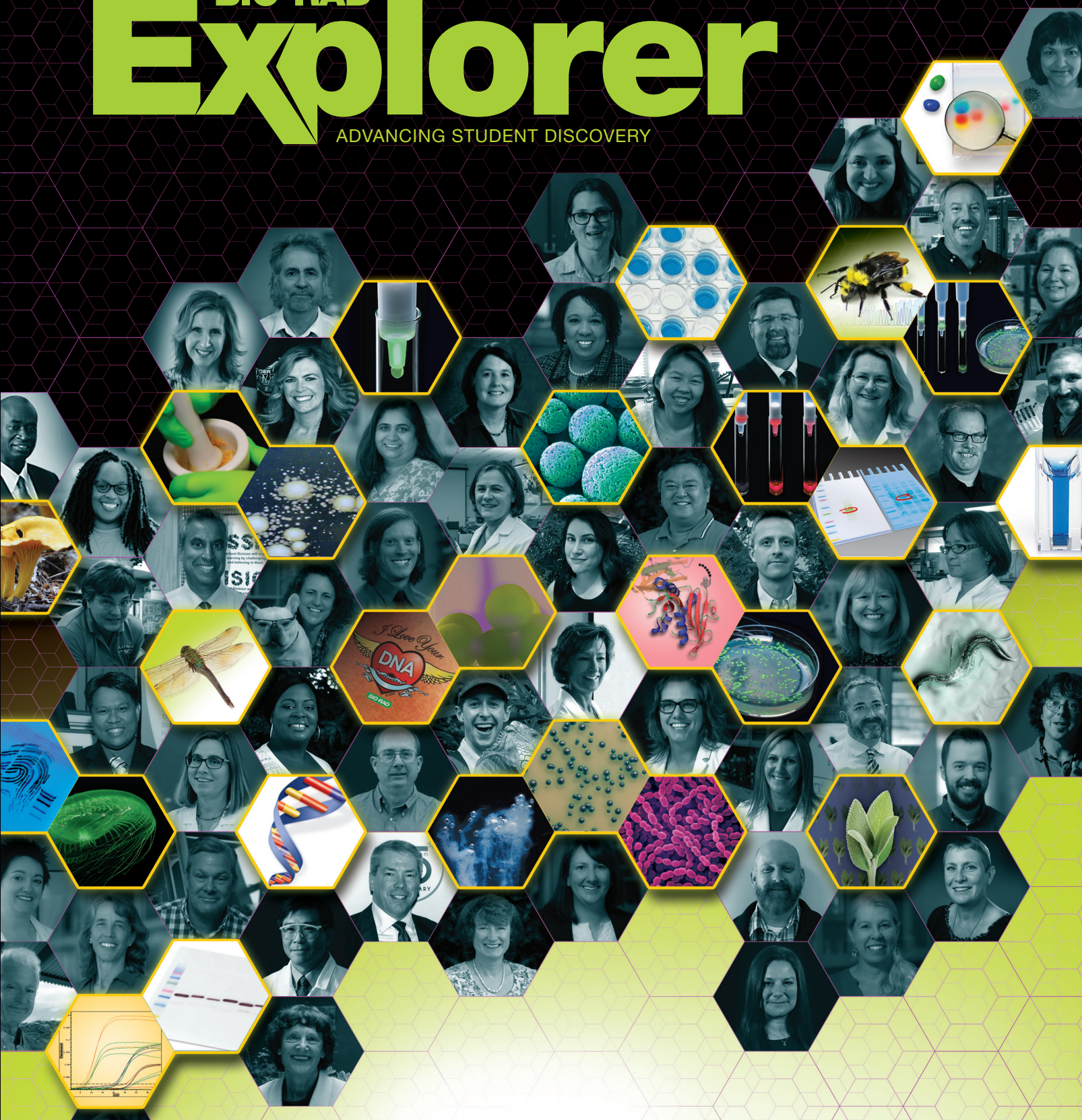
BIO-RAD

Explorer

ADVANCING STUDENT DISCOVERY



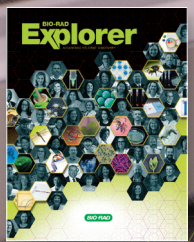
BIO-RAD

Bio-Rad Explorer Program

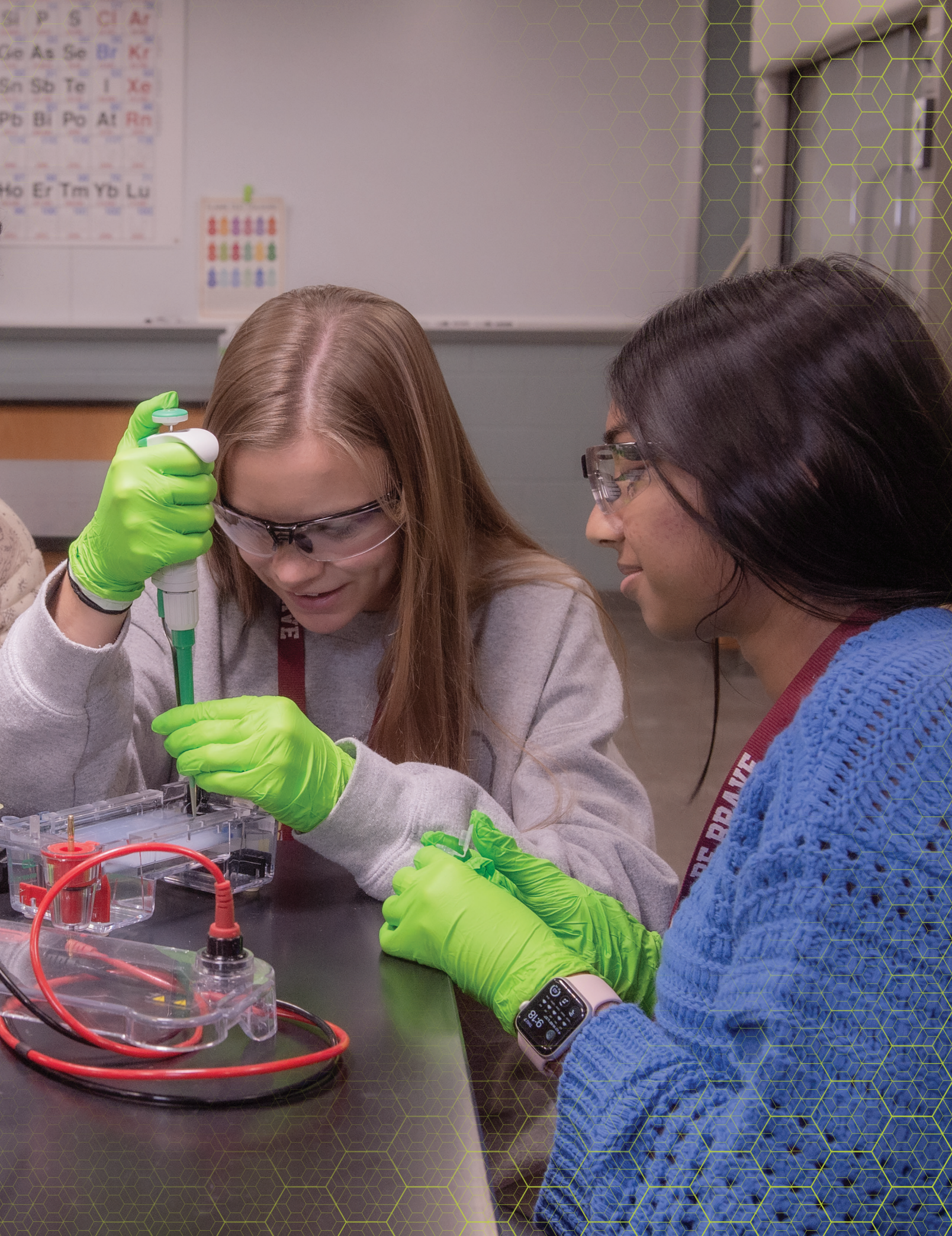
As a teacher, you bring the beauty and complexity of the life sciences to light for your students. As their innate curiosity inspires their exploration of the natural world, they are also more aware of the impact that science has on their lives. They see the challenges in changing environments and outbreaks of pathogens but also the promise of powerful new treatments and cures for diseases that were once debilitating and deadly. In addition to guiding this exploration, you are tasked with helping them understand the importance of critical thinking, thoughtful data generation and analysis, and collaborative research for their future.

The Bio-Rad Explorer Program exists to support the teacher-student connection. For nearly 30 years, we have collaborated with educators, researchers, and industry leaders to bring state-of-the-art technology into your classroom. Use our innovative, hands-on laboratory activities and equipment to support your lessons and prepare your students with both foundational and cutting-edge skills from micropipetting to CRISPR gene editing — in a safe and student-appropriate format. Partner with us for award-winning training and resources to stay on top of all the latest advances in technology and research. Rely on us for the quality, reliability, and customer service Bio-Rad is known for.

As your students become familiar with scientific concepts and techniques, it is our hope they also gain confidence in their ability to apply their learning to their own life choices and develop a lifelong passion for understanding and protecting the natural world around them.



On the cover:
Thank you for decades of passion and dedication to life science education.
The Bio-Rad Explorer program would like to thank all of you for your passion and dedication to life science education. It is our goal to support you with the resources you need to focus on what you do best — teach. And it is our honor to support the lifelong connections you build with our students and with the study of life.



Experience Expanded Learning

Contents

Explorer Kit Levels

Skills-Based Hands-On Labs for Life Science and Biotechnology

Introductory Kits

Intermediate Kits

Advanced Kits and Topics

Partnerships

Growing through Partnership

For over 25 years, the Bio-Rad Explorer program has grown through collaboration with academic and industry researchers, master teachers, professional curriculum developers, and prominent educational and nonprofit organizations. These partnerships provide valuable insights that help us create and expand our offering of innovative lab kits, curricula, and professional development programs and ensure they align with current science education standards, industry needs, and student and teacher interests.

For more information about all our partnerships, see **bio-rad.com/partners**.

ADInstruments offers Lt, an online learning platform designed for first-year undergraduate introductory Biology. Integrated within the platform, Bio-Rad's educational kits provide an engaging, hands-on learning experience for students.

Biotility has developed and administers the Biotechnician Assistant Credentialing Exam (BACE), an industry-recognized credential that allows students to demonstrate mastery of the knowledge and skills valued by the biotechnology industry. Bio-Rad has partnered with Biotility to ensure the Biotechnology textbook is aligned with the BACE.

HOSA Future Health Professionals is a career technical student organization (CTSO) that Bio-Rad is proud to partner with and work with to develop and support the Competitive Event in Biotechnology.

InnovATEBIO partners with Bio-Rad to meet the growing need for a skilled biotechnology and biomanufacturing workforce.

District Level Support

Program Support

Let Bio-Rad help you set up or expand your life science or biotechnology program

The life sciences and biotechnology industries are growing and continue to hire at a rapid pace, creating an ongoing need for talent. The time to educate, build confidence, and prepare your students for this exciting future is now.

Prepare Students by Partnering with Bio-Rad

With over 25 years of experience in science education and 75 years as a global biotechnology leader, Bio-Rad Laboratories can help you develop a 21st-century biotechnology course or program.

Partner with us to create a robust, flexible, and scalable curriculum that can adapt to your needs.

Industry-Quality Products That Work

Success creates confidence and ignites passion. This is why Bio-Rad partners with master teachers and researchers to create relevant and robust educational products that work. All products undergo rigorous quality control to guarantee reliability and longevity. Our award-winning teaching resources and technical and curricular support allow teachers to expand their understanding and boost their confidence with new topics, technology, and applications.

Biotechnology: A Laboratory Textbook

Aligned to the Biotechnology Assistant Credentialing Exam (BACE), our textbook can guide development of a new course or supplement existing programs.

Innovative Hands-On Lab Activities

From DNA extraction to protein purification and real CRISPR gene editing, our hands-on lab activities complement the textbook and are guaranteed to work. Set your students up for success!

Real, Industry Research Equipment

Students learn on the same instruments used in research centers and laboratories.

Professional Development

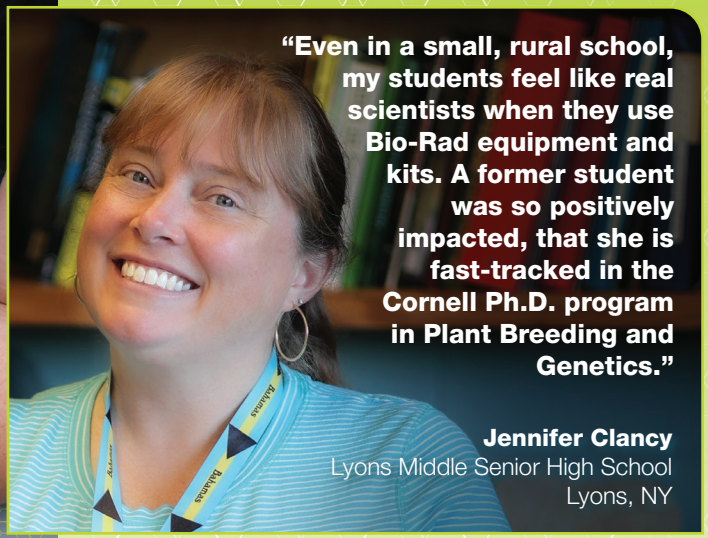
Online or in-person, we offer training matching each teacher's background and training needs.

Visit **info.bio-rad.com/ExplorerContactUs** to connect with a curriculum training specialist near you.

Featured Bio-Rad Explorer Kits

Section Contents

Featured Bio-Rad Explorer Kits



"Even in a small, rural school, my students feel like real scientists when they use Bio-Rad equipment and kits. A former student was so positively impacted, that she is fast-tracked in the Cornell Ph.D. program in Plant Breeding and Genetics."

Jennifer Clancy
Lyons Middle Senior High School
Lyons, NY

Bio-Rad Explorer Teacher and Student Alumni

DNA Barcoding Kits — Explore Your Local Biodiversity

Scientists Use Barcoding to Catalog Species Before They Are Lost

DNA barcoding adds a level of genetic identification to species classification. Traditionally, taxonomists based species determinations on observations of physical and environmental characteristics of a specimen. Now, DNA barcoding can help distinguish between species that look and behave so similarly that they would be considered the same species based on traditional taxonomic criteria.

Students Can Barcode Species in Their Own Backyards

With our DNA Barcoding Kits, students use molecular tools to identify species. They extract DNA from samples they collect, use PCR to amplify the DNA, and perform agarose gel electrophoresis to verify PCR products. Next, after receiving DNA sequencing results (sequencing services not included), they use bioinformatics to identify the species using the sequence obtained. Students may also collect samples from local shops to see if marketplace substitution is occurring!

DNA Barcoding Kits

Each kit supports 32 students.

Fish DNA Barcoding Kit
Catalog # **17007432EDU**

Includes DNA Extraction Module (12016408EDU) and Fish PCR Module (12016300EDU); for extraction and PCR amplification of up to 16 fish DNA and control samples.

Mammals, Insects, and Fungi DNA Barcoding Kit
Catalog # **17007366EDU**

Includes DNA Extraction Module (12016408EDU) and Mammals, Insects, and Fungi PCR Module (12016353EDU); for extraction and PCR amplification of up to 16 DNA and control samples.

Fish, Mammals, Insects, and Fungi DNA Barcoding Kit
Catalog # **17007154EDU**

Includes two DNA Extraction Modules (12016408EDU), one Fish PCR Module (12016300EDU), and one Mammals, Insects, and Fungi PCR Module (12016353EDU).

Ships at room temperature. Immediately store temperature-sensitive reagents at –20°C or 4°C as indicated. Visit bio-rad.com/barcoding for information on additional bundle options.

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.

Lab Preparation Checklist

Kit includes one DNA Extraction Module and one PCR Module.

Kit contains sufficient materials for 8 student workstations (2–4 students per workstation).

DNA Extraction Module:

Cell resuspension solution, 5 ml	1
Cell lysis solution, 5 ml	1
Neutralization solution, 5 ml	1
Wash buffer, 10 ml	1
Matrix, 5 ml	1
Spin filters with caps	20
Microcentrifuge tubes, 2 ml	250

PCR Module:

PCR tubes, 0.2 ml	50
PCR master mix (Taq DNA polymerase, dNTPs, buffer), 1.2 ml	1
Primer mix (40x), 50 µl	1
COI-ITS PCR Control DNA, 25 µl	1
UView 6x Loading Dye and Stain, 200 µl	1
PCR molecular weight ruler, 200 µl	1
Sterile water, 2.5 ml	1

Curriculum, including Easy Start and Answer Guide; Instructor and student guides are free downloads.

Required Accessories Not Included in Kit:

Tissue samples	2–16
Dry bath or water bath	1
Microcentrifuge	≥14,000 x g
Horizontal gel electrophoresis chamber with gel casting tray and comb	4–8
Power supplies	1–4
Thermal cycler with at least 32 wells	1
2–20 µl adjustable-volume micropipet	8
20–200 µl adjustable-volume micropipet	8
100–1,000 µl adjustable-volume micropipet	8
100–1,000 µl pipet tips	1 bag
2–20 µl aerosol barrier pipet tips	1 bag
20–200 µl aerosol barrier pipet tips	1 bag
UV transilluminator or imaging system	1

Recommended (Optional) Accessories:

Vortexer, p. 149	1

ReadyAgarose Precast Mini Gels, p. 120
Gel Staining Trays, p. 157
Gel Documentation System, pp. 146–147

Refresh Kit Components: (more info pp. 157–159)

DNA Extraction Module (12016408EDU), reagents and plastic consumables for chromosomal DNA extraction, includes resuspension, lysis, and neutralization solutions, wash buffer, matrix, spin filters, and 2.0 ml microtubes for up to 16 extractions

DNA Extraction Reagent Pack (1665105EDU), reagents for chromosomal DNA extraction, includes resuspension, lysis, and neutralization solutions, wash buffer, matrix, and spin filters for up to 16 extractions

Fish PCR Module (12016300EDU), includes 2x master mix, PCR primers, control DNA, sterile water, molecular weight ruler, fluorescent DNA loading dye and stain, and PCR tubes

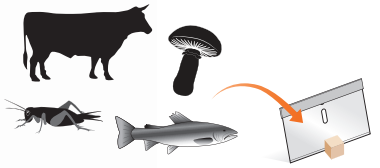
Mammals, Insects, and Fungi PCR Module (12016353EDU), includes 2x master mix, PCR primers, control DNA, sterile water, molecular weight ruler, fluorescent DNA loading dye and stain, and PCR tubes

0.2 ml PCR Tubes (TWI0201EDU), p. 124
2 ml Microtubes (2239430EDU), p. 157
2x Master Mix for PCR, p. 129
UView 6x Loading Dye and Stain, p. 122

Lab 1

Sample preparation

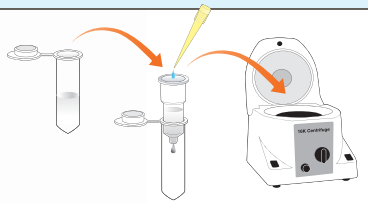
Select mammalian, insect, fungal, or fish sample



Prepare a small tissue sample

DNA extraction

Prepare DNA samples using extraction buffers and centrifugation

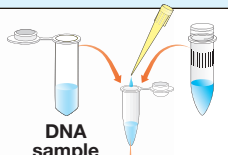


Purify DNA using spin colum

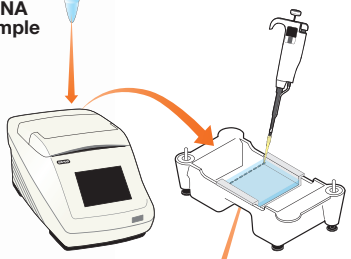
Elute DNA from spin column

PCR amplification and electrophoresis

Add master mix to DNA samples and control DNA



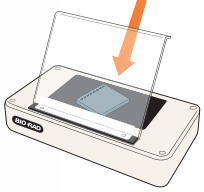
Amplify target sequences



Analyze DNA via electrophoresis

PCR results analysis

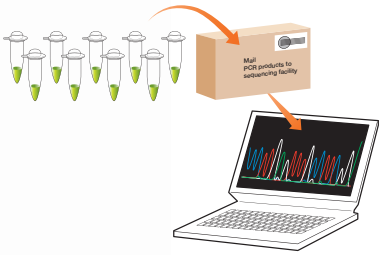
View results on a UV transilluminator



Use UView 6x Loading Dye and Stain for **instant results**

Sequencing and bioinformatics for species identification

Ship PCR products to your sequencing facility*



Analyze sequences using DNA bioinformatics platform

Bioinformatics analysis

Extension: Look more closely at DNA structure with the DNA model, p. 118

* Sequencing not included with the kit.

Virus Detection and Transmission Kit — Was It Something They Ate?

Solve the Mystery of How a Virus Spread through a Restaurant

Based on published viral transmission case studies, this hands-on lab activity puts your students into the roles of emergency room doctor, medical laboratory scientist, epidemiologist, and public health official as they combine molecular data with other information to determine how a novel virus spread through a restaurant.

Choose from Four Virus and Transmission Scenarios

Choose to follow either a novel norovirus or novel coronavirus, then choose one of two possible transmission scenarios — a total of four different activity options!

Examine Molecular Diagnostics and the Chain of Infection

Use the included preamplified DNA samples to teach diagnostic PCR applications without a thermal cycler. Analyze simulated samples by agarose gel electrophoresis, compile class data, and then analyze infection patterns and other patient information to deduce the mode of virus transmission. Along the way, career highlights introduce students to opportunities within the health and life sciences.

Virus Detection and Transmission Kit

Each kit supports 32 students.

Virus Detection and Transmission Kit
Catalog # **17008261EDU**

Virus Detection and Transmission Kit plus Fast Blast Electrophoresis Reagents
Catalog # **17008251EDU**

Virus Detection and Transmission Kit plus UView Electrophoresis Reagents
Catalog # **17008241EDU**

Ships at ambient temperature. Store reagent pack at –20°C.

Key Kit Features

- Curricular connections to virology, pathophysiology, epidemiology, gel electrophoresis, PCR, and reverse-transcription PCR
- Preamplified PCR DNA samples to teach PCR without a thermal cycler

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.

Lab Preparation Checklist

Kit contains sufficient materials for 24 student workstations (2–4 students per workstation).

1.5 ml EZ Micro Test Tubes	90
Molecular weight ruler	200 µl
DNA Sample 1	215 µl
DNA Sample 2	250 µl
Orange G Loading Dye, 5x	1 ml
Answer Guide	
Instructor and Student Guides available online free for download	

Fast Blast Electrophoresis Reagents

Fast Blast DNA Stain	100 ml
Certified Molecular Biology Agarose	5 g
TAE Electrophoresis Buffer, 50x	100 ml

UView Electrophoresis Reagents

UView 6x Loading Dye and Stain	200 µl
Certified Molecular Biology Agarose	5 g
TAE Electrophoresis Buffer, 50x	100 ml

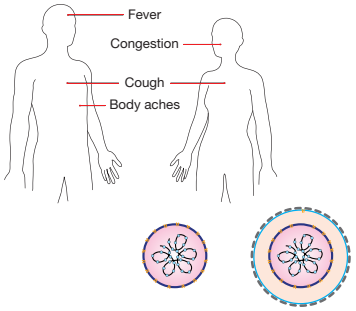
Required Accessories Not Included in Kit:

Adjustable micropipets and tips, pp. 152–154	
20–200 µl	1
1–20 µl	8
or fixed volume micropipets, 50 µl	8
Horizontal gel electrophoresis chambers, p. 117	4–8
Power supply, p. 155	1–8
UV transilluminator (if using UView 6x Loading Dye and Stain), p. 146	1
Gel staining trays, p. 157	

Refresh Kit Components: (see pp. 157–159)
Gel Staining Trays, 4 (#1660477EDU)
UView 6x Loading Dye and Stain, p.122
DNA Electrophoresis Reagent Packs, p. 119

Activity 1: Learning about virus biology, pathophysiology, and detection

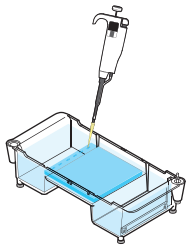
Review patient symptoms, make a hypothesis about cause



Discuss viral biology, pathophysiology, and molecular diagnostic tests

Activity 2: Activity 2: Infection detection

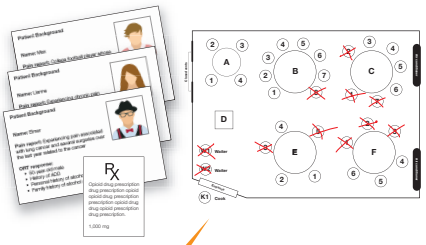
Load restaurant staff and patron samples

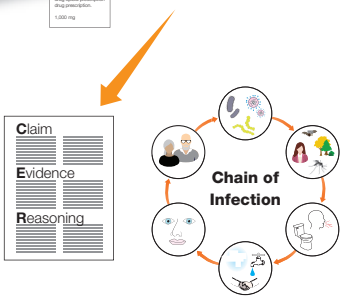


Run DNA gel electrophoresis

Activity 3: Building transmission models

Apply data to restaurant layout

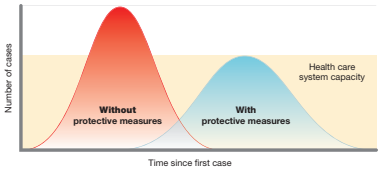




Develop a model for how transmission occurred in the restaurant

Activity 4: Mitigating risk (optional)

Decide whether and how to mitigate further spread



pGLO Bacterial Transformation Kit for General Biology

A Scaffolded Approach to pGLO Bacterial Transformation

This kit converts the classic pGLO transformation lab into a student-driven experimental design experience. Students first observe fluorescent organisms and create models to explain their observations and then transform bacteria with the pGLO plasmid to collect data about the role of antibiotic selection markers. They then design and run a second experiment to switch on expression of the GFP gene and see the bacteria glow under UV light. Finally, students engage in an engineering design challenge in which they apply what they've learned to design a biosensor, based on bacterial transformation, to solve a real-world problem.

pGLO: An Unforgettable Way to Teach Gene Expression and Regulation

Bacteria transformed with the pGLO plasmid glow a brilliant fluorescent green under UV light. Once students perform this transformation, they never forget the central dogma of molecular biology: DNA > RNA > Protein > Trait — Green Fluorescence.

Aligned to NGSS

The activities in this kit include modeling, experimental design, and design engineering that align to the Next Generation Science Standards (NGSS) and modern teaching methods. The lessons are designed to help students make sense of gene expression and bacterial transformation through progressive rounds of careful observation and data analysis.

pGLO Bacterial Transformation Kit for General Biology

Each kit supports 48 students.

pGLO Bacterial Transformation Kit for General Biology

Catalog # **17006991EDU**

A printed curriculum manual is not included in the kit. It is available for download at bio-rad.com/pGLOGenBio free of charge.

Convenient lyophilized reagents. Ships at room temperature. Store at 4°C.

Key Kit Features

- Includes consumables and reagents for 12 laboratory workstations or 48 students
- Enables students to design and analyze two gene expression experiments
- Allows students to create and revise models to explain their observations
- Activities designed for three to five 50-minute class periods

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.

pGLO Kits Comparison	pGLO Bacterial Transformation Kit
Overview	The classic, skills-based activity in which students investigate antibiotic resistance and inducible GFP expression
Workstations	8
Laboratory activities	1
Class periods (50 min)	2
Standards alignment	General

Lab Preparation Checklist

Kit contains sufficient materials for 12 student workstations (2–4 students per workstation).

Plasmid (pGLO), lyophilized	1
E. coli strain HB101 K-12, lyophilized	1
LB nutrient broth, sterile	1
LB nutrient agar powder	1
Ampicillin, lyophilized	1
Arabinose, lyophilized	1
Sterile transformation solution ($CaCl_2$)	1
Petri dishes, 60 mm, sterile	40
Inoculation loops, sterile	80
Microcentrifuge tubes, 2.0 ml, sterile, color coded	60
Foam floats	8
Disposable plastic transfer pipets	50
UV pen light	1
Answer Guide	
Instructor and Student Guides available online free for download	

Recommended (Optional) Accessories:

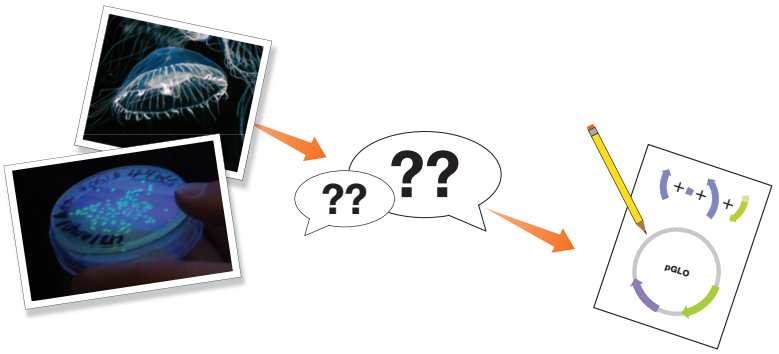
Incubation oven, p. 150	
Water bath or dry bath, p. 150	
UV lamps, p. 146	4–8
Microwave oven	

Refresh Kit Components: (more info pp. 157–159)

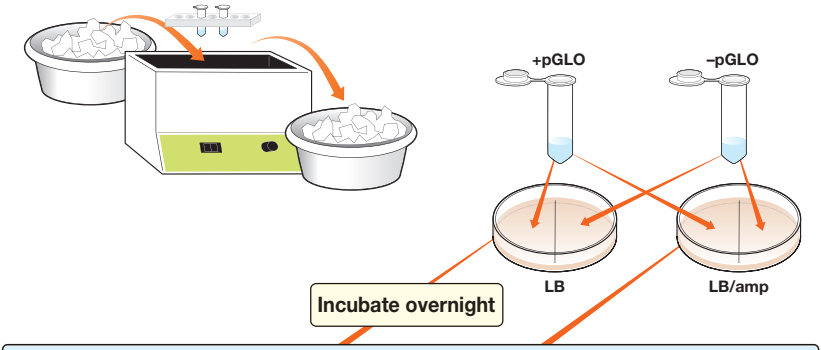
Transformation Kit Reagent Refill Pack (#1660555EDU), includes pGLO plasmid, *E. coli* strain HB101 K-12, LB nutrient broth, transformation solution, ampicillin, arabinose
pGLO Plasmid (#1660405EDU)
E. coli Strain HB101 K-12 (#1660408EDU)
LB Nutrient Broth, 10 ml (#1660421EDU)
Ampicillin (#1660407EDU)
Arabinose (#1660406EDU)
LB Nutrient Agar Powder, 20 g (#1660600EDU) or 500 g (#1660472EDU)
Transformation Solution, 15 ml (#1660409EDU)
Petri Dishes, 60 mm, sterile, 500 (#1660470EDU)
Inoculation Loops, 10 µl, sterile, 100 (#1660471EDU)
Disposable Plastic Transfer Pipets, sterile, 500 (#1660474EDU)
Jellyfish Foam Floating Racks, 8 racks (#1660479EDU)

	pGLO Bacterial Transformation Kit for General Biology	pGLO Bacterial Transformation and Inquiry Kit for AP Biology
	A phenomenon-based, scaffolded approach to bacterial transformation in which students investigate antibiotic resistance and inducible GFP expression sequentially	An inquiry-based approach to bacterial transformation and gene expression and regulation
	12	8
	2	5
	3–5	Flexible to fit a range of class periods
	NGSS, TEKS	AP Biology and inquiry (structured, guided, or open)

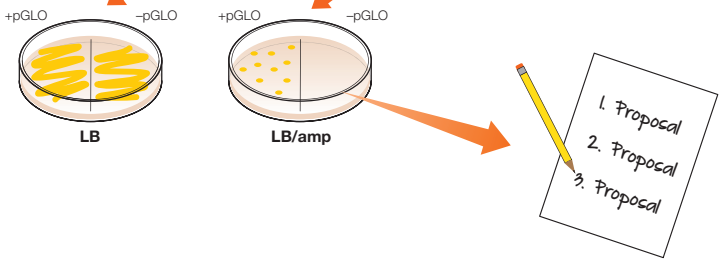
Observe fluorescent organisms, discuss ideas, and model gene transfer



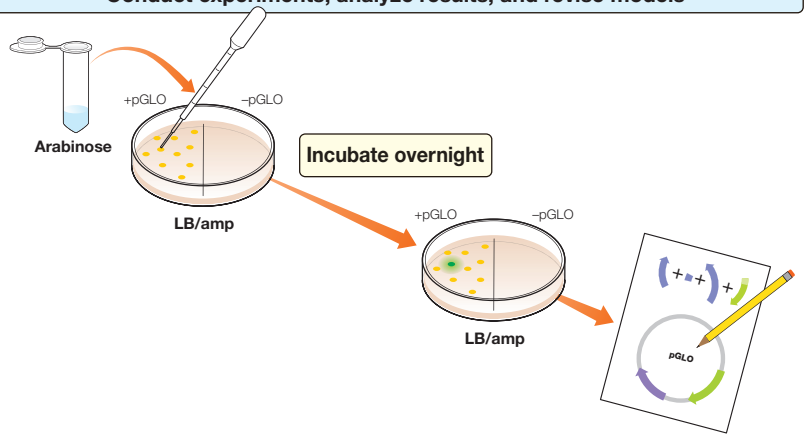
Transform bacteria with the pGLO plasmid



Analyze results, make claims, and design an experiment to switch ON the *GFP* gene with arabinose



Conduct experiments, analyze results, and revise models



Optional Extension: Design a biosensor to solve a real world problem

Section Contents

Genetic Engineering, Microbiology, and Model Organism Kits

"Bio-Rad has some of the most reliable biotech products ever! Their technical support is beyond compare. I really love the Photosynthesis and Cellular Respiration lab that demonstrates that some organisms can complete both photosynthesis and cellular respiration!"

Karen Davis
College Board Consultant
for AP Biology
New Braunfels, TX

Bio-Rad Explorer Teacher and Student Alumni

Do true CRISPR gene editing in your classroom!

Propel your students to the very cutting edge of life science research with the Bio-Rad Out of the Blue CRISPR and Out of the Blue Genotyping Extension Kits. With CRISPR technology, researchers have unprecedented flexibility and control over gene editing, and now your students can use it, too. The Out of the Blue CRISPR and Genotyping Extension Kits are accessible and safe with visibly stunning results.

Wow! I did CRISPR!

The innovative and unique Out of the Blue CRISPR Kit allows students to use real CRISPR-Cas9 technology to introduce a stop codon into the chromosomal *lacZ* gene in *E. coli.* A vibrant blue-white colony screening reveals the phenotype associated with gene editing. The optional genotyping extension kit allows your students to confirm the genomic edit with PCR analysis and gel electrophoresis. Armed with experimental evidence, your students then explore the possibilities and ethics of CRISPR technology in therapeutic applications.

Out of the Blue Kits

Each kit supports 32 students.

Out of the Blue CRISPR Kit
Catalog # **12012608EDU**

Out of the Blue Genotyping Extension
Catalog # **12012607EDU**

Out of the Blue CRISPR and Genotyping Extension Kits
Catalog # **17006081EDU**

Ships at ambient temperature. Immediately store temperature-sensitive reagents at –20°C or 4°C as indicated.

Visit **bio-rad.com/outoftheblue** for information on additional Out of the Blue bundle options.

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.

Lab Preparation Checklist

Kit contains sufficient materials for 8 student workstations (2–4 students per workstation).

