



Laboratory Experiments Biology School · University



Your solution with just one click!



Our comprehensive Internet site **www.phywe.com** provides you with all the information you need covering the full spectrum of solutions and products from PHYWE – in five languages! Whether your specific needs involve physics, chemistry, biology or applied sciences, and whether you are looking for information relating to school or university-level materials, you can always find just the right products there quickly and easily.

Further highlights on our website include:

- More than 50 product videos
- Complete assembly instructions in video form
- Up-to-date software downloads
- Free-of-charge descriptions of the experiments
- Operating manuals and instruction sheets to download

- 1 Language
- 2 Subject area = Physics, Chemistry, Biology, Applied Sciences
- 3 Education level = School, University
- 4 Media e. g. product videos
- 5 Downloads e. g. experimental literature



Visit us today: **www.phywe.com**

TESS expert Biology

1	About PHYWE	2
2	Microscopy / Cell Biology	19
3	Ecology and Environment	33
4	Behavioural Biology	47
5	Plant Physiology / Botany	51
6	Animal Physiology	63
7	Human Physiology	71
8	Biochemistry	91
9	Microbiology	95
10	Neurobiology	101
11	Biotechnology	109
12	Modern Imaging Methods	115
13	Indices	139

Traditional yet modern 100 years of quality

Those who know nothing must
believe everything.

Marie von Ebner-Eschenbach

With a 100-year tradition of excellence, PHYWE Systeme GmbH & Co. KG stands for technical capability, innovation, quality and customer satisfaction. As a leading supplier of premium quality teaching and learning materials, PHYWE is one of the world's largest providers of system solutions for the instruction of the natural sciences.

The product range comprises scientific equipment, experiments and solution systems along with modern blended learning systems, literature and software for the areas of physics, chemistry, biology, medicine, material science and earth science. A broad spectrum of services such as training programmes, installation and comprehensive consulting services completes the portfolio.

PHYWE solutions can be individually adapted to the specific curricula in each country and provide ideal coverage for the full spectrum of performance specifications and requirements. Ask us to prepare a customised equipment offering to suit your special needs!





How to use

Facts about the TESS expert catalogue

The TESS expert catalogue is adapted to the PHYWE reference curriculum. PHYWE's experiments fit to the content of experimental lectures and lab courses of schools, colleges and universities. The description of each experiment offers you a lot of information:

Article number

Experimental setup

Description of main principle

Tasks for students

Related scientific topic

List of main articles

Complete list see: www.phywe.com

5 Plant Physiology
5.1 Photosynthesis

P4110660


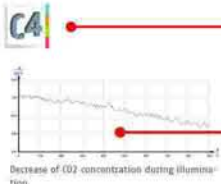
The importance of Carbon dioxide for Photosynthesis

Pictograms for quick overview

Exemplary measurement result

Variations of the main experiment (e.g. the same experiment with PC-interface) and experiments with similar topics

Devices suitable for the experiment

Principle

This experiment shows that carbon dioxide is consumed during photosynthesis, whereas it is produced through cellular respiration.

Tasks

- Determine the CO₂-consumption during photosynthesis
- Determine the CO₂-production during cellular respiration

What you can learn about

- photosynthesis
- cellular respiration
- oxygen
- carbon dioxide


Main articles

Software Cobra4 - multi-user licence	14550-61	1
Cobra4 Sensor-Unit CO ₂	12671-00	1
Cobra4 Wireless-Link	12601-00	1
Ceramic lamp socket E27 with reflector, switch, safety plug	06751-01	1
Cobra4 Wireless Manager	12600-00	1
Lab jack, 160 x 130 mm	02074-00	1
Holder for Cobra4 with support rod	12680-00	1
Support base variable	02001-00	1
Filament lamp, 220V/120W, w.infl.	06759-93	1
Erlenmeyer flask, narrow neck, PN 29	36424-00	1

Related Experiment

Paper chromatography of chloroplast pigments

Cobra4 Sensor-Unit CO₂



Function and Applications

Sensor of the Cobra4 family for the measurement of the CO₂ concentration in the air. The measured data of the sensor can be transferred with the Cobra4 Wireless Link by radio to the PC in connection with the Cobra4 Wireless Manager.

12671-00

Pictograms for a quick overview of categories, related films or information:



Experiments with the Computer based measuring system Cobra4



Demonstration experiments



Experiments with laser



Experiments which have received a Nobel Prize



Computer based measuring



Experiments with radioactivity



Product movie available - click at www.phywe.com

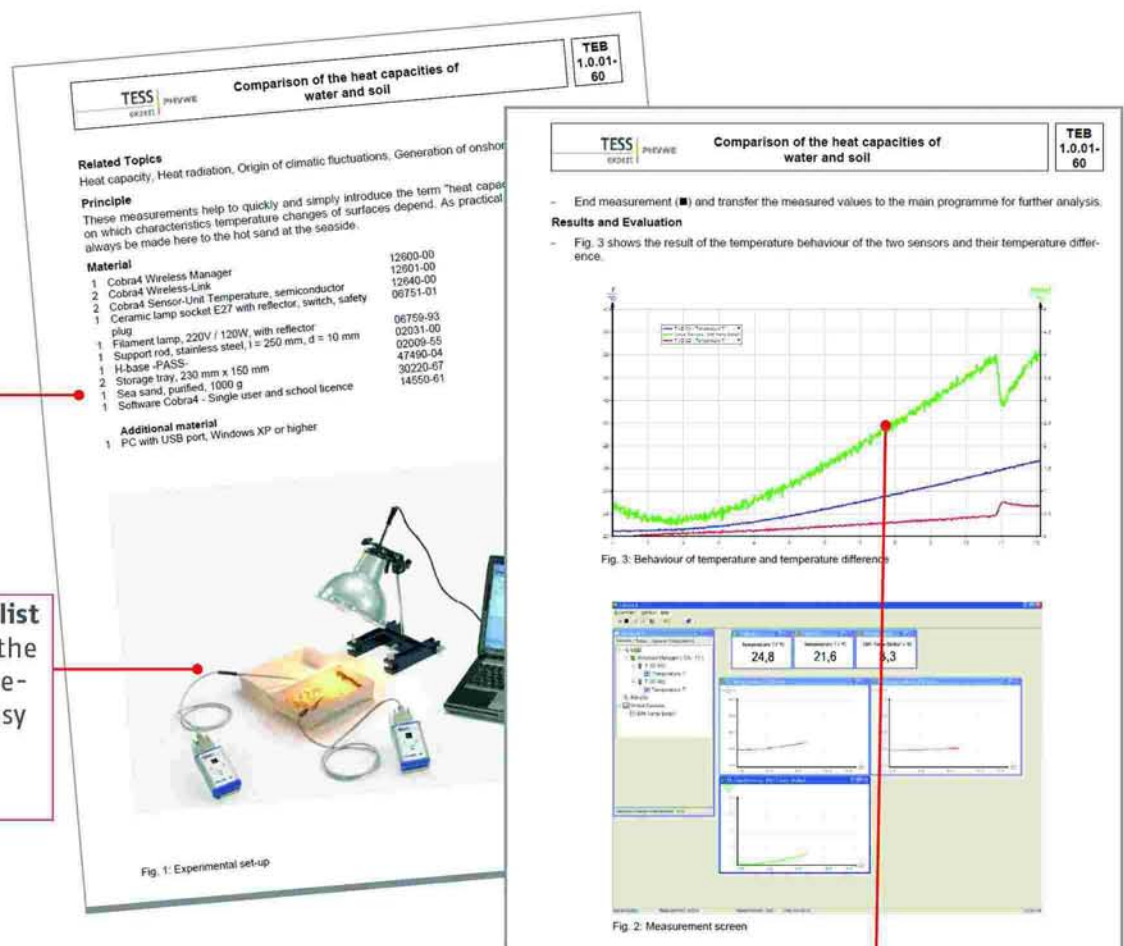


New and completely revised experiments

Didactic literature – comprehensive guide for every experiment

Extensive experimental literature is available for all our university level experiments. Rely on the advantages of our TESS expert experiment descriptions:

- All experiments are uniformly built up
- Experiments cover the entire range of classical and modern biology
- Didactically adapted descriptions – enables direct preparation by the student
- Developed and proven by practitioners – comfortable and reliable performance
- Excellent measurement accuracy – results agree with theory
- Computer-assisted experiments – easy, rapid assessment of results
- Modular experimental set-up – multiple use of individual devices, cost effective and flexible



Picture, Equipment list and instruction for the execution of the experiment guarantee easy conduction of the experiment.

Theory and evaluation includes full theory of the experiment and shows graphical and numerical experimental results.

Computer assisted measurement – for your educational requirements

With computer-assisted experiments from PHYWE you rely on a system that perfectly matches the demands of modern scientific education. The corresponding software **measure** enables simple and reliable data recording, analysis and further processing.

At present, the computer assisted recording of measurement data for TESS expert university experiments - approx 50% of total - are mostly realized with the Cobra3 system. The Cobra3 system will be replaced by Cobra4 until end of 2013. Therefore a significant number of experiments are already based on Cobra4 which are shown in this catalogue. Furthermore all future Cobra4 experiments are clearly displayed aside the relevant topic.

The key advantages of Cobra4

- wireless measurement data transfer
- up to 99 sensors can be addressed simultaneously
- can be used as a hand-held measuring instrument
- wide range of sensors (30 units)

The Cobra4 interfaces:



Wireless measurement with
Wireless-Link & Wireless
Manager + Remote-Link



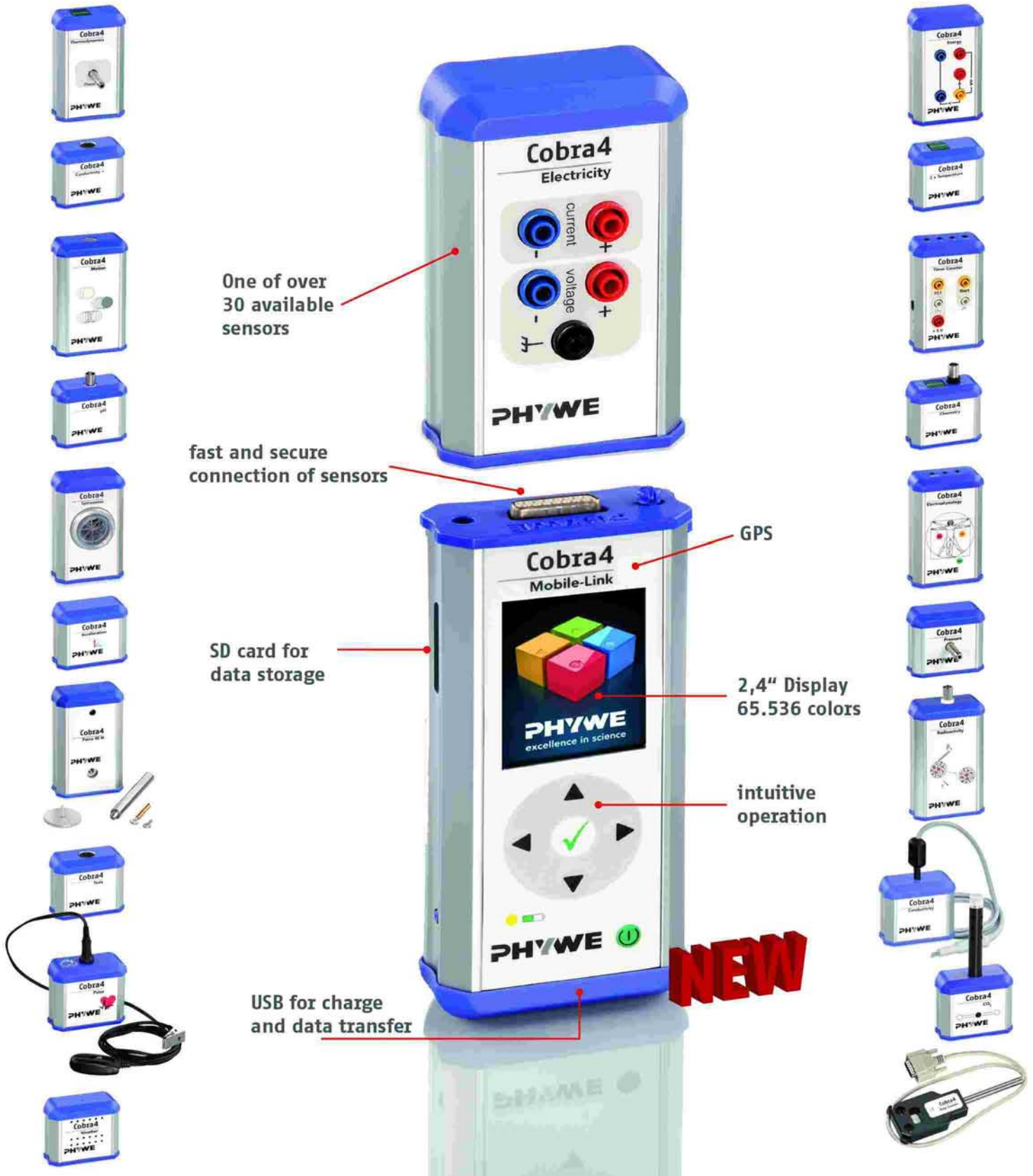
High data rate
measurement
with the USB-Link



Outdoor
measurement with
the Mobile-Link
(Redesign 2013)

The Cobra4 sensor family

Cobra4 | PHYWE



Digital function generator – universal and intuitive

Cobra4
compatible

NEW



Features

- Universal, programmable voltage source with a bandwidth of 1 MHz and an output current of 1 A
- Can be used with Cobra4 or as a stand-alone device
- Intuitive operation via function keys and a rotary control knob
- Illuminated display for optimum visibility
- Low distortion factor and high signal-to-noise ratio for brilliant signals (acoustics/hearing)
- $U = U(f)$ output for a particularly easy pick-up of the frequency – ideal for analysing circuits with frequency ramps
- Part of more than 25 TESS experiments



Human merging frequency and upper hearing threshold (P4040101)



Time resolving capability of the human eye (P4070300)

Our roadmap for future products – Coming up 2013



Cobra4 Sensors



Sound level
(12669-00)

Skin resistance
(12677-00)

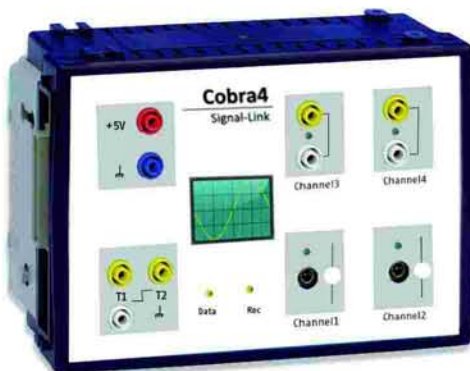
Oxygen
(12676-00)

Forceplate
(12661-00)

Colorimeter
(12634-00)

Cobra4 Signal-Link –

The integrated and high accuracy interface for high speed experiments



Features

- Integrated unit of voltage & current sensors + USB interface
- 4 channels (2x current, 2x voltage), electrically isolated
- True RMS converter for all channels
- High resolution: up to 5 microvolts, up to 1 microampere
- Sampling rate: > 1 MHz for current channels and >5 MHz for voltage channels
- Compatible to all Cobra4 equipment

Curricula Compliant Experiments – for your educational requirements

Innovative experimental set-ups by PHYWE play a decisive role for a successful education of students in natural sciences, especially in biology.

PHYWE experiments are matched with the curricula of more than 30 selected universities worldwide. The interaction between PHYWE's experiments and the content of experimental lectures and lab courses has led to a comprehensive and best fitting worldwide.

The PHYWE TESS expert biology program covers almost all relevant topics for bachelor and master courses in biology!



Bachelor of Science in Biology – Reference Example

Content	1. Sem.	2. Sem.	3. Sem.	4. Sem.	5. Sem.	6. Sem.
Laboratory Experiments	Microscopy / Cell Biology 1 6 CP	Plant Physiology / Botany 10 CP		Ecology 1 11 CP	Plant and Animal Physiology 11 CP	Human Physiology Neurobiology 5 CP
Lecture, Tutorial, Experiments	Experimental Physics* 9 CP	Microscopy / Cell Biology 2 6 CP		Zoology 2 6 CP	Ecology 2 6 CP	
Subsidiary Subject	Mathematics for Biologists 6 CP	Biochemistry 10 CP		Biotechnology 6 CP	Subsidiary and Elective Subjects 20 CP	
Elective Subject		Mol. Genetics 5 CP	Behavioural Biology 4 CP	Microbiology 10 CP		Modern Imaging Methods 6 CP
Interdis. Subject	General Chemistry* 6 CP	Organic Chemistry* 6 CP		Communication, Languages, Presentation Techniques, e. g. 4 CP		
Theoretical Biology	Genetics 3 CP	Statistics 3 CP	Zoology 1 3 CP	Ecology / Pop. Genetics 3 CP	Evol. Biology 3 CP	Ethics 4 CP
Bachelor Thesis						Bachelor Thesis 6 CP

PHYWE Experiments

* Please refer to TESS expert Physics and TESS expert Chemistry catalogues
CP = Credit Points

More than 80% of the experimental courses are covered by PHYWE experiments!

Use the curricula-based content on the next pages to find your topics and our corresponding experiments. The TESS expert catalogue is adapted to international university curricula making it easy for you to find experiments corresponding to your desired topic. On each page you find the detailed description of one of our university level experiments. More information including the complete experiment description is available on our website www.phywe.com.

Overview TESS expert

2 Microscopy / Cell Biology

2.2 Cell Components

P1441301	Chromoplasts	24
P1441201	Chloroplasts in moss leaves	24
P1441401	Nucleus and chromosomes	24

2.3 Seed Plants

P1442301	Stem of a monocotyledonous plant	25
P1442601	Starch as a nutritional reserve substance in plants	25
P1442101	Cross-section of a conifer (gymnosperm) leaf	25

2.4 Investigating Invertebrates

P1443201	Kidney	26
P1443301	Liver cells (hepatocytes)	26
P1443101	Blood cells	26
P2538000	Basic methods in imaging of micro and nano structures with atomic force microscopy (AFM)	27

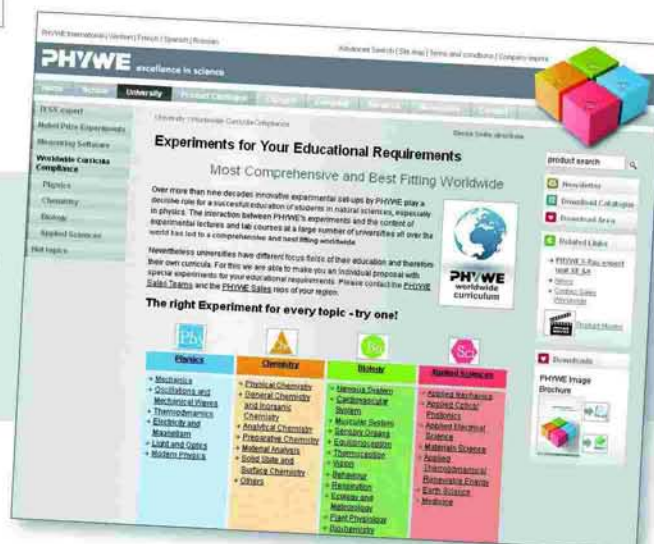
Curricular topic = main chapter of the catalogue

Curricular subtopic = sub-chapter of the catalogue

Curricular fitting PHYWE experiments

Find the overview of all experiments fitting to the international Reference Curriculum on our homepage!

Click www.phywe.com



2 Microscopy / Cell Biology

2.2 Cell Components		
P1441301	Chromoplasts	24
P1441201	Chloroplasts in moss leaves	24
P1441401	Nucleus and chromosomes	24
2.3 Seed Plants		
P1442301	Stem of a monocotyledonous plant	25
P1442601	Starch as a nutritional reserve substance in plants	25
P1442101	Cross-section of a conifer (gymnosperm) leaf	25
2.4 Investigating Invertebrates		
P1443201	Kidney	26
P1443301	Liver cells (hepatocytes)	26
P1443101	Blood cells	26
P2538000	Basic methods in imaging of micro and nano structures with atomic force microscopy (AFM)	27
P2538400	Imaging of biological and medical micro and nanostructure with atomic force microscopy (AFM)	27
09700-99	Compact-Atomic Force Microscope (AFM)	28
2.5 Other Animals under the Microscope		
P1443701	Planaria	29
P1443801	Nematoda	29
P1443901	Brine shrimp (Artemia salina)	29
2.6 Other Plants and Fungi		
P1444201	Spore capsules of ferns	30
P1444301	Mould fungi growing on food	31
P1444501	Colony-forming ciliates in an aquarium	31
P1444901	Bacteria	31
2.7 Literature		
13290-02	TESS advanced Biology manual Microscopy	32

3 Ecology and Environment

3.1 Water		
P4100160	Comparison of the heat capacities of water and soil (with Cobra4)	34
P4100560	Conductivity of various water samples (with Cobra4)	35
P4100760	The origin of acid rain (with Cobra4)	36

P4100840	The twenty-four-hour rhythm of an aquatic plant (with Cobra3)	37
P4100860	The twenty-four-hour rhythm of an aquatic plant (with Cobra4)	37
3.2 Air		
P4100260	Bergmann rule: heat loss as a function of the body surface area and volume (with Cobra4)	38
P4100360	Insulating effect of body coverage (with Cobra4)	39
P4100460	24-hour weather observation (with Cobra4)	40
3.3 Soil		
P1521163	Salinity of soils and plant substrates (with Cobra4)	41
P1521063	The pH value of various soils (with Cobra4)	42
3.4 Sets		
30837-77	TESS Biology set chemo-physical water testing	43
30834-77	Ecology case, biological water analysis	43
30839-00	Reagent case for water analysis with filter photometer	44
30838-77	TESS Applied Sciences Set Gas examination	44
30836-77	TESS Applied Sciences set examination of soil	45
30346-00	Excursion set, soil analysis	45
3.5 Literature		
12622-02	TESS advanced Applied Sciences manual Cobra4 environment and outdoors	46

4 Behavioural Biology

4.1 Behavioural Science		
P4080300	Learning performance of humans	48
P1522260	Measuring reading skills (with Cobra4)	49
P1056600	Learned behaviour in fish	50
P0938300	Agonistic behaviour in male fighting fish	50
P0938400	Shooling behaviour in fish	50

5 Plant Physiology / Botany

5.1 Photosynthesis		
P4110160	Photosynthesis (bubble counting method) (with Cobra4)	52

P4110260	Photosynthesis (measurement of oxygen pressure) (with Cobra4)	53
P4100840	The twenty-four-hour rhythm of an aquatic plant (with Cobra3)	53
P4110660	The importance of Carbon dioxide for Photosynthesis	54
P0892300	Paper chromatography of chloroplast pigments	54
5.2 Water Balance		
P4110360	Transpiration of leaves (with Cobra4)	55
5.3 Mineral Balance		
P1135700	Osmosis - dependence of the osmotic pressure on the concentration	56
P4120260	The ionic permeability of the cell membrane (with Cobra4)	56
P1521163	Salinity of soils and plant substrates (with Cobra4)	57
P0898200	Spectroscopic identification of sodium, potassium, and calcium in plant ashes	58
P1034700	Absorption of minerals by plants	58
5.4 Growth and Development		
P4050200	The effect of gravity and centrifugal force on plants	59
P4110460	Glycolysis (pressure measurement) (with Cobra4)	60
P4110560	Glycolysis (temperature measurement) (with Cobra4)	61
5.5 Literature		
01331-02	Demo advanced Biology Manual Cobra4 Biochemistry & plant physiology	62

6 Animal Physiology

6.1 Animal Physiology		
P4010111	Recording of nerve and muscle potentials by mechanical stimulation at the rear end of an earthworm (Cobra3)	64
P4010211	Recording of nerve and muscle potentials by mechanical stimulation at the front end of an earthworm (Cobra3)	64
P4010311	Recording of nerve potentials after the electrical stimulation of an anaesthetised earthworm (with Cobra3)	65
P4010462	Model experiment illustrating the development of resting potential (with Cobra4)	65
P4060200	Preferential temperature in insects	66
P0911700	Humidity preferendum of soil arthropods	67
P4070100	Optomotor response in insects	68

P4090100	Volumetric measurement of breathing in small animals	69
P5950400	Ultrasonic investigation with eye dummy	70

7 Human Physiology

7.1 Heart and Circulatory System

P4020160	Human electrocardiography (ECG) (with Cobra4)	72
P4020360	Blood pressure measurement (with Cobra4)	73
P4020460	Changes in the blood flow during smoking (with Cobra4)	74
P5950100	Doppler sonography	75
P1522160	We investigate our physical fitness - the heart under stress (with Cobra4)	76
P4020211	Phonocardiography: Cardiac and vascular sonic measurement (PCG) (with Cobra3)	77
P4020260	Phonocardiography: Cardiac and vascular sonic measurement (PCG) (with Cobra4)	77
P5950200	Ultrasonic Time Motion Mode	78

7.2 Musculature

P4030160	Electromyography (EMG) on the upper arm (with Cobra4)	79
P4030211	Muscle stretch reflex and determination of the conducting velocity (with Cobra3)	80
P4030260	Muscle stretch reflex and determination of the conducting velocity (with Cobra4)	80

7.3 Hearing Sense

P4040101	Human merging frequency and upper hearing threshold	81
P4040215	Hearing threshold and frequency differentiating threshold in humans (with Cobra3)	81
P4040311	Acoustic orientation in space (with Cobra3)	82

7.4 Visual Sense

P4070300	Time resolving capability of the human eye	83
P4070200	Determination of the human visual field	83
P4070600	Additive colour mixing and colour masking	83
P4070760	Electronystagmography (with Cobra4)	84
P4070560	Human electrooculography (EOG) (with Cobra4)	85

7.5 Other Senses

P4060360	Regulation of human body temperature (with Cobra4)	86
----------	----------------------------------------------------	----

P4070400	Test of human reaction capacity	87
7.6 Respiration		
P4090260	Measurement of the respiratory rate (with Cobra4)	88
P8001060	How much air can our lungs contain?	88
P8001160	Direct determination of lung volume from a spirogram	88
P8001260	Does the lung volume depend on how tall you are?	88
P8001360	Diagnosis of lung illnesses (FEV) (with Cobra4)	89
7.7 Literature and Sets		
12673-12	TESS advanced Biology manual Cobra4 Electrophysiology: ECG, EMG, EOG	90
12673-89	TESS advanced Applied Sciences set Electrophysiology, EP with english manual	90

8 Biochemistry

8.1 Biochemistry		
P4120260	The ionic permeability of the cell membrane (with Cobra4)	92
P4120360	Determination of the Michaelis constant (with Cobra4)	93
P4120460	Substrate inhibition of enzymes (with Cobra4)	93
P4120560	Enzyme inhibition (poisoning of enzymes) (with Cobra4)	93
P4120140	Determination of the isoelectric point of an amino acid (glycine) (with Cobra3)	94

9 Microbiology

9.1 Microbiology		
P4140100	Fundamental microbiological working methods	96
P4140500	Evidence of the effect of antibiotics, chemotherapeutics and disinfectants	96
P4140200	Evidence of the spread of bacteria	97
P4100900	Microbial decomposition of mineral oil	97
P4140300	Microscopy of bacteria	98
P4140400	Determination of the microbial count	99
P2538400	Imaging of biological and medical micro and nanostructure with atomic force microscopy (AFM)	100
P2538000	Basic methods in imaging of micro and nano structures with atomic force microscopy (AFM)	100

10 Neurobiology

10.1 Basics		
P4010462	Model experiment illustrating the development of resting potential (with Cobra4)	102
P4120260	Ionic permeability of the cell membrane (with Cobra4)	103
10.2 Nerve Cell - Functions, Interactions and Networks		
P4010511	Neurosimulator: membrane time constant and low-pass filtering (with Cobra3)	104
P4010611	Neurosimulator: mode of operation of excitatory synapses (with Cobra3)	104
P4010560	Neurosimulator: membrane time constant and low-pass filtering (with Cobra4)	104
P4010711	Neurobiology: the nerve cell	105
P4010760	Neurobiology: the nerve cell (with Cobra4)	105
P4010860	Neurobiology: nerve cell interactions (with Cobra4)	105
P4010811	Neurobiology: nerve cell interactions	105
P4010911	Neurobiology: neural networks	106
P4011011	Neurobiology: complex neural networks	106
P4010960	Neurobiology: neural networks (with Cobra4)	106
10.3 Stimuli Transmission		
P4010111	Recording of nerve and muscle potentials by mechanical stimulation at the rear end of an earthworm (with Cobra3)	107
P4010211	Recording of nerve and muscle potentials by mechanical stimulation at the front end of an earthworm (with Cobra3)	107
P4010311	Recording of nerve potentials after the electrical stimulation of an anaesthetised earthworm (with Cobra3)	107
10.4 Literature		
16506-02	Laboratory Experiments Biol., L.V.	108

11 Biotechnology

11.1 Biotechnology		
P1313600	Fermentation of molasses to ethanol with yeast	110
P1313700	Microbial synthesis of ethanol by <i>Zygomonas mobilis</i> subsp. <i>mobilis</i>	111

P1313800	Production of amino acids by fermentation of <i>Corynebacterium glutamicum</i>	112
P1313900	Bacteria and mining - microbial extraction of ore by <i>Thiobacillus ferrooxidans</i> and thiooxidans	113
P1314000	Immobilised cells in the service of biotechnology - microbial synthesis of acetic acid with <i>Acetobacter acetii</i>	114

12 Modern Imaging Methods

12.1 X-ray Imaging

P2550100	Computed tomography	119
09180-88	XRCT 4.0 X-ray Computed Tomography upgrade set	120
09057-40	XR 4.0 X-ray Direct Digital Image Sensor (XRIS) with USB cable	121
09057-42	XR 4.0 X-ray CT Z-rotation stage (XRstage)	121
14421-61	XR 4.0 Software measure CT	121
P2540020	Radiographic examination of objects	122
P2541901	Contrast medium experiment with a blood vessel model	123
P2542001	Determination of length and position of an object which can not be seen	124
P2540030	Qualitative examination of absorption	125
P2541101	Absorption of X-rays	126
P2541801	X-ray dosimetry	127
P2540040	Ionizing effect of X-radiation	127

12.2 Magnetic Resonance Imaging

P5942100	Basic principles in Nuclear Magnetic Resonance (NMR)	128
P5942400	Magnetic Resonance Imaging (MRI)	128
P5942200	Relaxation times in Nuclear Magnetic Resonance	128
P5942300	Spatial encoding in Nuclear Magnetic Resonance	128
09500-99	Compact magnetic resonance tomograph (MRT)	129

12.3 Ultrasonic Imaging

P5161200	Ultrasonic computertomography	130
P5160200	Ultrasonic echography (A-Scan)	131
P5160300	Ultrasonic echography (B-Scan)	131
P5950100	Doppler sonography	132
P5950200	Ultrasonic Time Motion Mode	133
P5950300	Ultrasonic investigation with breast dummy	133
P5950400	Ultrasonic investigation with eye dummy	133

12.4 Nano Imaging

P2538000	Basic methods in imaging of micro and nanostructures with atomic force microscopy (AFM)	134
P2538400	Imaging of biological and medical micro and nanostructure with atomic force microscopy (AFM)	135
09700-99	Compact-Atomic Force Microscope (AFM)	136

12.5 Literature

01200-02	Handbook Physics X-Ray Experiments	137
01232-02	Laboratory Experiments Application of ultrasounds in medicine, material sciences and industry	138
01233-02	Laboratory Experiments Magnetic Resonance Tomography (MRT) Applications in physics, biology, chemistry and medicine	138

PHYWE supplies more than 50 Nobel Prize awarded experiments

The Nobel Prize is awarded annually in the disciplines of physics, chemistry, physiology or medicine, literature and peace. For scientists and researchers, it is the highest award.

PHYWE supplies more than 50 Nobel Prize awarded experiments. From Conrad Röntgen to Max Planck or Albert Einstein. Experiments in the footsteps of Nobel Prize winners. PHYWE made Nobel Prize experiments understandable.



Nobel Prize awarded experiments (Selection)

1900 ...

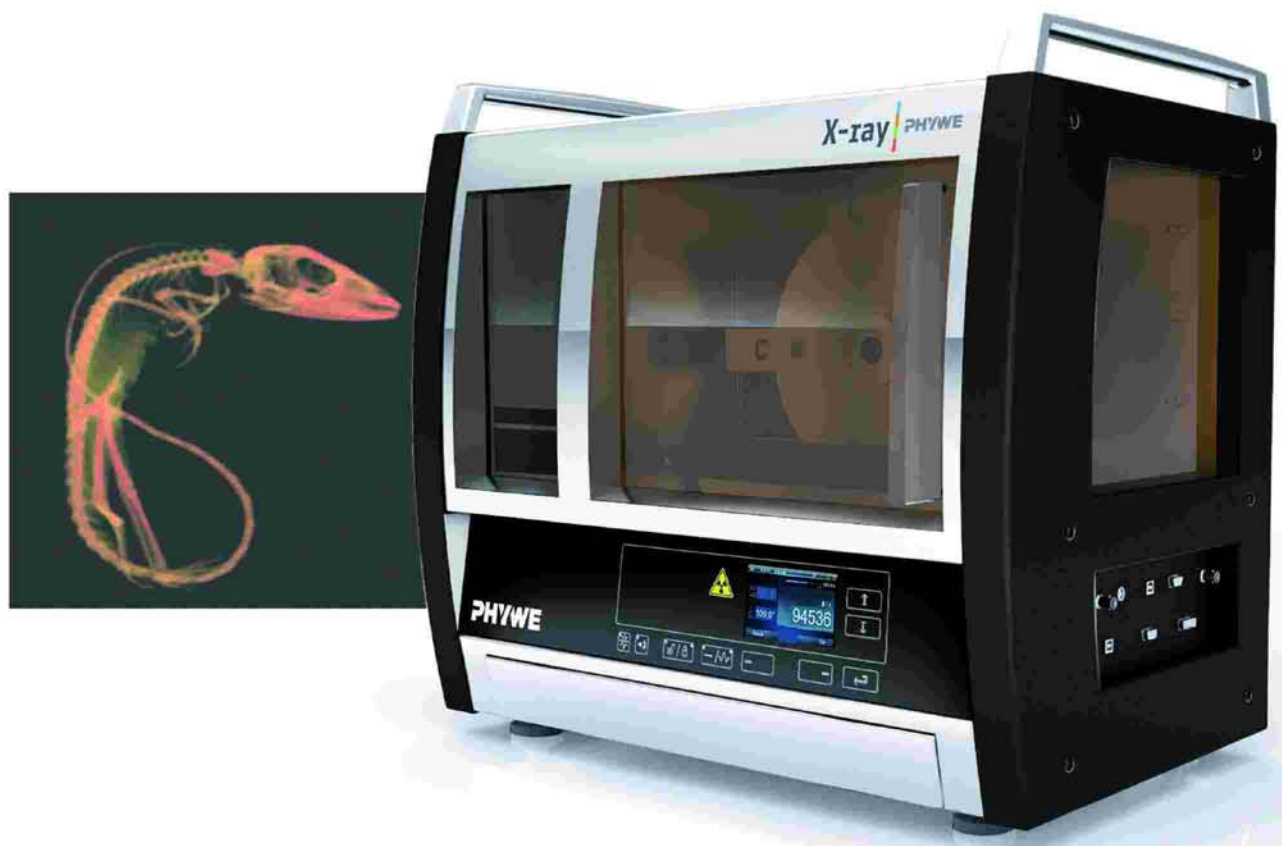
1901 – Wilhelm Conrad Röntgen
1901 – Jacobus Henricus van 't Hoff
1902 – Hendrik A. Lorentz,
Pieter Zeeman
1902 – R. Ross
1903 – Henri Becquerel, Pierre Curie,
Marie Curie
1907 – Albert A. Michelson
1908 – Ernest Rutherford

1910 ...

1911 – A. Gullstrand
1914 – Max von Laue
1915 – W.H. Bragg, W.L. Bragg
1918 – Fritz Haber
1918 – Max Planck

1920 ...

1921 – Albert Einstein
1922 – Niels Bohr
1923 – Robert A. Millikan
1924 – Manne Siegbahn
1924 – Willem Einthoven
1925 – James Franck, Gustav Hertz
1927 – Arthur H. Compton
1927 – C.T.R. Wilson
1929 – Louis de Broglie



1930 ...

1930 – Karl Landsteiner
1931 – Carl Bosch
1932 – W. Heisenberg
1932 – C.S. Sherrington, E.D. Adrian
1936 – Victor F. Hess, Carl D. Anderson

1940 ...

1943 – Otto Stern
1945 – Wolfgang Pauli
1948 – Arne Tiselius
1952 – F. Bloch, E.M. Purcell

1950 until today

1954 – Max Born, Walther Bothe
1971 – Dennis Gabor
1979 – A.M. Cormack, G. Hounsfield
1986 – Heinrich Rohrer, Gerd Binnig
2003 – P.C. Lauterbur,
Sir P. Mansfield
2009 – Charles K. Kao

Cooperations – Reliable partner for education

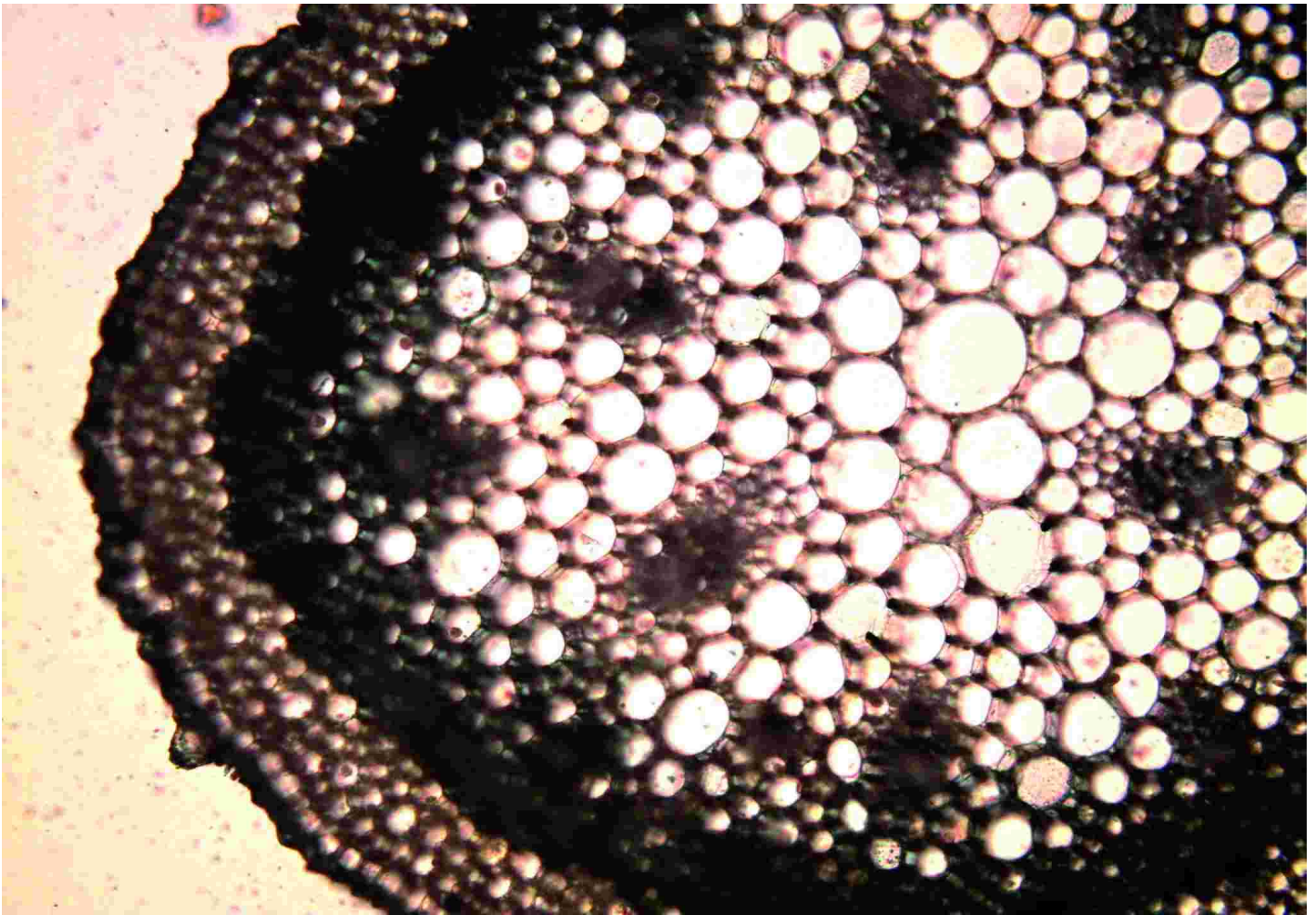
There's a way to do
it better – find it.

Thomas Edison

The share of ideas and transfer of knowledge between academia and PHYWE is one of our major attempts in R&D. Our network is spread out worldwide and comprises cooperation projects, research assignments, and the education of expert staff.

Some breathtaking novelties of our new XR 4.0 platform are one by one the result of fruitful cooperation in this regard - thank you!





Microscopy / Cell Biology

2.1	Overview Microscopes	20
2.2	Cell Components	24
2.3	Seed Plants	25
2.4	Investigating Invertebrates	26
2.5	Other Animals under the Microscope	29
2.6	Other Plants and Fungi	30
2.7	Literature	32

SWIFT available from PHYWE – Microscopes for all areas of applications

**NEW IN
EUROPE!**

SWIFT has been a globally renowned brand for top-quality microscopes for more than 50 years. Microscopes and stereo microscopes made by SWIFT are designed especially for teaching purposes, which is why they are ideally usable for students, teachers, lecturers, and participants of basic university courses. Their robust design makes them highly durable and perfectly suitable for daily use at schools and universities. Their optical and mechanical quality reflects first-class workmanship and they are particularly easy to use so that even untrained users can quickly produce fascinating images.

In addition to classic microscopes, we offer a series of SWIFT microscopes with integrated digital cameras that ideally meet the requirements of teachers and lecturers. You will surely find the perfect microscope for your individual needs and with an optional price/performance ratio in line with your budget among our new SWIFT microscopes.

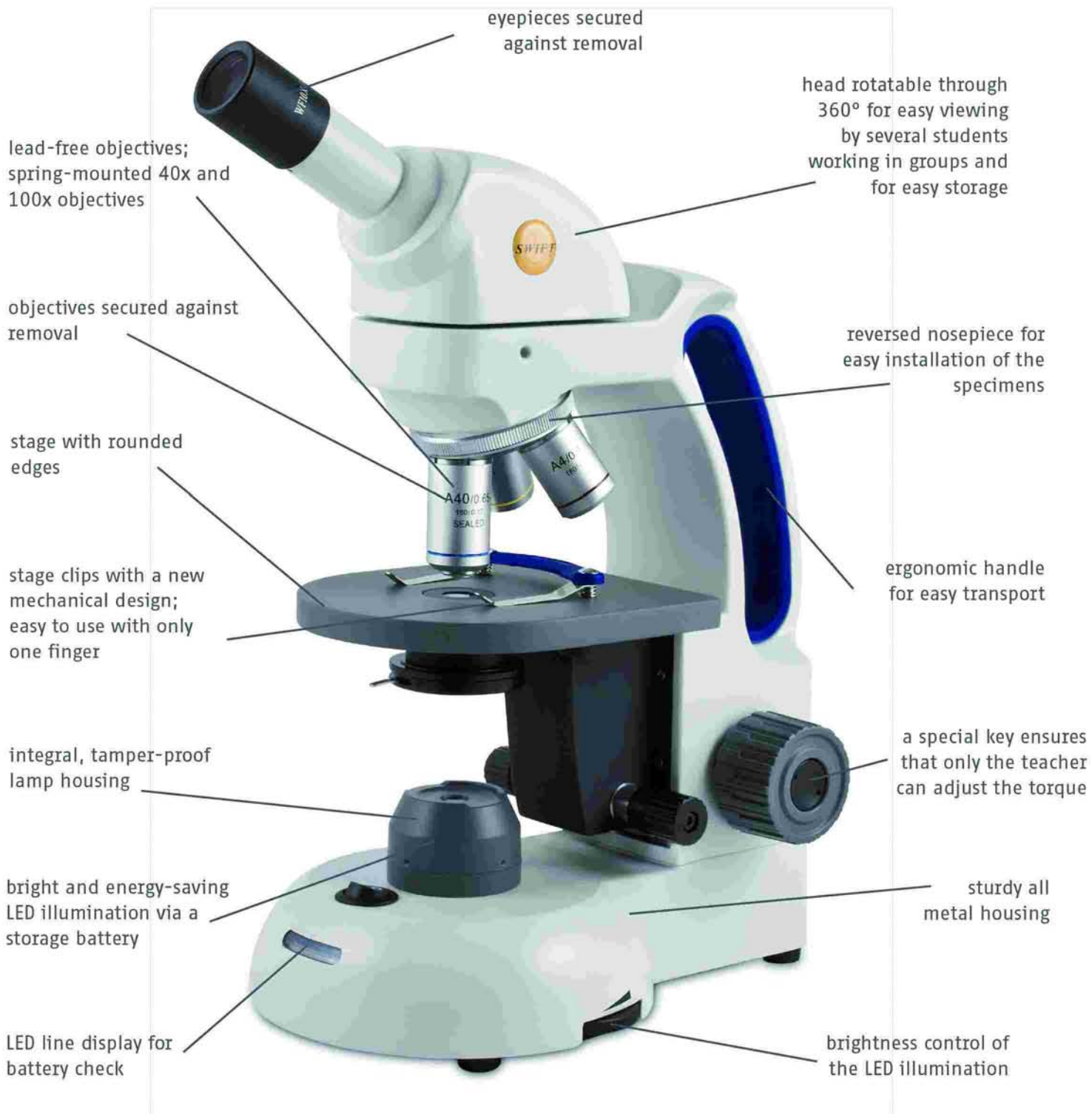
Top features of SWIFT microscopes:

- All-metal design: the all-metal housing and the exclusive use of metal parts inside the microscope ensure a long and trouble-free service life
- Modern, ergonomic design for working without fatigue
- No edges or sharp angles in order to reduce the risk of injury
- Integrated cable holder – trouble-free storage
- Lead-free objectives and eyepieces
- Ergonomic handle for the easy transport of the microscope
- Energy-efficient LED illumination: cold light, low current consumption, and durable
- Variable and controllable illumination for all models; 5 adjustable illumination combinations for stereo microscopes
- Rechargeable LED illumination for mains-power-independent work with battery check via an LED line display
- "Student-proof" student microscopes: objectives and eyepieces secured against removal
- Mechanical and microscope stages with state-of-the-art stage clips: 1-finger-operation





Advantages of the new "student-proof" student microscopes by SWIFT



Microscope Classes –

the right product for every application

Macro-/ Microscopes				
				
SWIFT M3-M monocular Item No. 63001-99	SWIFT M3-B binocular Item No. 63002-99			
Analog Microscopes				
				
MOTIC SFC-100FL Item No. 62417-93	MOTIC SFC-100FL (H) Item No. 62418-93	MOTIC SFC-100F-LED Item No. 62421-93	MOTIC SH Kolleg 3430 Item No. 62223-93	SWIFT M3601C Item No. 63020-99
				
MOTIC 2801-LED monocular Item No. 62195-93	MOTIC 2802-LED monocular Item No. 62196-93	MOTIC 2820-LED binocular Item No. 62197-93	SWIFT M3602C-3 Item No. 63021-99	SWIFT M3702CB-4 Item No. 63022-99
				
SWIFT M10B-S Item No. 63023-99	SWIFT M10T-S Item No. 63024-99	MOTIC BA210 Bino LED Item No. 63101-99	MOTIC BA210 Trino LED Item No. 63102-99	MOTIC BA310 Bino LED Item No. 63111-99
				
MOTIC BA310 Trino LED Item No. 63112-99	MOTIC BA410 Bino Item No. 63121-99	MOTIC BA410 Trino Item No. 63122-99		

Motic®
MORE THAN MICROSCOPY



Stereo Microscopes



MOTIC ST-30C-2L00, 2x/4x
Item No. 62459-93



MOTIC ST-30C-6LED, 2x/4x
Item No. 62466-93



SWIFT SM101-C
Item No. 63061-99



SWIFT SM102-C
Item No. 63062-99



SWIFT SM105-C
Item No. 63063-99



MOTIC SMZ-140-N2GG
Item No. 62478-93



MOTIC SMZ-143-N2GG
Item No. 63201-93



MOTIC SMZ-168-BLED
Item No. 63205-99

Digital Microscopes



SWIFT M3602C-3DGL
Item No. 63041-99



SWIFT M10DB-S
Item No. 63042-99



SWIFT M10LB-S
Item No. 63043-99



MOTIC D-EL1
Item No. 62620-00



MOTIC DS-300 mit USB
Item No. 88037-04

Inverted Microscopes



MOTIC AE2000 Trino
Item No. 63131-99

Cameras



Moticam 1SP
Item No. 63301-00

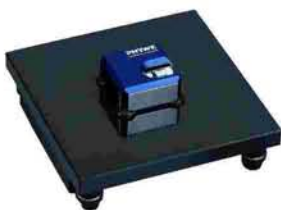


Moticam 3
Item No. 63302-00

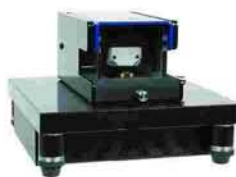


Moticam 580
Item No. 63303-99

Nano Imaging

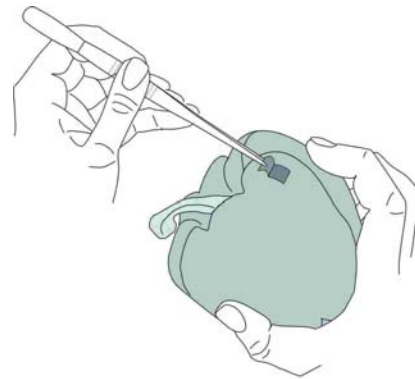
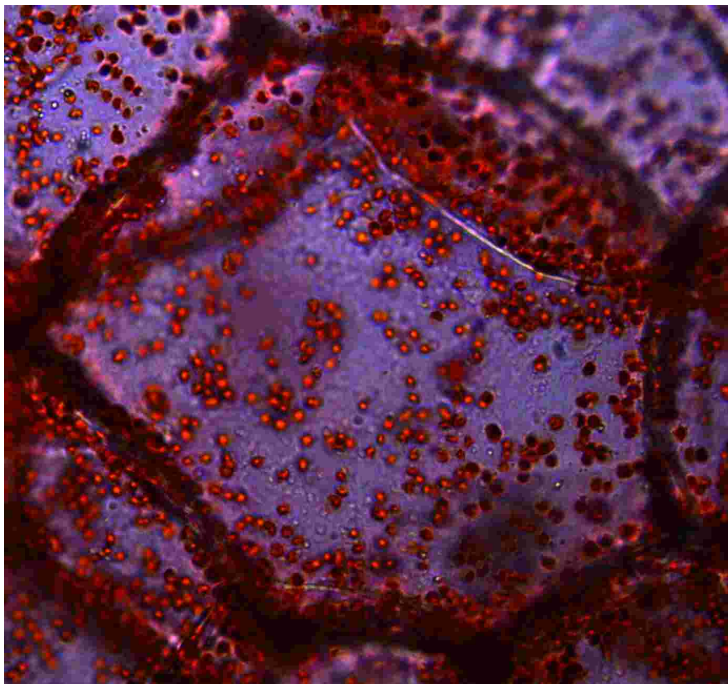


Compact-Scanning Tunneling Microscope (STM)
Item No. 09600-99



Compact-Atomic Force Microscope (AFM)
Item No. 09700-99

P1441301 Chromoplasts



Peel off a piece of skin from the red-pepper fruit using forceps.

