

Physics

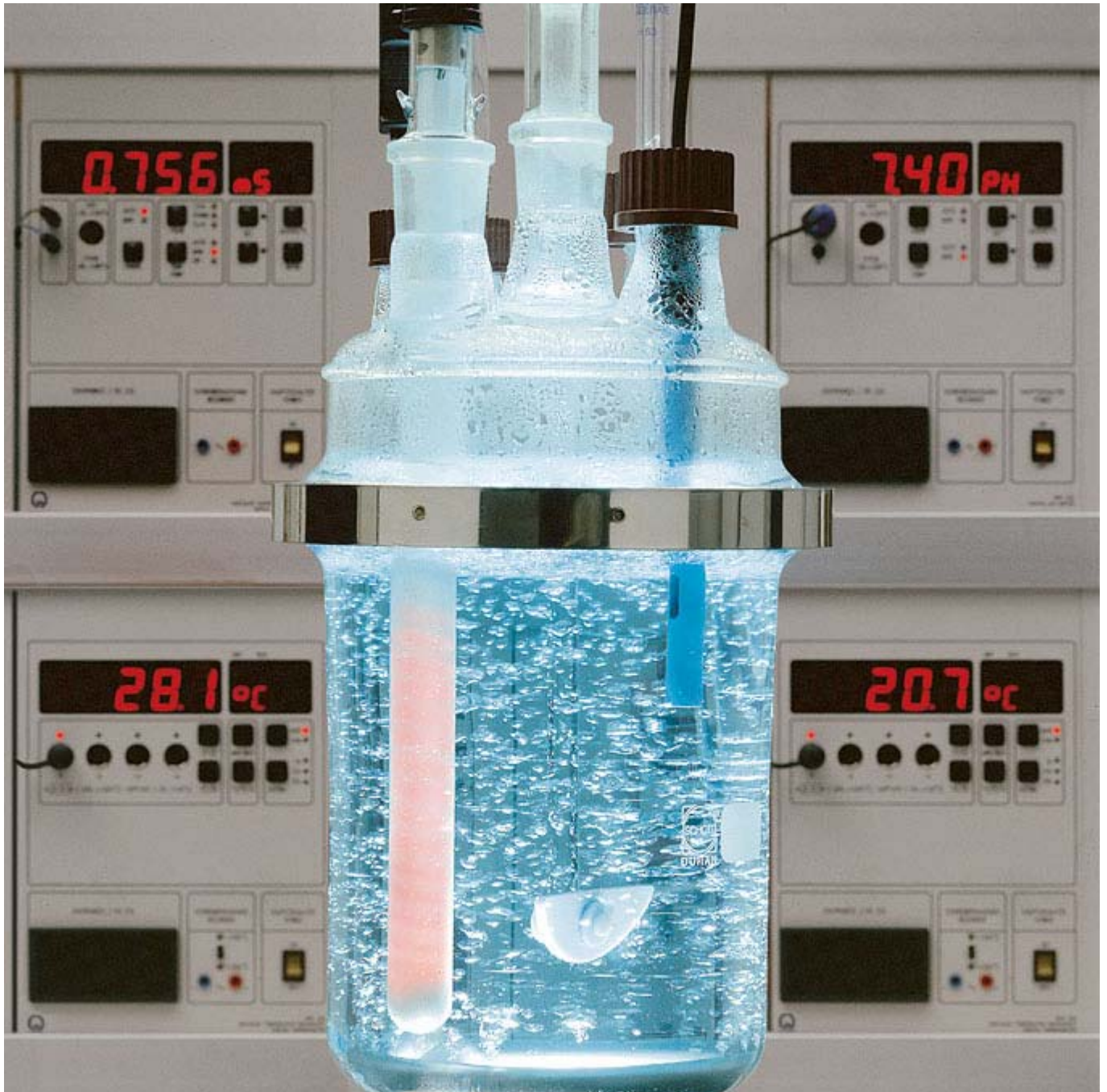
Chemistry · Biology

Technology



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Biotechnology



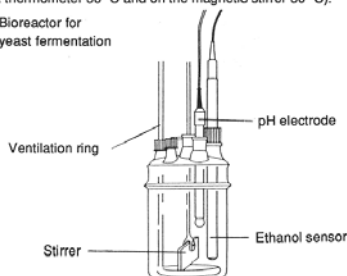
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Experiment Procedure

After the bioreactor has been assembled completely with all of the probes (c.f. Fig. 28) it is filled with the remaining nutrient medium found in the 2 l volumetric flasks, and while stirring (600 min⁻¹) it is warmed up to 30 °C on the heatable magnetic stirrer (setting on the contact thermometer 30 °C and on the magnetic stirrer 50 °C).

Figure 28 Bioreactor for yeast fermentation



When constant temperature has been reached and when all of the preparations for the complementing experiment analysis (glucose determination, OD-determination, and if necessary ethanol determination) have been completed, 15 g of baking yeast are suspended in the 40 ml of remaining nutrient medium while stirring with a spatula. Then the bioreactor is inoculated with this yeast suspension.

The actual growth experiment begins when the ventilation has been set to 120 l/hr using the fine regulating valve of the rotameter and after any necessary correction of the pH level has been carried out.

Every 30 minutes samples are taken from the bioreactor for the determination of the optical density (OD) as well as the determination of the glucose (and, if necessary, determination of the ethanol).

Note: If it is not possible to process the samples immediately, they must be stored in a cool place in order to stop the metabolic activity of the cells.

Furthermore, the pH-level must be monitored constantly and if necessary corrected using soda lye, c(NaOH) = 1 mol/l.

Plot the results of the experiment against time in the prepared diagram (c.f. appendix).

Using the data gained, the growth rate μ and duplication time t_d can be determined.



5.3.2.3 Determining the Growth Rate μ as well as the Duplication Time via the Optical Density

The following section is more detailed and was intended for those students who wish to go deeper into the material.

The growth rate μ and the duplication time t_d derived from this can easily be determined from the optical density (OD) in form of a graph; this will be described later.