Out of the Blue CRISPR Kit

E. coli strain HB101-pBRKan, lyophilized	1
pLZDonor plasmid	250 µl
pLZDonorGuide plasmid	250 µl
Spectinomycin powder	18 mg
L(+) arabinose powder	25 g
LB nutrient agar powder	25 g
LB nutrient broth capsule	1
Transformation solution	15 ml
KIX mix, powder	250 mg
Inoculation loops, sterile	80
Petri dishes, sterile	60
Microcentrifuge tubes, 2.0 ml, clear	90

Out of the Blue Genotyping Extension

Primer mix	20 µl
Positive control DNA	150 µl
2x PCR master mix	1,200 µl
PCR MW marker	200 µl
Orange G loading dye	1 ml
InstaGene Matrix	20 ml
PCR tube	100
1.5 ml Microtube	90
1.5 ml Screwcap microtube	50
Printed answer guides included. Instructor and student guides available online free for download	1

Required Accessories Not Included in Kits

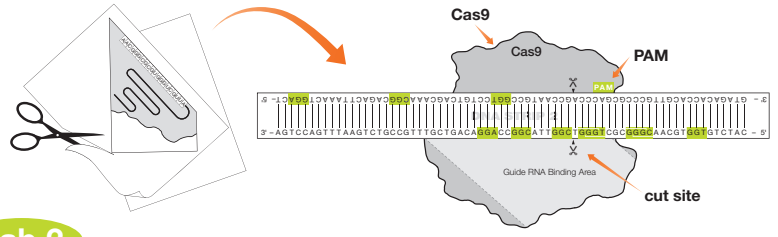
Adjustable-volume micropipets and tips, 100–1,000, 20–200, 1–20 µl, pp. 152–154	1–8
Balance with 1–10 g range	
Water bath or dry bath, p. 150	

Recommended (optional) Accessories:
Incubation oven, p. 150
Pipet controller, p. 153
Autoclave or microwave oven

Refresh Kit Components: (see pp. 157–159)
Out of the Blue CRISPR Kit Refill Pack (#12012620EDU)
Out of the Blue Genotyping Extension Refill Pack (#12012708EDU)

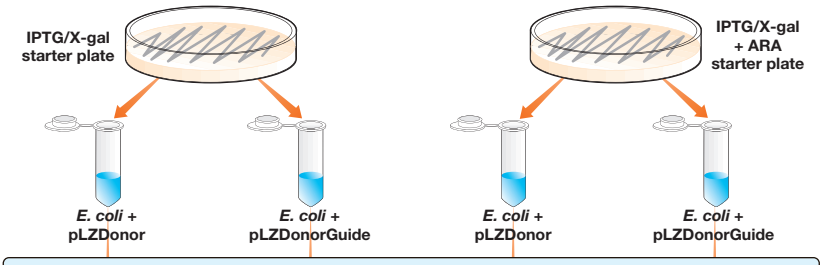
Lab 1

Optional CRISPR-Cas9 Paper Model Introductory Activity



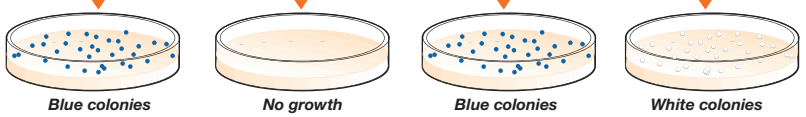
Lab 2

Streak starter plates with *E. coli*



Heat shock at 60°C for 50 sec, recover on ice, then add nutrient broth

Spread bacteria on agar plates and incubate overnight at 37°C



Count colonies and calculate gene editing efficiency

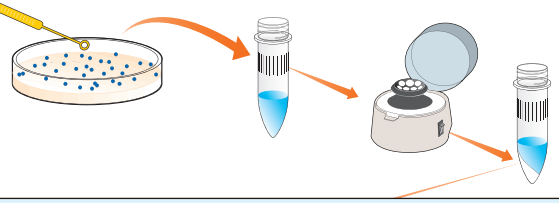
Optional: Guided debate on the ethics of CRISPR technology applications

Lab 3

Genotyping Extension*: Verify gene editing by PCR

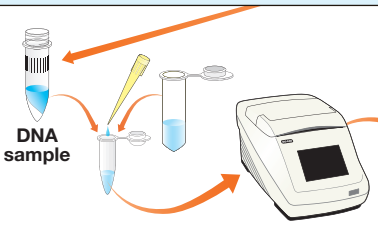
Extract DNA from colonies

Pick colonies for DNA extraction



Amplify samples by PCR and electrophorese

Add master mix to DNA samples and controls



Amplify target sequences

Analyze DNA via electrophoresis

Capstone Activity: Propose target CRISPR-Cas9 cut sites for gene therapy and use bioinformatics to evaluate the possibility of off-targets. Genotyping Extension not required.

* Requires the Out of the Blue Genotyping Extension, sold separately.

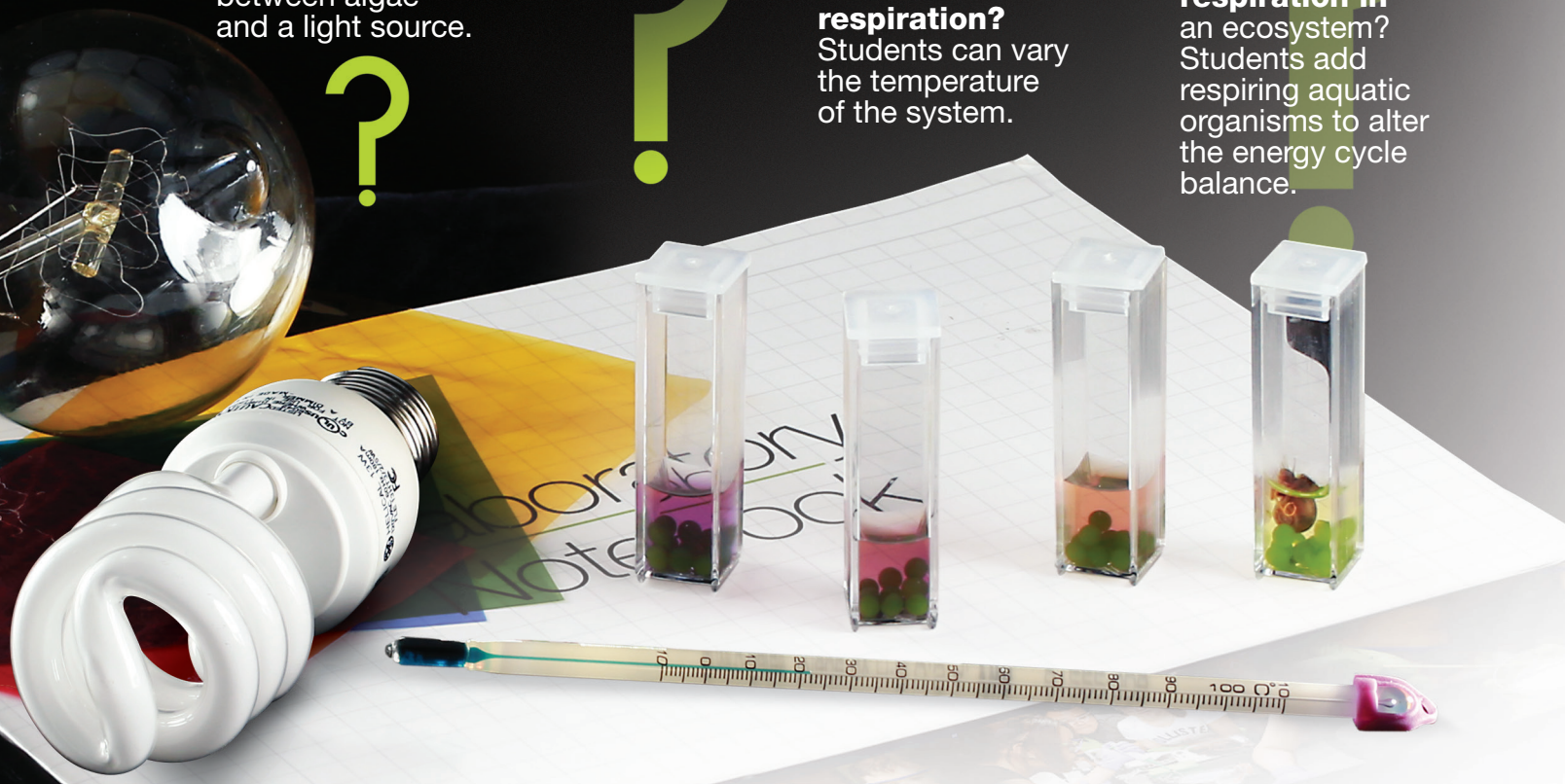
Photosynthesis & Cellular Respiration Kit for AP Biology — A ThINQ! Investigation

How does light intensity influence photosynthesis? Students can vary the distance between algae and a light source.

Does the wavelength of light matter? Students can choose colored light filters.

Will temperature change the rate of cellular respiration? Students can vary the temperature of the system.

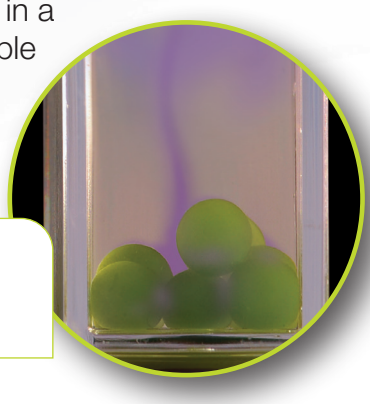
What affects the balance of photosynthesis and cellular respiration in an ecosystem? Students add respiring aquatic organisms to alter the energy cycle balance.



Now You Can Teach Photosynthesis and Cellular Respiration Together

Premade algae beads included in this kit can be used to answer experimental questions about both photosynthesis and cellular respiration in a single lab activity. Students will explore both processes in a single organism (an alga) using a simple colorimetric assay to yield qualitative and/or quantitative results.

Recommended for
AP Biology
Big Ideas
1 2 3 4



Energy transfer your students can see!
Reusable algae beads cause a vibrant shift in the color of indicator solution when doing either photosynthesis or cellular respiration.

Photosynthesis and Cellular Respiration Kit for AP Biology

Each kit supports 32 students.

Photosynthesis and Cellular Respiration Kit for AP Biology*
Catalog # **17001238EDU**
Ships on ice. Store at 4°C.

Key Kit Features

- Connects photosynthesis and cellular respiration
- Provides structured, guided, and open inquiry
- Aligns to AP Biology Big Idea 2, connects to 1 and 4
- Contains reusable premade algae beads
- 6 inquiry investigations, all reagents included

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.

Lab Preparation Checklist

Kit contains sufficient materials for 8 student workstations (2–4 students per workstation).

Algae beads, 170 beads	1
10x CO_2 indicator, 50 ml	1
Debeading solution, 20 ml	1
Disposable cuvettes with caps	100
Disposable plastic transfer pipets	60
Indicator color guide	8
Curriculum, including teacher's guide	1
Student manual available online	

Recommended (Optional) Accessories:

Beaker, 100–150 ml	1
Graduated cylinders, 100 ml and 10 ml	1 ea
Distilled water	1 L
Lamp fitted with a 60–100 W bulb	1–8
Clock or timer for counting seconds	1–8
Microscopes	1–8
Microscope slides	1–8
Coverslips	1–8
Aluminum foil	
Printer and transparency film or colored cellophane, multiple colors	1
Ruler/meter or yard stick/measuring tape	1–8
Thermometers (0–100°C)	2–8
Waterbath, p. 150	1
Aquatic snail or other heterotroph	varies

Refresh Kit Components: (see pp. 157–159)
Photosynthesis and Cellular Respiration Reagent Refill Pack* (#12002353EDU)

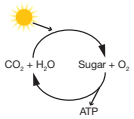
* For availability outside the U.S. and Canada, please contact your local Bio-Rad office. See back cover.

Pre-lab activities

Pre-lab #1

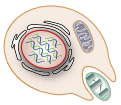
Chloroplast and mitochondrion structure

Pre-lab #2



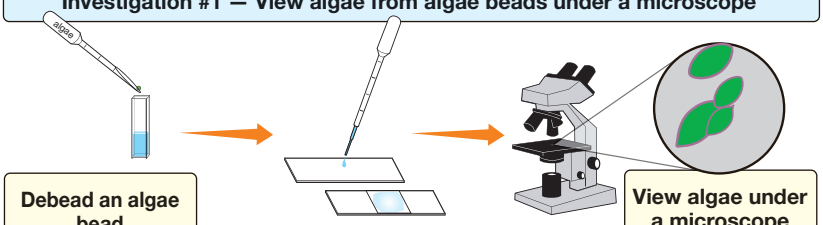
Photosynthesis and cellular respiration

Pre-lab #3



Endosymbiosis theory

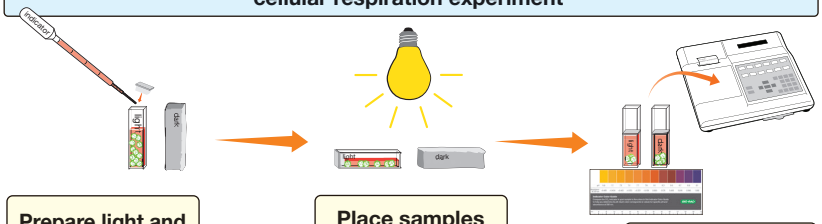
Investigation #1 — View algae from algae beads under a microscope



Debead an algae bead

View algae under a microscope

Investigation #2 — Conduct core photosynthesis and cellular respiration experiment



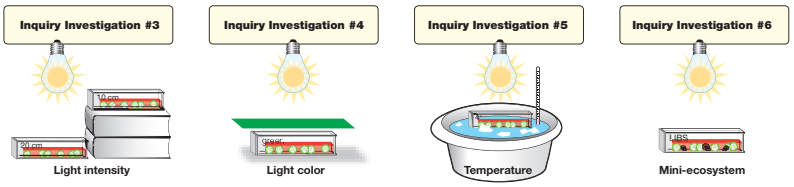
Prepare light and dark algae bead samples

Place samples under light

Monitor sample color change

Analyze results

Structured/guided/open inquiry extensions — materials included



Photosynthesis and Cellular Respiration Kits

	For AP Biology (#17001238EDU)	For General Biology (#1200553EDU), p. 22
Standards alignment	AP Biology	NGSS**, TEKS
Learning focus	Quantitative data collection and experimental design	Developing scientific explanations for observed phenomena 3-dimensional learning
Kit contents	Materials for 8 student workstations to perform pre-lab activities and 6 inquiry investigations	Materials for 24 student workstations to perform pre-lab activities and 1 inquiry investigation sequence

** Next Generation Science Standards is a registered trademark of Achieve. Neither Achieve nor the lead states and partners that developed the Next Generation Science Standards were involved in the production of this product, and do not endorse it.

Photosynthesis & Cellular Respiration Kit for General Biology — A ThINQ! Investigation

Do plants perform cellular respiration?
Students measure photosynthesis and cellular respiration in algae beads.

How can photosynthesis be measured?
Students can watch for color changes caused by algae beads.

What is a good model to describe photosynthesis and cellular respiration?
Students create, revise, and refine models.

Lead your students from phenomenon to scientific explanation

Put your students at the center of instruction as they design experiments and create models to understand the basic details of photosynthesis and cellular respiration — with algae beads!

Energy transfer your students can see!
Reusable algae beads cause a vibrant shift in the color of indicator solution when doing either photosynthesis or cellular respiration.

Photosynthesis and Cellular Respiration Kit for General Biology

Each kit supports 96 students.

Photosynthesis and Cellular Respiration Kit for General Biology*
Catalog # **12005534EDU**
Ships on ice. Store at 4°C.

Key Kit Features

- Connects photosynthesis and cellular respiration
- Includes materials for 3 classes of 8 student workstations (24 total workstations)
- Designed for the Next Generation Science Standards**
- Contains reusable premade algae beads

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.

Lab Preparation Checklist

Kit contains sufficient materials for 24 student workstations (2–4 students per workstation).

Algae beads, 170 beads	1
10x CO_2 indicator, 50 ml	1
Debeading solution, 20 ml	1
0.2 ml PCR tubes with domed lids	150
Disposable plastic transfer pipets	60
Indicator color guides	12
Printed Instructor's Answer Guide	1
Instructor's and Student Guides available free online for download	

Required Accessories Not Included in Kit:

Clear plastic cups or conical tubes	2–48
Beaker, 100–150 ml	2
Beaker, 250–500 ml	1
Graduated cylinders, 25 ml and 250 ml	1 ea
Distilled water	1 L
Lamp fitted with a 60–100 W bulb	1–24
Clock or timer for counting seconds	1–28
Aluminum foil	
Parafilm or plastic wrap	

Recommended (Optional) Accessories:

Microscopes	1–24
Microscope slides and coverslips	1–24

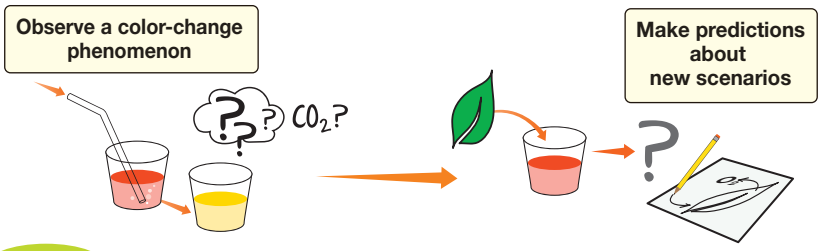
Refresh Kit Components: (see pp. 157–159)
Photosynthesis and Cellular Respiration Reagent Refill Pack* (#12002353EDU)

* For availability outside the U.S. and Canada please contact your local Bio-Rad office. See back cover.

** The Next Generation Science Standards is a registered trademark of Achieve. Neither Achieve nor the lead states and partners that developed the Next Generation Science Standards were involved in the production of this product, and they do not endorse it.

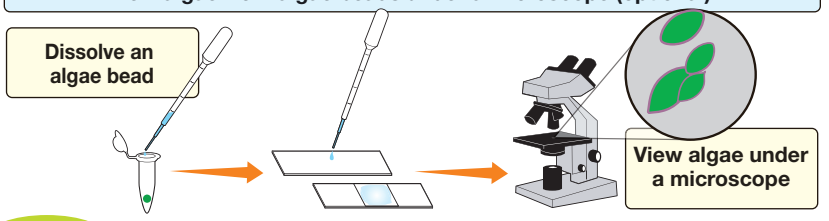
Lab 1

Students make predictions about photosynthesis and cellular respiration



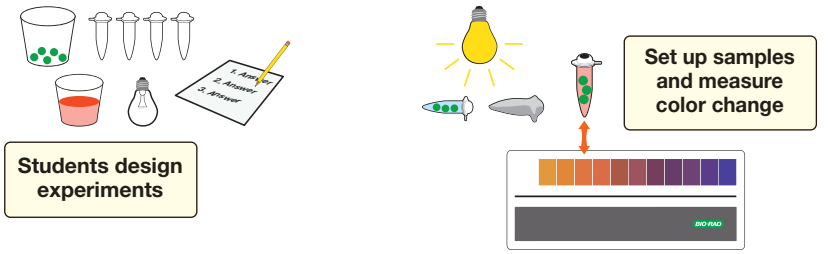
Lab 2

View algae from algae beads under a microscope (optional)



Lab 3

Conduct student experiments using algae beads



Analyze results and revise models

Post-lab assessment and extension

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and using models	Organization for matter energy flow in organisms	Energy and matter
Planning and carrying out investigations	Cycles of matter and energy transfer in ecosystems	Systems and system models
Constructing explanations and designing solutions		Cause and effect
Engaging in argument from evidence		

Photosynthesis and Cellular Respiration Kits

	For General Biology (#1200553EDU)	For AP Biology (#17001238EDU), p. 20
Standards alignment	NGSS**, TEKS	AP Biology
Learning focus	Developing scientific explanations for observed phenomena 3-dimensional learning	Quantitative data collection and experimental design
Kit contents	Materials for 24 student workstations to perform pre-lab activities and 1 inquiry investigation sequence	aterials for 8 student workstations to perform pre-lab activities and 6 inquiry investigations

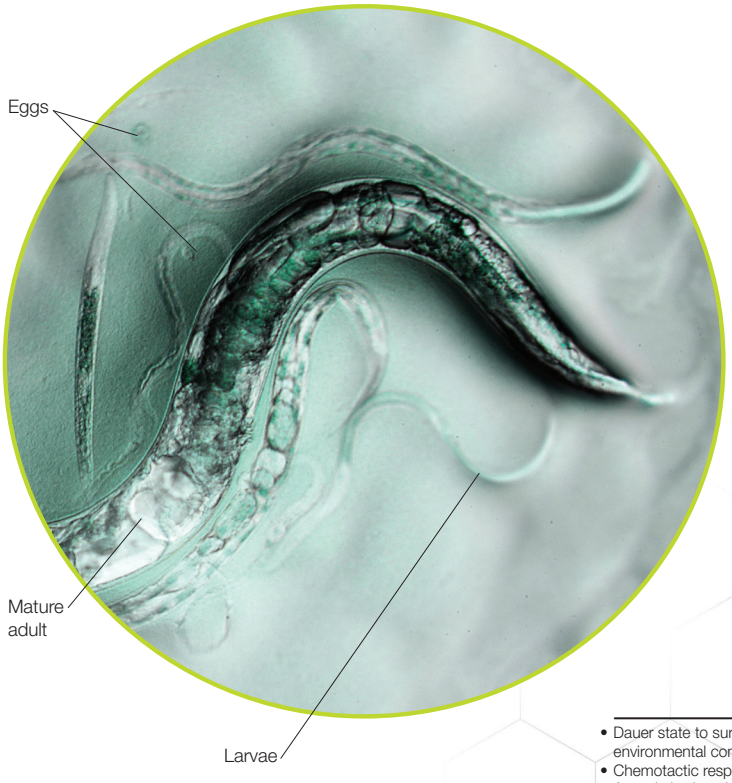
C. elegans Behavior Kit — AP Big Ideas 1, 2, 3, and 4: Pavlov's Worm

A captivating twist on the classical behavior lab. No more fruit flies!
Explore the fascinating life cycle of *Caenorhabditis elegans* in this chemotaxis experiment. Compare the learning ability of a wild-type strain to a neurologic mutant as they associate the presence of salt with food.

C. elegans was the first multicellular organism to have its complete genome sequenced. The Nobel Prize in Physiology or Medicine was awarded to *C. elegans* researchers in 2002 (genetics of organ development and apoptosis), 2006 (RNA interference), and 2008 (GFP expression), emphasizing the importance of research on this model organism. This microscopic nematode is ideal for students to learn about subculturing so that they can observe the life cycle and different stages of development of the worms.

Following life cycle observation, students will monitor *C. elegans* chemotaxis. When wild-type *C. elegans* are fed in the presence of salt they learn to associate food with the salt, and will migrate toward salt in search of food. A mutation affecting the daf-18 gene (and subsequently the AIY and ASE neurons) prevents worms from associating salt with food. While the mutant *C. elegans* are able to display chemotaxis in response to many chemicals, they will not migrate toward higher salt concentrations in search of food.

Check out our online calculator at **bio-rad.com/cat/celegans** to help plan when to prepare the various stages of the lab.



C. elegans Behavior Kit

Each kit supports 32 students.

C. elegans Behavior Kit*

Catalog # **1665120EDU**

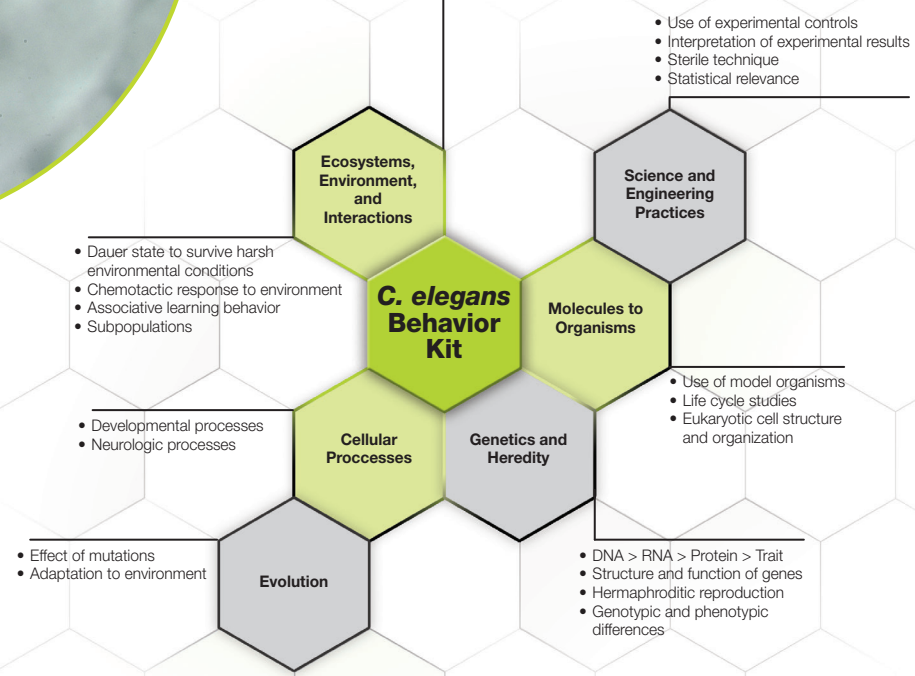
The worms are provided frozen and must be kept on dry ice (–70°C or colder). *C. elegans* will be shipped separately on requested date.

Key Kit Features

- Aligns with AP Biology Big Ideas 1, 2, 3, and 4; Investigation 12
- Includes neurobiology, BLAST analysis, and chi square statistic supplements
- Observe and study the life cycle of *C. elegans*, a model eukaryotic organism
- Utilize microscope skills
- Learn about genetics and its effect on behavior
- Complete student activities in two 45 minute lab sessions

* For availability outside the U.S. and Canada, contact your local Bio-Rad office. See the back cover.

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.



Lab Preparation Checklist

Follow kit insert instructions to receive your *C. elegans* in a separate shipment. Prepare the NGM Lite agar plates before receiving your *C. elegans*. Upon arrival, immediately place the bag containing *C. elegans* in a –70°C freezer or on dry ice until you follow the thaw procedure. DO NOT store *C. elegans* in a –20°C freezer.

Kit contains sufficient materials for 8 student workstations (2–4 students per workstation).

E. coli OP50-pBAD, lyophilized	1
Cholesterol in alcohol	200 µl
Ampicillin, lyophilized	30 mg
NGM Lite agar	11 g
Assay agar	4 g
2.5 M NaCl	0.5 ml
C. elegans wash buffer (10x)	30 ml
Microcentrifuge tubes, 2.0 ml	90
Microcentrifuge tubes, 1.5 ml	30
Petri dishes, 60 mm	60
Disposable plastic transfer pipets	50
C. elegans wild-type and mutant redemption instructions	1
Curriculum, including teacher's guide, student manual, and graphic quick guide	1

Required Accessories Not Included in Kit:

Adjustable micropipets, pp. 152–153	
2–20 µl (or 10 µl fixed volume)	8
100–1,000 µl	1–8
Pipet tips, p. 154	
2–200 µl, BR-35	1–8
100–1,000 µl, BR-40	1–8
Microwave oven, hot plate, or autoclave for preparing agar	1
Incubation oven, p. 150	1

Refresh Kit Components: (more info pp. 157–159)

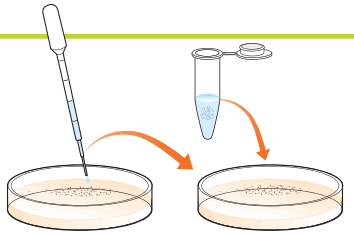
- *C. elegans* Behavior Kit RT Reagent Refill Pack (#1665121EDU), includes NGM lite and assay agar, wash buffer, and salt solution
- *C. elegans* Behavior Kit TS Reagent Refill Pack (#1665123EDU), includes *E. coli* OP50-pBAD, cholesterol, and ampicillin
- *C. elegans* Behavior Kit Wild-Type and Mutant worm strains (#1665122EDU) **must be kept at –70°C or on dry ice until ready to plate**
- NGM Lite Agar (#1665125EDU), 11 g, for growth of wild-type and mutant *C. elegans* worm strains

***C. elegans* neurons at www.openworm.org**
Visit OpenWorm to see the entire worm connectome — you can see every neuron within the worm and how they all connect!

Web
Check This Out!

Lab 1

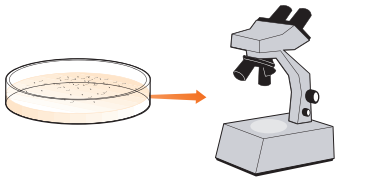
Prepare an NGM agar plate with a lawn of *E. coli*



Transfer a small group of *C. elegans* (wild type and mutant, each on separate plates)

Culturing

Identify all stages of *C. elegans* development



Life cycle observations

Lab 2

Wash the wild type and mutant *C. elegans* to remove *E. coli*

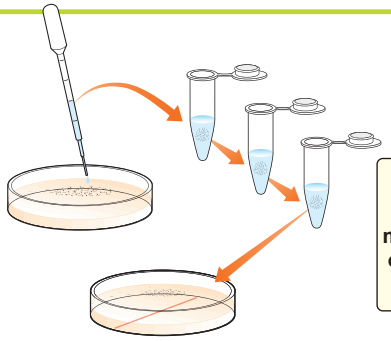
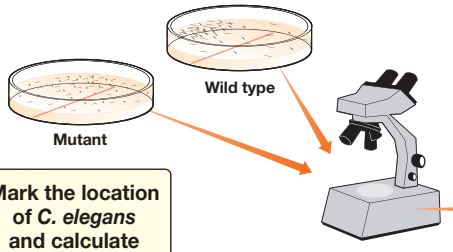


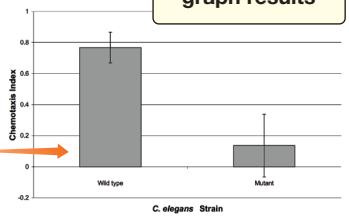
Plate each wild type and mutant *C. elegans* onto chemotaxis assay plate

Chemotaxis assay



Mark the location of *C. elegans* and calculate chemotaxis index

Analyze graph results



Chemotaxis results analysis

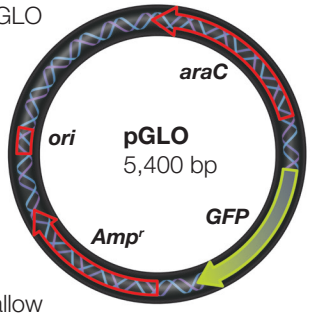
Lab 3

Optional: Neurobiology, BLAST analysis, and chi square statisical analysis supplemental learning

pGLO Bacterial Transformation Kit: Shine a Little Light on Your Molecular Biology —

Genetic engineering is the process of manipulating the genetic material of an organism, often to include the DNA from a foreign organism. In this activity, students transform bacteria by introducing a gene from a bioluminescent jellyfish. They use the same procedure used for creating "designer proteins" that has led to the explosion of new health treatments, agricultural applications, and environmental solutions.

Jellyfish genes make the invisible — visible! In this lab, students transform bacteria with a gene from the bioluminescent jellyfish Aequorea victoria. Bio-Rad's exclusive pGLO plasmid is constructed with the jellyfish gene that encodes green fluorescent protein (GFP), an antibiotic-resistance gene that encodes β-lactamase protein, and the araC gene, encoding a regulator protein that turns the GFP gene on and off. Bacteria transformed with the pGLO plasmid are selected by ampicillin resistance and, when induced to express GFP, the bugs glow fluorescent green under UV light!



Gene regulation. With the pGLO plasmid, students analyze the growth of bacteria on various media and examine the roles that external and internal factors play in gene regulation.

Gene expression in all organisms is carefully regulated to allow adaptation to differing conditions and to prevent wasteful production of proteins. The bacterial genes encoding the enzymes needed to metabolize the simple sugar arabinose are a perfect example. A promoter region upstream of these genes acts as a molecular on/off switch that regulates their expression. The genes are activated only when arabinose is present in the environment. Bio-Rad's pGLO plasmid incorporates the arabinose promoter, but the genes involved in the breakdown of arabinose have been replaced with the jellyfish gene encoding GFP. When bacteria transformed with the pGLO plasmid are grown in the presence of arabinose, the GFP gene switches on, causing the bacteria to express GFP and to fluoresce brilliant green.

When students genetically engineer bacteria with the genes from a bioluminescent jellyfish, they never forget the central dogma of molecular biology:

DNA ➤ RNA ➤ Protein ➤ Trait — Green Fluorescence!

pGLO Bacterial Transformation Kit

Includes free UV pen light!

Each kit supports 32 students.

pGLO Bacterial Transformation Kit
Catalog # **1660003EDU**

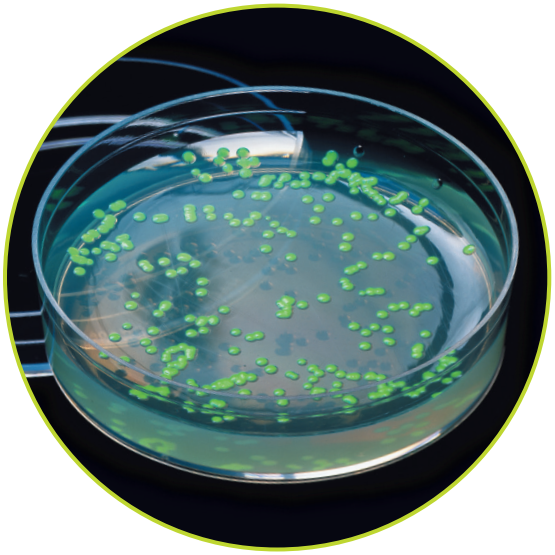
A printed curriculum manual is not included in the kit. It is available for download at bio-rad.com/pGLO free of charge. Convenient lyophilized reagents. Ships at room temperature. Store at 4°C.

pGLO Bacterial Transformation Kit with printed curriculum manual
Catalog # **1660043EDU**

Key Kit Features

- Aligns with AP Biology Big Idea 3; Investigation 8
- Transform bacteria with jellyfish gene
- Turn the modified genes on or off
- Study gene regulation
- Complete in two 45 minute lab sessions

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.



pGLO Kits Comparison	pGLO Bacterial Transformation Kit	pGLO Bacterial Transformation Kit for General Biology	pGLO Bacterial Transformation and Inquiry Kit for AP Biology
Overview	The classic, skills-based activity in which students investigate antibiotic resistance and inducible GFP expression	A phenomenon-based, scaffolded approach to bacterial transformation in which students investigate antibiotic resistance and inducible GFP expression sequentially	An inquiry-based approach to bacterial transformation and gene expression and regulation
Workstations	8	12	8
Laboratory activities	1	2	5
Class periods (50 min)	2	3–5	Flexible to fit a range of class periods
Standards alignment	General	NGSS, TEKS	AP Biology and inquiry (structured, guided, or open)

Lab Preparation Checklist

Kit contains sufficient materials for 8 student workstations (2–4 students per workstation).

Plasmid (pGLO), lyophilized	1
E. coli strain HB101 K-12, lyophilized	1
LB nutrient broth, sterile	1
LB nutrient agar powder	1
Ampicillin, lyophilized	1
Arabinose, lyophilized	1
Sterile transformation solution ($CaCl_2$)	1
Petri dishes, 60 mm, sterile	40
Inoculation loops, sterile	80
Microcentrifuge tubes, 2.0 ml, sterile, color coded	60
Foam floats	8
Disposable plastic transfer pipets	50
UV pen light	1
Instructor's manual available online free for download or printed and bundled with a kit (#1660043EDU)	

Recommended (Optional) Accessories:

Incubation oven, p. 150	
Water bath or dry bath, p. 150	
UV lamps, p. 146	4–8
Microwave oven	

Refresh Kit Components: (more info pp. 157–159)

Transformation Kit Reagent Refill Pack (#1660555EDU), includes pGLO plasmid, *E. coli* strain HB101 K-12, LB nutrient broth, transformation solution, ampicillin, arabinose
pGLO Plasmid (#1660405EDU)
E. coli Strain HB101 K-12 (#1660408EDU)
LB Nutrient Broth, 10 ml (#1660421EDU)
Ampicillin (#1660407EDU)
Arabinose (#1660406EDU)
LB Nutrient Agar Powder, 20 g (#1660600EDU) or 500 g (#1660472EDU)
Transformation Solution, 15 ml (#1660409EDU)
Petri Dishes, 60 mm, sterile, 500 (#1660470EDU)
Inoculation Loops, 10 µl, sterile, 100 (#1660471EDU)
Disposable Plastic Transfer Pipets, sterile, 500 (#1660474EDU)
Jellyfish Foam Floating Racks, 8 racks (#1660479EDU)
Curriculum Manual, printed (#1660033EDU)

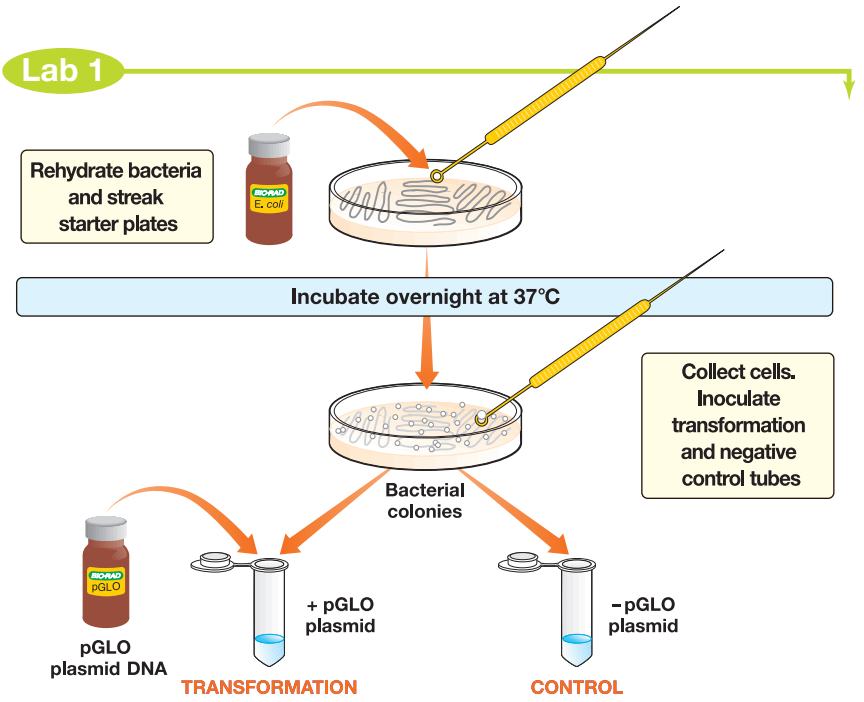
Extra Curriculum for pGLO on the Web
Visit **bio-rad.com/teachpGLO** for a range of free resources that include the pGLO sequence and map, instructional and editable PowerPoints, and a link to our YouTube playlist.

Web
Check This Out!

This hands-on activity is integrated with the Lt Biology Collection, the online learning platform from ADInstruments.