Principle

The fruits and blossoms of many plants possess intensively bright colors. The colorful fruit attracts animals, are devoured by them and the seeds are excreted at other places. This is how the plant is dispersed.

Colorful blossoms attract insects that harvest nectar from the blossoms. Pollen is concomitantly transported from plant to plant. This ensures fertilization.

Yellow and red pigments are mostly located in particular cell organelles, the chromoplasts.

Tasks

Describe shape and arrangement of the chromoplasts in a plant cell!

What you can learn about

- Chromoplasts
- Cell organelles
- Blossoms

Main articles

SWIFT Microscope M3601C	63020-99	1
Dropping pipette with bulb, 10pcs	47131-01	1
Scalpel holder	64615-00	1
Scalpel blades, rounded tip, 10 off	64615-02	1
Tweezers, straight, pointed, 120mm	64607-00	1

Related Experiments

Chloroplasts in moss leaves

P1441201

Nucleus and chromosomes

P1441401

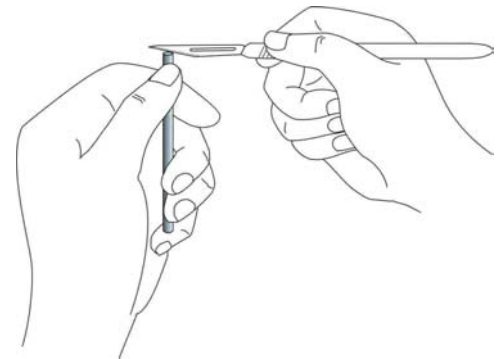
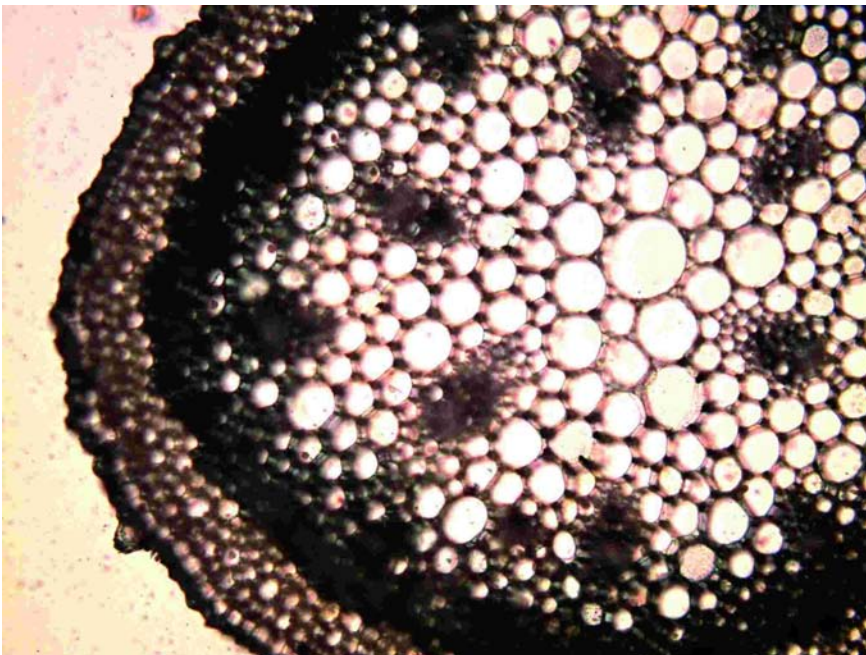
SWIFT Microscope M3601C



63020-99

Stem of a monocotyledonous plant

P1442301



The thin sections are placed directly in the drop on the slide using forceps.

Principle

The stem of plants must accomplish various functions. It supports the leaves, the lateral branches, and the blossoms. The mechanical supportive tissue (collenchyma) is responsible for the necessary stability and elasticity. Did you ever come to think about how a 20 m-tall tree is capable of transporting water all the way from its roots to its crown? Or how it may be possible that assimilates from the leaves ever arrive at the roots? We want to explore this pathway of transportation, for which all plants possess a one-way traffic system. The vascular bundles contain vessels for transporting water from the bottom up, and sieve tubes for transporting assimilates from the top down to the bottom. The structural arrangement of the vascular bundles in the dicotyledonous plants differs distinctly from the arrangement found in the monocotyledonous plants.

Tasks

Explore the structure of the stem and the arrangement of the vascular bundles in monocotyledonous plants!

What you can learn about

- Stem; Monocotyledonous plants
- Leaves; Lateral branches
- Blossoms; Vascular bundles

Main articles

SWIFT Microscope M3601C	63020-99	1
Chemicals set for TESS Microscopy (for up to 10 workgroups)	13290-10	1
Dropping pipette with bulb, 10pcs	47131-01	1
Tweezers, straight, pointed, 120mm	64607-00	1
Microscopic slides, 50 pcs	64691-00	1

Related Experiments

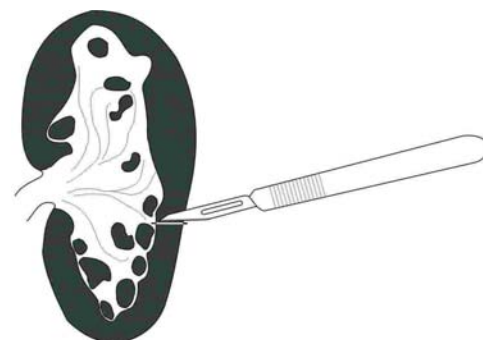
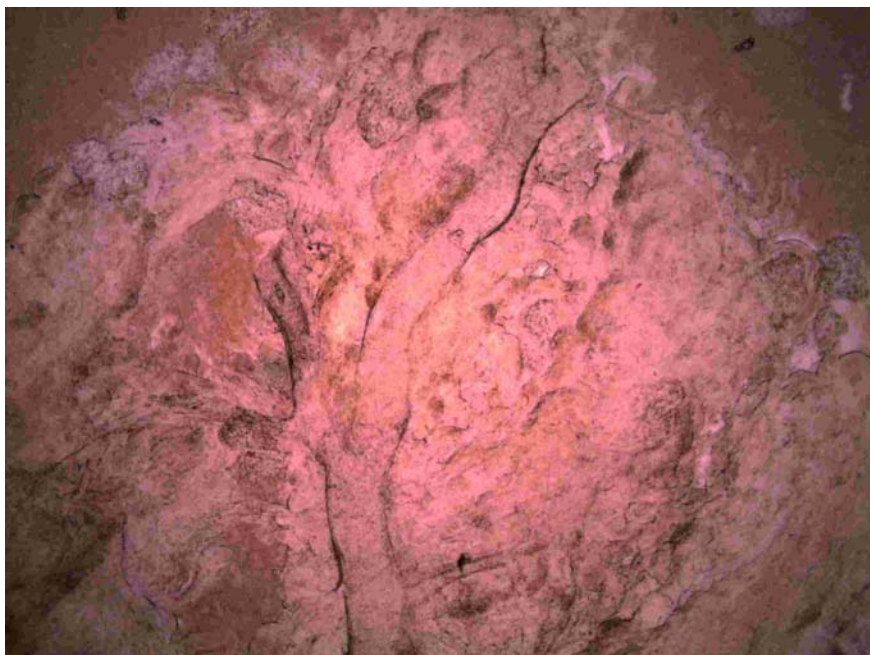
Starch as a nutritional reserve substance in plants

P1442601

Cross-section of a conifer (gymnosperm) leaf

P1442101

P1443201 Kidney



Cut a small strip of tissue out of the renal cortex with the scalpel.

Principle

Compared to the liver, the kidney is a rather small organ, however, it is the most significant excretion organ in humans apart from the skin and the lungs. Water and the substances dissolved in it are first transferred to the renal corpuscle (Malpighian body). The liquid travels through delicate tubes, i.e. renal tubes, while a part of the substances is returned to the blood.

Ultimately, the excessive proportion of water, salts, and decomposition products are passed on to the urinary bladder and then excreted.

Tasks

Explore and explain the morphology of the renal corpuscles.

What you can learn about

- Kidney
- Excretion organ
- Renal corpuscle
- Delicate tubes

Main articles

SWIFT Microscope M3601C	63020-99	1
Dropping pipette with bulb, 10pcs	47131-01	1
Tweezers, straight, pointed, 120mm	64607-00	1
Microscopic slides, 50 pcs	64691-00	1
Cover glasses 18x18 mm, 50 pcs.	64685-00	1

Related Experiments

Liver cells (hepatocytes)

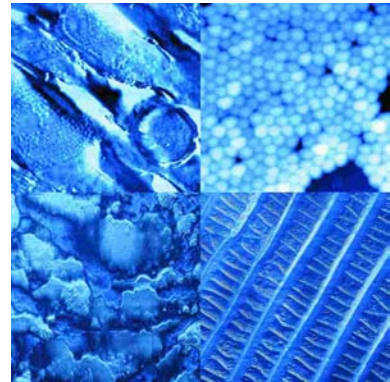
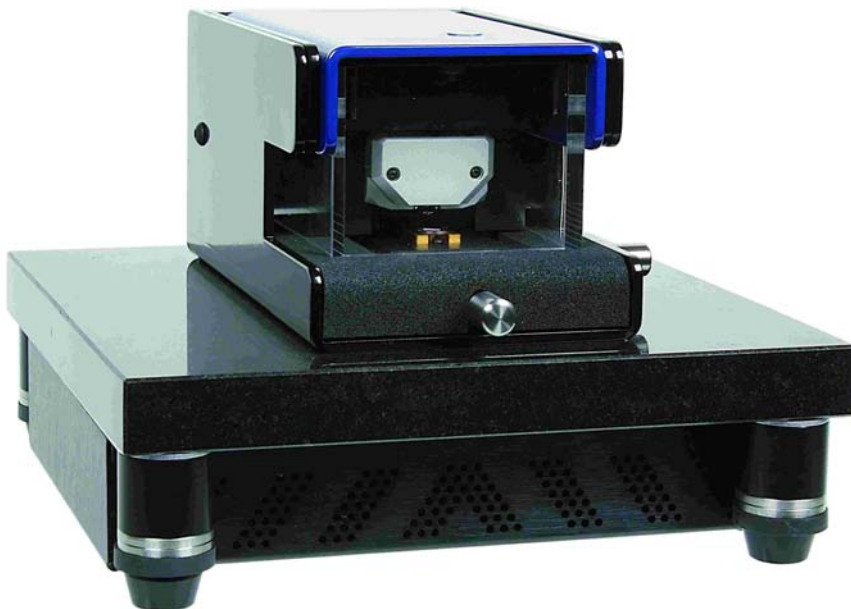
P1443301

Blood cells

P1443101

Basic methods in imaging of micro and nano structures with atomic force microscopy (AFM)

P2538000



Topography of Skin Cross-Section (60 micrometer), Staphylococcus Bacteria (10 micrometer), Human hair (40 micrometer), and Butterfly Wing (10 micrometer) FLTR.

Principle

Approaching a sharp silicon tip mounted on a cantilever to a sample surface leads to an atomic scale interaction. The result is a bend of the cantilever which is detected by a Laser. In static mode the resulting deflection is used to investigate the topography of the sample surface line-by-line using a feedback loop. In dynamic mode the cantilever is oscillated at fixed frequency resulting in a damped amplitude near the surface. The measurement parameters (setpoint, feedback gain,...) play a crucial role for image quality. The dependence on the imaging quality is investigated for different nano structured samples.

Tasks

1. Set-up the microscope and start up the software. Mount a cantilever (with tip) and approach the tip towards a sample.
2. Investigate the influence of the scanning parameters on the imaging quality and performance, e.g. PID gain, setpoint (force), vibrational amplitude, and scanning speed. Use both static and dynamic force mode.
3. Image 7 different samples (microstructures, carbon nano tubes, skin cross-section, bacteria, CD stamper, chip structure, glass beads) by optimizing the parameters respectively.

What you can learn about

- Atomic Force Microscopy (AFM)
- Lennard-Jones potential
- Imaging of nano structures
- Static Force Mode
- Dynamic Force Mode
- Feedback Loop
- Force
- Vibrational Amplitude

Main articles

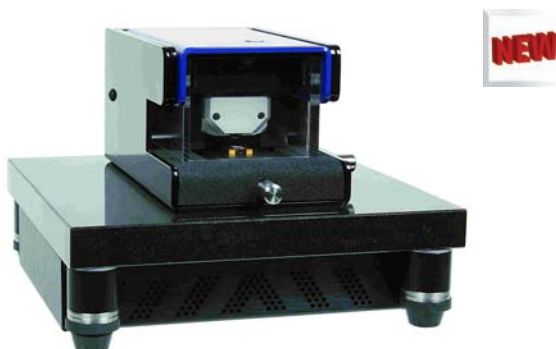
Compact-Atomic Force Microscope (AFM)	09700-99	1
---------------------------------------	----------	---

Related Experiment

Imaging of biological and medical micro and nanostructure with atomic force microscopy (AFM)

P2538400

Compact-Atomic Force Microscope (AFM)



Function and Applications

Compact and easy to use atomic force microscope to visualize and image structures on the micro and nano meter scale. Developed for educational purposes in practical lab course and pre-research labs in physics, chemistry, life sciences and material sciences. Also suitable to determine material characteristics (e.g. stiffness, magnetization, charging, material and phase contrast) and for manipulation (e.g. lithography).

Benefits

- Out-of-the-box device with integrated damping plate and control unit underneath
- Complete set, incl. Sample Set, Cantilever, Tools and Consumables
- Tip Scanner AFM for standard cantilever
- Easy and safe cantilever exchange and use: Flip mechanism with automatic laser switch off,
- No laser alignment, mechanical stopper for longer lifetime of cantilevers
- Digital top view camera for easy positioning and side view lens for easy and fast approach
- Portable and compact: transportable, easy to install with a small footprint
- Easy to use: Ideal for nanotechnology education, preparing students for their work on high-level research devices, and outreach

Equipment and technical Data

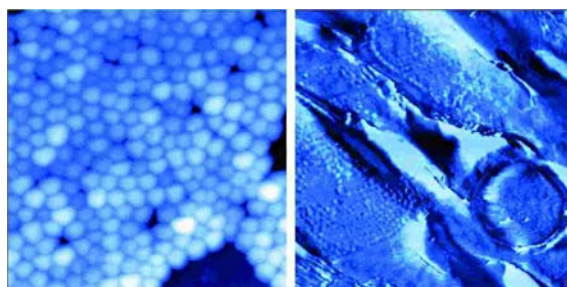
- Scan head with integrated control-unit on vibration-isolated experimentation board: 21cm x 21cm x 18cm, USB 2.0 interface, 16 bit DA converter (XYZ), 16 bit AD converter (7 channels)
- Max scanning speed 60 ms/line, up to 2048x2048 data points
- Scan type (tip scanner): Linear low voltage electro magnetic
- Scan Range: 70 micro meter (1.1 nm resolution)
- Z-range: 14 micro meter (1.1 nm resolution); Z noise level (RMS): 0.6 / 0.5 nm (static / dynamic); Automatic approach: vertical, range 4.5 mm
- Sample: max. 13 mm in diameter, horizontal mount, LED illumination, Micrometer translation stage xy: min. +/- 5 mm
- Cantilever Alignment: automatic adjustment, alignment grooves from various suppliers; Camera system for top view: USB digital color, 3.1 M pixels
- Modes of operation: Static Force, Dynamic Force, Force Distance Spectroscopy, Amplitude Distance Spectroscopy

- Other modes (MFM,AFM, Phase contrast, lithography and advanced spectroscopy modes)
- available with upgrade options material and spectroscopy and manipulation
- User expandability (scripting) available (upgrade option); Set of 10 Cantilever, 6 samples, Toolset
- Software for measuring, manipulation, analysing and visualization, Handbook and Quick Installation Guide

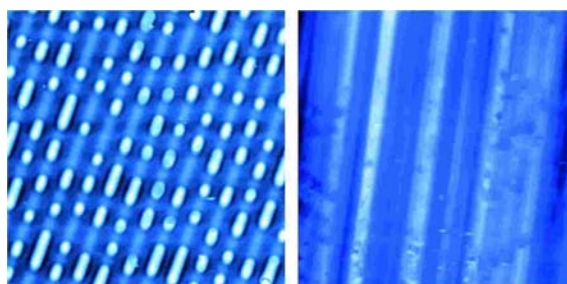
Accessories

- Material upgrade (Art. 09701-00): Additional Operating Modes (Phase Contrast, EFM, MFM, Force Modulation, Spreading Resistance), set of samples and cantilevers
- Spectroscopy and Manipulation upgrade (Art. 09702-00): Additional Operating Modes (Advanced Spectroscopy, Lithography (scratching, oxidation), Manipulation (oxidation, cutting and moving/pushing of nanoparticles)), User expandability (Visual basic, LabView, etc.), set of cantilevers and samples
- Side View Camera System (available 2013), other samples

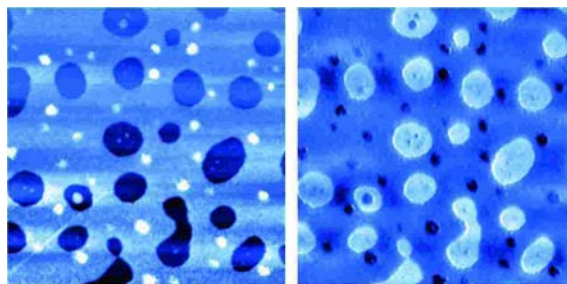
09700-99



Staphylococcus Bacteria, 10 μm and Skin Cross-Section, 60μm



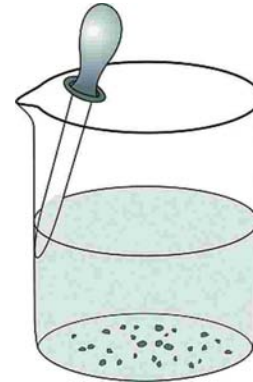
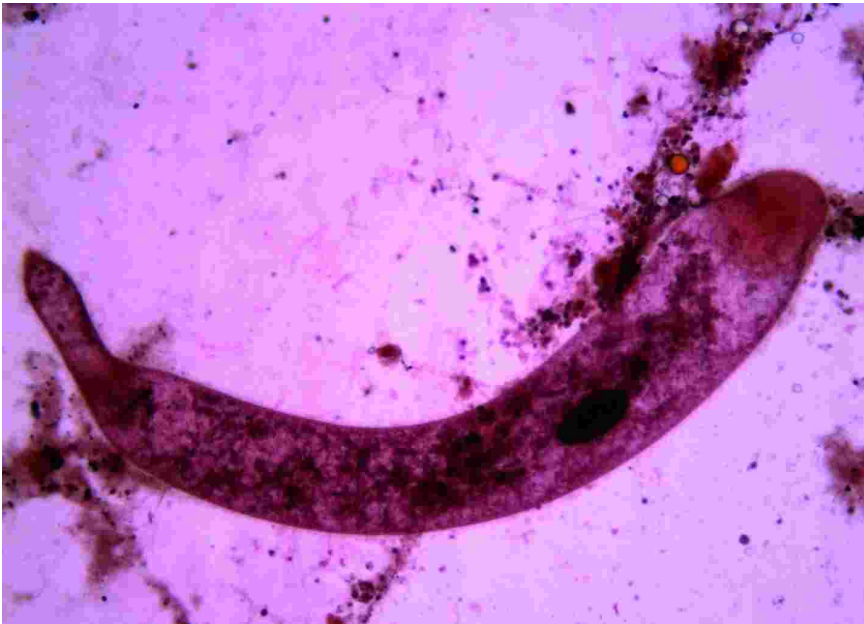
CD Stamper, 20 μm and Aluminum Foil, 60μm



PS/PMMA films: Topography and Phase Contrast, 3μm

Planaria

P1443701



Siphon a planarian from the lateral wall and examine it under the microscope with the lowest power.

Principle

Planarians belong to the class of the free-living flatworms (Turbellaria) and these, in turn, belong to the phylum of platyhelminthes (flatworms). They occur in both freshwater and marine environments, feeding as predators, for example, on the eggs of fishes and shrimps in aquaria. They therefore present a problem to breeders of ornamental fishes. On account of its large number of stem cells, the planarian *Dugesia tigrina* is of great significance to research.

Tasks

Gather information as to why they are feared and explore the structure of these flatworms.

What you can learn about

- Planarians
- Flatworms

Main articles

SWIFT Microscope M3601C	63020-99	1
Dropping pipette with bulb, 10pcs	47131-01	1
Magnifier, plastic, 5x, d=30mm	88002-01	1
Microscopic slides, 50 pcs	64691-00	1
Cover glasses 18x18 mm, 50 pcs.	64685-00	1

Related Experiments

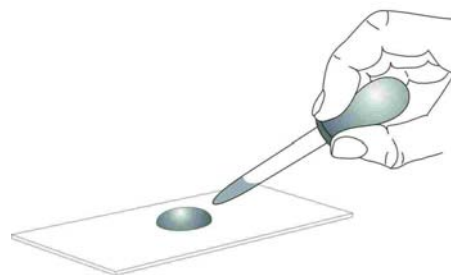
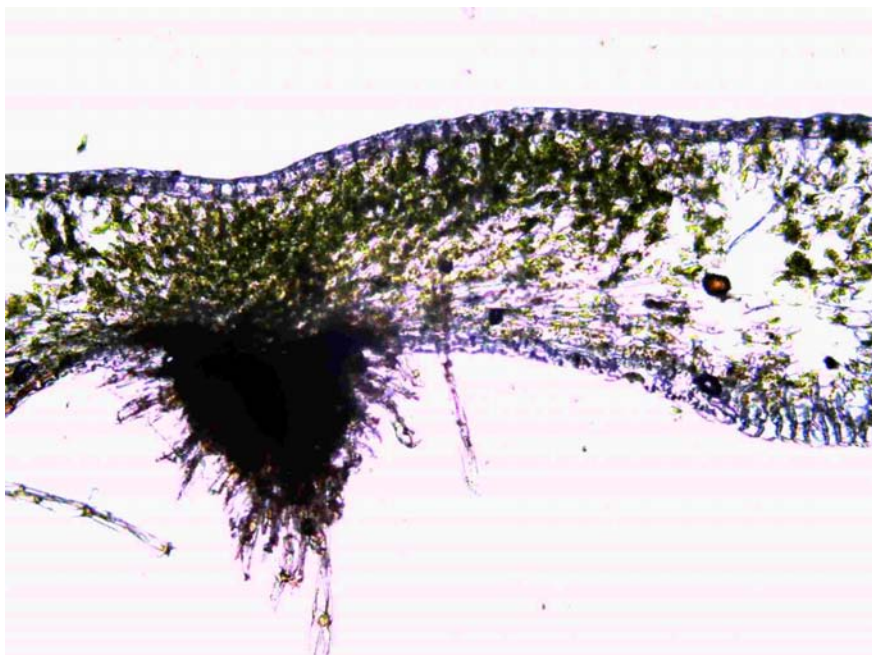
Nematoda

P1443801

Brine shrimp (*Artemia salina*)

P1443901

P1444201 Spore capsules of ferns



Apply the solution to the slide and make numerous very thin cuts through the leaf containing the sori immersed in it.

Principle

Weedy fern plants are often found in moist forests. In the tropical regions, however, there are even tree ferns that can be up to 10 meters tall.

The ferns do not belong to the flowering plants and therefore do not produce any seeds. Like the mosses, they reproduce by spores. On the underside of a frond (the leaf), there are small aggregations of spore capsules (sori). They show a regular arrangement and a species-specific pattern. The fern expert is able to identify a species on account of this characteristic pattern.

Tasks

Examine the spore capsule of a fern plant!

What you can learn about

- Ferns
- Spore capsules
- Frond

Main articles

SWIFT Microscope M3601C	63020-99	1
Chemicals set for TESS Microscopy (for up to 10 workgroups)	13290-10	1
Dropping pipette with bulb, 10pcs	47131-01	1
Scissors, straight, pointed, l 110mm	64623-00	1
Scalpel holder	64615-00	1
Scalpel blades, rounded tip, 10 off	64615-02	1
Tweezers, straight, pointed, 120mm	64607-00	1
Microscopic slides, 50 pcs	64691-00	1
Cover glasses 18x18 mm, 50 pcs.	64685-00	1

Chemicals set for TESS Microscopy (for up to 10 workgroups)



Function and Applications

Chemicals set for TESS Microscopy (for up to 10 workgroups).

Equipment and technical data

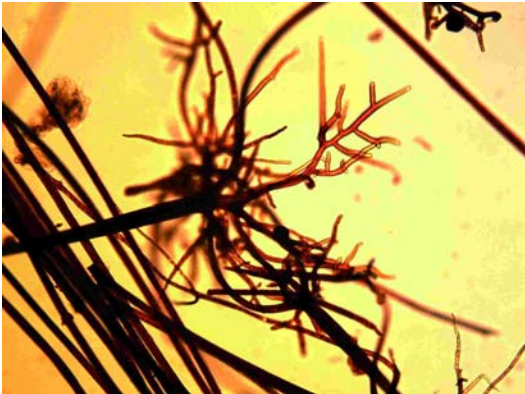
Contents:

- Acetic acid 99 %, 250 ml; Raw alcohol (96% and 70%)
- Isopropanol, absolute, 250 ml; Rotihistol, 250 ml
- Glycerol, 100 ml; Canada balsam (malinol), 50 ml
- Sodium chloride; Safranin solution 1%, 50 ml
- Lugol's solution, 100 ml; Modified azure eosine methylene blue solution (Giemsa), modified, 50 ml
- Neutral red, 5 g; Carmineacetic acid solution, 50 ml
- Methyl green, 10 g; Distilled water, 500 ml

13290-10

P1444301

Mould fungi growing on food



Principle

Surely you have seen on several occasions that molds have grown on food. Molds live on organic matter composed of carbohydrates, fat, and protein. As foodstuffs contain these substances and the required moisture, they make an ideal substrate.

The macroscopically visible mold is just one part of the fungus. It only emerges when the food is fully interspersed with mycelial threads (hyphae). As many molds produce toxic substances, moldy foodstuff should not be consumed.

For more details refer to www.phywe.com

P1444501

Colony-forming ciliates in an aquarium



Principle

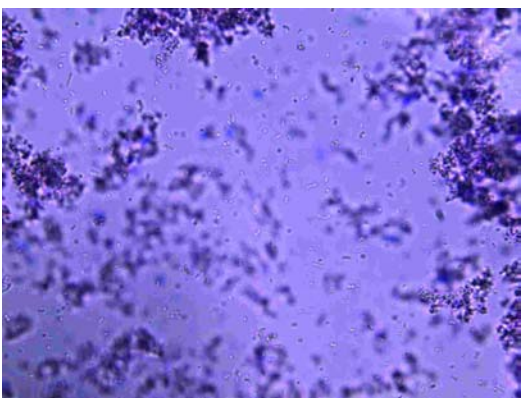
Life in the aquarium is more variegated than one may perceive at first glance. You can not only see how fish feed but also observe the movements of gill covers and how water flows through a fish's body. Besides you can observe mating behavior and territorial fights among the fishes.

But did you ever see that fishes eat something from the glass pane which is invisible to the human eye? Small organisms settle on the glass pane and on water plants as well. With a little trick you can get some of them under your microscope.

For more details refer to www.phywe.com

P1444901

Bacteria



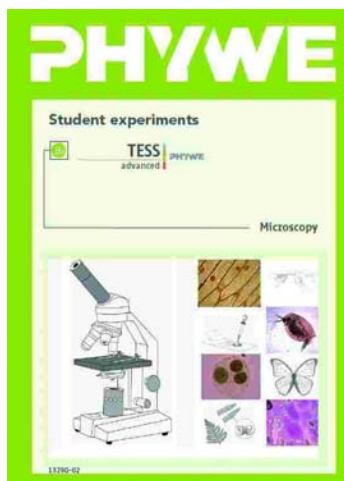
Principle

Bacteria are real life artists: Some of the organisms belonging to this group find adequate life conditions everywhere on earth, in the depths of the oceans, on highest mountains, in hot springs, and in the Arctic.

Bacteria can be compared with regard to various aspects, whether they are pathogens or of beneficial use, whether they can only survive or die in an atmosphere containing oxygen. Today you will learn to differentiate bacteria on account of their various shapes.

For more details refer to www.phywe.com

TESS advanced Biology manual Microscopy



Article no. 13290-02

Description

Experimental literature for 50 experiments with:

1. Student worksheets with black/white drawings for easy copying and Teacher's sheets with colored digital microscopy images.
2. CD-ROM with master copies of: color presentation files (PDF format) for 47 microscopy topics to print transparencies or to show directly via a video beamer and PDF files of student worksheets and teacher's sheets.

Topics

- Basics of microscopy
- Worktechniques
- Cell components
- Seed plants and ferns
- Vertebrates and invertebrates
- Fungi
- Protists
- Prokaryotes

Equipment and technical data

200 pages

This documentation contains the following experiments:

The components of a microscope MI 1.1

P1440001

Working with the microscope

P1440101

Microscopic magnification

P1440201

Preparation of temporary microscopic slides

P1440301

Manual section technique

P1440401

Staining of living organisms

P1440501

Rapid staining technique

P1440601

Fixation and staining

P1440701

Embedding in Canada balsam

P1440801

Preparation of reagents

P1440901

The cell wall of the onion

P1441001

The cellular membrane of animal cells

P1441101

Chloroplasts in moss leaves

P1441201

Chromoplasts

P1441301

Complete experiment list see www.phywe.com

13290-02

Material

TESS advanced Biology set Microscopy, BS 4

15290-88

Set of TESS Microscopy MIC, with CD-ROM and
Microscope SWIFTM3-M

15290-33

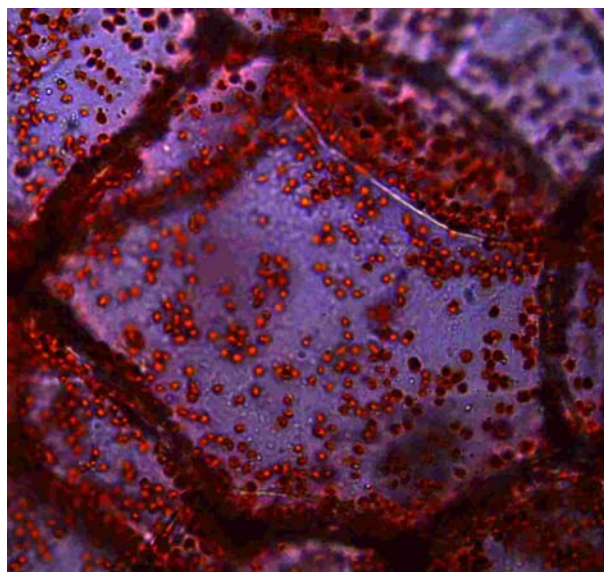
Accessories

TESS advanced Microscopy MIC necessary accessories for
1 group

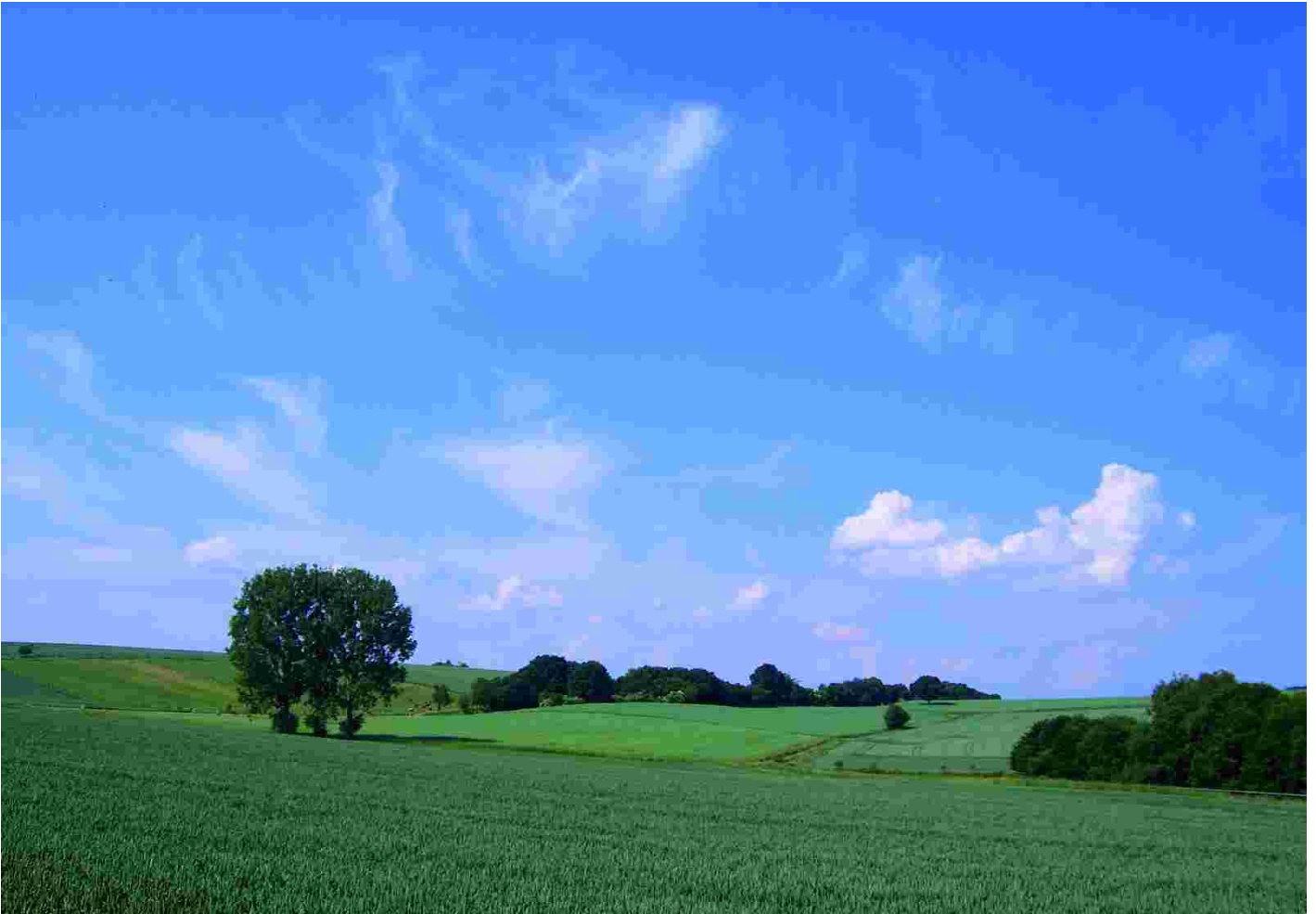
13443-88

TESS advanced Microscopy MIC consumables for 10
groups

13444-88



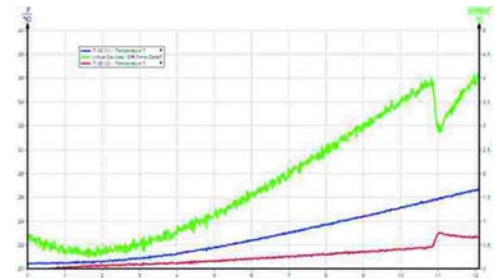
P1441301 - Chromoplasts - page 24



Ecology and Environment

3.1	Water	34
3.2	Air	38
3.3	Soil	41
3.4	Sets	43
3.5	Literature	46

P4100160 Comparison of the heat capacities of water and soil (with Cobra4)



Behaviour of temperature and temperature difference.

Principle

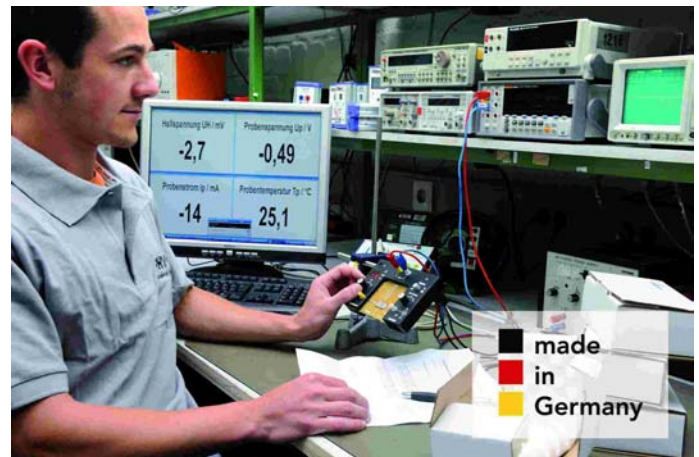
These measurements help to quickly and simply introduce the term "heat capacity". The students learn on which characteristics temperature changes of surfaces depend. As practical example, reference can always be made here to the hot sand at the seaside.

Tasks

1. To prepare comparison curves showing the different heat capacities of water and land.
2. To interpret data on climate and to explain how onshore and offshore wind originate.

What you can learn about

- Heat capacity
- Heat radiation
- Origin of climatic fluctuations
- Generation of onshore and offshore winds

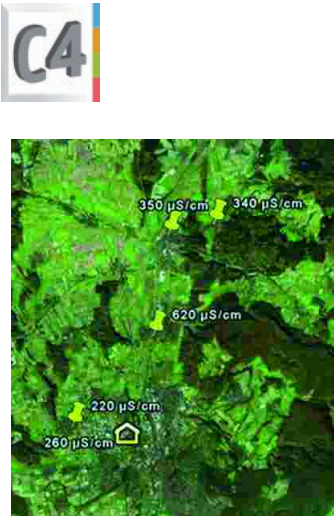


Main articles

Software Cobra4 - multi-user licence	14550-61	1
Cobra4 USB-Link	12610-00	1
Ceramic lamp socket E27 with reflector, switch, safety plug	06751-01	1
Cobra4 Sensor-Unit Temperature, semiconductor -20...110 °C	12640-00	2

Conductivity of various water samples (with Cobra4)

P4100560



Conductivity of drinking water, depending on its geographic location in and around Göttingen (Germany)

Principle

This experiment shows how much the quality of drinking water of various locations in the same region may vary. The comparison of tap water with bottled mineral water and distilled water leads to surprising results.

Tasks

1. To determine the conductivity of various water samples.
2. To discuss the reasons for the big differences in conductivity.

- What you can learn about**
- Conductivity of water samples
 - Rainwater
 - Drinking water
 - Aquarium water
 - River water
 - Mineral water
 - Electrolytes waste water
 - Eluviation
 - Contamination by inorganic salts
 - Horizontal/vertical zones

Main articles		
Software Cobra4 - multi-user licence	14550-61	1
Cobra4 Sensor-Unit Conductivity, with stainless steel electrodes	12633-00	1
Cobra4 USB-Link	12610-00	1
Reagent bottle,scr.cap,cl.,50ml	46191-00	10

Cobra4 Sensor-Unit Conductivity, with stainless steel electrodes



Function and Applications

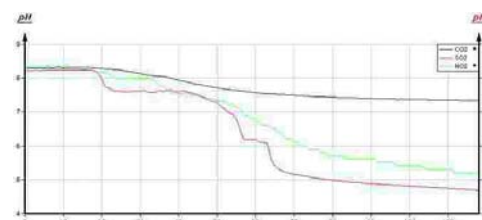
The Cobra4 Sensor-Unit Conductivity/Temperature with stainless steel electrodes can be connected directly to the Cobra4 Wireless-Link, the Cobra4 Mobile-Link or the Cobra4 USB-Link using a secure and reliable plug-in / lockable connection.

Benefits

Particularly good application for school and outdoor experimentation, as the measuring gauge is already firmly connected.

12633-00

P4100760 The origin of acid rain (with Cobra4)



pH time curve for SO₂, NO₂ and CO₂.

Principle

Acid rain is caused by emissions from power plants, households and traffic. Gases such as sulfur dioxide, nitrogen dioxide and carbon dioxide dissolve in rainwater, the products of which form the acids (acids containing sulfur, nitrous acid, nitric acid, carbonic acid). Acid rain reduces the pH of soils and waters. Environmental damage such as forest dieback is the result.

In this experiment acid rain will be produced artificially by adding the gases SO₂, NO₂ and CO₂ to water. The fall of the pH value is registered.

Tasks

1. Drop in pH resulting from the formation of acid then recorded

What you can learn about

- Acid rain
- Anthropogenic air pollution
- Damage to forests
- Acidification of soil and water
- Gaseous and aerosol emissions

Main articles

Software Cobra4 - multi-user licence	14550-61	1
Cobra4 USB-Link	12610-00	1
Cobra4 Sensor-Unit pH, BNC connector	12631-00	1

Cobra4 Sensor-Unit pH, BNC connector



Function and Applications

The Cobra4 Sensor-Unit pH, BNC connection is a measuring recorder for pH measurements, which is controlled by micro-controller.

Benefits

- It can be fitted with a pH probe, in order to measure pH values
- The unit can be connected to the Cobra4 Wireless-Link, the Cobra4 Mobile-Link or the Cobra4 USB-Link using a secure and reliable plug-in / lockable connection.

Equipment and technical data

pH:

- Measuring range: 0...14 pH; Resolution: 0.01 K; Measuring accuracy: ± 0.5 %

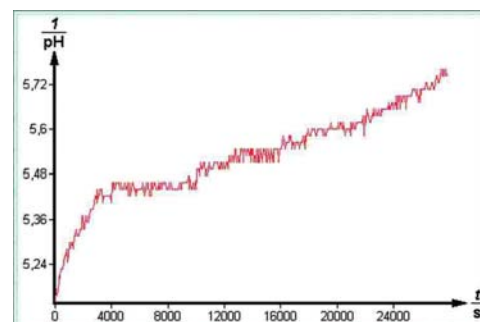
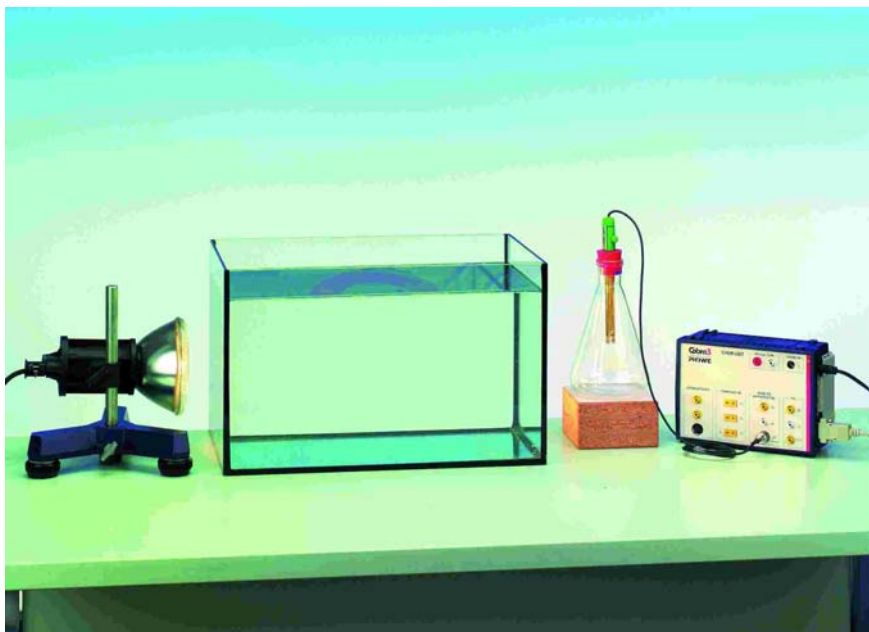
General:

- Data flow rate: 5 Hz; Dimensions (mm): 62x63; Weight: 70 g

12631-00

The twenty-four-hour rhythm of an aquatic plant (with Cobra3)

P4100840



Curve of pH against time for the reaction of waterweed in daylight.

Principle

Plants produce oxygen by photosynthesis under the influence of light (during the day). Carbon dioxide is hereby consumed. In the dark (at night), however, they consume oxygen and produce carbon dioxide.

Tasks

1. This day and night rhythm in an aquatic plant has to be followed over a longer period by pH measurements.

What you can learn about

- Photosynthesis
- Daylight reaction
- Dark reaction
- Diurnal rhythm
- Nocturnal rhythm
- pH measurement
- Carbon dioxide consumption and production

Main articles

Cobra3 Chem-Unit, USB	12153-50	1
Ceramic lamp socket E27 with reflector, switch, safety plug	06751-01	1
Software Cobra3 Chem-Unit	14520-61	1
pH-electrode, plastic body, gel, BNC	46265-15	1
Compressed gas, oxygen, 12 l	41772-05	1
Power supply 12V / 2A	12151-99	1

Cobra4 Experiment - available 2013**The twenty-four-hour rhythm of an aquatic plant (with Cobra4)**

P4100860

pH-electrode, plastic body, gel, BNC**Function and Applications**

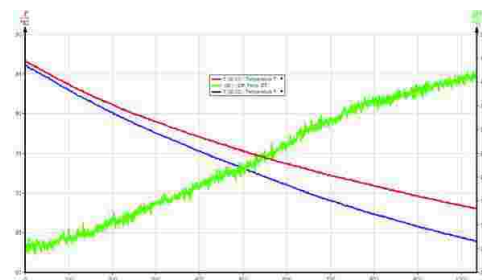
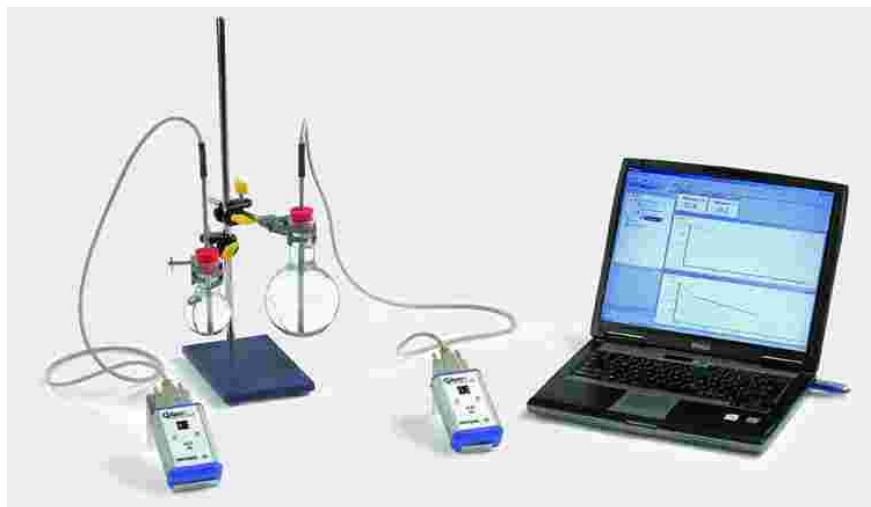
This simple pH single rod measuring cell, consisting of a glass electrode and a silver / silver chloride reference electrode with fixed cable with BNC plug, with plastic shaft is distinguished by its robust design.

Benefits

- Low- maintenance because of gel electrolyte.
- The glass membrane of the pH electrode is relatively well protected against mechanical damage through the shaft that extends through the membrane.

46265-15

P4100260 Bergmann rule: heat loss as a function of the body surface area and volume (with Cobra4)



The behaviour of temperature and temperature difference.

Principle

This experiment confirms the Bergmann rule which says that animals in cold regions are larger than near relatives in hotter regions. The reason for this is that larger animals experience a smaller heat loss than smaller animals, as their body surface area is smaller in relation to their volume than that of a smaller animal. Using a model consisting of different sized round bottom flasks that are filled with water the heat loss for different relationships between volume and body surface area is illustrated.

Tasks

1. To prepare a graph which demonstrates the different heat losses with different volumes and body surface areas.
2. To interpret data on the settling of warm and cold regions by larger or smaller animals.