Theoretical Derivation of the Growth Rate μ and the Duplication Time

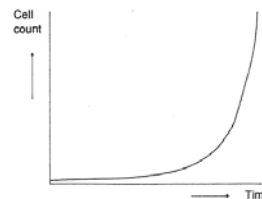
The reproduction of cells can be described mathematically as follows:

$$N_t = N_0 \cdot 2^n$$

N_t = cell count for time point t_t
 N_0 = cell count for the time point t_0
 n = number of cell divisions

The cell count increases exponentially, which in the form of a graph, leads to the well known growth curve (Fig. 29):

Figure 29: Exponential cell increase with respect to time



But just how fast the increase of the cell count is, i.e. how large or small the time interval between two cell divisions, depends on the environmental conditions influencing the cells.

The aim of cell cultivation in a bioreactor is to keep the time between two cell divisions as brief as possible for those cases, where we are dealing with the production of biomass (as, for example, in the present experiment on the cultivation of yeast), or expressed differently, to make the rate of division (duplication per time unit) as large as possible.

This aim is reachable only when

- The yeast cells in the bioreactor are adapted to the nutrient medium, which means after the lag phase, and
- The nutrient medium provides the yeast cells with all of those elements required for life in a well balanced amount, i.e. carbon sources, nutrient substances, trace elements, growth factors and oxygen.



668082

Biotechnology - theory and experiments

157 pages, A 4,

by C. D. Paul and U. Maerz.

The manual provides an introduction to the subject of biotechnology. A total of 45 experiment descriptions are presented. Most of these can be carried out in schools or vocational education programs and are designed to accompany the biotechnology equipment series. The manual lists additional up-to-date sources, defines important topics (glossary) and contains suggestions for use in instruction and training.

Topics:

- Biotechnological production processes
- Biotechnology and environmental protection
- Immobilization of biological catalysts
- Controlling and monitoring of reactions in fermentation processes
- Classical biotechnology processes

The biotechnological experiments are complemented by a comprehensive introduction to microbial and biochemical working techniques. The experiments are designed so that they can be carried out in either a vocational context or in general secondary education.

Topics

Biotechnological production processes

Recovering copper
with microorganisms
Manufacturing isosyrup
Production of citric acid
Production of invert sugar

Biotechnology and environmental protection

Microbial desulfurization of coal
Biotechnological use of whey

Immobilization of bio-catalysts

Binding invertase
to non-organic base materials
Inclusion of yeast in alginate
Inclusion of enzymes in plastic films

Control and regulation of fermentation processes

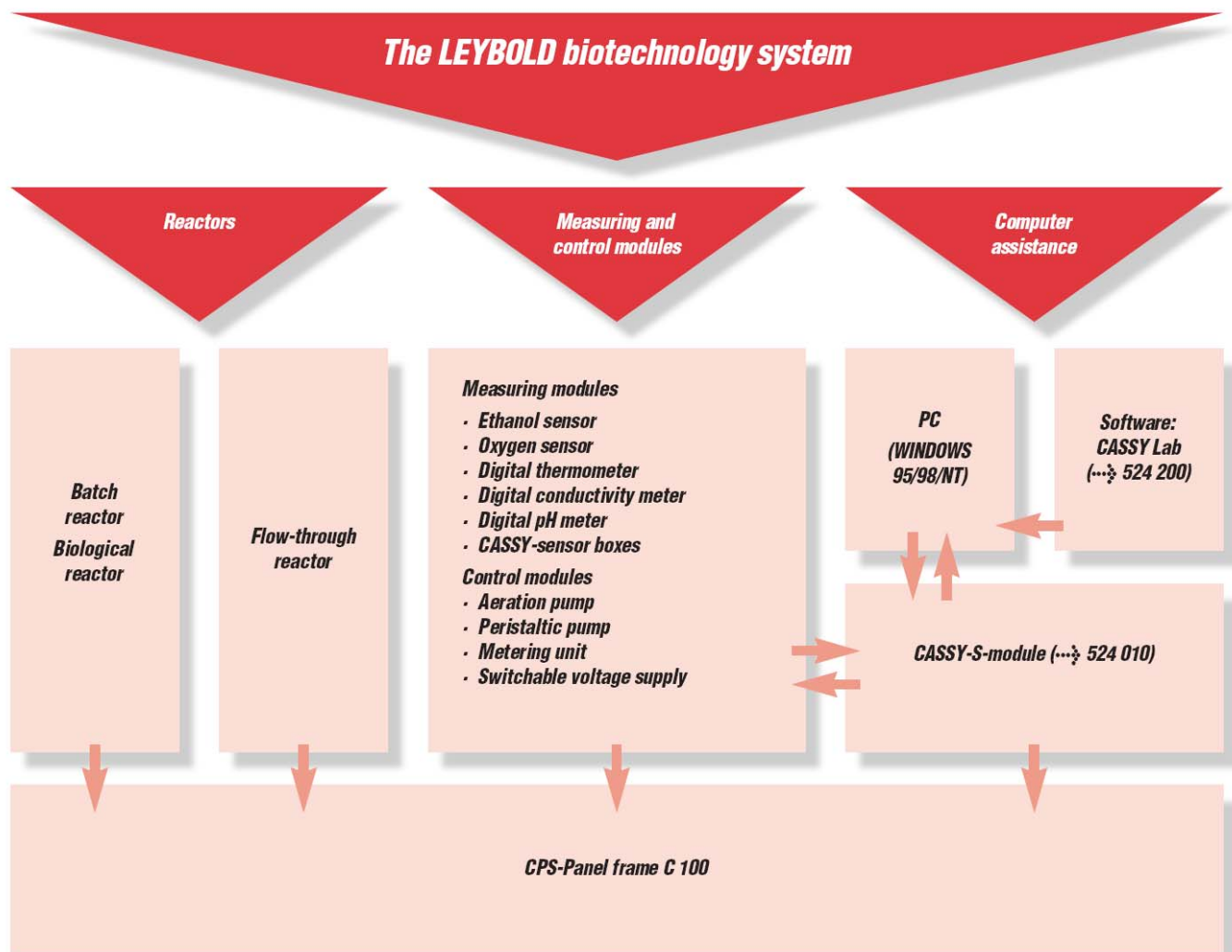
Manufacture of biomass
Fermentation of *E. coli*
Manufacture of bakers' yeast

Classical processes in biotechnology

Manufacturing curds
Manufacturing yogurt

The goal of biotechnology is to use microorganisms, plant or animal cells and their components in industrial processes. Biotechnology makes it possible to exploit the metabolic functions of these biological systems for production, analysis or disposal purposes.

The fascination of biotechnology is also due to the fact that this new field of technology promises the key to solving crucial problems of the present and the future. This is a topic which should not be missed in any course of science instruction which lays claim to being topical.