Lt
ADINSTRUMENTS making science easier

Lab 1

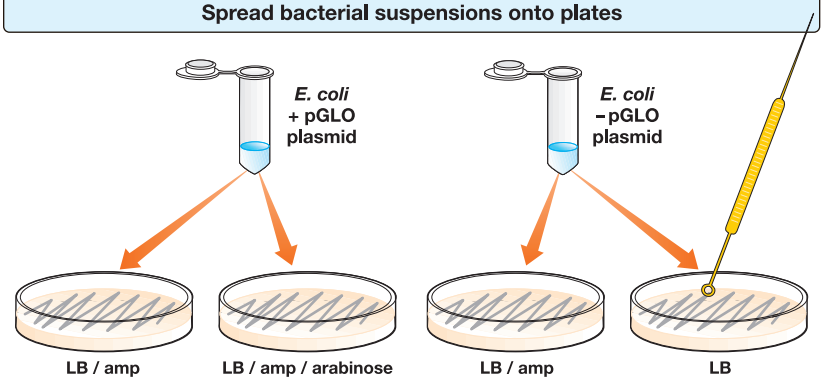


Incubate both tubes on ice for 15 minutes

Heat shock at 42°C for 50 seconds, place on ice for 2 minutes

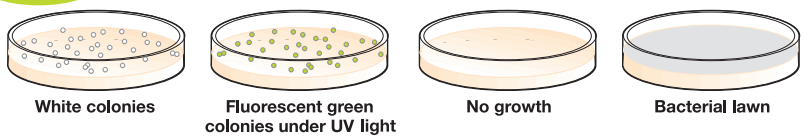
Add nutrient broth and incubate at room temperature for 10 minutes

Spread bacterial suspensions onto plates



Incubate overnight at 37°C

Lab 2



Analyze and interpret results

Extension: **GFP chromatography kit**, see pp. 30

Extension: **pGLO kit SDS-PAGE extension**, see p. 32

For an inquiry approach

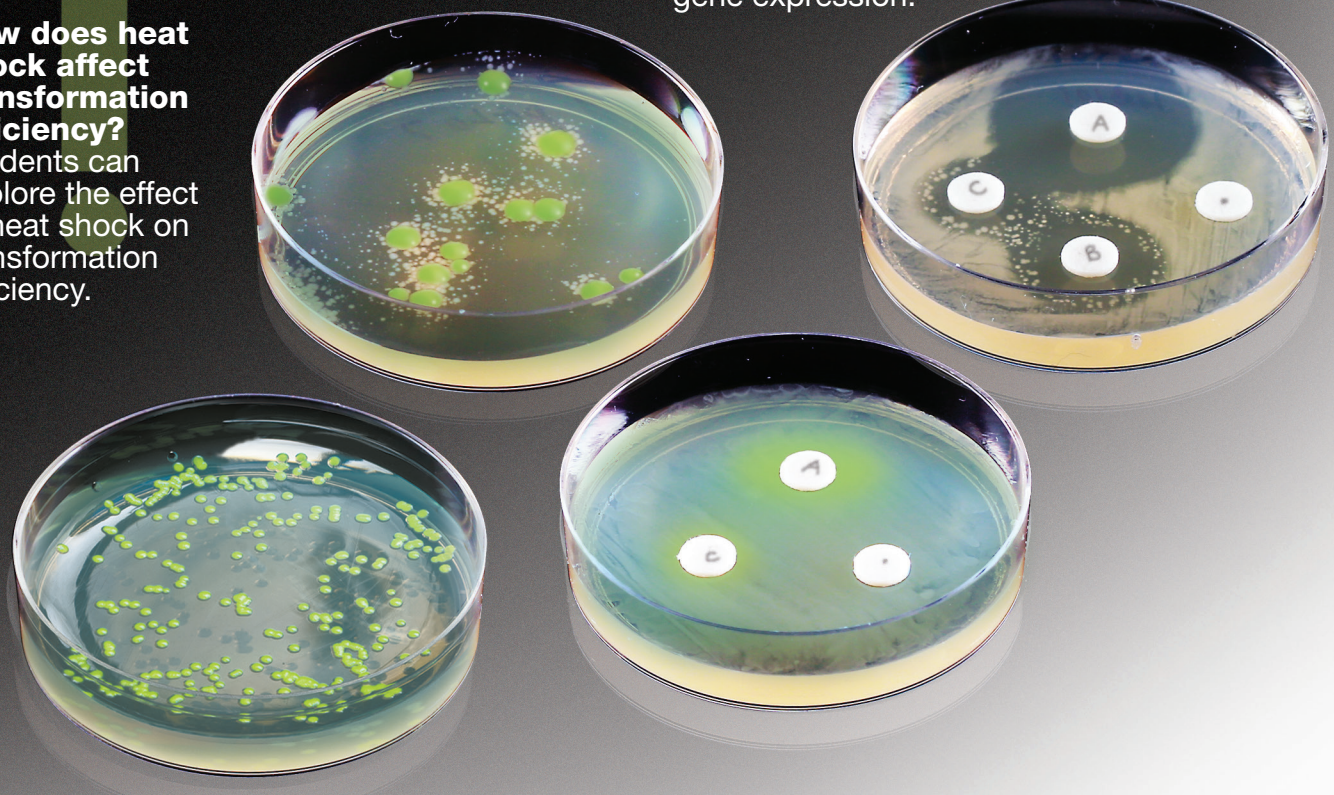
pGLO Transformation and Inquiry Kit for AP Biology, see p. 28

How does heat shock affect transformation efficiency?
Students can explore the effect of heat shock on transformation efficiency.

Why are there satellite colonies?
Some colonies are growing but not glowing. How is that possible?

What effect does arabinose have?
Students can expose bacteria to different levels of arabinose and examine levels of gene expression.

What effect does ampicillin have?
Students can expose bacteria to different levels of ampicillin and examine growth.



Recommended for
AP Biology
Big Ideas
1 2 3 4

More than just Classic pGLO, ThINQ! through each piece of the puzzle!

Explore the process of bacterial transformation (genetic engineering) using Bio-Rad's exclusive pGLO plasmid in a structured inquiry activity. Then you or your students choose and design a series of four additional inquiry investigations — materials included! — that explore the effects of changes in scientific design and challenge their students' understanding of the principles surrounding bacterial transformation.

The pGLO Transformation and Inquiry Kit for AP Biology includes the reagents, protocols, and background information for the classic pGLO Bacterial Transformation Lab (p. 26) plus the materials for four additional inquiry investigations.

pGLO Transformation and Inquiry Kit for AP Biology

Each kit supports 32 students.

pGLO Bacterial Transformation Inquiry Kit
Catalog # **1660335EDU**

Includes a free UV pen light.

Convenient lyophilized reagents.
Ships at room temperature. Store at 4°C.

Key Kit Features

- Classic pGLO transformation plus four additional lab activities in one kit, all reagents included
- Aligns with AP Biology Big Ideas 1 and 3, connects to 2 and 4; Investigation 8
- Study gene regulation
- Teacher materials to support inquiry

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.

Lab Preparation Checklist

Kit contains sufficient materials for 8 student workstations (2–4 students per workstation).

Plasmid (pGLO), lyophilized	2
E. coli strain HB101 K-12, lyophilized	1
LB broth capsule	1
LB nutrient broth, sterile	1
LB nutrient agar powder, 10 ml	2
Ampicillin, lyophilized	3
Arabinose, lyophilized	3
Sterile transformation solution ($CaCl_2$)	2
Petri dishes, 60 mm, sterile	80
Inoculation loops, sterile	80
Blank disks, 6 mm, sterile	50
Microcentrifuge tubes, 2.0 ml, sterile	90
Foam floats	8
Disposable plastic transfer pipets	100
UV pen light	1
Inquiry curriculum, including teacher's guide	1
Student manual available online	

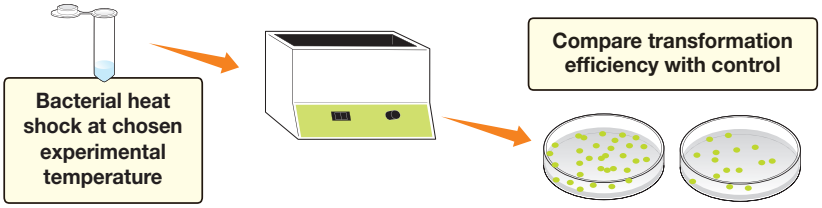
Recommended (Optional) Accessories:

Incubation oven, p. 150	
Water bath, p. 150	
UV lamps, p. 146	4–8
Microwave oven	

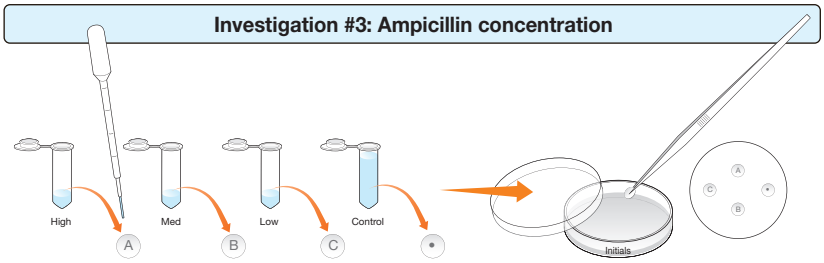
Refresh Kit Components: (see pp. 157–159)
pGLO Inquiry Reagent Refill Pack (#1660336EDU)
Blank Disks 6 mm, sterile, 50 (#1660468EDU)
For additional refresh components see
pGLO Bacterial Transformation Kit, p. 27

Investigation #1: pGLO Bacterial Transformation (materials included, see p. 27 for details**)**

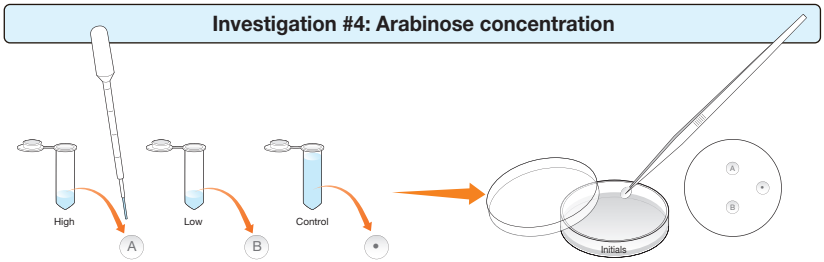
Investigation #2: Transformation efficiency



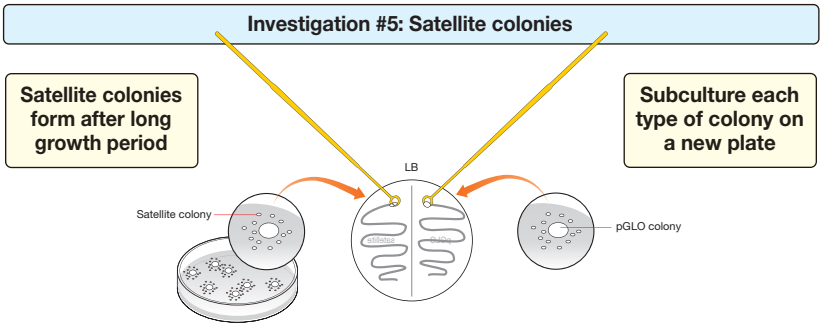
Investigation #3: Ampicillin concentration



Investigation #4: Arabinose concentration



Investigation #5: Satellite colonies



pGLO Kits Comparison	pGLO Bacterial Transformation Kit	pGLO Bacterial Transformation Kit for General Biology	pGLO Bacterial Transformation and Inquiry Kit for AP Biology
Overview	The classic, skills-based activity in which students investigate antibiotic resistance and inducible GFP expression	A phenomenon-based, scaffolded approach to bacterial transformation in which students investigate antibiotic resistance and inducible GFP expression sequentially	An inquiry-based approach to bacterial transformation and gene expression and regulation
Workstations	8	12	8
Laboratory activities	1	2	5
Class periods (50 min)	2	3–5	Flexible to fit a range of class periods
Standards alignment	General	NGSS, TEKS	AP Biology and inquiry (structured, guided, or open)

Green Fluorescent Protein (GFP) Chromatography Kit: Capture the Glow!

Take your pGLO transformation lab to the next level! Take your students through the process of creating a new product — from lab discovery to biomanufacturing to market. Show your students the relevance of the science they learn in the classroom to science in their lives. Encourage them to imagine the possibilities and to think critically and creatively.

In biotechnology research and industry, transformation is the first step in producing genetically engineered "designer" proteins. Genetically engineered proteins have unlimited applications — from medicines to treat human diseases to powerful enzymes incorporated into nonpolluting laundry detergents — but they must be overexpressed, mass produced, and purified to be marketable.

Chromatography 101. Chromatography to purify proteins of interest depends on a protein's chemical or physical properties, such as molecular weight, electrical charge, or solubility. Green fluorescent protein (GFP) is extremely hydrophobic compared to most bacterial proteins. This unique characteristic of GFP enables the purification of GFP from bacterial cell proteins using hydrophobic interaction chromatography (HIC). When placed in a buffer containing a high concentration of salt, the HIC matrix selectively binds hydrophobic GFP molecules while allowing the bacterial proteins to pass right through the column. Then, simply lowering the salt concentration of the buffer causes GFP to elute from the column in a purer form.

Students begin this activity with the pGLO bacterial transformation kit. A colony of transformed bacteria is placed in liquid culture to grow overnight, then the cells are lysed to release their contents. GFP is purified from the bacterial contaminants using the HIC columns provided in the kit.

The unique fluorescent property of GFP allows real-time monitoring of the extraction and purification processes. pGLO transformation and GFP purification together are key processes used in biotechnology to produce and purify designer proteins with commercial or research value.

GFP Chromatography Kit*

Each kit supports 32 students.

Green Fluorescent Protein Chromatography Kit*
Catalog # **1660005EDU**

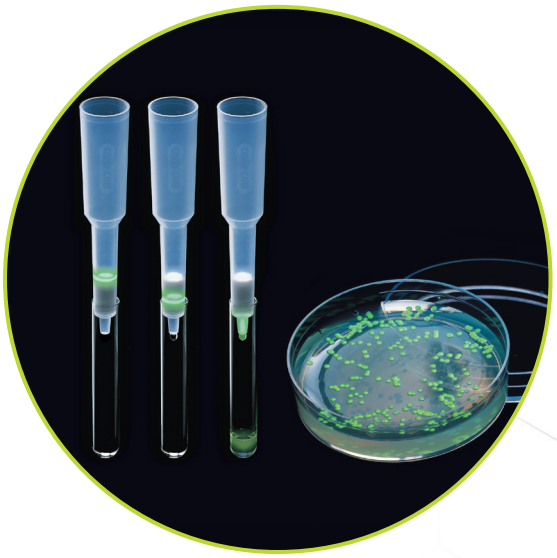
Ships at room temperature. Store lysozyme at –20°C.

* Transformed bacterial colonies from pGLO bacterial transformation required. See p. 14, 26, or 28.

Key Kit Features

- Transform bacteria with a gene from a bioluminescent jellyfish
- Induce transformed bacteria to overexpress green fluorescent protein
- Purify GFP using chromatography
- Complete in three 45 minute lab sessions

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.



Lab Preparation Checklist

Kit contains sufficient materials for 8 student workstations (2–4 students per workstation).

Ampicillin, lyophilized	1
Arabinose, lyophilized	1
Lysozyme, lyophilized	1
LB nutrient broth capsule	1
Binding buffer	1
Column equilibration buffer	1
Column wash buffer	1
Elution buffer	1
HIC chromatography columns	8
Inoculation loops, sterile	20
Disposable plastic transfer pipets	40
Microcentrifuge tubes, 2.0 ml, clear	30
Cell culture tubes, 15 ml, sterile	25
Sample collection tubes, 5 ml	25
Curriculum, including teacher's guide, student manual, and graphic quick guide	1

Required Accessories Not Included in Kit:

Transformed bacterial colonies from pGLO bacterial transformation, pp. 14, 26, or 28
UV lamps, p. 146 4–8
Centrifuges, p. 148 1–2

Recommended (Optional) Accessories:

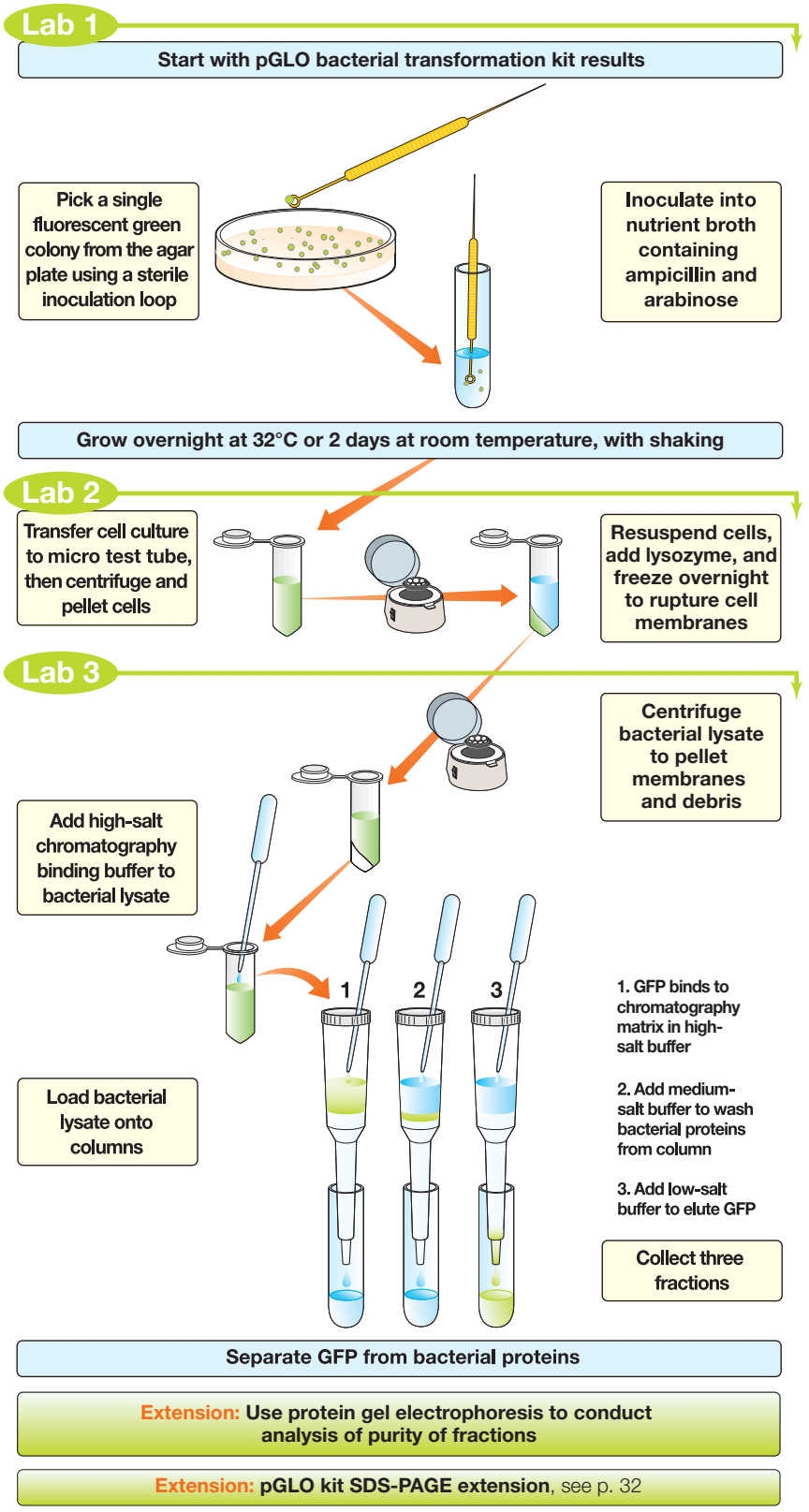
Incubation oven, p. 150
Rocking platform, p. 149
Tube roller, p. 149
Microwave oven

Refresh Kit Components: (more info pp. 157–159)

GFP Lyophilized Components Refill Pack (#1660015EDU), includes ampicillin, arabinose, LB nutrient broth tablet, lysozyme
GFP Chromatography Buffers Refill Pack (#1660016EDU), includes binding buffer, column equilibration buffer, column wash buffer, elution buffer
HIC Chromatography Columns and Caps, 8 each (#1660413EDU)
Inoculation Loops, 10 µl, sterile, 100 (#1660471EDU)
Jellyfish Foam Floating Racks, 8 racks (#1660479EDU)
Disposable Plastic Transfer Pipets, sterile, 500 (#1660474EDU)
Cell Culture Tubes, 17 x 100 mm, 14 ml, sterile, 25 (#1660476EDU)
Clear Polystyrene Tubes, 13 x 100 mm, 9 ml, 1,000 (#2239750EDU)
Green Racks, set of 5 racks (#1660481EDU)
15 ml Tube Racks, holds 60 tubes, set of 5 racks (#1660483EDU)
Poly-Prep Columns, empty, 50 (#7311550EDU)
Macro-Prep HIC Support, 100 ml (#1560080EDU)

Extra Curriculum for GFP on the Web
Download the Weigh To Go! curriculum that embeds the GFP purification lab in topical case study scenario format, from the Morehead Planetarium and Science Center Mobile Labs Program. **Visit bio-rad.com/GFPChromKit** to download the complete PDF.

Web
Check This Out!



pGLO Kit SDS-PAGE Extension: What's after pGLO Bacterial Transformation?

Don't stop at cloning the gene — identify the protein responsible for green fluorescence! The bacterial proteome contains thousands of proteins, but only the cloned green fluorescent protein (GFP) glows! Learn how GFP expressed from Bio-Rad's pGLO plasmid can be used to help illustrate and teach the central doctrine of biology, from the transformation of DNA to the expression of a protein to the visualization of a trait.

Take white and green colonies from your transformed plates, prepare sample lysates, and identify the pGLO protein on SDS-PAGE gels.

DNA ➤ RNA ➤ Protein ➤ Trait — Green Fluorescence!

The two Bio-Rad Explorer kits used in this application, pGLO bacterial transformation kit (#1660003EDU) and pGLO kit SDS-PAGE extension (#1660013EDU) can be used to directly link gene expression to identification of a protein responsible for a specific trait. In the first part of the exercise, a plasmid encoding GFP is transformed into *E. coli*, a common prokaryotic organism used for DNA propagation and protein expression. Colonies of *E. coli* are qualitatively examined for fluorescence, which suggests that the pGLO gene is being expressed. In the second part of the lab, gel electrophoresis is used to separate the entire repertoire of proteins expressed in *E. coli*, which includes the foreign GFP responsible for the fluorescence trait.

This extension links two of the most commonly used techniques in biotechnology labs: transformation and electrophoresis. Moreover, this extension illustrates the versatility and robustness of one of the most commonly used proteins in modern biology, GFP. In its native environment, GFP fluoresces in the deep sea jellyfish, *Aequorea victoria*. GFP retains its fluorescent properties when cloned and expressed in *E. coli* and when isolated from *E. coli* and separated on polyacrylamide gels. These amazing properties of GFP and the powerful methodologies of protein electrophoresis allow students to visualize the phenotypic properties of a protein and identify the single protein "band" responsible for the trait. **Find the protein in the haystack!**

pGLO Kit SDS-PAGE Extension

Each kit supports 32 students.

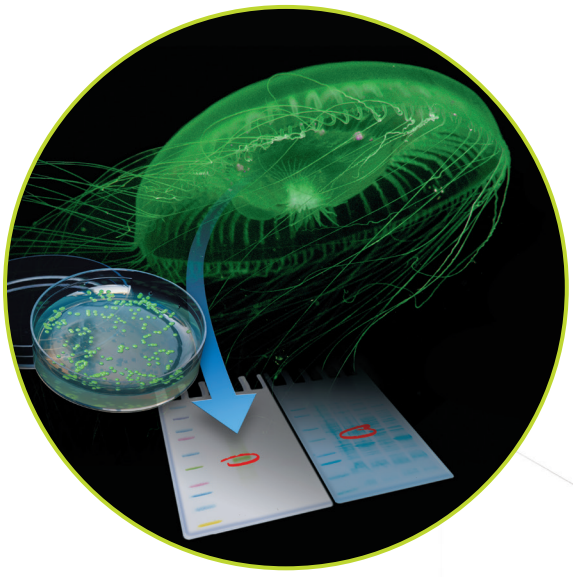
pGLO Kit SDS-PAGE Extension
Catalog # **1660013EDU**

Ships at room temperature. Store Precision Plus Protein Kaleidoscope standards at –20°C. Mini-PROTEAN TGX precast gels (12 month shelf life) available separately.

Key Kit Features

- Perform real biotechnology workflows
- Identify proteins by conformation and size
- Link gene induction to protein expression to protein identification
- Understand chromophores and the basis of protein fluorescence

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.



Lab Preparation Checklist

Kit contains sufficient materials for 8 student workstations (2–4 students per workstation).

Dithiothreitol (DTT), 1 g	1
Precision Plus Protein Kaleidoscope standards, 50 µl	2
Bio-Safe Coomassie stain for proteins, 100 ml	1
	1
10x Tris/glycine/SDS electrophoresis buffer, 1 L	1
Laemmli sample buffer, 30 ml	1
Curriculum, including teacher's guide and student manual	1

Required Accessories Not Included in Kit:

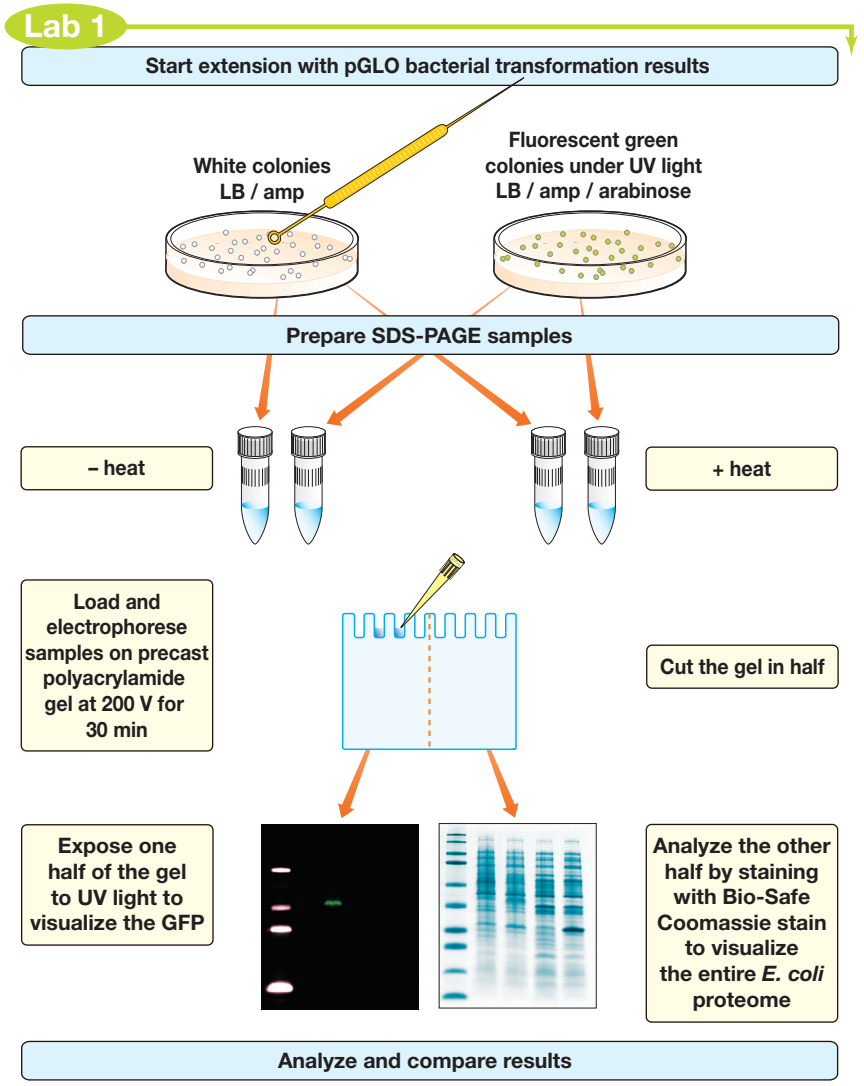
Amp (white) and Amp/ara (green) Colonies from a pGLO Bacterial Transformation, p. 14, 26, or 28	4–8
Any kD Mini-PROTEAN TGX Precast Polyacrylamide Gels, 10-well each, p. 138	4–8
Vertical Gel Electrophoresis Chambers, p. 135	1–4
Power Supplies, p. 155	1–4
Water Bath or Dry Bath, p. 150	1
Adjustable Micropipets, pp. 152–153	
2–20 µl	4–8
100–1,000 µl	4–8
Pipet Tips, p. 154	
2–200 µl, BR-35	1 bag
100–1,000 µl, BR-40	1 bag
0.5–200 µl, Prot/Elec	1 bag
UV Lamps, p.146	4–8
Screwcap Microcentrifuge Tubes, 1.5 ml, 500, p. 157	1 bag
Gel Staining Trays, p. 157	4–8
Foam Floating Racks, p. 157	8

Recommended (Optional) Accessories:

Rocking platform, p.149
Gel documentation system, pp. 146–147

Refresh Kit Components: (more info pp. 157–159)

Gel Staining Trays, 4 (#1660477EDU)
Inoculation Loops, 10 µl, sterile, 100 (#1660471EDU)
Jellyfish Foam Floating Racks, 8 racks (#1660479EDU)
Green Racks, set of 5 racks (#1660481EDU)
DTT, p. 140
Precision Plus Protein Kaleidoscope Standards, p. 139
Bio-Safe Coomassie Stain, p. 139
10x Tris/Glycine/SDS Electrophoresis Buffer, p. 140
Laemmli Sample Buffer, p. 140



Secrets of the Rainforest Kit: Apply Genetic Engineering to Cure Human Diseases

Experience the world of commercial biotechnology
The Secrets of the Rainforest lab is a fantastic way to introduce your students to the world of commercial drug discovery and biomanufacturing.

In this kit, students assume the role of scientists working for a biotechnology company, Biotex, Inc. Biotex scientists have constructed a bacterial library from the genome of a medicinal rain forest plant whose green glowing leaves have anticancer properties. Now the particular protein must be identified and purified for further analysis.

Students will streak out and grow a bacterial library and select colonies that have the green glowing trait from a background of nonglowing bacteria. A scaled-up culture of green glowing bacteria is grown and the green glowing protein is then purified by column chromatography. In both this classroom simulation and commercial biotech labs the principle is the same: a gene derived from a natural source encodes a novel protein with commercial value.

This practical activity is followed by dry-lab lessons in which the purified green protein is put through the drug discovery process. Students will create presentations as they learn about Food and Drug Administration regulations, animal testing, marketing practices for introducing a new drug, financing, ethical issues, and the needs and viewpoints of advocacy groups.

How are a bacterial library created and a gene cloned? A bacterial library is constructed by first generating a random assortment of DNA fragments from the medicinal plant using a restriction enzyme. Some of those fragments will contain the gene for green glowing protein. When the same restriction enzyme is used to cut (digest) a plasmid (the "destination") it produces an opening in the plasmid. The plant DNA fragments are inserted into the digested plasmids, resulting in plasmids that contain random assortments of DNA fragments derived from the genome of the medicinal plant. The plasmids are transformed into the bacteria *E. coli,* which replicate the plasmid when they divide. Some of the transformed bacterial cells will contain copies of the plasmid containing the plant gene that encodes the protein of interest.

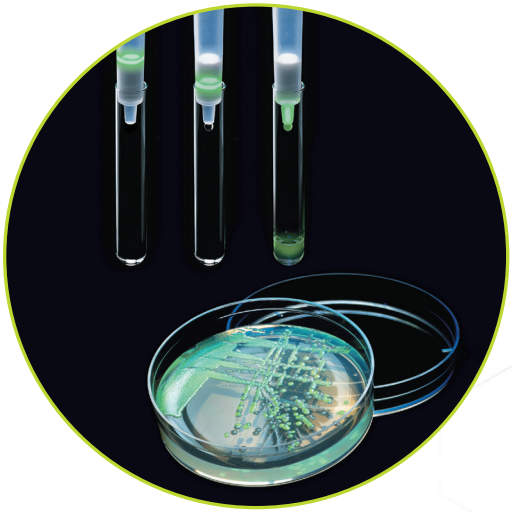
Secrets of the Rainforest Kit

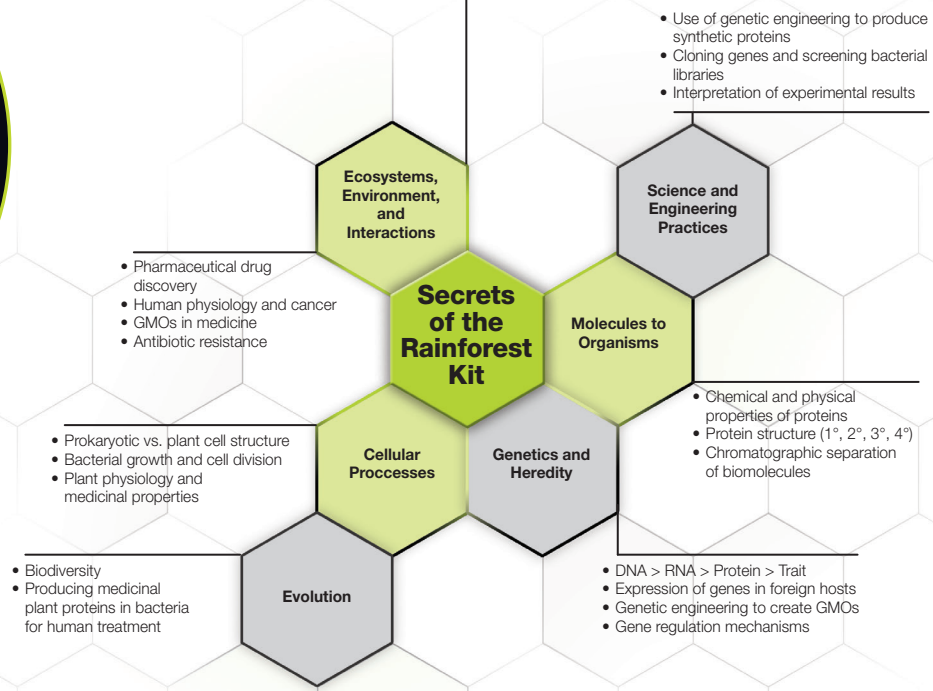
Each kit supports 32 students.

Secrets of the Rainforest Kit
Catalog # **1660006EDU**
Ships at room temperature. Store lysozyme at –20°C.

Key Kit Features
- Grow a bacterial library
- Clone a gene of interest in bacteria
- Express a protein of interest in bacteria
- Purify a protein of interest from bacteria
- Take a protein to market
- Complete in four 45 minute lab sessions

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.





Lab Preparation Checklist

Kit contains sufficient materials for 8 student workstations (2–4 students per workstation).