What you can learn about

- Bergman rule
- Heat losses
- Larger versus smaller animals
- Cooler versus warmer regions of the world

Cobra4 Sensor-Unit Temperature, semiconductor -20...110 °C



Funktion and Applications

Cobra4 -20...110°C Sensor-Unit Temperature-semiconductor

Benefits

- can be connected directly to the Cobra4Wireless-Link, the Cobra4 Mobile-Link or the Cobra4 USB-Link.

Equipment and technical data

- Sensor jacket: stainless steel
- Measuring range: -20...+110°C
- Absolute accuracy: $\pm 0.5^\circ\text{C}$
- Resolution: 0.05°C
- Time constant: 7 s
- Data flow rate: 200 Hz
- Connecting port: sub-D-15-pole
- Sensor length / diameter: 200 mm, 6 mm
- Cable length: 120 cm
- Weight: 125 g

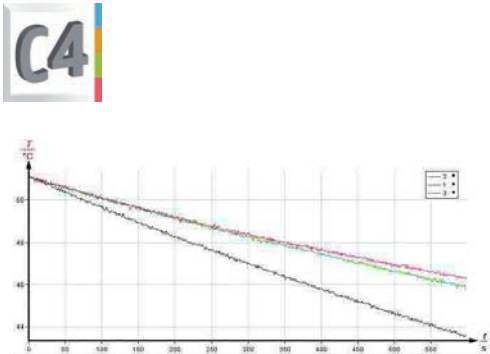
12640-00

Main articles

Software Cobra4 - multi-user licence	14550-61	1
Cobra4 USB-Link	12610-00	1
Cobra4 Sensor-Unit Temperature, semiconductor -20...110 °C	12640-00	2

Insulating effect of body coverage (with Cobra4)

P4100360



The insulating effect of body coverage.

Principle

This experiment shows that warm-blooded animals are able to use their fur to keep their body temperature constant. The coat of feathers of birds is another form of natural insulating covering to protect against cold. The insulating effect of different types of body coverage (clothing/fur) is presented using a diagram.

Tasks

1. To prepare curves showing the insulation effect of various body coverage's.
2. To discuss the reason of different isolating characteristics.

What you can learn about

- Insulation effects
- Body coverage's
- Coat of animals
- Fur
- Wool
- Feathers

Main articles		
Software Cobra4 - multi-user licence	14550-61	1
Cobra4 Wireless-Link	12601-00	1
Cobra4 Wireless Manager	12600-00	1
Cobra4 Sensor-Unit Temperature, semiconductor -20...110 °C	12640-00	1
Gasket for GL 18, 6mm hole, 10pcs	41239-03	1

Cobra4 Wireless-Link



Function and Applications

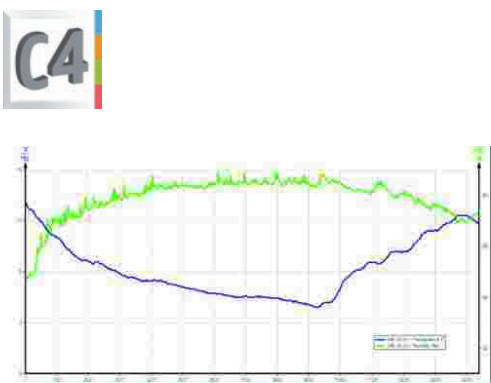
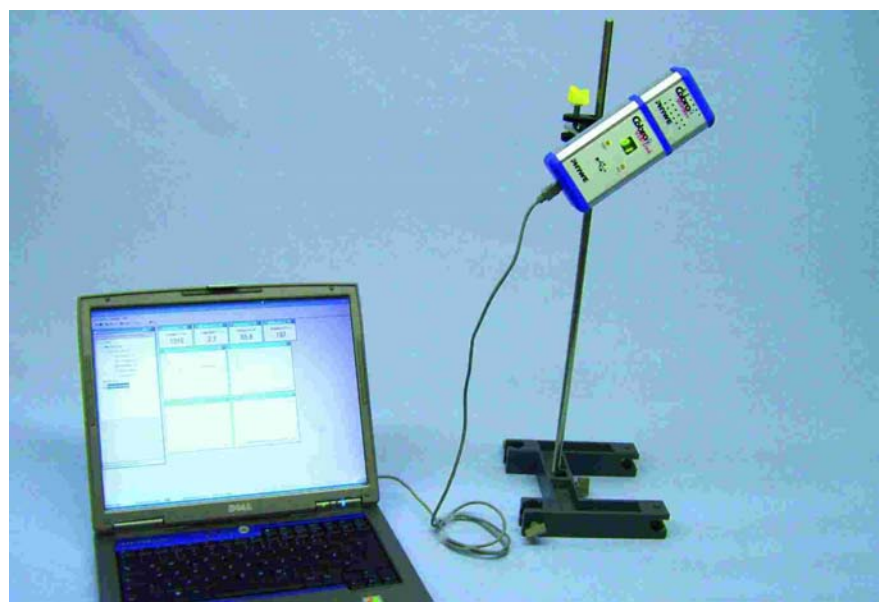
Interface module for the radio-based transmission of sensor measuring values in conjunction with the Cobra4 wireless manager.

Benefits

- All Cobra4 Sensor-Units can be quickly connected using a secure and reliable plug-in / lockable connection.
- All Cobra4 measuring sensors are easy to plug in and automatically detected.
- The radio network with the Cobra4 Wireless Manager is established automatically and is extremely stable, as it uses its own radio protocol.
- Up to 99 Cobra4 Wireless-Links can be connected to one Cobra4 Wireless-Manager.

12601-00

P4100460 24-hour weather observation (with Cobra4)



Temperature and relative humidity.

Principle

Set up your own weather station with the compact Cobra4 Weather multisensor with little means. The sensor shows the relations between air pressure, humidity, temperature, and brightness. Fluctuations over a period of 24 hours are shown as an example, but the same set-up also enables longterm measurements to be carried out.

Tasks

In a 24-hour long-term measurement the course of luminosity is recorded in the immediate vicinity of a window. The dependence on the season, the geographical location and the current degree of cloudiness, fog etc. has to be discussed.

What you can learn about

- Long-term measurement
- Course of luminosity
- Seasonal influences
- Geographical location
- Cloudiness
- Fog

Main articles

Software Cobra4 - multi-user licence	14550-61	1
Cobra4 Sensor-Unit Weather: Humidity, Air pressure, Temperature, Light intensity, Altitude	12670-00	1
Cobra4 USB-Link	12610-00	1

Cobra4 Sensor-Unit Weather: Humidity, Air pressure, Temperature, Light intensity, Altitude



Function and Applications

Depending on application type, the Cobra4 Sensor-Unit Weather can be connected to the Cobra4 Wireless-Link, the Cobra4 Mobile-Link, the Cobra4 USB-Link oder the Cobra4 Junior-Link using a secure and reliable plug-in/ lockable connection.

Benefits

- At the same time, the following measuring parameters may be recorded: air pressure, relative humidity, air temperature, brightness, height
- Ideal for use in outdoor experiments, on class trips or for project or school hiking days.

12670-00

Salinity of soils and plant substrates (with Cobra4)

P1521163



Set-up for an additional experiment.

Principle

Demonstration experiment using wireless data communication to send readings to a large-size display. How suitable are certain soils and plant substrates in terms of plant nutrition? This experiment is concerned with the measurement of conductivity, which gives an indication of which of the studied soils and plant substrates already contain nutrient salts necessary for the growth of plants and which ones would be better if nutrients were added in the form of fertiliser. Plants gain their nutrition in the form of salt ions from the soil. The most important of the 16 nutrients which plants need to grow are nitrogen in the form of nitrates and ammonia, phosphorus in the form of phosphates and potassium in the form of potassium salts. In addition, soils need to have lime (calcium carbonate) to reduce their acidity (reduction in pH). For agricultural purposes, such nutrients are added to the soil in the form of inorganic fertilisers. For house plants, fertiliser-enriched potting soil is used.

Tasks

1. Measure the conductivity of the samples in the supernatant and note the values

What you can learn about

- Conductivity
- Salinity
- Acidity
- Inorganic fertilisers

Main articles

Large-scale display, digital, RS-232 port	07157-93	1
Cobra4 Display-Connect, Set of transmitter and receiver for using the Cobra4 Mobile-Link with large-scale displays	12623-88	1

Cobra4 Mobile-Link set, incl. rechargeable batteries, SD memory card, USB cable and software "measure"	12620-55	1
Cobra4 Sensor-Unit Conductivity, with stainless steel electrodes	12633-00	1
Portable Balance, OHAUS JE120	48895-00	1

Cobra4 Display-Connect, Set of transmitter and receiver for using the Cobra4 Mobile-Link with large-scale displays

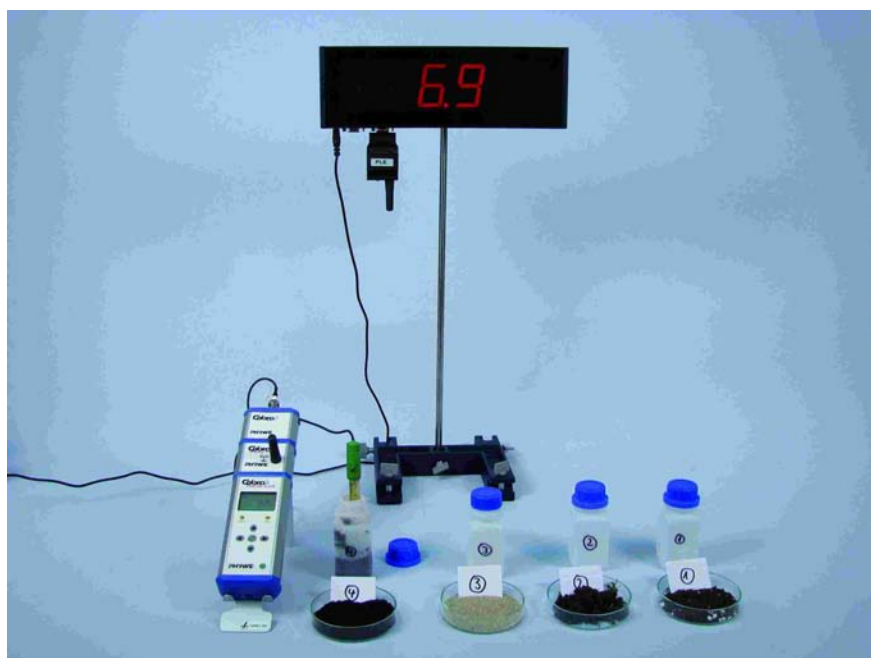


Function and Applications

Device combination from a sender and a receiver for the radio-based communication between a Cobra4 Mobile Link and up to 2 digital large displays.

12623-88

P1521063 The pH value of various soils (with Cobra4)



Ground profile of luvisol on loess (with three measuring points).

Principle

Demonstration experiment using wireless data communication to send readings to a large-size display. Knowledge of soil characteristics is highly important for agriculture. To familiarise students with this topic, two sub-experiments use pH readings to demonstrate how different soils from different places can be (sub-experiment "Characteristic pH values for soils") and how varied the soil can be down below the surface (sub-experiment "Soil profiles").

Tasks

1. Determine the characteristic pH values of various soil samples
2. Investigate the soil profile of your area

What you can learn about

- Acidity of soils
- pH value
- substratum
- Soil horizon

Main articles

Cobra4 Mobile-Link set, incl. rechargeable batteries, SD memory card, USB cable and software "measure"	12620-55	1
Cobra4 Sensor-Unit pH, BNC connector	12631-00	1
pH-electrode, plastic body, gel, BNC	46265-15	1
Buffer solution tablets pH4, 100	30281-10	1
Buffer solution tablets pH10, 100	30283-10	1

TESS Applied Sciences set examination of soil



Function and Applications

The case includes accessories and reagents to field-test soil on: mineral matter, body of humus, water/air, soil structure, acidity, nutrients, soil life.

The 60-page manual describes 19 soil analysis methods and includes an exhaustive theoretical treatise on the following topics:

- basic principles of soil science
- soil as a site factor in forests
- soil fertility factors
- changes in the soil

30836-77

TESS Biology set chemo-physical water testing



Function and Applications

This kit allows up to 8 work groups to carry out field examinations of running water and lakes.

The following parameters are measured:

- temperature
- oxygen content
- pH-conductivity
- nitrate, nitrite, phosphate and ammonium content
- alkalinity (total hardness)

The examinations can be extended to further parameters when the kit is supplemented with extra equipment, available as accessories and for which room has been reserved in the case:

- depth of transparency (measured using a Secchi disc or a Lux meter with immersion probe)
- water profiles (measurement down to 10 m depth using a water scoop)

The methods are mainly chemico-physical determinations acc. to BACH. They allow an objective assessment of the water quality and are referred to by the Scottish and American Environmental Authorities, as well as those of some German Federal States, in their reports on water quality. The chemico-physical examination methods always give momentary values and so allow measurements of variation over time (daily and seasonal variations) as well as at different positions (e.g. pollution by influents). Added meaning is given by supplementing these methods with biological methods, which aim at the documentation of long-term changes in the condition of the body of water.

Equipment and technical data

The following units are included:

- rapid test for ammonia, pH, nitrate, nitrite, phosphate, oxygen and total hardness
- conductivity tester 0-20 mS/cm, thermometer -10 ... +50 °C
- 500-ml bottles (2x for waste); detailed manual

in the case is also room for:

- Secchi disk (water transparency); water bottles (water profile)
- 2 hand-held instruments according to choice

30837-77

Ecology case, biological water analysis



Function and Applications

Eco-Kit "Biological testing of water quality". The physical, chemical, and bacteriological examination procedures primarily allow an assessment of the momentary water quality. As the variety of species in a body of water decreases with increasing pollution, and the composition of the organism societies thereby changes, the biological determination of the water quality provides additional important indications on the water quality and allows conclusions to be drawn on the previous pollution. The species and frequency of indicator organisms at various degrees of pollution are thereby coupled to the water quality classes I to IV.

Benefits

- This kit enables 6 working groups to simultaneously carry out examinations of running and standing waters in the field. All important pieces of equipment are present 6-fold.
- The enclosed manual containing tables and sheets for analysis allow assignment to the water quality classes I. ... IV

Equipment and technical data

- Screens
- Trays
- Dishes, large and small
- Tweezers
- Brushes
- Pipettes
- Magnifier glasses, large and small
- Petri dishes
- Dip net for catching aquatic organisms
- Caliper
- Rulers
- Manual with identification key
- Snap lid jars

30834-77

3 Ecology and Environment

3.4 Sets

Reagent case for water analysis with filter photometer



Function and Applications

This excursion case enables students to actively participate in the measurement of water parameters in your immediate neighbourhood. Rapid chemical analyses provide meaningful results in a very short time. The colourimetric tests can be reproducibly and exactly evaluated by using the portable filter photometer.

Benefits

- Compact water laboratory for mobile use with photometer, reagents and accessories in a new robust case with a premium foamed plastic insert
- increased accuracy and reproducibility by photometric evaluation of colourimetric tests
- economic refill packs with up to 200 determinations per parameter

Equipment and technical data

- Reagent case with Photometer PF-12 incl. manual and 4 batteries with filters for the following wave lengths: 345 / 436 / 470 / 540 / 585 / 620 / 690 nm
- Software for transferring the measured data to a PC
- Manual with test instructions for test kits
- 4 empty tubes; 1 funnel; 1 beaker 25 ml
- 1 syringe 5 ml; 1 syringe 1 ml
- 1 thermometer, 2 titration syringes with dropping tips
- 2 titration test tubes
- The following test kits: Ammonium, iron, nitrate, nitrite, phosphate, pH, carbonate hardness and total hardness

Accessories

- Ni-MH accumulators, Mignon, 1.2 V, 2000 mAh, Eneloop Type, 4 pcs. (07930-03)
- Fast Charging System for up to 4 Ni-MH accumulators, 100...240 V (07930-99)
- Refill packs of the test kits

30839-00

TESS Applied Sciences Set Gas examination



Function and Applications

For investigating air pollution caused by car exhaust gases.

Equipment and technical data

The case contains the following:

- Gas detector pump (100 ml air/stroke)
- Test tube for carbon monoxide
- sulphur dioxide
- 2x carbon dioxide
- ozone, nitrous gases
- benzene and hydrocarbons
- 100-l test bag for exhaust gases with measuring connection, rubber hose and clamp
- Handbook with detailed instructions

30838-77



TESS Applied Sciences set examination of soil



Function and Applications

The case includes accessories and reagents to field-test soil on: mineral matter, body of humus, water/air, soil structure, acidity, nutrients, soil life.

The 60-page manual describes 19 soil analysis methods and includes an exhaustive theoretical treatise on the following topics:

- basic principles of soil science
- soil as a site factor in forests
- soil fertility factors
- changes in the soil

30836-77



Soil Analysis

Excursion set, soil analysis



Function and Applications

The case contains the complete equipment for the determination of the type of soil, the soil structure, the pH of the soil and its nutrient content, i.e. the nitrogen, phosphate and potassium content available to plants.

Benefits

- The manual contains detailed descriptions of experiments for determining soil characteristics
- It contains a complete schedule for soil testing, from taking samples to differentiating the various soil types, from the determination of the nutrient content to the calculation of the amount of fertiliser required
- It also supplies valuable background information
- All necessary reagents, equipment and accessories are clearly positioned in the case, so that a glance suffices to check that it is complete.

Equipment and technical data

- Extraction Solutions
- Balance
- 2 scoops
- 3 syringes
- Pleated filter
- Colander
- Spray bottle
- 5 containers
- 2 cylinders
- 2 funnels
- Blades
- Spoon

Accessories

- Soil auger (64221-01)
- Soil auger, small (64222-00)

30346-00

TESS advanced Applied Sciences manual Cobra4 environment and outdoors



Article no. 12622-02

Description

Experimental descriptions from the fields of environment and outdoors that pay particular attention to the advantages of data acquisition with the Cobra4 Mobile-Link. In total more than 15 demonstration and student experiments are described in detail.

Topics

- Learning stations using the experimentation case "Environment and Outdoors"
- We examine our drinking water
- Acidity changes of a watercourse
- Salinity changes of a watercourse
- Water quality - heavy metal pollution
- Salinity of soils and plant substrates
- Acidity of soils
- Raised bogs and fens
- Comparison of soil and air temperature during the course of a day
- Weather observation
- Changes of the light conditions in a deciduous forest
- Altitude measurement on a trail
- Measurement of the height of a tower
- Terrain mapping
- Air pressure and relative humidity in a plane
- We visit a wastewater treatment plant

Equipment and technical data

DIN A4 stapled, colour, 80 pages

This documentation contains the following experiments:

Water quality - contamination with heavy metals
P0990162

We examine our drinking water
P1520062

Altitude measurement on a trail
P1520262

Measuring the height of a tower
P1520362

Weather observation with the Cobra4 Mobile-Link
P1520462

Terrain mapping
P1520662

Changes of the light conditions in a deciduous forest
P1520762

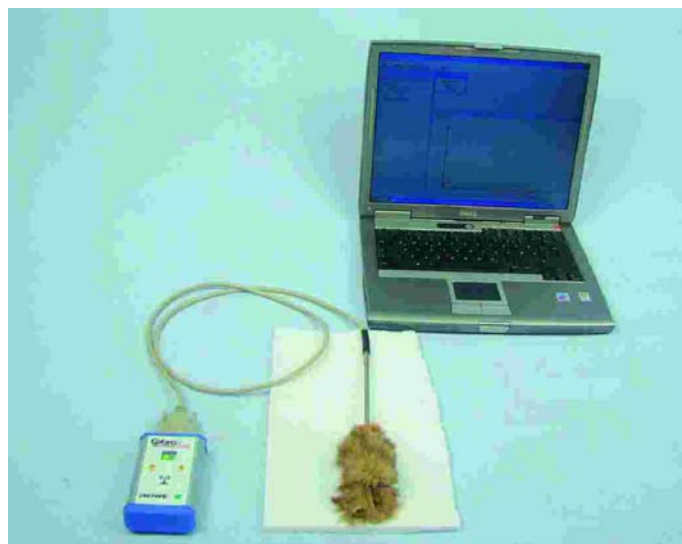
Acidity changes of a watercourse
P1520862

Comparison of soil and air temperatures in the course of a day
P1520962

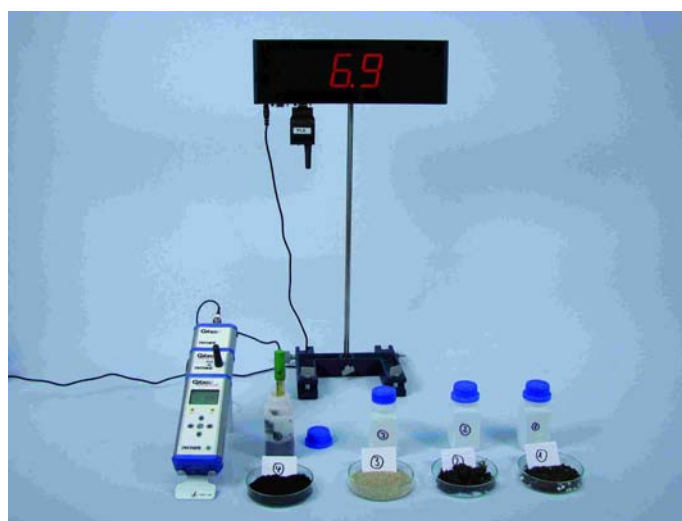
The pH value of various soils
P1521062

Complete experiment list see www.phywe.com

12622-02



P4100360 - Insulating effect of body coverage - page 41



P1521063 - The pH value of various soils - 44

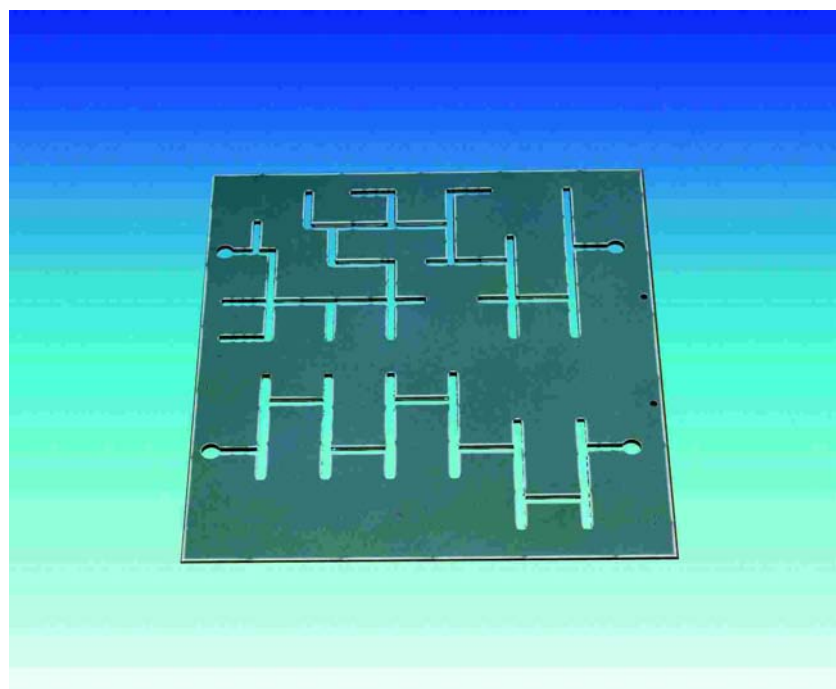


Behavioural Biology

4.1 Behavioural Science

48

P4080300 Learning performance of humans



Maze.

Principle

The blindfolded test subject has to find the way to the finish with a felt-tip pen in the slits of a finger labyrinth. Success and error are checked by placing a sheet of paper underneath. If a person has to find his way through a labyrinth, he will first of all attempt to obtain an overall view of the labyrinth. If, however, an overview of the labyrinth is prohibited, the test subject is obliged to find his way by trial and error. In the first attempt incorrect paths are frequently selected and the time taken to cross is relatively long. In subsequent practice crossings the number of errors as well as the time required are reduced steadily, until the values settle at a particular level.

Tasks

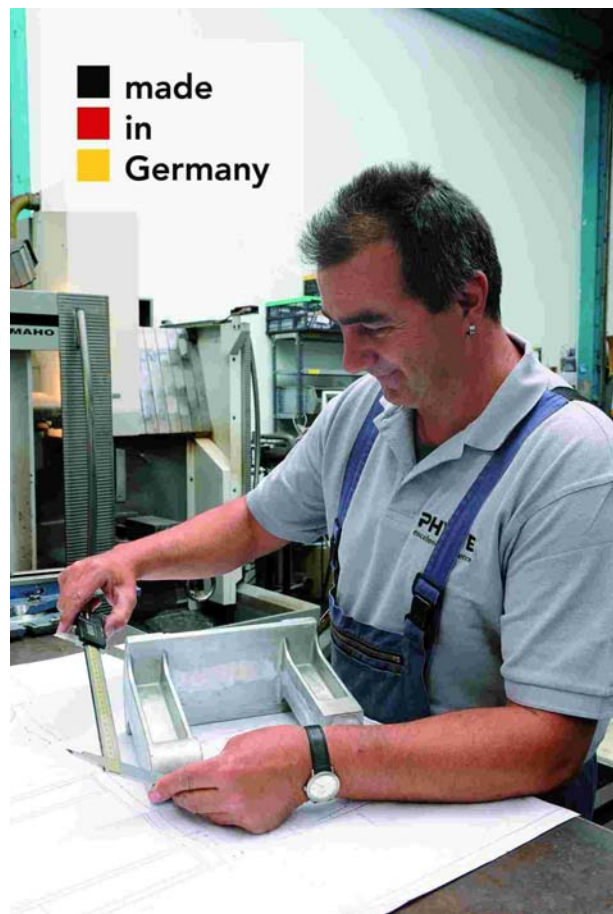
The learning curves for two different test objectives are drawn: to cross the maze with the least number of errors and as quickly as possible.

What you can learn about

- Finger labyrinth
- Learning behaviour
- Learning curve
- Short term memory
- Medium term memory

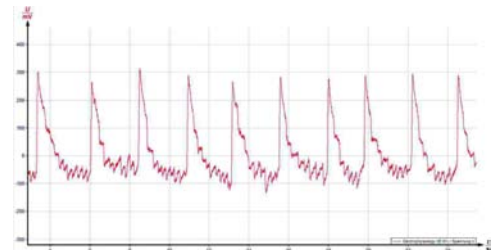
Main articles

Stop watch, interruption type	03076-01	1
Finger labyrinth	65990-00	1



Measuring reading skills (with Cobra4)

P1522260



Fastening of the electrodes around the eyes.

Principle

With this experiment, you can determine your own personal reading speed. One's reading speed can be trained and is an important prerequisite for the proper handling of all kinds of texts. You can precisely study the movement of your eyes during the measurement.

Tasks

Explore your reading behaviour reading easy and difficult texts.

What you can learn about

- Reading speed
- Movement of eyes
- Typoglycemia

Main articles

Software Cobra4 - multi-user licence	14550-61	1
Cobra4 Sensor-Unit Electrophysiology: ECG, EMG, EOG	12673-00	1
Cobra4 Wireless-Link	12601-00	1
Cobra4 Wireless Manager	12600-00	1
Shielded leads for electrophysiology, color-coded, 3/pkg	12673-01	1
Electrodes for ECG Sensor, 100 pcs.	12559-01	1

Cobra4 Sensor-Unit Electrophysiology: ECG, EMG, EOG



Function and Applications

To perform electrophysiological, noninvasive, measurements of heart, eye and muscle activities.

Benefits

- The measurement electrodes are connected to 3,5-mm jacks using three separate and shielded measurement cords.
- The sensor can be connected to a PC wirelesslink or to a USB-port.
- Requires measurement cords and ECG and/or EMG/EOG electrodes.

12673-00

P1056600

Learned behaviour in fish



For more details refer to www.phywe.com

Principle

Fish are able to learn that certain colours are connected to food. A fish is fed as follows: Choose one plate (e.g. the red one) and clamp a living worm (Tubifex spec.) to the plate. Offer all of the three plates to the fish. It is going to detect the worm and eat it. Change the positions of the plates so that only the colour leads to the worm. After a few days the fish is going to swim to the red plate immediately after entering the aquarium.

P0938300

Agonistic behaviour in male fighting fish



For more details refer to www.phywe.com

Principle

Betta males defend their territories strongly. Penetrates a conspecific the territory, the area owner reacts first with posturing. The intruder responds with escape, display or fighting behavior. This is done by a rigidly fixed innate ritual. This experiment analyses the behaviour using a mirror. The frequency of the various behavioral characteristics (behavior sequence) is determined.

P0938400

Shooling behaviour in fish



For more details refer to www.phywe.com

Principle

Living in a swarm is advantageous for fish as predators are confused by a swarm of fish (much like a goalie, who is confronted with a lot of balls at the same time).

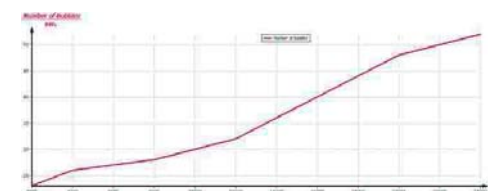
The swarm behavior is shown in this experiment by the fact that the individual fish clearly prefer the side of the aquarium in which the swarm is staying. Knocking on the glass of the aquarium the parallel orientation of the fish to each other becomes evident.



Plant Physiology / Botany

5.1	Photosynthesis	52
5.2	Water Balance	55
5.3	Mineral Balance	56
5.4	Growth and Development	59
5.5	Literature	62

P4110160 Photosynthesis (bubble counting method) (with Cobra4)



Number of bubbles/min as a function of Light intensity (lx)

Principle

To measure the dependence of photosynthesis on light.

Tasks

1. To measure the dependence of photosynthesis on light by counting the oxygen bubbles given off by an aquatic plant.
2. To investigate the influence of the carbon dioxide content of the water on the rate of photosynthesis.

What you can learn about

- Dependence of photosynthesis on light and carbon dioxide content
- Oxygen bubble counting
- Lux measurement

Main articles

Software Cobra4 - multi-user licence	14550-61	1
Cobra4 Sensor-Unit Weather: Humidity, Air pressure, Temperature, Light intensity, Altitude	12670-00	1
Cobra4 USB-Link	12610-00	1
Ceramic lamp socket E27 with reflector, switch, safety plug	06751-01	1

Cobra4 Sensor-Unit Weather: Humidity, Air pressure, Temperature, Light intensity, Altitude



Function and Applications

Depending on application type, the Cobra4 Sensor-Unit Weather can be connected to the Cobra4 Wireless-Link, the Cobra4 Mobile-Link, the Cobra4 USB-Link oder the Cobra4 Junior-Link using a secure and reliable plug-in/ lockable connection.

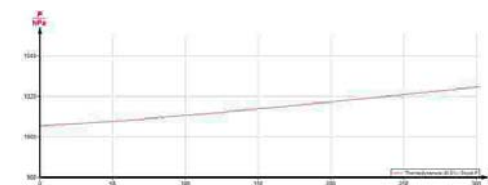
Benefits

- At the same time, the following measuring parameters may be recorded: airpressure, relative humidity, airtemperature, brightness, height
- Ideal for use in outdoor experiments, on classtrips or for project or school hikingdays.

12670-00

Photosynthesis (measurement of oxygen pressure) (with Cobra4)

P4110260



Oxygen pressure (hPa) as function of time (s) with white light.

Principle

To compare the increase in oxygen pressure during photosynthesis.

Tasks

1. To compare the increase in oxygen pressure during photosynthesis in white light, green light and in the dark.
2. To discuss the reasons for the differences of the pressure curve rise.

What you can learn about

- Photosynthesis
- Intensity and colour of the light
- Pressure measurement

Main articles

Software Cobra4 - multi-user licence	14550-61	1
Cobra4 Sensor-Unit Thermodynamics, pressure abs. 2 bar and 2 temperature NiCr-Ni	12638-00	1
Cobra4 USB-Link	12610-00	1
Ceramic lamp socket E27 with reflector, switch, safety plug	06751-01	1

Related Experiment

The twenty-four-hour rhythm of an aquatic plant (with Cobra3)

P4100840

Cobra4 Sensor-Unit Thermodynamics, pressure abs. 2 bar and 2 temperature NiCr-Ni



Function and Applications

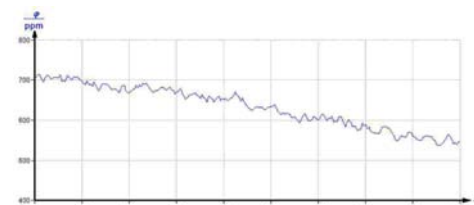
The Cobra4 Sensor-Unit Thermodynamics is a measuring recorder for pressure and temperature measurements, which is controlled by micro-controller.

Benefits

- It can be fitted with two NiCr-Ni thermoelements (type K), in order to measure up to two temperatures and one absolute pressure value simultaneously
- The unit can be connected to the Cobra4 Wireless-Link, the Cobra4 Mobile-Link or the Cobra4 USB-Link using a secure and reliable plug-in/ lockable connection.

12638-00

P4110660 The importance of Carbon dioxide for Photosynthesis



Decrease of CO₂ concentration during illumination.

Principle

This experiment shows that carbon dioxide is consumed during photosynthesis, whereas it is produced through cellular respiration.

Tasks

1. Determine the CO₂-consumption during photosynthesis
2. Determine the CO₂-production during cellular respiration

What you can learn about

- Photosynthesis
- Cellular respiration
- Oxygen
- Carbon dioxide

Main articles

Software Cobra4 - multi-user licence	14550-61	1
Cobra4 Sensor-Unit CO ₂	12671-00	1
Cobra4 Wireless-Link	12601-00	1
Ceramic lamp socket E27 with reflector, switch, safety plug	06751-01	1
Cobra4 Wireless Manager	12600-00	1

Related Experiment

Paper chromatography of chloroplast pigments

P0892300

Cobra4 Sensor-Unit CO₂



Function and Applications

Sensor of the Cobra4 family for the measurement of the CO₂ concentration in the air. The measured data of the sensor can be transferred with the Cobra4 Wireless Link by radio to the PC in connection with the Cobra4 Wireless Manager. All Cobra4 Sensor Units are quickly connectable through a secure and reliable plug-in / lockable connection.

Equipment and technical data

- measuring range: 0... 6000 ppm
- resolution: 50 ppm; data transfer rate: 1 Hz
- dimensions (L x W x H): 60 mm x 70 mm x 30 mm
- weight: 60 g

12671-00

Transpiration of leaves (with Cobra4)

P4110360



Measurement result (Experiment 1) - Plant transpiration in still air.

Principle

Plants "sweat" just as people do and are thereby physiologically and morphologically suited to their specific environment. They transpire at high temperatures and pass water to the environment. Transpiration also serves for the transport of water and nutrients. The underpressure that is caused by transpiration draws water up from the roots, substances are transported further.

Tasks

1. To prepare and analyse diagrams to illustrate the transpiration of plants, depending on different environmental conditions.
2. To discuss the reasons of the differences of the pressure curve decrease.

What you can learn about

- Transpiration
- Water and nutrients transport
- Influence of wind
- Temperature
- Humidity and type of leaves

Main articles

Software Cobra4 - multi-user licence	14550-61	1
Cobra4 Sensor-Unit Thermodynamics, pressure abs. 2 bar and 2 temperature NiCr-Ni	12638-00	1
Cobra4 USB-Link	12610-00	1
Hot/cold air blower, 1800 W	04030-93	1
Bunsen burner /DIN/, nat.gas	32165-05	1

Cobra4 Sensor-Unit Thermodynamics, pressure abs. 2 bar and 2 temperature NiCr-Ni



Function and Applications

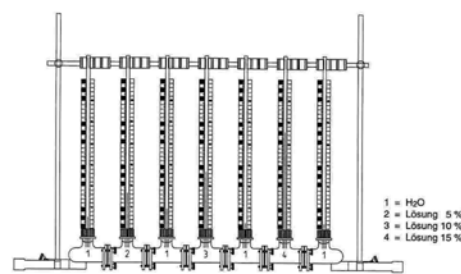
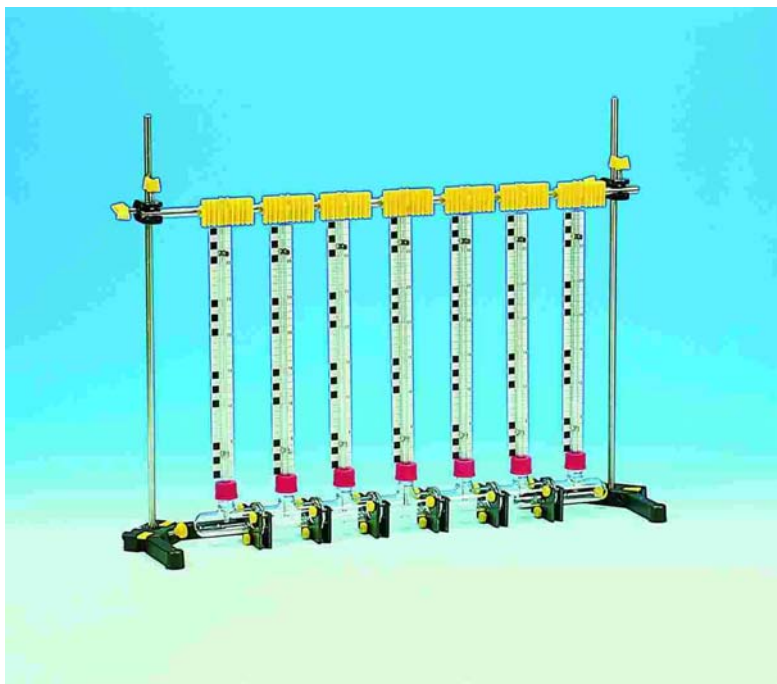
The Cobra4 Sensor-Unit Thermodynamics is a measuring recorder for pressure and temperature measurements, which is controlled by micro-controller.

Benefits

It can be fitted with two NiCr-Ni thermoelements (type K), in order to measure up to two temperatures and one absolute pressure value simultaneously

12638-00

P1135700 Osmosis - dependence of the osmotic pressure on the concentration



Levels of different solutions during experiment.

Principle

Osmosis describes the phenomenon that solvent molecules move through a partially permeable membrane into a region of higher solute concentration. Thus, the concentration of solute is equalized on both sides. The experimental set-up consists of seven chambers that are filled with solutions of sugar with different concentrations. The liquid column in the capillaries is determined and the dependence of the osmotic pressure on the concentration can easily be shown.

Tasks

1. Investigate the phenomenon of osmosis in a simple model experiment
2. Determine the dependence of osmotic pressure on concentration of dissolved molecules

What you can learn about

- Osmosis
- Osmotic pressure
- Concentration

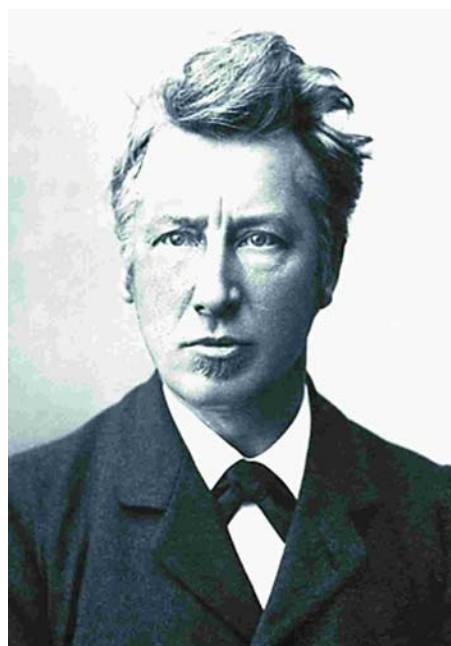
Main articles

Set of Precision Balance Sartorius CPA 623S and measure software, 230 V	49224-88	1
Osmosis and electrochemistry chamber	35821-00	1
Suppl. chamber f. osmosis/el. chem.	35821-10	5
Filtration stand for 2 funnels	33401-88	1
Scale 350 mm	64840-00	7

Cobra4 Experiment - available 2013

The ionic permeability of the cell membrane (with Cobra4)

P4120260



Jacobus Henricus van 't Hoff
1901, Nobel Prize in Chemistry

Salinity of soils and plant substrates (with Cobra4)

P1521163



Set-up for an additional experiment.

Principle

Demonstration experiment using wireless data communication to send readings to a large-size display. How suitable are certain soils and plant substrates in terms of plant nutrition? This experiment is concerned with the measurement of conductivity, which gives an indication of which of the studied soils and plant substrates already contain nutrient salts necessary for the growth of plants and which ones would be better if nutrients were added in the form of fertiliser. Plants gain their nutrition in the form of salt ions from the soil. The most important of the 16 nutrients which plants need to grow are nitrogen in the form of nitrates and ammonia, phosphorus in the form of phosphates and potassium in the form of potassium salts. In addition, soils need to have lime (calcium carbonate) to reduce their acidity (reduction in pH). For agricultural purposes, such nutrients are added to the soil in the form of inorganic fertilisers. For house plants, fertiliser-enriched potting soil is used.

Tasks

1. Measure the conductivity of the samples in the supernatant and note the values

What you can learn about

- Conductivity
- Salinity
- Acidity
- Inorganic fertilisers

Main articles

Large-scale display, digital, RS-232 port	07157-93	1
Cobra4 Display-Connect, Set of transmitter and receiver for using the Cobra4 Mobile-Link with large-scale displays	12623-88	1

Cobra4 Mobile-Link set, incl. rechargeable batteries, SD memory card, USB cable and software "measure"

12620-55 1

Cobra4 Sensor-Unit Conductivity, with stainless steel electrodes

12633-00 1

Large-scale display, digital



Function and Applications

Special four-digit large-format display for presenting the measurement data supplied by the new Cobra4 Mobile-Link with Cobra4 Display-Connect, the Cobra3 Com-Unit, the PHYWE hand-held measuring instruments and Sartorius or Scaltec balances equipped with data interfaces.

07157-93

P0898200

Spectroscopic identification of sodium, potassium, and calcium in plant ashes



Principle

The content of plant ash is investigated to investigate the mineral content of plants. The characteristic lines of the elements are determined using a small spectroscope. The cations of sodium, potassium and calcium are detected qualitatively.

For more details refer to www.phywe.com

P1034700

Absorption of minerals by plants



Principle

This experiment offers the opportunity to treat the flame coloration as a test method once more. If desired, cobalt glasses can be used for demonstrating the violet coloration due to potassium ions and sodium ions also in the case of the non-fertilized plant in order to show that mineral matters are even contained in drinking water/ground water and that these mineral matters are absorbed by the plants, too.

For more details refer to www.phywe.com

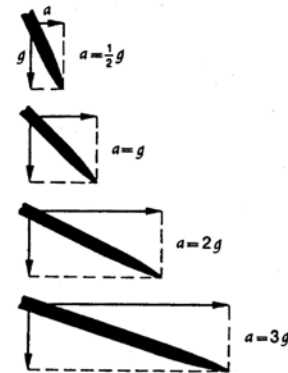
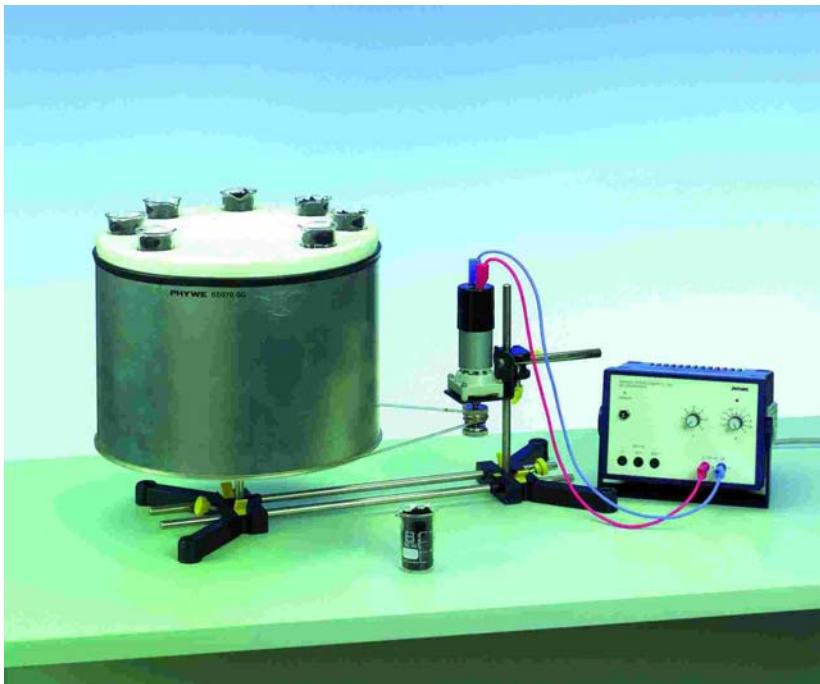
You need more information?
Just click www.phywe.com

WEB@ PHYWE



The effect of gravity and centrifugal force on plants

P4050200



Root orientation.

Principle

The main shoot of a plant generally follows a perpendicular direction away from the centre of gravity of the earth (negative geotropism), whereas the main root grows towards the centre of gravity (positive geotropism). If however the plant is placed on a rotating horizontal disk, this will alter the direction of growth of the shoot and of the root.

Tasks

1. Measure the alignment of shoots and roots under the effect of centrifugal forces which are less than, equal to or greater than gravity
2. Raise sunflower seedlings in small beakers in a rotating drum
3. Set different centrifugal forces by changing the speed of rotation of the drum motor.

What you can learn about

- Geotropism
- Positive geotropism of roots
- Negative geotropism of shoots
- Centrifugal force
- Rotational speed
- Statoliths

Main articles

Strobe drum	65976-00	1
Power supply 0...12 V DC/ 6 V, 12 V AC, 230 V	13505-93	1
Motor with disk holder	11614-00	1
Support base variable	02001-00	1

Strobe drum



Function and Applications

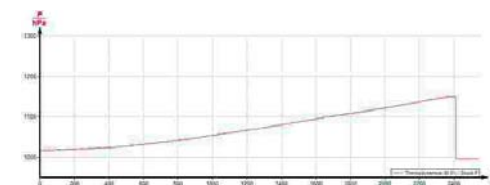
To produce moving stimuli for the investigation of the resolving power of the eye, for testing human reaction capacity and as a type of centrifuge for investigating the effects of mass acceleration on plants and animals.

Equipment and technical data

- Diameter: 32 cm
- Circumference: 100 cm
- Height: 20 cm
- Pattern: 180 black stripes
- With drive belt

65976-00

P4110460 Glycolysis (pressure measurement) (with Cobra4)



Measurement of CO₂ pressure versus time result at room temperature.

Principle

The aim of this experiment is to prove glycolysis by means of measuring the CO₂ production under various experimental conditions (temperature, pH).

Tasks

1. To identify glycolysis by measuring the production of CO₂ and plotting graphs.
2. To investigate the influence of temperature and pH on metabolic activity.

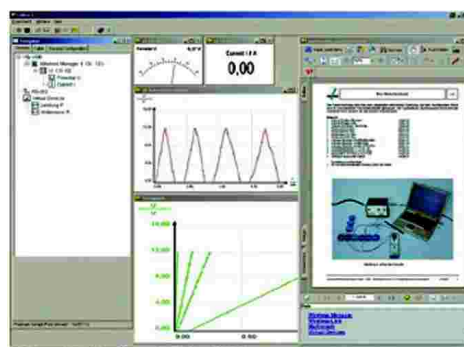
What you can learn about

- Glycolysis
- Yeast fermentation of sugar
- CO₂ pressure measurement
- Influence of temperature and pH

Main articles

Software Cobra4 - multi-user licence	14550-61	1
Cobra4 Sensor-Unit Thermodynamics, pressure abs. 2 bar and 2 temperature NiCr-Ni	12638-00	1
Cobra4 Wireless-Link	12601-00	1
Cobra4 Wireless Manager	12600-00	1
Magnetic stirrer Mini / MST	47334-93	1
Holder for Cobra4 with support rod	12680-00	1
Support base variable	02001-00	1
Bunsen burner /DIN/, nat.gas	32165-05	1

Software Cobra4 - multi-user licence



Function and Applications

The "measure Cobra4" measuring software leaves nothing to be desired.

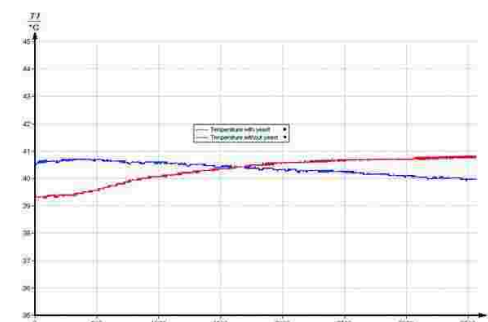
As soon as a Cobra4 sensor is connected to a PC, irrespective of whether by Cobra4 Wireless or Cobra4 USB, the "measureCobra4" software opens completely automatically and shows the connected sensors, the required measuring windows and the current measuring data.

Measurement recording is then started with a single CLICK. This all takes under 40 seconds!

14550-61

Glycolysis (temperature measurement) (with Cobra4)

P4110560



Measurement of temperature versus time during fermentation.

Principle

Investigating the temperature increase during the fermentation of sugar by yeast cells. This experiment enables a discussion to be carried out on metabolic processes and phenomena such as glycolysis, fermentation, aerobic vs. anaerobic respiration, the Pasteur effect.

Tasks

1. To depict the increase in temperature, which results, when yeast cells ferment sugar.
2. To compare the temperature curves of the solutions with and without yeast.