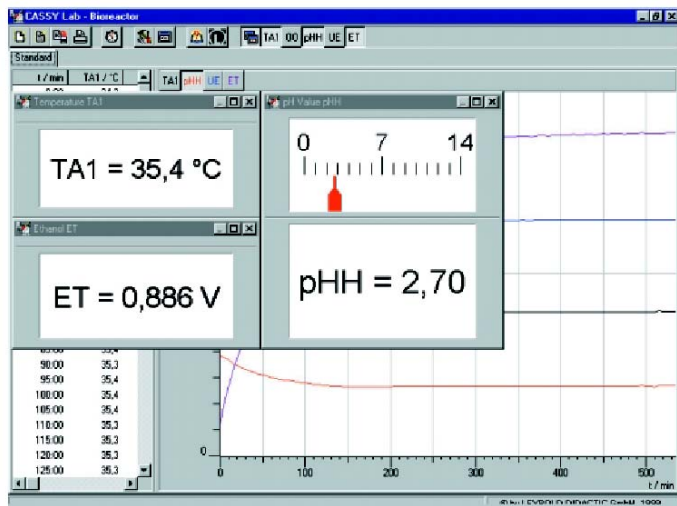


Experiment setup for fermentation

Control and reaction monitoring in fermentation processes

Microorganisms can be used in biological reactors, e.g. for the production of enzymes or in the preparation of drugs. However, this involves extensive measurement and control equipment to maintain optimal conditions for growth of the microorganisms used (e.g. baker's yeast).

A relatively simple and completely safe example of this is the production of ethanol from baker's yeast (*Saccharomyces cerevisiae*). This is a biochemical means of preparing alcohol from sugar using yeast cells. The process is controlled and monitored by the CASSY-S module and the software CASSY Lab.



Equipment list

Control and reaction monitoring in fermentation processes

Qty.	Description	Catalog No.
1	CPS-Biological reactor, basic kit	666 410
1	Controllable aeration pump	666 482
1	Plastic tubing, 6 mm ^Ø , 1 m	307 641
1	CPS-holder with bosshead, height adjustable	666 470
1	Stirrer motor, 60 to 700 rpm	607 190
1	HWS -turbine stirrer	661 361
1	Stirring seal	661 366
1	Stirrer coupling	661 367
1	CPS ethanol sensor for 666 410	666 411
1	CPS-metering unit	666 413
1	CPS voltage supply, switchable through programmable control signal, TTL signal or contact thermometer	666 471
1	CPS mains distributor	665 497
2	Sensor-CASSY, USB	524 010USB
1	CASSY Lab (software)	524 200
1	pH adapter S	524 037
1	pH single rod measurement cell (glass electrode)	667 4242
1	Temperature-box (NiCrNi/NTC)	524 045
1	Temperature sensor, NTC	666 212
2	Connection lead, 50 cm, red	500 421
2	Connection lead, 25 cm, blue	500 412
2	Connection lead, 50 cm, black	500 424
3	CPS blank panel, 100 mm	666 464
3	CPS blank panel, 200 mm	666 467
1	CPS blank panel, 300 mm	666 468
1	Adapter for flat ground cover 664 346	664 347
1	Schuko socket strip, 5 sockets (Safety mains sockets)	663 615

additionally necessary:

- 1 PC (with Windows 98/Me/2000/XP) and free USB port

Yeast
Sterile sugar solution

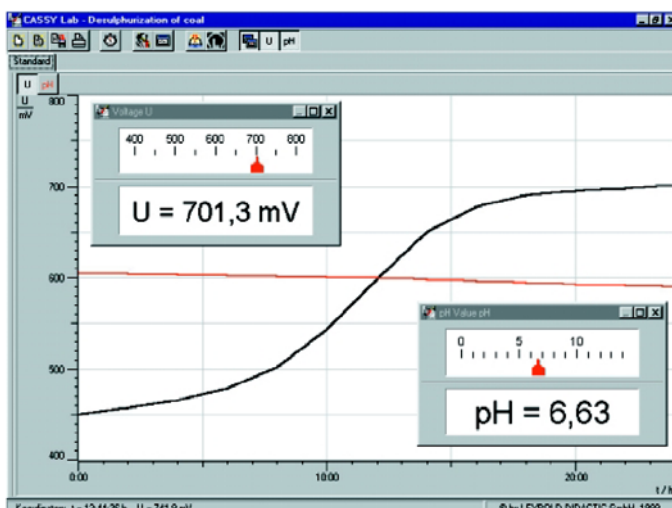
Microbial desulfurization of coal

Alternative desulfurization methods rely on removing the sulfur from the coal before it is burned. Besides chemical methods, the method of leaching by microorganisms is being investigated, a method familiar in ore mining operations.

Microbial desulfurization primarily uses *Thiobacillus ferrooxidans* and *T. thiooxidans*. The former are capable of obtaining the energy to maintain their metabolism by oxidizing pyrite directly. The Fe^{3+} ions formed in this process also oxidize the pyrite by purely chemical means. *T. thiooxidans* then oxidizes the released elementary sulfur to sulfuric acid.



CPS experiment assembly for microbial desulfurization of coal

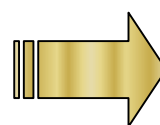


The values for pH and redox potential are plotted in a diagram against the time. The redox potential has increased considerably. This can be taken as an indication that the sulfur and Fe(II) have been oxidized. The pH remains virtually unchanged.