Module 1: Preparing a Bacterial Library

Bacterial library, *E. coli*, lyophilized	1
LB nutrient agar tablets	5
Petri dishes, 60 mm, sterile	20
Inoculation loops, sterile	10
Disposable plastic transfer pipets	10

Module 2: Protein Purification

Ampicillin, lyophilized	1
Arabinose, lyophilized	1
Lysozyme, lyophilized	1
LB nutrient broth capsule	1
Binding buffer	1
Column equilibration buffer	1
Column wash buffer	1
Elution buffer	1
HIC chromatography columns	8
Inoculation loops, sterile	20
Disposable plastic transfer pipets	40
Microcentrifuge tubes, 2.0 ml, clear	30
Cell culture tubes, 15 ml, sterile	25
Sample collection tubes, 5 ml	25
Curriculum, including teacher's guide, student manual, and graphic quick guide	1

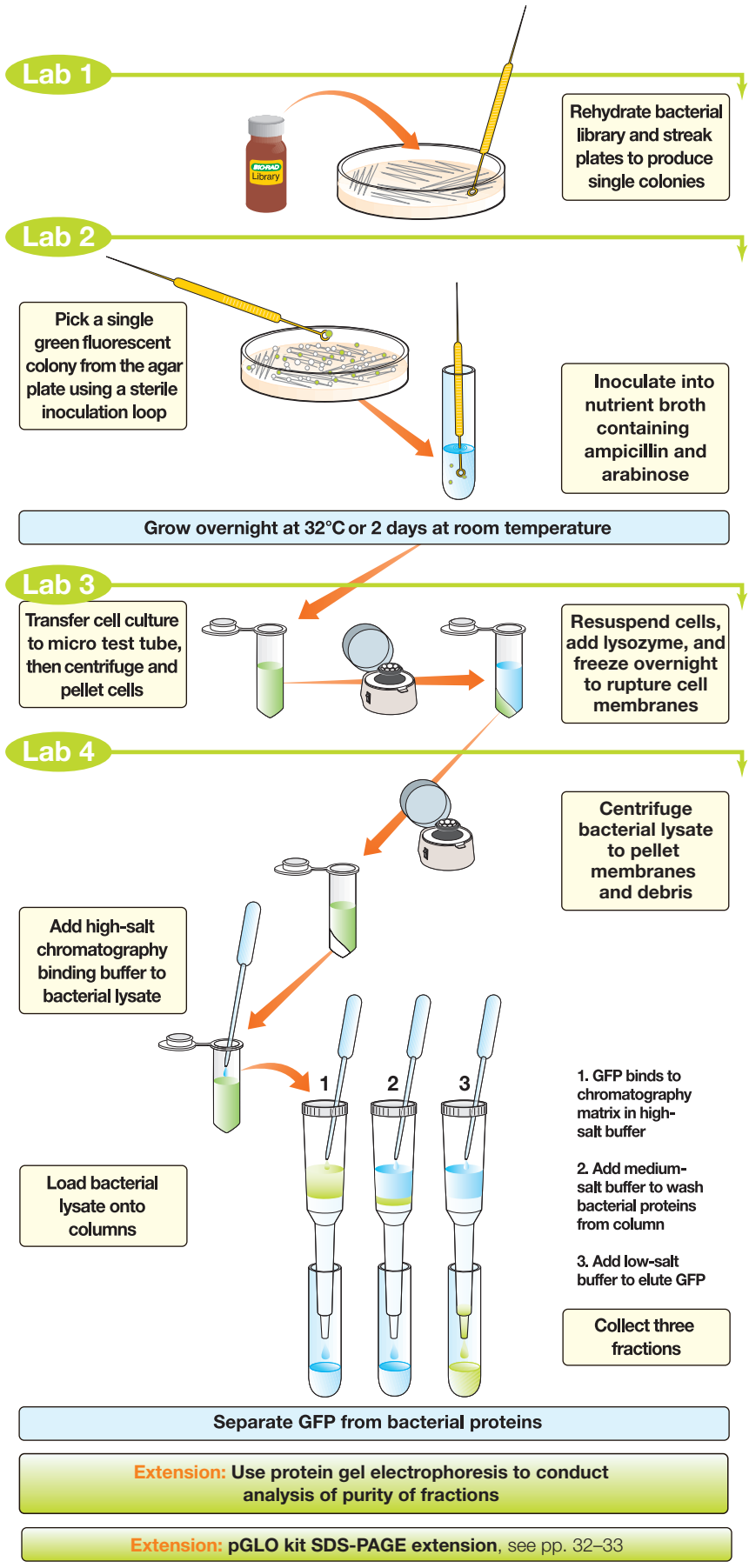
Required Accessories Not Included in Kit:

UV lamps, p. 146	4–8
Centrifuges, p. 148	1–2

Recommended (Optional) Accessories:

Incubation oven, p. 150
Rocking platform, p. 149
Tube roller, p. 149
Microwave oven

Refresh Kit Components: (more info pp. 157–159)
Bacterial Library (#1660411EDU), *E. coli*, lyophilized
GFP Lyophilized Components Refill Pack (#1660015EDU), includes ampicillin, arabinose, LB nutrient broth tablet, lysozyme
GFP Chromatography Buffers Refill Pack (#1660016EDU), includes binding buffer, column equilibration buffer, column wash buffer, elution buffer
HIC Chromatography Columns and Caps, 8 each (#1660413EDU)
LB Nutrient Agar Powder, 20 g (#1660600EDU) or 500 g (#1660472EDU)
Petri Dishes, 60 mm, sterile, 500 (#1660470EDU)
Inoculation Loops, 10 µl, sterile, 100 (#1660471EDU)
Jellyfish Foam Floating Racks, 8 racks (#1660479EDU)
Disposable Plastic Transfer Pipets, sterile, 500 (#1660474EDU)
Cell Culture Tubes, 17 x 100 mm, 14 ml, sterile, 25 (#1660476EDU)
Clear Polystyrene Tubes, 13 x 100 mm, 9 ml, 1,000 (#2239750EDU)
Poly-Prep Columns, empty, 50 (#7311550EDU)
Macro-Prep HIC Support, 100 ml (#1560080EDU)



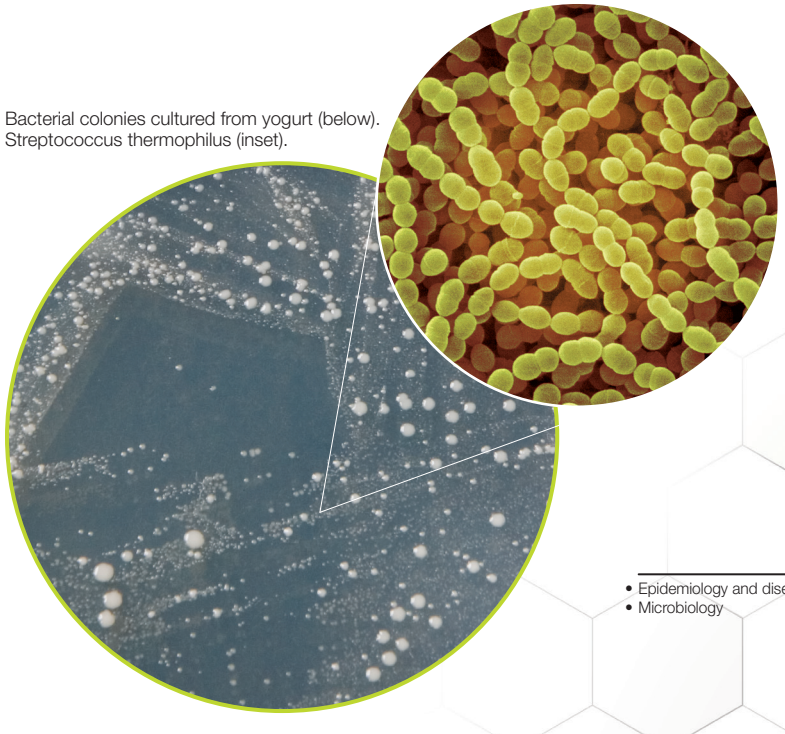
Microbes and Health Kit: “What Causes Yogurtness?”

The chemistry of the bacterial cell is brought into focus as students examine bacteria and their interaction with the environment. Enzyme-catalyzed chemical reactions in bacteria provide energy for the bacteria as they change food into secreted waste products. In some cases, bacterial waste products can be the cause of disease symptoms, and in other cases they may create foods and nutrients for people. Thus bacteria can sometimes be our friends and other times be our foes. For a long time, biotechnology has utilized friendly bacteria in the production of foods such as cheese, sauerkraut, kimchi, coffee, sour cream, vinegar, sausage, and yogurt. Other bacteria cause cholera, typhus, leprosy, tuberculosis, and anthrax. In this lab students will examine both the risks and benefits of bacteria to better understand their role in disease and food production.

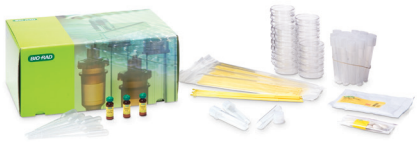
Discover the cause of disease. In the 18th century bacterial diseases were still a deadly mystery. Bacteria were sometimes found in diseased humans and animals — but did the bacteria cause the disease or did the bacteria merely follow a disease caused by another unknown agent? To know the cause is the first step toward cure or prevention. Join Robert Koch, Louis Pasteur, and the founders of modern microbiology in a thrilling search to find the bacterial culprit behind a new disease. The new disease examined in this lab is “yogurtness” — an affliction of “healthy” milk that causes it to become acidic and thick. What is the cause of yogurtness? Can you use Koch’s postulates, the standard of proof in the identification of microbial disease agents, to identify the guilty microbe in this inquiry-based activity?

Students will use microscopes, agar plates, and their powers of observation to identify the bacteria used to produce yogurt and to provide proof for their hypothesized identification. Use this kit to examine metabolism, cellular chemistry, and the role of bacteria in both disease and food microbiology.

Bacterial colonies cultured from yogurt (below). Streptococcus thermophilus (inset).



Microbes and Health Kit



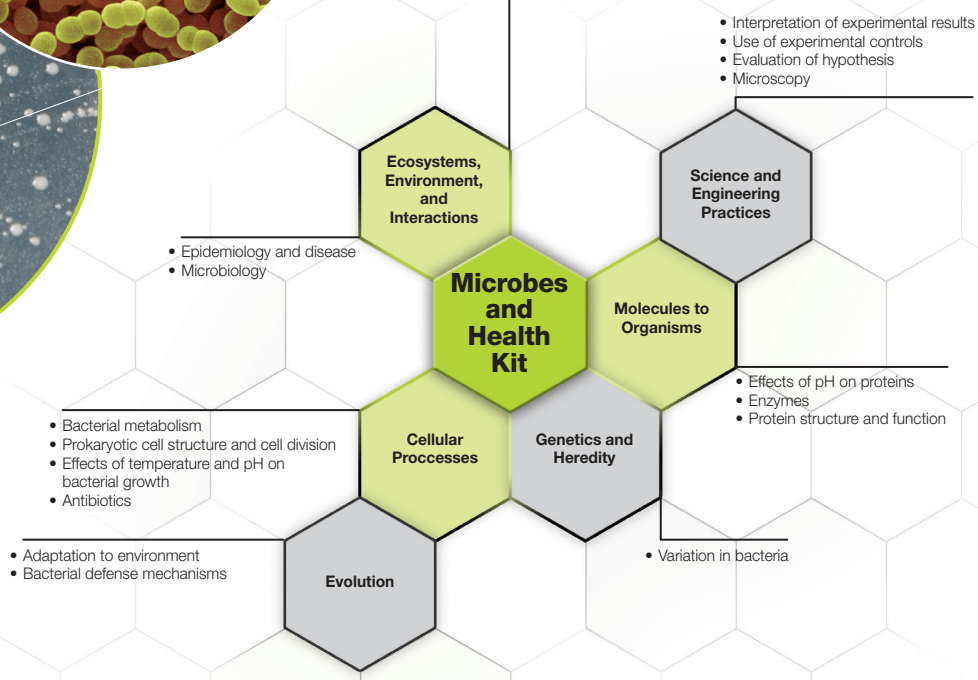
Each kit contains sufficient materials for 8 student workstations.

Microbes and Health Kit
Catalog # **1665030EDU**
Ships and stores at room temperature.

Key Kit Features

- Isolate yogurt-causing bacteria
- Culture bacteria from yogurt
- Follow Koch’s postulates
- Learn laboratory microbiology skills
- Study food microbiology and bacterial metabolism
- Complete in three 45 minute lab sessions

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.



Lab Preparation Checklist

Kit contains sufficient materials for 8 student workstations (2–4 students per workstation).

Ampicillin, lyophilized	2
LB nutrient agar powder	1
LB broth capsules	12
E. coli strain HB101 K-12, lyophilized	1
Petri dishes, 60 mm, sterile	40
Cell culture tubes, 15 ml, sterile	75
Inoculation loops, sterile	80
Disposable plastic transfer pipets	10
Curriculum, including teacher's guide, student manual, and graphic quick guide	1

Required Accessories Not Included in Kit:

Incubation oven, p. 150	1
Microscopes	2–8
pH paper strips (range 4–7)	48
Yogurt	2–4 types
Milk	400 ml
Toothpicks	

Recommended (Optional) Accessories:

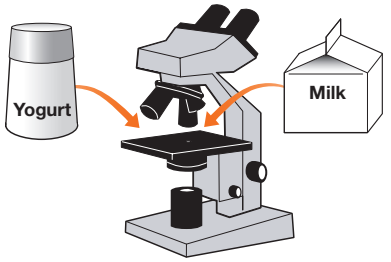
Magnifying glasses
Microwave oven

Refresh Kit Components: (more info pp. 157–159)

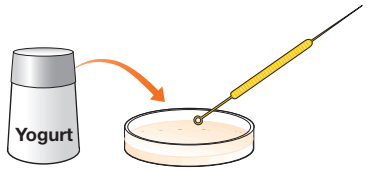
Microbial Culture Kit Reagent Refill Pack (#1665021EDU) includes ampicillin, LB broth capsules (12), LB Nutrient Agar Powder, *E. coli* strain HB101 K-12
LB Nutrient Agar Powder, 20 g (#1660600EDU) or 500 g (#1660472EDU)
Ampicillin (#1660407EDU)
E. coli Strain HB101 K-12 (#1660408EDU)
Petri Dishes, 60 mm, sterile, 500 (#1660470EDU)
Inoculation Loops, 10 µl, sterile, 100 (#1660471EDU)
Disposable Plastic Transfer Pipets, sterile, 500 (#1660474EDU)
Cell Culture Tubes, 17 x 100 mm, 14 ml, sterile, 25 (#1660476EDU)
15 ml Tube Racks, holds 60 tubes, set of 5 racks (#1660483EDU)

Lab 1

Observe yogurt and milk using a microscope to identify potential yogurt-causing bacteria



Define characteristics of yogurtness: pH, consistency, and smell

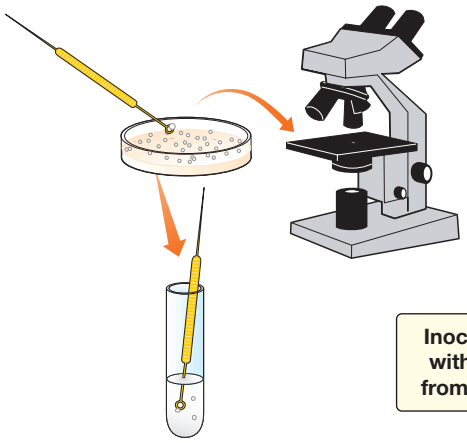


Inoculate petri dish with yogurt

Grow bacteria cultures overnight at 37°C

Lab 2

Observe bacterial colonies using a microscope

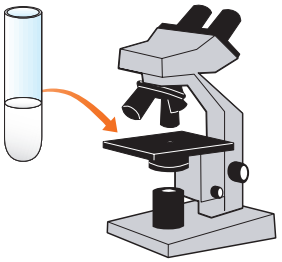


Inoculate milk with bacteria from petri dish

Incubate overnight at 37°C

Lab 3

Observe freshly cultured yogurt using a microscope to match bacteria to original colony



Got yogurt?


BE BRAVE
BE BRAVE
BE BRAVE
BE BRAVE
BIO-RAD
WARNING

Section Contents

Protein Analysis Kits

"Bio-Rad products are a must-have for my bioscience labs. I can always count on high-quality reagents, materials, and awesome technical support for labs and equipment. I also really appreciate the extra reagents for those 'oops' moments."

Michelle Landreville
Paradise Valley High School (CREST)
Phoenix, AZ

Bio-Rad Explorer Teacher and Student Alumni

Engineering Practices and the Biology of Nutrition

World hunger is a global health crisis that affects millions worldwide and gives context for students to study proteins and nutrition. In this activity, your students will use engineering practices to define a problem involving protein energy undernutrition (PEU) and design a solution in the form of a treatment plan. They will use a Bradford assay to collect data about protein content in foods and use their data to design a prototype. Finally, after receiving additional constraints, they will revisit the design process and revise their designs.

Engineering Solutions for Global Health Kit

Each kit supports 32 students.

Engineering Solutions for Global Health Kit
Catalog # **17005278EDU**
Ships on ice. Store at 4°C.

Key Kit Features

- Use iterative engineering practices in the biology classroom
- Engage in complex global issues
- Create and use protein standards
- Explore protein structure and function

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.

Lab Preparation Checklist

Kit contains sufficient materials for 8 student workstations (2–4 students per workstation).

Quick Start Bradford 1x Dye Reagent	1 L
Protein Standard II (lyophilized BSA)	1
Disposable Plastic Transfer Pipets, nonsterile	500
Conical Centrifuge Tubes, 15 ml	100
Printed Instructor's Guide and Instructor's Answer Guide included	1 ea
Instructor's and Student Guides available online free for download	

Required Accessories Not Included in Kit:

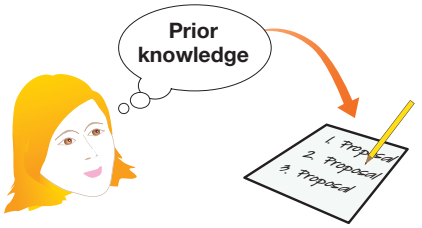
Distilled water	1 L
Protein drinks for testing, at least four types	1 ml each

Recommended (Optional) Accessories:
Tube racks, pkg of 5, 15 ml (#1660483EDU)

Refresh Kit Components: (see pp. 157–159)
Quick Start Bradford 1x Dye Reagent (#5000205EDU)
Protein Standard II (lyophilized BSA) (#5000007EDU)
Disposable Plastic Transfer Pipets, pkg of 500, nonsterile (#1660480EDU)
Conical Centrifuge Tubes, pkg of 50, 15 ml (#1660475EDU)

Activity 1

Define a problem involving undernutrition

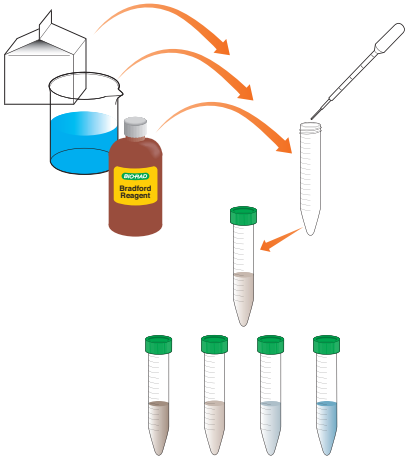


Summarize the problem of protein energy undernutrition

Activity 2

Investigate protein content in food

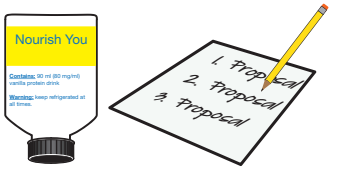
Prepare standards and liquid food samples



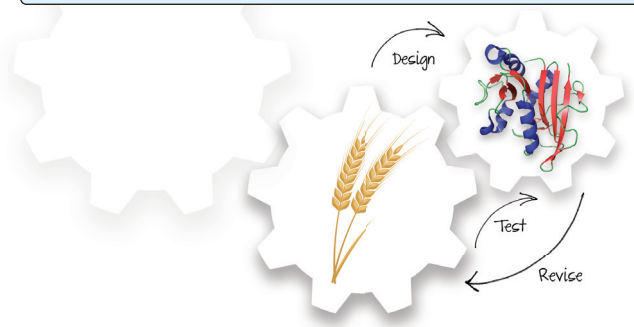
Compare samples to standards to estimate protein concentration

Activity 3

Design a treatment for protein energy undernutrition



Consider constraints and revise initial proposals



Got Protein? Kit: What You See Is What You Get!

The Got Protein? kit is designed to introduce students to proteomics and provides the tools for them to develop their own protein-based experiments.

Based on the Bio-Rad Quick Start Bradford protein assay, this inquiry-based biophotonics lab allows students to analyze and compare the protein content in milk, sports drinks, egg, muscle tissue, saliva, tears, or any source of soluble, biologically derived material. Protein quantitation is often necessary before isolation, separation, and analysis by chromatography, electrophoresis, or western blotting. This lab integrates biology, chemistry, and physics, allowing students to develop an understanding about how the chemical, physical, and biological properties of proteins determine their structure and function.

It is impossible to place biological material under a microscope and count the number of protein molecules per unit volume the way we can count the number of cells. Therefore, something measurable that is proportional to the concentration of the substance of interest must be identified. **Beer's law** states that when a solute absorbs light of a particular wavelength, the absorbance is directly proportional to the concentration of substance in solution. The measurement most commonly used in protein assays is the absorbance of light.

However, proteins do not absorb sufficient light to assay — by themselves.

The Bradford method is based on the color development formed when the dye Coomassie Blue G-250 binds to protein. The unique chemical properties of the dye allow it to interact with the side chains, or R-groups, of specific amino acids. There is a correlation between the amount of blue color and the amount of protein in the sample: the more protein, the more intense the blue color. The simplicity of the assay allows the results to be measured qualitatively by eye or quantitatively with a spectrophotometer.

In this lab, students use absorbance values from a set of protein samples with known concentrations to create a standard curve on linear graph paper. Protein concentrations of their test samples can then be extrapolated by hand or plotted using a graphing utility such as Microsoft Excel. Students also learn to use a spectrophotometer, micropipet, and computer, which are all invaluable tools in modern bioscience research.

Got Protein? Kit

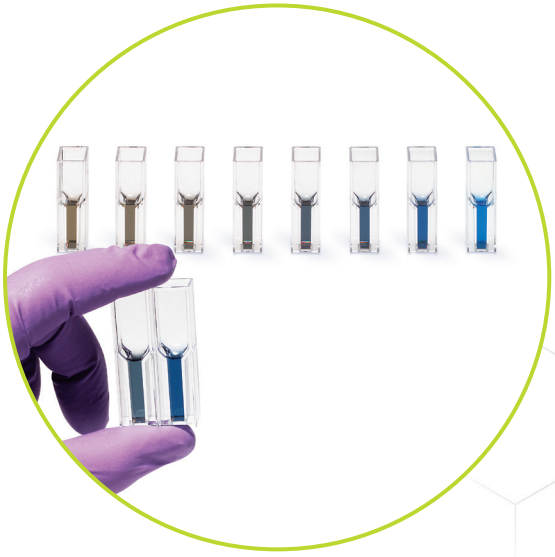
Each kit supports 320 students.

Got Protein? Kit
Catalog # **1662900EDU**
Standards ship on blue ice. Store at 4°C.

Key Kit Features

- Explore biophotonics
- Study protein structure/function
- Apply Beer's law
- Measure protein concentrations
- Learn spectrophotometry
- Complete in one 45 minute lab session

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.



Lab Preparation Checklist

Kit contains sufficient materials for 80 student workstations (2–4 students per workstation).

Quick Start Bradford protein assay kit 4, includes 1x dye reagent (1 L), bovine γ-globulin standard set (2 sets of 7 standards, 0.125–2.0 mg/ml, 2 ml)	1
10x PBS, 100 ml	1
1.5 ml standard disposable polystyrene cuvettes, 100	1
Curriculum, including teacher's guide, student manual, and graphic quick guide	1

Required Accessories Not Included in Kit:

Adjustable Micropipets, pp. 152–153	
2–20 µl	1–8
100–1,000 µl	1
Pipet Tips, p. 154	
2–20 µl, BR-35	1 box
100–1,000 µl, BR-40	1 box
Microcentrifuge Tubes, 1.5 ml , p. 157	1 bag
Conical Centrifuge Tubes, 15 ml, p. 157	8
Distilled Water	100 ml
Milk Samples (suggestions: low fat, fat free, soy, baby formula, etc.)	10 ml

Recommended (Optional) Accessories:
Spectrophotometer

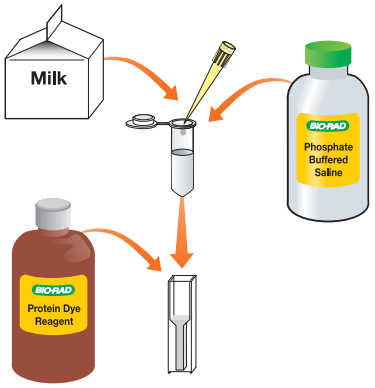
Refresh Kit Components: (more info pp.157–159)
Quick Start Bradford Protein Assay Kit 4 (#5000204EDU) includes 1x dye reagent (1 L), bovine γ-globulin standard set (2 sets of 7 standards, 0.125–2.0 mg/ml, 2 ml)
10x PBS, 100 ml (#1662403EDU)
1.5 ml Standard Disposable Polystyrene Cuvettes, 100 (#2239955EDU)
Conical Centrifuge Tubes, 15 ml, 50 (#1660475EDU)
Green Racks, set of 5 racks (#1660481EDU)
Cuvette Racks, holds 12 standard size cuvettes, set of 5 racks (#1660485EDU)

This hands-on activity is integrated with the Lt Biology Collection, the online learning platform from ADInstruments.

Lab 1

Prepare test samples for spectral analysis

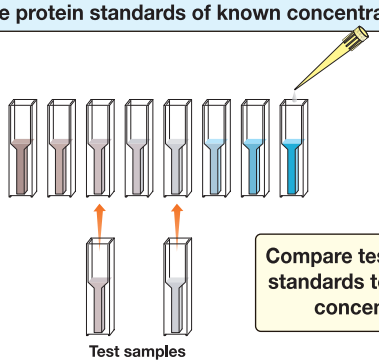
Dilute test samples of unknown protein concentration 1:50 in phosphate buffered saline



Add 20 µl diluted test samples and 1 ml protein dye reagent to cuvettes

Prepare protein standards of known concentration

Add 20 µl of a series of protein standards of known concentration to cuvettes

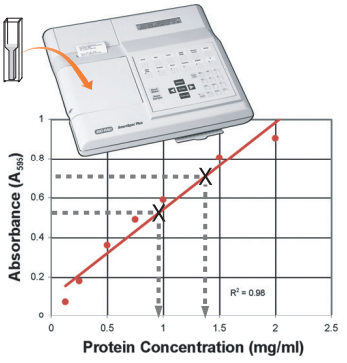


Add 1 ml protein dye reagent to each cuvette

Compare test samples to protein standards to estimate unknown concentrations by eye

Read protein standards and test samples in spectrophotometer

Generate standard curve from protein standards' absorbance data



Determine protein concentrations of test samples from the standard curve

Compare test samples' true protein concentration to published product labels

Biofuel Enzyme Kit: Can Enzymes Combat Climate Change?

Enzymes are a core biological function that can be applied across several disciplines and taught at a variety of levels. This kit allows you to tailor your content with single or multiple activities.

Fueling Our Future

Fossil fuels are based on a natural decomposition process, so the fuel you use today might be several million years old! The need for energy is outpacing the supply as markets globalize, more countries become industrial contributors, and populations increase. As the overall demand for energy rises, science is at the forefront of identifying potential fuel sources. Solar, hydrogen, wind, nuclear, and biofuels are just a few possible renewable fuel supplies that could replace nonrenewable petroleum.

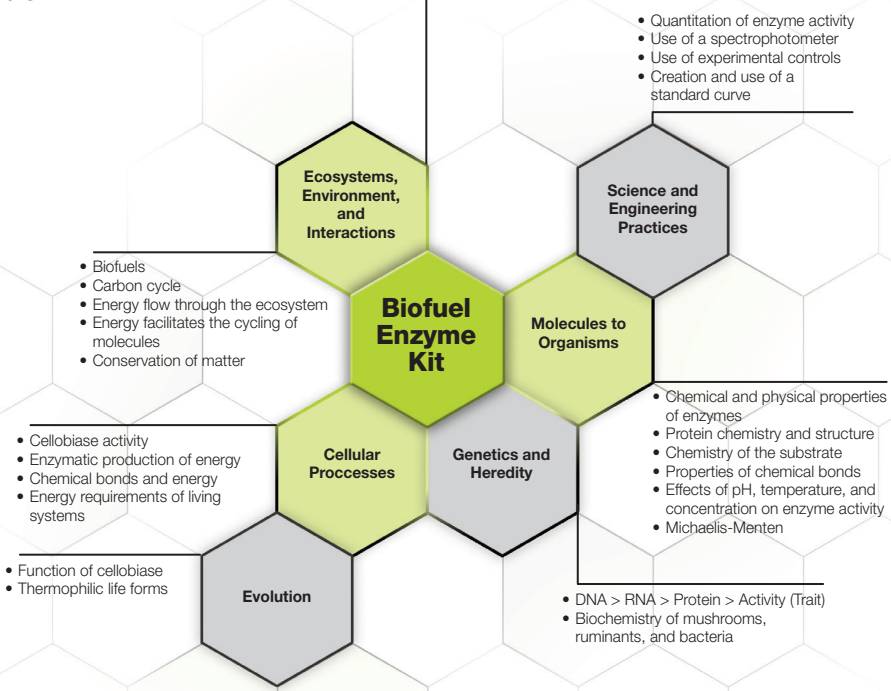
Cellulosic ethanol is a biofuel derived from plant matter. Cellulose is a polysaccharide found in the cell walls of plants. The breakdown of cellulose into sugar is a multistep process that is facilitated by a family of enzymes called cellulases. Each cellulase has its unique role in processing cellulose from a long strand of glucoses down to single units that can then undergo microbial fermentation to produce ethanol.

Enzymes and Energy

Reveal the power of enzyme kinetics by illustrating the theory through the real-world application of biofuel production. The biofuel enzyme kit tests the ability of an enzyme to increase the rate of conversion of a clear substrate to a colored product. Students will test and calculate the rate of conversion of a sugar substrate (*p*-nitrophenyl glucopyranoside) to *p*-nitrophenol and glucose in the presence or absence of the enzyme cellobiase (part of the cellulase family). After establishing the rate of reaction in the presence of the enzyme, various conditions influencing the reaction rate can be tested. In addition, students can perform independent inquiry with mushroom extracts and consider ecology and evolution of mushrooms.

Activity 1: Determine the reaction rate in the presence or absence of an enzyme
Activity 2: Determine the effect of temperature on the reaction rate
Activity 3: Determine the effect of pH on the reaction rate
Activity 4: Determine the effect of enzyme concentration on the reaction rate
Activity 5: Determine the effect of substrate concentration on the reaction rate
Activity 6: Test the ability of mushroom extracts to increase the reaction rate

Can enzymes combat climate change?
Let your students decide whether this is possible!



Biofuel Enzyme Kit

Each kit supports 32 students for all 6 activities.

Biofuel Enzyme Kit
Catalog # **1665035EDU**
Ships at room temperature. Store at 4°C.

Key Kit Features

- Aligns with AP Biology Big Idea 4; Investigation 13
- Guides instruction on enzyme kinetics and biofuel energy sources
- Contains no strong oxidizing agents
- Incurs no expensive hazardous waste disposal costs
- Enables both qualitative and quantitative measurement of reactions
- Complete core activity in one 45 minute session
- Includes 5 additional enrichment activities

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.

Lab Preparation Checklist

Kit contains sufficient materials for 8 student workstations (2–4 students per workstation).

Enzyme, cellobiase, 1 ml	1
Substrate, *p*-nitrophenyl glucopyranoside, 90 mg	1
Standard, *p*-nitrophenol (1 mM, 4 ml)	1
2x stop solution, 100 ml	1
10x resuspension buffer, 50 ml	1
Extraction buffer, 50 ml	1
Disposable plastic transfer pipets	40
1.5 ml microcentrifuge tubes	90
15 ml conical tubes	50
1.5 ml standard disposable polystyrene cuvettes	100
Curriculum, including teacher's guide, student manual, and graphic quick guide	1

Required Accessories Not Included in Kit:

Deionized or distilled water	1 L
Timers or stopwatches	8

Activity 2: Effects of Temperature

Thermometers	8

Activity 6: Mushroom Extracts

Mortars and pestles	8
Balance	1

Recommended (Optional) Accessories:

Adjustable Micropipets, pp. 152–153 100–1,000 µl	1–8
Pipet tips, p. 154 100–1,000 µl, BR-40	1 bag

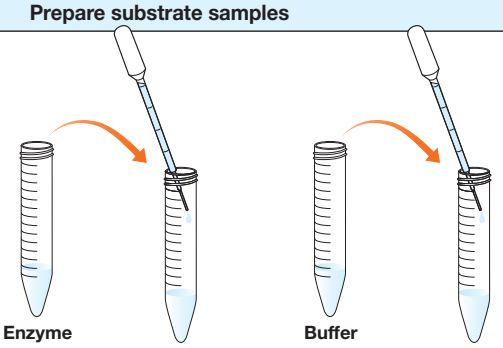
Spectrophotometer
Water Bath or Dry Bath, p. 150
Incubation Oven, p. 150
Centrifuge, p. 148

Refresh Kit Components: (more info pp. 157–159)
Biofuel Enzyme Kit Temperature-sensitive reagent refill pack (#1665036EDU) includes enzyme (cellobiase), substrate (*p*-nitrophenyl glucopyranoside), standard (*p*-nitrophenol), 2x stop solution, 10x resuspension buffer, extraction buffer
1.5 ml Standard Disposable Polystyrene Cuvettes, 100 (#2239955EDU)
Conical Centrifuge Tubes, 15 ml, 50 (#1660475EDU)
Disposable Plastic Transfer Pipets, nonsterile, 500 (#1660480EDU)
1.5 ml EZ Micro Test Tubes, 500 (#2239480EDU)
Green Racks, set of 5 racks (#1660481EDU)
15 ml Tube Racks, holds 60 tubes, set of 5 racks (#1660483EDU)
Cuvette Racks, holds 12 standard size cuvettes, set of 5 racks (#1660485EDU)

Lab 1

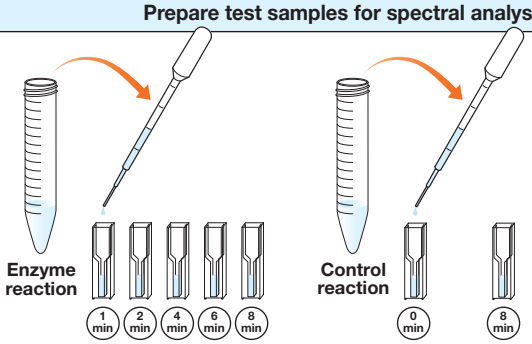
Prepare substrate samples

Add enzyme and buffer (control) to substrate

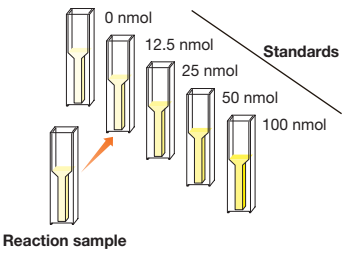


Prepare test samples for spectral analysis

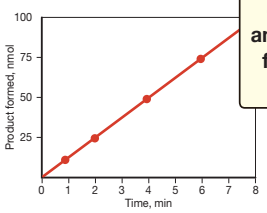
At specified times, remove aliquots and add to stop solution



Compare enzyme and control reaction time points to standards to determine amount of product formed

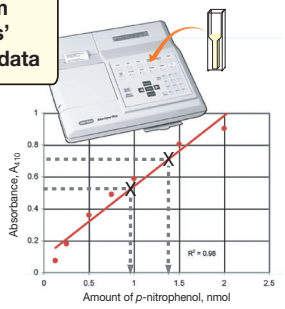


Generate a reaction curve from the amount of product formed at each time point

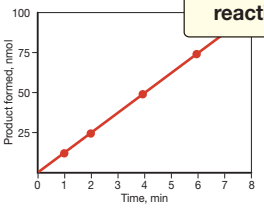


Extension: Read standards and reaction samples in spectrophotometer

Generate standard curve from standards' absorbance data



Determine the amount of product formed at each reaction time point. Generate a reaction curve



Optional Activities: Determine the effects of temperature, pH, enzyme concentration, and substrate concentration on reaction rate

For an inquiry approach

Biofuel Enzyme Reactions Kit for AP Biology, pp. 46–47

Biofuel Enzyme Reactions Kit for AP Biology — A ThINQ! Investigation

Parasitic mushrooms feast on nutrients from their living hosts. If their cellobiase activity is high, will they kill the host?

Mycorrhizal mushrooms form beneficial symbioses with plant roots. Should their cellobiase activity be high?

Saprophytic mushrooms are the cleanup crew. They draw nutrients from dead and decaying material. How active would their cellobiase be?

Recommended for
AP Biology
Big Ideas
1 **2** 3 **4**

Which mushroom is best for biofuel production?
Mushrooms use the enzyme cellobiase to break down plant material into glucose, which can be fermented into biofuel. But not all cellobiases are equal. The ecology of a mushroom impacts the function of its cellobiase.

With this kit your students will assume the role of bioengineer as they investigate how to optimize the efficiency of cellobiase and explore solutions to real-world energy issues.

Biofuel Enzyme Reactions Kit for AP Biology

Each kit supports 32 students.

Biofuel Enzyme Reactions Kit
Catalog # **17001235EDU**
Ships at room temperature. Store at 4°C.

Key Kit Features

- Includes inquiry-based curriculum
- Engages students in bioengineering
- Aligns with AP Biology Big Ideas 2 and 4

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.

Lab Preparation Checklist

Kit contains sufficient materials for 8 student workstations (2–4 students per workstation).

Enzyme, cellobiase, 1 ml	1
Substrate, p-nitrophenyl glucopyranoside, 90 mg	1
Standard, p-nitrophenol (1 mM, 4 ml)	1
2x stop solution, 100 ml	1
10x Resuspension Buffer, 50 ml	1
Extraction Buffer, 50 ml	1
Disposable Plastic Transfer Pipets	40
1.5 ml Microcentrifuge Tubes	90
15 ml Conical Tubes	50
1.5 ml Standard Disposable Polystyrene cuvettes	100
Inquiry curriculum, including teacher's guide	1
Student manual available online	

Required Accessories Not Included in Kit:

Deionized or distilled water	1 L
Timers or stopwatches	8

Investigation 1: Mushroom Extracts

Mushrooms, see instruction manual for recommended species	8 g
Mortars and pestles	1–8
Balance	1
Cheesecloth	1

Investigation 2: Effects of Temperature

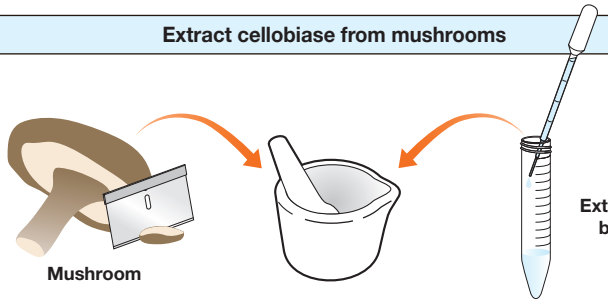
Thermometers	1–8

Recommended (Optional) Accessories:

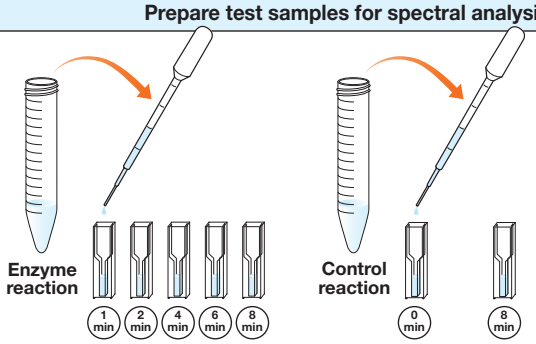
Adjustable Micropipets, 100–1,000 µl, pp. 152–153	1–8
Pipet Tips, 100–1,000 µl, p. 154	1 bag
Spectrophotometer	
Water Bath or Dry Bath, p. 150	
Incubation Oven, p. 150	
Centrifuge, p. 148	

Refresh Kit Components: (see pp. 157–159)
Biofuel Enzyme Kit Temperature Sensitive Reagent Refill Pack (#1665036EDU)
See p. 45 for details on reagent refill packs

Extract cellobiase from mushrooms

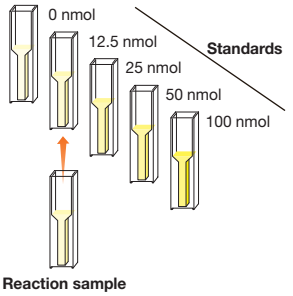


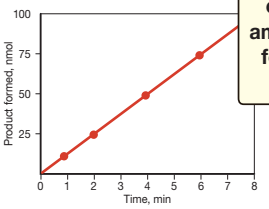
Prepare test samples for spectral analysis



At specified times, remove aliquots and add to stop solution

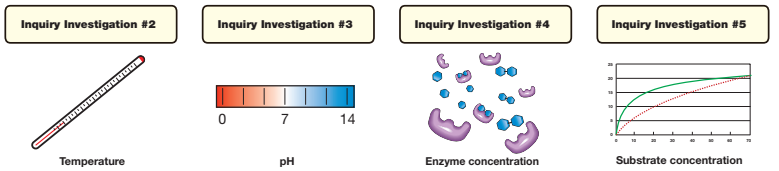
Compare enzyme and control reaction time points to standards to determine amount of product formed





Generate a reaction curve from the amount of product formed at each time point

Structured/guided/open inquiry investigations 2–5 — materials included



Synthesize conclusions into an optimized protocol

ThINQ! Biofuel Kit vs Classic Biofuel Kit

	ThINQ! Biofuel Kit (#17001235EDU)	Classic Biofuel Kit (#1665035EDU), p. 44
Class type	AP Biology, inquiry-based	General Biology or Biotechnology, skills-based
Inquiry type	Structured, guided, and open	Structured
Standards alignment	AP Biology	General

Size Exclusion Chromatography Kit: Sizing Up the Situation

This chromatography kit teaches the basic principles of size exclusion chromatography.

