long-term.

Watch the Quick Start VIDEO Guide on the “ADC BioScientific Ltd” [YouTube channel](#).

A friendly team at ADC BioScientific Ltd. are also on hand to answer any queries you may have: sales@adc.co.uk

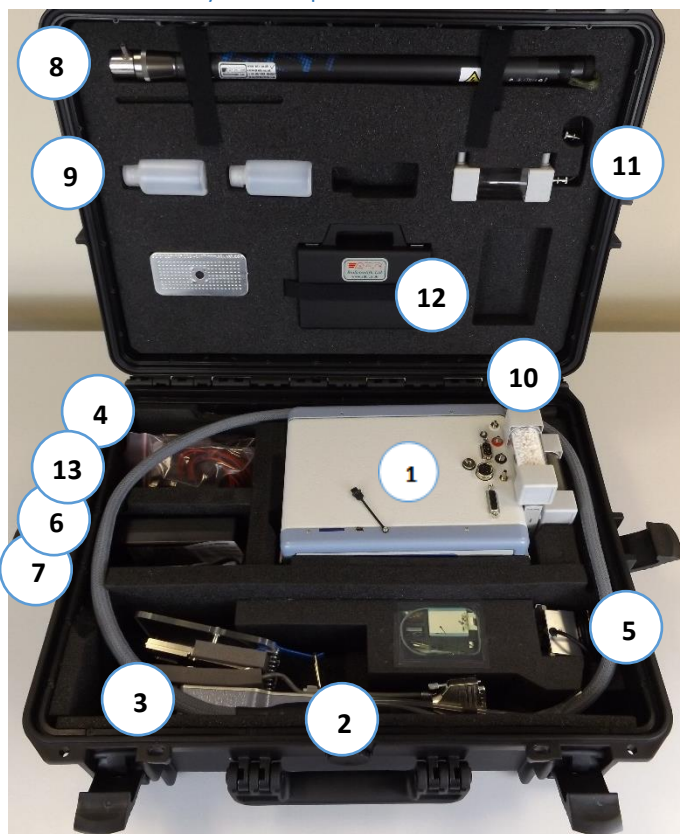
Overview

The LCpro T performs measurements and calculations of photosynthesis and transpiration whilst automatically controlling the leaf chamber climate.

The LCpro T leaf chamber analyses both CO₂ and H₂O. The single infrared gas analyser performs CO₂ measurements. H₂O measurements are made by two water vapour sensors.

The LCpro T can be programmed to automatically control the leaf chamber climate. CO₂, H₂O, light and temperature can all be controlled at constant or sequential levels, either individually or in any combination. All measurements, calculations and experimental programs can be stored in files on SD cards. Data may be reviewed on the LCpro T touch screen LCD, or downloaded to a PC via the USB port.

Included with your LCpro T



1. LCpro T Analyser "Console"
2. LCpro T Analyser "Handle" or "PLC" (Plant Leaf Chamber)
3. Leaf chamber
4. Leaf thermistor M.PLC-011
5. LED light unit (store the light unit here when not in use)
6. Battery charger and "mains lead", to operate from 90V to 260V/AC.

7. Carrying strap
8. Air probe to supply stable ambient air to your LCpro T.
9. Two small plastic bottles, to hold a replacement set of chemicals.
10. The additional soda lime chemical column.
11. Humidifying “Wetter” column with co-axial lead.
12. Tool box containing: ‘pot adjustor’ calibration tool, stylus for calibrating the LCpro T touch screen, ‘CO₂ discharge tool’, ‘jaw adjustment tool’, ground spike for the air probe, spare Broad or Narrow chamber gasket set and SD card.
13. An RS232 cable and a USB cable to download data to a computer.

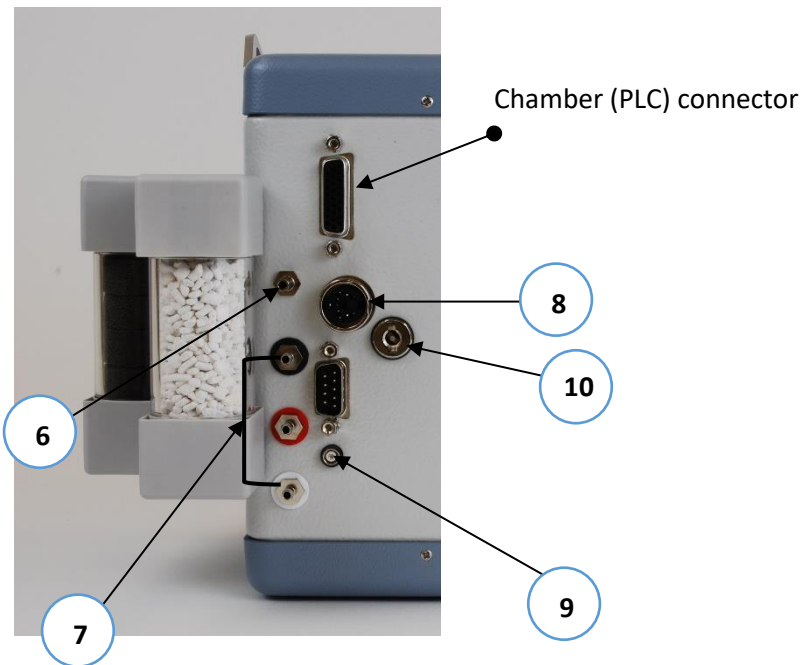
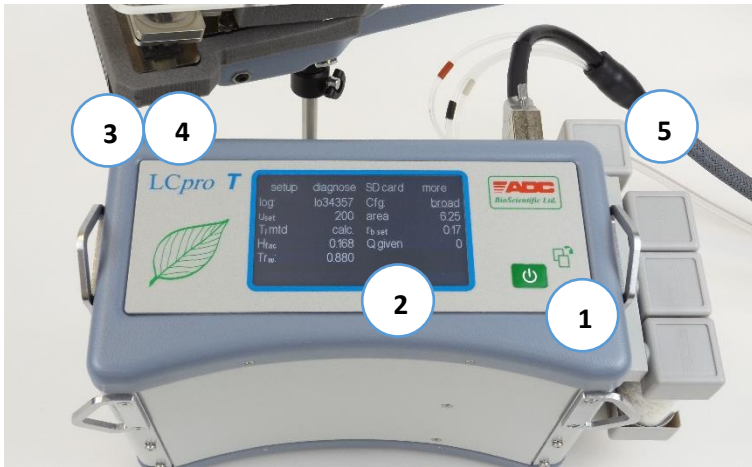
LCpro T “User Guide” manual, a menu structure card and this quick start guide are also inside the case.