Equipment list**Microbial desulfurization of coal**

Qty.	Description	Catalog No.
1	CPS-biological reactor, basic	666 410
1	Controllable aeration pump	666 482
1	Sensor-CASSY, USB	524 010USB
1	CASSY-Display, USB	524 020USB
1	pH adapter S	524 037
1	Redox probe	667 416
1	pH single rod measurement cell (glass electrode)	667 4242
1	Stirrer motor	607 190
1	Stirrer, 370 mm with Teflon shaft and Teflon blades, 370 mm	666 826
1	CPS-holder with bosshead, height adjustable	666 470
Bacteria strains:		
Thiobacillus ferrooxidans*		
Thiobacillus thiooxidans*		
Additional required:		
1	CASSY Lab (software)	524 200

*available from Deutsche Sammlung von Mikroorganismen (German Microorganism Collection), Brunswick, Germany



For more information on computer-assisted measured-value recording see page 15



666 410 CPS-biological reactor

Complete with mounting hardware. Suitable for experiments on:

- all fermentation processes based on the batch method

- Dimensions: 300 x 297 x 280 mm
- Experiment panel: 300 x 297 mm
- Weight: 10.0 kg

Scope of delivery:

- 1 Beaker with ground lip, 2000 ml
 - 1 Ground glass cover, 2 ST 29, 2 GL 32, 2 GL 18
 - 2 Adapters for standard electrodes (GL 18 and GL 25)
 - 1 Aeration ring
 - 1 Heating rod, 100 W, ST 29
 - 1 Universal holder for glassware
 - 1 Stirring sleeve, ST 29/32
 - 1 Three-level panel frame (C 100)
- Mounting hardware



666 411 CPS ethanol sensor

Used to measure ethanol either in solution or in the gas collection chamber.

Applications:

- Process monitoring in the manufacture of ethanol or fermented acetic acid
- Determining the ethanol concentration in liquids
- Determining the ethanol content in the breath

Sensor with sintered ceramic plate in a stainless steel housing; the sensitivity can be adapted to suit the particular measurement task by adjusting the amplifier gain. The electronics are located in a separate housing on the rear. Can be connected to the CASSY interface device. With O-ring and special membrane (two).

- Analog output : 0 ... 2 V
- Sensor: 350 mm long; 20 mm \varnothing
- Length of lead: 1700 mm
- Weight: 0.8 kg



666 482 CPS aeration pump

For continuous aeration. The pump can also be used to create a partial vacuum. The flow rate can be controlled either manually (via a control knob) or externally (by means of a control voltage 0...10 V).

- Pump capacity: 0...3 l/min, manually set or externally controllable
- Max. pressure: 2 bar
- Partial vacuum: min. 380 mbar
- Supply voltage: 13 V/1.3 A via enclosed plug-in supply unit (230 V/50 Hz)
- Dimensions: 100 x 297 x 130 mm
- Weight: 1.3 kg

666 416 Aeration ring

To supply oxygen to aerobic fermentation processes in the biological reactor. For use with CPS aeration pump 666 482. Stainless steel.

- Length: 300 mm
- Diameter: 120 mm



666 413 CPS-metering unit

For metering of liquids via a solenoid valve; the valve may be operated manually or via a computer. With two sockets for connection to the relay output of a computer interface, 1 pushbutton for manual operation, 1 LED for operation monitoring. Intended, for example, to maintain the pH value in the bioreactor during fermentation.

- Power supply: 12 V AC/580 mA via plug-in power unit (included)
- Dimensions: 150 x 297 x 240 mm
- Experiment panel: 150 x 297 mm
- Weight: 1.1 kg

Scope of delivery:

- 1 Reservoir vessel, 250 ml, with built-in scale, GL 45 screw thread and GL 14 screw thread
 - 1 Solenoid valve, 12 V, resistant to alkalis and acids, with hose nipple
 - 1 Experiment panel
- Mounting hardware

666 418 CPS flow-through reactor

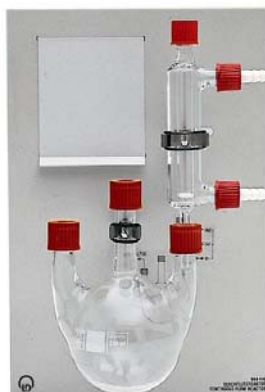
Complete with standardized spacers and mounting hardware. Using the column reactor can help to clarify biotechnological processes which take place in a fluid-bed reactor or in which continuous recirculation of liquids is necessary. Examples here include:

- Enzyme breakdown of lactose
- Manufacture of invert sugar
- Microbiological recovery of copper from excavated material (leaching of ore)

- Dimensions: 200 x 297 x 140 mm
- Weight: 0.7 kg

Scope of delivery :

- 1 Column reactor, 200 mm, with cooling jacket, 3 GL 14, 2 with nipples for connecting to a thermostat
 - 1 3-neck round bottom flask, 250 ml, 3 GL 18
 - 1 Labelling plate
 - 1 Experiment panel
 - 1 Book: Biotechnology
- Mounting hardware



666 420 Peristaltic pump

For continuous pumping of liquids. The flow volume is varied using three different silicone hoses.

- Maximum back pressure: 0.357 bar
- Flow volume: 0.75; 2.0; 4.0 [ml/min]
- Hose inside diameters: 1.0; 2.5; 5.0 [mm]
- Supply voltage: 230 V/50 Hz
- Dimensions: 100 x 297 x 100 mm
Experiment panel: 100 x 297 mm
- Weight: 0.7 kg



665 498 Peristaltic pump PM 2

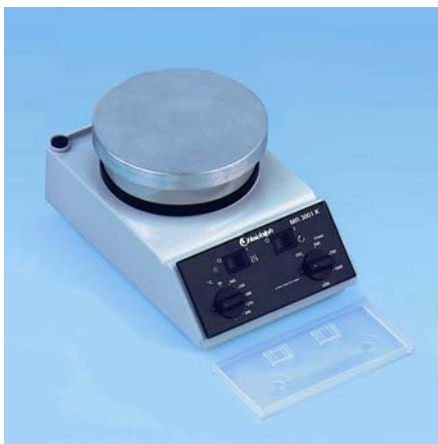
Hose pump with controllable capacity, switchable to control via external clock generator (e.g. computer). The pump capacity is designed for long-term constant operation! Fast replacement of hose section which is subject to wear via a quick release coupling.

- Pump capacity : 0 ... 2 l/h
- Supply voltage: 230 V/50 Hz
- Dimensions: 100 x 297 x 140 mm
Experiment panel: 100 x 297 mm
- Weight: 2.2 kg

666 847 Magnetic stirrer with hotplate

Stainless steel hotplate, heating control via relay. With fitting for attaching the M 10 stand rod. Temperature is automatically limited to 350 °C, so that the unit cannot be destroyed if accidentally left on for long periods of time. The unit is equipped with connector sockets for contact thermometers (e.g. 666 195), making possible external control of heating power. The status of the heater and stirring motor is indicated by LEDs. Complete with power cord and plug.