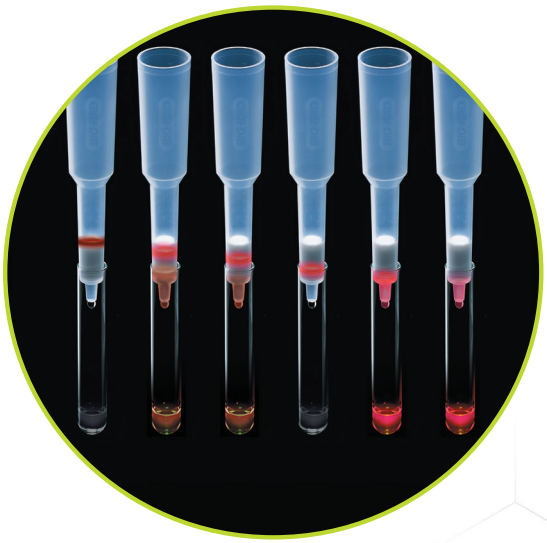
Column chromatography is the most common method used in biotechnology research and industry for separating a mixture of components in a liquid. Biochemists and molecular biologists use a variety of chromatography techniques to isolate and purify proteins, DNA, or other molecules from a mixture.

This method of separating one substance from a complex mixture is based on the physical and chemical characteristics of the molecules of interest — properties such as molecular weight, electrical charge, or solubility in various solvents. Successful separation of a molecule of interest by chromatography requires that it be sufficiently different from the majority of other components in the mixture in one or more of these properties to be distinguished from them. Size exclusion chromatography separates solubilized molecules such as proteins by their size, or molecular weight, from both larger and smaller contaminating proteins.

In this lab, a mixture of molecules in solution is applied to a chromatography column containing microscopic porous beads. As the solution flows through the column, the larger molecules bypass and flow around the beads. They are "excluded" from entering the pores by their size, and flow through the column with relative speed. The smaller molecules enter the porous beads, and are impeded in their flow through the column. The different rates of travel of the solutes through the column lead to effective separation.

This kit utilizes the colored molecules hemoglobin (reddish-brown) and vitamin B12 (pink). The contrasting colors are easily visible as the molecules pass through the column and into collection tubes at different rates due to their molecular weights.

Vitamin B12 — mass 1,350 daltons
Hemoglobin — mass 65,000 daltons



Size Exclusion Chromatography Kit

Each kit supports 32 students.

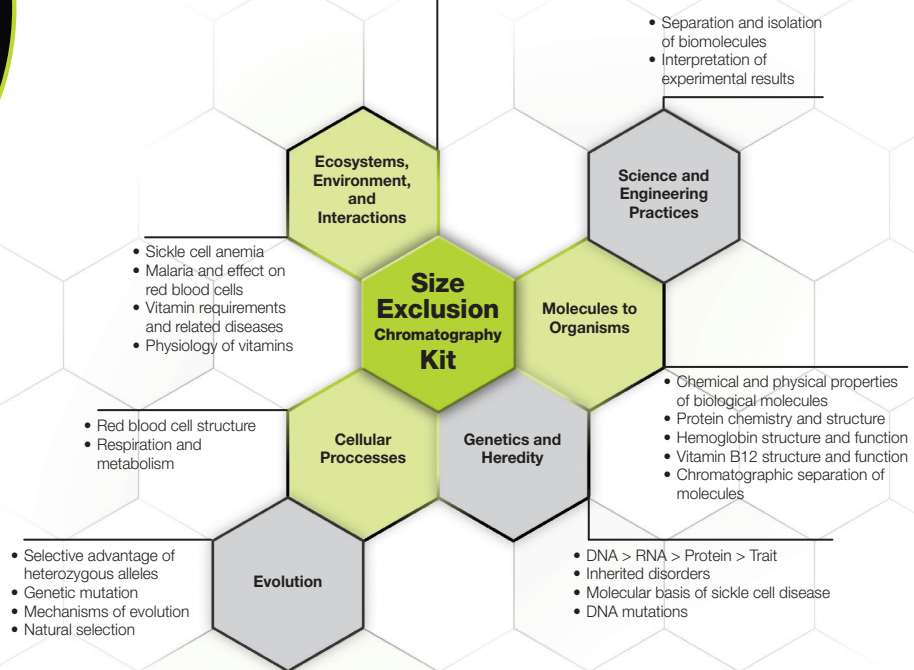
Size Exclusion Chromatography Kit
Catalog # **1660008EDU**

Convenient lyophilized reagents. Ships and stores at room temperature.

Key Kit Features

- Separate a mixture of biomolecules
- Determine the number of components in a mixture
- Study the chemical and physical properties of biomolecules
- Apply the principles of chromatography
- Complete in one 45 minute lab session

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.



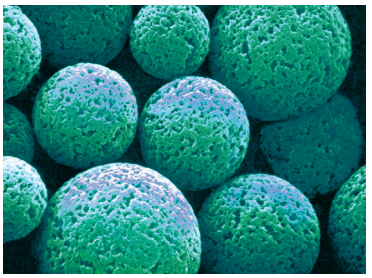
Lab Preparation Checklist

Kit contains sufficient materials for 8 student workstations (2–4 students per workstation).

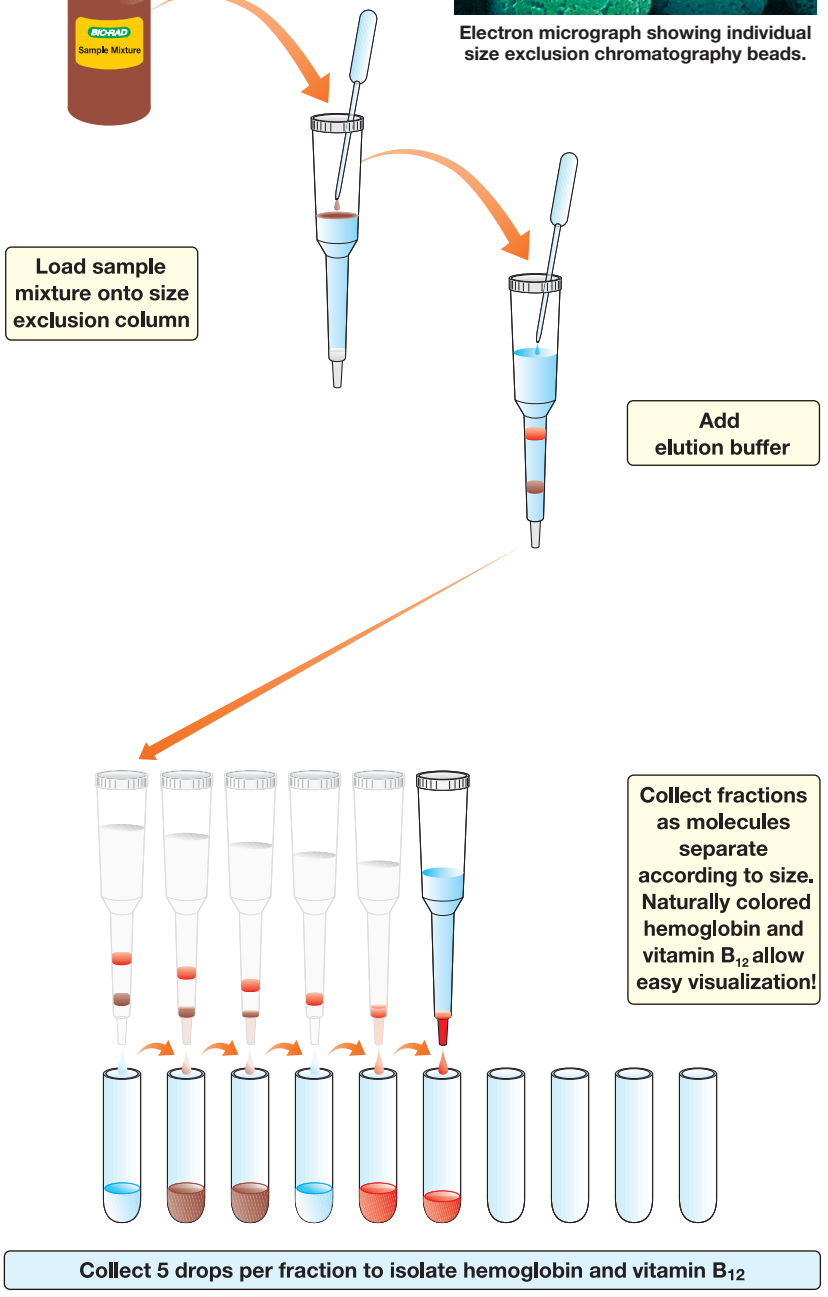
Hemoglobin/vitamin B12 sample mixture	1
Bio-Gel P-60 columns with caps	8
Disposable plastic transfer pipets	10
Column chromatography buffer, 50 ml	1
Sample collection tubes, 5 ml	100
Curriculum, including teacher's guide, student manual, and graphic quick guide	1

Refresh Kit Components: (more info pp. 157–159)
Sample Mixture and Column Chromatography Buffer (#1660018EDU)
Bio-Gel P-60 Columns with Caps, 8 (#1660020EDU)
Disposable Plastic Transfer Pipets, nonsterile, 500 (#1660480EDU)
Clear Polystyrene Tubes, 13 x 100 mm, 9 ml, 1,000 (#2239750EDU)
15 ml Tube Racks, holds 60 tubes, set of 5 racks (#1660483EDU)
Bio-Gel P-60 Gel, medium, 100 g (#1504160EDU)
Poly-Prep Columns, empty, 50 (#7311550EDU)

Lab 1



Electron micrograph showing individual size exclusion chromatography beads.



ELISA Immuno Explorer Kit: Real Antibodies, Real Learning, Real Fun

Use real antibodies to see how a real ELISA works. Explore biodefense, immunology, or health science with this topical, hands-on lab. **Simulate the outbreak of a disease in your classroom and use real antibodies** to track it. Teach your students how protein structure and enzyme substrate interactions are used to detect HIV, bird flu, genetically modified organisms (GMOs), and the molecular markers of cancer, pregnancy, or drug use.

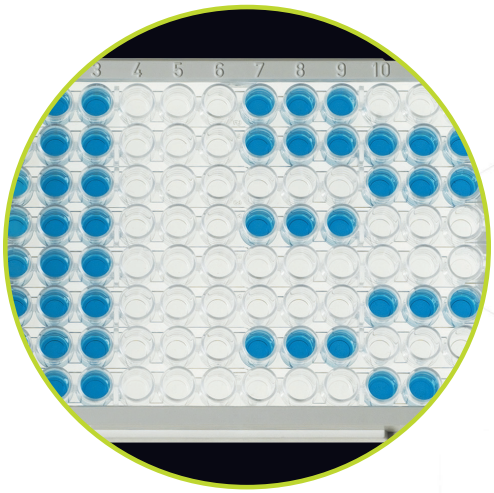
What is ELISA? The enzyme-linked immunosorbent assay (ELISA for short) is a technique used to detect the presence of an antibody or an antigen* in a sample. It harnesses antibodies' ability to act like magic bullets and attach themselves to their targets (antigens). An ELISA utilizes two antibodies, one of which is specific to the antigen and another that is coupled to an enzyme. This second antibody gives the assay the enzyme-linked part of its name, and will cause a chromogenic substrate to produce color wherever it is bound. ELISA is a powerful antibody-based biodetection tool used in the field to hunt for pathogens in water, food, or air, whether they emerge naturally or through acts of aggression.

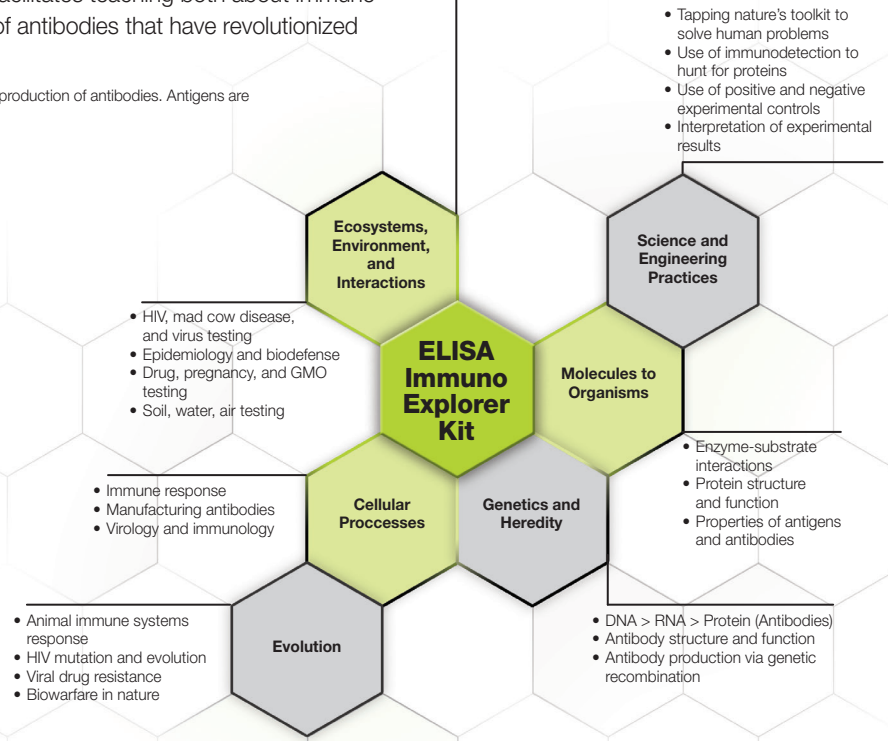
How this kit works: Three approaches to ELISA may be taken with this kit. Curriculum guides and instructions for each protocol are included in the kit, complete with teacher's guides and student manuals. Select the type of test most relevant to your current course work.

1. **ELISA for disease outbreaks — tracking the spread of disease through a classroom exchange of simulated body fluids.**
   Test applications: HIV, bird flu, West Nile, and swine flu viruses, common cold, cholera, smallpox, anthrax, influenza, and STD detection.
2. **ELISA for detecting antigens in a sample.**
   Test applications: Pregnancy hormone, drug, allergen, and GMO discovery; air, food, and water testing; HIV, mad cow disease, and smallpox, West Nile, bird flu, and swine flu virus detection.
3. **ELISA for detecting antibodies in a blood sample for past exposure to a disease.**
   Test applications: Lyme disease, trichinosis, HIV, West Nile virus, bird flu virus, and swine flu virus detection.

This kit integrates multiple core content areas and facilitates teaching both about immune system functions and about the unique properties of antibodies that have revolutionized medicine, epidemiology, and life science research.

* An antigen is a substance that stimulates an immune response and the production of antibodies. Antigens are usually proteins, but can be any type of molecule.





ELISA Immuno Explorer Kit

Each kit supports 48 students.

ELISA Immuno Explorer Kit
Catalog # **1662400EDU**

Convenient lyophilized reagents. Ships at room temperature. Store at 4°C.

Key Kit Features

- Apply a genuine diagnostic procedure
- Simulate real-world HIV testing
- Simulate GMO, pregnancy, and drug testing
- Complete in one 45 minute lab session

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.

Lab Preparation Checklist

Kit contains sufficient materials for 12 student workstations (2–4 students per workstation).

Antigen (chicken γ-globulin)*	1
Primary antibody (rabbit anti-chicken polyclonal antibody)*	1
Secondary antibody (goat anti-rabbit antibody conjugated to horseradish peroxidase, or HRP)*	1
HRP enzyme substrate (TMB), 25 ml	1
10x PBS, 100 ml	1
10% Tween 20, 5 ml	1
Disposable plastic transfer pipets	80
Microplates with 12-well strips (8 rows of 12 wells)	3
Yellow microcentrifuge tubes, 2.0 ml	60
Colored microcentrifuge tubes, 2.0 ml	85
Curriculum, including teacher's guide, student manual, and graphic quick guide	1

Required Accessories Not Included in Kit:

Adjustable micropipets, 20–200 µl, pp. 152–153	12
Or fixed volume micropipets, 50 µl, pp. 152–153	12
Pipet tips, 2–200 µl, BR-35, p. 154	1 bag

Refresh Kit Components: (more info pp.157–159)
ELISA Kit Reagent Refill Pack (#1662401EDU) includes antigen, primary antibody, secondary antibody, 10% Tween 20, 10x PBS, HRP enzyme substrate
HRP Enzyme Substrate (TMB), 25 ml (#1662402EDU)
10x PBS, 100 ml (#1662403EDU)
Microplate with 12-well Strips (8 rows of 12 wells), 3 plates (#1662405EDU)
Disposable Plastic Transfer Pipets, nonsterile, 500, (#1660480EDU)
Antigen (chicken γ-globulin)* (#1662406EDU)
Primary Antibody (rabbit anti-chicken polyclonal antibody)* (#1662407EDU)
Secondary Antibody (goat anti-rabbit antibody conjugated to horseradish peroxidase, or HRP)* (#1662408EDU)
Green Racks, set of 5 racks (#1660481EDU)
10% Tween 20, p. 140

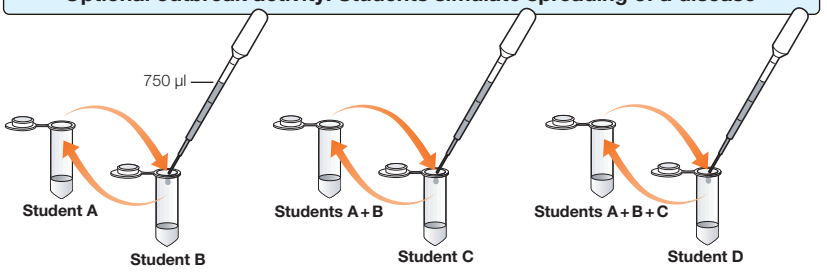
* Convenient lyophilized reagents.

Extra Curriculum for ELISA on the Web
Download the Biological Bodyguards curriculum that embeds the ELISA Immuno Explorer lab in topical case study scenario format, from the Morehead Planetarium and Science Center Mobile Labs. Visit **bio-rad.com/biobodyguard/ELISAKit** to download the complete PDF.

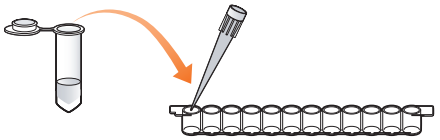
Web
Check This Out!

Lab 1

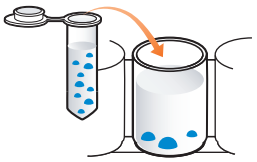
Optional outbreak activity: Students simulate spreading of a disease



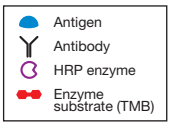
Load positive and negative controls in triplicate into wells of microplate strips

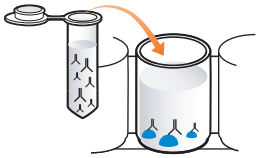


Complete antigen- or antibody-detection ELISA protocol



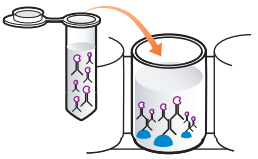
Load student samples (unknowns) in triplicate into wells of the microplate strips. Incubate for 5 min. Rinse



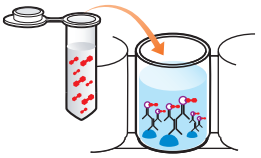


Add primary antibody to all wells. Incubate for 5 min. Rinse

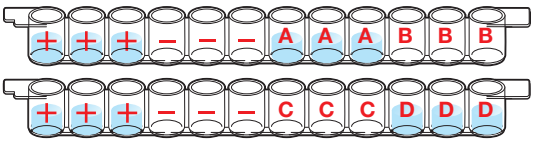
Add enzyme-linked secondary antibody to all wells. Incubate for 5 min. Rinse



Add enzyme substrate to all wells. Incubate for 5 min



Watch for color development



Extension: Perform quantitative analysis using a microplate absorbance reader

ELISA kit comparison

	Classic ELISA Immuno Explorer Kit (#1662400EDU)	ThINQ! A Giant Panda Problem Kit for AP Biology (#17002878EDU, p. 52)
Class type	General Biology or Biotechnology, skills-based	AP Biology, inquiry-based
Inquiry type	Structured	Structured, guided, and open
Activities	12 workstations; one structured hands-on activity	8 workstations; Two hands-on inquiry investigations

A Giant Panda Problem Kit for AP Biology — A ThINQ! Investigation

Why are giant panda populations declining?
Students discuss the causes of declining giant panda populations.

Are there potential pregnancy complications?
Students can check for pre-eclampsia in simulated panda samples using ELISA.

How can fertility be measured?
Students detect a chosen fertility marker using ELISA.

Recommended for
AP Biology
Big Ideas
1 **2** 3 **4**

Save the pandas!
With decreased habitat and low birth rates, the survival of the giant panda populations depends on the dedicated support of scientists and caregivers. Let your students use the same cutting-edge combination of endocrinology and immunology that scientists use to determine the right time frame for optimal fertility.

Giant Panda Problem Kit for AP Biology

Each kit supports 32 students.

Giant Panda Problem Kit for AP Biology
Catalog # **17002878EDU**

Convenient lyophilized reagents. Ships at room temperature. Store at 4°C.

Key Kit Features

- Uses genuine ELISAs to study fertility
- Aligns with AP Biology Big Ideas 2 and 4
- Enables multiple levels of inquiry and student-designed experimentation

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.

Lab Preparation Checklist

Kit contains sufficient materials for 8 student workstations (2–4 students per workstation).

Antigen (chicken γ-globulin)*	1
Primary Antibody (rabbit anti-chicken polyclonal antibody)*	1
Secondary Antibody (goat anti-rabbit antibody conjugated to horseradish peroxidase, or HRP)*	1
HRP Enzyme Substrate (TMB), 25 ml	1
10x PBS, 100 ml	1
10% Tween 20, 5 ml	1
Disposable Plastic Transfer Pipets	80
Microplates with 12-well Strips (8 rows of 12 wells)	3
Yellow Microcentrifuge Tubes, 2.0 ml	60
Colored Microcentrifuge Tubes, 2.0 ml	85
Curriculum, including printed instructor's guide and instructor's answer guide; instructor's and student guides available free to download	

Required Accessories Not Included in Kit:

Adjustable micropipets, 20–200 µl, pp. 152–153	12
Or fixed volume micropipets, 50 µl, pp. 152–153	12
Pipet tips, 2–200 µl, BR-35, p. 154	1 bag
Thermometers	1–8

Refresh Kit Components: (more info pp.157–159)
ELISA Kit Reagent Refill Pack (#1662401EDU) includes antigen, primary antibody, secondary antibody, 10% Tween 20, 10x PBS, HRP enzyme substrate (TMB)
For additional refresh components, see ELISA Immuno Explorer Kit, p. 51

* Convenient lyophilized reagents.

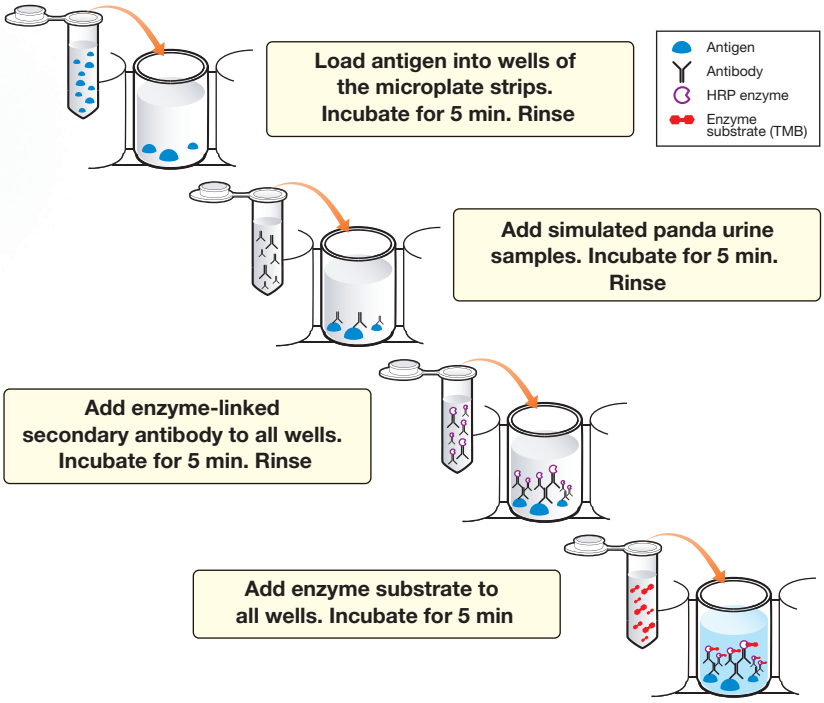
This hands-on activity is integrated with the Lt Biology Collection, the online learning platform from ADInstruments.

Lt

ADINSTRUMENTS making science easier

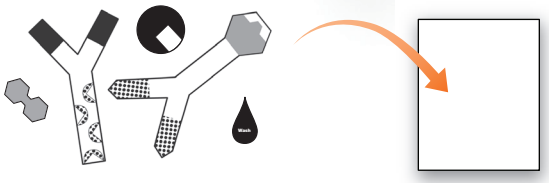
Structured Inquiry Investigation #1 — Antibody detection ELISA

Complete digital simulation or optional hands-on activity to check for pre-eclampsia

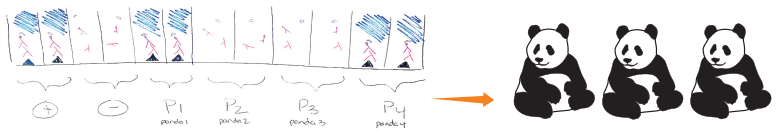


Watch for color development

ELISA Paper Model (optional assessment activity)



Structured/guided/open Inquiry Investigation #2 — Antigen detection ELISA



Students select a hormone and design an antigen detection ELISA

Determine which panda is ovulating

For a skills-based approach to teaching ELISA, see ELISA Immuno Explorer Kit, pp. 50–51

ELISA kit comparison

	ThINQ! A Giant Panda Problem Kit for AP Biology (#17002878EDU)	Classic ELISA Immuno Explorer Kit (#1662400EDU, p. 50)
Class type	AP Biology, inquiry-based	General Biology or Biotechnology, skills-based
Inquiry type	Structured, guided, and open	Structured
Activities	8 workstations; Two hands-on inquiry investigations	12 workstations; one structured hands-on activity

Comparative Proteomics Kit I: Protein Profiler Module — AP Big Idea 1: Does Molecular

Proteomics asks the question: What do our genes do? Genes encode proteins that determine an organism's form, function, and phenotype — the raw material of natural selection. Proteomics is the study of the structure, function, and interaction of proteins with each other and with their environment.

The protein profiler module moves beyond DNA and allows students to employ protein electrophoresis, the most widely used technique in life science research, to study protein structure and function. Students learn to use SDS-PAGE to generate protein profiles from the muscles of both distantly and closely related species of fish. From their results, they compare the different species' profiles to test the hypothesis that protein profiles can be indicators of evolutionary relatedness.

This kit allows your students to explore evolution at the molecular level within the context of the central molecular framework of biology:

DNA ➤ RNA ➤ Protein ➤ Trait — Phenotype

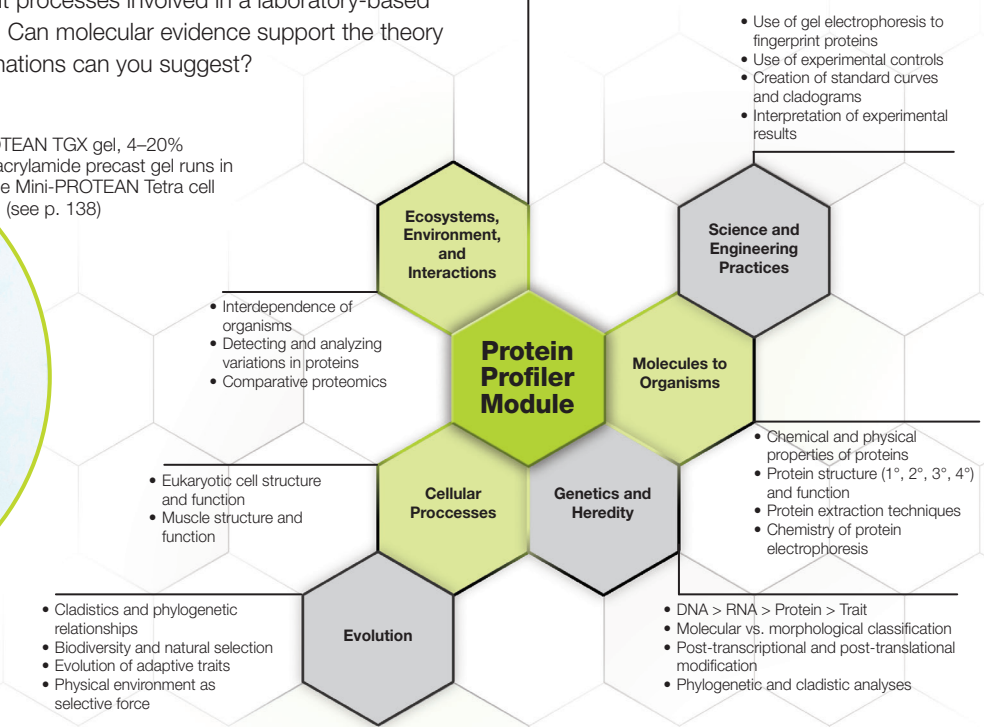
Changes in proteins can reflect changes in the gene pool. Actin and myosin are the major muscle proteins essential for locomotion and survival in all animals. Muscle consists mainly of actin and myosin, but numerous other proteins also compose muscle tissue. The structures and functions of actin and myosin have remained relatively stable or "conserved" in all animals over evolutionary time. However, other muscle proteins exhibit considerable variation, even among closely related species. Detectable variations between organisms' protein profiles reflect physiological adaptations to different environments, but they originate as random DNA mutations. Such mutation events, if favorable, persist through the natural selection process and contribute to the evolution of species with new specialized functions.

Mutation ➤ Variation ➤ Specialization ➤ Speciation — Evolution

This is an open-ended, inquiry-based kit. Students make predictions about their results in prelab activities using Internet databases and published phylogenetic information. They generate novel results and apply their findings directly to the problem of solving evolutionary relationships by constructing cladograms (phylogenetic trees). From their gel data, they build up a tree and assign each organism a branch. Students can decide whether their results support their predictions.

The kit guides students through the thought processes involved in a laboratory-based scientific investigation. Students are asked: Can molecular evidence support the theory of evolution? Why or why not? What explanations can you suggest?

Mini-PROTEAN TGX gel, 4–20% polyacrylamide precast gel runs in the Mini-PROTEAN Tetra cell (see p. 138)



Kit I: Protein Profiler Module

Each kit supports 32 students.

Kit I: Protein Profiler Module
Catalog # **1662700EDU**
Electrophoresis reagents not included — available separately.

Kit I: Protein Profiler Module plus 10 pack of Mini-PROTEAN TGX Precast Gels, 4–20%, 10 well each
Catalog # **17006136EDU**

Kit I: Protein Profiler Module plus 10 pack of Mini-PROTEAN TGX Stain-Free Precast Gels, 4–20%, 10 well each
Catalog # **17006135EDU**

Kits I and II:
Protein Profiler and Western Blot Modules
Catalog # **1662850EDU**
Ships at room temperature. Immediately store temperature-sensitive reagents at –20°C as indicated.
Obtain fish samples locally. Mini-PROTEAN TGX precast gels (12 month shelf life) available separately.

Key Kit Features

- Aligns with AP Biology Big Idea 1; Investigation 3
- Curriculum connections to evolution, protein structure/function, and protein electrophoresis
- Construct cladograms
- Complete in three 45 minute lab sessions

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.

Lab Preparation Checklist

Kit contains sufficient materials for 8 student workstations (2–4 students per workstation).

Laemmli Sample Buffer, 30 ml	1
Precision Plus Protein Kaleidoscope standards, 50 µl	1
10x Tris/glycine/SDS Electrophoresis Buffer, 1 L	1
Bio-Safe Coomassie Stain for Proteins, 100 ml	2
Experimental Standard, 500 µg lyophilized	1
Dithiothreitol (DTT), 0.3 g	1
Prot/Elec Pipet Tips for gel loading	1 rack
1.5 ml Fliptop Microcentrifuge Tubes	60
1.5 ml Screwcap Microcentrifuge Tubes	50
Disposable Plastic Transfer Pipets	30
Curriculum, including teacher's guide, student manual, and graphic quick guide	1

Required Accessories Not Included in Kit:

Fish Samples	5–8 types
Adjustable Micropipets, 2–20 µl, pp. 152–153	8
Power Supplies, p. 155	2–4
Water Bath or Dry Bath, p. 150	1
Gel Staining Trays, p.157	4–8
Foam Floating Racks, p.157	8

If Using Polyacrylamide Gel Electrophoresis:

Required Accessories

Vertical Gel Electrophoresis Chambers, p. 135	2–4
Mini-PROTEAN TGX Precast (or stain-free if using GelDoc Go or ChemiDoc Imaging System) polyacrylamide gels, 4–20%, 10-well each, p. 136	8

If Using Agarose Gel Electrophoresis:

Required Accessories

Horizontal Gel Electrophoresis Chambers, pp. 117–118	4–8
Low-melt Agarose, 25 g, p. 119	
Pipet Tips, 2–20 µl, TBR-35, p. 154	
Acetic Acid, 100 ml	
Reagent Alcohol/ethanol, 400 ml	

Recommended (Optional) Accessories:

Sample loading guides, p. 135
Gel Documentation system, pp. 146–147

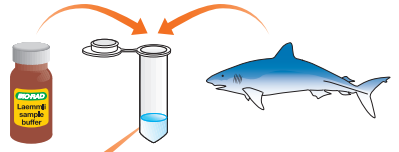
Refresh Kit Components: (more info pp.157–159)
Protein Profiler Temperature-sensitive Reagent Refill Pack (#1662701EDU), includes Precision Plus Protein Kaleidoscope standards, experimental standard, and DTT
Experimental Standard (#1660010EDU)
Gel Staining Trays, 4 (#1660477EDU)
Jellyfish Foam Floating Racks, 8 racks (#1660479EDU)
Laemmli Sample Buffer, p. 140
Precision Plus Protein Kaleidoscope standards, 500 µl, p. 139
10x Tris/glycine/SDS Electrophoresis Buffer, p. 140
Bio-Safe Coomassie Stain, p. 139
DTT, p. 140

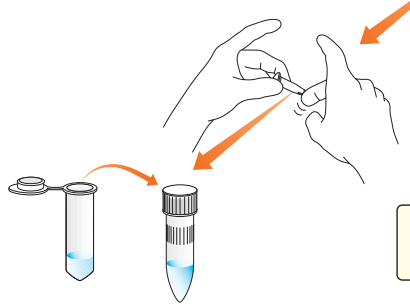
This hands-on activity is integrated with the Lt Biology Collection, the online learning platform from ADInstruments.

Lab 1

Extract fish muscle proteins

Add fish muscle and Laemmli sample buffer to micro test tube





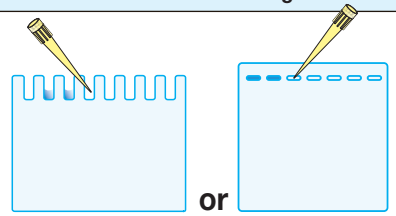
Gently flick tube to agitate sample

Pour extracted protein samples into screwcap tubes

Lab 2

Heat protein samples at 95°C for 5 minutes. Run gels or store samples overnight

Load and electrophorese samples on precast polyacrylamide gels at 200 V for 30 min



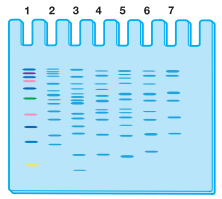
or

Load and electrophorese samples in 4% low-melt agarose at 100 V for 45 min

Lab 3

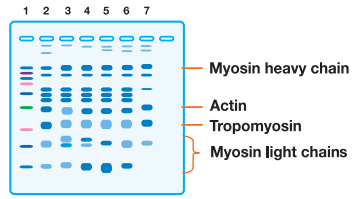
Stain gels with Bio-Safe Coomassie stain then destain with water

Lanes:
1 Size standards
2 Shark
3 Salmon
4 Trout
5 Catfish
6 Sturgeon
7 Experimental standard



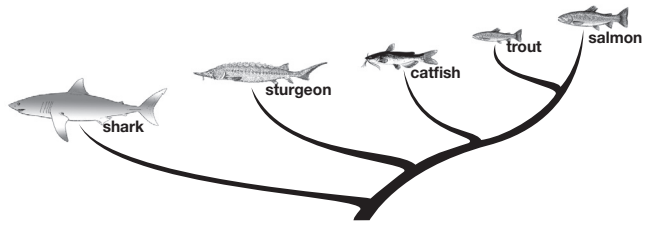
Polyacrylamide gel results

or



Agarose gel results

Analyze results and create cladograms from gel data



Extension 1: Western Blot Module, see pp. 56–57

Extension 2: Conduct Web-based bioinformatics studies and compare student results to published phylogenetic data

Comparative Proteomics Kit II: Western Blot Module: Tapping Nature's Toolkit

When foreign invaders are detected, animal immune systems naturally generate antibodies to tag them for destruction. The ability of antibodies to act like magic bullets and target viral, bacterial, and allergenic antigens in the body also makes them ideal tools in the hunt for specific molecules in bioscience research and diagnostic tests.