What you can learn about

- Glycolysis
- Yeast fermentation of sugar
- Temperature measurement
- Respiration energy

Main articles

Software Cobra4 - multi-user licence	14550-61	1
Cobra4 Sensor-Unit Thermodynamics, pressure abs. 2 bar and 2 temperature NiCr-Ni	12638-00	1
Cobra4 USB-Link	12610-00	1
Immersion probe NiCr-Ni, steel, -50...400°C	13615-03	2
Thermos flask	64841-00	2
Beaker, low, BORO 3.3, 1000 ml	46057-00	1
Rubber stopper, d=41/34mm, 2 holes	39261-02	2

Immersion probe NiCr-Ni, steel, -50...400°C



Function and Applications

NiCr-Ni thermocouples with 2 pin standard flat plug Type K, free of thermal tension.

Benefits

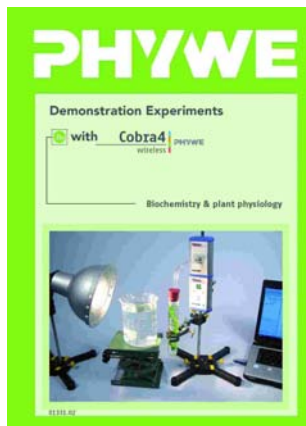
- Suitable for e.g. Digital Thermometer Hand-held measuring device Temperature or interfaces.

Equipment and technical data

- Temperature range: - 50 ... + 400°C
- Response time: approx. 5 s
- Length of lead: 100 cm, Diameter: 3 mm
- Length: 120 mm

13615-03

Demo advanced Biology Manual Cobra4 Biochemistry & plant physiology



Article no. 01331-02

Description

Experimental descriptions from the fields of biochemistry and plant physiology that pay particular attention to the advantages of data acquisition with the Cobra4 System. In total more 10 demonstration experiments are described in detail.

Topics

- Photosynthesis (2 different methods)
- Transpiration of leaves
- Glycolysis (2 different methods)
- The ionic permeability of the cell membrane
- Determination of the Michaelis constant
- Enzyme inhibition
- Substrate inhibition of enzymes
- The enzymatic activity of catalase

Equipment and technical data

Din A4 stapled; in colour, 56 pages

This documentation contains the following experiments:

Transpiration of leaves

P1351260

Photosynthesis (02 pressure measurement) (with Cobra4)

P1351360

Glycolysis (temperature measurement)

P1351460

The enzymatic activity of catalase

P1360760

Photosynthesis (bubble-counting-method)

P1360860

Glycolysis (pressure measurement)

P1360960

Ionic permeability of the cell membrane

P1369760

Determination of the Michaelis constant

P1369860

Complete experiments see www.phywe.com

01331-02



P4110160 - Photosynthesis (bubble counting method) (with Cobra4) - page 54



P4110460 - Glycolysis (pressure measurement) - page 62



P1521163 - Salinity of soils and plant substrates - page 59

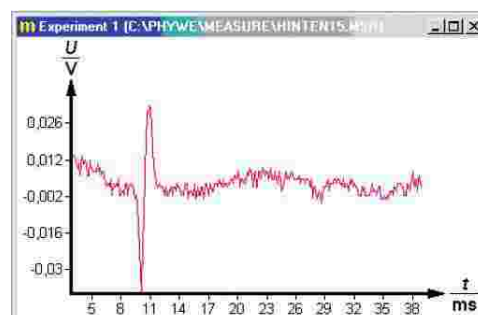


Animal Physiology

6.1 Animal Physiology

64

P4010111 Recording of nerve and muscle potentials by mechanical stimulation at the rear end of an earthworm (Cobra3)



Result with weak stimulation.

Principle

Earthworms have a median giant nerve fibre, which reacts to stimulation at the front end, and two lateral giant fibres, which can be stimulated at the rear end. The experiment covers the following topics: the course of a biphasic action potential over time, estimation of the conduction velocity and coding of the stimulant intensity as frequency modulation

Tasks

1. stimulate the earth worm with weak, moderate and strong stimulation.
2. observe the course of the biphasic action potential over time
3. estimate the conduction velocity

What you can learn about

- Nerve and muscle potentials
- Mechanical stimulation
- Biphasic action potential
- Frequency modulation
- Median and lateral giant nerve fibres
- Conduction velocity

Main articles

Cobra3 BASIC-UNIT, USB	12150-50	1
Biological amplifier	65961-93	1
Earthworm experiment chamber	65981-20	1
Stimulus bristle, triggering	65981-21	1
Power supply 12V / 2A	12151-99	1
Software Cobra3 Universal recorder	14504-61	1

Cobra4 Experiment - available 2013

Recording of nerve and muscle potentials by mechanical stimulation at the rear end of an earthworm (Cobra4)

P4010160

Related Experiment

Recording of nerve and muscle potentials by mechanical stimulation at the front end of an earthworm (Cobra3)

P4010211

Biological amplifier



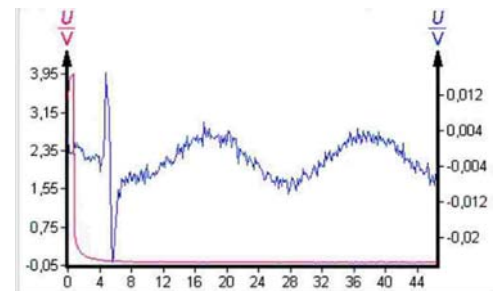
Function and Applications

With the aid of this biological amplifier a wide range of electrophysiological experiments can be carried out on human beings, insects and earthworms.

65961-93

Recording of nerve potentials after the electrical stimulation of an anaesthetised earthworm (with Cobra3)

P4010311



Result with a weak stimulus.

Principle and tasks

To work on the following themes by measuring nerve and muscle potentials:

- The action of an anaesthetic
- The different conduction velocities of median and lateral giant fibres
- Refractory period of the median giant fibre

What you can learn about

- Nerve and muscle potentials
- Electrical stimulation
- Anaesthetization of muscles
- Electrical resistance of nerve fibres
- Double pulse stimulation
- Refractory period

Main articles

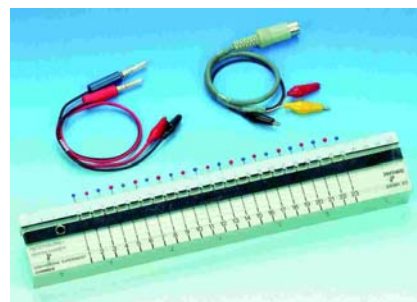
Cobra3 BASIC-UNIT, USB	12150-50	1
Biological amplifier	65961-93	1
Stimuli generator	65962-93	1
Earthworm experiment chamber	65981-20	1
Power supply 12V / 2A	12151-99	1
Software Cobra3 Universal recorder	14504-61	1

Cobra4 Experiment - available 2013

Model experiment illustrating the development of resting potential (with Cobra4)

P4010462

Earthworm experiment chamber



Function and Applications

The earthworm experiment chamber is used for non-harming neurophysiological experiments on earthworms. The worm is placed in a channel which can be closed by an acrylic glass cover, which has holes in it for inserting a bristle etc. The channel in which the worm lies has along row of 23 pin electrodes which can be connected to the biological amplifier by means of special cables. The experimental data is displayed either on a computer screen or by a storage oscilloscope. The experiment does not harm the earthworm in any way. Much information can be obtained by using the worm as it is and irritating it with a softbristle. Some phenomena can only be measured, or at least be better measured, however, using electrical stimulation (requires a stimuli generator). For this it is necessary to anaesthetise the worm for a short time.

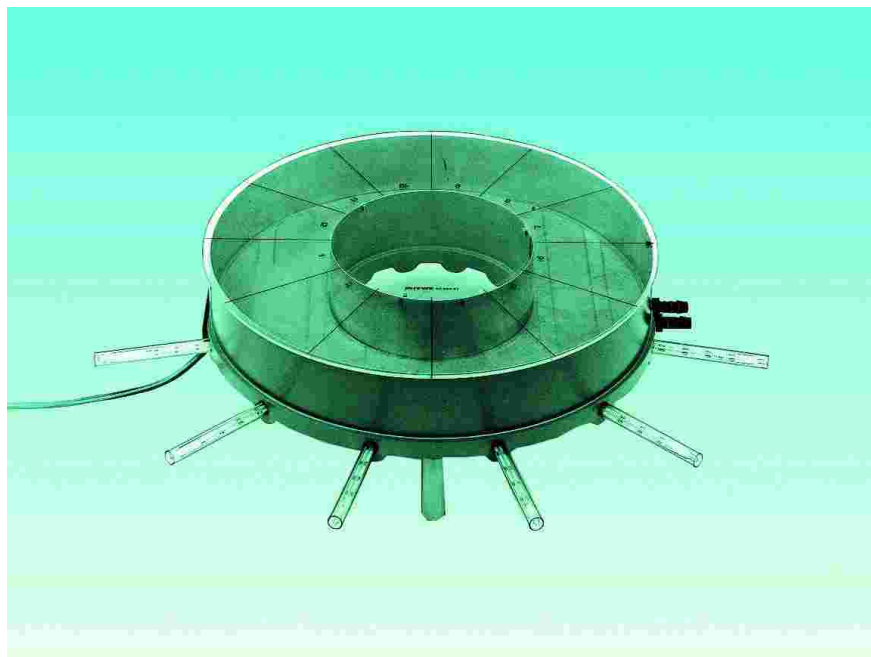
Equipment and technical data

Dimensions (cm) 32×6×4

65981-20

P4060200

Preferential temperature in insects



Insects.

Principle

The temperature requirements of animals with regard to their environment differ widely: they vary from temperatures just below 0°C for arctic and antarctic animals to temperatures of around 50°C for desert animals and animals from hot springs. Within these limits many species prefer one range: the preferential temperature. Using their thermoreceptors the animals recognize the temperature which suits them, gather in an area at the corresponding temperature (thermotaxis) and thus show their preferred temperature.

Tasks

1. Test the temperature demands of poikilothermic animals
2. Produce a temperature gradient between approximately 45°C and 10°C using a ring shaped temperature organ
3. Record the positions of the individual animals.

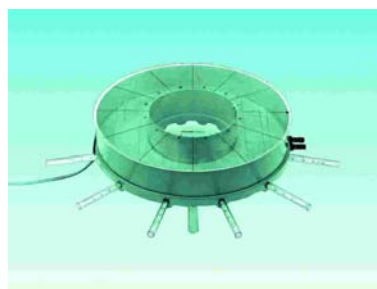
What you can learn about

- Temperature optimum
- Poikilothermic animals
- Thermotaxis
- Phototaxis
- Thigmotaxis
- Torpor
- Environmental requirements
- Geographical separation

Main articles

Temperature organ	65983-93	1
Immersion thermostat Alpha A, 230 V	08493-93	1
Bath for thermostat, Makrolon	08487-02	1

Temperature organ



Function and Applications

This ring-shaped apparatus enables a temperature gradient to be formed and is a valuable tool for working out ecological relationships.

Benefits

- It allows, e.g., to observe the influence of the temperature of soil on germination and growth of plants
- Soil organisms placed in the temperature organ can move freely and migrate the region they prefer so that their temperature and/or moisture preferences can be studied

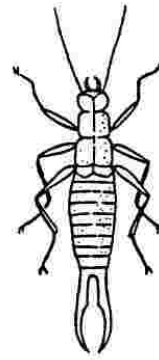
Equipment and technical data

- Temperature gradient 10 to 45°C
- Built-in electric heater and through-flow cooling
- 12 radial holes to insert thermometers
- Transparent cover plate with 12 sections

65983-93

Humidity preferendum of soil arthropods

P0911700



Earwig.

Principle

Heat radiated by a lamp gradually causes soil to dry out. That and the light emitted cause any creatures in a sample to burrow to the bottom where they are sieved into a funnel and collected inside a vessel. The vessel contains moist filter paper in order to capture the creatures alive or otherwise contains a fixing solution. The creatures obtained from the soil in this way can be studied under a normal or a stereo microscope and thus identified.

Tasks

1. Determine the humidity of your soil sample.
2. Investigate which creatures live in the soil samples.

What you can learn about

- Berlese apparatus
- Woodlouse
- Earwig
- Springtail
- Humidity preferendum

Main articles

Humidity determination apparatus in transport box	64203-02	1
Balance OHAUS LG 311, 4 beams, 0...311 g	44007-31	1
Stereo microscope ST-30-2L0,2x/4x	62459-93	1
Berlese apparatus	64204-88	1

Humidity determination apparatus in transport box



Function and Applications

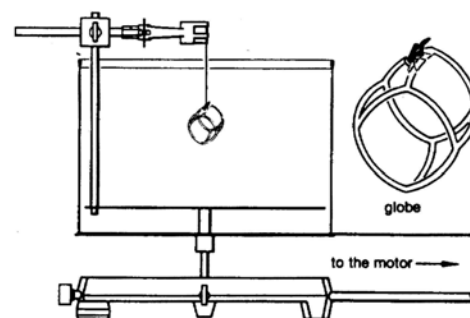
To determine the moisture content of the soil. This method can be implemented particularly in ecological pilot projects, which it provides fast and reliable results.

Equipment and technical data

- CM pressure cylinder
- manometer, sealings
- precision spring balance
- testing medium for the manometer
- metal grinding bowl
- 4 stainless steel bullets in plastic can
- 20 calciumcarbide phials in plastic can

64203-02

P4070100 Optomotor response in insects



Fastening the fly in place.

Principle

Behavioural physiological measurement of the time resolving capacity of the compound eye of flies (without electrophysiological leads). Many insects try to follow movements in their surroundings not only with their head but with their whole body. If a striped strobe pattern passes from left to right in front of the head the insect makes a right turn. This optomotor response can be used to determine the speeds at which the insect can still perceive the strobe pattern. The movements (optomotor response) indicate whether or not the fly can resolve the strobe pattern with the drum set at a constant speed.

The use of *Calliphora Spec* is recommended.

Tasks

1. To determine the ratio of right and left turns made by a fly attached to the centre of a strobe drum.

What you can learn about

- Optomotor response
- Time resolving capability
- Compound eye
- Strobe drum, Pattern frequency
- Left- and right-hand movements of flies

Main articles

Strobe drum	65976-00	1
Power supply 0...12 V DC/ 6 V, 12 V AC, 230 V	13505-93	1
Motor with disk holder	11614-00	1
Fine control valve	33499-00	1
Compressed gas, CO ₂ , 21 g	41772-06	1
Caterpillar breeding box 200x280	64564-00	1

Power supply 0...12V DC/ 6 V, 12V AC, 230V



Function and Applications

High quality power supply specially suitable for student experiments in electricity and electronics as well as for demonstration.

Equipment and technical data

- Stabilised
- Shortcircuit proof
- Output voltage: 1...12 V DC, 6 V / 12 V AC
- Rated current: DC 0...2 A / AC 5 A
- Ripple: max 1 mV
- Resistance: 1 mΩ
- Mains voltage: 230 V
- Housing dimensions: 194 x 140 x 130 mm

13505-93

Volumetric measurement of breathing in small animals

P4090100



Respirometer

Principle

The measurement of breathing processes, i.e. determination of the consumption of oxygen or release of carbon dioxide is carried volumetrically. Therefore, an animal is enclosed in a temperature-controlled spirometer. The exhaled carbon dioxide is absorbed by concentrated potassium hydroxide solution.

Tasks

1. Measure the oxygen consumption of insects in relation to ambient temperature and body weight.

What you can learn about

- Oxygen consumption
- Volumetric measurement
- Respirometer
- Carbon dioxide consumption
- Compensation vessel
- Q_{10} value

Main articles

Immersion thermostat Alpha A, 230 V	08493-93	1
Respirometer, complete assembly	65998-00	1
Bath for thermostat, Makrolon	08487-02	1
Support base variable	02001-00	1
Pipettor	36592-00	1
Glass beads, d 6 mm, 850 pcs.	36756-25	1

Respirometer, complete assembly



Function and Applications

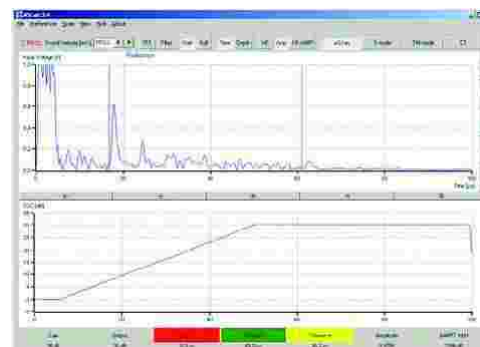
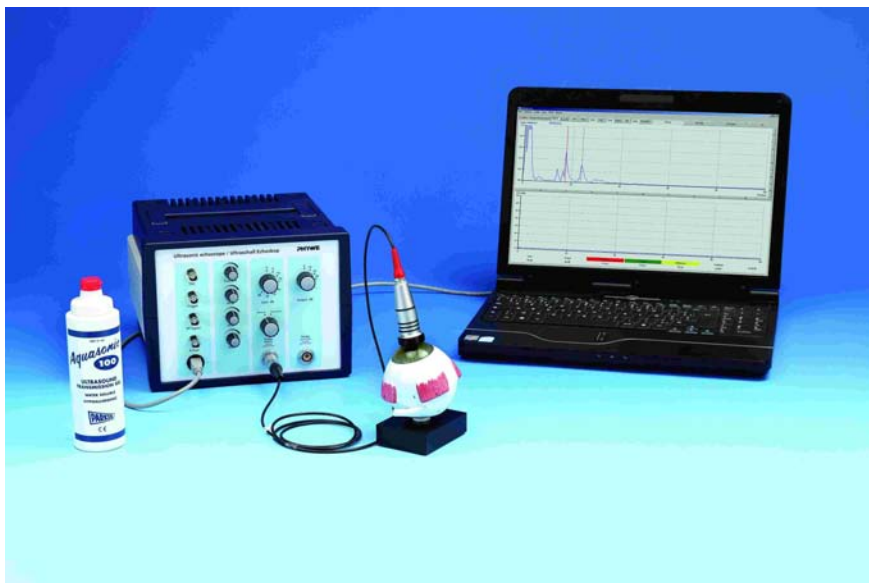
Respirometer, complete assembly of 2 containers and a U-shaped manometer in between, troughs for potassium hydroxide, volumetric measurement of breathing processes, compensation of air pressure fluctuations.

Equipment and technical data

- Measuring bottle for object
- Vascular compensation to compensate for atmospheric pressure fluctuations
- Manometer

65998-00

P5950400 Ultrasonic investigation with eye dummy



Measured Reflexes with the ultra echo software.

Principle

This experiment shows a typical application of A-scan ultrasound biometry in medical diagnostics for ophthalmology. On the eye dummy the different parts of an eye can be identified and the time of flight is measured in each part so that the different dimensions in the eye structure can be determined.

Tasks

1. Measure the different parts of the eye, determine the time of flight and depth of the structures (lens, iris, retina).
2. Compare the dimensions measured on each separate part with those obtained using average velocity for the whole eye.

What you can learn about

- Cornea and retina distance
- Lens thickness
- Biometry
- Eye sonography
- Mean ultrasound velocity
- Time of flight
- A-mode

Main articles

Basic Set Ultrasonic echoscope	13921-99	1
Extension set: medical ultrasonic diagnostics	13921-04	1

Basic Set Ultrasonic echoscope



Function and Applications

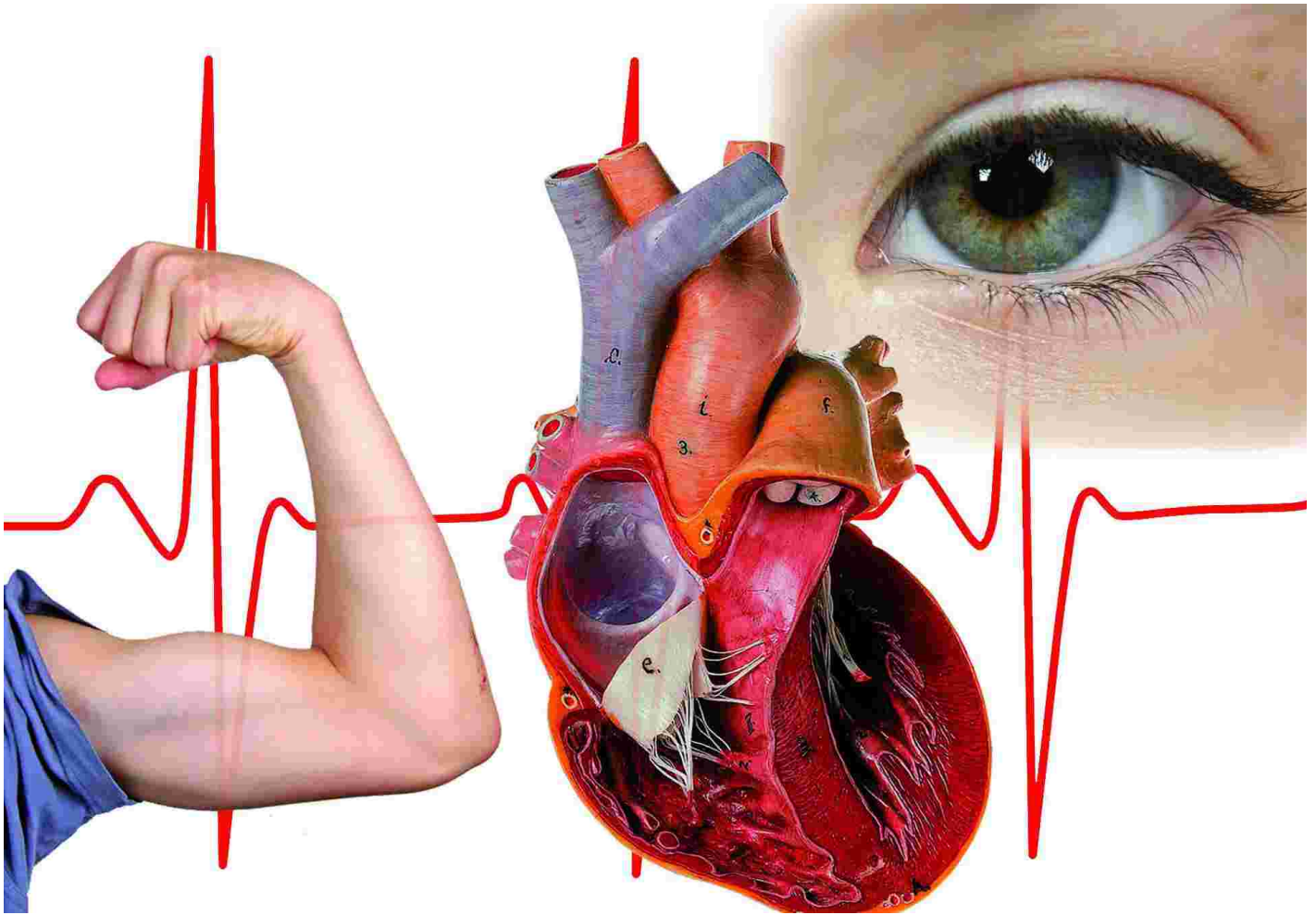
With the ultrasonic echoscope the basics of ultrasound and its wave characteristics can be demonstrated. Terms like amplitude, frequency, sound velocity or Time Gain Control TGC will be explained.

The cylinder set can be used to vividly demonstrate reflection as well as sound velocity and frequency depending on attenuation in solid state materials.

The knowledge e.g. regarding sound velocity will be used to measure the test block.

The principles of image formation from A-scan to B-scan can be explained. With the different probes the frequency depending resolution can be evaluated.

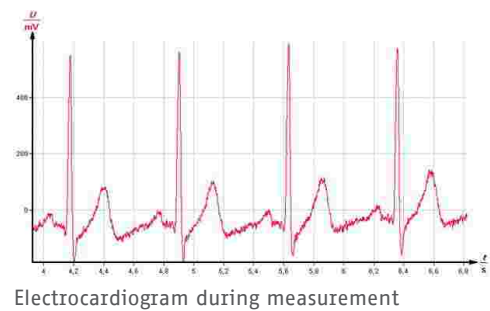
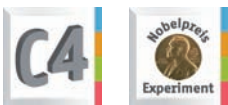
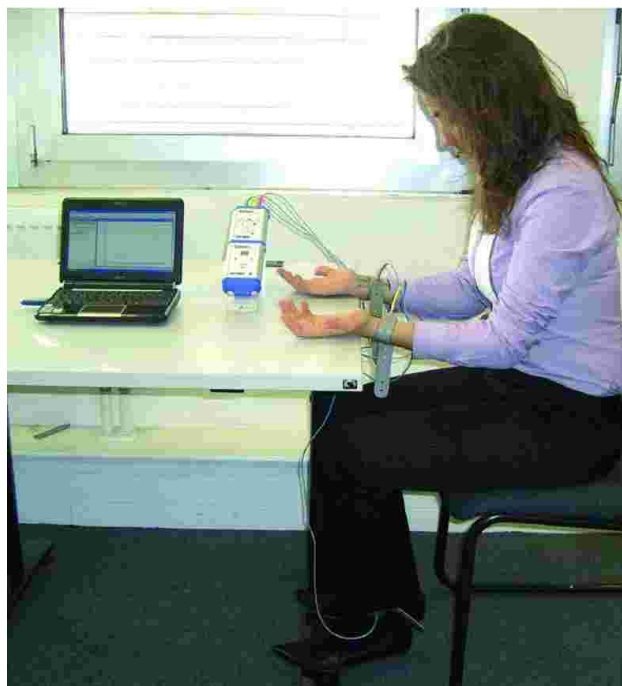
13921-99



Human Physiology

7.1	Heart and Circulatory System	72
7.2	Musculature	79
7.3	Hearing Sense	81
7.4	Visual Sense	83
7.5	Other Senses	86
7.6	Respiration	88
7.7	Literature and Sets	90

P4020160 Human electrocardiography (ECG) (with Cobra4)



Principle

A typical human electrocardiogram is recorded. The resulting diagram shows all the expected elements that can be expected in an electrocardiogram: P wave, PR segment, Q wave, R wave, QRS complex, S wave, ST segment, and T wave of a normal sinus rhythm for the human heart.

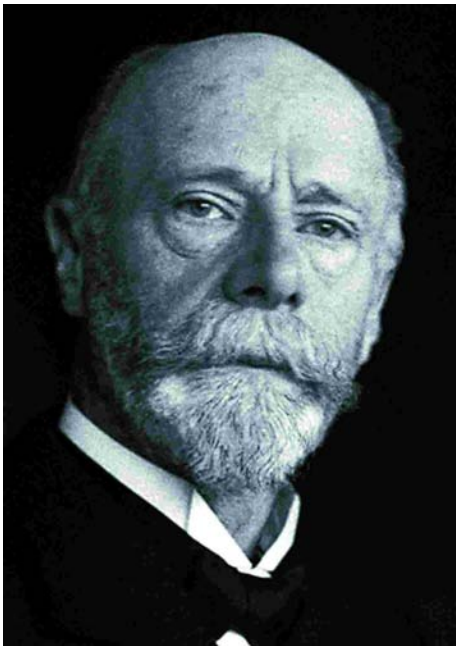
Tasks

1. Record an electrocardiogram (ECG) between the left leg and the right and left arm (lead II according to Einthoven).
2. Relate the ECG segments to the course of heart contraction (P wave, P-Q segment, QRS complex, T wave).

What you can learn about

- Electrocardiogram according to Einthoven
- Heart rate
- Quiet and strained heart
- ECG segments
- Atria
- Ventricles
- AV nodes

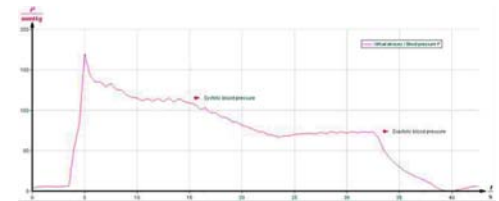
Main articles			
Software Cobra4 - multi-user licence	14550-61	1	
Cobra4 Sensor-Unit Electrophysiology: ECG, EMG, EOG	12673-00	1	
Cobra4 USB-Link	12610-00	1	
ECG electrodes, 3/pkg	65981-01	1	
Shielded leads for electrophysiology, color-coded, 3/pkg	12673-01	1	



Willem Einthoven
1924, Nobel Prize in Medicine

Blood pressure measurement (with Cobra4)

P4020360



Typical result: The graph shows the three stages of the measurement: (1) pumping up to 20 mmHg above the normal blood pressure value, (2) the systolic blood pressure and (3) the diastolic blood pressure. Both blood pressures are visible in the graph because the valve was briefly closed each time, creating two plateaus.

Principle

Didactical blood pressure measurement system for wireless data transfer of measurement data from test person to computer, thereby permitting flexible and mobile experimental setup.

Tasks

To prepare a plot of blood pressure measurement and to read the values of systolic and diastolic blood pressure.

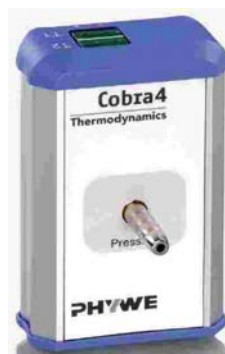
What you can learn about

- Systolic blood pressure
- Diastolic blood pressure
- Measuring cuff
- Blood pulse waves

Main articles

Software Cobra4 - multi-user licence	14550-61	1
Cobra4 Sensor-Unit Thermodynamics, pressure abs. 2 bar and 2 temperature NiCr-Ni	12638-00	1
Cobra4 USB-Link	12610-00	1
Blood pressure measuring unit	64234-00	1

Cobra4 Sensor-Unit Thermodynamics, pressure abs. 2 bar and 2 temperature NiCr-Ni



Function and Applications

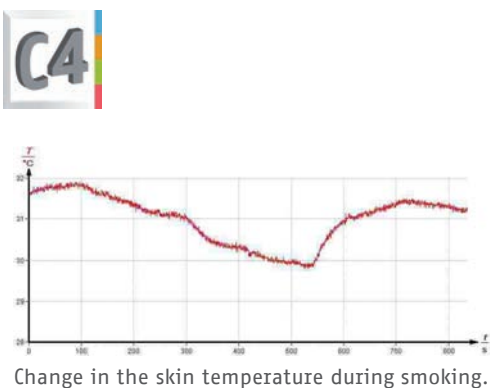
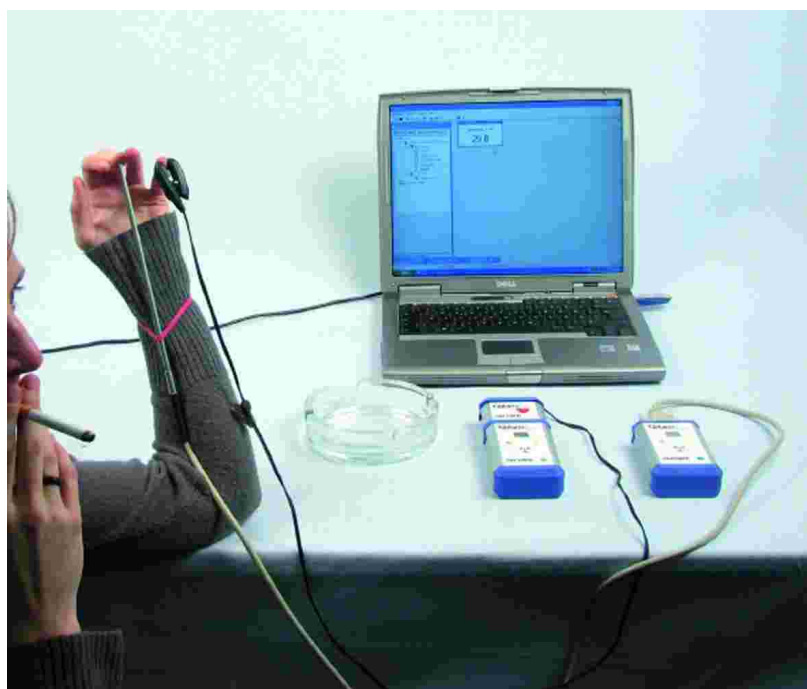
The Cobra4 Sensor-Unit Thermodynamics is a measuring recorder for pressure and temperature measurements, which is controlled by micro-controller.

Benefits

- It can be fitted with two NiCr-Ni thermoelements (type K), in order to measure up to two temperatures and one absolute pressure value simultaneously
- The unit can be connected to the Cobra4 Wireless-Link, the Cobra4 Mobile-Link or the Cobra4 USB-Link using a secure and reliable plug-in/ lockable connection.

12638-00

P4020460 Changes in the blood flow during smoking (with Cobra4)



Principle

Cigarette consumption influences the diameter and therefore the circulation of the peripheral blood vessels. This experiment studies the change of the finger temperature during smoking.

Tasks

How the temperature curve differs should be discussed with reference to the tested persons' regular smoking habits.

What you can learn about

- Skin temperature
- Heavy and moderate smokers
- Occasional smokers
- Non-smokers

Main articles

Software Cobra4 - multi-user licence	14550-61	1
Cobra4 USB-Link	12610-00	1
Cobra4 Sensor-Unit Temperature, semiconductor -20...110 °C	12640-00	1

Cobra4 Sensor-Unit Temperature, semiconductor -20...110 °C



Funktion and Applications

Cobra4 -20...110°C Sensor-Unit Temperature-semiconductor

Benefits

- can be connected directly to the Cobra4 Wireless-Link, the Cobra4 Mobile-Link or the Cobra4 USB-Link.

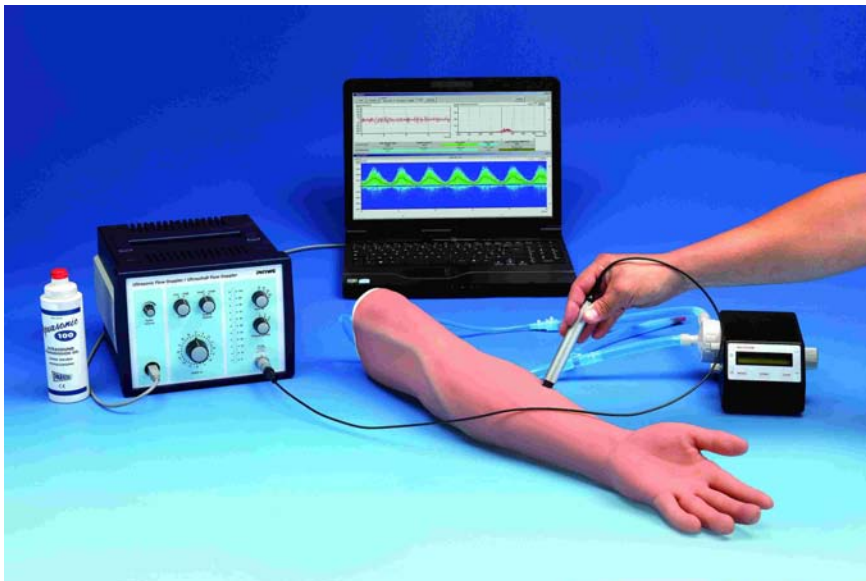
Equipment and technical data

- Sensor jacket: stainless steel
- Measuring range: -20...+110°C
- Absolute accuracy: ± 0.5°C
- Resolution: 0.05°C; Time constant: 7 s
- Data flow rate: 200 Hz, Connecting port: sub-D-15-pole
- Sensor length / diameter: 200 mm, 6 mm
- Cable length: 120 cm; Weight: 125 g

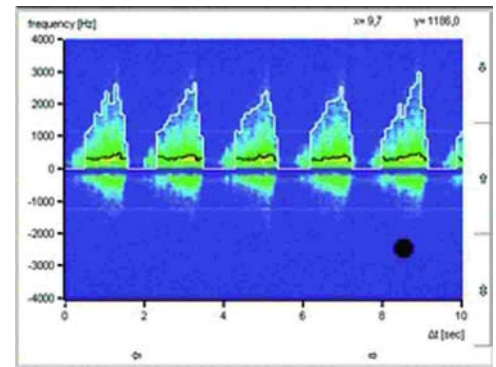
12640-00

Doppler sonography

P5950100



NEW



Typical spectral window pump mode 4 measured with PHYWE measure Ultra Flow software.

Principle

This set-up shows how blood flow studies are performed using Doppler ultrasound (Doppler sonograph). On a realistic arm dummy, the differences between continuous (venous) and pulsating (arterial) flow are shown as well as the difference in flow through a normal blood vessel and a stenosis.

Tasks

1. Analyse blood flow and search positive and negative flow components. Explain the differences
2. Locate the built-in stenosis and compare the spectral distribution upstream and downstream of the stenosis
3. Examine and compare the three pulse modes of the pump.

What you can learn about

- Venous Flow
- Arterial flow
- Stenosis
- Blood flow velocity tracings
- Frequency shift
- Doppler effect
- Doppler angle
- Doppler sonography
- Colour Doppler
- Continuity equation

Main articles

Basic set: Ultrasonic Doppler technique	13923-99	1
Extension Set: medical Doppler Sonography	13923-02	1

Basic set: Ultrasonic Doppler technique



Function and Applications

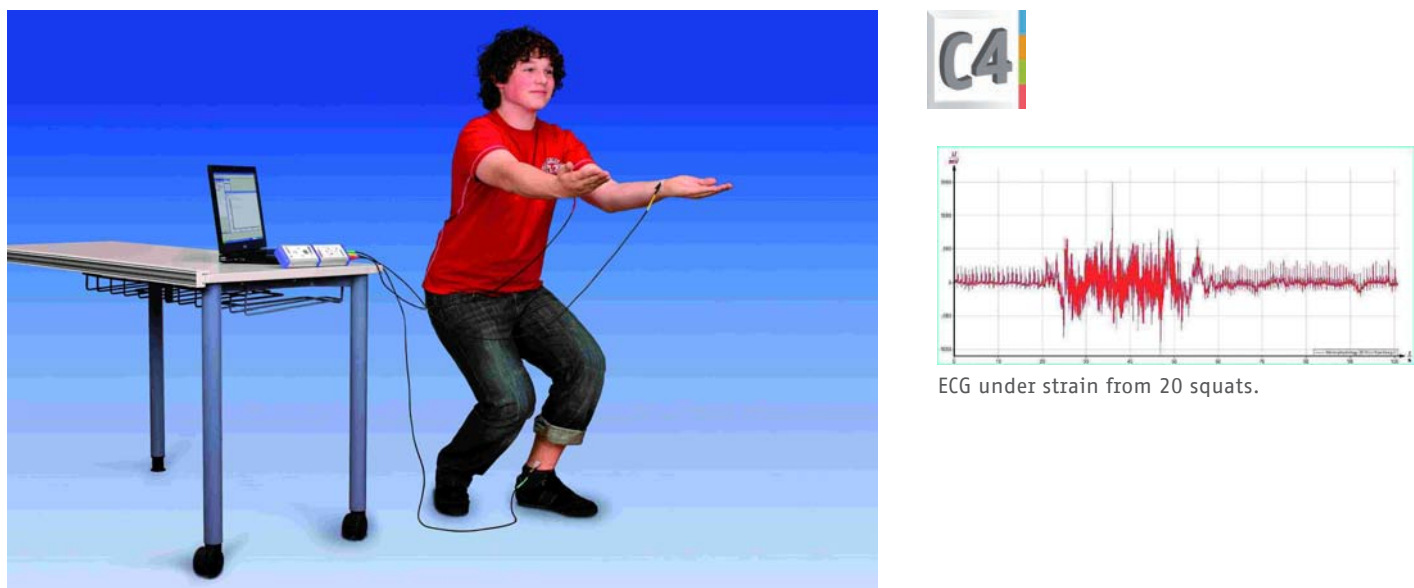
Kit containing instrument and accessories for general ultrasonic sonography experiments. The software displays the measured data from the ultrasonic doppler apparatus, basic instrument of this kit, in realtime on the computer screen. Modular and extendable with accessory kits for experimentations in the fields of hydraulics and medical diagnostics.

Benefits

- This kit forms a very didactic experimentation system beginning from the basics of sonography and can with accessory kits be extended for the use in specific applications as hydraulics and medical diagnostics (only for training purposes!)
- an experimentation manual is included

13923-99

P1522160 We investigate our physical fitness - the heart under stress (with Cobra4)



Principle

An electrocardiogram (ECG) can record the sum of the electrical activities of all of the heart muscle fibres. Under stress, cardiac activity increases in order to maintain the stability of the cardiovascular system. The heart contraction cannot be controlled at will. This experiment enables you to study how physical stress affects the respective activity of your heart.

Tasks

1. Record an ECG while switching from rest to strain (20 squats)
2. Record an ECG while switching from strain to rest and calculate the time that elapses until the resting heart rate is reached again

What you can learn about

- Electrocardiogram (ECG)
- Cardiac activity
- Heart muscle

Main articles			
Software Cobra4 - multi-user licence	14550-61	1	
Cobra4 Sensor-Unit Electrophysiology: ECG, EMG, EOG	12673-00	1	
Cobra4 Wireless-Link	12601-00	1	
Cobra4 Wireless Manager	12600-00	1	
Shielded leads for electrophysiology, color-coded, 3/pkg	12673-01	1	
Electrodes for ECG Sensor, 100 pcs.	12559-01	1	

Cobra4 Sensor-Unit Electrophysiology: ECG, EMG, EOG



Function and Applications

To perform electrophysiological, noninvasive, measurements of heart, eye and muscle activities.

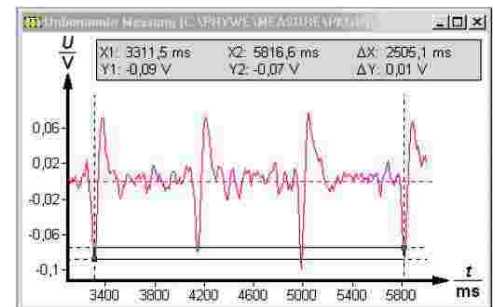
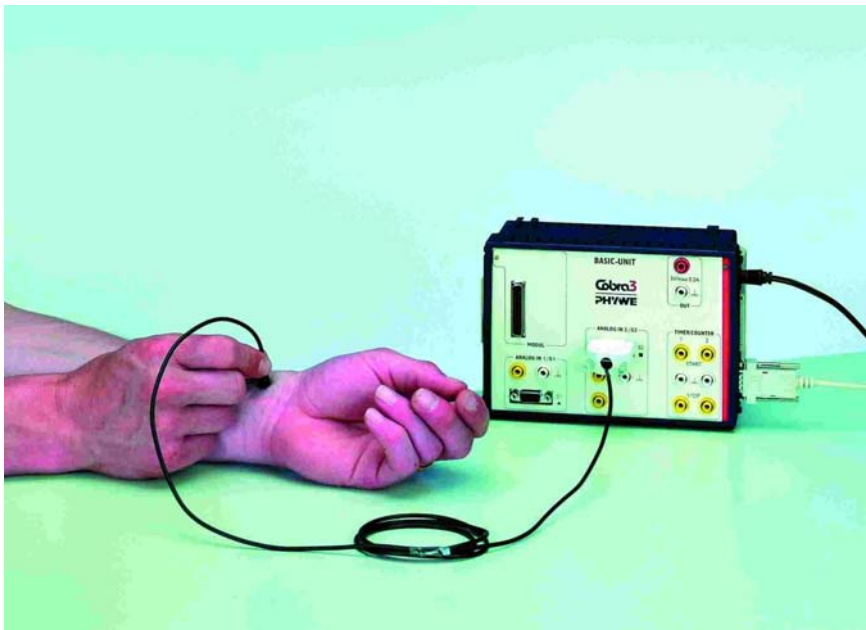
Benefits

- The measurement electrodes are connected to 3,5-mm jacks using three separate and shielded measurement cords.
- The sensor can be connected to a PC wireless link or to a USB-port.
- Requires measurement cords and ECG and/or EMG/EOG electrodes.

12673-00

Phonocardiography: Cardiac and vascular sonic measurement (PCG) (with Cobra3)

P4020211



Typical vascular phonometric measurement.

Principle

With Phonocardiography the sounds of the heart are graphically represented. Cardiac and vascular measurements are recorded at different locations of the circulatory systems.

Tasks

1. Cardiac and vascular sonic measurement at different locations of the circulatory system
2. Measurement of the pulse rate at different levels of athletic loading.

What you can learn about

- Pulse; Throat and chest sonic measurement
- Quiet and strained heart; Contracting tune
- Systole; Flapping sound; Diastole

Main articles

Cobra3 BASIC-UNIT, USB	12150-50	1
Acoustic probe for COBRA3	03544-00	1
Power supply 12V / 2A	12151-99	1
Software Cobra3 Universal recorder	14504-61	1

Cobra4 Experiment - available 2013

Phonocardiography: Cardiac and vascular sonic measurement (PCG) (with Cobra4)

P4020260

Power supply 12V / 2A



Function and Applications

Small switching power supply with safety class 2.

Benefits

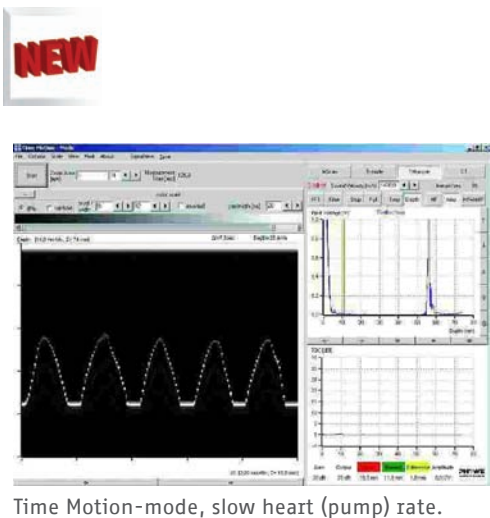
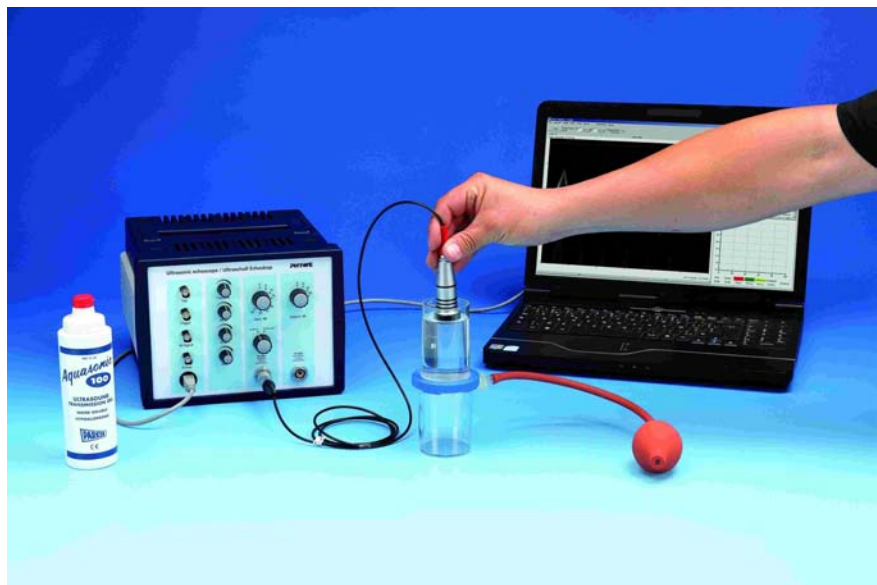
- Stabilised output voltage and short circuit resistant.
- Including power supply cable.
- Recommended for use with Cobra3.

Equipment and technical data

- Supply voltage: 100...230 V AC
- Supply frequency: 50...60 Hz

12151-99

P5950200 Ultrasonic Time Motion Mode



Principle

Using a simple heart model, the wall motion is recorded with the ultrasonic time motion method (M-mode or also TM-mode). The heart rate and the cardiac output (CO) are determined from the recorded TM-mode curve.

- Tasks**
- Simulate with heart model, the cardiac wall motion and record a time motion-image
 - On basis of the time-motion image, determine the cardiac output and heart rate parameters.

- What you can learn about**
- Pulse duration (DT)
 - Heart rate
 - End systolic diameter ESD
 - End systolic volume ESV
 - Cardiac output (CO)
 - Heart wall motion
 - Echocardiography
 - Time-Motion-Mode
 - Representation of motion sequences
 - Ultrasonic echography

Main articles			
Basic Set Ultrasonic echoscope	13921-99	1	
Extension set: medical ultrasonic diagnostics	13921-04	1	

Extension set: Medical ultrasonic diagnostics



Function and Applications

Kit containing medical models for experiments in the field of medical diagnostics (echo-cardiography, breast tumour diagnostics and ophthalmology (thickness measurements in the eye).

Benefits

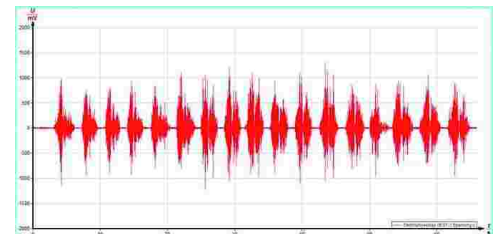
With this dummies real applications of ultrasonic diagnostics can be simulated in a very didactical manner.

- Equipment and technical data**
- 1 x simplified heart dummy for echocardiography
 - 1 x breast dummy
 - 1 x eye dummy

13921-04

Electromyography (EMG) on the upper arm (with Cobra4)

P4030160



Compound action potentials of the biceps under load by 5-kg dumbbells, as measured on the skin surface. At the end of this measurement, the biceps was not exhausted.

Principle

With the exception of the heart muscle, the contractions of striated muscles can be controlled at will. This characteristic enables the observation of the activities of individual muscle groups. An electromyogram (EMG) can be used to measure (record) the electrical activity (i.e. the sum of the action potentials) of a muscle or even of several muscles on the skin surface when they contract. For an electromyogram, the electrical activity of a muscle is recorded in the relaxed state as well as during contractions of varying strength.

Tasks

1. To prepare an electromyogram (EMG) from a contracting or relaxing upper arm muscle (biceps) using surface electrodes.
2. Measurement of the frequency and the amplitude of the EMG at maximum concentration.