- Rotation speed: 0 to 1250 rpm (continuous)
- Plate: stainless steel, 14.5 cm^Ø
- Heating power: 600 W, relay control
- Temperature constancy: ±1 K
- Power supply: 230 V/50 Hz
- Weight: 3.2 kg



607 190 Stirrer Eurostar digital

Laboratory stirrer for work up to the "medium-viscosity"-range, with constant speed controlled by a microprocessor.

- narrow design allows for efficient utilization of space
- safe, smooth start prevents spraying
- easy height adjustment of stirring shaft
- quiet operation
- precision chuck for shaft-Ø from 0.5 - 10 mm
- electronic safety circuit
- speed range from 50-2000 1/min, without gear change
- digital display presents all data clearly



666 824 Stirrer sleeve, 100 mm

With ST 29/32 standard ground joint core, 10 mm nominal width.

666 825 Stirrer sleeve, 175 mm

With ST 29/32 standard ground joint core, 10 mm nominal width.

666 823 Stirrer

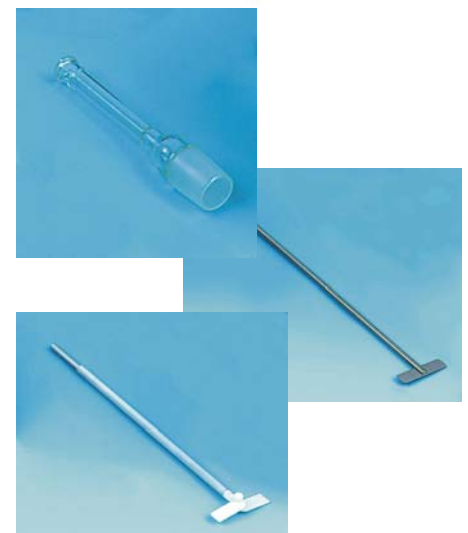
With adjustable stainless steel paddles.

- Length: 400 mm
- Diameter: 7.5 mm

666 826 Stirrer

With PTFE shaft and paddles, fitting the 666 824 and 666 825 sleeve, KPG tube.

- Length: 370 mm



666195 Contact thermometer

Used for temperature regulation in baths, etc. Rod-shaped, with milk glass scale. Set-point temperature can be set with rotary magnet. Mercury filled.

- Range: -10 ... 250°C
- Length: 460 mm
- Rod diameter: 9 mm approx.



607 096 KOMET magnetic stirrer bar

Stirrer bar made of high-energy magnet material for medium to large stirring quantities. Octagonal shape. Including stirrer bar holder for attaching the stirrer bar to the magnetic stirrer

- Length: 50 mm
- Diameter: 21 mm

664 321 Flat ground cover

Nominal width 150 mm, 4 sockets ST 29/32 ST.

664 346 Flat ground cover

Nominal width 150 mm, two sockets ST 29/32, 3 screw connections GL 45, 1 GL 18 screw connection and two adaptors for standard electrodes /GL 18 and GL 25).

664 347 Adapter for electrodes

For use in connection with standard electrodes in the biological reactor (666 410).

- Length: 200 mm
- Screw connection: GL 25

666 421 CPS universal glassware holder

CPS holder for glassware with different radii and outlet positions.

- Experiment panel: 300 x 297 mm
- Metal base with spring clip: depth 250 mm
- Weight: 1.8 kg



664 326 O-ring

For flat ground beakers, 150 nominal width.

664 325 Quick closure

For flat ground beakers, 150 nominal width.

664 340 Flat ground beaker

Duran®, nominal width 150 mm.

- Contents: 2000 ml
- Flange O.D.: 18 mm
- Beaker dia.: 154 mm
- Height: 200 mm
- Weight: 2.0 kg

666 757 Quartz heating element 100 W

With ST 29, fitting the flat ground beaker (664 340).

- Length: 300 mm

666 756 Quartz heating element 1000 W

With ST 29, fitting the flat ground beaker (664 340).

- Length: 30 cm



666 426 CPS panel frame C 100

For holding equipment on CPS panels, three levels, with wiring tunnel.

- Dimensions: 1160 x 930 mm (W x H)
- Weight: 7.5 kg

666 470 CPS-holder with clamp, height-adjustable

For attachment of equipment using a universal clamp or devices with stand rod (e.g. stirrer motor). The holder is height-adjustable along a slot for adjustment to different spacings. Panel can be secured against movement.

- Dimensions: 10 cm x 29.7 cm x 12 cm
- Weight: 0.5 kg



Equipment platforms

For supporting bench-top devices which are to be integrated into the experiment assemblies.

726 21 35 cm x 44 cm

726 22 50 cm x 44 cm

301 312 30 cm x 15 cm



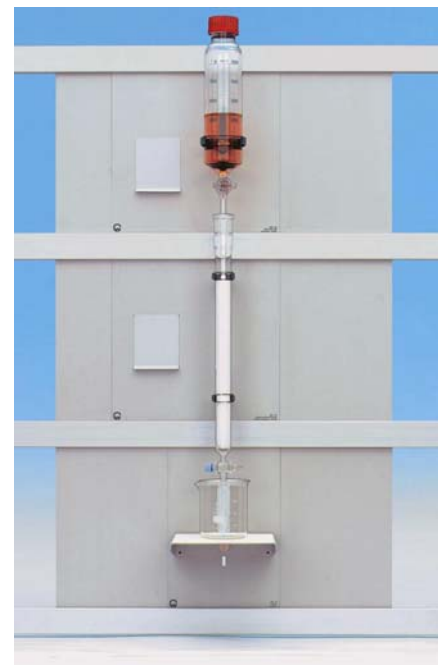
Constituents of foodstuffs - Protein separations - Modern analysis methods

Important and spectacular scientific discoveries, e.g. in the areas of protein synthesis, pharmaceuticals, genetic technology or biological technology, make biochemical knowledge in natural science instruction more important than ever.

Until recently, biochemistry teaching was limited to describing the relative material classes such as proteins, carbohydrates or fats. The experiment setups shown here prove that the equipment of a school laboratory can be used to do a great deal more.