Western blotting employs antibodies to pinpoint specific proteins of interest in complex protein mixtures such as cell extracts. Because of its accuracy, western blotting is used as the confirmatory diagnostic test for HIV and mad cow disease (bovine spongiform encephalopathy).

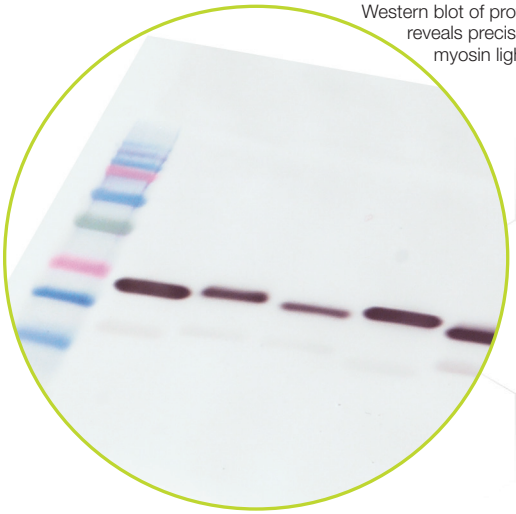
Western blotting is used extensively in research to determine the presence of specific proteins, to quantitate their expression levels, and to determine whether they have undergone genetic or post-translational modifications. This surefire method categorically identifies proteins of interest based on two distinguishing features: molecular mass and antibody binding specificity.

Myosin is a major muscle protein essential for locomotion and survival in all animals. The essential structure and function of myosin has remained relatively stable or "conserved" in all animals over evolutionary time. However, differences in the molecular weights of the myosin light chain proteins of different species are detectable via western blotting, enabling students to hypothesize about how these variations relate to their evolutionary relationships.

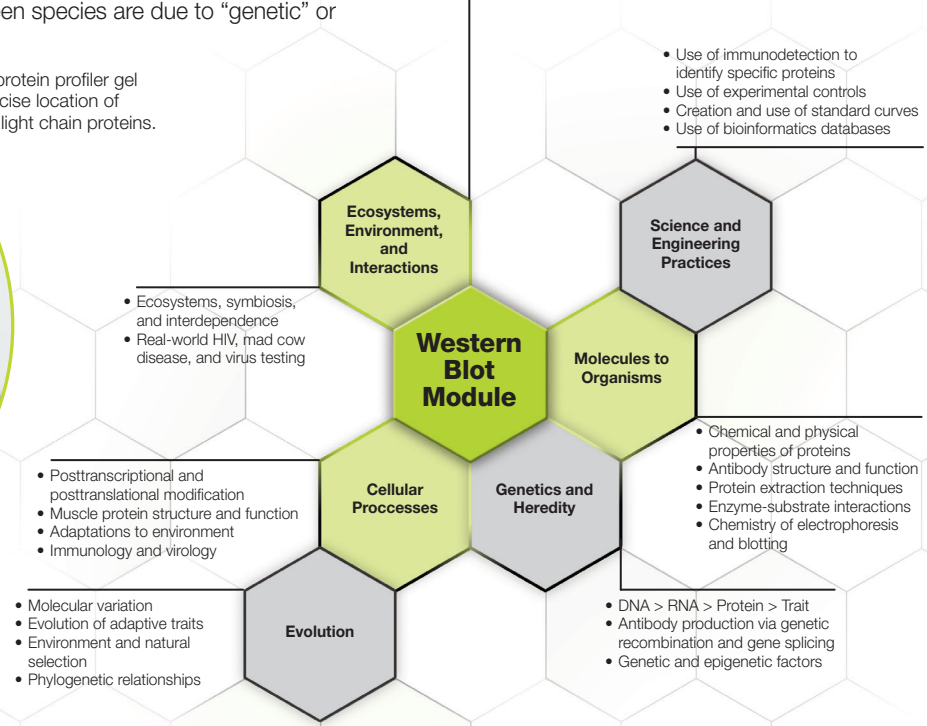
This western blot module allows your students to take protein profiling to the next level. Students use western blotting to specifically identify myosin light chain from the hundreds of other proteins that make up the muscle cell extracts of closely and distantly related species of fish.

In the first part of this laboratory (protein profiler module), students generate protein profiles and visualize the unique arrays of proteins composing the muscle tissues from each of their samples. From their protein gel results, students make educated guesses as to the identities of the proteins. However, based on their relative molecular masses alone these inferences remain guesses. Via western blotting, the protein bands in their polyacrylamide gels are transferred horizontally to a membrane and an anti-myosin light chain antibody is employed to precisely identify which protein in each species' profile is myosin light chain.

Using Internet-based bioinformatics databases, students can compare their experimentally determined results to actual protein sequence data derived from DNA and RNA sequences and consider whether variations in myosins between species are due to "genetic" or "epigenetic" factors.



Western blot of protein profiler gel reveals precise location of myosin light chain proteins.



Kit II: Western Blot Module

Each kit supports 32 students.

Kit II: Western Blot Module
Catalog # **1662800EDU**

Kits I and II:
Protein Profiler and Western Blot Modules
Catalog # **1662850EDU**

Convenient lyophilized reagents. Ships at room temperature. Immediately store temperature-sensitive reagents at –20°C as indicated. Obtain fish samples locally. Mini-PROTEAN TGX precast gels (12 month shelf life) available separately. Protein profiler module required.

Key Kit Features

- Explore immunodetection
- Explain HIV detection
- Apply immunology
- Use antibodies as tools
- Complete in four 45 minute lab sessions

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.

Lab Preparation Checklist

Kit contains sufficient materials for 8 student workstations (2–4 students per workstation).

Primary Antibody (anti-myosin light chain mouse monoclonal), lyophilized	1
Secondary Antibody (goat anti-mouse polyclonal antibody conjugated to horseradish peroxidase, or HRP), lyophilized	1
HRP Color Detection Reagent A	1
HRP Color Detection Reagent B	1
10x Tris/Glycine, 1 L	1
Nonfat Dry Milk Blocker	1
10x Phosphate Buffered Saline (PBS), 100 ml	2
10% Tween 20, 5 ml	1
Nitrocellulose, 0.45 µm	8 sheets
Blotting Paper	16 sheets
Reagent Tubes	25
Curriculum, including teacher's guide, student manual, and graphic quick guide	1

Required Accessories Not Included in Kit:

Comparative Proteomics Kit I: Protein Profiler Module, p. 54	1
Mini-PROTEAN TGX Precast Polyacrylamide Gels, 4–20%, 10-well each, p. 138	8
Vertical Gel Electrophoresis Chambers, p. 135	4
Adjustable Micropipet, 2–20 µl, pp. 152–153	4–8
Power Supplies, p. 155	2–4
Water Bath or Dry Bath, pp. 150	1
Rocking Platform, pp. 149	1
Reagent Alcohol or Ethanol	0–2 L
Fish Samples	5–8 types

Recommended (Optional) Accessories:

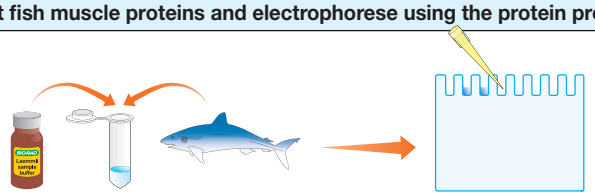
Electroblotter, p. 136	4

Refresh Kit Components: (more info pp. 157–159)

Western Blot Temperature-sensitive Reagent Refill Pack (#1662801EDU) includes primary antibody, secondary antibody, HRP color detection reagents A and B
Primary Antibody (anti-myosin light chain antibody), 200 µg, lyophilized (#1662804EDU)
Secondary Antibody (goat anti-mouse HRP), 2 ml (#1721011EDU)
Horseradish Peroxidase (HRP) conjugate substrate kit (#1706431EDU)
Cell Culture Tubes, 17 x 100 mm, 14 ml, sterile, 25 (#1660476EDU)
Gel Staining Trays, 4 (#1660477EDU)
Tube Racks, p.156
Protein Profiler Temperature-sensitive Reagent Refill Pack, p. 54
Nitrocellulose, 0.45 µm, 10 sheets, p. 137
Nitrocellulose/Filter Paper Packs, p. 137
Thick Blot Paper, 50 sheets, p. 137
Blotting-grade Blocker, nonfat dry milk, 300 g, p. 140
Laemmli Sample Buffer, p. 140
Precision Plus Protein Kaleidoscope standards, p. 139
Experimental Standard, p. 54
10x Tris/glycine/SDS, p. 140
10x Tris/glycine, p. 140
10x Phosphate Buffered Saline (PBS), p. 140
10% Tween 20, p. 140
Bio-Safe Coomassie Stain, p. 139

Labs 1 & 2

Extract fish muscle proteins and electrophorese using the protein profiler module



Extract fish muscle proteins

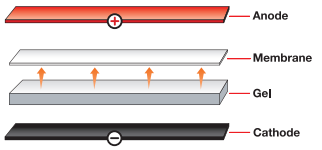
Electrophorese samples on precast polyacrylamide gels for 30 minutes at 200 V

Stain gels with Bio-Safe Coomassie stain (optional), or proceed to lab 3, or store unstained gels in precast gel cassettes overnight

Lab 3

Assemble western blot and transfer muscle proteins to membrane

Electroblot proteins from gel to membrane: 100 V / 30 min or 20 V / 2.5 hrs

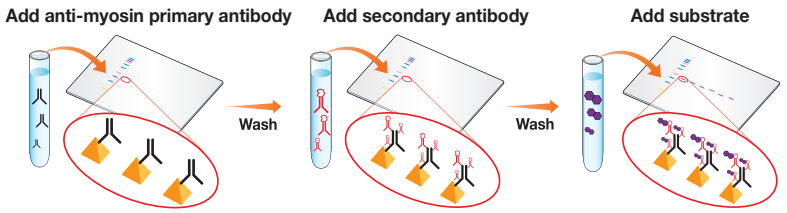


Alternative: Blot proteins by capillary action from gel to membrane for 48 hrs

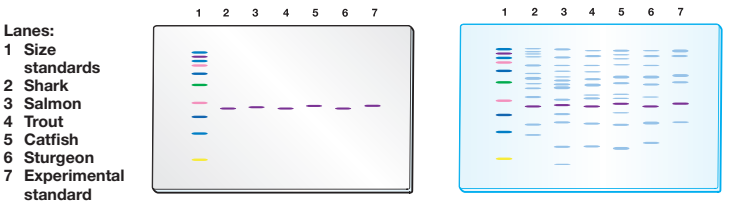
Store blotted membranes in blocking solution

Lab 4

Run immunodetection procedure to detect myosin light chain



Watch for color development



Unstained gel results

Stained gel results

Extension 1: Construct a standard curve from protein standards

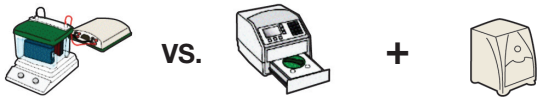
Extension 2: Determine sizes of myosin light chains from different species

Extension 3: Compare results with published bioinformatics databases

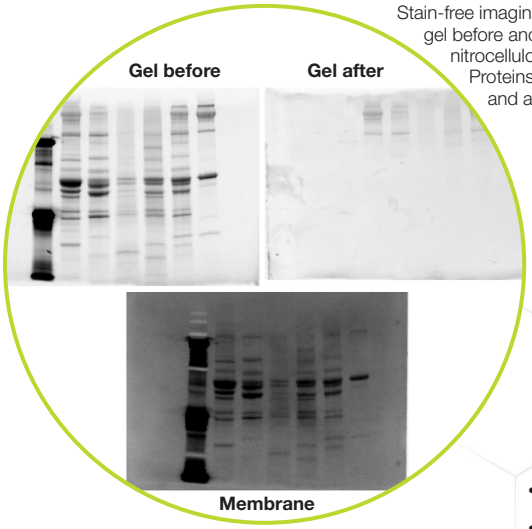
To western blot in less than 2 hours, see pp. 58–59

Rapid Blotting — V3 Western Workflow: Stain-Free Rapid Blotting

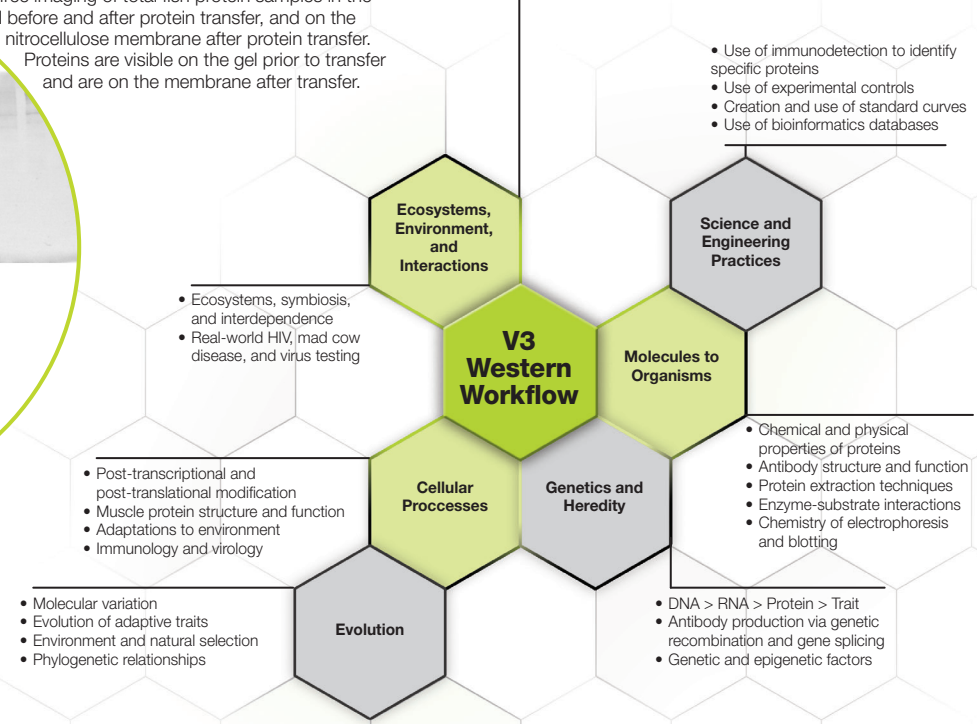
Western blotting in less than 2 hours! Using our new rapid blotting or V3 Western Workflow (stain-free rapid blotting) options allows you to complete the entire western blot workflow in less than 2 to 5 hours, depending on which time-saving steps you incorporate. TGX Stain-Free gels combined with our super-fast Trans-Blot Turbo transfer system provide the fastest speed and most time savings — a complete workflow in less than a single 3 hour lab block. Teach your students about the exciting new chemistry that allows visualization of samples separated on PAGE gels without staining! To learn more, visit us at explorer.bio-rad.com to download the Rapid Blotting + V3 Western Workflow application note, which shows you how to perform the Comparative Proteomics kits I and II: Protein Profiler and Western Blot modules in less than 2 hours. This same workflow can provide time savings for any western blotting application. See for yourself why thousands of researchers are using this new process!



Hands-on time expenditure, in min	Tank blotting	Rapid blotting (staining required)	V3 Western Workflow (staln-free rapid blotting)
Protein extraction	15	15	15
Electrophoresis	18	18	18
Protein visualization	180	180	<3
Protein Transfer			
Equilibration	15	0	0
Setup	30	5	5
Transfer	30–150	15	15
Immunoblotting	45	45	45
Color detection	all 10 min-overnight		
Total hands-on time	**5 hrs 43 min – 7 hrs 25 min**	**4 hrs 48 min**	**1 hr 51 min**
Total Time Savings of 55 min to 7 1/2 hrs			



Stain-free imaging of total fish protein samples in the gel before and after protein transfer, and on the nitrocellulose membrane after protein transfer. Proteins are visible on the gel prior to transfer and are on the membrane after transfer.



Rapid Blotting — V3 Western Workflow

Each kit contains sufficient materials for 8 student workstations.

Rapid Blotting + V3 Western Workflow Starter Kit

Catalog # **1662875EDU**

Includes Protein Profiler and Western Blot modules; Trans-Blot Turbo mini nitrocellulose transfer pack, 10 pack; TGX Stain-Free precast gels, 4–20%, 10 pack; Rapid Blotting + V3 Western Workflow Application Note.

Obtain fish samples locally. Mini-PROTEAN TGX Stain-Free gels require a UV imager to visualize the resolved protein samples. Traditional SDS-PAGE gels can be used in place of Mini-PROTEAN TGX Stain-Free gels, but require staining/destaining of gels to visualize the resolved protein samples.

Key Kit Features

- Explore immunodetection
- Apply immunology
- Use antibodies as tools
- Understand how protein variation supports evolutionary relatedness
- Compare information provided by stained gels vs. immunoblots
- Complete in less than 2 hours

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.

Lab Preparation Checklist

Kit contains sufficient materials for 8 student workstations (2–4 students per workstation).

- Comparative Proteomics Kits I and II: Protein Profiler and Western Blot Modules (1662850EDU)
- Trans-Blot Turbo Mini Nitrocellulose Transfer Pack, 10 pack
- Mini-PROTEAN TGX or TGX Stain-Free 4–20% Precast Polyacrylamide Gels, 10 pack
- Rapid Blotting + V3 Western Workflow application note

Required Accessories Not Included in Kit:

- Vertical Gel Electrophoresis chambers, p. 135 — 8
- Power Supplies, p. 155 — 2–4
- Dry Bath, p. 150 — 1
- Rocking Platform, p. 149 — 1
- Adjustable Micropipets, 2–20 µl, pp. 152–153 — 4–8
- Trans-Blot Turbo Transfer System, p. 136 — 1–4
- Fish Samples — 5–8 types
- Gel Staining Trays, p. 157 — 4–8

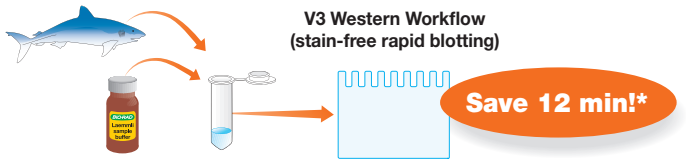
Recommended (Optional) Accessories:

- Gel Imaging System with White Light Sample Tray, p. 147
- Sample Tray Holder, p. 147
- Pipet Controller, p. 153
- Gel Cutter (1703760EDU) or Gel Releasers, p. 135
- Blot Roller, p. 137

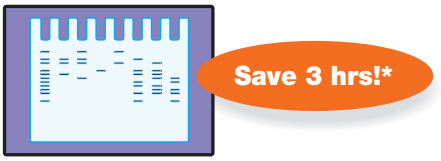
Refresh Kit Components: (more info pp. 157–159)
Kit I: Protein Profiler Module (1662700EDU)
Kit II: Western Blot Module (1662800EDU)
Trans-Blot Turbo Mini Nitrocellulose Transfer Pack, 10 pack (1704158EDU) or
Trans-Blot Turbo Midi Nitrocellulose Transfer Packs, 10 pack (1704159EDU)
TGX Stain-Free Precast Gels, 4–20%, 10 pack (4568093EDU)

Lab 1

Extract fish muscle proteins and electrophorese samples on TGX precast polyacrylamide gels for 18 min at 300 V

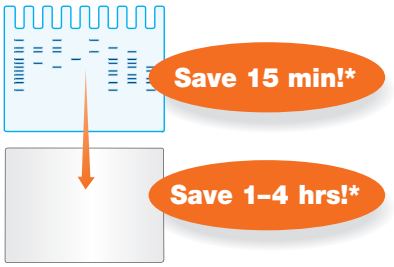


Visualize separated proteins without staining/destaining



Assemble western blot and transfer muscle proteins to membrane using the Trans-Blot Turbo transfer system

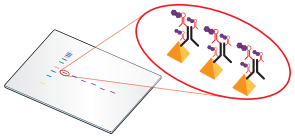
Transfer proteins from gel to membrane



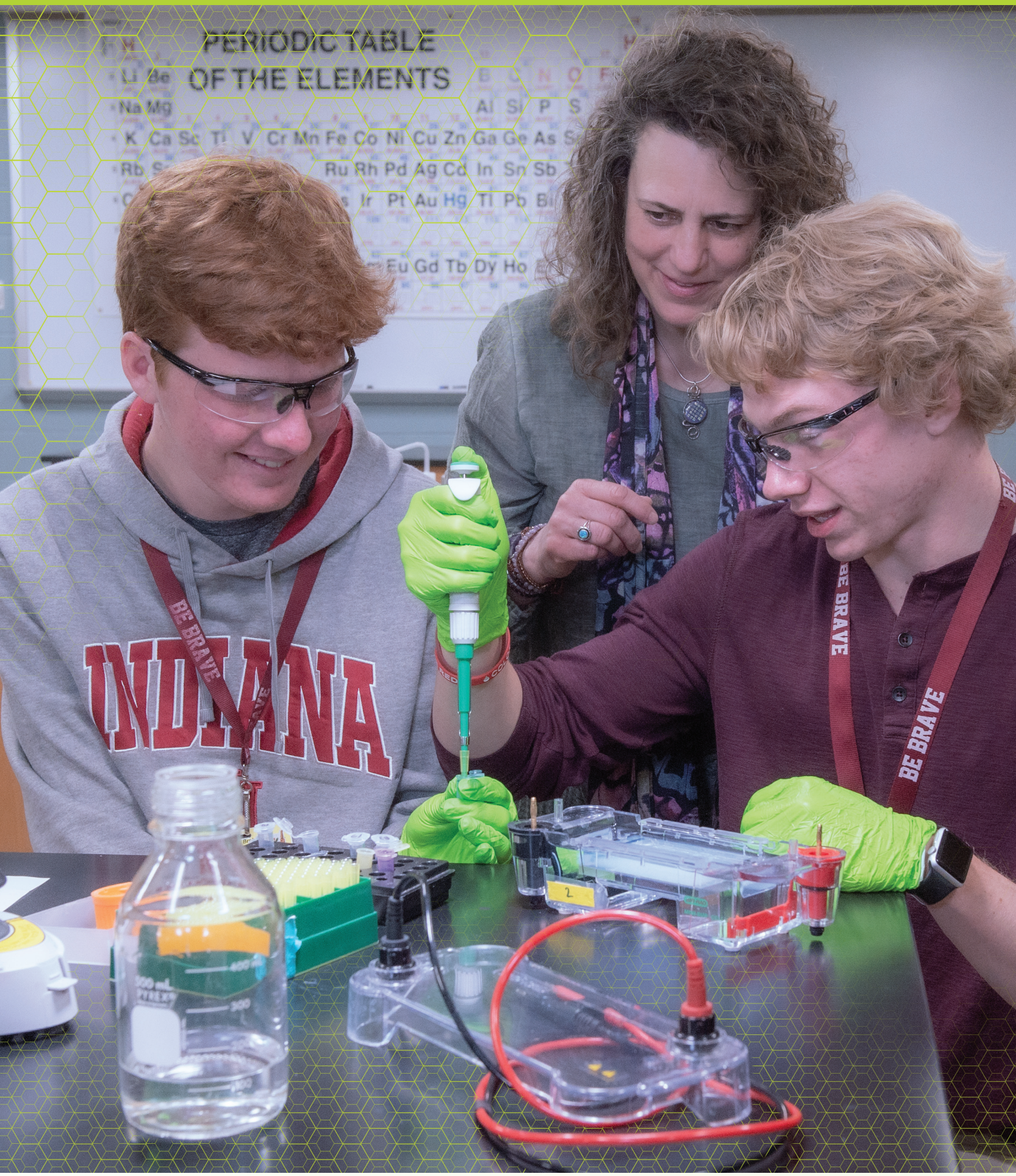
* Optional entry points for time savings when using some traditional equipment and techniques.

V3 Western Workflow (stain-free rapid blotting)
Option: Image gel or blot after transfer to confirm protein transfer to blot

Perform immunodetection procedure to detect myosin light chain and watch for color development



Total time savings up to 7 1/2 hrs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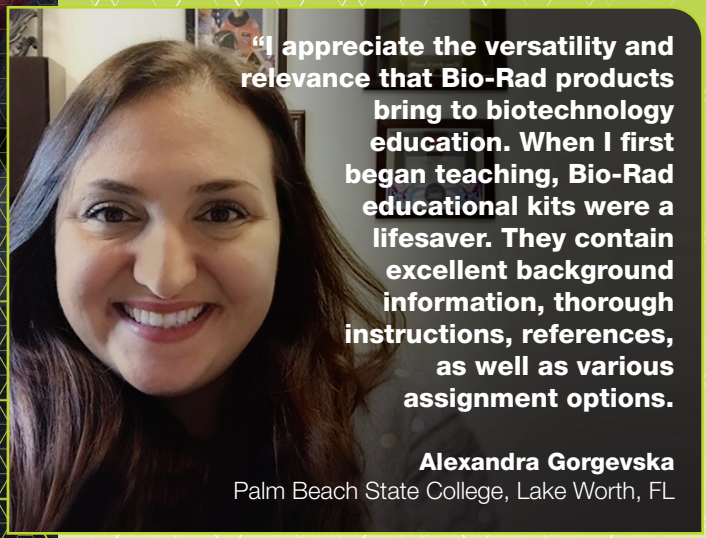
Section Contents

DNA Analysis and Agarose Gel Electrophoresis Kits



"I appreciate the versatility and relevance that Bio-Rad products bring to biotechnology education. When I first began teaching, Bio-Rad educational kits were a lifesaver. They contain excellent background information, thorough instructions, references, as well as various assignment options.

Alexandra Gorgevska
Palm Beach State College, Lake Worth, FL

Bio-Rad Explorer Teacher and Student Alumni

Genes in a Bottle Kit: Make Biology Personal

Seeing is believing. Introduce your students to molecular biology with their own DNA! Enable your students to see the normally invisible substance of life and begin to comprehend the meaning of their own genetic makeup. In this activity your students employ the same real-world laboratory procedure used to extract DNA from many different organisms for a variety of biotechnology research applications. Students extract genomic DNA from their own cheek cells, then precipitate and bottle it in a ***fabulously cool helix keepsake***.

For students learning about the molecular framework of biology for the first time, DNA is abstract and intangible. This procedure makes the invisible visible — seeing their own DNA makes it real and helps students comprehend this primary substance of life. From cell structure to genetics to the chemistry of life, this kit integrates multiple life science standards in a single lesson. Seeing DNA makes it real. Wearing it makes the lesson memorable!

How do scientists separate pure DNA from cells composed mainly of lipids, proteins, carbohydrates, and salts? Membranes are first ruptured with detergent to release DNA into a solution, then proteins and other organic molecules are digested and separated while retaining intact DNA. The DNA is finally collected by precipitation in a form that can be manipulated as desired.

With this simple lab activity, your students will extract genomic DNA from their own cheek cells and watch it precipitate from solution as floating white strands. The DNA strands are then easily collected and transferred to a helix keepsake vial, and the vial is fashioned into a necklace!

Learning opportunities for all levels of instruction. This activity is designed for any classroom environment and requires no specialized equipment or stains. For secondary and college level instruction, lessons on DNA structure and function, cell structure, and enzyme function can be introduced or reinforced with this laboratory activity. For middle school students, it's a perfect introduction to the exciting world of DNA science.

Genes in a Bottle Kit

Each kit supports 36 students.

Genes in a Bottle Kit

Catalog # **1662300EDU***

Ships and stores at room temperature.

* Includes 1 DNA extraction module and 1 DNA necklace module.

Catalog # **1662000EDU**

DNA Extraction Module

Catalog # **1662250EDU**

Helix DNA Necklace Module (36 necklaces)

Ships with both temperature sensitive and room temperature components. Immediately store temperature sensitive items at 4°C or –20°C as indicated.

Key Kit Features

- Perform real research techniques
- Collect cheek cells
- Extract, precipitate, and bottle your DNA
- Use as introductory or capstone activity

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.

Lab Preparation Checklist

Kit contains sufficient materials for 9 student workstations (2–4 students per workstation).

1 DNA Extraction Module

Lysis Buffer, 100 ml	1
Powdered Protease + Salt, 1.5 g	1
Conical Tubes, 15 ml	50
Multicolor Microcentrifuge Tubes	60
Disposable Plastic Transfer Pipets	60
Curriculum, including teacher's guide, student manual, and graphic quick guide	1

DNA Necklace Module

Helix keepsake vials	36
Silver screw caps	36
Waxed string	36

Required Accessories Not Included in Kit:

91% isopropyl alcohol or 95% ethanol, 360 ml	1

Recommended (Optional) Accessories:

Water Bath or Dry Bath with thermometer, p. 150	1
Rack to hold 15 ml tubes in water bath (need space for 36 tubes) (#1660483EDU)	1

Refresh Kit Components: (more info pp. 157–159)

Genes in a Bottle DNA Extraction Reagent Refill Pack (#1662001EDU) includes lysis buffer and powdered protease + salt

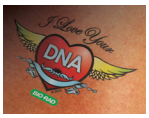
Lysis Buffer, 100 ml (#1662002EDU)

Conical Centrifuge Tubes, 15 ml, 50 (#1660475EDU)

Disposable Plastic Transfer Pipets, nonsterile, 500 (#1660480EDU)

Green Racks, set of 5 racks (#1660481EDU)

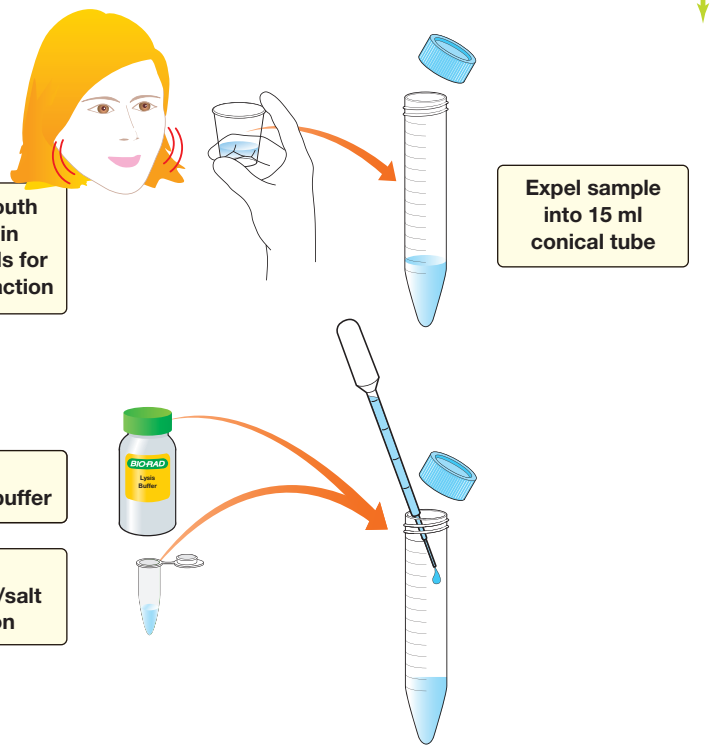
15 ml Tube Racks, holds 60 tubes, set of 5 racks (#1660483EDU)



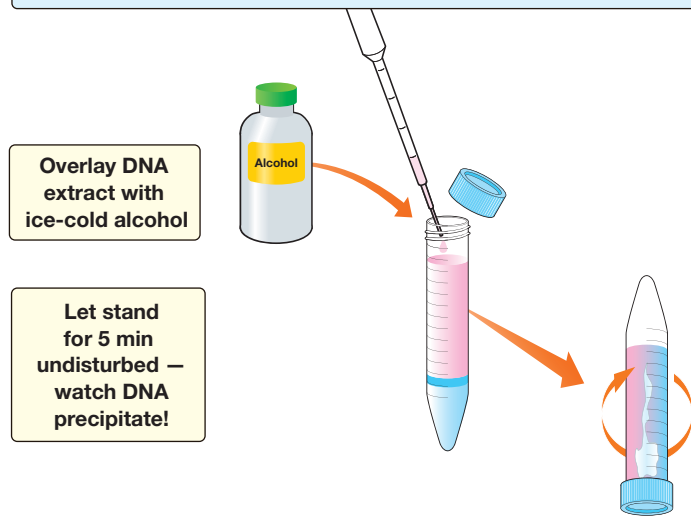
I Love Your DNA Tattoos, 200 temporary tattoos (#1662004EDU)

DNA Model, p. 118 (#1667015EDU)

Lab 1

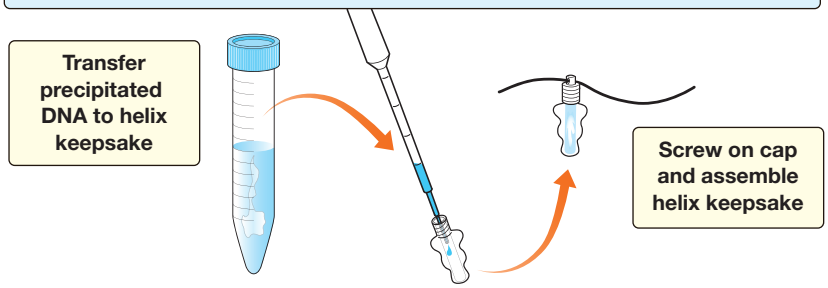


Gently invert tube to rupture cell and nuclear membranes
Incubate at 50°C for 10 min to digest all cellular proteins



Invert tube to mix phases and complete DNA precipitation reaction

Extension: Create DNA necklace



IDEA — Inquiry Dye Electrophoresis Activity and STEM Electrophoresis Kits

Electrophoresis is a fundamental skill used daily in the molecular biology laboratory. Bridge the gap between textbook science and students' lives by using dyes extracted from candy coatings to perform agarose gel electrophoresis. Bio-Rad's IDEA Kit is a dazzling way for students to learn the basics of this key technique using dyes that are commonly found in the foods they eat. Combine this with the power of inquiry to encourage your students to ask questions and seek answers. What dye combinations create the colors in the hard-shell candies of their choice? Do red and blue make purple? Is pink really pink? The colorful results may surprise you and will certainly get your students talking about their discoveries.

Engineer the tools for biological discovery. What actually happens in an agarose gel electrophoresis chamber? Reveal the secrets of this "black box" with Bio-Rad's **STEM Electrophoresis Kit.** Give your students the opportunity to learn about critical design aspects of an electrophoresis unit by engineering one! This activity addresses the fundamentals of science, technology, engineering, and math (STEM) with an integrated hands-on approach. This gel electrophoresis unit is designed to run the IDEA kit, which will bring engagement and an additional inquiry component into your classroom.

IDEA and STEM Electrophoresis Kits

IDEA Kit Starter Pack supports 8 student workstations.

STEM Electrophoresis Kit Starter Pack supports 8 student workstations.

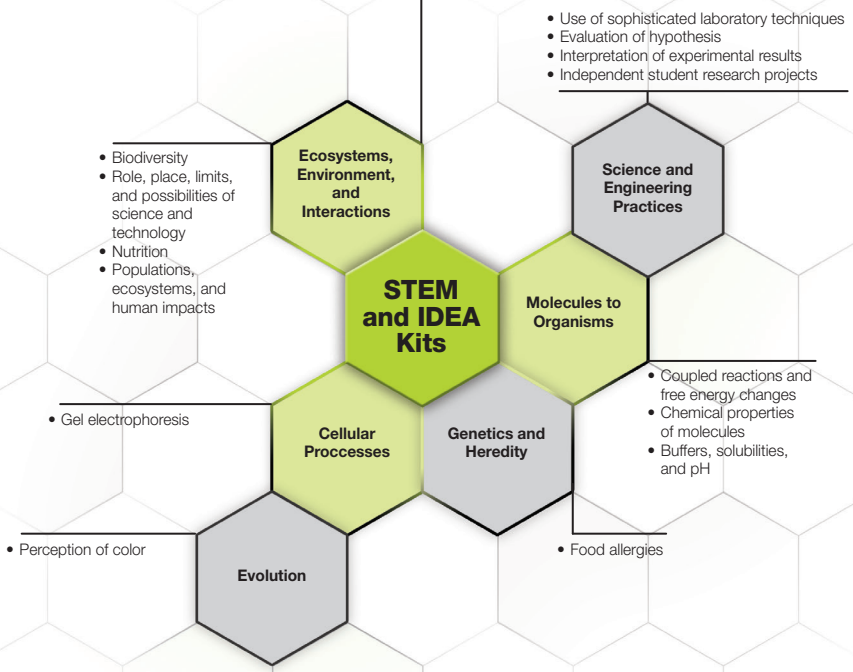
Ordering Information

Description	100 ml 50x TAE and 5 g Agarose	IDEA Kit Reagent Refill*	10 µl Fixed Volume Micropipets	STEM Electrophoresis Engineering Module**	Printed Manual	Number of Workstations	Catalog #
IDEA Kits							
IDEA Kit	yes	yes	—	—	IDEA	8	1665075EDU
IDEA Kit Reagent Refill Pack	—	yes	—	—	—	8	1665076EDU
IDEA Kit Starter Pack	yes	yes	8	—	IDEA	8	1665077EDU
STEM Electrophoresis Kits							
STEM Electrophoresis Teacher Demonstration Kit	yes	yes	—	1	STEM	2	1665080EDU
STEM Electrophoresis Kit	—	—	—	1	STEM	2	1665085EDU
STEM Electrophoresis Classroom Kit	yes	yes	—	4	STEM	8	1665090EDU
STEM Electrophoresis Kit Starter Pack	yes	yes	8	4	STEM	8	1665095EDU

* Includes 4 reference dyes, dye extraction solution, and microcentrifuge tubes (1665076EDU).
** Includes red and black alligator clips, 8-well combs, paperclips, and plastic hinged box, 2 workstations per module (1665085EDU).