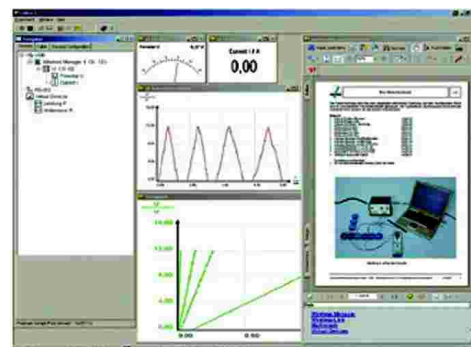
What you can learn about

- Electromyogram
- Muscle contractions
- Biceps
- Muscle potentials
- Compound action potentials

Main articles

Software Cobra4 - multi-user licence	14550-61	1
Cobra4 Sensor-Unit Electrophysiology: ECG, EMG, EOG	12673-00	1
Cobra4 USB-Link	12610-00	1
Shielded leads for electrophysiology, color-coded, 3/pkg	12673-01	1
Electrodes for ECG Sensor, 100 pcs.	12559-01	1

Software Cobra4 - multi-user licence



Function and Applications

The "measure Cobra4" measuring software leaves nothing to be desired.

As soon as a Cobra4 sensor is connected to a PC, irrespective of whether by Cobra4 Wireless or Cobra4 USB, the "measureCobra4" software opens completely automatically and shows the connected sensors, the required measuring windows and the current measuring data.

Measurement recording is then started with a single CLICK.

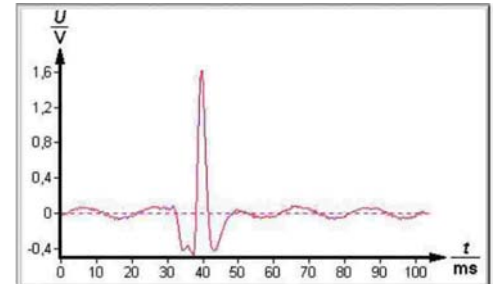
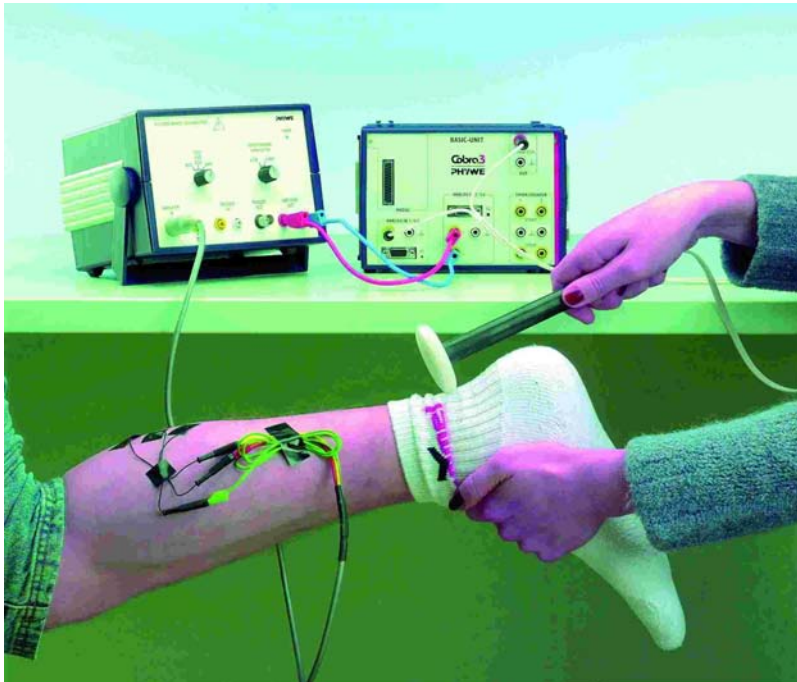
This all takes under 40 seconds!

Benefits

Embedded experiments with online documentation and measurement examples and automatic configuration.

14550-61

P4030211 Muscle stretch reflex and determination of the conducting velocity (with Cobra3)



The reflex latency is approximately 40 ms. With a nerve tract length (Achilles tendon - spinal cord - muscle) of 2 m, the conduction velocity is 50 m/s

Principle

Tapping the Achilles' tendon stretches the calf muscle and causes a reflex contraction in the muscle. This happens because the spindles sense the stretch and send an action potential to the motor neurons which then cause the muscle to contract. The amplitude of the muscle action potential is higher with tensed arm musculature than with relaxed arm musculature (approx. 3 mV compared to approx. 2 mV). The cause of this so-called Jendrassik effect is that, as a result of the tensing of the arm musculature, the other motoneurons of the spinal cord are innervated (facilitation).

Tasks

1. Trigger a stretch reflex in the lower leg musculature by tapping the Achilles tendon (Achilles tendon reflex)
2. Record the compound action potential and determine the reflex latency and the conduction velocity.

What you can learn about

- Electromyogram; Muscle stretch reflex; Achilles tendon
- Reflex latency; Conduction velocity; Jendrassik effect; Facilitation

Main articles

Cobra3 BASIC-UNIT, USB	12150-50	1
Biological amplifier	65961-93	1
Reflex hammer, triggering	65981-10	1
Electrode commoning cable	65981-03	1
EMG electrodes, 3 off	65981-02	1
Software Cobra3 Universal recorder	14504-61	1

Cobra4 Experiment - available 2013

Muscle stretch reflex and determination of the conducting velocity (with Cobra4)

P4030260

Biological amplifier



Function and Applications

With the aid of this biological amplifier a wide range of electrophysiological experiments can be carried out on human beings, insects and earthworms.

The frequency range for the measurement can be pre selected to match the different biological current sources as in ECG, EMG, EEG, EOG, ENG.

65961-93

Human merging frequency and upper hearing threshold

P4040101



goldfish	up to 4 kHz
frog	30 Hz to 15 kHz
chaffinch	200 Hz to 29 kHz
cat	up to 50 kHz
bat	up to 90 kHz
whale	up to 150 kHz

Animals also have a typical hearing range, and even vertebrates may have ranges differing very considerably from the human range.

Principle

The hearing range of the human depends greatly on age. While tones above the upper acoustic threshold are not perceived at all, individual sounds under the lower hearing threshold are perceived as a continuous deep tone (merging).

Tasks

1. Determine the merging frequency and upper acoustic threshold of test subjects of various ages.
2. Stimulate the ear with tones at the lower and upper acoustic threshold using a sine wave generator and headphones.

What you can learn about

- Acoustic hearing thresholds
- Merging frequency
- Hearing range
- Sine wave generator

Main articles

Digital Function Generator, USB, incl. Cobra4 Software	13654-99	1
Headphone, stereo	65974-00	1

Related Experiment

Hearing threshold and frequency differentiating threshold in humans (with Cobra3)

P4040215

Digital Function Generator, USB, incl. Cobra4 Software



Function and Applications

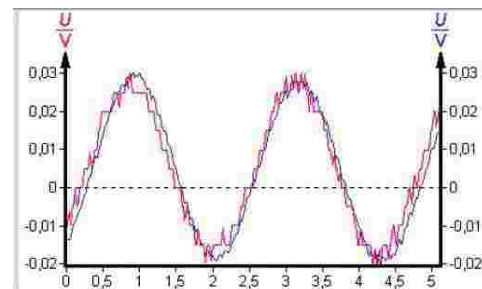
Digital signal generator for use as a programmable voltage source in practical or demonstration experiments, particularly in the disciplines of acoustics, electrical engineering and electronics

Benefits

- Can be used as universal stand-alone device or controlled via a USB interface
- Universally applicable thanks to broad, continually adjustable frequency range
- Usable as programmable voltage source via amplifier output
- Intuitive, menu-driven operation using control knob and function buttons, with help capability
- Illuminated monochrome graphic display for maximum visibility and readability
- Simple setting of voltage and frequency ramps in stand-alone mode
- Features $V = f(f)$ output for easy reading of frequency in the form of a voltage - ideal for measuring circuit response to frequency ramps using an oscilloscope
- Low distortion and signal-to-noise ratio for brilliantly clear signals - ideal for acoustics/audio experiments

13654-99

P4040311 Acoustic orientation in space (with Cobra3)



Overlapping of the two sound curves for the 0° position.

Principle and tasks

To localize a source of sound using an artificial head. To measure the time difference and the difference in intensity of the sound waves incident on each ear of the artificial head.

What you can learn about

- Spatial orientation; Artificial head
- Acoustic probes; Threshold angle
- Travelling time difference

Main articles

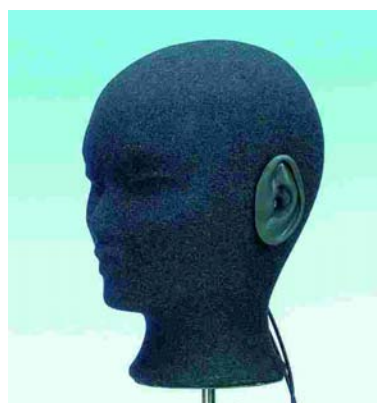
Cobra3 BASIC-UNIT, USB	12150-50	1
Artificial head w/o microphones	65975-01	1
Tripod base PHYWE	02002-55	1
Protractor scale with pointer	08218-00	1
Tuning fork, 440 Hz, on reson. box	03427-00	1
Acoustic probe for COBRA3	03544-00	2
Power supply 12V / 2A	12151-99	1
Software Cobra3 Universal recorder	14504-61	1

Cobra4 Experiment - available 2013

Acoustic orientation in space (with Cobra4)

P4040360

Artificial head w/o microphones



Function and Applications

For the demonstration of binaural (spatial) hearing and for measurement of the threshold angle.

Benefits

- Highly sensitive microphones can be positioned in the ears, which are faithful copies of the natural ones
- The microphones can be connected to the two amplifier inputs of a computer interface or storage oscilloscope.

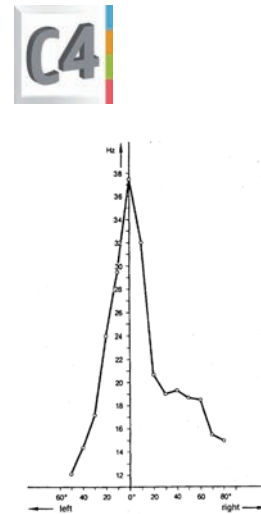
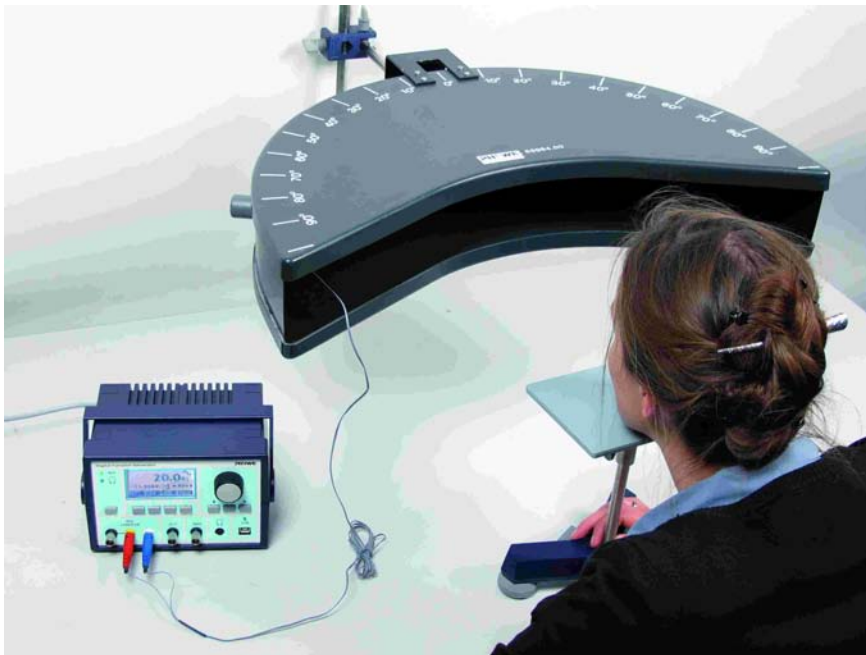
Equipment and technical data

- Head made of styropor, anthrazit
- Ears made of gum

65975-01

Time resolving capability of the human eye

P4070300



Flicker fusion frequency curve.

Principle

As excitation of the light-perceptive cells of the retina always takes a little longer than the light stimulus, only a limited number of stimuli per unit of time can be processed (time-related resolving power of the eye). If a light source is switched on and off periodically in increasingly rapid sequence the eye at first perceives the individual flashes, then the appearance of flicker occurs and finally the impression of a continuous light (fusion of the flicker).

Tasks

1. Determine the flashing frequency of an LED at which the impression of a continuous light just occurs
2. Change the direction of incidence of the light using a perimeter
3. Determine the flicker fusion threshold of the left and right eye in relation to the direction of incidence of light stimulus and the state of adaptation of the eyes.

What you can learn about

- Perimeter
- Time-related resolving power
- Flicker fusion frequency
- Light/dark adapted eye

Main articles

Digital Function Generator, USB, incl. Cobra4 Software	13654-99	1
Perimeter, diameter 60 cm	65984-00	1
Stimulant light source	65985-00	1

Related Experiments

Determination of the human visual field

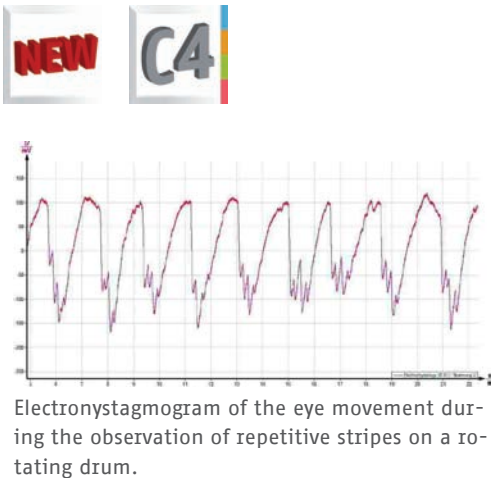
P4070200

Additive colour mixing and colour masking

P4070600



P4070760 Electronystagmography (with Cobra4)



Principle

Electronystagmography (ENG) is an electrophysiological diagnostic procedure for measuring the movement of the eyes. Several electrodes measure the potential differences that are caused by the eye movements. When looking at a moving, regular, repetitive pattern (e.g. the wagons of a passing train, stripes on a rotating drum), the eyes usually try to follow one point for as long as possible. When the object that the eyes are fixed on leaves the field of vision, the eyes then move rapidly in the opposite direction (regressive saccade) and seek a new fixation point.

Tasks

- 1. Record an electronystagmogram of your eye movements while looking at the stripes on a rotating drum.

What you can learn about

- Electronystagmography (ENG)
- Eye movements; Nystagmus

Main articles

Software Cobra4 - multi-user licence	14550-61	1
Cobra4 Sensor-Unit Electrophysiology: ECG, EMG, EOG	12673-00	1
Cobra4 Wireless-Link	12601-00	1
Strobe drum	65976-00	1
Power supply 0...12 V DC/ 6 V, 12 V AC, 230 V	13505-93	1
Motor, with gearing, 12 VDC	11610-00	1
Cobra4 Wireless Manager	12600-00	1
Shielded leads for electrophysiology, color-coded, 3/pkg	12673-01	1

Strobe drum



Function and Applications

To produce moving stimuli for the investigation of the resolving power of the eye, for testing human reaction capacity and as a type of centrifuge for investigating the effects of mass acceleration on plants and animals.

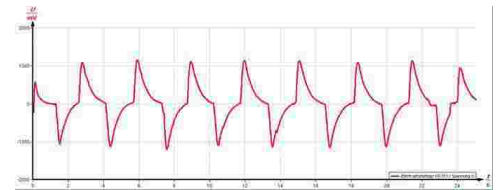
Equipment and technical data

- Diameter: 32 cm
- Circumference: 100 cm
- Height: 20 cm
- Pattern: 180 black stripes
- With drive belt

65976-00

Human electrooculography (EOG) (with Cobra4)

P4070560



Electrooculogram (alternating eye movements from the left to the right, and vice versa).

Principle

With this experiment, you can find evidence of the electrical activity that is generated during the movement of your eyes. Several electrodes attached to the skin of the face measure all the changes of the electrical voltage that are caused by the movement of the eyes. This method is referred to as electrooculography (EOG).

Tasks

1. Measure an electrooculogram (EOG) with a practised reader, a less practised (six year old) schoolchild and if possible, a test person who practises a rapid reading technique
2. Evaluate the rapid horizontal eye movements (sacchades) and the fixation periods.

What you can learn about

- Electrical field measurement
- Eye movements
- Dipole
- Sacchades
- Fixation period
- Practised reader versus schoolchild
- Rapid reading techniques

Main articles

Software Cobra4 - multi-user licence	14550-61	1
Cobra4 Sensor-Unit Electrophysiology: ECG, EMG, EOG	12673-00	1
Cobra4 USB-Link	12610-00	1
Shielded leads for electrophysiology, color-coded, 3/pkg	12673-01	1
Electrodes for ECG Sensor, 100 pcs.	12559-01	1
Crocodile clips for disposable electrodes, 3/pkg	12673-02	1

Cobra4 USB-Link



Function and Applications

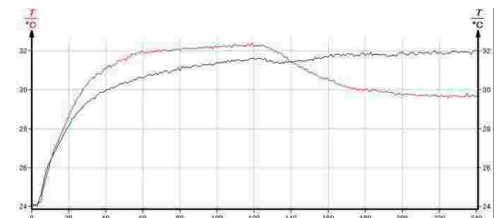
The Cobra4 USB-Link is a highly efficient interface module for the transmission of sensor measuring values to a PC via a USB connection.

Benefits

- All Cobra4Sensor-Units can be connected to the Cobra4 USB-Link using a stable plug-in / lockable connection. Up to 400,000 measuring values/sec
- Several Cobra4 USB links can be connected to one PC (via USB ports on the PC or by USB hub); Automatic detection of all Cobra4 Sensor-Units; Power supply from USB connection, no additional external power supply required.
- Especially for fast measurements (acoustic, electrical etc.); Demonstration experiments
- Student's experiments (if a PC is available for each work group).

12610-00

P4060360 Regulation of human body temperature (with Cobra4)



Regulation of the human body temperature through external influences.

Principle

How can our body temperature be regulated? This experiment shows why we sweat in summer and wear gloves in winter.

Tasks

1. To prepare curves demonstrating the regulation of body temperature.
2. To discuss different curves depending on the conditions at the hand of the test person.

What you can learn about

- Body temperature regulation
- Radiation
- Evaporation
- Skin temperature
- Heating/cooling effects

Main articles

Software Cobra4 - multi-user licence	14550-61	1
Cobra4 USB-Link	12610-00	1
Cobra4 Sensor-Unit Temperature, semiconductor -20...110 °C	12640-00	1
Hot/cold air blower, 1800 W	04030-93	1

Cobra4 Sensor-Unit Temperature, semiconductor -20...110 °C



Funktion and Applications

Cobra4 -20...110°C Sensor-Unit Temperature-semiconductor

Benefits

- It can be connected directly to the Cobra4 Wireless-Link, the Cobra4 Mobile-Link or the Cobra4 USB-Link.

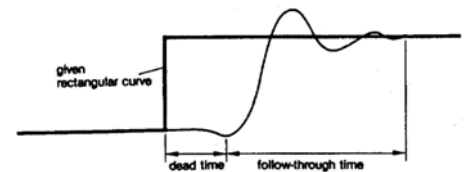
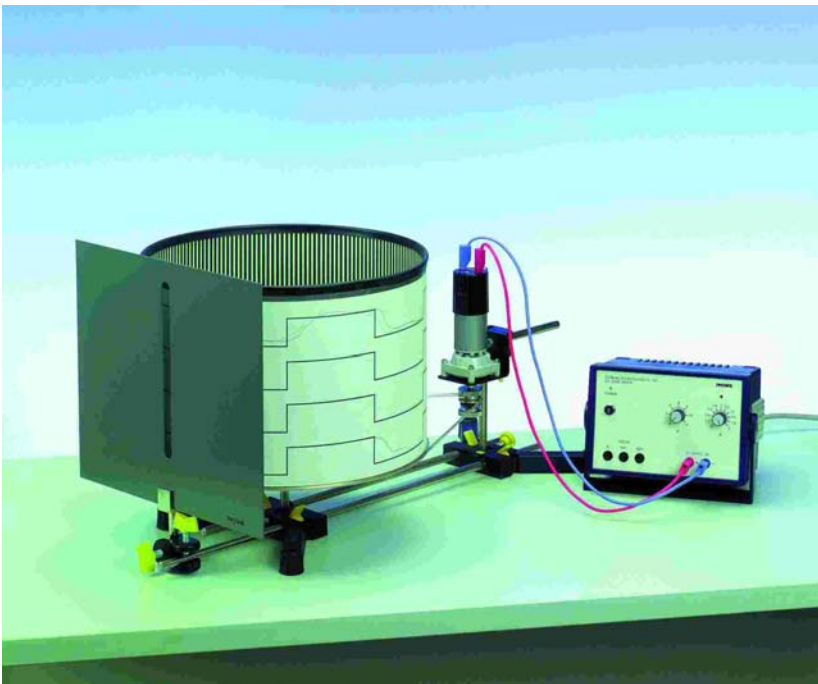
Equipment and technical data

- Sensor jacket: stainless steel
- Measuring range: -20...+110°C; Absolute accuracy: $\pm 0.5^\circ\text{C}$
- Resolution: 0.05°C ; Time constant: 7 s
- Data flow rate: 200 Hz; Connecting port: sub-D-15-pole
- Sensor length / diameter: 200 mm, 6 mm
- Cable length: 120 cm; Weight: 125 g

12640-00

Test of human reaction capacity

P4070400



Reaction curve

Principle

As in many technical processes, in the course of many biological functions the output values act back on the input values. With the many disturbing influences that affect biological systems, a feed-back reaction (control loop) of this type enables an equilibrium to be established. The components of a biological control loop (receptors, neurones, synapses, effectors) require a certain time for the transmission of a signal. This time between the onset of a disturbance (stimulus) and the reaction which it triggers is called the dead time. In this experiment the test subject follows a rectangular curve on a slowly rotating drum, using a felttip pen inserted into a slit. In a reaction test the dead time is determined.

Tasks

1. Measurement of dead time in a reaction test
2. Analysis of the transient response
3. Determination of threshold frequency for stimuli
4. Study of the effects of noise and alcohol on reaction capacity.

What you can learn about

- Reaction capacity; Strobe drum; Control loop
- Feedback reaction, Dead time; Follow-through time; Threshold frequency

Main articles

Strobe drum	65976-00	1
Power supply 0...12 V DC/ 6 V, 12 V AC, 230 V	13505-93	1
Motor with disk holder	11614-00	1

Power supply 0...12V DC/ 6V, 12 V AC, 230V



Function and Applications

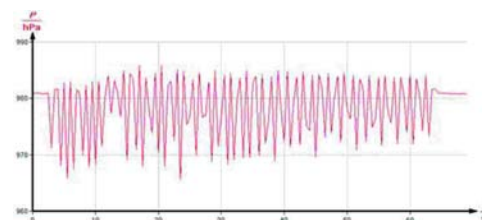
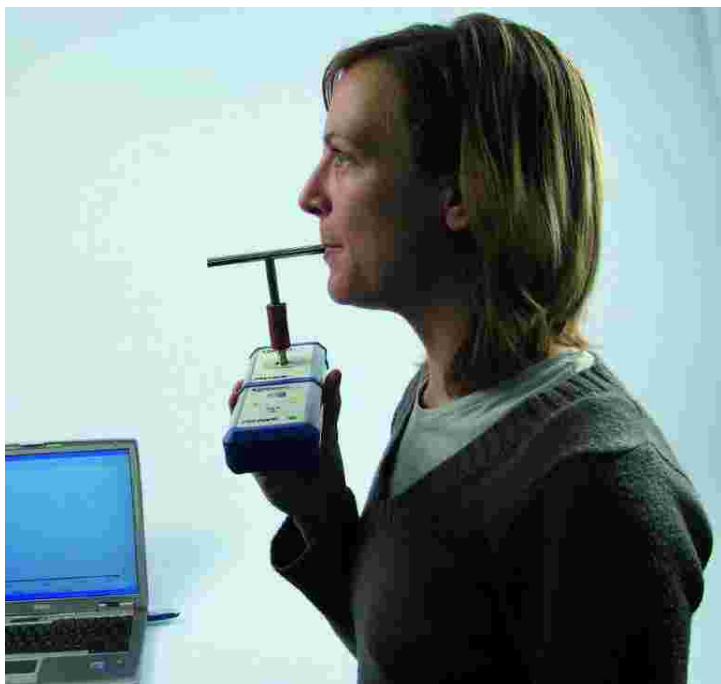
High quality power supply specially suitable for student experiments in electricity and electronics as well as for demonstration.

Equipment and technical data

- Stabilised
- Shortcircuit proof
- Output voltage: 1...12 V DC, 6 V / 12 V AC
- Rated current: DC 0...2 A / AC 5 A
- Ripple: max 1 mV
- Resistance: 1 mΩ
- Mains voltage: 230 V
- Housing dimensions: 194 x 140 x 130 mm

13505-93

P4090260 Measurement of the respiratory rate (with Cobra4)



Respiratory rate after strenuous exercise.

Principle

The respiratory rate increases with physical exertion. The amount of increase depends on different factors such as lung volume, age, sex and training condition. In this experiment the breathing frequency before and after physical exertion is measured and compared.

Tasks

1. The respiratory frequencies before and after bodily exertion are to be measured and compared.

What you can learn about

- Respiratory frequency
- Chest pressure measurement
- Breathing in resting position
- In slight and strong exertion
- Eupnea
- Diaphragmatic and thoracic respiration

Main articles

Software Cobra4 - multi-user licence	14550-61	1
Cobra4 Sensor-Unit Thermodynamics, pressure abs. 2 bar and 2 temperature NiCr-Ni	12638-00	1
Cobra4 USB-Link	12610-00	1
Connector, t-shaped, metal	05950-00	1

Related Experiments

How much air can our lungs contain?

P8001060

Direct determination of lung volume from a spirogram

P8001160

Does the lung volume depend on how tall you are?

P8001260

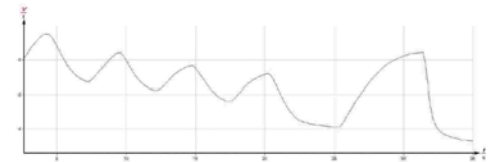
You need more information?
Just click www.phywe.com

WEB@ PHYWE



Diagnosis of lung illnesses (FEV) (with Cobra4)

P8001360



Display of recorded data for determining the FEV in one second.

Principle

The forced expiratory volume (FEV) in one second is used in the diagnosis of lung illnesses. For the measurement of this here, the student carrying out the test breathes normally a few times, presses out all the air he or she can, takes a deep breath and holds it for a moment before (at the beginning of measurement) force breathing out as much air as he or she can right from the start of measurement.

Further to this, the vital capacity (as inspiratory VC = IVC) is again to be determined here as it is required for the FEV1 and IVC quotient which is called the Tiffeneau value: $\text{Tiffeneau value} = \text{FEV1} / \text{IVC} [\%]$

With healthy young people, this quotient is 75%. In the case of a so-called obstructive respiratory illness, such as bronchial asthma, the value is far below 75%, as the forced expiratory volume per second is greatly reduced. As this FEV value, just as the vital capacity, depends on the age of the person, among others, older people only reach a value of about 70%.

In contrast to the obstructive illnesses, there are also so-called restrictive respiratory illnesses which cannot be determined using this method.

Tasks

1. Determine the inspiratory vital capacity (IVC) in litres
2. Determine the one-second forced expiratory volume in one second (FEV1) in litres

What you can learn about

- Lung illness; Forced expiratory volume (FEV); Vital capacity; Tiffeneau value
- Obstructive respiratory illness; Restrictive respiratory illnesses

Main articles

Software Cobra4 - multi-user licence	14550-61	1
Cobra4 Wireless-Link	12601-00	1
Cobra4 Sensor-Unit Spirometry, Pulmonary volume and wind speed	12675-00	1
Cobra4 Wireless Manager	12600-00	1

Cobra4 Sensor-Unit Spirometry, Pulmonary volume and wind speed

Function and Application

The Cobra4 Sensor Unit Spirometry is used for the measurement of the breath-dependent pulmonary volume. A measurement of wind speed is also possible.

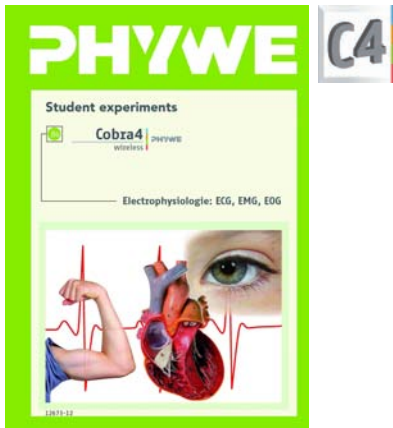
Benefits

Through the possibility of the recording of measurement one receives a diagram by means of which different function variables of the breath volume can be determined.

The velocity of the exhaled air is also displayed, therefore the Sensor-Unit Spirometry can be used to measure the wind speed.

12675-00

TESS advanced Biology manual Cobra4 Electrophysiology: ECG, EMG, EOG



Article no. 12673-12

Description

Manual with 7 student experiments in the fields of electrophysiology (ECG, EMG, EOG) for data acquisition with the wireless interface system Cobra4.

Topics

- We investigate our heartbeat (Electrocardiography)
- We determine our heart frequency
- We investigate our physical fitness (the heart under strain)
- We investigate our muscular power (Electromyography)
- We investigate our eye movements (Electrooculography)
- We measure our reading speed
- Electronystagmography

Benefits

- The students are enabled to carry out the experiments by themselves and to work on the topic of electrophysiology self-dependently.

Equipment and technical data

- Student sheets and corresponding teacher sheets
- In colour, 68 pages, incl. manual on software installation and handling.

This documentation contains the following experiments:

Electronystagmography

P0873560

We investigate our heartbeat - electrocardiography

P1332760

We investigate our muscular power - electromyography

P1350360

We measure our eye movements - electrooculography

P1350460

We determine our heart frequency

P1522060

We investigate our physical fitness - the heart under stress

P1522160

Complete experiment list see www.phywe.com

12673-12

TESS advanced Applied Sciences set Electrophysiology, EP with english manual



Function and applications

Complete instrument set and accessories to perform computer-assisted experiments in human and animal physiology:

- The heart/ ECG (3 exp.)
- Muscles/ EMG (1 exp.)
- The eye/ EOG (3 exp.)

Benefits

- Wireless transmitter and receiver units to connect to the electrophysiology sensor and to a PC, can also be used for others sensors to measure parameters common in physics, chemistry, biology and medical education

Equipment and technical data

- Electrophysiology sensor-unit for ECG, EMG and EOG with connectors for three measurement leads
- 3 separate and shielded leads, color-coded (red, yellow, green) with 3.5 mm phone jacks to connect to the sensor-unit and 2 mm jacks to connect to reusable and disposable electrodes
- 3 reusable stainless steel ECG electrodes, contact area 30 x 80 mm with connector for leads
- 3 reusable EMG electrodes with cable and 2 mm connectors
- Disposable electrodes (100 pcs.)
- 3 crocodile clips for disposable electrodes
- Electrode gel to improve contact between electrodes and skin
- Software for wireless and wired data acquisition, for data analysis, automatic sensor recognition, automatic setup of measurement parameters and integrated experiment instructions
- 68-page manual with experimental literature
- Storage box for instrument set and accessories.

12673-89

You need more information?
Just click www.phywe.com

WEB@ PHYWE



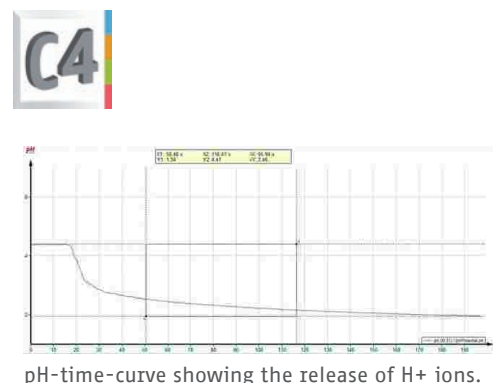


Biochemistry

8.1 Biochemistry

92

P4120260 The ionic permeability of the cell membrane (with Cobra4)



Principle

The cell membrane regulates the transport of nutrients and water into the cell, and of waste products and water out of the cell. This can take place passively, e.g. on the basis of osmotic processes (differences in concentration), as well as actively.

Tasks

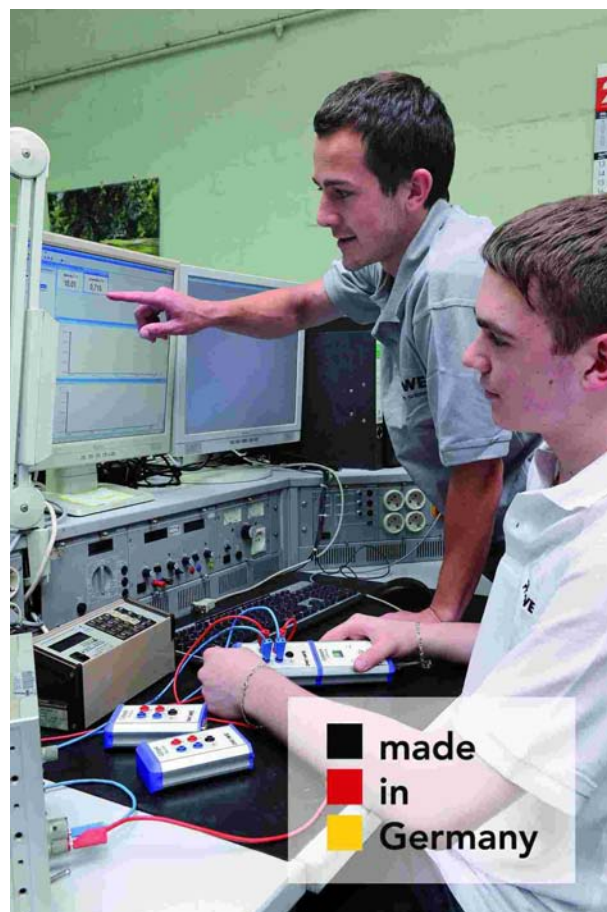
In this experiment, the selective permeability of an artificial cell membrane (dialysis tube) for H^+ and OH^- ions is to be examined.

What you can learn about

- Ionic permeability
- Artificial cell membrane
- Dialysis tube
- H^+ ions
- OH^- ions
- Osmotic processes

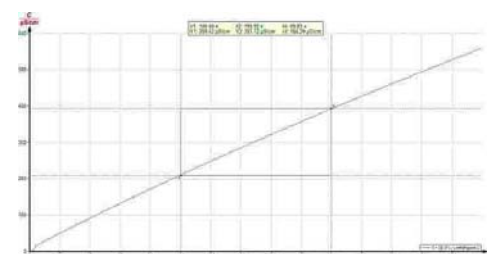
Main articles

Software Cobra4 - multi-user licence	14550-61	1
Cobra4 USB-Link	12610-00	1
Cobra4 Sensor-Unit pH, BNC connector	12631-00	1
Magnetic stirrer Mini / MST	47334-93	1
pH-electrode, plastic body, gel, BNC	46265-15	1
Retort stand, h 750 mm	37694-00	1



Determination of the Michaelis constant (with Cobra4)

P4120360



Conductivity-time-diagram of the urea hydrolysis by urease.

Principle

The enzymatic hydrolysis of urea in aqueous solution liberates carbon dioxide and ammonia. The ions of these compounds increase the conductivity of the solution. Conductivity measurements can so be made to determine the rate of hydrolysis of urea by the enzyme urease at various substrate concentrations.

Tasks

The Michaelis constant can then be calculated from these values.

What you can learn about

- Michaelis constant
- Enzymatic hydrolysis of urea
- Conductivity measurement
- Bodenstein principle
- Enzyme-substrate complex
- Lineweaver-Burk plot

Main articles

Software Cobra4 - multi-user licence	14550-61	1
Cobra4 Sensor-Unit Conductivity+, Conductivity/ Temperature (Pt1000)	12632-00	1
Cobra4 USB-Link	12610-00	1
Conductivity temperature probe Pt1000	13701-01	1
Urease soln.in 50% glycerol,10ml	31924-03	1
Magnetic stirrer Mini / MST	47334-93	1

Cobra4 Experiments

Substrate inhibition of enzymes (with Cobra4)

P4120460

Enzyme inhibition (poisoning of enzymes) (with Cobra4)

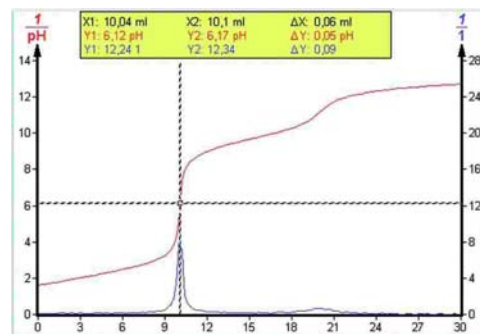
P4120560

Cobra4 Sensor-Unit Conductivity+, Conductivity/ Temperature (Pt1000)



12632-00

P4120140 Determination of the isoelectric point of an amino acid (glycine) (with Cobra3)



Titration curve for hydrochloric acid glycine solution against 1 mol/l NaOH.

Principle

Amino acid molecules carry both acid and amino groups. They can therefore form both acidic anions and basic cations. The pH at which these two types of ions are both present in the same concentration is called the isoelectric point.

Tasks

This isoelectric point is to be determined by recording the titration curve for the amino acid glycine.

What you can learn about

- Isoelectric point
- Acidic anions
- Basic cations
- Zwitterions
- Equivalence (inflection) points
- pK_s value
- Titration
- Motor piston burette

Main articles

Motor.piston burette,univer.50ml	36499-93	1
Cobra3 Chem-Unit, USB	12153-50	1
Software Cobra3 Chem-Unit	14520-61	1
Immers. probe NiCr-Ni, teflon, 200°C	13615-05	1
Magnetic stirrer Mini / MST	47334-93	1
pH-electrode, plastic body, gel, BNC	46265-15	1
Cable Chem-Unit/Motor piston burette	36501-01	1
Power supply 12V / 2A	12151-99	1

Motor.piston burette,univer.50ml



Function and Application

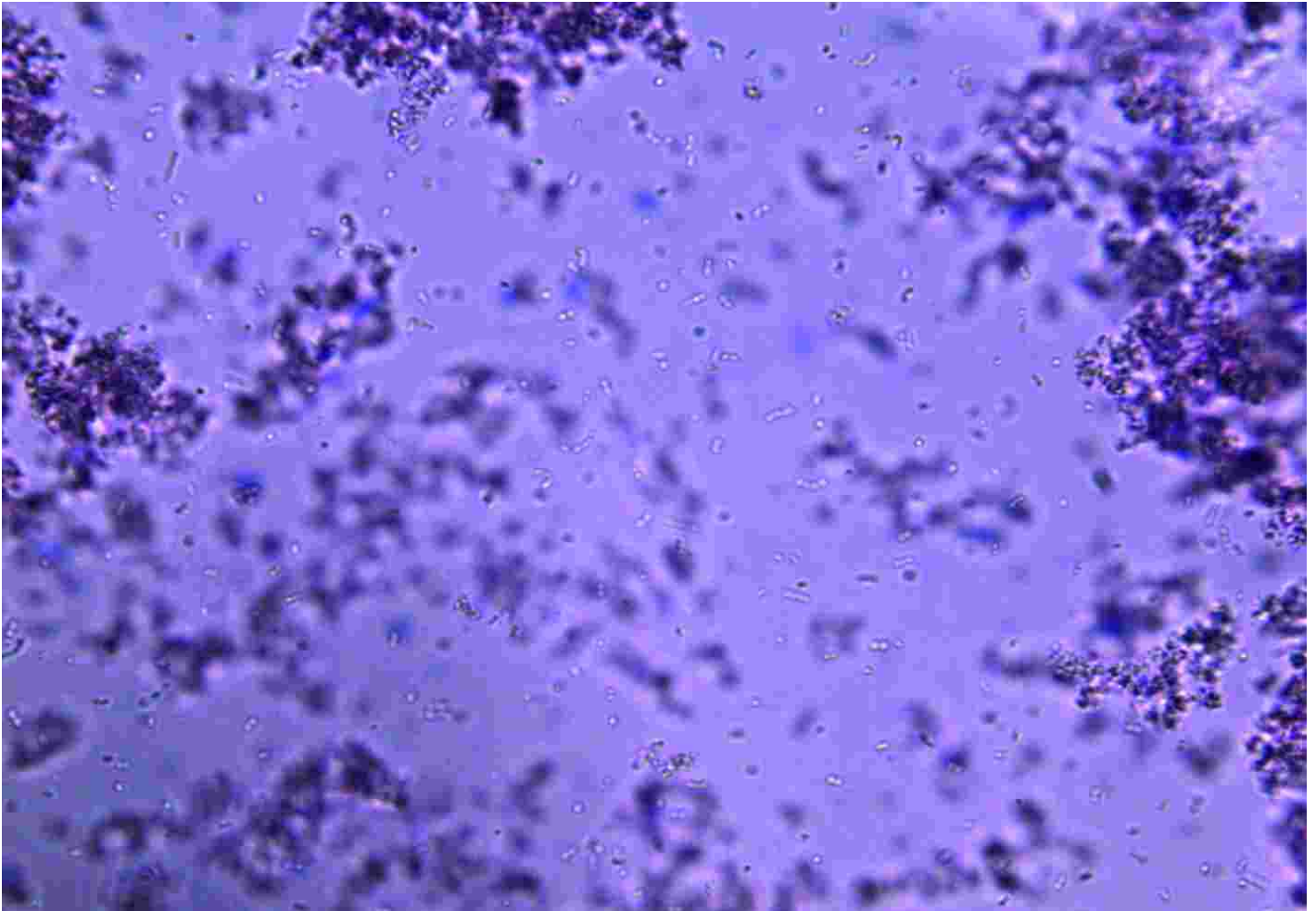
For uniform portioning and reproducible titrations. Microprocessor controlled, with remote control.

36499-93

Cobra4 Experiment - available 2013

Determination of the isoelectric point of an amino acid (glycine) (with Cobra4)

P4120160



Microbiology

9.1 Microbiology

96

P4140100 Fundamental microbiological working methods



Abb. 8
Desinfection of equipment.

Principle

In order to prevent nutrient media and cultures from being contaminated with microorganisms that adhere to the working equipment, the equipment, nutrient media, and nutrient solutions must be sterilised. Petri dishes filled with a solidified nutrient medium are called plates in the specialised language of microbiologists. The nutrient medium is poured into the dishes either from test tubes, with one test tube holding the required quantity of ready-made medium for one Petri dish, or from Erlenmeyer flasks if a large number of plates needs to be prepared at the same time.

Tasks

1. Sterilisation of equipment.
2. Preparation of standard nutrient agar for bacteria.
3. Preparation of standard nutrient agar for moulds and yeasts.
4. Preparation of a standard nutrient solution for bacteria.
5. Preparation of slant agar tubes.
6. Inoculation of microorganisms.

What you can learn about

- Disinfection
- Nutrient agar
- Sterility

Main articles

Autoclave with insert	04431-93	1
Drying oven UNB200, timer, 32 l	46959-93	1
Compact Balance OHAUS TA 302, 300 g/0.01 g	49241-93	1
Heating + cooking hotplate, 230V	04025-93	1

Related Experiment

Evidence of the effect of antibiotics, chemotherapeutics and disinfectants

P4140500

Autoclave with insert



Function and Applications

Portable autoclave

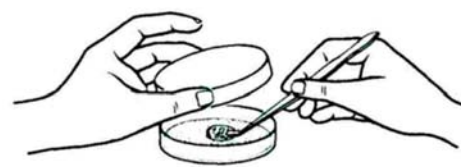
Equipment and technical data

- with precision manometer; thermometer
- integrated heating; application range up to 1.4 bar at 125°C or up to 2.7 bar at 140°C; volume: 12 liters; safety valve
- excess pressure safetyvalve; safety lock

04431-93

Evidence of the spread of bacteria

P4140200



Contamination of the agar plate.

Principle

Microorganisms are ubiquitous, i.e. they are present everywhere around us. This fact can be proved by touching the objects that are to be examined in view of the presence of microorganisms against the sterile nutrient medium in a Petri dish and by incubating the plates afterwards. The easy working methods that are to be applied for this purpose are described based on the following examples.

Tasks

Provide evidence concerning the presence of microorganisms

1. in the air.
2. on objects of daily use.
3. of microorganisms on the skin.
4. of microorganisms on insects.

What you can learn about

- Disinfection
- Nutrient agar
- Sterility

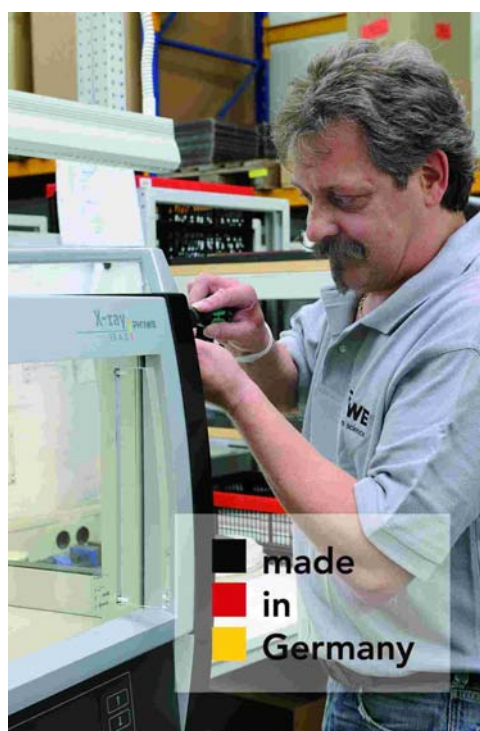
Main articles

Autoclave with insert	04431-93	1
Drying oven UNB200, timer, 32 l	46959-93	1
Compact Balance, OHAUS TA 302, 300 g/0.01g	49241-93	1
Heating + cooking hotplate, 230V	04025-93	1
Bunsen burner, natural gas, w. cock	32167-05	1
pH test sticks 6.5-10, 100 sticks	30301-04	1

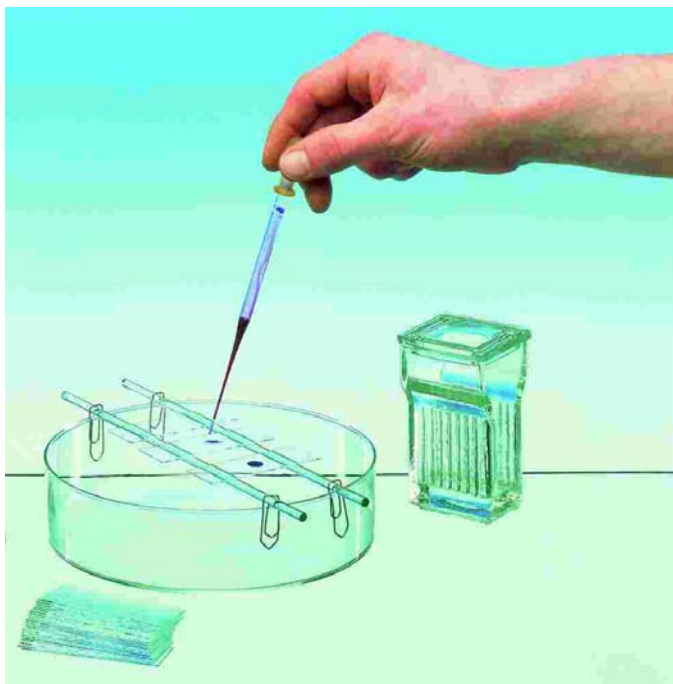
Related Experiment

Microbial decomposition of mineral oil

P4100900



P4140300 Microscopy of bacteria



Principle

The microscopic examination of microorganisms can be performed based on live specimens or in fixed and stained preparations. Live specimens of microorganisms are prepared in a drop of water (or liquid) culture. The aim of staining bacteria preparations is to increase the contrast between the bacteria and their environment from which they hardly stand out when unstained.

Tasks

Examine a bacteria preparation under a microscope and apply the standard methods that are described here in.

What you can learn about

- Bacteria
- Sterility
- Microscope
- Staining

Main articles

SWIFT Student Microscope M3602C-3	63021-99	1
Bunsen burner, natural gas,w.cock	32167-05	1
Culture vessel	64834-00	1
Immersion oil, 50 ml	31381-05	1



The bacteria are placed on the microscope slide.

SWIFT Student Microscope M3602C-3



Function and Applications

The monocular SWIFT M3602C-3 was developed in particular for using in schools: robust, reliable, long-lasting, durable, against removing protected eyepieces and objectives. An economical LED-light which is supplied with energy by an accumulator, allows also a working far away from the next mains socket.

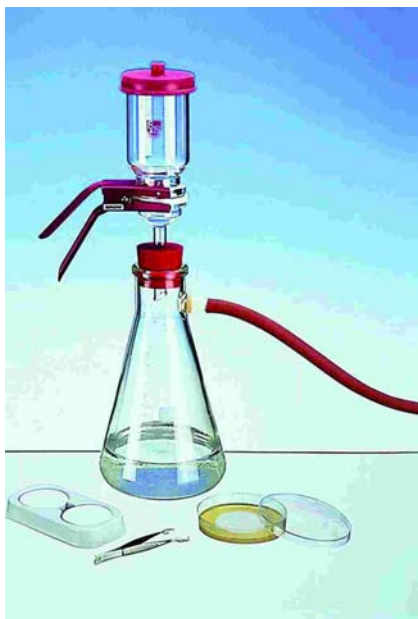
Benefits

- A whole metal case qualitatively produced on highest level and the exclusive use of metal parts in the interior of the microscope guarantees a long and trouble-free working.
- Eyepieces and objectives protected against removing.
- Plain stage with slowly closing clamp prevents damages at the specimen slides.

