

Product Survey: Thermocyclers

Speed up the heat!

Thermal cyclers are getting faster and faster every year. Actually, that's not the only thing they have in common with formula one racing cars. Some models are even available in Michael Schumacher's famous Ferrari red. And with a little imagination, the resemblance is quite astonishing.

In the course of my thesis work, more than ten years ago, I decided to start some overlap extension mutagenesis experiments. Since overlap extension meant that a lot of PCR fragments had to be produced, I first searched for a proper thermal cycler. To my surprise there was no modern thermal cycler available in the lab. The only thing I found, on a hidden rack in a dark corner, was something that reminded me of the very first cycler Cetus introduced in 1987. It consisted of a large heating block with only a few holes for 0.5 ml reaction tubes. Not exactly the kind of cycler a young, motivated PhD student envisaged using. So I grabbed a catalogue for laboratory equipment and studied the pages showing the latest thermal cycler models. Whilst flicking through the pages an advertisement showing Techne's Progene Cycler caught my eye. What impressed me the most was the rather self-assured accompanying text stating that the Progene is: *the smallest, fastest, least expensive thermal cycler with an unrivalled performance of 2.2°C cooling and 2.8°C heating rate per second.* "Wow!" I thought, "That's just the ticket!" and ordered the Progene a few days later. The cycler was really fast – in contrast to my experiments, which made only little progress. But that's another story...

Cool heating rates

The amusing thing is that ten years after the Progene, Techne still claims that their TC-312 is one of the smallest and cheapest cyclers on the market. But Techne has lost some ground in the rankings to maintain its claim as the fastest conventional PCR machine. Though at 3.6°C per second, ramp times for the Progene follow-up, TC-3000, are much faster for heating and cooling than that of the Progene, they are, however, several seconds slower than the current speed record. These days, gold-plated silver blocks enable heating rates of up to

10°C per second and cooling rates of more than 5°C per second. Using the fastest cyclers, a typical PCR run of 30 cycles takes about ten minutes and amplifications of 1 kb fragments are done in just half-an-hour. Pretty impressive figures if compared with PCR performance data of old.

Air-conditioned

In contrast to most thermal cyclers for conventional PCR, which use peltier blocks for heating and cooling, Real Time PCR machines often use air. Though these cyclers are rather sophisticated and expensive, the



Dream or nightmare?
A lab, jam-packed with PCR machines but deserted.

principle of heating and cooling the probes with air is simple. The PCR is done in thin glass capillaries that are placed in a sample carousel similar to kids sitting on a merry-go-round. During each cycle a small fan draws ambient air into the carousel; the air is warmed up by a heating coil. Cooling is simply done by drawing the air into the carousel without heating. Since air has a very low thermal capacity, it warms up extremely fast. Thus air-heated PCR machines may be capable of reaching ramp rates of up to 20°C per second.

Though speed is certainly an essential asset for any thermal cycler, you should also consider other features as well. If space is limited in your lab, a personal cycler with a small footprint may be a better choice than

a faster but also larger cycler. Some models offer interchangeable heating blocks for different-sized samples. If you want to perform conventional and Real Time PCR experiments on the same cycler, you should take a closer look at models with a Real Time-option. Gradient cyclers, enabling the testing of various annealing temperatures within the same block in one run, are fine for all researchers frequently optimising annealing and denaturing temperatures. Also recommendable, especially for high-throughput labs, are robot-compatible thermal cyclers that can be connected

to satellite systems. Some models allow networking of up to 30 satellite blocks, running in parallel. If design matters to you and you are fed up with outdated looking instruments in boring lab-grey, you may prefer models in Ferrari red or a bold Bondi blue. Some of today's PCR machines are sheer eye-catchers with a really cool design.