With the carrying case is a **spares kit**, which includes all required chemicals, CO₂ cartridges and a selection of spare parts.

Additional chamber options

Your LCpro T will have been configured to be either a Broad, Narrow or Conifer leaf chamber. It can be reconfigured using the touchscreen for use with any other ADC chamber.

LCpro T layout and external functions



1. On / Page button

Turns instrument on/off and scrolls through the 3 main menus. Also functions as a 'confirm' and returns you to the previous page when viewing the sub-menus.

2. Touch screen, colour LCD

All programming of the LCpro T is via the touch screen.

3. SD card drive

For storage of data logs, graphs and sequence files.

4. USB port

Connect a computer to transfer files to and from the SD card.

5. Chemical columns

Used to condition the system gas.



Column **1** should always be filled with Soda lime.

Column **2** should always be filled with Drierite.

Column **3** should either be filled with ferrous sulphate when in use, or the foam inserts should be placed inside the column, as shown.

Column **4** an additional soda lime column, which we recommend filling with an indicating Soda Lime when controlling CO₂ at elevated concentrations.

6. Air supply

Fresh reference air is taken in here. It is vital that incoming CO₂ concentrations are stable. Air drawn directly from occupied rooms, adjacent to vehicle traffic or a heavily populated canopy can result in unstable "reference C" and "delta C" data. The supplied air probe and tubing can be used here.

7. Plant leaf chamber connections

Connect the plant leaf chamber to console using the three, colour-coded entries to match the gas tubing.

8. Power supply

To connect to battery charger.

9. Column temperature probe socket

Connect only when controlling water vapour.

10. CO₂ regulator filter assembly and discharge valve

For CO₂ filter replacement and cartridge discharge.

LCpro T battery compartment

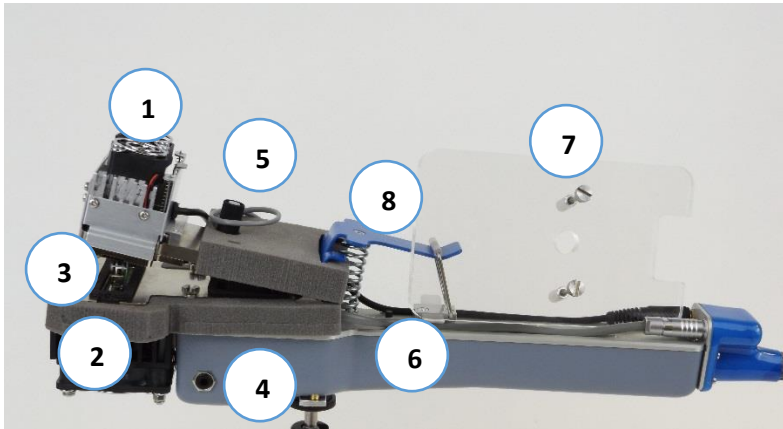
Located underneath the LCpro T console and containing:

Battery To maximise battery life, never store fully discharged.

CO₂ cartridge compartment Unscrew (when empty) and place in new cartridge. Never remove a cartridge that is not fully spent. If you need to empty a cartridge rapidly, fit the CO₂ discharge tool LCM-039 for an hour before removing.

Fuse A bayonet fitted cartridge, 3.15 A, 20mm glass T type fuse.

Plant Leaf Chamber



1. LED light unit – Either RGB or White

Detached using clip lever on top of unit. Must be removed if not controlling light concentrations within the leaf chamber.

2. Peltier heat exchanger

Used in automatic control of leaf chamber temperature.

3. Self-positioning leaf temperature sensor

4. Leaf thermistor assembly

Plug-in thermistor for manual attachment to the leaf when self-positioning temperature sensor is not suitable. Useful when measuring conifer leaves and pine needles.