63021-99

Determination of the microbial count

P4140400



Principle

The microbial count is the number of viable microorganisms in one millilitre or gramme of the material to be examined, e.g. water, soil, milk, ice cream, etc. It is of high practical importance for the analysis of drinking water, soil, and foodstuffs. The microbial count can only be determined exactly if all of the related tasks are performed in a way that prevents the material that is to be examined from being contaminated with foreign microorganisms.

Tasks

Determine the microbial count of the sample.

What you can learn about

- Microbial count
- Microorganisms
- Analysis of drinking water

Main articles

Autoclave with insert	04431-93	1
Drying oven UNB200, timer, 32 l	46959-93	1
SWIFT Student Microscope M3602C-3	63021-99	1
Compact Balance, OHAUS TA 302, 300 g / 0.01 g	49241-93	1
Diaphragm filter apparatus	64906-00	1
Diaphragm filters, pkg. of 100	64907-00	1
Heating + cooking hotplate, 230V	04025-93	1



Flame treatment of spatula.

Diaphragm filter apparatus



Function and Applications

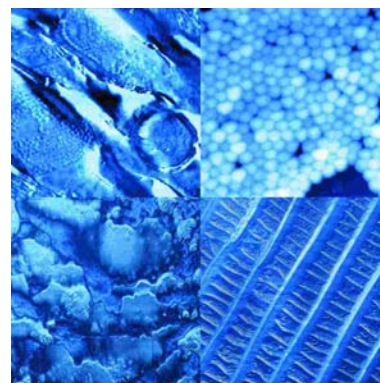
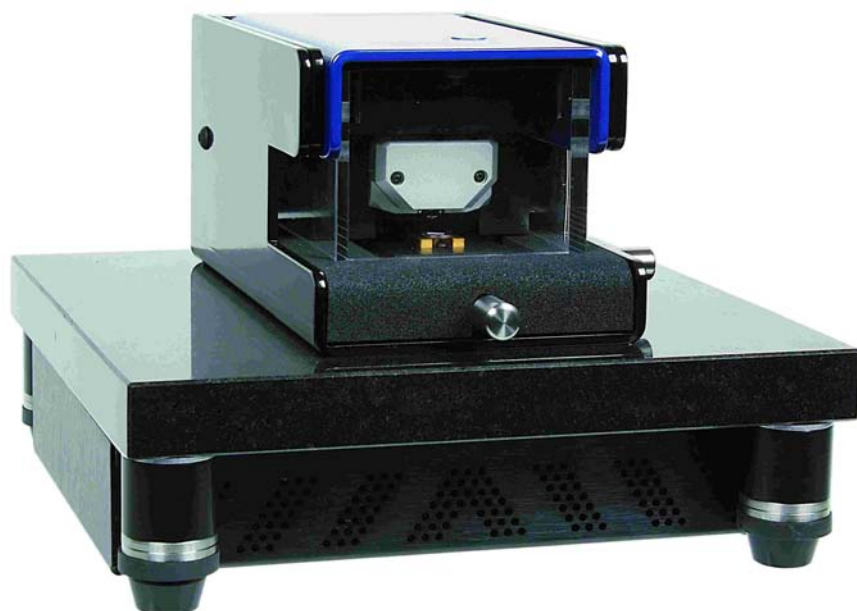
Diaphragm filter apparatus for determining the number of bacteria in water and soil samples, for harvesting organisms from cell suspensions and for sterile filtration of solutions.

Equipment and technical data

- made of borosilicate glass
- hopper 250 ml with rubber lid
- frit for membrane filter diameter: 50 mm
- base with spout
- metal clip

64906-00

P2538400 Imaging of biological and medical micro and nanostructure with atomic force microscopy (AFM)



Topography of Skin Cross-Section (60 micrometer), Staphylococcus Bacteria (10 micrometer), Human hair (40 micrometer), and Butterfly Wing (10 micrometer) FLTR.

Principle

Dynamic Atomic Force Microscopy is used to image and visualize several biological samples at a sub micrometer scale. A collection of both pre-prepared and freshly prepared samples are investigated, e.g. bacteria, skin cross-section, human hair, butterfly wing, blood cells, and fly eye. With high resolution imaging the relation between small biological structures and their function can be identified and different treatments could be recognized at this scale. One example is the imaging of different skin layers showing dead and living epithelial layer, collagen layer, hair follicle and structures within it. Another example is the imaging of different regular lattice structures to clarify the colour effect of butterfly wings.

Tasks

1. Set-up the microscope and start up the software. Mount a cantilever and approach the tip towards a sample.
2. Use pre-prepared samples and investigate their topography by optimizing the imaging parameters. Discuss the relation between the imaged structures with their function.
 - Skin cross-section: different layers and their structures
 - Staphylococcus Bacteria: form, alignment and surface structure
4. Prepare different samples and investigate their topography by optimizing the imaging parameters. Discuss the relation between the imaged structures with their function and treatment.
 - Blood cells: different form and structure, function
 - Butterfly wing: different regular structures, interference of light and colour effect
 - Fly eye: compound of many "eye" units, resolution, viewing angle, reaction time

- Human hair: treatment dependence of surface structure (coloured and non-coloured, wet and dry)

What you can learn about

- Atomic Force Microscopy
- Dynamic mode
- Feedback loop
- High resolution 3D imaging
- Nano Imaging of biological and medical samples
- Relation of structure and function
- Blood Cells; Butterfly Wing
- Insect Eye, Bacteria
- Skin; Human hair

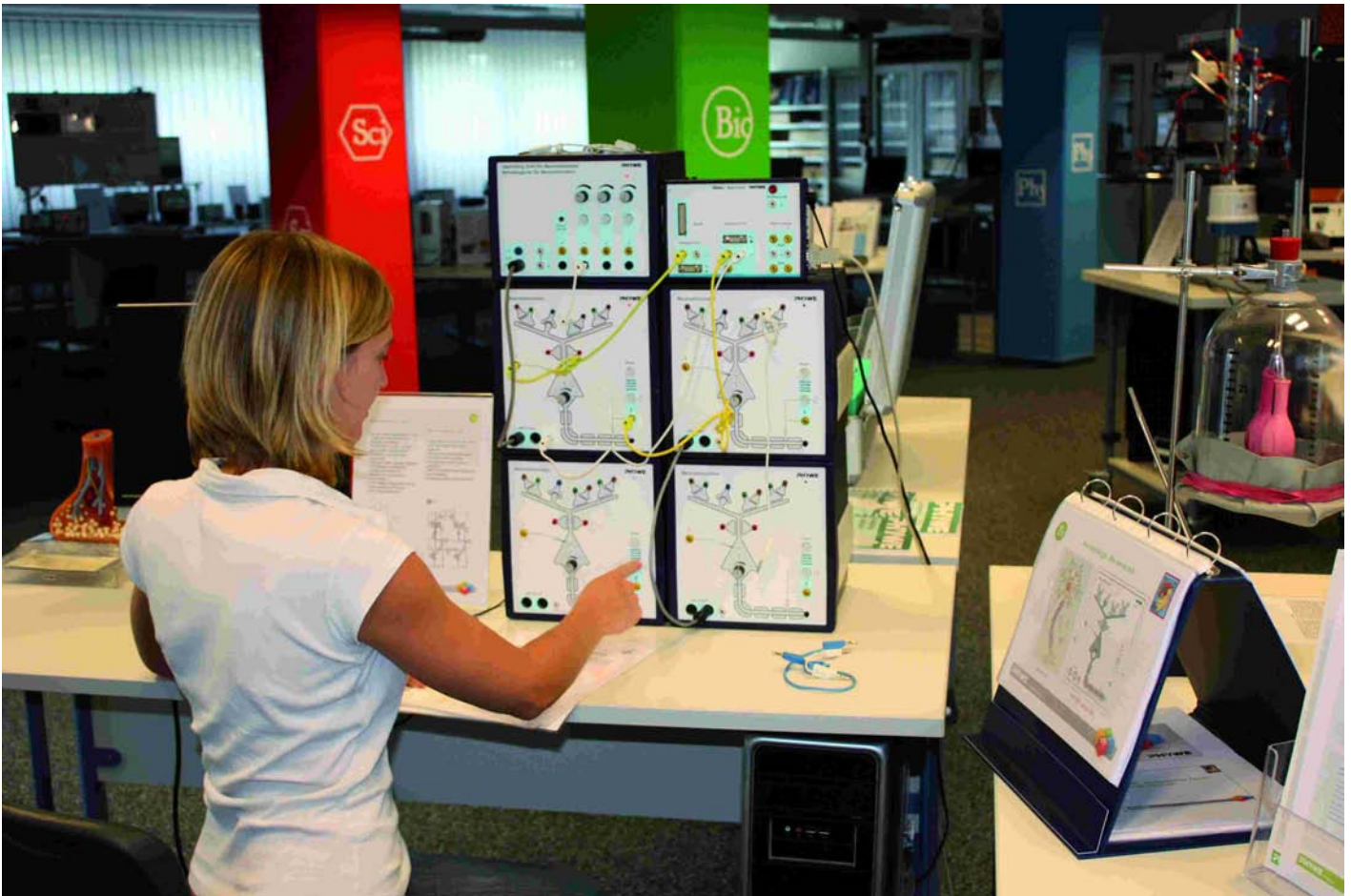
Main articles

Compact-Atomic Force Microscope (AFM)	09700-99	1
Sample support, 10 pcs, for Compact Scanning Tunneling Microscope and Atomic Force Microscope	09619-00	1

Related Experiment

Basic methods in imaging of micro and nano structures with atomic force microscopy (AFM)

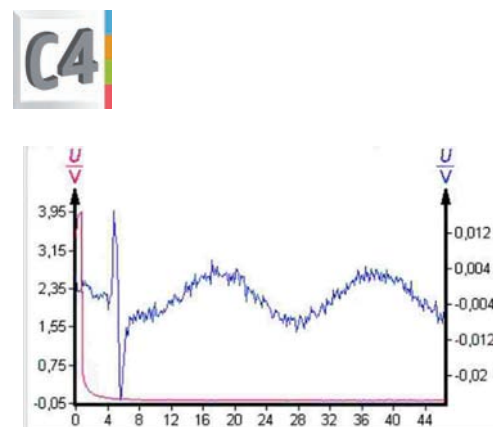
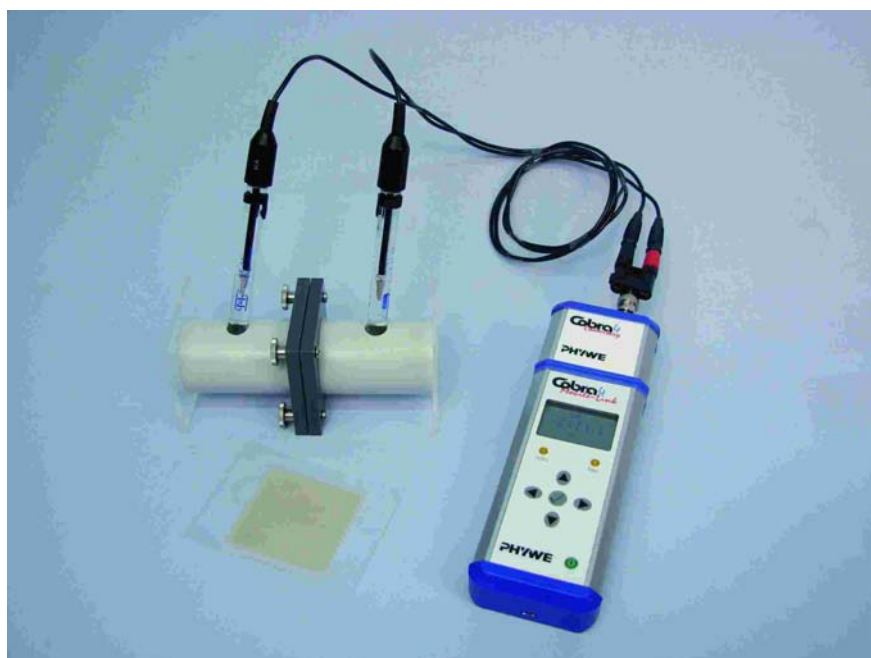
P2538000



Neurobiology

10.1	Basics	102
10.2	Nerve Cell - Functions, Interactions and Networks	104
10.3	Stimuli Transmission	107
10.4	Literature	108

P4010462 Model experiment illustrating the development of resting potential (with Cobra4)



Diffusion rates.

Principle

Biological membranes represent a boundary layer between two electrolyte solutions (e.g. Na^+ , K^+ , Cl^- and protein ions). An electrical potential difference arises at such boundaries when the mobility and concentration of the ions differ on the two sides of the boundary. In this experiment, the potential difference between two electrolyte concentrations separated by a membrane (cellophane or cation permeable) is detected by two silver chloride electrodes and measured with a mV meter.

Tasks

1. Measure the potential difference between two electrolyte concentrations.
2. Compare your results to calculated values.

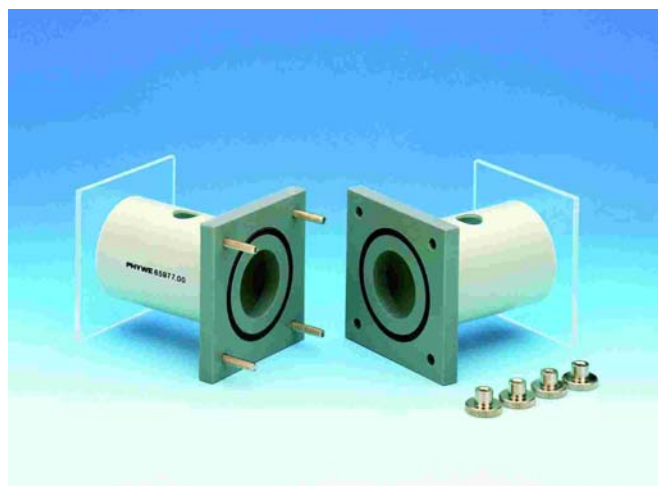
What we can learn about

- Selective ion permeability of membranes
- Resting potential
- Diffusion potential
- Asymmetry potential
- Silver chloride electrodes
- Ion pump

Main articles

Cobra4 Mobile-Link set, incl. rechargeable batteries, SD memory card, USB cable and software "measure"	12620-55	1
Cobra4 Sensor-Unit Chemistry, pH and 2 x Temperature NiCr-Ni	12630-00	1
Ussing chamber	65977-00	1
Reference electrode, AgCl	18475-00	2
Immersion probe NiCr-Ni, steel, -50...400°C	13615-03	1

Ussing chamber



Function and Applications

Ussing chamber, two polystyrene tubes with acrylic glass windows and flanges which can be screwed together.

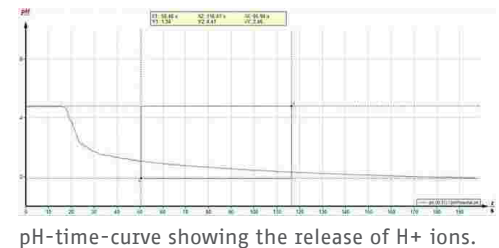
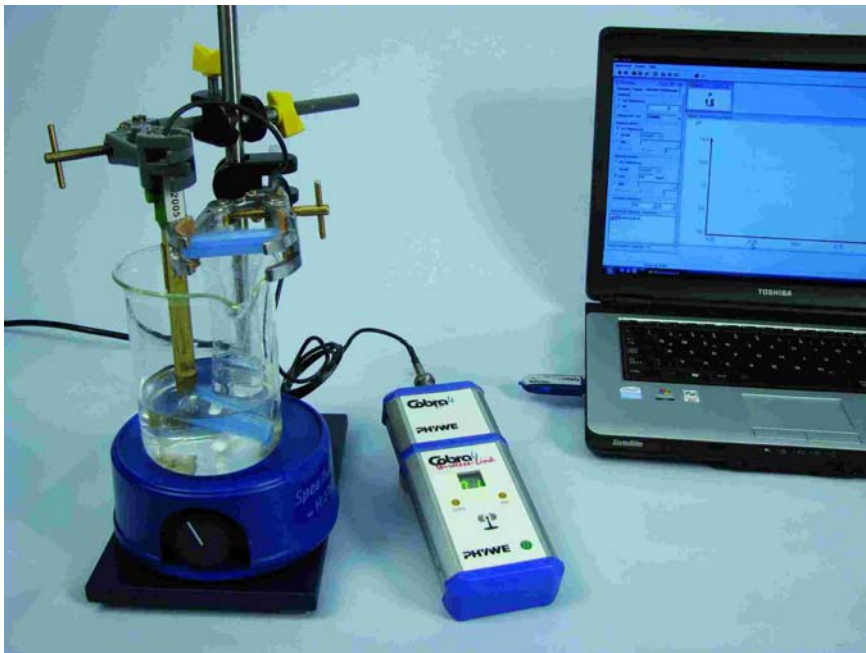
Equipment and technical data

- Each container with bore for electrodes
- Vascular content 120ml
- Measuring surface approx. 7 cm^2

65977-00

Ionic permeability of the cell membrane (with Cobra4)

P4120260



Principle

The cell membrane regulates the transport of nutrients and water into the cell, and of waste products and water out of the cell. This can take place passively, e.g. on the basis of osmotic processes (differences in concentration), as well as actively.

Tasks

In this experiment, the selective permeability of an artificial cell membrane (dialysis tube) for H^+ and OH^- ions is to be examined.

What you can learn about

- Ionic permeability
- Artificial cell membrane
- Dialysis tube
- H^+ ions
- OH^- ions
- Osmotic processes

Main articles

Software Cobra4 - multi-user licence	14550-61	1
Cobra4 USB-Link	12610-00	1
Cobra4 Sensor-Unit pH, BNC connector	12631-00	1
Magnetic stirrer Mini / MST	47334-93	1
pH-electrode, plastic body, gel, BNC	46265-15	1
Retort stand, h 750 mm	37694-00	1

Cobra4 USB-Link



Function and Applications

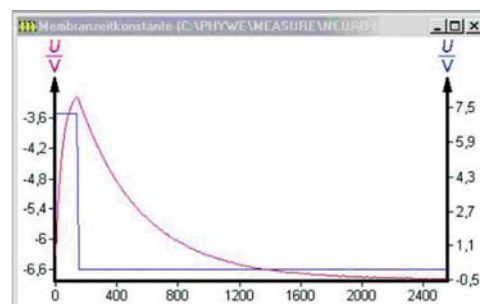
The Cobra4 USB-Link is a highly efficient interface module for the transmission of sensor measuring values to a PC via a USB connection.

Benefits

- All Cobra4Sensor-Units can be connected to the Cobra4 USB-Link using a stable plug-in / lockable connection. Up to 400,000 measuring values/sec
- Several Cobra4 USB links can be connected to one PC (via USB port on the PC or by USB hub). Automatic detection of all Cobra4Sensor-Units.
- Power supply from USB connection, no additional external power supply required.

12610-00

P4010511 Neurosimulator: membrane time constant and low-pass filtering (with Cobra3)



Result of a single stimulation.

Principle

To show the membrane time constant the neurosimulator is excited by a rectangular pulse from a synapse. The intracellular potential only increases slowly, and then falls off even slower when the stimulation stops. As a result of this behaviour, rapid and brief stimulating signals can only be weakly transmitted (low-pass characteristic of the membrane). In the second part of the experiment, low-pass filtering is investigated. When short rectangular impulses act at relatively large intervals, the intracellular potential can follow the stimulating pulse frequency. The low-pass characteristic of the membrane allows the conversion of the low frequencies to a response.

Tasks

To use a nerve function model to work on the following themes:

- The time constant of the nerve membrane and intracellular potential
- The low-pass characteristic of the nerve membrane

What you can learn about

- Time constant of nerve membrane
- Intracellular potential
- Low-pass characteristic

Main articles

Neuro-simulator	65963-00	1
Cobra3 BASIC-UNIT, USB	12150-50	1
Neuro-simulator, power supply	65963-93	1
Power supply 12V / 2A	12151-99	1
Software Cobra3 Universal recorder	14504-61	1

Related Experiment

Neurosimulator: mode of operation of excitatory synapses (with Cobra3)

P4010611

Cobra4 Experiment - available 2013

Neurosimulator: membrane time constant and low-pass filtering (with Cobra4)

P4010560

Neurosimulator, power supply



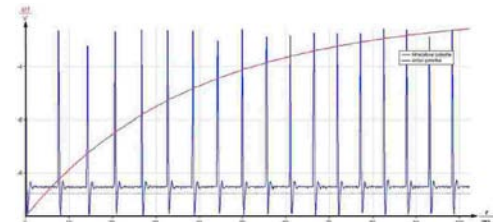
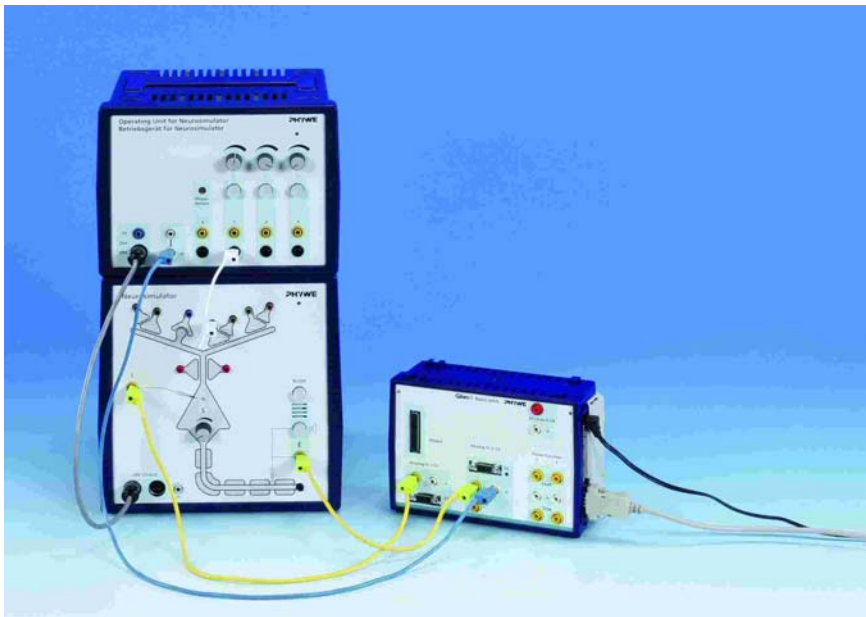
Function and Applications

The operating unit comprises the power supply of up to four neuron units, three touch simulators with a variable stimulating intensity and an optic sensor.

65963-93

Neurobiology: the nerve cell

P4010711



maximum stimulus intensity and low threshold (here: 0) creates fast frequency of action potential.

Principle

Action potential arises by influx of sodium ions through the sodium channels of the nerve cells. Stimulus movement along the axon occurs due to the consecutive influx of sodium ions along its cell membrane. With the measurement method of this experiment the action potential can be displayed (together with intracellular potential).

Tasks

Use the nerve function model to study the following aspects of a nerve cell: intercellular potential and action potential

What you can learn about

- Comparison between low and high threshold levels
- Comparison between low and high stimulus levels
- Membrane time constant and low pass filtering
- Excitatory Synapse; Veto synapse
- Depolarisation; Temporal summation; Spatial summation
- Synaptic amplification by terminal branches
- Effect of decreasing stimulus, Hebbian synapse
- Synaptic learning and forgetting; Inhibitory synapse
- Hyperpolarization; Spatial inhibitory-excitatory summation

Main articles

Neurobiology Lab, 230 V

65963-11 1

Related Experiment**Neurobiology: nerve cell interactions**

P4010811

Cobra4 Experiments - available 2013**Neurobiology: the nerve cell (with Cobra4)**

P4010760

Neurobiology: nerve cell interactions (with Cobra4)

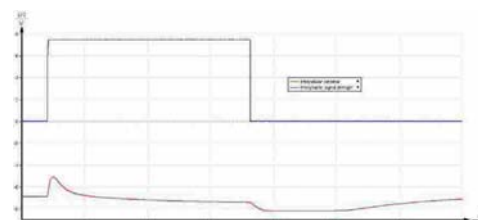
P4010860

Neurobiology Lab, 230 V**Function and Applications**

Complete instrument set consisting of neuron unit, operating unit, computer interface, measure software for data acquisition and analysis, diverse cables, experiment manual describing 31 experiments.

65963-11

P4010911 Neurobiology: neural networks



Transient responses: ON neuron.

Principle, tasks and what you can learn about:

To use a new function model to study the following aspects of neural networks:

- Transient (Phasic) Responses: Focus on visual sense
 - Transient responses: ON neuron
 - Transient responses: OFF neuron
 - Simultaneous activation of ON and OFF neurons
- Neuronal oscillator (Body Clock)
- Rotating excitation (Short-Term Memory)
 - Rotating excitation variation 1: dampening
 - Rotating excitation variation 2: convulsive excitation
 - Rotating excitation variation 3: equilibrium
- Special anatomical circuits
 - Cerebral cortex and sensoric learning
 - Functional characteristic of a triad

Main articles

Neurobiology Lab, 230 V	65963-11	1
Additional nerve cell	65963-10	2

Related Experiment

Neurobiology: complex neural networks

P4011011

Cobra4 Experiment - available 2013

Neurobiology: neural networks (with Cobra4)

P4010960

Additional nerve cell



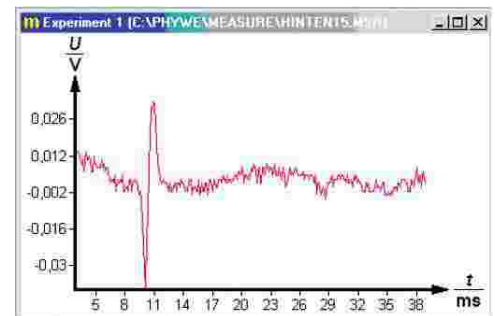
Function and Applications

Additional nerve cell unit to complement the Neurobiology Set.

65963-10

Recording of nerve and muscle potentials by mechanical stimulation at the rear end of an earthworm (with Cobra3)

P4010111



Result with weak stimulation.

Principle

Earthworms have a median giant nerve fibre, which reacts to stimulation at the front end, and two lateral giant fibres, which can be stimulated at the rear end. The experiment covers the following topics: the course of a biphasic action potential over time, estimation of the conduction velocity and coding of the stimulant intensity as frequency modulation

Tasks

1. stimulate the earth worm with weak, moderate and strong stimulation.
2. observe the course of the biphasic action potential over time
3. estimate the conduction velocity

What you can learn about

- Nerve and muscle potentials
- Mechanical stimulation
- Biphasic action potential
- Frequency modulation
- Median and lateral giant nerve fibres
- Conduction velocity

Main articles

Cobra3 BASIC-UNIT, USB	12150-50	1
Biological amplifier	65961-93	1
Earthworm experiment chamber	65981-20	1
Stimulus bristle, triggering	65981-21	1
Power supply 12V / 2A	12151-99	1
Software Cobra3 Universal recorder	14504-61	1

Related Experiments

Recording of nerve and muscle potentials by mechanical stimulation at the front end of an earthworm (with Cobra3)

P4010211

Recording of nerve potentials after the electrical stimulation of an anaesthetised earthworm (with Cobra3)

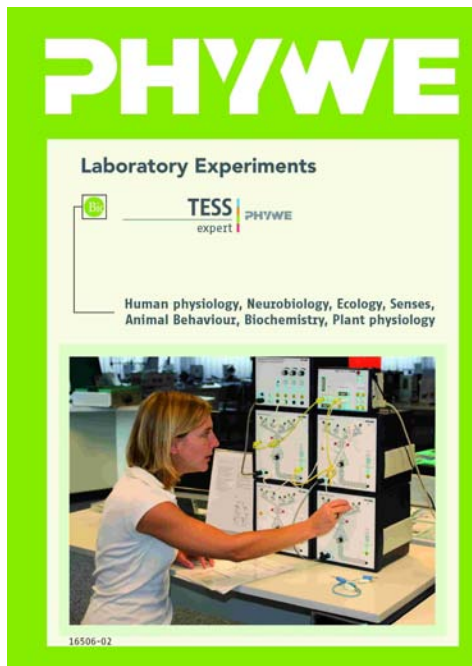
P4010311

Cobra4 Experiment - available 2013

Recording of nerve and muscle potentials by mechanical stimulation at the rear end of an earthworm (with Cobra4)

P4010160

Laboratory Experiments Biol., L.V.



Article no. 16506-02

Description

Instructions for more than 54 experiments covering various areas of biology.

Topics

- Nervous system
- Heart and circulation
- Musculature
- Hearing
- Balance
- Sensing temperature
- Sight
- Behaviour
- Respiration
- Ecology and the environment
- Plant physiology
- Biochemistry

Format

- DIN A4 handbook, spiral binding, b/w, 190 pages

This documentation contains the following experiments:

Recording of nerve and muscle potentials by mechanical stimulation at the rear end of an earthworm (Cobra3)

P4010111

Recording of nerve and muscle potentials by mechanical stimulation at the front end of an earthworm (Cobra3)

P4010211

Recording of nerve potentials after the electrical stimulation of an anaesthetised earthworm (with the Cobra3 Basic-Unit)

P4010311

Model experiment illustrating the development of resting potential (with Cobra4)

P4010462

Neurosimulator: membrane time constant and low-pass filtering (with the Cobra3 Basic-Unit)

P4010511

Neurosimulator: mode of operation of excitatory synapses (with the Cobra3 Basic-Unit)

P4010611

Neurobiology: the nerve cell

P4010711

Neurobiology: nerve cell interactions

P4010811

Neurobiology: neural networks

P4010911

Neurobiology: complex neural networks

P4011011

Changes in the blood flow during smoking (with Cobra4)

P4020460

Muscle stretch reflex and determination of the conducting velocity (with Cobra3 Basic-Unit)

P4030211

Human merging frequency and upper hearing threshold

P4040101

Hearing threshold and frequency differentiating threshold in humans (with the Cobra3 Basic-Unit)

P4040215

Acoustic orientation in space (with the Cobra3 Basic-Unit)

P4040311

Phototropism and geotropism

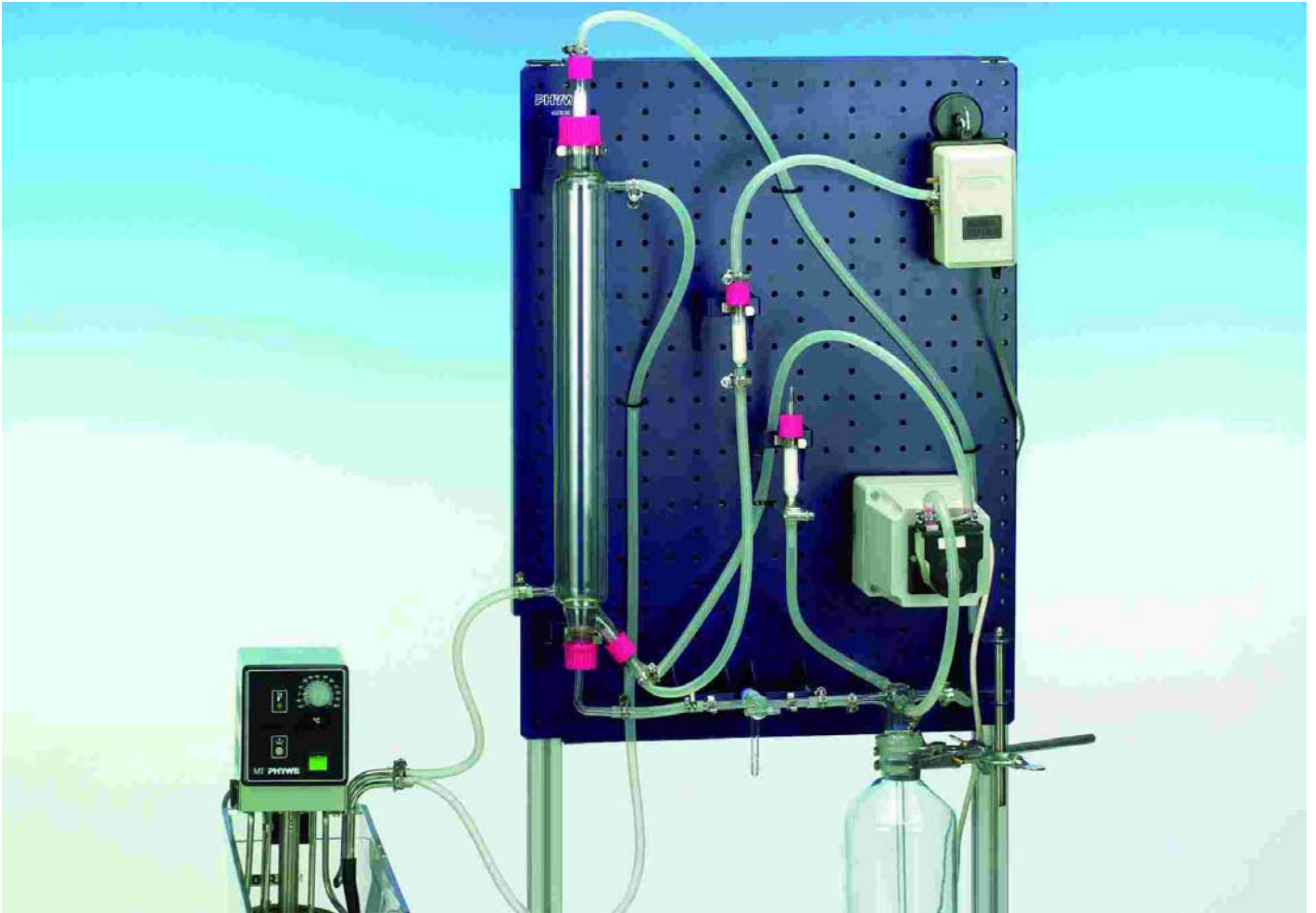
P4050100

Complete experiment list see www.phywe.com

16506-02



P4010911 - Neurobiology: neuronal networks - page 115



Biotechnology

11.1 Biotechnology

110

P1313600 Fermentation of molasses to ethanol with yeast



Principle

As a result of the need to save energy and the increased consciousness of environmental problems, biotechnological production methods are on the advance. Fermenters are used for the biotechnological production of enzymes and other products using bacteria, yeast and cell cultures. For educational purposes a bubble bioreactor used in this experiment is a more convenient and economical alternative to commercial fermenters. To demonstrate how fermenters work, in this experiment molasses which is a waste product of sugar production is fermented in the so-called batch process.

Tasks

1. Molasses is to be fermented to ethanol
2. Determine the yield of your process

What you can learn about

- Fermentation
- Ethanol
- Bioreactor
- Yeast

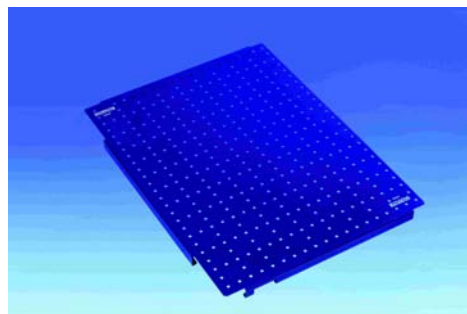
Main articles

Immersion thermostat Alpha A, 230 V	08493-93	1
Heating mantle for roundbottom flask, 250 ml, 230 V, with safety switch	49542-93	1
Bubble bioreactor	65999-00	1
Frame for complete experiments	45500-00	1
Power regulator	32288-93	1
Bath for thermostat, Makrolon	08487-02	1
Liebig Condenser, with head, GL18/8	35795-15	1



Distillation of the fermented mash.

Panel for complete experimental set-ups



Function and Applications

Panel with regular punching to receive the hooks of the holder horizontal or vertical positioning in the frame, one panel is necessary for each experiment

Equipment and technical data

- Material: sheet steel, powder painted with good mechanical and chemical resistance
- Dimensions: 65x48.8x2.5 cm

45510-00

Microbial synthesis of ethanol by *Zymomonas mobilis* subsp. *mobilis*

P1313700



Principle

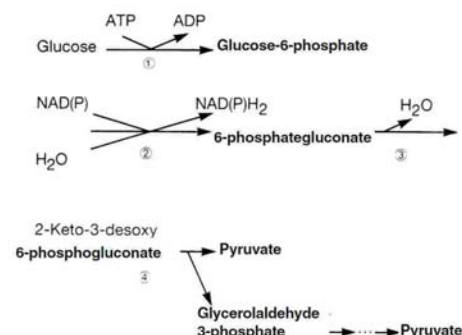
The properties of the microorganism *Zymomonas mobilis* have been used in the production of alcohol for centuries. Nevertheless, the bacterium in palm wine and pulque, the fermented juice of the agave plant, was not identified and recognised as being responsible for their alcoholic fermentation until the twentieth century. *Zymomonas* was found to synthesize ethanol much more effectively than yeast does. In this experiment, *Zymomonas mobilis* is grown in a bioreactor. The medium is blended by means of a magnetic stirrer and its temperature is controlled by means of a heating coil and a water bath with thermostats. The discharge of used medium and the supply of fresh medium can be dispensed with. This is a so-called 'static culture' (batch culture). The cell density can first be determined photometrically in the samples taken and the cell count can be determined in the counting chamber, and those data can be used to generate a growth curve. Chemical and enzymatic tests show the consumption of glucose and the production of ethanol. The experiment is easy to perform. It does not take long to prepare. The evaluation of the test results is very conclusive and clearly illustrates the methods of biotechnology.

Tasks

1. Prepare the agar plates that are to be used for strain maintenance of the bacteria to be used.
2. Determine the course of the fermentation of *Zymomonas* by a turbidimetric procedure.
3. Determine the cell count microscopically in a haemocytometer

What you can learn about

- Turbidimetry; *Zymomonas mobilis*; Cell count
- Haemocytometer; Yeast; Fermentation



Enzymatic processes.

Main articles

Spectrophotometer S800, 330...800 nm	35600-99	1
Autoclave with insert	04431-93	1
Drying oven UNB200, timer, 32 l	46959-93	1
Centrifuge with angle rotor 8x15 ml	65973-93	1
Immersion thermostat Alpha A, 230 V	08493-93	1
Bioreactor, 1 l, 7 connections	66000-00	1

Spectrophotometer S800, 330...800 nm



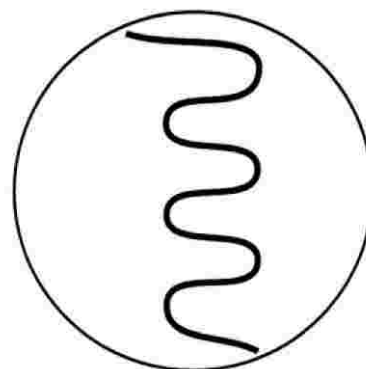
Function and Applications

This visible diode array spectrophotometer has been designed to meet the routine spectroscopy needs of customers requiring a small, lightweight instrument that is easy to use.

This photometer is ideal for use in educational, biotech or industrial establishments.

35600-99

P1313800 Production of amino acids by fermentation of *Corynebacterium glutamicum*



Preparation of the strain maintenance plate.

Principle

A bacteria culture of *Corynebacterium glutamicum* is used in a bioreactor at a constant temperature of 30°C to produce amino acids. Under these conditions the fermentation of *Corynebacterium glutamicum* takes place in a so-called batch process for 7 to 10 days.

Tasks

1. Start the fermentation of *Corynebacterium glutamicum*
2. Determine the yield of the process
3. Determine the composition of the mixture of amino acids using TLC

What you can learn about

- Fermentation; Thin layer chromatography; Amino acids

Main articles

Set of Precision Balance Sartorius CPA 423S and measure software, 230 V	49223-88	1
Autoclave with insert	04431-93	1
Drying oven UNB200, timer, 32 l	46959-93	1
Immersion thermostat Alpha A, 230 V	08493-93	1
Bioreactor, 1 l, 7 connections	66000-00	1
Cobra4 Mobile-Link set, incl. rechargeable batteries, SD memory card, USB cable and software "measure"	12620-55	1
Frame for complete experiments	45500-00	1
Microliterpipette dig. 100-1000µl	47141-05	1
Yeastbroth, w/o carb., nitrog. 100g	31364-10	1
Cobra4 Sensor-Unit pH, BNC connector	12631-00	1

Bioreactor, 1 l, 7 connections



Function and Applications

For the production of biotech products, such as Citric acid or penicillin using bacteria, yeasts, and lower fungi.

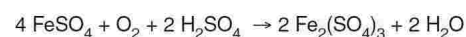
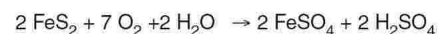
Benefits

- The connectors serve for sample removal, introduction of measuring probes, introducing and removing medium, addition of acids or bases and for air venting.
- In this bioreactor, mixing and tempering are carried out using a magnetic stirrer with hot plate or heating coil.
- An aquarium pump is used for a aeration.

66000-00

Bacteria and mining - microbial extraction of ore by *Thiobacillus ferrooxidans* and *thiooxidans*

P1313900



Chemical process during extraction.

Principle

Scientists first recognised importance of certain bacteria for the extraction of metals from ore in the 1950s. Nowadays the microbial ore leaching with so-called 'lean ores' represents more than 10% of the total production of copper in the USA alone. The bioreactor shown here can be used to clearly demonstrate to the students this method of extraction (e.g. copper from copper ore) using such bacteria (*Thiobacillus ferrooxidans*).

Tasks

1. Reactivate and multiply the two bacteria strains *Thiobacillus ferrooxidans* and *Thiobacillus thiooxidans*
2. Extract copper from copper ore using the "percolator leaching" method

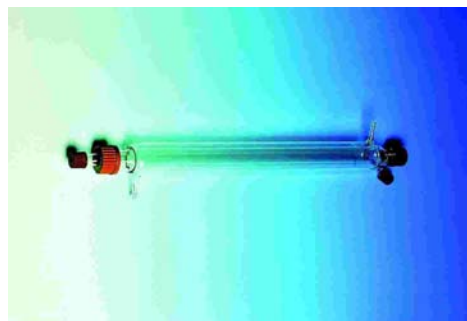
What you can learn about

- Ore
- Bubble bioreactor
- Oxidation
- Bacterial leaching
- Microbial extraction

Main articles

Set of Precision Balance Sartorius CPA 423S and measure software, 230 V	49223-88	1
Autoclave with insert	04431-93	1
Drying oven UNB200, timer, 32 l	46959-93	1
Cobra4 Mobile-Link set, incl. rechargeable batteries, SD memory card, USB cable and software "measure"	12620-55	1
Bubble bioreactor	65999-00	1

Bubble bioreactor



Function and Applications

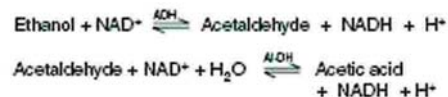
This consists of a long glass tube jacket for temperature control and a glass insert tube which reaches from tip to tip. The jacket has two hose nipples for entry and exit of the temperature controlling liquid. The GL 32/18 opening in the bottom of the reactor is for aeration, the two openings at the top (GL25/8 and GL 18/8) are for the addition of the culture medium or for removal of final products.

Equipment and technical data

- length: 400 mm
- diameter: 50 mm

65999-00

P1314000 Immobilised cells in the service of biotechnology - microbial synthesis of acetic acid with *Acetobacter aceti*



The biochemical oxidation of alcohol.

Principle

As early as 1864, Louis Pasteur recognised that both alcoholic fermentation and the oxidation of alcohol to acetic acid depend upon the metabolic performance of specific bacteria. Gram-negative, flagellated rods are responsible for the formation of acetic acid. Two large groups are differentiated here, the representatives of one of these are comprised of the genus *Acetobacter*, and those of the other of the genus *Gluconobacter*. In Nature, these bacteria are to be found on fruit, in floral nectar and leaf nectar, as well as in beer, wine and fruit juices. They are capable of utilising simple sugar as well as simple alcohol as substrate.

Tasks

1. Determine the ethanol content by an enzymatic indicator reaction
2. Determine content of acetic acid by an enzymatic indicator reaction
3. Produce acetic acid with the "Rapid vinegar procedure"

What you can learn about

- "Rapid vinegar procedure"
- Acetic acid
- Immobilised cells
- Bacterial culture

Main articles

Set of Precision Balance Sartorius CPA 423S and measure software, 230 V	49223-88	1
Spectrophotometer S800, 330...800 nm	35600-99	1
Autoclave with insert	04431-93	1
Drying oven UNB200, timer,32 l	46959-93	1

Centrifuge w. angle rotor 8x15 ml	65973-93	1
Peristaltic pump, 220V, 8 to 60 ml/min.	35705-93	1
Immersion thermostat Alpha A, 230 V	08493-93	1
Bubble bioreactor	65999-00	1
Frame for complete experiments	45500-00	1
Microliterpipette dig.2-20 µl	47141-01	1

Centrifuge w. angle rotor 8x15 ml



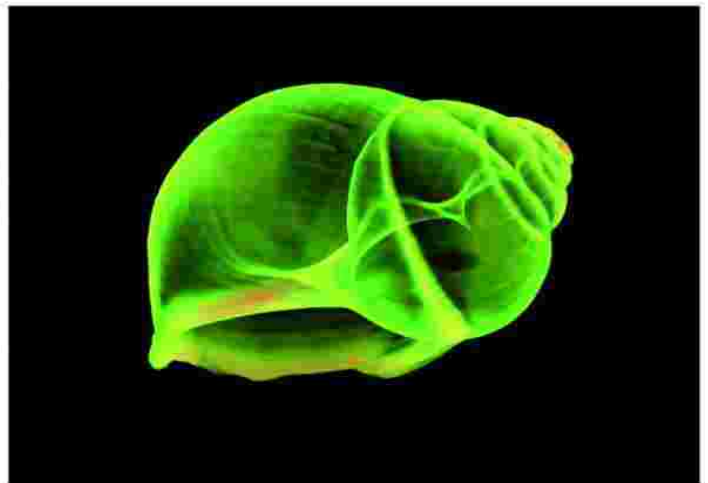
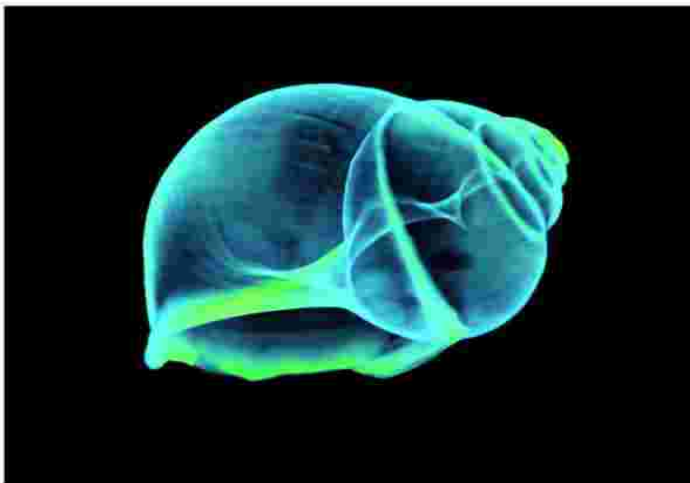
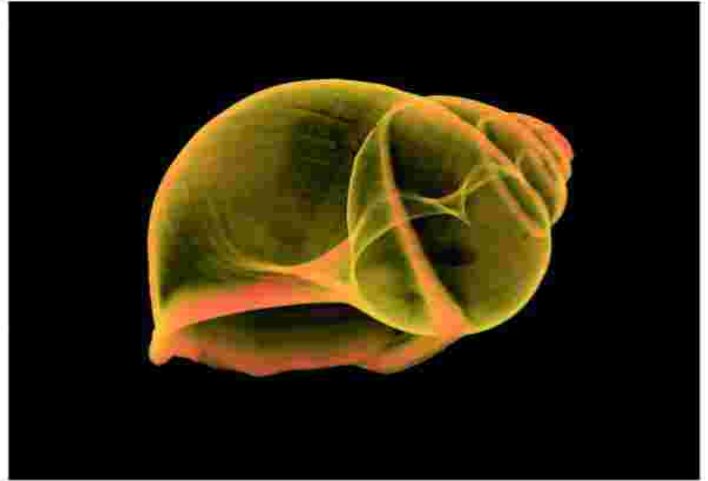
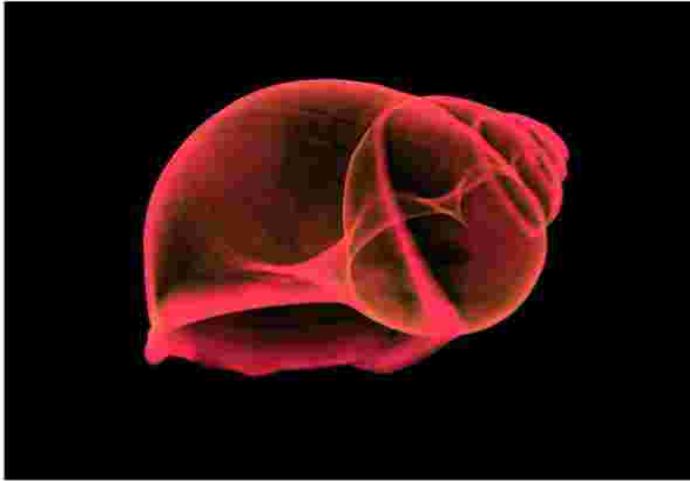
Function and Applications

Centrifuge with angle rotor.