Trust is good, control is better

But don't be too blinded by stylish cyclers. According to a paper by Dagmar Schoder et al. (*Journal of Clinical Microbiology* Vol. 43, No.6, 2005 p.2724-2728), one

should handle published performance data of thermal cyclers with great care. Schoder and her colleagues checked six brand new thermal cyclers for their physical functionality and found that: *the cyclers did not perform within the manufacturer's specifications... and... premature timing, under- and overshooting, and spatial variation of heat transfer were found to be the critical factors.* That's not really astonishing, since researchers working with different PCR machines have known for quite some time that a cycling programme that works on one brand of instrument may not necessarily work on another. The authors therefore recommend using a temperature validation system to test the performance of in-house cyclers.

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Thermocyclers							
Company	Model	Heating Block Capacity	Block Uniformity Temperature Range	Heating / Cooling Rate	Real-Time Det. / Automatic sample prep.	Miscellaneous Specialities Generally	Price [EUR]
Analytik Jena Jena, Germany www.analytik-jena.com Contact: Alexander Berka Phone +49 3641 77 9400 biosolutions@analytik-jena.de	Speed-Cycler	Rapid block 36 or 96, fast block 24	± 0.2°C 4-105°C (± 0.2°C)	Rapid block: 10°C/s heat; 6°C/s cooling Fast block: 8°C/s; 5°C/s	No Possible	25 cycles less than 8 min	from 6.600,-
	FlexCycler	60 x 0.5 ml, 96 x 0.2 ml, 384 well block, twin 30 x 0.5, twin 48 x 0.2 ml, 30 x 0.5 ml & 48 x 0.2 ml as mix, Insitublock	± 0.5°C (at 72°C) 4-99°C (< ± 0.3°C at 72°C)	Heating: 4°C/s Cooling: 3°C/s	No No	Interchangeable independent blocks	from 4.700,-
Applied Biosystems Applera Germany, Darmstadt Contact: Phone +49 6151 9670 5335 Germany.order@eur.appliedbiosystems.com	2720	96 well	± 0.5°C 4-99.9°C (± 0.5°C)	Heat 2.7 peak Cool 1.0 peak	No No	Heated lid Calibrated temperature verification probes available	4.800,-
	9800	96 well	± 0.5°C 4-99.9°C (± 0.5°C)	Heat 5.0 peak Cool 2.6 peak	No No	FAST PCR See above	11.200,-
	9700 Alu	96 well	± 0.5°C 4-99.9°C (± 0.5°C)	Heat 2.3 peak Cool 1.5 peak	No No	Heated lid See above	7.950,-
	9700 Gold	96 well	± 0.5°C 4-99.9°C (± 0.5°C)	Heat 3.5 peak Cool 1.5 peak	No No	Heated lid Gold plated silver block See above	9.900,-
	9700	60 well	± 0.5°C 4-99.9°C (± 0.5°C)	Heat 2.3 peak Cool 1.5 peak	No No	Heated lid Calibrated temperature verification probes available	8.400,-
	9700 Dual 96	2 x 96 well	± 0.5°C 4-99.9°C (± 0.5°C)	Heat 2.3 peak Cool 1.5 peak	No No	See above	14.450,-