5. PAR sensor: Photosynthetically Active Radiation sensor.

6. Record button: Pressing initiates an instant data record.

7. Infra-red radiation shield: Fit when a light unit is not in use.

8. Thumb latch with spring adjustor Store the jaws open, as shown, to maintain the gaskets (foam which makes a good seal around the leaf).

Using your LCpro T for the first time

Connecting things up*

1. Connect the PLC to your LCpro T console, using the colour-coded gas connections and the electrical connection. When assembling the system for the first time, we advise you not to connect an LED light unit or insert a CO₂ cartridge as yet.
2. Connect a stable supply of air to the air supply inlet, using the length of tubing supplied. This is essential to provide stable CO₂ readings. Without a stable air supply connected to the LCpro T, your CO₂ readings will not be stable.

Using a stable air supply

You may use the air probe, supplied, when outdoors. Extend the probe fully and secure in the ground using the ground spike provided. Attach the tubing, with the metal filter close to the probe end). Position the probe around 1m away from your sample area.

Alternatively, you may construct your own buffer volume (this can be portable, attaching to a belt or back pack) using a plastic or glass container with a screw top lid*.

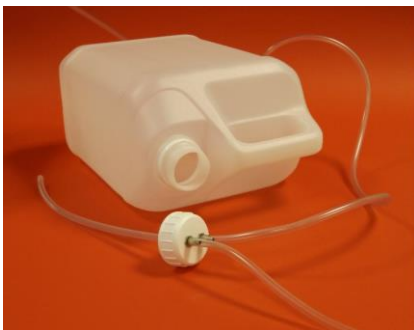
Drill two holes into the lid and glue in place 2 x air entries, provided in the spares kit.



*See photographs on next page.

One entry carries “air in” (connected to a length of PVC tubing, supplied, which can be hung out of a window) and the other carries “air out” (connected to a tube which is connected to the LCpro/LCi console “air in” entry).

The “air in” entry on the container should also have a length of PVC tubing connected to it, which hangs down inside the container and extends to the bottom of the container. This piece of tubing ensures that the air is drawn out of the container from the top, so that air is fully “volumised”.



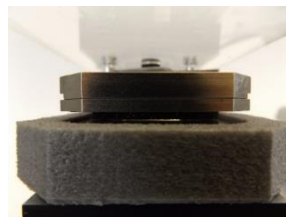
The same method can be repeated to make a smaller volume from a glass bottle with a screw-top lid.



3. Fill and attach the chemical columns as previously directed.
4. Insert an SD card into the drive.

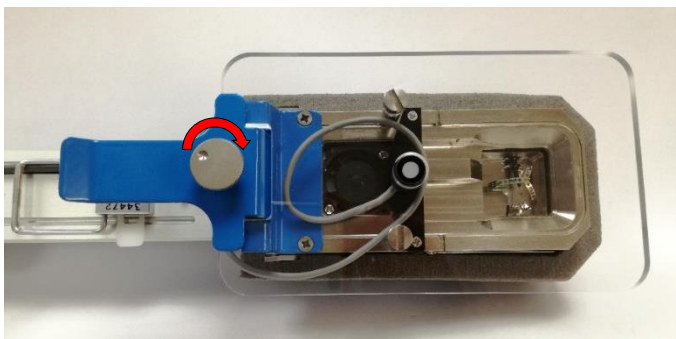
*Refer to the photograph on the next page for guidance.

5. With the jaws closed, check the seal between the chamber gaskets. New chambers have 'springy' gaskets, which can produce a gap between the upper and lower jaw at first use. To correct this, use an elastic band, or fingers, to carefully hold the jaws together for a couple of minutes before rechecking. When there is no longer a gap, you can be confident that the chamber will make a good seal around your leaves.



Using the jaw spring adjustor tool

Turn the spring adjustor clockwise to apply more force to the spring, ensuring that the gasket seal is airtight around the leaf. Please do not leave this engaged when not required.



When to use: Only turn the thumb screw when required, and do not overtighten. If the jaw clamping pressure is too high, there is a risk of damage to the leaf.

Do not leave the thumbscrew engaged for long periods of time otherwise the compressed gaskets may not recover. It is suggested that the screw be slackened off every 10 minutes to see if it is still needed.

Only use when:

- You can see a gap between the two “gaskets” (shown opposite, where light is coming through). Any gap will cause a leak in the system and incorrect results.
- You are working with a leaf which has thick veins or ribs, or is an undulating shape.
- The A and ΔC values are lower than expected.
Applying more pressure to the gaskets with $\frac{1}{2}$ turn of the tool may increase A values to the expected range.

Switching ON


Switch the LCpro T on using the ON / PAGE button:



Initially, the LCpro T will display the software version and instrument serial number.

It takes just a few minutes for the LCpro T to warm up after switching on. During this time, CO₂ related data will not be presented. If fresh chemicals and a stable air supply are in place, up to 30 minutes may be required to achieve stable gas readings.

Switching OFF


To turn the unit off, hold down  continuously OR press 'power off' on main menu 3. The LCpro T will then power down.

The assembled system





The Main Menu Structure

There are 3 Main Menu pages. Press  or swipe horizontally across the LCD to move between them.

Main Menu 1


Displays the CO₂ / water vapour reference, analysis and differential readings, together with PAR, atmospheric pressure and chamber temperature.