Equipment and technical data

- Contin.speed adjustm max. 6000 U/min
- Connection voltage 230V/ 50-60 Hz; Power requirement 60W
- Overheating protection; Impulse key for short runs

65973-93



Modern Imaging Methods

12.1	X-ray Imaging	116
12.2	Magnetic Resonance Imaging	128
12.3	Ultrasonic Imaging	130
12.4	Nano Imaging	134
12.5	Literature	137

XRE 4.0 expert set – Details at a glance

Experience the perfect synthesis of innovative technology, highest level of safety, well-proven PHYWE quality and modern design. Extensive performance characteristics and ideas make working with the PHYWE XR 4.0 a special experience.

We have presented some device highlights for you here.

Tube XChange Technology

- Self-adjusting X-ray tubes with quick-change technology
- Contact protection against hot parts
- 4 anode materials for specific experiments (W, Mo, Cu, Fe)



Touch Panel

- Simultaneous control, manually and by computer
- Interactive, intuitive handling
- Self-explanatory icons for fast operation

3View – Insight provides a transparent view

- Exceptional observability of the experimentation space
- Extra-large window front on 3 sides (Diagonals: : 18"/18"/14", 46cm/46cm/36cm)



XXL Chamber

- Large space for large experiments
- Temperature-controlled, internally-ventilated experimentation space





Optical bench with riders

- Radiography experiments
- simple, precise positioning of optical components



S-Lock – new PHYWE Safety interlock

- Electrical and mechanical safety lock
- Prevents door opening with switched on X-radiation
- thus offers the highest possible safety
- patent pending

Goniometer (not pictured)

- Self-calibrating
- Collision protected
- Easy, safe handling

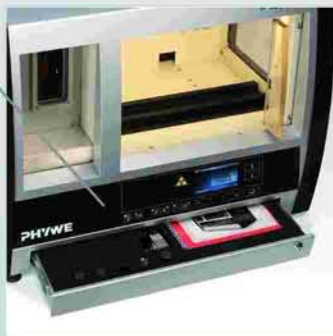


MultiLINK

- Connection field internal and external
- USB 2.0, N₂, BNC, XRED, Aux, etc.
- No annoying „cable-laying“
- In addition, extra-large cable conduit

High-resolution TFT backlit display

- diagonal 4,3"
- 480 x 272 Pixel
- 16 Bit, 65.536 colors
- with LED lighting
- Optimal, dynamic representation of all important device parameters and measured values




Safekeeping drawer

- All accessories are kept safely and always ready at hand
- Lockable





12 Modern Imaging Methods

12.1 X-ray Imaging

XR 4.0 expert unit – Sets for all applications

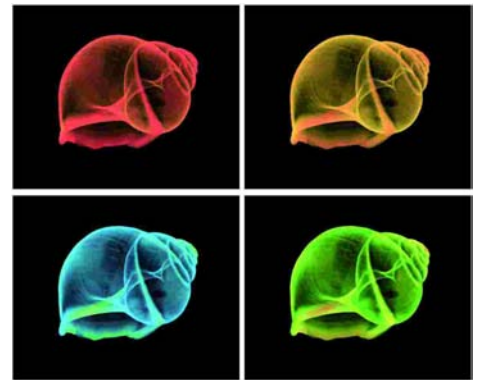
Basic set	Core components (incl. further Accessories)	Areas of application	Application examples
XRE 4.0 expert set Art. No. 09110-88 (Basic set)	<ul style="list-style-type: none"> ■ XR 4.0 expert unit (X-ray device); ■ Tungsten tube (W), ■ XR measure 4.0 X-ray software, ■ optical bank ■ TESS expert manual ■ fluorescent screen ■ USB cable, mains cable + adaptor 		<ul style="list-style-type: none"> ■ Basics & applications of X-radiation ■ Radiographic experiments ■ Radiology

Extend the basic set with the respective extension set according to area of application

Extension sets (optional)	Core components (incl. further accessories)	Areas of application	Application examples
XRP 4.0 solid-state physics Art. No. 09120-88	<ul style="list-style-type: none"> ■ Goniometer, GM counter tube, ■ LiF / KBr single crystal ■ absorption set 		<ul style="list-style-type: none"> ■ Diffractometry ■ X-ray spectroscopy ■ Bragg-reflection / Bremsstrahlung spectrum ■ Characteristic lines
XRC 4.0 characterization Art. No. 09130-88	<ul style="list-style-type: none"> ■ 3 X-ray tubes (Cu, Fe, Mo) ■ Goniometer, GM counter tube, ■ LiF / KBr single crystal 		<ul style="list-style-type: none"> ■ Radiation spectrums of the anode ■ Moseley law ■ Rydberg constant ■ Duane-Hunt law
XRS 4.0 structure analysis Art. No. 09140-88	<ul style="list-style-type: none"> ■ Goniometer, GM counter tube, ■ LiF / KBr / NaCl single crystal ■ Crystal holder ■ powder samples 		<ul style="list-style-type: none"> ■ Structure investigations ■ Laue patterns ■ Debye-Scherrer recordings ■ X-ray analysis
XRM 4.0 material analysis Art. No. 09160-88	<ul style="list-style-type: none"> ■ Goniometer ■ X-ray energy detector ■ Multi-channel analyzer ■ Sample sets 		<ul style="list-style-type: none"> ■ X-ray fluorescence spectroscopy ■ Non-destructive testing (NDT) ■ Compton Effect ■ Energy-dispersive experiments
XRI 4.0 radio photography Art.-Nr. 09150-88	<ul style="list-style-type: none"> ■ Camera ■ Radiographic object ■ Model loader ■ Implant model 		<ul style="list-style-type: none"> ■ Basics for the X-ray image provision ■ Radiography ■ Radiology ■ Non-destructive testing (NDT)
XRD 4.0 dosimetry and radiation damage Art. No. 09170-88	<ul style="list-style-type: none"> ■ Parallel-plate capacitor ■ Power supply unit 600 V ■ DC current amplifier ■ Camera 		<ul style="list-style-type: none"> ■ Dosimetry ■ Degradation ■ Damage ■ Ionization of air
XRCT 4.0 computer tomography Art. No. 09180-88	<ul style="list-style-type: none"> ■ Direct, digital X-ray image sensor ■ Rotation unit, vertical rotation ■ measure Tomography software package 		<ul style="list-style-type: none"> ■ 3-dimensional reconstruction ■ Sectional drawings in respective position ■ Direct, digital image provision
XRW 4.0 wireless demonstration Art. No. 09115-88	<ul style="list-style-type: none"> ■ Digital display panel ■ Cobra4 Display-Connect ■ Transmitter and receiver, etc. 		<ul style="list-style-type: none"> ■ Demonstration experiments (operation without computers) ■ Placard-style representation of the measured values and parameters

Computed tomography

P2550100



CT of a Snail shell.

Principle

The CT principle is demonstrated with the aid of simple objects. In the case of very simple targets, only a few images need to be taken in order to achieve a good result. The more complicated the objects are, the more images are necessary in order to show all the details. In addition, special samples are used to demonstrate how artefacts are generated and what causes beam hardening.

Tasks

1. Record a CT scan of the simple objects. While doing so, vary the number of steps.
2. Record a CT scan of the metal samples and analyse the result in view of beam hardening.

What you can learn about

- Beam hardening; ; Artefacts; Algorithms

Main articles

XRE 4.0 X-ray expert set	09110-88	1
XR 4.0 X-ray Direct Digital Image Sensor (XRIS) with USB cable	09057-40	1
XR 4.0 X-ray CT Z-rotation stage (XRstage)	09057-42	1

Best fitting X-ray sets for this experiment:

XRE 4.0 X-ray expert set

09110-88

XRCT 4.0 X-ray Computed Tomography upgrade set

09180-88



EduMedia Award for Didactical Software for:



Allan M. Cormack (left)

Sir Godfrey Newbold Hounsfield (right)

1979, Nobel Prize in Medicine

12 Modern Imaging Methods

12.1 X-ray Imaging

XRE 4.0 X-ray expert set



Function and Applications

Basic set covering the fundamental principles and areas of applications of X-rays, e.g. fluoroscopy experiments and X-ray photography. It can be extended by upgrade sets for specific applications and topics.

Benefits

- Safety concept complying with the applicable standards and regulations
- S-Lock - PHYWE novel Safety interlock
- Tube XChange Technology
- Touch Panel
- 3View - Insight provides a transparent view
- High-resolution TFT backlit display
- XXL Chamber
- Optical bank with riders
- Goniometer (optional)
- MultiLINK
- Safekeeping drawer

Equipment and technical data

The set includes the following components:

- XR 4.0 expert unit
- XR 4.0 X-ray plug-in unit with a tungsten X-ray tube
- XR measure 4.0 X software
- TESS expert manual "Experiment with X-radiation"
- USB cable
- Mains cable with adaptor
- Optical bench with
- Quick-start guide
- Operating instruction
- Fluorescent screen

Recommended upgrade sets for various applications and topics

- XRW 4.0 X-ray wireless demonstration upgrade set, 09115-88
- XRP 4.0 X-ray solid state upgrade set, 09120-88
- XRC 4.0 X-ray characteristics upgrade set, 09130-88
- XRS 4.0 X-ray structural analysis upgrade set, 09140-88
- XRI 4.0 X-ray imaging upgrade set, 09150-88
- XRM 4.0 X-ray material analysis upgrade set, 09160-88
- XRD 4.0 X-ray dosimetry and radiation damage upgrade set, 09170-88
- XRCT 4.0 X-ray Computer Tomography upgrade set, 09180-88

09110-88

XRCT 4.0 X-ray Computed Tomography upgrade set



Function and Applications

Upgrade set as an extension of the XRE 4.0 expert set (09110-88). Show the fundamental principles of computed tomography (CT) with the aid of a state of the art system whose technology is currently applied in medical and industrial applications. The interfaces of this method towards medicine, materials science, and engineering make the "Computed Tomography Set" particularly suitable for laboratory experiments and lectures in physics, medicine, and materials science. The set covers the following experiments and topics:

- X-ray imaging of biological and technical samples
- Non-destructive testing (NDT)
- Digital image processing for the generation of three-dimensional images of an object
- digital images of Laue patterns

Benefits

- Direct acquisition of the X-ray images by a direct X-ray direct digital image sensor: No extra fluorescent screen is necessary, experimentation under daylight conditions is possible.
- High-performance image sensors for the direct digital X-ray radiography to create superior image quality, and high resolution based on CMOS technology. Even pictures with low contrast like Laue patterns are made in less than 1 min
- Z-axis rotation of the sample to be analysed: Movement of the sample is not influenced by gravitational effects, rigid bodies of flexible size can be analysed on a simple way.
- Acquisition of high resolution CT scan, 360° image stack within 10 minutes (one frame per second, one degree per frame)

Equipment and technical data

The set includes the following components:

- XR 4.0 direct digital image sensor, 09057-41
 - Active area 5 x 5 cm²
 - Resolution 46µm
 - Image depth 12 bit
 - USB 2.0 interface
- XR 4.0 CT object Z-rotation unit, 09057-41
 - Angle resolution < 1 degree
 - Motorised, USB 2.0 interface
 - stepper motor with 4200 steps/360°
- Measure XRt 4.0 tomography software package, 14421-61
- XR 4.0 CT accessories, 09057-42

09180-88

XR 4.0 X-ray Direct Digital Image Sensor (XRIS) with USB cable



Function and Applications

Digital X-ray camera to perform X-ray imaging (radiography), and X-ray Computer Tomography (CT) experiments. Particularly suitable for experiments in lab courses and lectures in physics, medical education and material sciences.

Benefits

- Direct acquisition of the X-ray images by a direct X-ray direct digital image sensor: Experimentation under daylight conditions
- High-performance CMOS image sensors for the direct digital X-ray radiography to create superior image quality, high resolution, and large active area images based on CMOS technology.

Equipment and technical data

- Active area 5 x 5 cm², Resolution 48 µm, Image depth 12 bit
- USB 2.0 interface

The includes the XRIS camera and USB-cable to connect it to the PC.

09057-40

XR 4.0 X-ray CT Z-rotation stage (XRstage)



Function and Applications

Rotating tabel to position samples e.g. for the CT application.

Benefits

- Z-axis rotation of the sample to be analysed: Movement of the sample is not influenced by gravitational effects, rigid bodies of flexible size can be analysed on a simple way.

Equipment and technical data

- Angle resolution < 1 degree, Motorised
- plug&measure interface, stepper motor with 4200 steps/360°

09057-42

XR 4.0 Software measure CT



Function and Applications

Software package of the "measure" series for controlling the digital X-ray sensor XRIS and the X-ray unit XR 4.0. The data can be exported in all of the established formats and then evaluated with the aid of professional software. This ensures a smooth transition from training to professional application.

Benefits

Plug & measure:

- The intuitive user concept considerably simplifies the operation of the complex devices and puts the experiment into the focus of attention. Automatic identification of the connected devices of the XR 4.0 series. Working directly without the need for specialist knowledge.

Double Control:

- Simultaneous operation via manual control or via a computer.

Reference experiments:

- The comprehensive collection of reference experiments and projects simplifies the selection of suitable experiments and can be used as a template for own experiment scripts/laboratory handbooks.

Clear structure:

- The software is clearly divided into the 4 basic steps "Parameters", "CT scan", "Reconstruction", and "3D view". As a result, even beginners can easily familiarise themselves with the topic. Visualisation of the devices: In the first steps, numerous parameters must be set, e.g. the anode current and voltage. In order to facilitate these steps, the corresponding devices are displayed as virtual devices.

CT scan with live reconstruction:

- Sectional images are reconstructed during the scanning process. While at the beginning of the measurement hardly anything can be discerned, the contours become increasingly clear over time.

Reconstruction as an independent step: Reconstruction is the most important process step in computed tomography. Again, numerous parameters play an important role during this step. They can be changed in their own screen and their effect can be observed directly in an example image.

x,y,z-viewer and 3D view

- This area shows the results of the reconstruction process. The data can now be evaluated with professional software that the students will encounter in their future daily work. The data can be exported in all of the established formats.

Recommended System requirements:

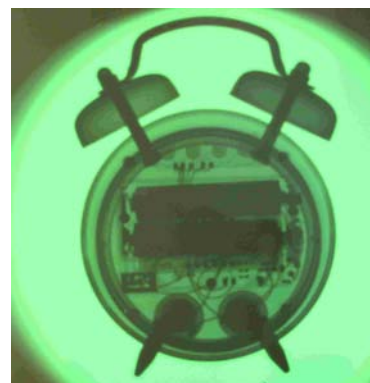
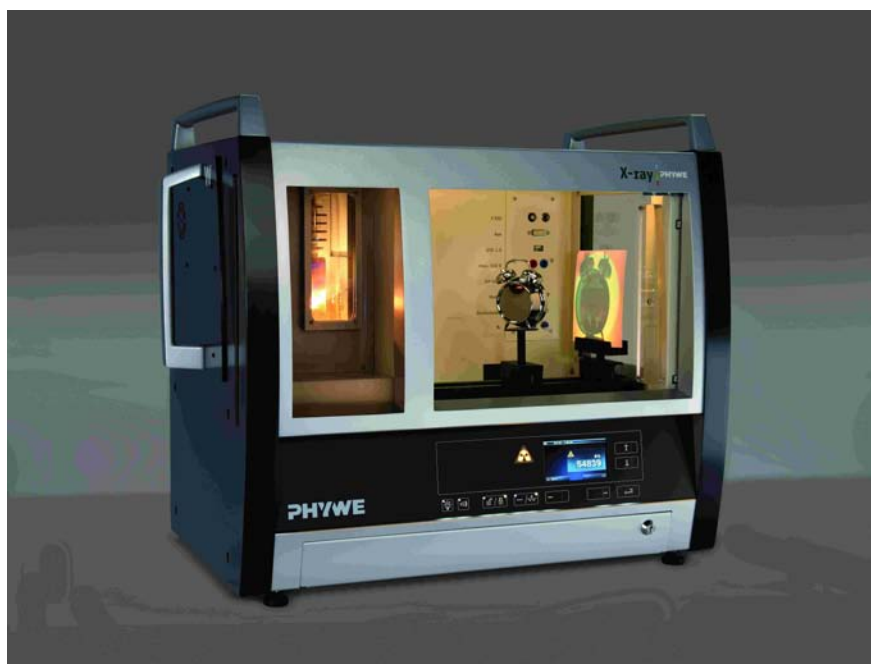
PC with at least an Intel Core i7 2600 (3.4GHz) 8MB - 4 Cores, 8GB (2x 4GB) 1600MHz DDR3, 40GB free hard drive space, DVD-drive, 4x USB 2.0, Microsoft Windows 7 64bit or higher. Graphic card: MSI nVidia GeForce N440GT 1GB or better.

14421-61

12 Modern Imaging Methods

12.1 X-ray Imaging

P2540020 Radiographic examination of objects



Radiography of a digital alarm clock.

Principle

An X-ray tube produces X-rays that cause a fluorescent screen to emit light. Objects that are located between the X-ray source and the fluorescent screen will be irradiated so that their inner structure becomes visible. If one varies the anode current and voltage, the change in intensity can be observed in a qualitative manner on the fluorescent screen.

Tasks

1. X-ray an object and observe the result on the fluorescent screen.
2. Vary the anode current and voltage and observe the result on the fluorescent screen.

What you can learn about

- X-ray tube; absorption of X-rays, radiography, fluorescence

Main articles

XR 4.0 expert unit	09057-99	1
XR 4.0 X-ray plug-in unit W tube	09057-80	1
XR 4.0 X-ray fluorescent screen	09057-26	1

Best fitting X-ray set for this experiment:

XRE 4.0 X-ray expert set

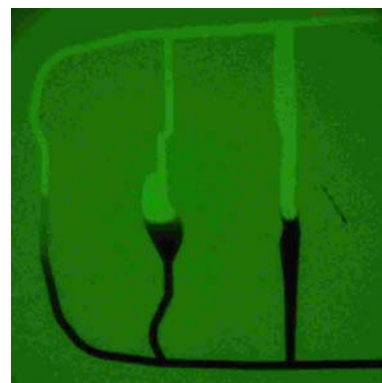
09110-88



Wilhelm Conrad Röntgen
1901, Nobel Prize in Physics

Contrast medium experiment with a blood vessel model

P2541901



Blood vessel model with the contrast medium half filled

Principle

When a blood vessel model is irradiated with X-rays, the blood vessels themselves are not visible at first. It is only after the injection of a contrast medium that the blood vessels become visible.

Tasks

1. Inject a 50% potassium iodide solution into the blood vessel model.
2. Observe the fluorescent screen of the X-ray basic unit to follow the course taken by the injected solution in the blood vessel model.

What you can learn about

- X-ray radiation, Bremsstrahlung
- Characteristic radiation
- Law of absorption
- Mass absorption coefficient
- Contrast medium

Main articles

XR 4.0 expert unit	09057-99	1
XR 4.0 X-ray plug-in unit W tube	09057-80	1
XR 4.0 X-ray fluorescent screen	09057-26	1
XR 4.0 X-ray Blood vess.model f.contrast fluid	09058-06	1
XR 4.0 X-ray optical bench	09057-18	1
Slide mount for optical bench, h = 30 mm	08286-01	2

Best fitting X-ray sets for this experiment:

XR 4.0 X-ray expert set

09110-88

XR 4.0 X-ray imaging upgrade set

09150-88

XR 4.0 Mobile X-ray Lab

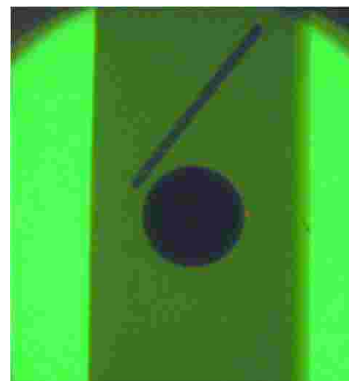


09057-48

12 Modern Imaging Methods

12.1 X-ray Imaging

P2542001 Determination of length and position of an object which can not be seen



Pictures of the implant model projection in the y,z-plane

Principle

This experiment provides training in determining the length and position of an object based on an X-ray image. A metal pin that is embedded in a wooden block is used as the model. This experiment is also an excellent preparatory exercise for demonstrating the principle of computed tomography.

Tasks

1. Record a bi-planar radiogram of two perpendicular planes of a metal pin which cannot be seen.
2. Determine the true length of the pin by taking into account the magnification factor which results from the divergence of the X-rays.
3. Determine the spatial position of the pin.

What you can learn about

- X-ray radiation
- Bremsstrahlung
- Characteristic radiation
- Law of absorption
- Mass absorption coefficient
- Stereographic projection

Main articles

XR 4.0 expert unit	09057-99	1
XR 4.0 X-ray plug-in unit W tube	09057-80	1
XR 4.0 X-ray fluorescent screen	09057-26	1
XR 4.0 X-ray Implant model for x-ray photography	09058-07	1

Best fitting X-ray sets for this experiment:

XRE 4.0 X-ray expert set

09110-88

XRI 4.0 X-ray imaging upgrade set

09150-88

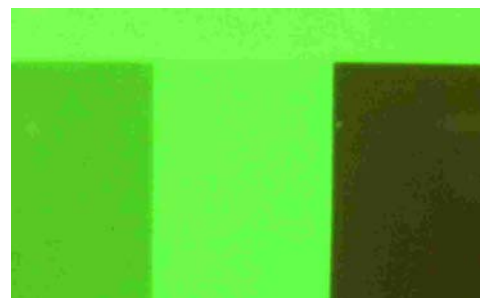
XR 4.0 expert unit



09057-99

Qualitative examination of absorption

P2540030



From left to right: aluminium, cardboard, iron
(all of them: $d = 1\text{ mm}$)

Principle

X-rays penetrate objects that are impenetrable for visible light. The absorption depends on the thickness and type of the material. This dependence is demonstrated in a qualitative manner on a fluorescent screen with the aid of various different absorption specimens.

Tasks

1. Observe the transmission of X-rays as a function of the material thickness.
2. Determine how the atomic number of the elements in a material affects the transmission of X-rays.

What you can learn about

- X-ray tube, absorption of X-rays; atomic number
- fluorescence, Lambert-Beer

Main articles

XR 4.0 expert unit	09057-99	1
XR 4.0 X-ray plug-in unit W tube	09057-80	1
XR 4.0 X-ray fluorescent screen	09057-26	1
XR 4.0 X-ray optical bench	09057-18	1
Slide mount for optical bench, $h = 30\text{ mm}$	08286-01	2

Best fitting X-ray set for this experiment:

XRE 4.0 X-ray expert set

09110-88

XR 4.0 X-ray plug-in unit W tube



Function and Applications

Factory adjusted tungsten tube in sheet steel housing ready for use in connection with XR 4.0 expert unit. Housing with plugs to accept the tubes operating quantities from the basic unit. With handle, mechanical lock and two switching pins, which only operate correspondingly security microswitches of the basic unit when the plug-in module is correctly inserted.

Benefits

Tube XChange Technology:

- Quick-change technology for four different X-ray tubes (W, Cu, Mo, and Fe), adjustment free, Complete protection against touching hot parts

Equipment and technical data

- Anode angle 19° , Max. operation datas 1 mA/35 kV
- Test voltage 50 kV, Mass 4.3 kg
- Dimensions (26.7 x 18.8 x 20.3) cm, Incl. dust protection cover.

09057-80

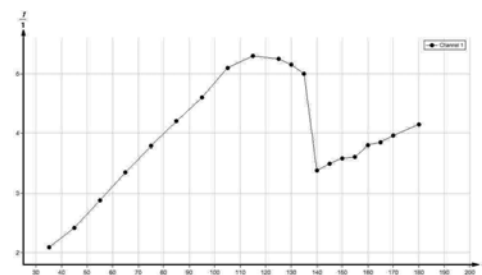
12 Modern Imaging Methods

12.1 X-ray Imaging

P2541101 Absorption of X-rays



NEW



Absorption edge of copper; UA = 25 kV; $\lambda_K = 138$ pm

Principle

The polychromatic X-radiation that is emitted by an X-ray tube is filtered in terms of its energy with the aid of a monocrystal.

The resulting monochromatic radiation is used as the primary radiation source for examining the absorption behaviour of various metal foils of different thicknesses.

Tasks

1. Determine the attenuation of the X-radiation by aluminium and zinc foils of different thicknesses and at two different wavelengths of the primary radiation.
2. Determine the mass absorption coefficient μ/ρ for aluminium, zinc, and tin absorbers of constant thickness as a function of the wavelength of the primary radiation. Prove the validity of $\mu/\rho = f(\lambda^3)$ in a graphical manner.
3. Determine the absorption coefficients μ for copper and nickel as a function of the wavelength of the primary radiation. Determine the energy values of the corresponding K shells based on the graphical representation. Prove the validity of $\mu/\rho = f(\lambda^3)$.

What you can learn about

- Bremsstrahlung; Characteristic radiation
- Bragg scattering; Law of absorption
- Mass absorption coefficient; Absorption edge
- Half value thickness; Photoelectric effect
- Compton scattering; Pair production

Main articles

XR 4.0 expert unit	09057-99	1
XR 4.0 X-ray goniometer	09057-10	1
XR 4.0 X-ray Plug-in Cu tube	09057-50	1
XR 4.0 Software measure X-ray	14414-61	1
Geiger-Mueller Counter tube, type B	09005-00	1

Best fitting X-ray sets for this experiment:

XRE 4.0 X-ray expert set

09110-88

XRP 4.0 X-ray Solid state physics upgrade set

09120-88

XR 4.0 X-ray goniometer



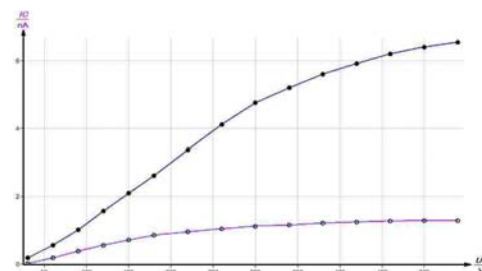
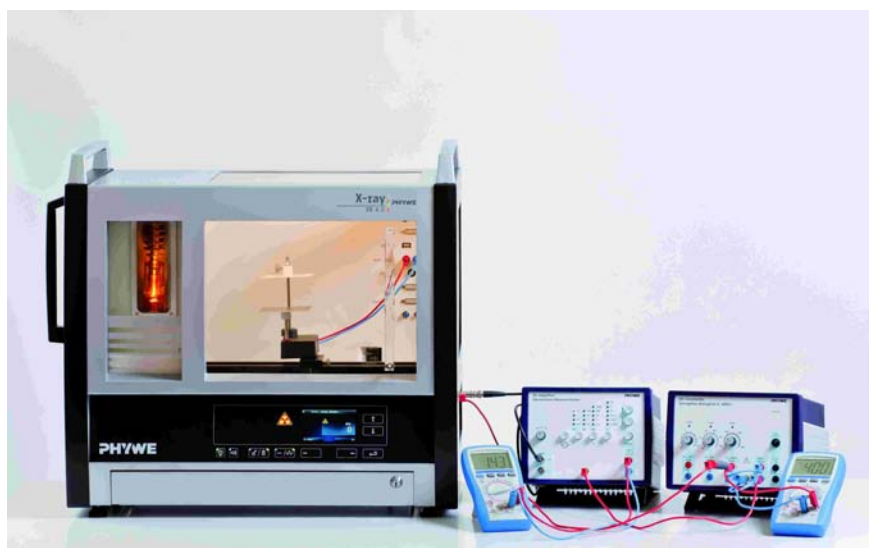
Function and Applications

Goniometer with two independent stepper motors for the precise angular positioning of a sample and detector.

09057-10

X-ray dosimetry

P2541801



Ionisation current I_C as a function of the capacitor voltage U_C for different diaphragm tubes.

Principle

Dosimetry, as a subspecialty of medical physics, deals with the determination and calculation of dose rates, which is also of great importance in view of the radiation protection directives. This experiment demonstrates the principle of measurement and it explains the various units of absorbed dose, equivalent dose, and absorbed dose rate. Inside a plate capacitor, an air volume is irradiated with X-rays. The resulting ion current is used to determine the dosimetric data.

Tasks

1. Using the two different diaphragm tubes and the fluorescent screen, the given distance between the aperture and the radiation source at maximum anode voltage and current is to be determined.
2. The ion current at maximum anode voltage is to be measured and graphically recorded as a function of the capacitor voltage by using two different beam limiting apertures. The ion dose rate and the energy dose rate are to be determined from the saturation current values.
3. Using the $d = 5$ mm aperture, the ion current is to be determined and graphically recorded at various anode currents but with maximum anode and capacitor voltages.
4. The ion current is to be measured and graphically recorded as a function of the capacitor voltage at different anode voltages and the corresponding saturation currents plotted graphically.

What you can learn about

- X-rays
- Absorption inverse square law
- Ionizing energy
- Energy dose
- Equivalent dose and ion dose and their Rates
- ϕ factor
- Local ion dose rate
- Dosimeter

Main articles

XR 4.0 expert unit	09057-99	1
XR 4.0 X-ray plug-in unit W tube	09057-80	1
DC measuring amplifier	13620-93	1
Power supply, 0...600 VDC	13672-93	1
XR 4.0 X-ray Capacitor plates f.x-ray-unit	09058-05	1

Related X-ray Experiment

Ionizing effect of X-radiation

P2540040

Best fitting X-ray sets for this experiment:

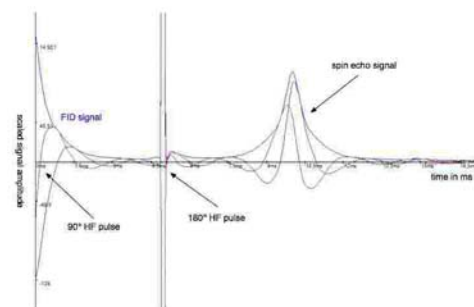
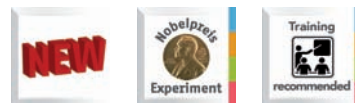
XRE 4.0 X-ray expert set

09110-88

XRD 4.0 X-ray dosimetry upgrade set

09170-88

P5942100 Basic principles in Nuclear Magnetic Resonance (NMR)



Spin echo signal of an oil sample occurring 10 ms (echo time) after a 90° HF pulse (FID signal is shown). To generate the echo signal a 180° HF pulse has to be switched after half the echo time.

Principle

The basic principles concerning the phenomenon of nuclear magnetic resonance (NMR) are demonstrated. Experiments are executed with a MRT training device giving the opportunity to investigate some small probes in the sample chamber. Device control is done with the provided software. Investigations comprise the tuning of the system frequency to the Larmor frequency, the determination of the flip angle of the magnetization vector, the effects of the substance quantity, the influence of particular magnetic field inhomogeneities, the measurement of a spin echo signal and an averaging procedure to maximize the signal-to-noise ratio. The adjustment of all parameters in these experiments are inevitable to obtain an adequate MR image.

Tasks

1. Tuning of the system frequency to the Larmor frequency.
2. Setting of the HF (High Frequency) pulse duration to determine the flip angle of the magnetization vector.
3. Effects of the substance quantity on the FID signal (Free Induction Decay) amplitude.
4. Minimizing magnetic field inhomogeneities via a superimposed magnetic field (shim).
5. Retrieving a relaxed FID signal via a spin echo flipping nuclear spins by 180°.
6. Improving the signal-to-noise ratio (SNR) of the FID signal.

What you can learn about

- Nuclear spins
- Atomic nuclei with a magnetic moment
- Precession of nuclear spins; Magnetization
- Resonance condition, MR frequency
- MR flip angle, FID signal (Free Induction Decay), Spin echo
- Relaxation times (T1: longitudinal magnetization, T2: transverse magnetization)
- Signal-to-noise ratio

Main articles

Compact magnetic resonance tomograph (MRT)	09500-99	1
--------------------------------------------	----------	---

Related Experiments

Magnetic Resonance Imaging (MRI)

P5942400

Relaxation times in Nuclear Magnetic Resonance

P5942200

Spatial encoding in Nuclear Magnetic Resonance

P5942300

Training recommended

Service | PHYWE

For this experiment we recommend a seminar on equipment technology, handling and information of equipment-specific characteristics on site.

03333-02

Compact magnetic resonance tomograph (MRT)



Function and Applications

The system gives you the unique opportunity of offering training at a real MRT machine directly on site. This is the only way to provide for realistic and practice-oriented nuclear magnetic resonance (NMR) training for all fields of science and medicine. The training software makes it easy for the users to experience all aspects of magnetic resonance tomography. The special option to influence experiments on runtime and to directly visualize the results gives users an unprecedented learning experience. In addition to parameters accessible only through MRT, as for example the tuning of the system frequency to the Larmor frequency or the specification of relaxation times, high-resolution tomographic MR images can be produced. Image artifacts found in clinical MRT can be examined directly in a simple process.

The system differs from other magnetic resonance tomographs only in the sample size and the fact that it is portable. However, in order to generate a fairly homogeneous magnetic field the sample chamber has to be comparatively small. The MRT compact set consists of the control unit, the magnet unit, and the training software and is optimized for education and training purposes. In addition to carrying out fundamental and basic experiments on MR technology, students can generate, export and analyze numerous images with all relevant contrasts in a high spatial resolution.

Benefits

- easy to connect and immediately operative (USB 2.0)
- new and numerous education experience
 - training at a real MRT in compact format with clinically relevant measuring procedures; high resolution MR imaging (2D, 3D)
 - live visualization of data; realtime control of experimental parameters
- realistic and practice-oriented training for all fields of science and medicine
 - T1/T2 measurements; all MR parameters accessible
 - experiment is selected from a clearly structured menu
 - measure a multitude of samples with a diameter up to one centimeter
 - software perfectly adapts to the operation for study purposes
 - suitable for a wide range of experiments, from basic understanding of magnetic resonance to complex imaging
- literature tailored precisely to the experiments (available with the set "compact magnetic resonance tomograph": 4 TESS experimental units
- possibility to select courses in which only the relevant parameters necessary for the findings are adjusted

Equipment and technical Data

The system includes the following components:

- Control unit:
 - gradient amplifier and transmitter and receiver unit
 - PC connection: USB-B; Connection of the imaging unit (gradient): RJ45; Connection of the receiver/transmitter unit: BNC; Power supply: 12 V DC, 2 A; Power supply unit (external): 100-240 VAC, 50/60 Hz, 2 A
 - Dimensions (length x width x height): 27 cm x 9.5 cm x 14 cm; Weight: 2.3 kg
- Magnet unit:
 - high-end gradient system for 2D and 3D images; System frequency: 22 MHz
 - Field intensity: 500 mT; Field homogeneity: < 100 ppm
 - Sample diameter: max. 10 mm
 - Connection of the imaging unit (gradient): RJ45
 - Connection of the receiver/transmitter unit BNC
 - Dimensions (length x width x height): 27 cm x 25 cm x 14 cm; Weight: 17.5 kg
- Training Software:
 - Languages: German/English (other languages on request)
 - Product license: Training version; Data formats: DICOM, JPEG, CSV, TXT; Media types: USB stick
- Sample set
 - 5 different samples (water and oil samples each of with 5 and 10 mm diameter, sample with a particular structure)
 - 1 empty sample tube, 10 mm
 - Sturdy carrying case for safe transport
 - USB stick incl. training software, comprehensive descriptions of the experiments, detailed theoretical background, structured implementation plan, exercises, analyses with many figures clearly arranged (possibility to extend the basic set), operating manuals

Accessories

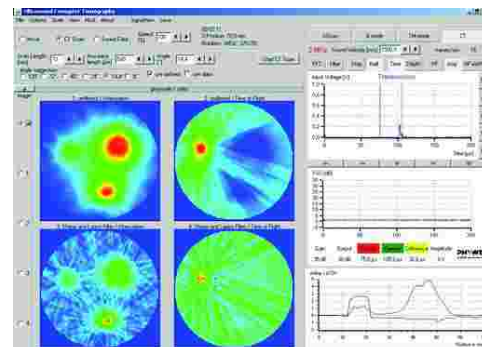
- Computer (min. processor 1.6 GHz) with Windows XP (32-Bit)/Vista (32-Bit)/7, USB 2.0 interface, min. 1 GB RAM, min. of 1 GB hard-disk space, 1024 x 758 graphics card (min. 256 MB, compatible with DirectX 9.0), 16-bit color resolution or better
- Soundbox for realistic background noise to connect the experiments with everyday experiences

09500-99



Cross-sectional image of a branch

P5161200 Ultrasonic computertomography



Input of the CT-scan parameters.

Principle

This experiment explains the fundamental principles of the image formation with a CT algorithm. A simple test object is used to create an attenuation tomogram and a time-of-flight tomogram followed by a discussion of the respective differences.

Tasks

1. Creation of several attenuation and time-of-flight tomograms
2. Variation of the device parameters
3. Discussion of the differences

What you can learn about

- Ultrasonic echography (A-scan)
- Tomography
- Resolution

Main articles

Basic Set Ultrasonic echoscope	13921-99	1
Extension Set: CT Scanner	13922-99	1
Ultrasonic probe 2 MHz	13921-05	1

Extension Set: CT Scanner



Function and Applications

This set is an extension to the ultrasonic pulse echo methods, including automated imaging methods like CT and B mode. With this set the development of a CT image can be demonstrated step by step. Automated B-scan images can be made with this set as well. The scanned objects can be measured and evaluated in axial and lateral direction. The results of the automated measurements with scanner have a much better quality, especially with the imaging methods.

Benefits

For a rather low invest, compared to real life systems, the advantages of mechanical scanning can be demonstrated in a very comprehensible way.

Equipment and technical data

- 1x CT scanner
- 1x CT control unit with tomography software
- 1x Water tank
- 1x CT sample

13922-99

Ultrasonic echography (A-Scan)

P5160200

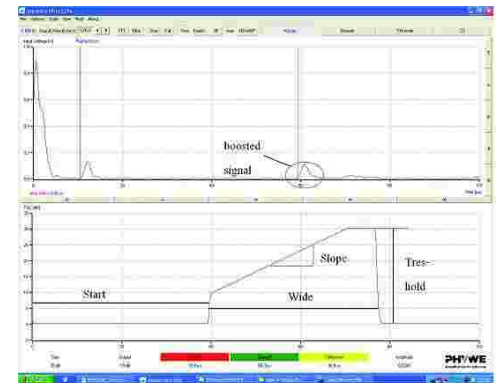
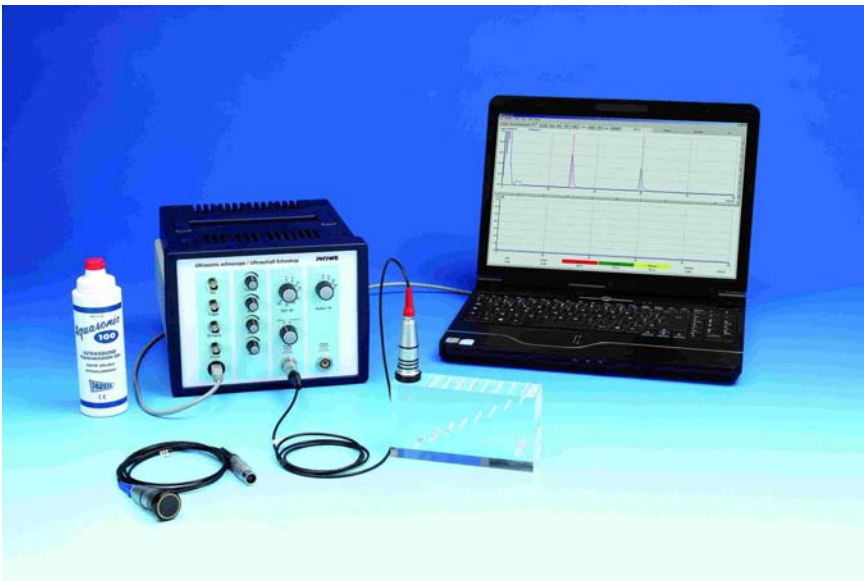


Illustration of the effects of the amplifier or booster settings on the diagram.

Principle

An ultrasonic wave transmitted in a sample will be reflected at discontinuities (defects, cracks). From the relationship between the time of flight of the reflected wave and the sound velocity, the distance between ultrasonic transducer and defects(reflector) can be calculated. Position and size of these defects can be determined by measuring in different directions.

Tasks

1. Measure the longest side of the block with the calliper and the time of light of ultrasound wave for this distance with the 2 MHz probe
2. Calculate the sound velocity.
3. Measure the position and the size of the different defects of the test block with the calliper and the ultrasound echography method.

What you can learn about

- Propagation of ultrasonic waves; Time of flight; Echo amplitude
- Reflection coefficient; A-scan; Flaw detection
- Non destructive testing (NDT); Ultrasonic transceiver

Main articles

Basic Set Ultrasonic echoscope	13921-99	1
Vernier caliper	03010-00	1

Related Experiment

Ultrasonic echography (B-Scan)

P5160300

Basic Set Ultrasonic echoscope



Function and Applications

With the ultrasonic echoscope the basics of ultrasound and its wave characteristics can be demonstrated. Terms like amplitude, frequency, sound velocity or Time Gain Control TGC will be explained.

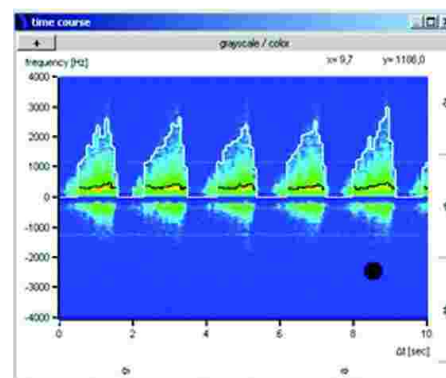
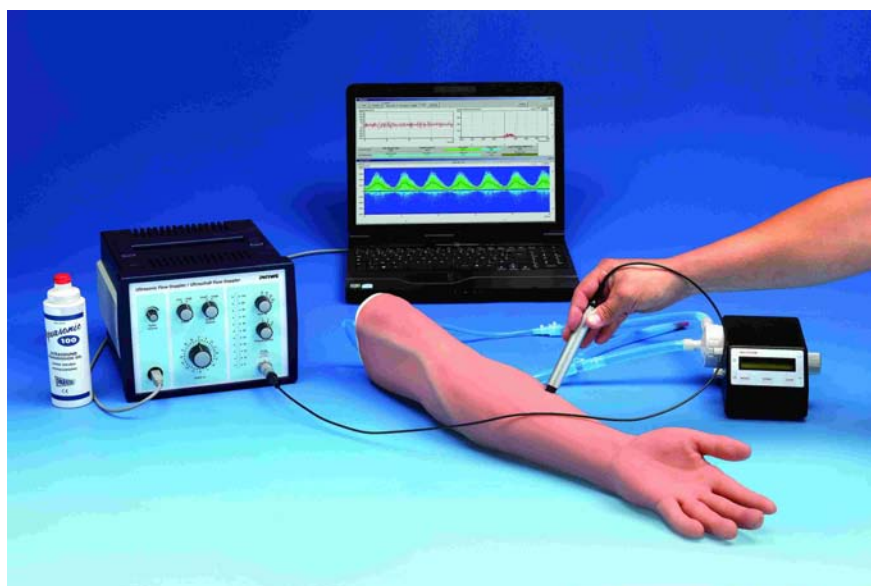
The cylinder set can be used to vividly demonstrate reflection as well as sound velocity and frequency depending on attenuation in solid state materials.

The knowledge e.g. regarding sound velocity will be used to measure the test block.

The principles of image formation from A-scan to B-scan can be explained. With the different probes the frequency depending resolution can be evaluated.

13921-99

P5950100 Doppler sonography



Typical Doppler signal measured with PHYWE measure Ultra Flow software.

Principle

This set-up shows how blood flow studies are performed using Doppler ultrasound (Doppler sonograph). On a realistic arm dummy, the differences between continuous (venous) and pulsating (arterial) flow are shown as well as the difference in flow through a normal blood vessel and a stenosis.

Tasks

1. Analyse blood flow and search positive and negative flow components. Explain the differences
2. Locate the built-in stenosis and compare the spectral distribution upstream and downstream of the stenosis
3. Examine and compare the three pulse modes of the pump.

What you can learn about

- Venous Flow
- Arterial flow
- Stenosis
- Blood flow velocity tracings
- Frequency shift
- Doppler effect
- Doppler angle
- Doppler sonography
- Colour Doppler
- Continuity equation

Main articles

Basic set: Ultrasonic Doppler technique	13923-99	1
Extension Set: medical Doppler Sonography	13923-02	1

Basic set: Ultrasonic Doppler technique



Function and Applications

Kit containing instrument and accessories for general ultrasonic sonography experiences. The software displays the measured data from the ultrasonic doppler apparatus, basic instrument of this kit, in realtime on the computer screen. Modular and extendable with accessory kits for experimentations in the fields of hydraulics and medical diagnostics.

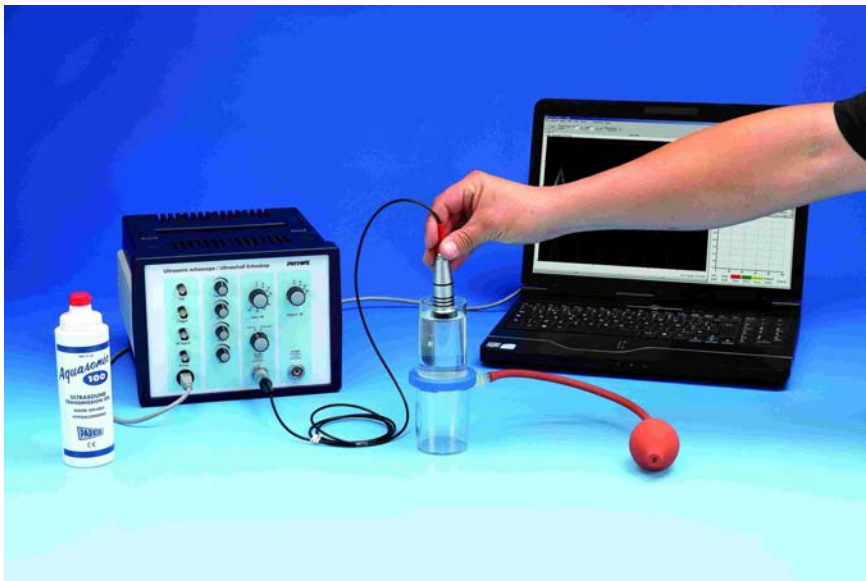
Benefits

- This kit forms a very didactic experimentation system beginning from the basics of sonography and can with accessory kits be extended for the use in specific applications as hydraulics and medical diagnostics (only for training purposes!)
- an experimentation manual is included

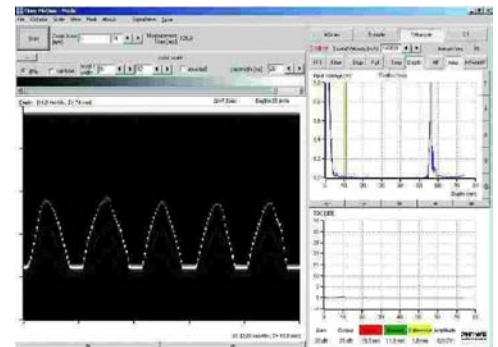
13923-99

Ultrasonic Time Motion Mode

P5950200



NEW



Time Motion-mode, slow heart (pump) rate.

Principle

Using a simple heart model, the wall motion is recorded with the ultrasonic time motion method (M-mode or also TM-mode). The heart rate and the cardiac output (CO) are determined from the recorded TM-mode curve.

Tasks

- Simulate with heart model, the cardiac wall motion and record a time motion-image
- On basis of the time-motion image, determine the cardiac output and heart rate parameters.

What you can learn about

- Pulse duration (DT)
- Heart rate
- End systolic diameter ESD
- End systolic volume ESV
- Cardiac output (CO)
- Heart wall motion
- Echocardiography
- Time-Motion-Mode
- Representation of motion sequences
- Ultrasonic echography

Main articles

Basic Set Ultrasonic echoscope	13921-99	1
Extension set: medical ultrasonic diagnostics	13921-04	1

Related Experiments

Ultrasonic investigation with breast dummy

P5950300

Ultrasonic investigation with eye dummy

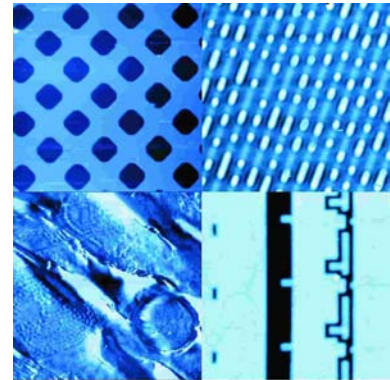
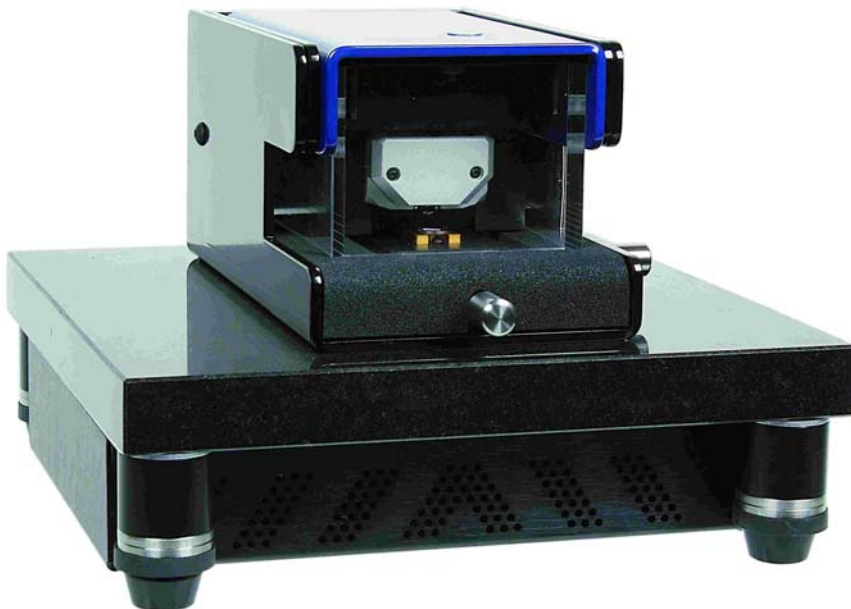
P5950400



made
in
Germany

P2538000

Basic methods in imaging of micro and nanostructures with atomic force microscopy (AFM)



Topography of Microstructure (50 micrometer), CD Stamper (20 micrometer), Skin Cross-Section (60 micrometer), and SCA chip structure (40 micrometer) FLTR.