	9700 Dual 384	2 x 384 well	± 0.5°C 4-99.9°C (± 0.5°C)	Heat 2.3 peak Cool 1.5 peak	No No	See above	14.450,-
	9700 Dual 384 Auto-lid	2 x 384 well	± 0.5°C 4-99.9°C (± 0.5°C)	Heat 2.3 peak Cool 1.5 peak	No No	Heated automatic lid Calibrated temperature verification probes available	16.900,-
9700 Networking software	Several TC units can be linked & run by PC	-	-	-	-	Networkong software allows many thermocyclers to be run from a central PC	1.970,- (4 leads)/66,- (5 extr. le.)
Barloworld Scientific Staffordshire, UK www.barloworld-scientific.com Contact: Hunggia Diep Phone +44 1785 810 239 hunggia.diep@barloworld-scientific.com	TC-3000 thermal cycler	20 (0.5ml) 25 (0.2ml)	+ 0.1°C at 50°C 4-99°C	3.6°C/s	-	Small footprint Reliable High performance Affordable	2.868,-
	TC-412 thermal cycler	60 (0.5ml) 96 (0.2ml)	<+ 0.3°C at 50°C 4-99°C	2.6°C/s	-	High performance Intuitive programming Versatile block format	5.435,-
	TC-512 thermal cycler	60 (0.5ml) 96 (0.2ml)	<+ 0.3°C at 50°C 4-99°C	3.0°C/s	-	Gradient cycler with graphical display	7.140,-
Bio-Rad Laboratories München, Germany www.bio-rad.com/ amplification Contact: Javier Alba Tel. +49 89-31884-177 TechSupport.Germany@bio-rad.com	MJ Mini	48	0.4°C 0-99°C (±0.2°C at 90°C)	Heat.: 2.5°C/s	Real-Time upgrade. No	Gradient capability Small footprint Adjustable heated lid Graphical interface PCR licensed	4.305,-
	MyCycler	96	0.5°C 4-100°C (±0.5°C at 90°C)	Heat.: 2.5°C/s Cool.: 1.5°C/s	No No	Gradient capability Graphical interface Small footprint Self-adjustable heated lid PCR licens.	5.034,-
	DNA Engine (PTC-200)	Depending on module (2 x 48, 96, 384, slides, etc.)	0.4°C 0-105°C (±0.3°C at 90°C)	Heating: 3°C/s Cooling: 2°C/s	Real-Time Upgradeable Yes	Interchangeable blocks Gradient capability Adjustable heated lid PCR licensed	8.444,- (with 96-well mod.)
	iCycler	Depending on modules (2 x 48, 60, 96, 384)	0.4°C 4-100°C (±0.3°C at 90°C)	Heat.: 3.3°C/s Cooling: 2°C/s	Real-Time upgradeable No	Interchangeable blocks Graphical interface Gradient capability Self-adjustable heated lid PCR licensed	8.084,- (with 96-well mod.)
	Dyad	Multibay (2 modules). Up to 768 samples	0.4°C 0-105°C (±0.3°C at 90°C)	Heating: 3°C/s Cooling: 2°C/s	No Yes	Two-bay system Interchangeable blocks Gradient capability Adjustable heated lid PCR licensed	Depending on Modules choice.
	Disciple	See above	0.4°C 0-105°C (±0.3°C at 90°C)	Heating: 3°C/s Cooling: 2°C/s	Real-Time upgrade. Yes	See above	See above
	Tetrad2	Multibay (holds up to 4 modules). Up to 1536 samples	0.4°C 0-105°C (±0.3°C at 90°C)	Heating: 3°C/s Cooling: 2°C/s	No Yes	4-bay system See above	Depending on Modules choice.