Main Menu 2

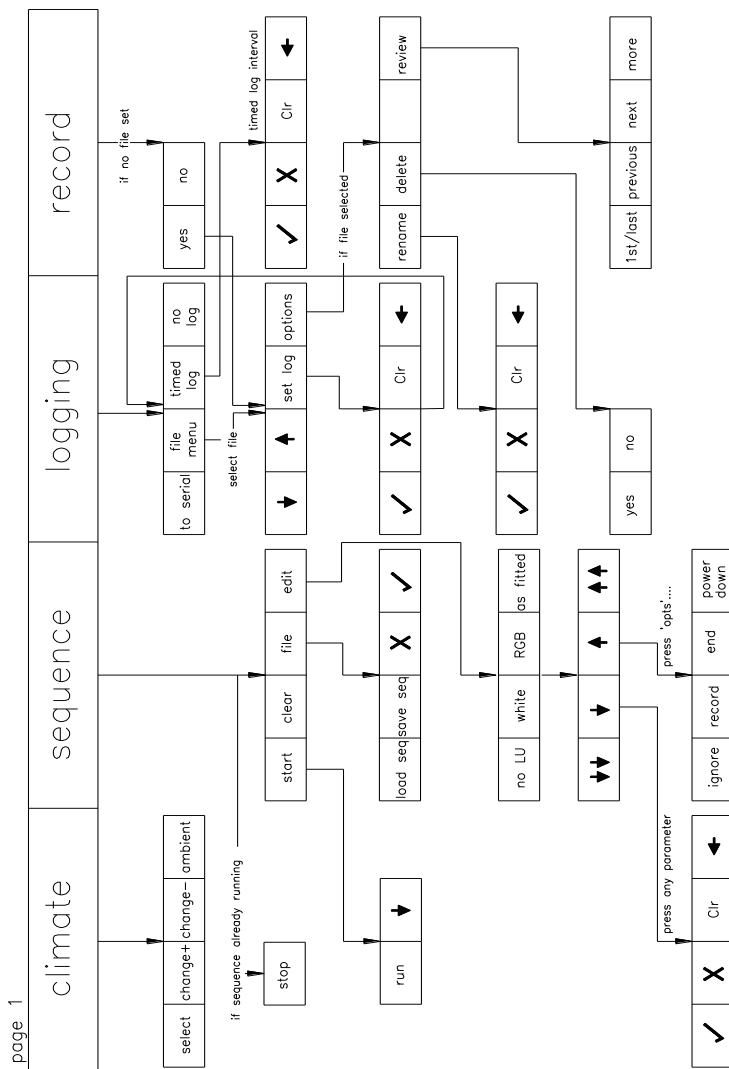
Includes all calculated parameters including; photosynthesis rate, transpiration rate, stomatal conductance and sub-stomatal CO₂. Leaf temperature, set flow and actual flow rate are also displayed. A power bar indicates the level of battery charge. A count within the selected record file is also displayed.

Main Menu 3

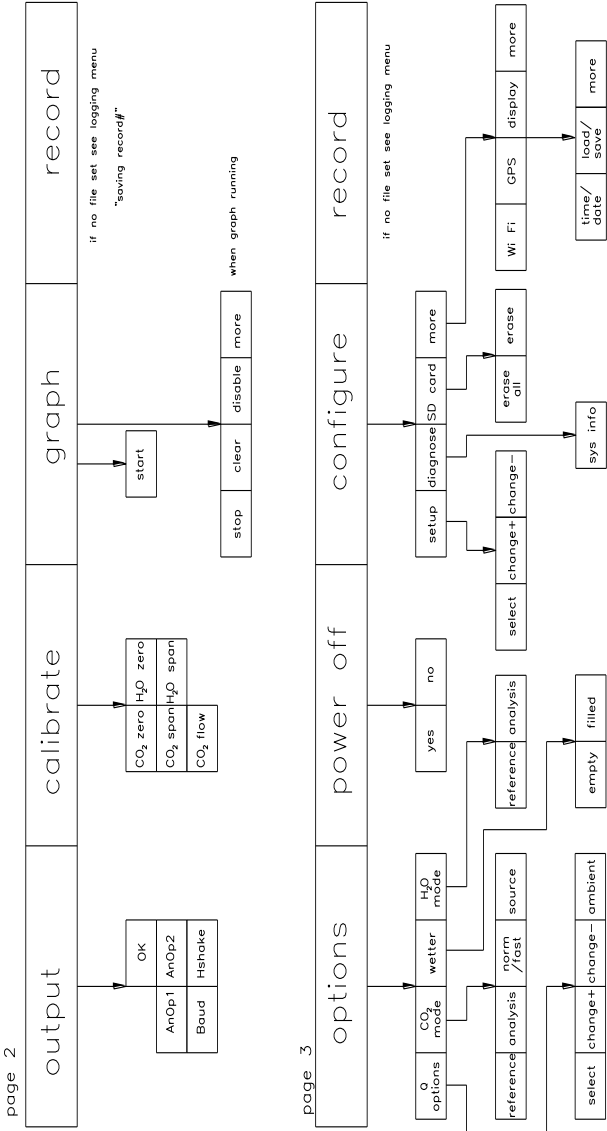
The configuration menu, **configure**. Here you can select which leaf chamber head is being used. Your *LCpro T* will have been delivered pre-set with the type of chamber head fitted to your *LCpro T*. Also on this page is the setting for the flow rate **uset**, pre-set at $200 \mu\text{mol m}^{-2} \text{s}^{-1}$. The method chosen to measure leaf temperature is shown (pre-set to “calculated”).