Each kit ships and stores at room temperature.

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.



Lab Preparation Checklist

The number of workstations vary depending on the kit purchased. Please refer to the chart for information regarding the number of workstations served.

IDEA Kit (1665075EDU)

Dye Extraction Solution, 25 ml	1
Blue 1 Reference Dye, 150 µl	1
Yellow 5 Reference Dye, 150 µl	1
Yellow 6 Reference Dye, 150 µl	1
Red 40 Reference Dye, 150 µl	1
Electrophoresis Buffer, 50x TAE, 100 ml	1
Molecular Biology Grade Agarose, 5 g	1
2 ml Microcentrifuge Tubes	72
Curriculum, including teacher's guide, student manual, and graphic quick guide	1

Required Accessories
Not Included in IDEA Kit:

Horizontal Gel Electrophoresis Chambers, pp. 117–118 or STEM kit	4–8
Adjustable Micropipets, pp. 152–153	
2–20 µl or 10 µl fixed volume	1–8
20–200 µl and 100–1,000 µl	1 each
Pipet Tips, p. 154	
Power Supplies, p.155	2–4

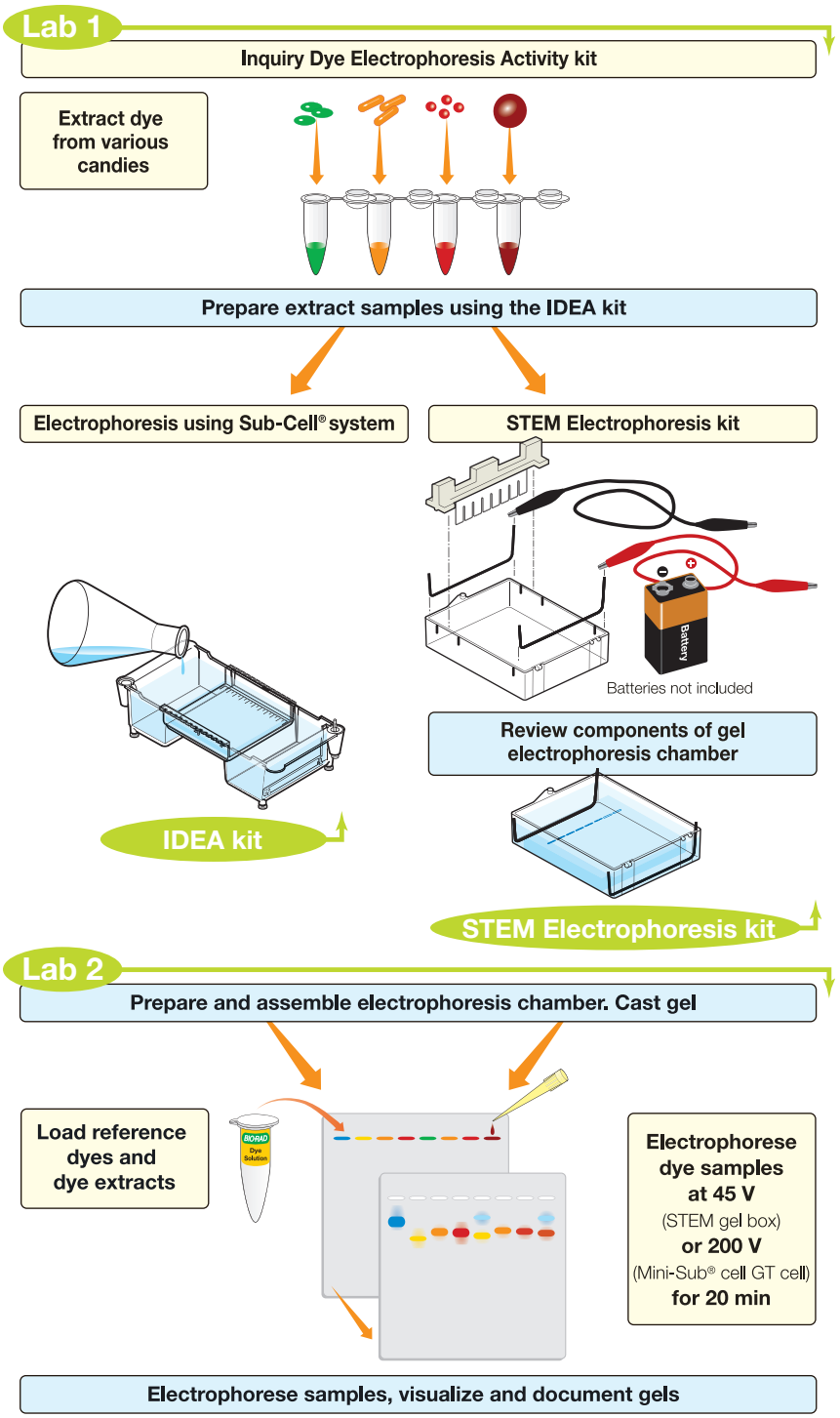
Required Accessories
Not Included in STEM Electrophoresis Kit:

9 V Batteries	3–5 per workstation
2–20 µl Adjustable or 10 µl Fixed-volume Pipets, pp. 152–153	1–8
2–200 µl Pipet Tips, p. 154	
Plastic Rulers or Plastic Card to cut gels	8
Eye Droppers	8
IDEA Kit or IDEA Reagent Refill Pack and 1% ReadyAgarose Precast Mini Gels, p. 120	

Refresh Kit Components: (more info pp. 157–159)

IDEA Kit Reagent Refill Pack (1665076EDU) includes blue 1 reference dye, yellow 5 reference dye, yellow 6 reference dye, red 40 reference dye, dye extraction solution, and 72 microcentrifuge tubes

2 ml Microcentrifuge Tubes, clear, 500 (2239430EDU)



Both Genetics and Environment

Put your students in the roles of doctor and researcher as they consider both environmental factors and genetic links to opioid dependence. Susceptibility to opioid dependence is a complex phenotype without straightforward causes. Access to opioids, personal history, and one's genetics all play into its expression. Help your students understand genotype and phenotype as they participate in scientific discussion about the opioid crisis.

The Value of Controls and Statistical Analysis

Selecting participants for case and control groups is crucial for the success of a research study. In this kit, your students will practice identifying good controls as they outline a human research study to investigate the connection between opioid dependence and a dopamine receptor gene mutation. Then they will analyze preamplified and predigested patient DNA samples by agarose gel electrophoresis. Finally, they will use statistical methods to interpret their results and discuss how to address public policy.

Science of Opioid Dependence Kit

Each kit supports 32 students.

Science of Opioid Dependence Kit
Catalog # **17005316EDU**

Science of Opioid Dependence Kit plus Fast Blast Electrophoresis Reagents
Catalog # **17005297EDU**

Science of Opioid Dependence Kit plus UView Electrophoresis Reagents
Catalog # **17005313EDU**

Ships at ambient temperature. Store reagent pack at –20°C.

Key Kit Features

- Curriculum connections to genetics, neurobiology, DNA structure, PCR, and statistical analysis
- Pre-amplified PCR DNA samples to teach PCR without a thermal cycler

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.

Lab Preparation Checklist

Kit contains sufficient materials for 24 student workstations (2–4 students per workstation).

1.5 ml EZ Micro Test Tubes	90
Molecular weight ruler	200 µl
DNA Sample 1	215 µl
DNA Sample 2	250 µl
Orange G Loading Dye, 5x	1 ml

Fast Blast Electrophoresis Reagents

Fast Blast DNA Stain	100 ml
Certified Molecular Biology Agarose	5 g
TAE Electrophoresis Buffer, 50x	100 ml

UView Electrophoresis Reagents

UView 6x Loading Dye and Stain	200 µl
Certified Molecular Biology Agarose	5 g
TAE Electrophoresis Buffer, 50x	100 ml
Instructor and Student Guides available online free for download	

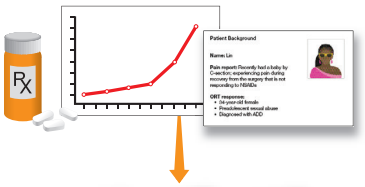
Required Accessories Not Included in Kit:

Adjustable micropipets and tips, pp. 152–154	
20–200 µl	1
1–20 µl	8
or fixed volume micropipets, 50 µl	8
Horizontal gel electrophoresis chambers, pp. 117–118	4–8
Power supply, p. 155	1–8
UV transilluminator (if using UView 6x Loading Dye and Stain), p. 146	1
Gel staining trays, p. 157	

Refresh Kit Components: (see pp. 157–159)
Gel Staining Trays, 4 (#1660477EDU)
UView 6x Loading Dye and Stain, p.122
DNA Electrophoresis Reagent Packs, p. 119

Activity 1: Learning about Factors in Opioid Dependence

Discuss opioid epidemic data

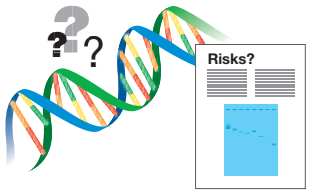


Evaluate patient data

Calculate risk of dependence

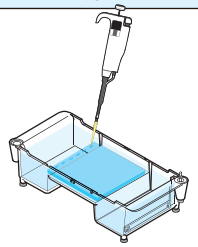
Activity 2: Designing a Human Genetic Research Study

Design a study of genetic links to dependence



Activity 3: Conducting the Research Study

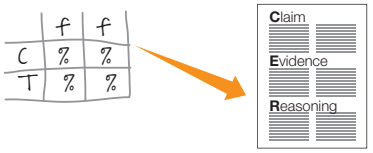
Load participant PCR DNA samples



Run DNA gel electrophoresis

Activity 4: Analyzing Data and Making a Claim

Calculate allele frequencies



Make claims from evidence

Activity 5: Establishing Data Confidence and Addressing the Crisis

Analyze p-values and published data

Reevaluate pain prescribing

Forensic DNA Fingerprinting Kit — AP Big Idea 3: Who Done It?

Using DNA as evidence, students figure out for themselves, "Who done it?" DNA evidence assists in criminal, missing person, mass disaster, and paternity cases. It can be used to identify a perpetrator or exonerate the innocent. Using real DNA as evidence, your students play the role of crime scene investigator.

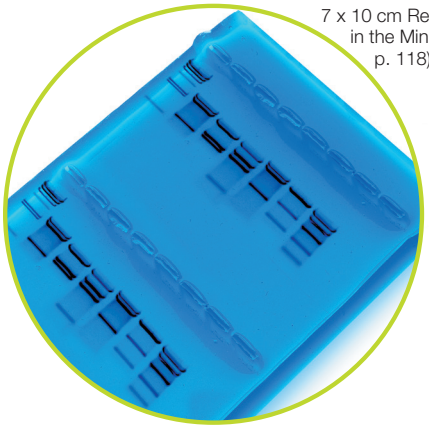
Restriction enzymes are essential tools for molecular cloning and the mapping of genes and genomes. They are also used in genetic engineering to create recombinant DNA molecules for transforming bacterial, plant, or animal cells. Restriction enzymes recognize specific double-stranded DNA sequences and they cut the DNA by making two incisions, one through each of the phosphate backbones of the double helix. The chemical bonds that the enzymes cleave are easily reformed by DNA ligases, so that restriction fragments carved from the DNA of different organisms can be spliced together, creating new hybrid organisms.

In this lab, students observe the effects of two DNA restriction enzymes on a series of plasmid DNA samples. The six DNA samples in this kit are plasmids engineered to mimic the natural variations in DNA that exist between one human being and another. One DNA sample has been collected from a "crime scene" and five samples have been obtained from various "suspects." Each sample is digested using a mixture of two DNA restriction enzymes, generating a distinct set of DNA fragments for each sample. The resulting DNA fragments are separated by agarose gel electrophoresis and visualized using Bio-Rad's revolutionary Fast Blast DNA stain.

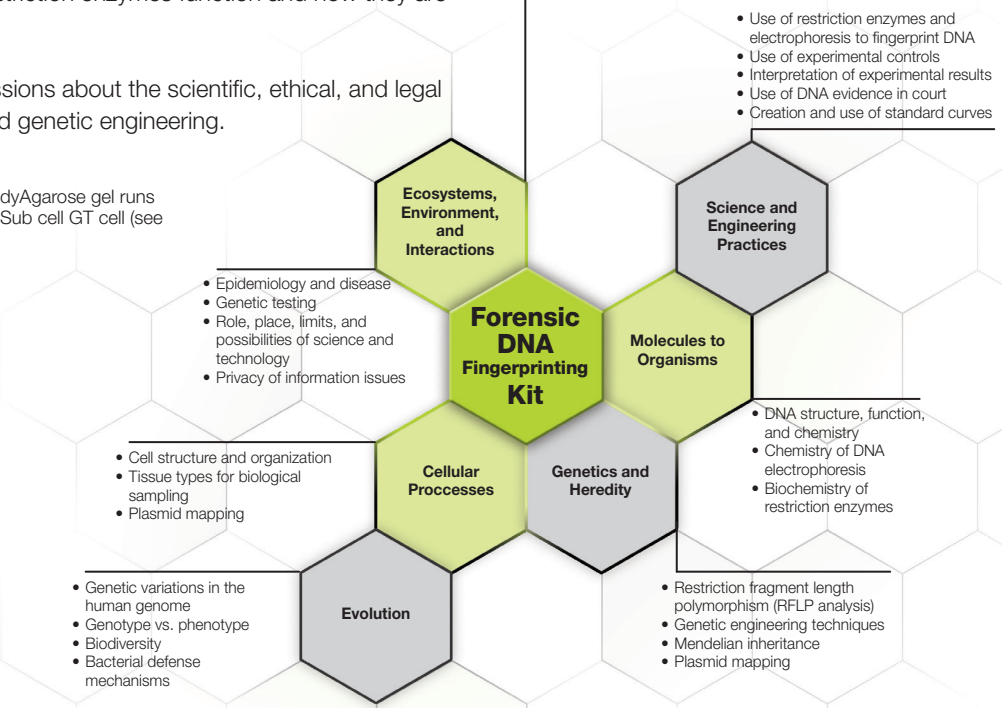
This activity provides in-depth explanations about how restriction enzymes cut DNA and how electrophoresis is used to separate and visualize DNA fragments. The unique curriculum provided in this kit guides students through the procedure of constructing a standard curve using their own gel data. They can then use their standard curve to estimate the molecular weights of the unknown DNA fragments generated by different restriction enzymes.

Electrophoretic techniques that distinguish DNA fragments by size are essential in forensics and in the mapping of restriction sites within genes. With the curriculum in this kit, students also have the opportunity to read plasmid maps and predict the sizes of DNA fragments from restriction enzyme digests prior to performing the lab. They can go one step further and use restriction digest maps of lambda bacteriophage genomes (provided in the kit curriculum) to design novel plasmids. In the process of doing these extension activities, students learn how restriction enzymes function and how they are used in genetic engineering.

Use this kit to open the door to rich discussions about the scientific, ethical, and legal implications of forensics, DNA profiling, and genetic engineering.



7 x 10 cm ReadyAgarose gel runs in the Mini-Sub cell GT cell (see p. 118)



Forensic DNA Fingerprinting Kit

Each kit supports 36 students.

Forensic DNA Fingerprinting Kit
Catalog # **1660007EDU**

We've gone green! The curriculum manual is no longer included in this kit. It is available to download free of charge online.

Convenient lyophilized reagents. Ships at room temperature. Store reagents bag at –20°C.

Forensic DNA Fingerprinting Kit with printed curriculum manual
Catalog # **1660037EDU**

Key Kit Features

- Aligns with AP Biology Big Idea 3; Investigation 9
- Study DNA and restriction enzyme functions
- Use electrophoresis to visualize DNA fragments
- Construct standard curves from student data
- Make precise determinations of DNA fragment sizes
- Complete in two 45 minute lab sessions

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.

Lab Preparation Checklist

Kit contains sufficient materials for 8 student workstations (2–4 students per workstation).

DNA Size Standard (HindIII lambda DNA digest), 100 µl	1
DNA Samples, lyophilized, 60 µg each	
Crime scene sample	1
Suspect samples	5
EcoRI/PstI Restriction Enzyme Mix, lyophilized, 3,000 units	1
Sample Loading Buffer, 5x, 1 ml	1
Electrophoresis Buffer, 50x TAE, 100 ml	1
Sterile Water, 2.5 ml	1
Agarose Powder, 5 g	1
Fast Blast DNA Stain, 500x, 100 ml	1
Colored Microcentrifuge Tubes, 2.0 ml	60
Microcentrifuge Tubes, 1.5 ml	30
Foam Floats	8
We've gone green! The curriculum is available to download free online or printed for a small fee when ordering with the kit (#1660037EDU).	

Required Accessories Not Included in Kit:

Horizontal Gel Electrophoresis chambers, pp. 117–118	4–8
Adjustable Micropipets, pp. 152–153	
2–20 µl	1–8
20–200 µl and 100–1,000 µl	1 each
Pipet Tips, p. 154	
2–1,000 µl, BR-35, 40	1 bag each
Power Supplies, p. 155	2–4
Gel Staining Trays, p. 157	4–8

Recommended (Optional) Accessories:

Water Bath or Dry Bath, p. 150
Mini Centrifuge, p. 148
Rocking Platform, p. 149
Gel Support Film, p. 119
Gel Documentation System, pp. 146–147
Microwave Oven

Refresh Kit Components: (more info pp. 157–159)
DNA Fingerprinting Kit Reagent Refill Pack (#1660027EDU) includes crime scene + suspect DNA samples, EcoRI/PstI restriction enzyme mix, sample loading buffer, DNA size standard, sterile water
EcoRI/PstI Restriction Enzyme Mix, lyophilized, 3,000 units (#1660047EDU)
Fast Blast DNA Stain (#1660420EDU)
UView 6x Loading Dye and Stain, p. 122
Gel Staining Trays, 4 (#1660477EDU)
Jellyfish Foam Floating Racks, 8 racks (#1660479EDU)
Curriculum Manual, printed (#1660077EDU)
DNA Electrophoresis Reagent Packs, p. 119

See Bulletin 5396
Visit **bio-rad.com/fastgel** for information on Bio-Rad's 10 minute Fast Gel Protocol.

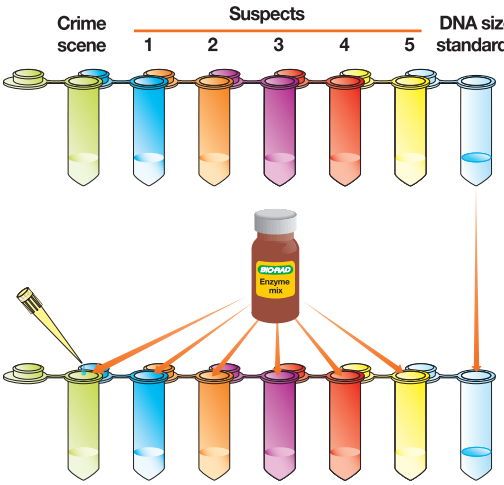
10 Minute Gels

This hands-on activity is integrated with the Lt Biology Collection, the online learning platform from ADInstruments.

ADINSTRUMENTS making science easier

Lab 1

Rehydrate DNA samples and restriction enzymes



Obtain samples of DNA from crime scene and 5 suspects, and include DNA size standards

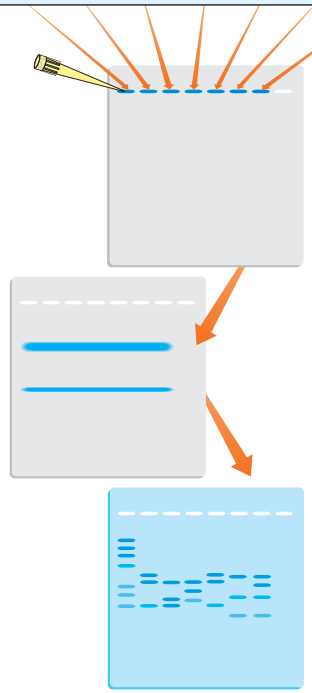
Digest DNA samples with EcoRI/PstI restriction enzyme mix

Incubate at 37°C for 45 min or at room temperature overnight

Lab 2

Add loading dye to all digested DNA samples

Load digested DNA samples and DNA size standards onto agarose gels



Electrophorese DNA samples at 100 V for 30 min

Monitor migration of loading dyes

Stain gels with Fast Blast DNA stain

Match crime scene DNA with suspects' DNA: Who done it?

Construct a standard curve using DNA size standard, then determine size of unknown fragments in DNA samples

Extension: Plasmid mapping using restriction enzymes

Extension: Look more closely at DNA structure with the DNA model, p. 118

Lambda DNA Kits — AP Big Idea 3: How's This for a Slice of Life?

Restriction enzymes are essential tools for genetic engineering, gene mapping, and genome sequencing. Restriction enzymes recognize specific double-stranded DNA sequences and they cut the DNA by making two incisions, one through each of the phosphate backbones of the double helix. The chemical bonds that restriction enzymes cleave are easily reformed such that DNA fragments carved from a virus, bacteria, plant, or animal can be inserted (subcloned) into vectors such as plasmid DNA or lambda DNA, creating recombinant DNA molecules that can be sequenced (or transformed back into bacterial, animal, and plant cells) creating hybrid organisms with new genetic traits to study.

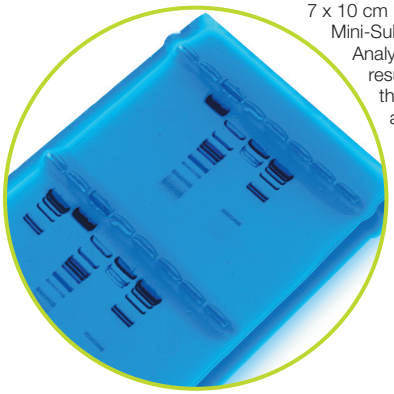
The restriction digestion and analysis of lambda DNA kit uses three different restriction enzymes to digest genomic samples of the lambda bacteriophage. The lambda genome has approximately 48,000 base pairs. Each restriction enzyme will cut the lambda DNA several times, generating distinct sets of DNA restriction fragments of different sizes. The three different sets of DNA fragments that result are separated by agarose gel electrophoresis and visualized using Bio-Rad's safe Fast Blast DNA stain.

The analysis of precut lambda DNA kit demonstrates the principles, results, and analysis of restriction digestion without the extra time needed to perform the digestion.

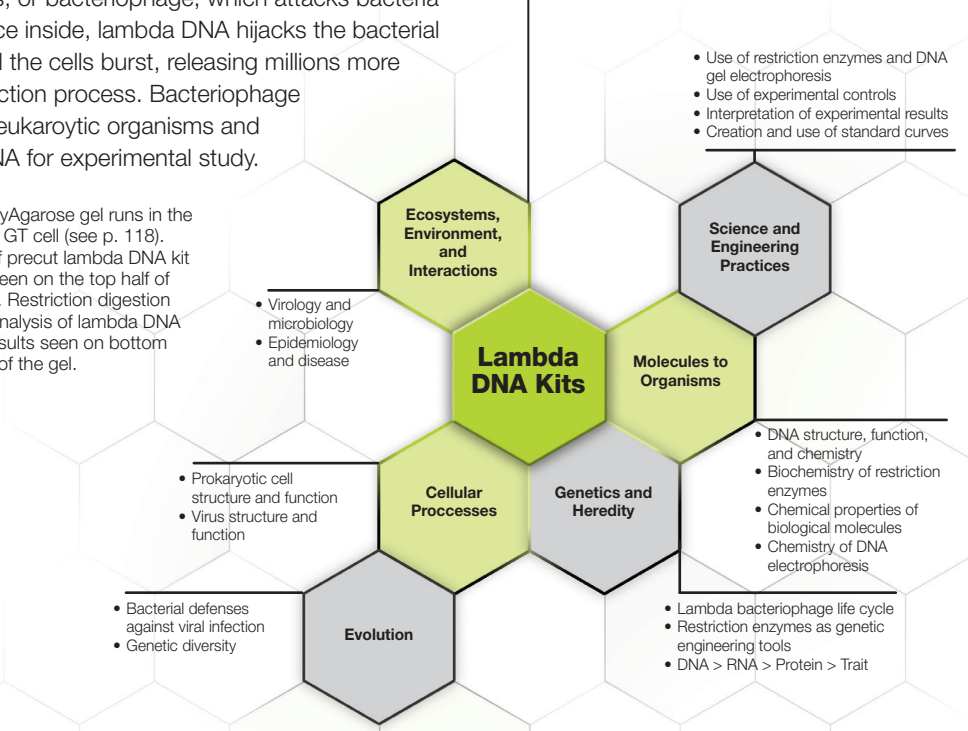
Electrophoretic techniques that distinguish DNA fragments by size are essential in forensics and in the mapping of restriction sites within genes. The restriction digestion and analysis of lambda DNA kit and the analysis of precut lambda DNA kit each provide in-depth explanations about how restriction enzymes cut DNA and how electrophoresis can be used to separate and visualize DNA fragments.

Banding patterns from each sample are then compared to each other and to a DNA size standard. From their electrophoresis results, students construct standard curves and determine the precise DNA fragment sizes generated by the different restriction enzymes. By visualizing the effects of different enzymes on identical samples of double-stranded DNA, students learn that different restriction enzymes recognize and cut different DNA sequences.

Lambda bacteriophage has been a workhorse of molecular biology for decades. It is vital in the fields of molecular cloning and genomic sequencing since it can be used to subclone very long genomic DNA fragments much more efficiently than plasmid vectors. Lambda DNA comes from a bacterial virus, or bacteriophage, which attacks bacteria by injecting them with its nucleic acid. Once inside, lambda DNA hijacks the bacterial cellular machinery and replicates itself until the cells burst, releasing millions more bacteriophages to carry out the same infection process. Bacteriophage lambda is harmless to humans and other eukaroytic organisms and therefore makes an excellent source of DNA for experimental study.



7 x 10 cm ReadyAgarose gel runs in the Mini-Sub cell GT cell (see p. 118). Analysis of precut lambda DNA kit results seen on the top half of the gel. Restriction digestion and analysis of lambda DNA kit results seen on bottom half of the gel.



Lambda DNA Kits

Each kit supports 36 students.

Analysis of Precut Lambda DNA Kit
Catalog # **1660001EDU**
Ships at room temperature; store at 4°C.

Restriction Digestion and Analysis of Lambda DNA Kit
Catalog # **1660002EDU**
Restriction enzymes ship on dry ice; store in freezer (–20°C).

Key Kit Features

- Aligns with AP Biology Big Idea 3; Investigation 9
- Study DNA restriction enzyme function
- Use electrophoresis to separate DNA fragments
- Construct standard curves from student data
- Make precise determinations of DNA fragment sizes
- Complete in one to two 45 minute lab sessions

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.

Lab Preparation Checklist

Kit contains sufficient materials for 8 student workstations (2–4 students per workstation).

Analysis of Precut Lambda DNA kit contains:	
PstI Lambda DNA Digest	1
EcoRI Lambda DNA Digest	1
Restriction Digestion and Analysis of Lambda DNA kit contains:	
HindIII Restriction Enzyme	1
PstI Restriction Enzyme	1
EcoRI Restriction Enzyme	1
Restriction Buffer	1
Foam Floats	8
Both lambda DNA kits contain:	
Lambda DNA, uncut	1
DNA Size Standard (HindIII lambda DNA digest)	1
Sample Loading Buffer, 5x, 1 ml	1
Agarose Powder, 5 g	1
Electrophoresis Buffer, 50x TAE, 100 ml	1
Fast Blast DNA Stain, 500x, 100 ml	1
Colored Microcentrifuge Tubes, 2.0 ml	60
Curriculum, including teacher's guide, student manual, and graphic quick guide	1

Required Accessories Not Included in Kit:

Horizontal Gel Electrophoresis Chambers, pp. 117–118	4–8
Adjustable Micropipets, pp. 152–153	
2–20 µl	4–8
20–200 µl	1
Pipet Tips, p. 154	1 bag
2–200 µl, BR-35	
Power Supplies, p. 155	2–4
Gel Staining Trays, p. 157	4–8

Recommended (Optional) Accessories:

Water Bath or Dry Bath (for Restriction Digestion and Analysis of Lambda DNA kit), p. 150
Rocking Platform, p. 149
Gel Support Film, p. 119
Gel Documentation System, pp. 146–147
Microwave Oven

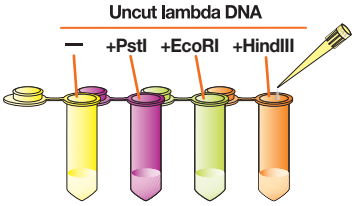
Refresh Kit Components: (more info pp. 157–159)
Restriction Digestion Kit TS Reagent Refill Pack (#1660012EDU), includes HindIII, PstI, and EcoRI restriction enzymes, restriction buffer, uncut lambda DNA, DNA size standard, sample loading buffer
Restriction Digestion Kit RT Reagent Refill Pack (#1660022EDU), includes agarose powder, electrophoresis buffer, Fast Blast DNA stain, microcentrifuge tubes, foam floats, curriculum
Precut Lambda DNA Kit Reagent Refill Pack (#1660011EDU), includes DNA size standard, PstI lambda DNA digest, EcoRI lambda DNA digest, uncut lambda DNA, sample loading buffer
Fast Blast DNA Stain (#1660420EDU)
UView 6x Loading Dye and Stain, p.122
Gel Staining Trays, 4 (#1660477EDU)
Jellyfish Foam Floating Racks, 8 racks (#1660479EDU)
DNA electrophoresis Reagent Packs, p. 119

See Bulletin 5396
Visit **bio-rad.com/fastgel** for information on Bio-Rad's 10 minute Fast Gel Protocol.

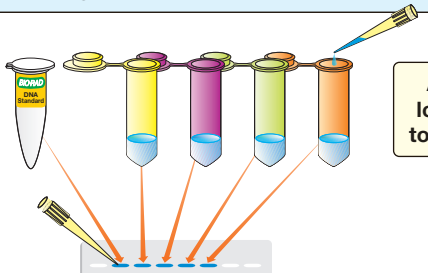
10 Minute Gels

Lab 1

Add lambda DNA, buffer, and restriction enzymes to micro test tube



Digest DNA at 37°C for 30 min or overnight at room temperature for the restriction digestion and analysis kit. DNA comes predigested for the precut lambda DNA kit



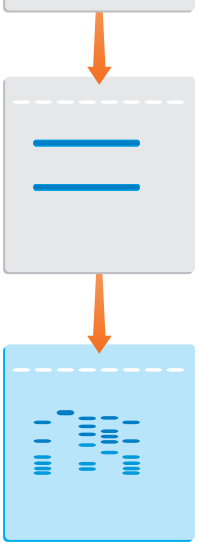
Add sample loading buffer to each sample

Load DNA size standard and digested samples onto agarose gel

Electrophorese DNA samples at 100 V for 30 min

Monitor migration of loading dyes

Stain gel with Fast Blast DNA stain



Construct a standard curve using DNA size standards

Determine sizes of DNA restriction fragments in samples

Verify restriction enzyme used in each case

Extension: Look more closely at DNA structure with the DNA model, p 118


ARTIC

Section Contents

PCR Amplification Kits

"I have used many Bio-Rad kits in my Biotechnology and AP Biology courses. Numerous students have reached out to me after graduation to thank me for teaching them lab skills. In college, they were able to get lab jobs because they knew how to use a micropipet and perform electrophoresis and PCR."

Staci Brown
Stillwater Area High School, Stillwater, MN

Bio-Rad Explorer Teacher and Student Alumni

Crime Scene Investigator PCR Basics Kit: How Does DNA Solve Crimes?

This introductory PCR kit allows students to simulate DNA profiling as commonly used in forensic labs. The lab is designed to introduce the concepts of PCR to students in two lesson periods without the need for complex genomic DNA extraction steps.

DNA profiling determines the exact genotype of a DNA sample and distinguishes one human being from another by identifying a DNA "barcode" that is unique to every individual. This powerful tool assists in investigations of crime scenes, missing persons, mass disasters, immigration disputes, and paternity testing.

What kinds of human DNA sequences are used in crime scene investigations? There are ~3 billion bases in the human genetic blueprint, and more than 99.5% of them do not vary among human beings. Within the variant areas of the genome are the special polymorphic ("many forms") sequences used in forensic applications. The DNA sequences used for forensic typing are derived from regions of our chromosomes that do not control any known traits and have no known functions. They contain segments of short tandem repeats, called STRs. STRs are very short DNA sequences that are repeated in direct head-to-tail fashion. The example below shows a locus (known as TH01) actually used in forensic DNA profiling. Its specific DNA sequence contains five repeats of [TCAT].

. . . C C C [T C A T] [T C A T] [T C A T] [T C A T] [T C A T] A A A . . .

For the TH01 STR locus, there are many alternate forms (alleles) that differ from each other by the number of [TCAT] repeats present in the sequence. More than 20 different alleles of TH01 have been discovered in people worldwide. Each of us still has only two alleles, one inherited from our mother and one inherited from our father.

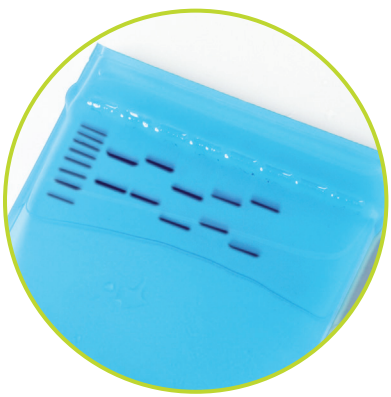
Two sample TH01 genotypes

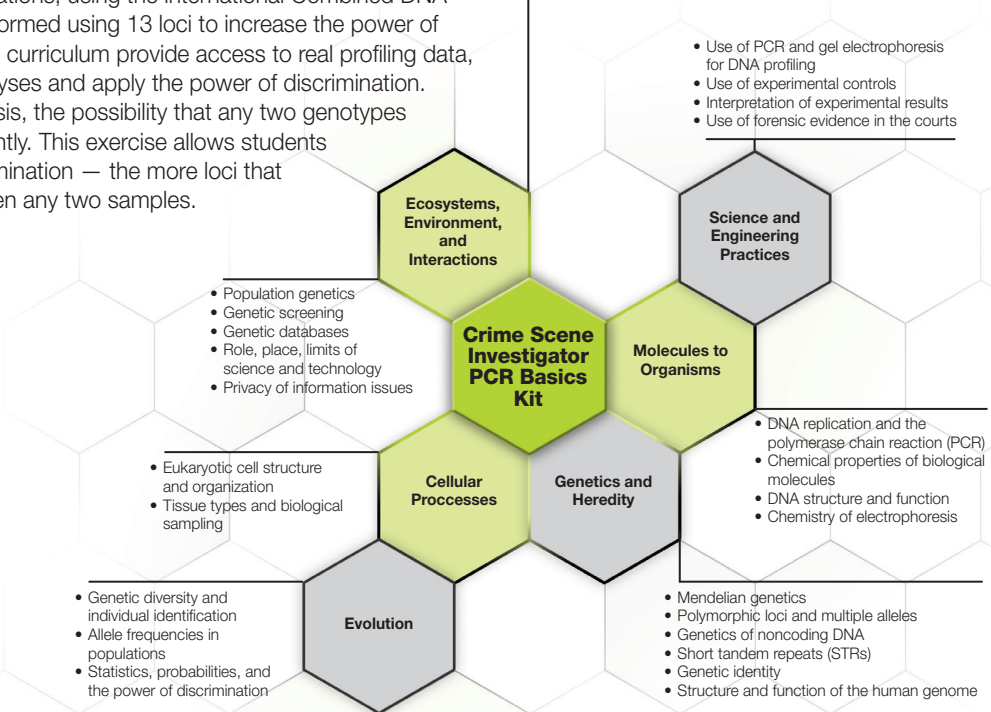
Suspect A's DNA type for the TH01 locus is (5–3)		Suspect B's DNA type for TH01 locus is (6–10)	
C C C [T C A T] [T C A T] [T C A T] [T C A T] [T C A T] A A A	5*	C C C [T C A T] [T C A T] [T C A T] [T C A T] [T C A T] [T C A T] A A A	6*
C C C [T C A T] [T C A T] [T C A T] A A A	3*	C C C [T C A T] [T C A T] [T C A T] [T C A T] [T C A T] [T C A T] [T C A T] [T C A T] [T C A T] [T C A T] A A A	10*

* Number of [TCAT] repeats

How are STR alleles detected? Each STR allele has a different length depending on the number of tandem repeats it contains. When the alleles are amplified by PCR, alleles of different lengths can be distinguished by electrophoresis. The number of tandem repeats contained in each allele can be determined by comparing the locations of the DNA bands with a DNA size standard that corresponds to the known sizes of TH01 alleles.

The DNA samples contained in this kit are plasmids that have been engineered to mimic the natural variations in human DNA that exist between one human being and another at a single STR locus. In real crime scene applications, using the international Combined DNA Index System (CODIS), DNA profiling is performed using 13 loci to increase the power of discrimination. Extension exercises in the kit curriculum provide access to real profiling data, enabling students to perform statistical analyses and apply the power of discrimination. With the addition of each locus to the analysis, the possibility that any two genotypes will match due to chance drops off significantly. This exercise allows students to grasp the concept of the power of discrimination — the more loci that are used, the finer the discrimination between any two samples.