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biostep Jahnsdorf, Germany www.biostep.de Contact: Silvana Boehme Phone +49 3721 3905 24 s.boehme@biostep.de	Techne TC-3000 Pers. Cycler	25 x 0.2ml 20 x 0.5 ml	± 0.1°C at 50°C 4-99°C	3.6°C	No No	High performance and reliability Fast track programming Space saving design Warranty: 4 years or 80,000 cycles	3.298,-
	Techne TC-512 Gradient Cycler	96 x 0.2 ml tubes/ 96well PCR-plates; 60 x 0.5 ml In-situ-object holder; 384well PCR-plates	< ± 0.3°C at 50°C 4-99°C	Heating: 3.0°C Cooling: 1.3°C	No No	Gradient thermal cycler with calculator Large touch screen Graphical display of Saving up to 550 programs Warranty: 4 years or 80,000 cycles	7.695,-
	Techne TC-412 Std. C.	See above	< ± 0.3°C at 50°C 4-99°C	Heating: 2.5°C Cooling: 1.6°C	No No	4-line display Easy-to-use software Warranty: 4 years or 80,000 cycles	5.925,-
Finnzymes www.finnzymesinstruments.com Germany/Austria: Biozym Scientific Hess. Oldendorf, Germany www.biozym.com Contact: Helmut Prechel Phone +49 5152 9020 support@biozym.com	24-well PIKO Thermal Cycler	24 x 0.2 ml	± 0.3°C 0-99.9°C	8°C/s max.	-	Fast PCR cycler Protocols <10 min. Motorized lid Small footprint	3.500,-
	96-well PIKO Thermal Cycler	96-well	± 0.3°C 0-99.9°C	8°C/s max.	-	See above	4.500,-
Corbett Research Mortlake, NSW, Australia www.corbettlifescience.com Contact: Thomas Kaiser Phone +61 2 9736 1320 info@corbettlifescience.com	RRotor-Gene 6000	36, 72 tubes or 72 & 100 well gene-discs	0.01°C Ambient - 99°C	Max. 10°C/10°C	Yes, up to 6 channels Yes / CAS-1820 and CAS-1200	High Resolution Melt Mutation screening High-Speed runs with standard chemistry 2-fold discrimination Single copy detection No ROX required Concentration analysis	Complete system including full software version.
Eppendorf Hamburg, Germany www.eppendorf.de Contact: Eppendorf Application Hotline Phone +49 1803 666 789 application-hotline@eppendorf.de	Master-cycler ep realplex	96 wells	20°-72°C: ±0.3°C 90°C ±0.4°C 4-99°C	Heating: up to 6°C/s Cool.: up to 4.5°C/s	Yes, up to 4 channels No	Low volumes possible Gradient function	31.880 to 40.240,-
	Master-cycler ep	96/384 wells	20°-72°C: ±0.3°C 90°C ±0.4°C 4-99°C	Heating: up to 6°C/s Cool.: up to 4.5°C/s	Upgradable (96 wells) Yes	See above Multi unit network	8.677 to 9.767,-
	Master-cycler	96 wells	20°-72°C: ±0.4°C 95°C ±0.5°C 4-99°C	Heating: 3°C/s Cooling: 2°C/s	No No	-	6.151,-
	Master-cycler gradient	96 wells	20°-72°C: ±0.4°C 95°C ±0.5°C 4-99°C	Heating: 3°C/s Cooling: 2°C/s	No No	Gradient function	7.589,-
	Master-cycler personal	25 x 0.2 ml or 16 x 0.5 ml	20°-72°C: ±0.4°C 95°C ±0.5°C 4-99°C	Heating: 3°C/s Cooling: 2°C/s	No No	-	3.315,-
G. Kisker Steinfurt, Germany www.kisker-biotech.com Contact: Miriam Köster Phone +49 2551-864310 contact@kisker-biotech.com	Combi-Cycler LCC4	25 x 0.2 ml tubes & 16 x 0.5 ml tubes	up to 95°C ±0.5°C up to 72°C ±0.3°C up to 65°C ±0.2°C +4°C up to +99°C (0.2°C)	Heating: ± 3°C/s Cooling: ± 2.3°C/s	No No	Heated lid 100 programmable files Number of steps in a file: up to 12 Number of steps in a cycle: up to 3	2.150,-
Peqlab Erlangen, Germany www.peqlab.de Contact: Christian Lohmann Phone +49 9131 610 7020 info@peqlab.de	Primus 25 advanced	25 x 0.2 ml tubes or 13 x 0.5 ml tubes	±0.7°C at 72°C 4-105°C (±0.1°C)	2°C/s	No No	Small footprint Easy programming Heatable lid GLP reports Remote control via PC possible	From 1.995,-
	Primus 96 advanced	96 x 0.2 ml tubes, 96 well PCR plates or 48 x 0.5 ml tubes. 384 well PCR plates. Up to 4 microscope slides.	±0.35°C at 72°C 4-105°C (±0.1°C)	Heating: 4°C/s Cooling: 2°C/s	No Yes	Optionally with High Pressure or Motor Lid Gradient upgrade available GLP reports Remote control via PC possible	From 3.995,-
	Primus 96 advanced Gradient	96 x 0.2 ml tubes, 96 well PCR plates or 48 x 0.5 ml tubes.	±0.35°C at 72°C 4-105°C (±0.1°C)	Heating: 4°C/s Cooling: 2°C/s	No Yes	See Primus 96 advanced Maximum temperature gradient of 39.8°C	From 5.195,-
	Smart-Cycler II	16 autonomous reaction modules per block for 25 µl or 100 µl Smart-Cycler tubes.	±0.5°C between 60-95°C Room temperature -100°C	Heating: 10°C/s Cooling: 2.5°C/s	Yes No	4 channel multiplex Real Time Cycler Each reaction site independently controllable Background subtraction and threshold definition Determination of Ct values Adjustable ramping	From 31.995,-