Pressing  again returns you to Main Menu 1.

Menu 1 Structure Flow Chart





Menu 2 and 3 Structure Flow Chart



Setting the date and time

Your LCpro T will have been set to your local time. If you need to change these settings, follow these steps:

1. Go to the Main Menu 2 and touch **configure**
2. Touch **more**
3. Touch **select** to underline the desired value:
Time (24hr): HOUR: MIN: SEC and
4. DATE (dmy): DAY: MONTH: YEAR
5. Use **change +** and **change-** to edit values
6. Once date and time are correct, press  to return to **configure** menu. Press  again to return to Main Menu 1.

Before taking measurements on a leaf:

1. Hold the chamber as steadily as possible during the measurement. The underside of the chamber has an attachment site for any standard tripod.
2. Check the chamber sensors. With the chamber closed, view the **CO₂ ref** and **CO₂ anl** readings on Main Menu 1. These should stabilise in seconds to give similar CO₂ concentrations.
3. The H₂O concentrations **e ref** and **e anl** should also be checked for similarity. Check also that the PAR and chamber temperatures (Tch) readings match ambient conditions.
4. A leaf, once enclosed in the chamber, may take two minutes (or less) to re-adjust to the new microclimate.

Watch for the Ci (sub-stomatal CO₂) value to stabilise, as a good indicator of leaf adjustment. We prefer to use 'Ci', rather than 'A' as the indicator. This is because 'A' mainly responds to changes in CO₂ concentration, which tend to be

faster than changes in H₂O vapour, 'e' values. Therefore, 'Ci' is normally the last value to settle. It is especially useful if you are interested in water vapour parameters.

Once values are stable, a **record** may be taken via the touch screen or chamber handle (see RECORDING DATA).

Changing the leaf chamber parameters

The **configure** menu allows you to set up the LCpro T for different experiments/applications. From this menu, you can edit the measured parameters within the chamber, also the airflow rate through and irradiance given to the leaf chamber.

1. To select a parameter to be changed, touch **configure** then **set up**.
2. Touch a parameter directly to select (any blue box).

Leaf chamber settings:

Cfg: Select the type of chamber head that is being used: Broad, Narrow, Conifer, Soil pot or Small. This will automatically set the AREA, rb, Hfac and Trw values for that chamber.

AREA: Represents the total area of the chamber. If your leaf does not fill the whole of the leaf chamber, determine and enter a value for the exposed area.

Rb: Boundary layer resistance.

Hfac: Leaf chamber energy transmission factor.

Trw: Chamber window transmission factor.

TI mtd: The method by which you want to measure leaf temperature. Touch to switch between:

Calculated: by 'energy balance equation'. Preferred method for broad leaves filling the entire chamber area.

Measured: by leaf temperature sensor. For the broad and narrow chambers, this defaults to the self-positioning sensor fixed inside the chamber. Once the plug-in thermistor is plugged in to the jack socket, measurements will automatically switch to this sensor.

(Q given: Allows a Q level from an external PAR sensor from another source to be input into data sets. It overrides the LCpro T PAR sensor value.)

Setting the flow rate

Uset: Changes air supply flow settings. The default and most commonly used value is $200 \mu\text{mol m}^{-2} \text{s}^{-1}$. When measuring samples with a high level of gas exchange, flow rate should be increased. When measuring samples with a low level of gas exchange, flow rate should be decreased.

Setting Light, Q or PAR (irradiance) levels

The blue button at the top right corner will switch between “%RGB” and “PAR” to display two different editing pages.

First, explore the PAR page. The top right button shows “%RGB” as the other option, *not* the current page.

1. Press **Qset** on the climate menu to display all options for setting the total **Qtot** Irradiance from a light unit fitted onto a chamber.
2. Touching on one of the blue boxes brings up a keypad for direct value input.

Illuminator PAR red

700

Enter a value between 40 and 4000
 $\mu\text{mol m}^{-2} \text{s}^{-1}$

7 8 9
4 5 6
1 2 3
0

✓ ✗ Clr ←

3. **Qtot** is the total output from either White or RGB light units, or, press **Qred**, **Qgrn** or **Qblu** to change the output from different coloured LEDs in the RGB light unit.

select	change +	change -	%RGB
Qred	525		
Qgrn	330		
Qblu	645		
Qtot			1500

Light unit PAR levels

4. Touch '%RGB' to edit the ratio of red to green to blue LEDs.
The total will always recalculate to 100%.

select	change +	change -	PAR
Q%red	33		
Q%grn	33		Q _{tot} 2400
Q%blu	33		
Light unit RGB ratios			
Status: Using Q from climate control			

IMPORTANT NOTES before entering Q values:

Set 1) Q%Red then 2) Q%Green then 3) Q%Blue **in this order** to allow the automatic recalculation of the other two colours, whilst keeping your set values as entered.

Irradiance, (PAR or Q), reaching the leaf plane will be LESS THAN your set values by the Window Transmission Factor (**Trw**). Please read **section 9.3 of the User Guide** to understand how to set Q values correctly before every use.