Equipment list Separation of chlorophylls

Qty.	Description	Catalog No.
1	CPS chromatography column	666 443
1	CPS drop funnel	666 437
1	Silica gel, 500 g	661 058
1	Beaker, 600 ml	664 132
1	CPS pedestal	666 441
1	Panel frame, C100	666 426

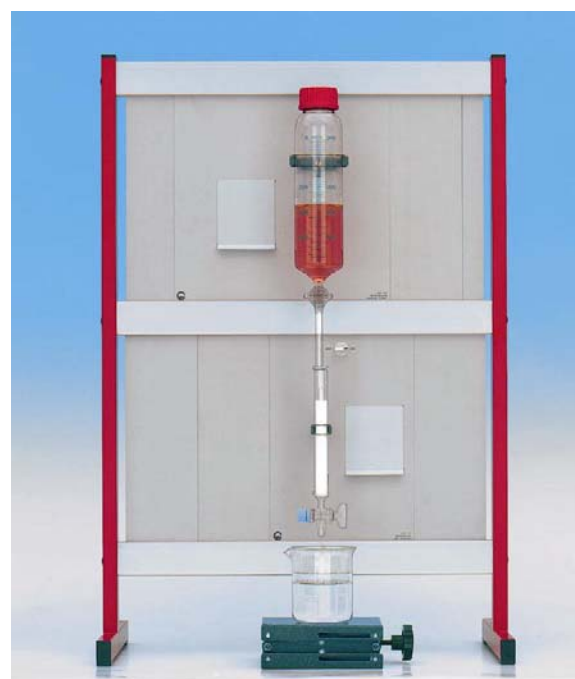


Equipment list Extraction after Soxhlet

Qty.	Description	Catalog No.
1	CPS extraction setup after Soxhlet	666 445
1	Joint clip, ST 29/32, metal	665 398
1	Heating mantle, 500 ml, 200W	666 753
1	Rubber tubing, 10 m	667 181
1	Extraction thimble, diam. 33 mm, set of 25	661 051
1	CPS pedestal	666 441
1	Panel frame, C100	666 426
4	CPS-blank panel, 100 mm	666 426

Equipment list Gel filtration

Qty.	Description	Catalog No.
1	CPS gel filtration	666 444
1	CPS drop funnel	666 437
1	Sephadex G-25	674 829
1	Bromthymol blue	671 070
1	Dextran blue	671 598
1	Beaker, 600 ml	664 132
1	CPS pedestal	666 441
1	Panel frame, C100	666 426
2	CPS-blank panel, 100 mm	666 464
1	CPS-blank panel, 200 mm	666 467





Creating primitive membranes Proteinoids in classroom instruction

Using a simple experiment setup, it is possible to create amino-acid membranes, the so-called proteinoid microspheres. The reaction takes place under protective gas, resp. nitrogen.

Equipment list

Creating primitive membranes

Qty.	Description	Catalog No.
1	Double-necked round-bottom flask, 500 ml, ST 29/32, GL 18	664 316
1	Suction part, ST 19/26 with ST cock	665 304
1	Stopcock, single-port, with ST stopcock	665 251
1	Joint clip, ST 19/26, metal	665 397
1	Heating mantle, 500 ml, 200W	666 753
Chemicals:		
	Asparaginic acid	670 6810
	Glutamic acid	672 1180
	Glycocol	672 1310

Sugar membranes

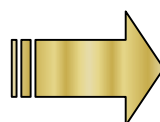
Enzymes can easily be embedded in membranes. Thus, it is possible to create a "model organism" in the classroom which can be used to explain the metabolism of a cell.

This experiment additionally requires an enzyme which catalyzes the reaction to a colored product, e.g. peroxidase (substrate: 3,3,5,5-tetramethyl benzidine).

Equipment list

Sugar membranes

Qty.	Description	Catalog No.
1	Beaker, 50 ml	664 100
1	Erlenmeyer-flask, 250 ml, nn	664 233
1	Syringe, plastic, 20 ml	375 21
1	Magnetic stirrer	666 845
1	Stirring bar	666 850
1	Glass stirring rod	665 212
Chemicals		
	Calcium chloride	671 2420
	Sodium alginate	



For detailed experiment descriptions refer to the manual "Biochemistry SII" (668 102).

Isolating nucleic acids

Nucleic acids can be isolated from wheat germ and their components identified in a simple school experiment

**666 010 Microliter pipette**

100 µl, with interchangeable tip, for simple and fast metering of minute volumes.

666 012 Microliter pipette

1000 µl, with interchangeable tip, for simple, fast metering of minute volumes.

Tips for microliter pipettes

50 pieces

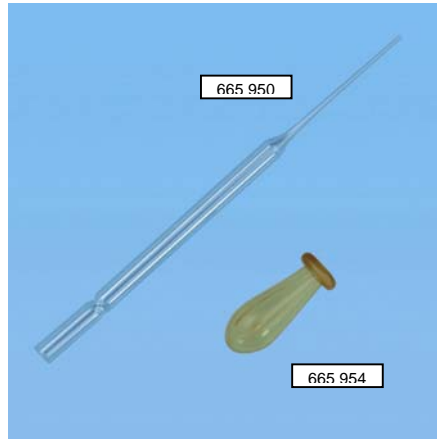
Cat.No.	Color	Volume
666 011	yellow	100 µl
666 013	blue	1000 µl

665 950 Pasteur pipettes, set of 250

- Length: 150 mm
- Diameter: 7 mm

665 954 Rubber bulbs, set of 10

Fitting the pasteur pipettes (665 950) and the pipettes (665 953).

**668 082****Biotechnology****- theory and experiments**

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by C. D. Paul and U. Maerz

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 - Controlling and monitoring of reactions in fermentation processes
 - Classical biotechnology processes
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**668 102****Biochemistry SII**

142 pages, DIN A 4, by Uwe Maerz, 83 experiments.

Topics:

- Isolation and chemical analysis of nucleic acids
- synthesis of peptides after MERRIFIELD
- Gel filtration
- Ion exchange chromatography
- Liquid chromatography - HPLC
- Separation and identification of proteins by SDS-gel electrophoresis
- Enzymatic determination of glucose with glucose oxidase and peroxidase
- Modern methods of analysis - Biological sensors

**Syringes**

With Luer fitting

Cat.No.	Volume	Graduation
665 957	1 ml	0.1 ml
665 955	5 ml	0.5 ml
665 958	10 ml	0.5 ml
603 020	20 ml	1.0 ml

665 956 Disposable needles

With Luer fitting. 10 pieces

- Diameter: 0.8 mm
- Length: 38 mm



✓
**Compatible
... all CASSY sensor
boxes and sensors
can be used with
CASSY**

✓
**With
serial interface
or USB port**

Scope of delivery:

- 1 Sensor-CASSY
- 1 CASSY Lab software, without activation code, with comprehensive help function (20 sessions free, then usable as demo version)
- 1 USB cable
- 1 Plug-in supply unit 12 V/ 1.6 A

524 010USB Sensor-CASSY® USB

Cascadable interface for measured-value recording.