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Company	Model	Heating Block Capacity	Block Uniformity Temperature Range	Heating / Cooling Rate	Real-Time Det. / Automatic sample prep.	Miscellaneous Specialities Generally	Price [EUR]
Roche Diagnostics Mannheim, Germany www.roche-applied-science.com Contact: Phone +49 621 759 8568 mannheim.biocheminfo@roche.com	Light-Cycler480	96- or 384 well format	Optimized well-to-well temperature homogeneity. 37-95°C (0.2°C)	Heating: 4.8°C/s Cooling: 2.5°C/s	6 channel Real-Time PCR platform Plate loading capability	40 min for 384-well format; 1 h for 96-well format Flexibility in detection formats Accurate data capture across the entire plate Bar Code Reader	On request
	LightCycler 2.0	32 capillaries	See above Uses air for heating and cooling (0.2°C)	Heating and Cooling: 20°C/s	See above Yes	Fast PCR with online detection: 20 min Flexibility in detection formats 20µl or 100µl capillaries Kits for RT-PCR and PCR available	On request
	LightCycler 1.5	32 capillaries	See above (0.2°C)	See above	3 cha. R-time PCR syst. See above	20µl capillaries Fast PCR with online detection: 20 min Kits for RT-PCR and PCR available	On request
SensoQuest Goettingen, Germany www.sensoquest.de Contact: Kay Terpe Phone +4955138919522/23 k.terpe@sensoquest.de	LabCycler Basic (no gradient)	Unique quick changing system for 48, 96, and 384 wells	±0.4°C -5°C to 99.9°C (±0.4°C)	Heating: 4.2°C/s Cooling: 3.2°C/s Gradients: -20 to +20°C	No Yes	Automatic lid Languages: English, German Line voltage: 85 V to 265 V Self-explanatory software, TFT-touchscreen Block change in 10 s.	5.875,- (without gradient) 6.575,- (with gradient)
	LabCycler Standard (gradient)						
Stratagene Amsterdam, The Netherlands www.stratagene.com Contact: Cedric Lemaire Phone +31 20 3125606 cedric.lemaire@stratagene.com	Mx3000P-QPCR System	96	±0.25°C at 72°C 25-96°C (±0.1°)	Up to 2.5°C/s	Yes 4 channels No	No refer. dye needed Build-in PC Cycles can be added during run Dynamic range: 10 orders of magnitude Cross talk below 0.1°C, heated lid	27.995,- (incl. PC)
	Mx3005P-QPCR Syst.	96	±0.25°C at 72°C 25-96°C (±0.1°)	Up to 2.5°C/s	Yes No	See above FRET capability Very easy to use software Thermal shift assays for proteins	29.995,- (incl. PC)
	RoboCycler-Gradient	96	±0.25°C at 72°C 4-100°C (±0.1°)	>11°C/s	No No	Robot. transfer of plates, tubes between preheated blocks Grad. function Lin. gradient Heated lid	6.090,-
TaKaRa Bio Europe Saint-Germain-en-Laye, France www.takara-bio.eu Contact: Francois-Xavier Sicot Phone +33 1 39 04 68 80 info@takara-bio.eu	TaKaRa PCR Thermal Cycler Dice (Gradient)	96 x 0.2ml tubes	±0.5°C 4-99.9°C (±0.5°C)	Heating: 3.0°C/s Cooling: 2.0°C/s	No No	Gradient temperature over the 12 columns Accurate temperature control Sliding heated-lid Pre-installed protocols	7.000 to 7.500,-