Recording Data

When will the LCpro T record measurements?

A record can be taken by either of two methods:

A. Press the record button on chamber handle

- Press (and release quickly) the black button beneath the red lever, on top of the leaf chamber.
- Beware: Hold this button down to delete the last record.
- Touch 'record', found on any of the Main Menu pages.

B. Automatic data recording/logging - To automatically take records at user selected time intervals.

Recorded data can be stored in named files. These can be accessed at any time for additional data storage, reviewing and downloading data.

What is recorded?


Parameters are listed below, in the order in which they appear in the data log file:

1. **Record**
2. **dt**, Date
3. **tm**, Time
4. **eref**, reference H₂O (mBar)
5. **Δe**, ΔH₂O, difference between e_{ref} and e_{an} (mBar)
6. **eset**, H₂O as set by user (mBar)
7. **Cref**, Reference CO₂ (vpm)
8. **ΔCO₂**, difference between C_{ref} and C_{an} (vpm)
9. **cset**, CO₂ as set by user (ppm)
10. **Qleaf**, PAR 'light' at the leaf plane ($\mu\text{mol m}^{-2} \text{s}^{-1}$)
11. **Qmode**, source of Q reading (climate or given)
12. **Qwhite**, white LED output ($\mu\text{mol m}^{-2} \text{s}^{-1}$)
13. **Qred**, red LED output ($\mu\text{mol m}^{-2} \text{s}^{-1}$)
14. **Qgrn**, green LED output ($\mu\text{mol m}^{-2} \text{s}^{-1}$)
15. **Qblu**, blue LED output ($\mu\text{mol m}^{-2} \text{s}^{-1}$)
16. **Tch**, Chamber Temperature (°C)
17. **Tset**, Leaf chamber temperature set by user (°C)
18. **Tleaf**, Leaf Temperature (°C)
19. **Tl mtd**, Method for leaf temperature (calc. or meas.)
20. **U**, Air flow ($\mu\text{mol s}^{-1}$)
21. **Uset**, user set flow rate ($\mu\text{mol s}^{-1}$)
22. **P**, Pressure (mBar)
23. **C_i**, Intercellular or sub-stomatal CO₂ (vpm)
24. **E**, Transpiration rate ($\text{mmol m}^{-2} \text{s}^{-1}$)

- 25. **Gs**, Stomatal Conductance ($\text{mmol m}^{-2} \text{s}^{-1}$)
- 26. **A**, Rate of Photosynthesis ($\mu\text{mol m}^{-2} \text{s}^{-1}$)
- 27. **Area**, of chamber window, or leaf, when entered (cm^2)
- 28. **Rb**, Boundary layer resistance ($\text{m}^2 \text{s mol}^{-1}$)
- 29-31. **Lat**, Latitude, **Long** Longitude and **Alt** Altitude (DMM)
- 32. **GPS Fix** (0-2) 33. **Chcfg**, Chamber Configuration.

Where is data recorded?

Create a data 'log' file

1. Swipe across the screen or press  to arrive at Main Menu 1.

2. Touch **file menu**, **set log**. Use keys to name log file with your choice of 7 digits (letters and numbers).


Log: Indicates where the recorded data will be stored.

3. To change the where the data will be stored, touch **logging**.

4. Then select either **To Serial** (directly via RS232), **File Menu** (a file name on the SD card), **Timed Log** or **No Log**.

5. Touch 'TimeLog' to enter a time interval in minutes, between 1 and 100, using the keypad.

Alternatively (less often required), press 'anl.cycles' to enter between 1 and 100 analysis cycles. The analysis cycle of measurements lasts for around 20 seconds, so a data point will be logged every 20 seconds.

6. Press  twice to return to Main Menu 1. Automatic logging will now take place.

No changes can be made or saved whilst logging is set to Timed. Ensure that "no log" is selected in the logging menu

before making, saving or changing sequence files OR when controlling climate Q.

Stop a data 'log' file


To stop a log file, for example at the end of a sequence, enter the logging menu:

1. Press 'no log'
2. Press 'log:' until it reads 'off'.

Access a saved data 'log' file

1. Touch **logging** on Main Menu 1.
2. Touch **file menu**. Use arrow keys to select the log file required. Then press **set log**.


How to review data

1. Press  to go to the first main menu screen.
2. Touch **logging, file menu**. Touch the arrows to select the data file for review.
3. Touch **options, review**. You now have access to the stored data in that file.
4. To review different data sets, use **1st**, **last**, **previous** and **next**. Use **more** to review different data pages of the file.

How to download data

1. Connect up the LCpro T with the USB cable provided. Alternatively, remove the SD Card (when not logging) and insert into a card reader.
2. The SD Card will appear as a mass storage device.
3. Files appear in Comma Delimited format .csv.
Save in suitable format (e.g. save as Excel™ Workbook) to preserve data.

Deleting data files

1. Press  to go to Main Menu 2.
2. Select 'Logging/File Menu' use arrow keys to select data file to be deleted.
3. 'Options' then 'Delete'. Confirm or NO to abort.

Controlling the leaf chamber climate

The LCpro T allows you to automatically control the climate within the leaf chamber. You can control any combination of CO₂, H₂O, PAR and Temperature for single or multiple parameter experiments.