- for connection to the USB port of a computer (WINDOWS 98/2000/XP), another CASSY module or the CASSY display
- Sensor-CASSY and Sensor-CASSY USB can be used mixed
- fourfold electrically isolated (inputs A and B, relay R, voltage source S).
- cascading of up to 8 CASSY modules possible (to multiply the inputs and outputs)
- up to 8 analog inputs per Sensor-CASSY retrofittable using sensor boxes
- automatic sensor box detection by CASSY Lab (plug and play) (524 200)
- microprocessor-controlled via the CASSY operating system (complete with software update functionality for fast, easy performance enhancements)
- can be set up as a benchtop, console or demonstration unit (also suitable for CPS/TPS panel frames)
- voltage supply 12 V AC/DC via cannon plug or an adjacent CASSY module

Note: also available with serial interface (524 010)

- **5 analog inputs** (any two inputs A and B usable simultaneously)
2 analog voltage inputs A and B on 4-mm safety sockets
Resolution: 12 bits
Measuring ranges: $\pm 0.3/1/3/10/30/100$ V
Measurement error: ± 1 % plus 0.5 % of range end value
Input resistance: 1 M Ω
Scanning rate: max. 200,000 values/s (= 100,000 values/s per input)
Number of measured values: nearly unlimited (depends on PC) up to 100 values/s, at higher measuring rate max. 32,000 values (= 16,000 values per input)
- **1 analog current input A** on 4-mm safety sockets
Measuring ranges: $\pm 0.1/0.3/1/3$ A
Measurement error: voltage error plus 1 %
Input resistance: <0.5 Ω (except under overload)
See voltage inputs for further data
- **2 analog inputs at sensor box connector sites A and B**
(All CASSY sensor boxes and sensors can be connected)
Measuring ranges: $\pm 0.003/0.01/0.03/0.1/0.3/1$ V
Input resistance: 10 k Ω
See voltage inputs for further data
The technical data will change according to a connected sensor box. In this case, the CASSY Lab automatically detects the possible measurement quantities and ranges when a sensor box is attached
- **4 timer inputs** with 32-bit counters at sensor box site (e.g. for BMW box, GM box or timer box)
Counting frequency: max. 100 kHz; time resolution: 0.25 μ s
Measuring time between two events at same input: min. 100 μ s
Measuring time between two events at different inputs: min. 0.25 μ s
Memory: max. 10,000 time points (= 2,500 values per input)
- **1 changeover relay** (with LED to indicate switching state)
Range: max. 100 V / 2 A
- **1 analog output** (PWM-output) (pulse-width modulated, switchable voltage source, LED switching state indicator, e.g. for holding magnet or supplying the experiment)
Variable voltage range: max. 16 V / 200 mA (load ≥ 80 Ω)
PWM range: 0% (off), 5-95% (1% resolution), 100% (on)
PWM frequency: 100 Hz
- **12 digital inputs** (TTL) on sensor box sites A and B (at present only used for automatic sensor box detection)
- **6 digital outputs** (TTL) on sensor box sites A and B (at present only used for automatic switching of the measuring range of a sensor box)
- **1 USB port** for connection to a computer
- **1 CASSY bus** for connecting additional CASSY modules
- Dimensions: 115 mm x 295 mm x 45 mm
- Weight: 1 kg

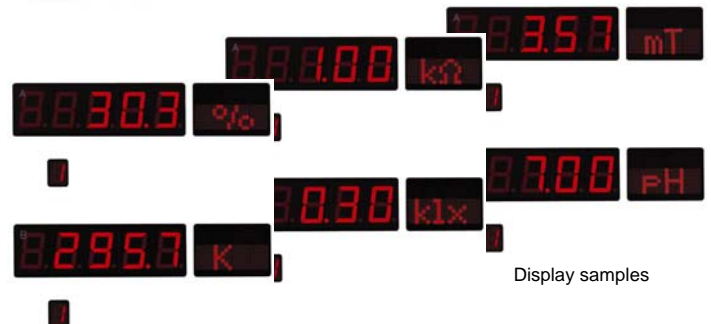
524 020USB CASSY®-Display USB

2-channel display for displaying measured values without a computer.

- Microprocessor-controlled via the CASSY operating system (complete with software update functionality for fast, easy performance enhancements)
- Can be set up as a benchtop, console or demonstration unit (also suitable for CPS/TPS panel frames)
- Supports up to 8 Sensor-CASSYs (equivalent to 16 measuring channels)
- Measurements are carried out using Sensor-CASSY or a sensor box connected there (see specifications of respective device for measurement quantities and ranges)
- Measured values can be switched and calibrated individually. The measuring range and unit are matched automatically when plugging and swapping sensor boxes
- With integrated real-time clock and data logger
The data memory for up to 32,000 measured values retains its contents even when the device is switched off so that it can be subsequently read out to a computer via the **USB-port**.
- Voltage supply 12 V AC/DC via canon plug
- Measured value recording also possible independently of mains with portable power supply unit (12 V)

Note: also available with serial interface (524 020)

- Dimensions: 215 mm x 295 mm x 45 mm
- Weight: approx. 1.8 kg



Display samples



The CASSY Display module shows the current measured values of all connected Sensor-CASSY units. The device automatically displays the quantity which matches the currently connected sensor box. As a result, it replaces a computer for simple measuring tasks, and can be used in conjunction with a Sensor-CASSY module in place of conventional demonstration measuring instruments (e.g. voltmeter, ammeter, tesla meter, newton meter, barometer). And the integrated CASSY Display data logger stores your measurement data for subsequent computer-based evaluation with CASSY Lab.



524 045 Temperature box (NiCr-Ni, NTC)

For temperature measurement with up to two NiCr-Ni or NTC temperature sensors (666 193 or 666 212).

- Measurement ranges:
NiCr-Ni: -200 ... +1100 °C
NTC: -20 ... +120 °C

666 193 Temperature sensor NiCr-Ni

NiCr-Ni thermocouple. With connection cable (1.5 mm) and DIN plug.