Principle

Approaching a sharp silicon tip mounted on a cantilever to a sample surface leads to an atomic scale interaction. The results is a bend of the cantilever which is detected by a Laser. In static mode the resulting deflection is used to investigate the topography of the sample surface line-by-line using a feedback loop. In dynamic mode the cantilever is oscillated at fixed frequency resulting in a damped amplitude near the surface. The measurement parameters (setpoint, feedback gain,...) play a crucial role for image quality. The dependence on the imaging quality is investigated for different nano structured samples.

Tasks

1. Set-up the microscope and start up the software. Mount a cantilever (with tip) and approach the tip towards a sample.
2. Investigate the influence of the scanning parameters on the imaging quality and performance, e.g. PID gain, setpoint (force), vibrational amplitude, and scanning speed. Use both static and dynamic force mode.
3. Image 7 different samples (microstructures, carbon nano tubes, skin cross-section, bacteria, CD stamper, chip structure, glass beads) by optimizing the parameters respectively.

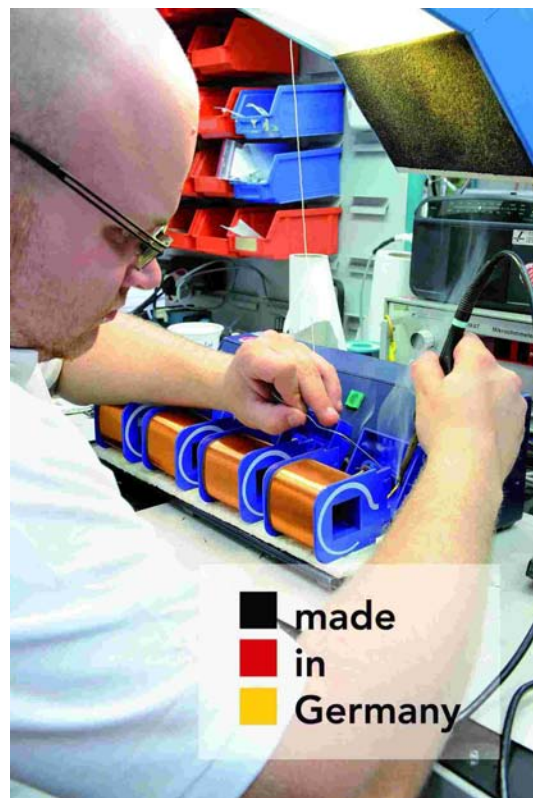
What you can learn about

- Atomic Force Microscopy (AFM)
- Lennard-Jones potential
- Imaging of nano structures
- Static Force Mode
- Dynamic Force Mode
- Feedback Loop
- Force
- Vibrational Amplitude

Main articles

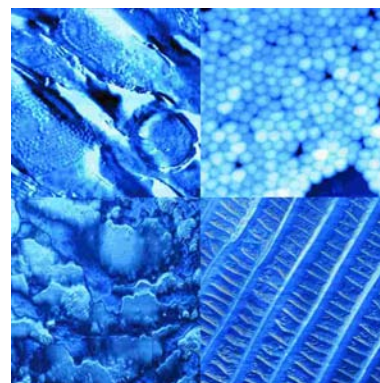
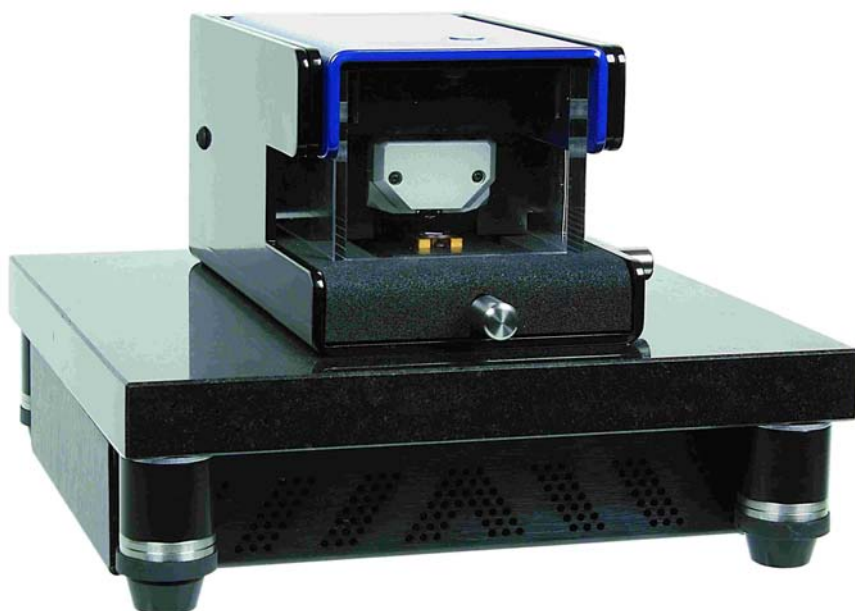
Compact-Atomic Force Microscope (AFM)

09700-99 1



Imaging of biological and medical micro and nanostructure with atomic force microscopy (AFM)

P2538400



Topography of Skin Cross-Section (60 micrometer), Staphylococcus Bacteria (10 micrometer), Human hair (40 micrometer), and Butterfly Wing (10 micrometer) FLTR.

Principle

Dynamic Atomic Force Microscopy is used to image and visualize several biological samples at a sub micrometer scale. A collection of both pre-prepared and freshly prepared samples are investigated, e.g. bacteria, skin cross-section, human hair, butterfly wing, blood cells, and fly eye. With high resolution imaging the relation between small biological structures and their function can be identified and different treatments could be recognized at this scale. One example is the imaging of different skin layers showing dead and living epithelial layer, collagen layer, hair follicle and structures within it. Another example is the imaging of different regular lattice structures to clarify the colour effect of butterfly wings.

Tasks

1. Set-up the microscope and start up the software. Mount a cantilever and approach the tip towards a sample.
2. Use pre-prepared samples and investigate their topography by optimizing the imaging parameters. Discuss the relation between the imaged structures with their function.
 - Skin cross-section: different layers and their structures
 - Staphylococcus Bacteria: form, alignment and surface structure
4. Prepare different samples and investigate their topography by optimizing the imaging parameters. Discuss the relation between the imaged structures with their function and treatment.
 - Blood cells: different form and structure, function
 - Butterfly wing: different regular structures, interference of light and colour effect
 - Fly eye: compound of many "eye" units, resolution, viewing angle, reaction time

- Human hair: treatment dependence of surface structure (coloured and non-coloured, wet and dry)

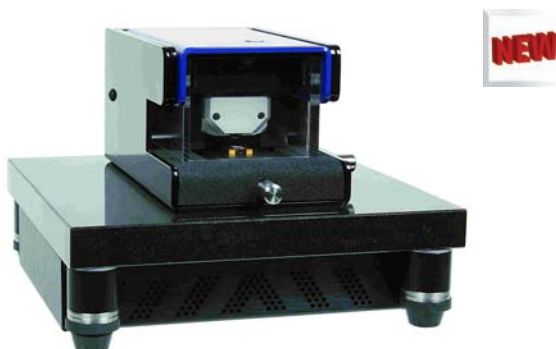
What you can learn about

- Atomic Force Microscopy
- Dynamic mode
- Feedback loop
- High resolution 3D imaging
- Nano Imaging of biological and medical samples
- Relation of structure and function
- Blood Cells
- Butterfly Wing
- Insect Eye
- Bacteria
- Skin
- Human hair

Main articles

Compact-Atomic Force Microscope (AFM)	09700-99	1
Sample support, 10 pcs, for Compact Scanning Tunneling Microscope and Atomic Force Microscope	09619-00	1

Compact-Atomic Force Microscope (AFM)



Function and Applications

Compact and easy to use atomic force microscope to visualize and image structures on the micro and nano meter scale. Developed for educational purposes in practical lab course and pre-research labs in physics, chemistry, life sciences and material sciences. Also suitable to determine material characteristics (e.g. stiffness, magnetization, charging, material and phase contrast) and for manipulation (e.g. lithography).

Benefits

- Out-of-the-box device with integrated damping plate and control unit underneath
- Complete set, incl. Sample Set, Cantilever, Tools and Consumables
- Tip Scanner AFM for standard cantilever
- Easy and safe cantilever exchange and use: Flip mechanism with automatic laser switch off,
- no laser alignment, mechanical stopper for longer lifetime of cantilevers
- Digital top view camera for easy positioning and side view lens for easy and fast approach
- Portable and compact: transportable, easy to install with a small footprint
- Easy to use: Ideal for nanotechnology education, preparing students for their work on high-level research devices, and outreach

Equipment and technical Data

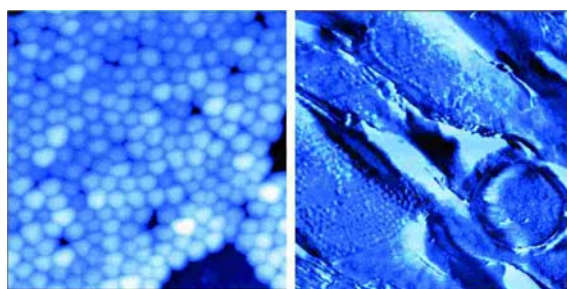
- Scan head with integrated control-unit on vibration-isolated experimentation board: 21cm x 21cm x 18cm, USB 2.0 interface, 16 bit DA converter (XYZ), 16 bit AD converter (7 channels)
- Max scanning speed 60 ms/line, up to 2048x2048 data points
- Scan type (tip scanner): Linear low voltage electro magnetic
- Scan Range: 70 micro meter (1.1 nm resolution)
- Z-range: 14 micro meter (1.1 nm resolution); Z noise level (RMS): 0.6 / 0.5 nm (static / dynamic); Automatic approach: vertical, range 4.5 mm
- Sample: max. 13 mm in diameter, horizontal mount, LED illumination, Micrometer translation stage xy: min. +/- 5 mm
- Cantilever Alignment: automatic adjustment, alignment grooves from various suppliers; Camera system for top view: USB digital color, 3.1 M pixels
- Modes of operation: Static Force, Dynamic Force, Force Distance Spectroscopy, Amplitude Distance Spectroscopy

- Other modes (MFM,AFM, Phase contrast, lithography and advanced spectroscopy modes)
- available with upgrade options material and spectroscopy and manipulation
- User expandability (scripting) available (upgrade option); Set of 10 Cantilever, 6 samples, Toolset
- Software for measuring, manipulation, analysing and visualization, Handbook and Quick Installation Guide

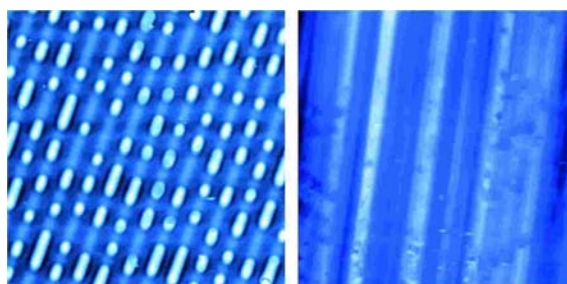
Accessories

- Material upgrade (Art. 09701-00): Additional Operating Modes (Phase Contrast, EFM, MFM, Force
- Modulation, Spreading Resistance), set of samples and cantilevers
- Spectroscopy and Manipulation upgrade (Art. 09702-00): Additional Operating Modes (Advanced Spectroscopy, Lithography (scratching, oxidation), Manipulation (oxidation, cutting and moving/pushing of nanoparticles)), User expandability (Visual basic, LabView, etc.), set of cantilevers and samples
- Side View Camera System (available 2013), other samples

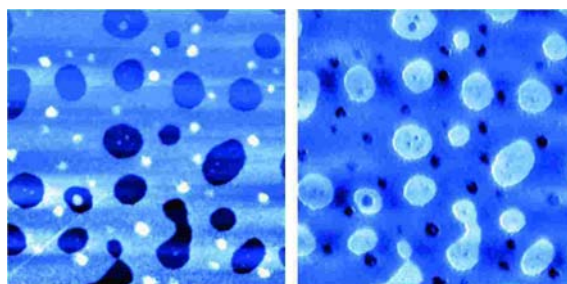
09700-99



Staphylococcus Bacteria, 10 μm and Skin Cross-Section, 60μm

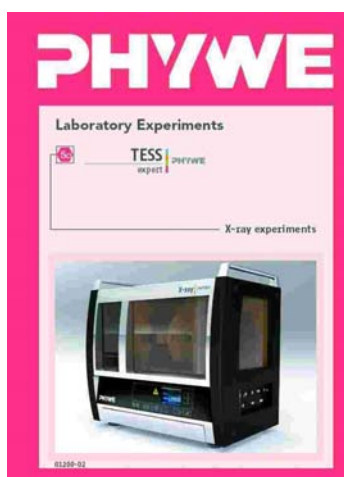


CD Stamper, 20 μm and Aluminum Foil, 60μm



PS/PMMA films: Topography and Phase Contrast, 3μm

Handbook Physics X-Ray Experiments



NEW

Article no. 01200-02

Experiments with X-rays and their use in physics, chemistry, biology, medicine, material science, and geology

Description

Comprehensive collection of reference experiments concerning the fundamental principles and use of X-rays in physics, chemistry, biology, medicine, material science, and geology with the XR 4.0 X-ray unit platform as a pool of ideas concerning the potential areas of application in demonstration and laboratory experiments.

A clear matrix simplifies the orientation in terms of scientific fields and topics.

Topics

- Characteristic X-radiation / atomic structure / quantum physics and chemistry
- X-ray absorption, Compton scattering, Dosimetry
- Crystal structures/structural analysis with X-rays/Debye-Scherrer experiments (counting tube goniometer)
- Transirradiation experiments/non-destructive testing

Features

- Experiment descriptions with clearly structured learning objectives, fundamental principles, photo of the set-up, equipment list, tasks, illustrated instructions concerning the set-up and procedure, theory and evaluation with example results plus important notes concerning the operation and safety of the equipment.
- This simplifies the orientation and execution as well as the selection of the experiment parts for personalised laboratory experiments. The information provided is so comprehensive that no other background information is required.
- For every experiment, the software package "XRM 4.0 measure X-ray" includes presettings for the easy and direct execution of the experiment at the push of a button as well as numerous example measurements.
- Experiment matrix for quick orientation
- Operating instructions concerning the components of the XR 4.0 platform including detailed information
- DIN A4 format, spiral-bound
- Colour print

This documentation contains the following experiments:

Counter tube characteristics

P2540010

Radiographic examination of objects

P2540020

Qualitative examination of the absorption of X-rays

P2540030

Ionizing effect of X-radiation

P2540040

Characteristic X-rays of copper

P2540101

Characteristic X-rays of iron

P2540301

The intensity of characteristic X-rays as a function of the anode current and anode voltage

P2540401

K alpha doublet splitting of iron X-rays / fine structure

P2540801

Duane-Hunt displacement law and Planck's "quantum of action"

P2540901

Characteristic X-ray lines of different anode materials / Moseley's law

P2541001

Absorption of X-rays

P2541101

K and L absorption edges of X-rays / Moseley's law and the Rydberg constant

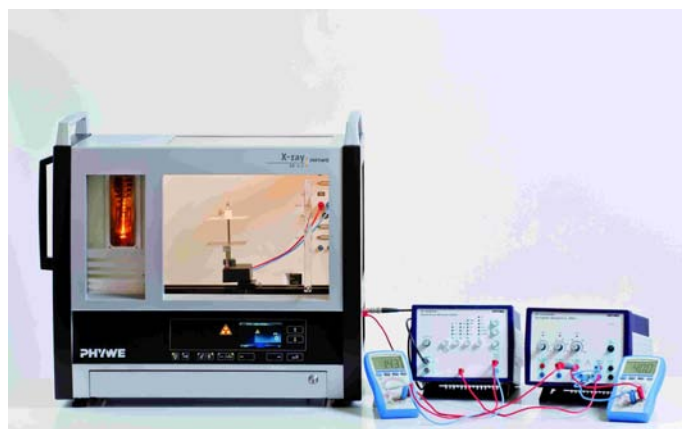
P2541201

Examination of the structure of NaCl monocrystals with different orientations

P2541301

Complete experiment list see www.phywe.com

01200-02



P2541801 - X-ray dosimetry - page 137

Laboratory Experiments Application of ultrasounds in medicine, material sciences and industry



Article no. 01232-02

Description

19 detailed experiment guides.

Topics

- medical diagnostics
 - echography / mammosonography
 - echography / ultra sonic biometry
 - echo-cardiography
 - Doppler-sonography
 - ultrasonic computerized tomography (CT)
- material sciences / physics
 - A-scan, B-scan
 - velocity and attenuation of ultrasound in solid state material
 - Shear waves
 - Focus zone, resolution power
 - non-destructive testing (NDT) (Detection of discontinuities, angle beam measurement, Time of flight diffraction (TOFD))
 - mechanical scan methods, ultrasonic computerized tomography (CT)
- fluid dynamics
 - Laws of flow, flow measurements
 - Level measurement

Features

- Experimental guides with clearly structured learning objectives, fundamental principles, photo of the set-up, equipment list, tasks, illustrated instructions concerning the set-up and procedure, theory and evaluation with example results plus important notes concerning the operation and safety of the equipment. In most cases no other background information is required.
- DIN A4 format, spiral-bound, colour print, 200 pages
- incl. operating manuals
- Experiment guides in English

01232-02

Laboratory Experiments Magnetic Resonance Tomography (MRT) Applications in physics, biology, chemistry and medicine



Article no. 01233-02

Description

Comprehensive collection of experiments regarding the magnetic resonance (MR) technology. The manual comprises basic experiments of the MR physics as well as experiments on complex MR imaging (2D and 3D). Experiments are didactically and precisely prepared and convey all relevant information about magnetic resonance tomography. Through questions, answers, evaluations and a comprehensive theory students are guided and are able to learn one of the most important procedures of medical diagnostics with a lot of fun and enjoyment. The software needed to perform the experiments perfectly fits the experimental literature and thus enables an unique learning and teaching experience. For example parameters can be directly varied during a measurement ("on runtime").

The manual is suitable for almost all fields of science. However, basically it is aimed at students with a deep medical background.

Topics

The manual consist of five TESS expert experimental units (P5942100-P5942500). Each unit consists of a multitude of single experiments an covers a very specific topic of MR physics and MR diagnostics.

- Basic principles in nuclear magnetic resonance (NMR)
- Relaxation times in nuclear magnetic resonance
- Spatial encoding in nuclear magnetic resonance
- Magnetic resonance imaging I (Spin Echo 2D, Flash 2D)
- Magnetic resonance imaging II (Localized Spin Echo 2D and 3D)

Features

- Experimental descriptions with a clear division in related topics, principle, equipment, set-up, questions, tasks, illustrated implementation related to the tasks, theory with many coloured figures and all necessary contents to process the questions and tasks, evaluation with exemplary results, and important notes for operation and safety.

01233-02



Indices

13.1	Numerical index	140
13.2	Alphabetical index	141

13 Indices

13.1 Numerical index

Art no.	Description	Page	Art no.	Description	Page
P0892300	Paper chromatography of chloroplast pigments	54	P4110660	The importance of Carbon dioxide for...	54
P0898200	Spectroscopic identification of sodium,...	58	P4120140	Determination of the isoelectric point of...	94
P0911700	Humidity preferendum of soil arthropods	67	P4120160	Determination of the isoelectric point of...	94
P0938300	Agonistic behaviour in male fighting fish	50	P4120260	The ionic permeability of the cell...	56, 92
P0938400	Shooling behaviour in fish	50	P4120360	Determination of the Michaelis constant...	93
P1034700	Absorption of minerals by plants	58	P4120460	Substrate inhibition of enzymes (with Cobra4)	93
P1056600	Learned behaviour in fish	50	P4120560	Enzyme inhibition (poisoning of enzymes)...	93
P1135700	Osmosis - dependence of the osmotic...	56	P4140100	Fundamental microbiological working methods	96
P1313600	Fermentation of molasses to ethanol with...	110	P4140200	Evidence of the spread of bacteria	97
P1313700	Microbial synthesis of ethanol by...	111	P4140300	Microscopy of bacteria	98
P1313800	Production of amino acids by fermentation...	112	P4140400	Determination of the microbial count	99
P1313900	Bacteria and mining - microbial...	113	P4140500	Evidence of the effect of antibiotics,...	96
P1314000	Immobilised cells in the service of...	114	P5160200	Ultrasonic echography (A-Scan)	131
P1441201	Chloroplasts in moss leaves	24	P5160300	Ultrasonic echography (B-Scan)	131
P1441301	Chromoplasts	24	P5161200	Ultrasonic computertomography	130
P1441401	Nucleus and chromosomes	24	P5942100	Basic principles in Nuclear Magnetic...	128
P1442101	Cross-section of a conifer (gymnosperm) leaf	25	P5942200	Relaxation times in Nuclear Magnetic...	128
P1442301	Stem of a monocotyledonous plant	25	P5942300	Spatial encoding in Nuclear Magnetic...	128
P1442601	Starch as a nutritional reserve substance...	25	P5942400	Magnetic Resonance Imaging (MRI)	128
P1443101	Blood cells	26	P5950100	Doppler sonography	75, 132
P1443201	Kidney	26	P5950200	Ultrasonic Time Motion Mode	78, 133
P1443301	Liver cells (hepatocytes)	26	P5950300	Ultrasonic investigation with breast dummy	133
P1443701	Planaria	29	P5950400	Ultrasonic investigation with eye dummy	70, 133
P1443801	Nematoda	29	P8001060	How much air can our lungs contain?	88
P1443901	Brine shrimp (Artemia salina)	29	P8001160	Direct determination of lung volume from...	88
P1444201	Spore capsules of ferns	30	P8001260	Does the lung volume depend on how tall...	88
P1444301	Mould fungi growing on food	31	P8001360	Diagnosis of lung illnesses (FEV) (with...	89
P1444501	Colony-forming ciliates in an aquarium	31	01200-02	Handbook Physics X-Ray Experiments	137
P1444901	Bacteria	31	01232-02	Laboratory Experiments Application of...	138
P1521063	The pH value of various soils (with Cobra4)	42	01233-02	Laboratory Experiments Magnetic Resonance...	138
P1521163	Salinity of soils and plant substrates...	41, 57	01331-02	Demo advanced Biology Manual Cobra4...	62
P1522160	We investigate our physical fitness - the...	76	04431-93	Autoclave with insert	96
P1522260	Measuring reading skills (with Cobra4)	49	07152-93	Large-scale display, digital	57
P2538000	Basic methods in imaging of micro and...	27, 100	09057-10	XR 4.0 X-ray goniometer	126
P2538400	Imaging of biological and medical micro...	27, 100	09057-40	XR 4.0 X-ray Direct Digital Image Sensor...	121
P2540020	Radiographic examination of objects	122	09057-42	XR 4.0 X-ray CT Z-rotation stage (XRstage)	121
P2540030	Qualitative examination of absorption	125	09057-48	XR 4.0 Mobile X-ray Lab	123
P2541101	Absorption of X-rays	126	09057-80	XR 4.0 X-ray plug-in unit W tube	125
P2541801	X-ray dosimetry	127	09057-99	XR 4.0 expert unit	124
P2541901	Contrast medium experiment with a blood...	123	09110-88	XRE 4.0 X-ray expert set	119, 120
P2542001	Determination of length and position of...	124	09120-88	XRP 4.0 X-ray Solid state physics upgrade set	126
P2550100	Computed tomography	119	09150-88	XRI 4.0 X-ray imaging upgrade set	123, 124
P4010111	Recording of nerve and muscle potentials...	64, 107	09170-88	XRD 4.0 X-ray dosimetry upgrade set	127
P4010160	Recording of nerve and muscle potentials...	64, 107	09180-88	XRCT 4.0 X-ray Computed Tomography...	119, 120
P4010211	Recording of nerve and muscle potentials...	64, 107	09500-99	Compact magnetic resonance tomograph (MRT)	129
P4010311	Recording of nerve potentials after the...	65, 107	09700-99	Compact-Atomic Force Microscope (AFM)	28, 136
P4010462	Model experiment illustrating the...	65, 102	12610-00	Cobra4 USB-Link	85, 103
P4010511	Neurosimulator: membrane time constant...	104	12623-88	Cobra4 Display-Connect, Set of...	41
P4010560	Neurosimulator: membrane time constant...	104	12638-00	Cobra4 Sensor-Unit Thermodynamics,...	55
P4010611	Neurosimulator: mode of operation of...	104	12670-00	Cobra4 Sensor-Unit Weather: Humidity, Air...	40
P4010711	Neurobiology: the nerve cell	105	12673-12	TESS advanced Biology manual Cobra4...	90
P4010760	Neurobiology: the nerve cell (with Cobra4)	105	12673-89	TESS advanced Applied Sciences set...	90
P4010811	Neurobiology: nerve cell interactions	105	13290-02	TESS advanced Biology manual Microscopy	32
P4010860	Neurobiology: nerve cell interactions...	105	13290-10	Chemicals set for TESS Microscopy (for up...	30
P4010911	Neurobiology: neural networks	106	13443-88	TESS advanced Microscopy MIC necessary...	32
P4010960	Neurobiology: neural networks (with Cobra4)	106	13444-88	TESS advanced Microscopy MIC consumables...	32
P4011011	Neurobiology: complex neural networks	106	13505-93	Power supply 0...12V DC/ 6 V, 12V AC, 230V	68, 87
P4020160	Human electrocardiography (ECG) (with Cobra4)	72	13615-03	Immersion probe NiCr-Ni, steel, -50...400°C	61
P4020211	Phonocardiography: Cardiac and vascular...	77	13654-99	Digital Function Generator, USB, incl....	81
P4020260	Phonocardiography: Cardiac and vascular...	77	13921-04	Extension set: Medical ultrasonic diagnostics	78
P4020360	Blood pressure measurement (with Cobra4)	73	13921-99	Basic Set Ultrasonic echoscope	70, 131
P4020460	Changes in the blood flow during smoking...	74	13922-99	Extension Set: CT Scanner	130
P4030160	Electromyography (EMG) on the upper arm...	79	13923-99	Basic set: Ultrasonic Doppler technique	75, 132
P4030211	Muscle stretch reflex and determination...	80	14421-61	XR 4.0 Software measure CT	121
P4030260	Muscle stretch reflex and determination...	80	14550-61	Software Cobra4 - multi-user licence	60, 79
P4040101	Human merging frequency and upper hearing...	81	15290-33	Set of TESS Microscopy MIC, with CD-ROM...	32
P4040215	Hearing threshold and frequency...	81	15290-88	TESS advanced Biology set Microscopy, BS 4	32
P4040311	Acoustic orientation in space (with Cobra3)	82	30346-00	Excursion set, soil analysis	45
P4040360	Acoustic orientation in space (with Cobra4)	82	30834-77	Ecology case, biological water analysis	43
P4050200	The effect of gravity and centrifugal...	59	30836-77	TESS Applied Sciences set examination of soil	45
P4060200	Preferential temperature in insects	66	30837-77	TESS Biology set chemo-physical water testing	43
P4060360	Regulation of human body temperature...	86	30838-77	TESS Applied Sciences Set Gas examination	44
P4070100	Optomotor response in insects	68	30839-00	Reagent case for water analysis with...	44
P4070200	Determination of the human visual field	83	35600-99	Spectrophotometer S800, 330...800 nm	111
P4070300	Time resolving capability of the human eye	83	36499-93	Motor.piston burette, univer.50ml	94
P4070400	Test of human reaction capacity	87	45510-00	Panel for complete experimental set-ups	110
P4070560	Human electrooculography (EOG) (with Cobra4)	85	46265-15	pH-electrode, plastic body, gel, BNC	37
P4070600	Additive colour mixing and colour masking	83	63020-99	SWIFT Microscope M3601C	24
P4070760	Electronystagmography (with Cobra4)	84	63021-99	SWIFT Student Microscope M3602C-3	98
P4080300	Learning performance of humans	48	64203-02	Humidity determination apparatus in...	67
P4090100	Volumetric measurement of breathing in...	69	64906-00	Diaphragm filter apparatus	99
P4090260	Measurement of the respiratory rate (with...	88	65961-93	Biological amplifier	80
P4100160	Comparison of the heat capacities of...	34	65973-93	Centrifuge w. angle rotor 8x15 ml	114
P4100260	Bergmann rule: heat loss as a function of...	38	65975-01	Artificial head w/o microphones	82
P4100360	Insulating effect of body coverage (with...	39	65976-00	Strobe drum	59, 84
P4100460	24-hour weather observation (with Cobra4)	40	65977-00	Ussing chamber	102
P4100560	Conductivity of various water samples...	35	65981-20	Earthworm experiment chamber	65
P4100760	The origin of acid rain (with Cobra4)	36	65983-93	Temperature organ	66
P4100840	The twenty-four-hour rhythm of an aquatic...	37, 53	65988-00	Respirometer, complete assembly	69
P4100860	The twenty-four-hour rhythm of an aquatic...	37	65999-00	Bubble bioreactor	113
P4100900	Microbial decomposition of mineral oil	97	66000-00	Bioreactor, 1 l, 7 connections	112
P4110160	Photosynthesis (bubble counting method)...	52			
P4110260	Photosynthesis (measurement of oxygen...	53			
P4110360	Transpiration of leaves (with Cobra4)	55			
P4110460	Glycolysis (pressure measurement) (with...	60			
P4110560	Glycolysis (temperature measurement)...	61			

A	
A-mode	70, 133
A-scan	131
Absorption inverse square law	127
Absorption of X-rays	122, 125
Acetic acid	114
Achilles tendon	80
Acid rain	36
Acidic anions	94
Acidification of soil and water	36
Acidity	41, 57
Acidity of soils	42
Acoustic hearing thresholds	81
Acoustic probes	82
Action potentials	104
Additive colour mixing	83
AFM	27, 28, 100, 134
Algorithms	119
Amino acids	112
Anaesthetization of muscles	65, 107
Analysis of drinking water	99
Analyzer	119, 120
Animal blood	26
Anthropogenic air pollution	36
Aquarium water	35
Aquatic plant	37, 53
Artefacts	119
Arterial flow	75, 132
Artificial cell membrane	56, 92, 103
Artificial head	82
Artificial head w/o microphones	82
Asymmetry potential	65, 102
Atomic Force Microscope	27, 100, 134
Atomic Force Microscopy	27, 100, 135
Atomic nuclei with a magnetic moment	128
Atomic number	125
Atria	72
Autoclave with insert	96
AV nodes	72
Axon	106

B	
B-scan	131
Bacteria	27, 31, 98, 100
Bacterial culture	114
Bacterial leaching	113
Basic cations	94
Basic set	124
Basic Set Ultrasonic echoscope	70, 131
Basic set: Ultrasonic Doppler technique	75, 132
Beam hardening	119
Berlese apparatus	67
Biceps	79
Binding energies	126
Biological amplifier	80
Biometry	70, 133
Bioreactor	110
Bioreactor, 1 l, 7 connections	112
Biphasic action potential	64, 107
Black masking	83
Blind spot	83
Bloch	129
Blood Cells	27, 100, 135
Blood flow during smoking	74
Blood flow velocity tracings	75, 132
Blood pressure measurement	73
Blood proteins	26
Blood pulse waves	73
Blood sugar level	26
Blood, Blood cells	26
Blossoms	24, 25
Bodenstein principle	93
Body coverage's	39
Body temperature regulation	86
Bohr's atomic model	126
Bragg	126
Breathing in resting position	88
Bremsstrahlung	123, 124
Brine shrimps	29
Bubble bioreactor	113
Butterfly Wing	27, 100, 135

C	
Capacitor	127
Carbon dioxide	25, 54
Carbon dioxide consumption	69
Carbon dioxide consumption and production	37, 53
Cardiac activity	76
Cardiac output (CO)	78, 133
Cell count	111
Cell division	24
Cell membrane	56, 92, 103
Cell organelles	24
Cellular respiration	54
Centrifugal force	59
Centrifuge w. angle rotor 8x15 ml	114
Characteristic X-rays	119, 120, 122, 123

Chemicals set for TESS Microscopy (for up to 10...	30
Chest pressure measurement	88
Chloroplasts	25
Chromatin	24
Chromoplasts	24
Chromosomes	24
Ciliates	31
Cloudiness	40
CO ₂ pressure measurement	60
Coat of animals	39
Cobra4 Display-Connect, Set of transmitter and...	41
Cobra4 Sensor-Unit Thermodynamics, pressure abs....	55
Cobra4 Sensor-Unit Weather: Humidity, Air...	40
Cobra4 USB-Link	85, 103
Colour Doppler	75, 132
Colour saturation	83
Compact magnetic resonance tomograph (MRT)	129
Compact-Atomic Force Microscope (AFM)	28, 136
Comparison between low and high stimulus levels	105
Comparison between low and high threshold levels	105
Compensation vessel	69
Complementary colour	83
Compound eye	68
Compton	119, 120, 122, 123
Computed tomography	119
Concentration	56
Conduction velocity	64, 80, 107
Conduction velocity in median and lateral giant...	64, 107
Conductivity	41, 57
Conductivity measurement	93
Conductivity of water samples	35
Conductivity-time plot	93
Coniferous leaf	25
Contamination by inorganic salts	35
Continuity equation	75, 132
Contracting tune	77
Contrast improve	105
Contrast medium	123
Control loop	87
Cornea and retina distance	70, 133
Course of luminosity	40
Cross-section	25
Crustaceans	29
CT table	121

D	
Damage to forests	36
Dark reaction	37, 53
Daylight reaction	37, 53
Dead time	87
Deciduous plant	25
Delicate tubes	26
Demo advanced Biology Manual Cobra4 Biochemistry...	62
Dependence of photosynthesis on light and carbon...	52
Depolarisation	105
Dialysis tube	56, 92, 103
Diaphragm filter apparatus	99
Diaphragmatic and thoracic respiration	88
Diastole	77
Diastolic blood pressure	73
Diffusion potential	65, 102
Digital Function Generator, USB, incl. Cobra4...	81
Digital imaging	123, 124
Dipole	85
Direct imaging sensor	121
Disinfection	96, 97
Diurnal rhythm	37, 53
Doppler angle	75, 132
Doppler effect	75, 132
Doppler sonography	75, 132
Dosimeter	127
Double pulse stimulation	65, 107
Drinking water	35
Dynamic Force Imaging	28, 136
Dynamic Mode	27, 100, 135

E	
Earthworm experiment chamber	65
Earwig	67
ECG segments	72
Echo amplitude	131
Echocardiography	78, 133
Ecology case, biological water analysis	43
EFM	28, 136
Electrical field measurement	85
Electrical resistance of nerve fibres	65, 107
Electrical stimulation	65, 107
Electrocardiogram (ECG)	76
Electrocardiogram according to Einthoven II	72
Electrolytes waste water	35
Electromyogram	79, 80
Electronystagmography	84
Electrostatic Force Microscopy	28, 136
Eluvation	35
End systolic diameter ESD	78, 133
End systolic volume ESV	78, 133
Energie dispersive measurement	119, 120
Energy dose	127

13 Indices

13.2 Alphabetical index

Energy level	126
Environmental requirements	66
Enzymatic hydrolysis of urea	93
Enzyme-substrate complex	93
Enzymolysis of urea	93
Equivalence (inflection) points	94
Equivalent dose and ion dose and their rates	127
Ethanol	110
Eupnea	88
Evaporation	86
Excitatory postsynaptic potential (EPSP)	104
Excitatory Synapse	105
Excretion organ	26
Excursion set, soil analysis	45
Expiratory reserve volume (ERV)	88
Extension Set: CT Scanner	130
Extension set: Medical ultrasonic diagnostics	78
Eye movements	49, 84, 85
Eye sonography	70, 133
F	
Facilitation	80
Feathers	39
Feedback loop	27, 28, 100, 134
Feedback reaction	87
Fermentation	110, 111, 112
Ferns	30
FEV	89
FID	129
FID signal (Free Induction Decay)	128
Field of view	83
Finger labyrinth	48
Fish swarm, Swarm behavior	50
Fixation period	85
Flame coloration	58
Flapping sound	77
Flatworms	29
Flaw detection	131
Flicker fusion frequency	83
Fluorescence	119, 120, 122, 123
Fluorescent screen	123, 124
Fluorexcence	126
Fog	40
Follow-through time	87
Force spectroscopy	28, 136
Forced expiratory volume (FEV)	89
Frequency differentiation threshold	81
Frequency modulation	64, 104, 107
Frequency shift	75, 132
Fronid	30
Fungus	31
Fur	39
G	
Ganglion cell	106
Gaseous and aerosol emissions	36
Generation of onshore and offshore winds	34
Geographical location	40
Geographical seperation	66
Geotropism	59
Gill covers	31
Glucose	25
Glycolysis	60, 61
Goniometer	126
Greyscale display	131
H	
H ⁺ ions	56, 92, 103
Haemocytometer	111
Handbook Physics X-Ray Experiments	137
Hearing range	81
Hearing thresholds curve	81
Heart muscle	76
Heart rate	72, 78, 133
Heart wall motion	78, 133
Heat capacity	34
Heat radiation	34
Heating / cooling effects	86
Heavy and moderate smokers	74
Horizontal/vertical zones	35
Human electrooculography	85
Human eye	83
Human Hair	27, 100, 135
Humidity and type of leaves	55
Humidity determination apparatus in transport box	67
Humidity preferendum	67
I	
Image artefacts	131
Imaging methods	129
Imaging of biological samples	27, 100, 135
Immersion probe NiCr-Ni, steel, -50...400°C	61
Immobilised cells	114
Implant model	123, 124
In slight and strong exertion	88
Influence of temperature and pH	60
Influence of wind	55
Inorganic fertilisers	41, 57

Insects	66
Inspiratory reserve volume (IRV)	88
Insulation effects	39
Intensity and colour of the light	53
Interneuron	106
Intracellular potential	104
Ion pump	65, 102
Ionic permeability	56, 92, 103
Ionizing energy	127
Isoelectric point	94
J	
Jendrassik effect	80
K	
Kidney	26
L	
Laboratory Experiments Application of ultrasounds...	138
Laboratory Experiments Magnetic Resonance...	138
Lambert-Beer	125
Large-scale display, digital	57
Larmor frequency	129
Lateral branches	25
Lateral inhibition	105
Lauterbur	129
Law of absorption	123, 124
Layer-thickness	119, 120
Learning behaviour	48
Learning curve	48
Leaves	25
Left- and right-hand movements of flies	68
Lennard-Jones-Potential	27, 100, 134
Lens thickness	70, 133
Light/dark adapted eye	83
Lineweaver-Burk plot	93
Liver	26
Liver cells	26
Local ion dose rate	127
Long-term measurement	40
Low-pass characteristic	104
Low-pass filtering	105
Lung illness	89
Lung volume	88
Lux measurement	52
M	
Magnetic Force Microscopy	28, 136
Magnetic Resonance Technology	138
Magnetization	128, 129
Mansfield	129
Mass absorption coefficient	123, 124
Mating behavior	31
Mean ultrasound velocity	70, 133
Measuring cuff	73
Mechanical stimulation	64, 107
Median and lateral giant nerve fibres	64, 107
Medical diagnostic	129
Medium term memory	48
Membrane time constant	105
Merging frequency	81
Metabolism	26
MFM	28, 136
Michaelis constant	93
Microbial count	99
Microbial extraction	113
Microbial synthesis of ethanol	111
Microorganisms	99
Microscope	98
Mineral water	35
Minerals	58
Minimum stimulus intensity	104
Mitosis	24
Molds	31
Monocotyledonous plants	25
Motor piston burette	94
Motor.piston burette,univer.50ml	94
MR flip angle	128
MR frequency	128
MR physics	128, 129
MRI	129
MRT	129
Multi-channel analyser	119, 120
Muscle contractions	79
Muscle potentials, Compound action potentials	79
Muscle stretch reflex	80
N	
Nano analysis	28, 136
Nano imaging	27, 28, 100, 134
Nano manipulation	28, 136
Nano technology	28, 136
Negative geotropism of shoots	59
Nematodes	29
Nerv cell interaction	105
Nerve and muscle potentials	64, 65, 107
Nerve cell interaction	106
Neural network	106

Neurosimulator	104
NMR	129
Nocturnal rhythm	37, 53
Nodes of Ranvier	104
Non destructive testing (NDT)	131
Non-invasive	129
Non-smokers	74
Nuclear spins	128, 129
Nuclear spins, Precession of nuclear spins,...	128
Nuclear spins, Resonance condition, MR frequency,...	128
Nucleus	24
Nutrient agar	96, 97
Nystagmus	84
O	
Obstructive respiratory illness	89
Occasional smokers	74
OH ⁻ ions	56, 92, 103
Optomotor response	68
Ore	113
Origin of climatic fluctuations	34
Osmosis	56
Osmotic pressure	56
Osmotic processes	56, 92, 103
Oxidation	113
Oxygen	31, 54
Oxygen bubble counting	52
Oxygen consumption	69
P	
Panel for complete experimental set-ups	110
Pathogens	31
Pattern frequency	68
Perimeter	83
pH measurement	37, 53
pH value	42
pH-electrode, plastic body, gel, BNC	37
Phase contrast	28, 136
Phonocardiography	77
Photosynthesis	25, 37, 52, 53
Phototaxis	66
PKs value	94
Planarians	29
Plants	25
Plug-in	125
Poikilothermic animals	66
Poisoning of enzymes	93
Positive feedback	64, 107
Positive geotropism of roots	59
Power supply 0...12V DC/ 6 V, 12V AC, 230V	68
Power supply 0...12V DC/ 6V, 12 V AC, 230V	87
Practised reader versus schoolchild	85
Precession of nuclear spins	128
Precession of nuclear spins, Resonance condition,...	128
Preferential temperature	66
Pressure measurement	53
Propagation of ultrasonic waves	131
Pulse	77
Pulse duration (DT)	78, 133
Purcell	129
Q	
Q factor	127
Q10 value	69
Qualitative analysis	119, 120
Quantitative	119, 120
Quiet and strained heart	72, 77
R	
Radiation	86
Radiography	122, 123, 124
Rainwater	35
Rapid reading techniques	85
Reaction capacity	87
Reaction velocity of enzymatic hydrolisis	93
Reading speed	49
Reagent case for water analysis with filter...	44
Reflection coefficient	131
Reflex latency	80
Refractory period	65, 107
Relaxation times	128
Relaxation times T1/T2	129
Renal corpuscle	26
Representation of motion sequences	78, 133
Resolution	130, 131
Resonance condition	128
Respiration energy	61
Respiratory frequency	88
Respirometer	69
Respirometer, complete assembly	69
Resting potential	65, 102
Restrictive respiratory illnesses	89
River water	35
Rods and cones	83
Rollaway table	123
Rotating tabel	121
Rotation table	121
Rotational speed	59

S	
Sacchades	85
Salinity	41, 57
Scotoma	83
Seasonal influences	40
Selective ion permeability of membranes	65, 102
Self-calibration of paired sensory channels	106
Set of TESS Microscopy MIC, with CD-ROM and...	32
Shapes	31
Short term memory	48
Signal-to-noise ratio	128
Silver chloride electrodes	65, 102
Silver nitrate inhibition of urease	93
Simple organization	29
Sine wave generator	81
Skin Cross-Section	27, 100, 135
Skin temperature	74, 86
Software Cobra4 - multi-user licence	60, 79
Soil horizon	42
Sound velocity	131
Spatial orientation	82
Spectrophotometer S800, 330...800 nm	111
Spectroscopy	58, 119, 120
Spin echo	128, 129
Spirogram	88
Spirometer	88
SPM	28, 136
Spore capsules	30
Springtail	67
Staining	98
Starch	25
Static Force Imaging	28, 136
Static mode, Dynamic Mode	27, 100, 134
Staloliths	59
Stem	25
Stenosis	75, 132
Stereographic projection	124
Sterility	96, 97, 98
Strobe drum	59, 68, 84, 87
Substrate inhibition	93
Substratum	42
Subtractive colour mixing	83
Supersonic	138
SWIFT Microscope M3601C	24
SWIFT Student Microscope M3602C-3	98
Synaptic depression	64, 107
Synaptic facilitation	64, 107
Systole	77
Systolic blood pressure	73
T	
Temperature	55
Temperature measurement	61
Temperature optimum	66
Temperature organ	66
Temporal summation	105
Territorial fights	31
TESS advanced Applied Sciences set...	90
TESS advanced Biology manual Cobra4...	90
TESS advanced Biology manual Microscopy	32
TESS advanced Biology set Microscopy, BS 4	32
TESS advanced Microscopy MIC consumables for 10...	32
TESS advanced Microscopy MIC necessary...	32
TESS Applied Sciences set examination of soil	45
TESS Applied Sciences Set Gas examination	44
TESS Biology set chemo-physical water testing	43
Thermotaxis	66
Thigmotaxis	66
Thin layer chromatography	112
Threshold angle	82
Threshold frequency	87
Throat and chest sonic measurement	77
Tidal volume (TV)	88
Tiffeneau value	89
Time constant of nerve membrane	104
Time of flight	131
Time of flight	70, 133
Time resolving capability	68
Time-Motion-Mode	78, 133
Time-related resolving power	83
Titration	94
Tomography	121, 129, 130
Torpor	66
Transpiration	55
Travelling time difference	82
Tungsten	125
Turbidimetry	111
Typoglycemia	49
U	
Ultrasonic	138
Ultrasonic echography	78, 131, 133
Ultrasonic echography (A-scan)	130
Ultrasonic transceiver	131
Ultrasound	138
Unilateral inhibition	106
Upgrade	119, 120, 123, 124

13 Indices

13.2 Alphabetical index

Upgrade set	119, 120, 122, 123
Ussing chamber	102
V	
Vascular bundles	25
Venous Flow	75, 132
Ventricles	72
Vibration Amplitude	27, 100, 134
Vinegar procedure	114
Visual field (for white, blue, red, green)	83
Vital capacity	88, 89
Vital capacity (VC)	88
Volumetric measurement	69
W	
Water	25
Water and nutrients transport	55
White masking	83
Woodlouse	67
Wool	39
X	
X-ray	119, 120, 121, 122
X-ray apparatus	124, 126
X-ray camera	121
X-ray dosimetry	127
X-ray energy detector	119, 120
X-ray expert unit	119, 120, 121, 122
X-ray fluorescence analysis	119, 120
X-ray photography	123, 124
X-ray radiation	123, 124
X-ray table	123
X-ray tube	122, 125
X-rays	127
XR 4.0	121
XR 4.0 expert unit	124
XR 4.0 Mobile X-ray Lab	123
XR 4.0 Software measure CT	121
XR 4.0 X-ray CT Z-rotation stage (XRstage)	121
XR 4.0 X-ray Direct Digital Image Sensor (XRIS)...	121
XR 4.0 X-ray goniometer	126
XR 4.0 X-ray plug-in unit W tube	125
XRCT 4.0 X-ray Computed Tomography upgrade set	119, 120
XRD 4.0 X-ray dosimetry upgrade set	127
XRE 4.0 X-ray expert set	119, 120, 122, 123
XRI 4.0 X-ray imaging upgrade set	123, 124
XRP 4.0 X-ray Solid state physics upgrade set	126
XRT	121
Y	
Yeast	110, 111
Yeast fermentation of sugar	60, 61
Z	
Zone of focus	131
Zwitterions	94
Zymomonas mobilis	111

Service from A to Z – our service, your satisfaction

Service | PHYWE



Customer service before, during and after your purchase

The PHYWE service does not end with the delivery of the equipment. With our after sales service, we offer you comprehensive support:

- ☒ Customized information
- ☒ Installation and setting-up
- ☒ Stockage service / instruction
- ☒ Training courses at PHYWE or on-site
- ☒ Technical service
- ☒ Repair service

Individual Service for individual needs

By choosing a PHYWE product you decide for a comprehensive service at the same time. We support you with our multi-level service concept. From planning through to installation and up to our extensive after sales service. Rely on our strengths: rugged and long-lasting products made in Germany, customized for your needs.

1st response within 24 hours

P. +49 (0) 551 604-196

F. +49 (0) 551 604-106

service@phywe.de

Service-
Helpdesk

Worldclass solutions
for better education:
www.phywe.com

PHYWE
excellence in science

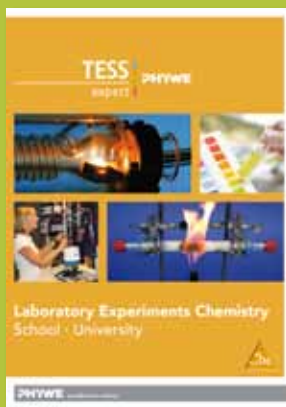
PHYWE Systeme GmbH & Co. KG

Robert-Bosch-Breite 10
D-37079 Göttingen

Tel. +49 (0) 551 604 - 0
Fax +49 (0) 551 604 - 107
info@phywe.com



Find more Laboratory Experiments in our special
catalogues Physics, Chemistry, Engineering and Medicine.



PHYWE excellence in science