Setting up

To control CO₂:

1. Ensure that CO₂ chemical columns (**1** and **4**) are filled with fresh Soda lime.
2. Place a new CO₂ cartridge in the CO₂ cartridge compartment in the battery box. **Please read Section 6.6 in the "LCpro T user guide" main manual, for instructions and safety advice before doing this.**

To control H₂O: Ensure that the Drierite is filled to reduce H₂O levels below ambient. Ensure that the wetter column is filled with ferrous sulphate to increase levels above ambient.

To control PAR: First, remove the radiation shield. Next, slide the LED light unit over leaf chamber window and secure into the upper plate recesses. Connect the light unit cable to the right-hand side socket on the chamber handle.

Now that the radiation shield is removed, the window transmission factor should be changed to **0.92** for broad or narrow, or 0.91 for conifer light units. Enter the “configure” menu from Main Menu 3 and touch **Trw**. Use the number keypad then ‘tick’ to confirm changes.

To control Temperature: Ensure that the Peltier cable is connected to the left-hand side socket on the chamber handle.

Single level control

1. Enter Main Menu 1.
2. Touch **climate**. You are now in the single level environmental control set-up screen.
3. Touch or select the chamber climate parameter that you wish to edit first: Tset (temperature), Qset (in $\mu\text{mol m}^{-2} \text{s}^{-1}$), QRGB (as %), Cset (CO_2) and eset (H_2O).
4. Use the number keys to set the parameter. To return to ambient concentrations, touch **ambient**. Touch the tick symbol to confirm changes. The parameter will remain as set until next changed.

Automatic climate sequence

This function allows you to set up an automatic experiment that runs through a sequence of user-selected environmental conditions. Light response curves and A/Ci curves can be programmed here.

1. Enter Main Menu 1.
2. Touch **sequence**. If you have not used this function before, "No climate sequence file is loaded" will appear. Otherwise, **load sequence** to view an existing file.

Create a climate sequence file

1. Touch **edit**.

2. You are presented with 4 options for setting a sequence file under different lighting conditions:

noLU: No Light Unit will be used in this sequence.

If no light unit is fitted, but you are creating a sequence, this message will appear: "No LU is currently connected. You can edit, but not run sequence files by selecting a LU type. Select LU?" Select Yes or No to continue.

white: The white light unit will be used. When selected, the parameter 'PAR' is displayed for editing.

RGB: The colour, RGB light unit will be used. When selected, the parameters: 'Qred', 'Qgrn' and 'Qblue' are displayed as values in $\mu\text{mol m}^{-2} \text{s}^{-1}$.

as fitted: The sequence file will automatically recognise which light unit is currently fitted, and allow you to edit according to the available lighting condition.

3. Confirm **yes** you want to create a new sequence. You are now presented with a table to program the environmental conditions of your sequence.

2. Step #1 can now be edited. Underlined will be **dwel**. This determines the length of a step, or dwell time. Touch **dwel** to edit. Use the pop-up keypad to set the time in minutes. Confirm changes and exit the menu by touching the tick symbol.

start		clear		file		edit	
Step#	Dwell	Temp	PAR	CO2	H2O	Opts	
1	1	amb.	amb.	0	amb.	-R--	
2	1	amb.	amb.	50	amb.	-R--	
3	1	amb.	amb.	100	amb.	-R--	
4	1	amb.	amb.	150	amb.	-R--	
5	1	amb.	amb.	200	amb.	-R--	
Sequence file 'seq-002'. 21 step(s).							

3. Set environmental parameters for the first step in the sequence by touching directly onto each parameter to edit it in the same way. Pressing **amb** returns the parameter to the ambient, uncontrolled condition. Confirm changes using the tick symbol. Clear or edit values using **Clr** or the arrow.

4. To select the environmental conditions of the second step of your sequence, touch ↓ to create a new step. Touch each parameter to edit, as before.

5. Continue to program each step of your sequence. Use the arrow keys ↓ ↓↓ ↑ ↑↑ to add new steps and to select subsequent or previous steps, for rapid editing.


To program other options into the sequence, press **opts**. By pressing the relevant key, the various options will be activated:

Ignore: This will cause this step in the sequence to be ignored so the sequence jumps automatically to the next step.

Record: A data set is automatically recorded just prior to the end of that step.

End seq: The sequence will automatically stop at the end of this step.

Power dn: The sequence will automatically stop, and the LCpro T will switch off after this step.

6. Once you have finished programming your sequence, press  or swipe upwards to return to top screen of sequence programming.

7. Press **start, run** to start your sequence experiment.



Editing total PAR or %RGB in a sequence file

It is possible to edit Q in both PAR and %RGB modes (for a colour light unit), within a sequence file. It is perhaps simpler to use just one mode per sequence file.

Mode option 1: Use the PAR menu to set **Qred, Q grn, Qblu** in $\mu\text{mol m}^{-2} \text{s}^{-1}$ values, before editing the total PAR if required. Only edit the total PAR through the sequence. Individual **Qred, Q grn, Qblu** values will automatically calculate to equal Qtotal. All values recorded in a sequence data file will be displayed as actual $\mu\text{mol m}^{-2} \text{s}^{-1}$ values, (not as %).