	(Standard Model)	96 x 0.2ml tubes	±0.5°C 4-99.9°C (±0.5°C)	Heat.: 3.0°C/s Cool.: 2.0°C/s	No No	Same as above except Gradient temperature	6.500 to 7.000,-
	TaKaRa PCR Ther. Cycler Dice mini	24 x 0.2ml tubes	±0.5°C (30-99.9°C) 4-99.9°C (±0.5°C)	Heat.: 3.0°C/s Cooling: 2.0°C/s	No No	Same as above with smaller footprint Personal Thermocycler	4.500 to 5.000,-
Thermo Fisher Scientific Langenselbold, Germany www.thermo.com Contact: Phone +49 6184 90 6940 info.labequipment.de@thermo.com	Thermo Scientific MultiBlock Syst. (MBS)	48 x 0.5ml 96 x 0.2 ml 384 x 0.04 ml (gradient or standard)	±0.3°C within 30 s 4-99°C	Heating: up to 3°C/s Cooling: up to 2°C/s	No No	Extra blocks can be added when required User-friendly software One PC controls up to 30 blocks	starting at 4.809,- (1 Block)
	Thermo Scienti Px2 Ther. Cycler	See above For 4 microscope slides	±0.3°C within 30 s 4-99°C	Heating: up to 3°C/s Cool.: up to 2°C/s	No No	Wide range of interchangeable blocks Active Tube Control function Adjustable heated lid Accurate temperature control	starting at 6.772,-
	Thermo Scientific Px2 The. Cycler	96 x 0.2 ml or 48 x 0.5 ml	±0.5°C within 30 s 4-99°C	Heating: up to 3°C/s Cool.: up to 2°C/s	No No	Accurate temperature control 96-well format Custom designed software	4.383,-
	Thermo Sci. PCR Sprint Th. Cycler	24 x 0.2 ml or 20 x 0.5 ml	±0.5°C within 15 s 4-99°C	Heating: up to 3°C/s Cool.: up to 2°C/s	No No	Heated lid Up to 60 programs can be stored Small footprint User-friendly Cost effective	2.652,-
Whatman Biometra Goettingen, Germany Contact: Markus Kapp Phone +49 551 506860 info@biometra.com	TProfessional	96 well 384 well 60 well	+0.15 3-99°C	Heating: 5.0°C Cooling: 3.5°C	-	High Speed Silver block Large graphical Display Spreadsheet or graphical programming Block exchange in less than 10 s Quick start of the last 5 programs	starting at 5.950,-
	TProfessional Basic	96 well	+0.2 3-99°C	Heating: 2.3°C Cooling: 1.7°C	-	Large graphical display Easy spreadsheet program. Gold anodized 96 w block High Performance Smart Lid Gradient or non Gradient version	starting at 5.250,-
	T3000 Thermocycler	3 x 48 well 3 x 20 well	+0.5 3-99°C	Heating: 2.2°C Cooling: 2.0°C	-	Three independent Thermocyclers in one housing Maximum capacity of 144 samples Three different block formats available Runs three different programs at same time Intuitive programming	starting at 9.490,-
	Tpersonal	48 well 20 well combi	+0.5 3-99°C	Heating: 3.0°C Cooling: 3.0°C	-	Small footprint Maximum capacity of 48 samples Three different block formats Fast heating and cooling Silent operation	starting at 2.990,-
	TRobot Thermocycler	96 well 384 well	+0.5 3-99°C	Heating: 3.5°C Cooling: 2.5°C	Specially designed for integration in robotic systems	Motorized heated lid Motorized plate lifter Minimum footprint External controller unit Low power consumption	13.950,-