- Measurement range: -200 to +1100 °C, (intermittently to 1200 °C)
- Tolerance classes: 1/3 DIN, (DIN IEC 584 Part 2)
- Diameter: 1.5 mm
- Overall length: 200 mm

666 212 Temperature sensor

NTC resistance element for more precise. measurement. With coiled cord (1.5 m) and DIN plug.

- Measurement range: - 20 to + 120 °C
- Tolerances: - 20 to + 70 °C: 0.2 K
+ 70 to + 120 °C: 0.4 K
- Diameter: 3 mm
- Overall length: 280 mm



524 067 pH-Adapter S

Enables a pH electrode to be connected to CASSY. Moreover, the voltage at the BNC socket can be measured at a very high resistance, e.g. for measuring electrochemical potentials.

- Measuring ranges: pH: 0 ... 14
- Resolution 0.01 pH
- Potential: -2 V...+2 V, -1 V...+1 V
- Input resistance: $>10^{13}$ Ohm
- Connection: BNC socket

667 4242 pH Probe with glass shaft, BNC

For measuring in aqueous medium, with BNC plug and fixed connected cable.

- Measuring range: 0...14 pH
- Resolution: 0.01 pH
- Cable length: 1 m

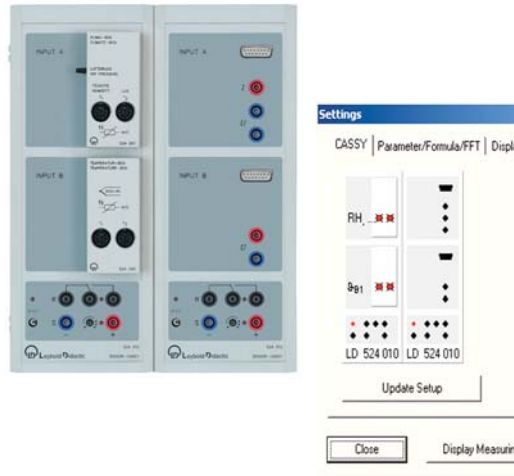


**Temperature measurement
with CASSY-Display:
it will be possible to connect
up to 4 temperature sensors
to Sensor-CASSY**

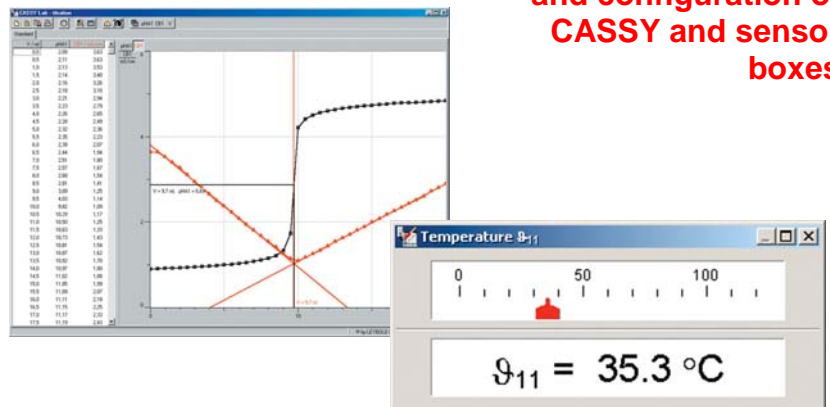
524 200 CASSY® Lab

Software for recording and evaluating measurement data acquired using the CASSY family, with comprehensive integrated help functionality.

- supports up to 8 Sensor- and Power-CASSYs on one USB port or serial interface
- supports alternatively up to 8 Pocket-CASSYs or Mobile-CASSYs at different USB ports
- supports all CASSY sensor boxes
- "plug and play" enabled for easy use: the software automatically detects the connected CASSYs and sensor boxes and displays these graphically, inputs and outputs are activated simply by pointing and clicking and typical experiment parameters are automatically loaded (depending on the connected sensor box)
- powerful evaluation functions including various fits (straight line, parabola, hyperbola, exponential function, free fit), integrals, diagram labeling, calculation of user-definable formulas, differentiation, integration, Fourier transforms
- convenient exporting of measurement data and diagrams via the clipboard
- free update at <http://www.leybold-didactic.com>
- graphical display of CASSY, sensor box and connector allocation when the experiment file is loaded
- hardware configuration (serial): Pentium class with Windows 95/98/Me/NT/2000/XP, free serial interface (RS232)
- hardware configuration (USB): Pentium III with Windows 98/Me/2000/XP, free USB port

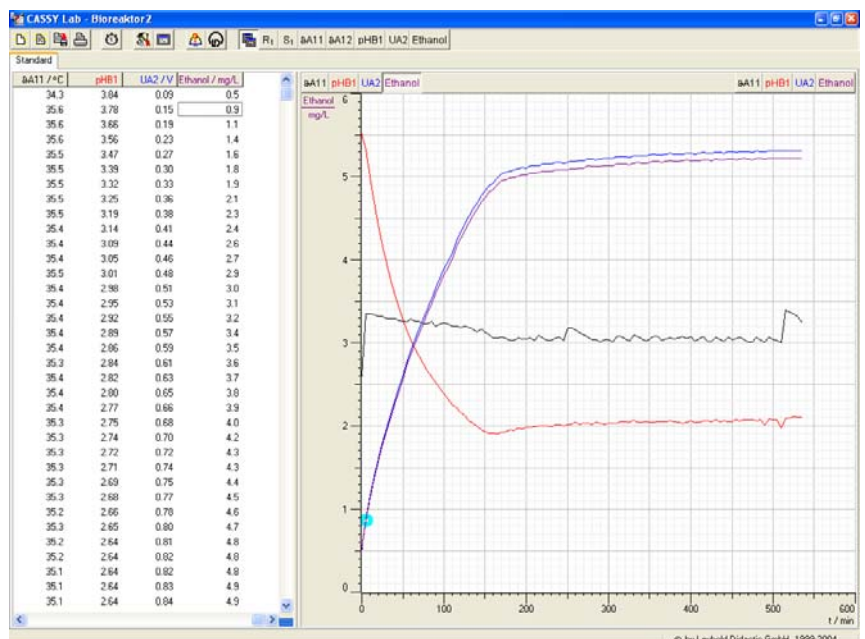


Plug and play
... automatic detection
and configuration of
CASSY and sensor
boxes



524 202 Software manual for CASSY Lab

All information on using CASSY Lab, plus all experiment examples, in a single ring binder.





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