Mode option 2: Set the %RGB and only edit %RGB through the sequence. QTotal will be automatically calculated according to your set %RGB values and total. All values recorded in a sequence data file will be displayed as actual $\mu\text{mol m}^{-2} \text{s}^{-1}$ values, (not as %).

Saving a climate sequence file

1. Your sequence may be saved by pressing  to return to top screen of sequence programming.
2. Press **file**, **save seq**.
3. Use keys to name file. Press  to save the sequence.

Using a climate sequence file

1. Enter the **sequence** menu. Touch **file**, **load seq**. Swipe downwards on the screen, or use the arrow key to select a program.
2. Press **load seq**. Your chosen sequence will now be loaded to either **start**, or, touch **edit** to create a new sequence from the existing sequence file.

After a sequence file has run and completed, this message is displayed: "Climate sequence stopped. End of sequence reached at step #.."

What happens after a sequence file has run?

1. This message is displayed: "PAR sequence stopped. End of sequence reached at step #.."
2. Q values will return to those set in the climate menu.
Before running a sequence file, please check that climate Q is set to a desired level (eg. ambient) either side of running a sequence file, to avoid exposing a leaf to unwanted irradiance before or after a sequence.

You must exit a sequence by pressing "clear", then select another file in order to edit or run a different sequence file.

Interpreting data file Q values

Columns taken from LCpro T 'timed log' data file:

A. When Trw is set to 0.92

8	9	10	11	12	13	
Qleaf	Q mode	Qwhite	Qred	Qgrn	Qblu	QTotal
2155	climate	n/a	773	796	773	2342
2208	climate	n/a	800	800	800	2400
1949	climate	n/a	708	702	708	2118
Qleaf = Total x Trw of 0.92						

B. When Trw is set to 1.00 (no Trw factor)

Qleaf	Q mode	Qwhite	Qred	Qgrn	Qblu
21	climate	n/a	7	7	7
34	climate	n/a	21	2	11
71	climate	n/a	53	5	13
70	climate	n/a	23	34	13

8. **Qleaf**, PAR at the leaf plane ($\mu\text{mol m}^{-2} \text{s}^{-1}$) will be corrected for Trw factor (0.92 for Broad or Narrow, 0.91 for Conifer chamber) if set by user in the "configure" menu, prior to setting data logging.

Otherwise, set Trw to 1.00 to ignore any correction in the data file (table B). If you do this, you then need to recalculate the Q values within the data file spreadsheet after logging.

With an RGB light unit fitted, QTotal is not recorded in data files. This value can be calculated by a sum of Qred, Qgrn and

Qblu columns. This will be the output from the light unit, from which Q_{leaf} is calculated (as $Q_{Total} \times Trw$).

With a white light unit fitted, the value for Q_{white} is equal to the Q_{Total} value.

Maximum achievable Q values at the leaf plane: The achieved Q values at the leaf plane level will be multiplied by a factor of 0.92 (Broad and Narrow) or 0.91 (Conifer).



A set Q value of 800 = 736 to the leaf (Q_{leaf})

A set Q_{Total} value of 2400 = 2208 to the leaf (Q_{leaf})


Please remember this, when setting Q!

Plotting a graph

Data can be viewed graphically in real time.

1. Touch  to enter Main Menu 1.
2. Touch **graph**
3. The X axis is displayed for editing on the left. Touch **x axis** to view parameter options. Swipe the screen downwards or use  to view all.
4. Touch the parameter to select it. Press **OK**. Now the parameter appears next to **x axis** inside the blue box.
5. Set how often the graph updates, using **every**. Set between 2 and 30 seconds. On this screen, **log record** will trigger the graph to be plotted at every log record.
6. Touch the tick symbol to confirm and exit.


7. Touch **Y axis** on the right, to select parameter options.

Swipe the screen downwards or use  to view all.

8. Touch the Y axis parameter and **OK** to confirm. Repeat for the four available legends (or fewer), displayed as: Y1, Y2, Y3 and Y4.

Four default colours: Blue, green, yellow and pink are provided. Each colour can be assigned to a particular parameter, according to preference.

5. Press **start**. The graph will now appear and be updated in real time.

6. Swipe across the screen horizontally with one finger, or touch  to scroll between the graph and the other three main menus. Doing so will not affect the graph.

Example: To plot a Light Response Curve, X is set to plot Q (PAR, $\mu\text{mol m}^{-2} \text{s}^{-1}$) and Y is set to plot A (Net CO₂ Assimilation Rate, $\mu\text{mol m}^{-2} \text{s}^{-1}$).

FAQ: How much data can be recorded on one graphing screen?

One graphing screen fills up in 12 minutes, if 'every' is set to 0:02 seconds. If 'every' is set to 0:30, 3 hours' worth of data are plotted in one screen.

FAQ: What happens when one graphing screen is filled? The

graph will continue to scroll along and auto-scale, so that the first screen will be unavailable to 'save'.

Further graphing options

Swipe downwards when the graphing screen is active, to reveal 3 options:-

Copy: Saves a Bitmap image of the graph at that moment, to the SD card.

Pause: Freezes the graph until 'resume' is pressed.

Export: Saves a .CSV file containing all data points from the graph at the time of export.

These can be opened in Excel spreadsheet and graphed manually or analysed further.