Crime Scene Investigator PCR Basics Kit

Each kit supports 32 students.

Crime Scene Investigator PCR Basics Kit
Catalog # **1662600EDU**

Ships at room temperature. Store reagents bag at –20°C. Electrophoresis reagents not included — available separately.

Small Fast Blast DNA Electrophoresis Reagent Pack
Catalog # **1660450EDU**

To pour, run, and stain forty-eight 1% or sixteen 3% 7 x 10 cm agarose gels

Crime Scene Investigator PCR Basics Kit Plus Small Fast Blast DNA Electrophoresis Reagent Pack
Catalog # **1662650EDU**

To pour, run, and stain forty-eight 1% or sixteen 3% 7 x 10 cm agarose gels

Key Kit Features

- Perform real-world DNA profiling
- Use PCR to amplify multiple DNA samples
- Use electrophoresis to visualize results
- Complete in two 45 minute lab sessions

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.

Lab Preparation Checklist

Kit (1662600EDU) contains sufficient materials for 8 student workstations (2–4 students per workstation).

Crime Scene DNA Sample, 250 µl	1
Suspect A DNA Sample, 250 µl	1
Suspect B DNA Sample, 250 µl	1
Suspect C DNA Sample, 250 µl	1
Suspect D DNA Sample, 250 µl	1
PCR Master Mix (Taq DNA polymerase, dNTPs, buffer), 1.2 ml	1
Primers (blue), 25 µl	1
Allele Ladder, 200 µl	1
Orange G Loading Dye, 1 ml	1
PCR Tubes, 0.2 ml	50
Capless PCR Tube Adaptors, 1.5 ml	50
Colored Microcentrifuge Tubes, 2.0 ml	60
Curriculum, including teacher's guide, student manual, and graphic quick guide	1

Required Accessories Not Included in Kit:

DNA Electrophoresis Reagent Pack, p. 119	1
Horizontal Gel Electrophoresis Chambers, pp. 117–118	4–8
Adjustable Micropipets, pp. 152–153	
2–20 µl	1–8
20–200 µl	1
Pipet Tips, aerosol barrier, p. 154	
2–20 µl, Xcluda B	1 box
20–200 µl, Xcluda D	1 box
Microcentrifuges, p. 148	1–4
Thermal cycler, p. 123	1
Power Supplies, p. 155	2–4
Gel Staining Trays, p. 157	4–8

Recommended (Optional) Accessories:

Adjustable Micropipets, pp. 152–153	
100–1,000 µl	1
Pipet Tips, aerosol barrier, p. 154	
100–1,000 µl, Xcluda E	1 box
Rocking Platform, p. 149	
Gel Documentation System, pp. 146–147	
Microwave Oven	

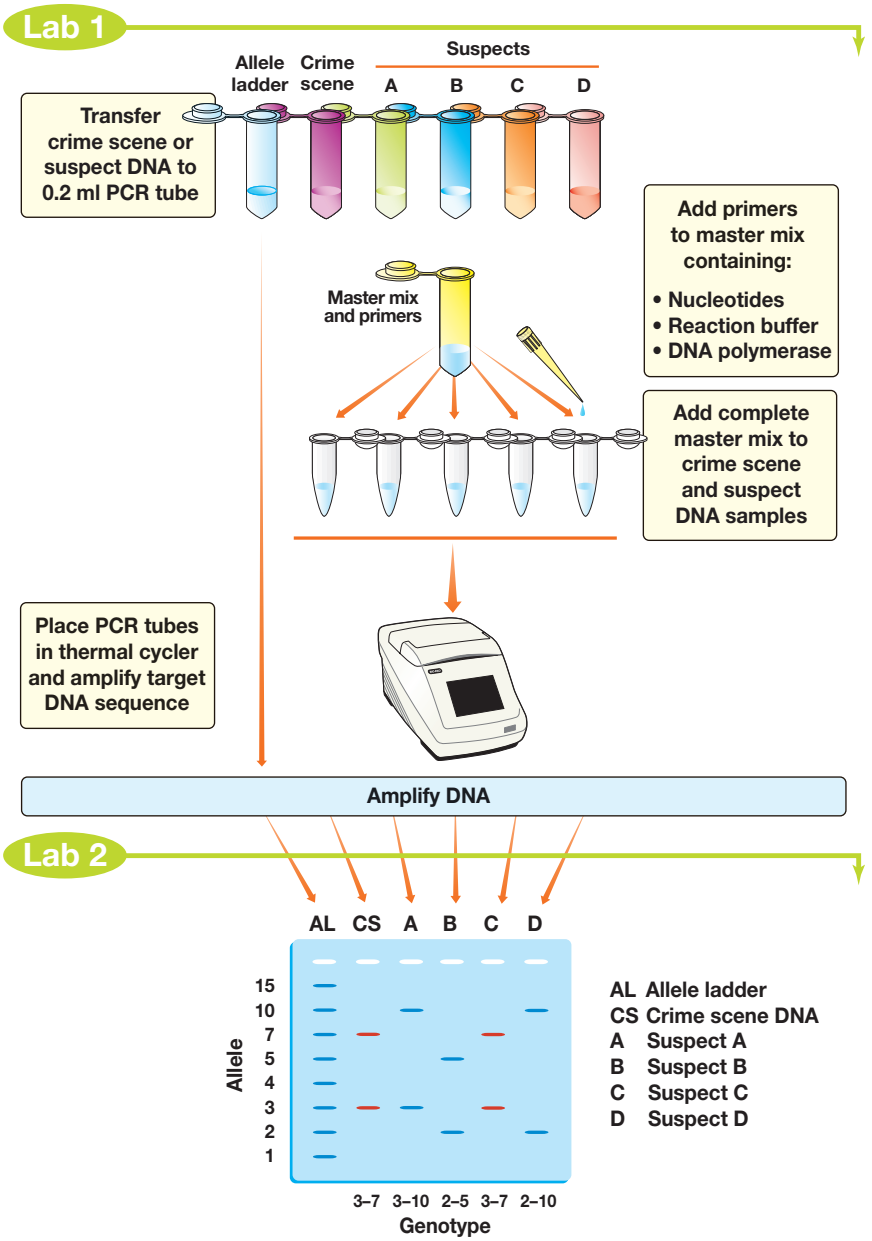
Refresh Kit Components: (more info pp. 157–159)
Crime Scene Investigator PCR Basics Kit Reagent Refill Pack (#1662601EDU) includes PCR master mix, primers, allele ladder, orange G loading dye, crime scene and suspect DNA samples
96-Place PCR tube Rack and Cover, 5 (#TRC0501EDU)
Gel Staining Trays, 4 (#1660477EDU)
2x Master Mix for PCR, p. 129
DNA Electrophoresis Reagent Packs, p. 119
UView 6x Loading Dye and Stain, p. 122

See Bulletin 5396
Visit **bio-rad.com/fastgel** for information on Bio-Rad's 10 minute Fast Gel Protocol.

10 Minute Gels

Crime Scene Investigator PCR Basics Brand Name Genes Curriculum
Download the topical case study senario from Morehead Planetarium and Science Center Mobile Science Labs Program. Visit **bio-rad.com/CrimeSceneKit** to download the complete PDF.

Web
Check This Out!



Electrophorese PCR Samples in agarose gels at 100 V for 30 min. Stain with Fast Blast DNA stain

Determine genotypes of samples from suspects and crime scene. Use the "power of discrimination" to verify the likelihood of a genotype match due to chance

Extension: Use Web-based interactive animated tutorial

Extension: Download our application notes for converting these kits into real-time PCR applications (see also pp. 80–81). **Available free on the Web: explorer.bio-rad-com**

Extension: Look more closely at DNA structure with the DNA model, p 118

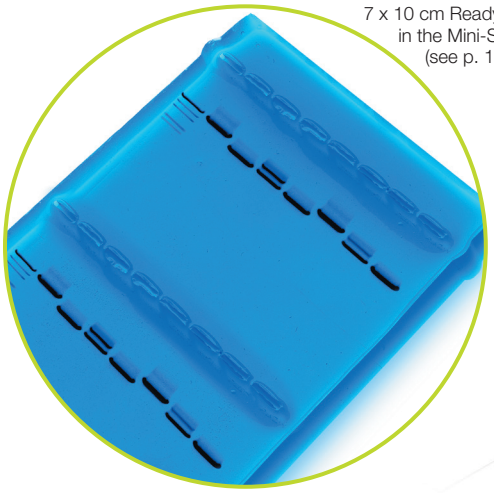
PV92 PCR Informatics Kit: Where Did You Get Those Genes?

Finally, a wet lab to teach the Hardy-Weinberg equation! The polymerase chain reaction (PCR) is widely used in forensics, diagnostics, and archeological procedures. In this activity, your students use real-world forensic techniques to extract DNA from their hair follicles or cheek cells, and then use PCR amplification and electrophoresis to fingerprint their own DNA at a specific genetic locus. Using their own results, students test Hardy-Weinberg equilibrium theory within their classroom population, then go online to compare classroom results to genetic data of populations worldwide.

The polymerase chain reaction (PCR) is a molecular biology technique that enzymatically replicates DNA, allowing a small amount of the DNA molecule to be amplified many times in an exponential manner. PCR is commonly used in detecting hereditary diseases, creating DNA fingerprints, diagnosing infectious diseases, cloning genes, testing paternity, and computing DNA. It has been said that the process of PCR is like finding a needle in a haystack and then making a haystack out of a needle.

The critical first step in preparation for PCR-based DNA profiling is extracting intact genomic DNA. Our hair follicle and cheek cell DNA extraction procedures produce greater amplification efficiencies than any other kit available. Your students will get great results. We guarantee it.

This activity will open the door to discussions about technical and ethical aspects of DNA profiling and genetic screening. Students hunt for a specific Alu repeat (a 300 base pair repetitive sequence of DNA) on chromosome 16. Over evolutionary time, up to 1 million copies of the Alu repeat have become randomly inserted throughout the human genome. Within a specific region on chromosome 16 called PV92, some of us carry an Alu insertion and some of us do not. Such variations among individuals' genotypes are inherited — and are the raw material of genetic diversity and evolution. These subtle variations in our DNA are evidence of our ancestry and form the basis of personal identification via DNA fingerprinting.



7 x 10 cm ReadyAgarose gel runs in the Mini-Sub cell GT cell (see p. 118)

PV92 PCR Informatics Kit

Each kit supports 32 students.

PV92 PCR Informatics Kit
Catalog # **1662100EDU**

Ships at room temperature. Immediately store temperature-sensitive reagents at –20°C or 4°C as indicated.

Protease Solution
Catalog # **1662003EDU**

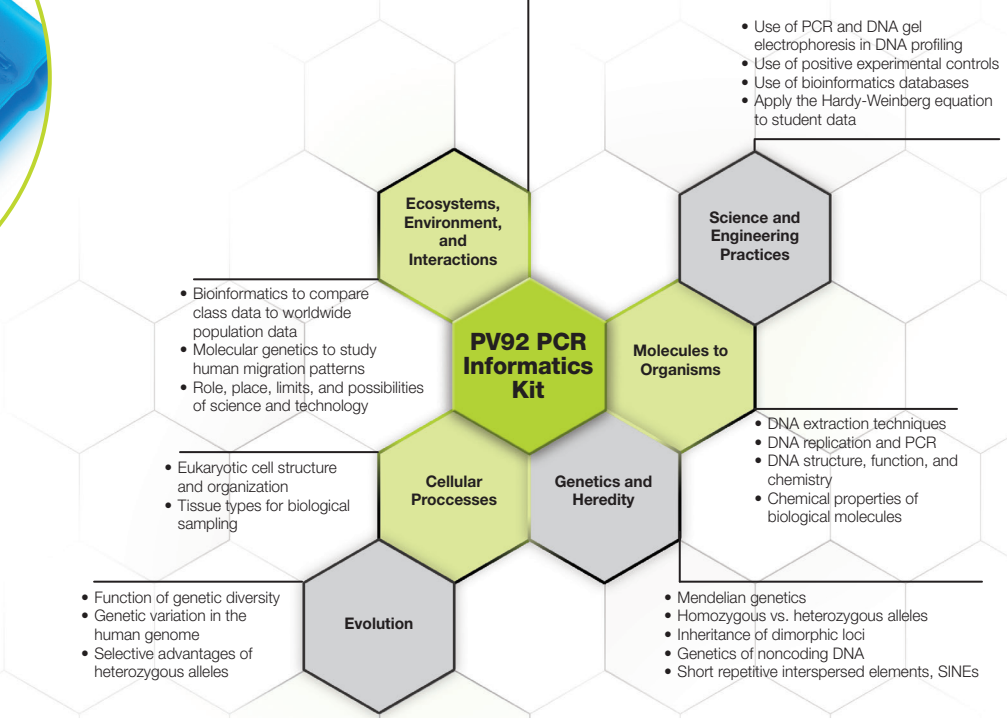
Required for DNA extraction from hair follicles.

Key Kit Features

- Aligns with AP Biology Big Idea 1; Lab 2
- Extract genomic DNA from students' cheek cells or hair follicles
- Amplify student and positive control DNA
- Analyze student allelic frequencies
- Compare classroom genetic composition with other populations around the world
- Complete in three 45 minute lab sessions

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.

This hands-on activity is integrated with the Lt Biology Collection, the online learning platform from ADInstruments.



Lab Preparation Checklist

Kit contains sufficient materials for 8 student workstations (2–4 students per workstation).

Positive Controls: homozygous (+/+), homozygous (–/–), heterozygous (+/–), 100 µl each	1 each
PCR Master Mix (Taq DNA polymerase, dNTPs, buffer), 1.2 ml	1
PCR Primers, 25 µl	1
DNA Molecular Mass Ruler, 100 µl	1
InstaGene DNA Extraction Matrix, 20 ml	1
Orange G Loading Dye, 1 ml	1
Microcentrifuge Tubes, 1.5 ml	60
PCR Tubes, 0.2 ml	50
Screwcap Microcentrifuge Tubes, 1.5 ml	50
Capless PCR Tube Adaptors, 1.5 ml	50
Agarose Powder, 5 g	1
Electrophoresis Buffer, 50x TAE, 100 ml	1
Fast Blast DNA stain, 500x, 100 ml	1
Curriculum including teacher's guide, student manual, and graphic quick guide	1

Required Accessories Not Included in Kit:

Protease Solution (for extraction from hair follicles)	1
Horizontal Gel Electrophoresis chambers, pp. 117–118	4–8
Adjustable Micropipets, pp. 152–153	
2–20 µl	1–8
20–200 µl and 100–1,000 µl	1 each
Pipet Tips, aerosol barrier, p. 154	
2–1,000 µl, Xcluda B, D, and E	
Power Supplies, p. 155	2–4
Thermal Cycler, p. 123	1
Microcentrifuges, p. 148	1–4
Gel Staining Trays, p. 157	4–8
Foam Floating Racks, p.157	8

Recommended (Optional) Accessories:

Water bath or Dry bath, p. 150
Rocking Platform, p. 149
Gel Support Film, p. 119
Vortexer, p. 149
Gel Documentation System, pp. 146–147
Microwave Oven

Refresh Kit Components: (more info pp. 157–159)
PV92 PCR Kit TS Reagent Refill Pack (#1662119EDU) includes PCR primers, positive controls, DNA molecular mass ruler, PCR master mix containing dNTPs, buffer, DNA polymerase, orange G loading dye
PV92 PCR Kit RT Reagent Refill Pack (#1662139EDU) includes InstaGene matrix, Fast Blast DNA stain, agarose, 50x TAE
Gel Staining Trays, 4 (#1660477EDU)
Jellyfish Foam Floating Racks, 8 racks (#1660479EDU)
2x Master Mix for PCR, p. 129
DNA Electrophoresis Reagent Packs, p. 119
InstaGene Matrix, p. 128
UView 6x Loading Dye and Stain, p. 122

See Bulletin 5396
Visit **bio-rad.com/fastgel** for information on Bio-Rad's 10 minute Fast Gel Protocol.

10 Minute Gels

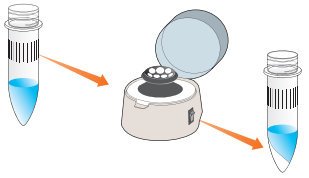
Bioinformatics link
Following electrophoresis of PCR products, students can enter class results into the Allele Server of Cold Spring Harbor Laboratory's Dolan DNA Learning Center. Test Hardy-Weinberg equilibrium theory within your classroom populations, then compare your classroom to the genetic composition of populations around the world.

Lab 1

Incubate at 56°C for 10 min, then agitate vigorously

Incubate at 100°C for 6 min, then repeat vigorous agitation

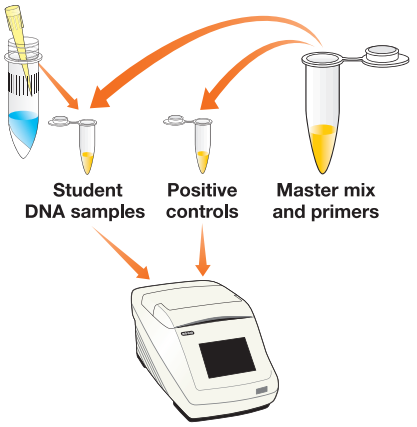
Centrifuge samples for 5 min to pellet matrix



DNA template preparation

Lab 2

Transfer supernatant with genomic DNA to 0.2 ml PCR tube



Add primers to master mix containing:
- Nucleotides
- Reaction buffer
- DNA polymerase

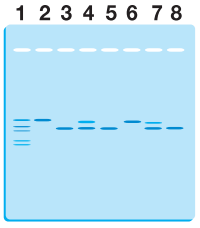
Place tubes in thermal cycler and amplify target DNA sequence

Add complete master mix to student DNA samples and positive controls

DNA amplification

Lab 3

The positive controls supplied in the kit represent the three possible student outcomes



Lanes:
1 DNA molecular mass ruler
2 Homozygous control (+/+)
3 Homozygous control (–/–)
4 Heterozygous control (+/–)
5 Student sample (–/–)
6 Student sample (+/+)
7 Student sample (+/–)
8 Student sample (–/–)

Electrophoresis PCR samples in agarose gels at 100 V for 30 min. Stain with Fast Blast DNA stain

Determine student genotypes for Alu insertion and perform Hardy-Weinberg analysis on class results

Extension: Web-based bioinformatics activity provided in the kit curriculum

GMO Investigator Kit: Have Your Favorite Foods Been Genetically Modified?

Genetically modified (GM) foods do not require labeling as such in the U.S., and foods with less than 5% content from genetically modified organisms (GMOs) can be labeled "GMO free." In much of Europe and Asia, GM foods require labeling even if they contain <1% GM content. This kit is designed to allow students to test their favorite foods for the presence of GM content.

Students engage in a complete investigation in which they gather sample food items from the grocery store, extract DNA from the samples, amplify the DNA using PCR, and use gel electrophoresis to identify the presence or absence of amplified GMO sequences.

The GMO Investigator kit uses PCR and DNA electrophoresis to test for the presence of two different GMO-associated DNA sequences: the 35S promoter of the cauliflower mosaic virus, and the terminator of the nopaline synthase gene of Agrobacterium tumefaciens. These DNA sequences are present in most (>85%) of the GM crops that are approved for distribution worldwide. In addition, the integrity of the plant DNA extracted from food is tested by using PCR to amplify a section of the photosystem II chloroplast gene that is common to most higher plants.

The kit allows a guided inquiry approach to this exercise. Students conduct sophisticated scientific procedures employing multiple levels of controls that allow them to assess the validity of their results. They determine the presence or absence of GMO sequences in their test food and answer the questions: did we successfully extract DNA; did our PCR work as expected, and do we have contamination?

Are GM crops a good thing? Many people who object to the use of GM crops argue that there is a potential for "superweeds" to arise through cross-pollination with herbicide-resistant crops. They also argue that "superbugs" will not be sensitive to the toxins in pest-resistant crops. Many are concerned about potential allergic reactions to novel proteins, antibiotic resistance arising from the selectable markers used to develop the crops, or other unforeseen effects on public health. Some voice concerns that we have not done enough research to fully understand the implications of altering the planet's plant diversity.

Proponents of GM crops and foods argue that these crops are beneficial for the environment because they reduce the use of herbicides and pesticides that are toxic to the environment and human health. In addition, GM crops may preserve arable land by reducing stresses on the land, improve the nutritional value of food for developing countries, and allow crops to be grown on previously nonarable land.

Regardless of where your students stand on the GM debate, won't they be interested to know how much of the corn- or soy-based foods they eat have been genetically modified?

GMO Investigator Kit

Each kit supports 32 students.

GMO Investigator Kit
Catalog # **1662500EDU**

Ships at room temperature. Immediately store reagents at –20°C or 4°C as indicated. Electrophoresis reagents not included — available separately.

Small Fast Blast DNA Electrophoresis Reagent Pack
Catalog # **1660450EDU**

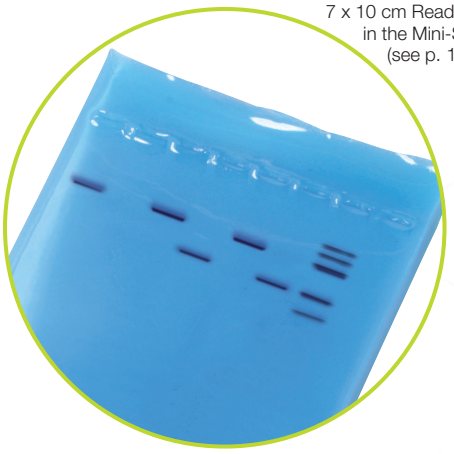
To pour, run, and stain forty-eight 1% or sixteen 3% 7 x 10 cm agarose gels

GMO Investigator Kit Plus Small Fast Blast DNA Electrophoresis Reagent Pack
Catalog # **1662550EDU**

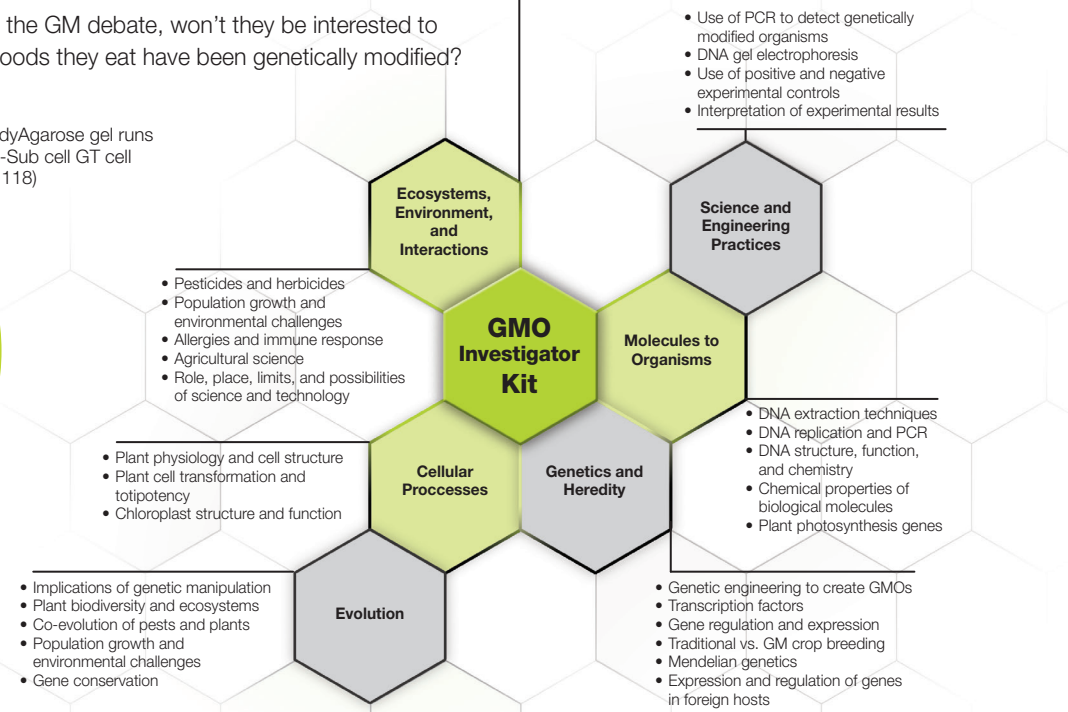
Key Kit Features

- Extract and amplify DNA from eight food samples
- Perform genuine diagnostic procedures
- Use PCR and electrophoresis
- Complete in three 45 minute lab sessions

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.



7 x 10 cm ReadyAgarose gel runs in the Mini-Sub cell GT cell (see p. 118)



Lab Preparation Checklist

Kit (1662500EDU) contains sufficient materials for 8 student workstations (2–4 students per workstation).

Bio-Rad Certified Non-GMO Food Control	1
InstaGene Matrix, 20 ml	1
GMO Positive Control DNA, 500 µl	1
PCR Master Mix (Taq DNA polymerase, dNTPs, buffers), 1.2 ml	1
GMO Primers (red), 15 µl	1
Plant PSII Primers (green), 15 µl	1
PCR Molecular Weight Ruler, 200 µl	1
Orange G Loading Dye, 1 ml	1
Disposable Plastic Transfer Pipets	20
Microcentrifuge Tubes, 1.5 ml	60
Screwcap Microcentrifuge Tubes, 1.5 ml	50
PCR Tubes, 0.2 ml	50
Capless PCR Tube Adaptors, 1.5 ml	50
Curriculum, including teacher's guide, student manual, and graphic quick guide	1

Required Accessories Not Included in Kit:

DNA Electrophoresis Reagent Pack, p. 119	1
Obtain food samples locally	
Horizontal Gel Electrophoresis Chambers, pp. 117–118	4–8
Adjustable Micropipets, pp. 152–153	
2–20 µl	1–8
20–200 µl	1
Pipet Tips, aerosol barrier, p. 154	
2–20 µl, Xcluda B	1 box
20–200 µl, Xcluda D	1 box
Water bath or Dry bath, p. 150	1
Microcentrifuges, p. 148	1–4
Thermal Cycler, p. 123	1
Power Supplies, p. 155	2–4
Mortars and Pestles	1–8
Balance with range 0.5–2 g	1
Weigh boats or Paper	16
Gel Staining Trays, p. 157	4–8
Foam Floating Racks, p.157	8

Recommended (Optional) Accessories:

Rocking Platform, p. 149
Gel Documentation System, pp. 146–147
Microwave Oven

Refresh Kit Components: (more info pp. 157–159)

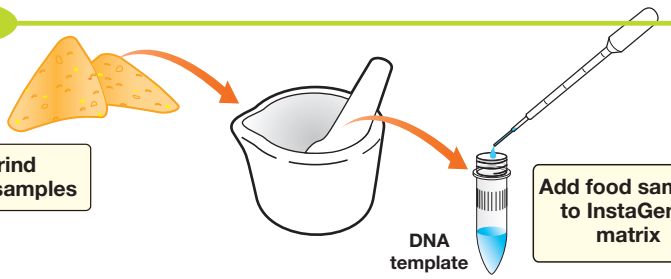
GMO Investigator Kit Reagent Refill Pack (#1662501EDU) includes PCR master mix, GMO primers, plant PSII primers, GMO positive control DNA, non-GMO food control, PCR molecular weight ruler, orange G loading dye
Disposable Plastic Transfer Pipets, sterile, 500 (#1660474EDU)
Jellyfish Foam Floating Racks, 8 racks (#1660479EDU)
Gel Staining Trays, 4 (#1660477EDU)
InstaGene Matrix, p. 128
2x Master Mix for PCR, p. 129
DNA Electrophoresis Reagent Packs, p. 119
UView 6x Loading Dye and Stain, p. 122

DNA Model, p. 118 (#1667015EDU)

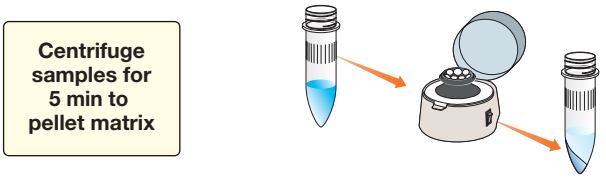
See Bulletin 5396
Visit **bio-rad.com/fastgel** for information on Bio-Rad's 10 minute Fast Gel Protocol.

10 Minute Gels

Lab 1

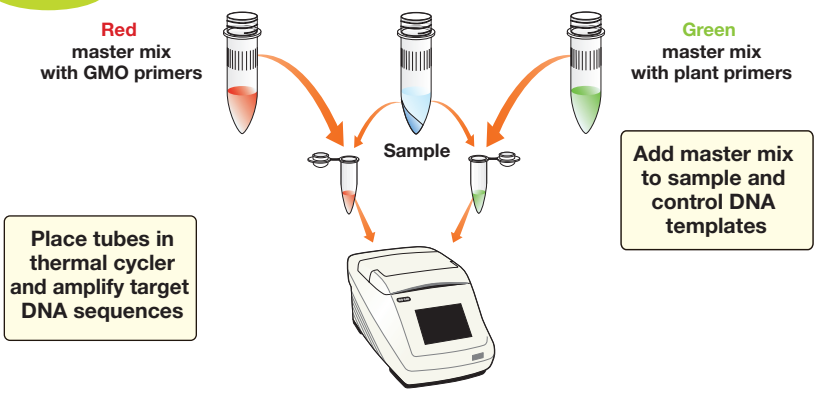


Incubate at 100°C for 5 min



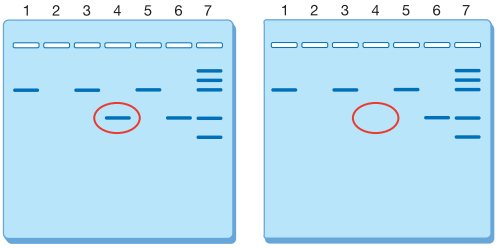
DNA template preparation

Lab 2



Set up polymerase chain reaction and amplify DNA samples

Lab 3



GMO-positive result GMO-negative result

PCR sample lanes:
1 Non-GMO food with plant primers
2 Non-GMO food with GMO primers
3 Test food with plant primers
4 Test food with GMO primers
5 GMO-positive control DNA with plant primers
6 GMO-positive control DNA with GMO primers
7 PCR molecular weight ruler

Electrophorese PCR products and stain gels

Dry gels and analyze results

Guided debate on GM foods

Extension: Download our application notes for converting these kits into real-time PCR applications (see also pp. 80–81). **Available free on the Web: explorer.bio-rad-com**

Extension: Look more closely at DNA structure with the DNA model, p 118

Real-Time PCR Kits: For Crime Scene Investigator PCR Basics and GMO Investigator Kits

Real-time PCR is the diagnostic technique of the present and future. PCR is now such a fundamental technique in the biotechnology lab that it has been said "PCR is to biology what petroleum is to transportation."* It forms a basis for multiple ways to analyze and detect nucleic acids ranging from DNA fingerprinting to DNA sequencing to mutagenesis. Real-time PCR is becoming the most widely used application of PCR in the research lab for genomic and gene expression analysis and is rapidly establishing itself as a technique in the clinical diagnostic lab. Real-time PCR is an extremely valuable analytical tool that not only reveals what DNA is present, but how much. The need for faster, more accurate, and more economical systems with a high throughput has fueled the popularity of real-time PCR.

How much DNA is there? Using genomic DNA as the template for amplification, real-time PCR can be used in infectious disease diagnostics to rapidly determine levels of specific pathogens in various tissues. The molecular diagnostic lab also relies heavily on real-time PCR for detection of aneuploidies and the diagnosis of other genetic diseases. In microbiology labs, real-time PCR can be used to detect and quantitate various microbial contaminants in environmental samples.

The Bio-Rad Crime Scene Investigator PCR Basics kit is a tool for teaching students the principles of PCR and its use in forensic DNA analysis. Using the Crime Scene Investigator PCR Basics kit to teach real-time PCR is a good starting point for novices to become familiar with real-time PCR techniques. Additionally, DNA fingerprints can still be investigated using gel electrophoresis and melt curve analysis, showing how real-time and conventional PCR can be complementary techniques.

The Bio-Rad GMO Investigator kit is a tool for teaching students the principles of PCR and its use in testing foods for genetic modifications. Using real-time PCR with the GMO Investigator kit can show how much plant DNA recovered from and compare how much genetically modified organism (GMO) DNA is in each food sample. It is even possible to determine what fraction of a food product has been made with genetically modified ingredients in the same manner standard testing labs do.

* Pray, L (2004). Consider the cycler. The Scientist. www.the-scientist.com/?articles.view/articleNo/15904/title/Consider-the-Cycler/. Accessed February 5, 2020.

Real-Time PCR Kits

Each kit supports 32 students.

Crime Scene Investigator PCR Basics Real-Time PCR Starter Kit
Catalog # **1662660EDU**

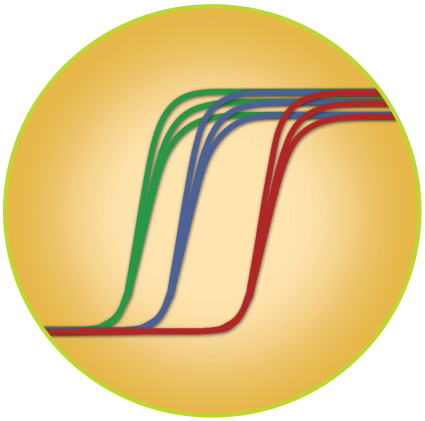
GMO Investigator Real-Time PCR Starter Kit
Catalog # **1662560EDU**

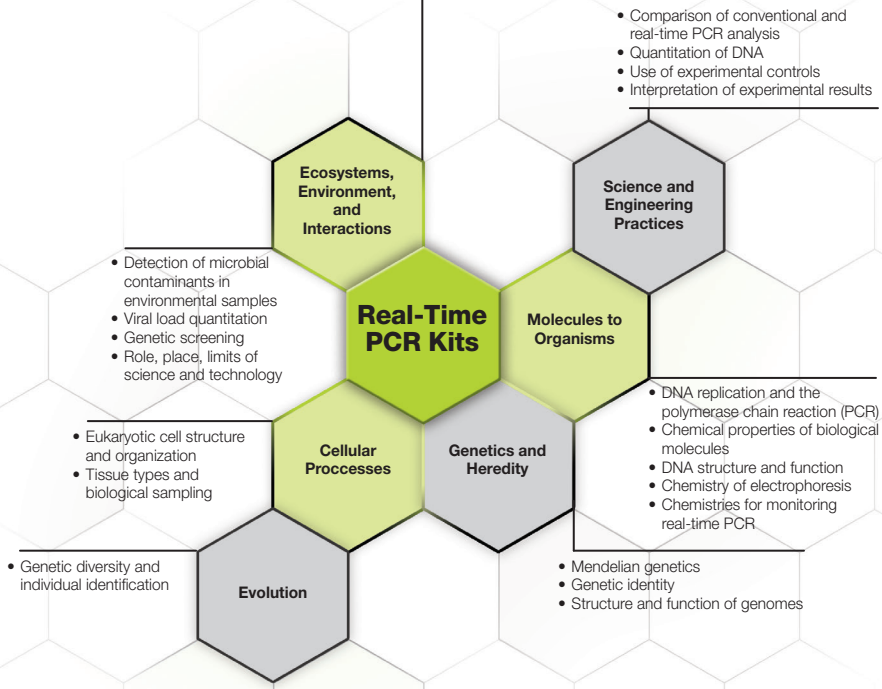
The above kits have components that ship at room temperature and at 4°C. Immediately store temperature-sensitive reagents at –20°C or 4°C as indicated.

Key Kit Features

- Quantitate DNA
- Discover key differences between conventional and real-time PCR analysis
- Analyze and evaluate real-time PCR results
- Perform melt curve analysis
- Determine the accuracy and reliability of pipetting techniques
- Learn the molecular basis of DNA amplification reactions using real-time PCR detection systems

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.





Lab Preparation Checklist

Kit contains sufficient materials for 8 student workstations (2–4 students per workstation), plus additional real-time reagents for further studies.

Crime Scene Investigator PCR Basics Kit or GMO Investigator Kit (based on which package chosen)	1
SsoAdvanced Universal SYBR® Green Supermix, 1 ml	2
Agarose powder, 25 g	1
Electrophoresis Buffer, 50x TAE, 100 ml	1
Fast Blast DNA Stain, 500x, 100 ml	1
Sterile Water, 500 ml	1
PCR Tube Strips	120
Optical Flat caps	120
Curriculum, including teacher's guide and student manual	1

Required Accessories Not Included in Kits:

Horizontal Gel Electrophoresis Chambers, pp. 117–118	4–8
Adjustable Micropipets, pp. 152–153	
2–20 µl	1–8
20–200 µl, 100–1,000 µl	1 each
Pipet Tips, aerosol barrier, p. 154	
2–1,000 µl, Xcluda B, D, and E	
Power Supplies, p. 155	2–4
Real-time Thermal Cycler, p. 123	1
Microcentrifuges, p. 148	1–4

Additional Required Accessories Not Included in GMO Investigator Real-Time PCR Starter Kit:

Obtain food samples locally	
Water bath or Dry bath, p. 150	1
Mortars and Pestles	1–8
Balance with range 0.5–2 g	1
Weigh boats or paper	16

Recommended (Optional) Accessories:

Rocking Platform, p. 149
Gel Documentation System, pp. 146–147
Microwave Oven

Refresh Kit Components: (more info pp. 157–159)

Crime Scene Investigator PCR Basics Kit Reagent Refill Pack (#1662601EDU), see p. 75
GMO Investigator Kit Reagent Refill Pack (#1662501EDU), see p. 79
Sterile Water, 500 ml (#1632091EDU)
96-Place PCR Tube Rack and Cover, 5 (#TRC0501EDU)
Gel Staining Trays, 4 (#1660477EDU)
InstaGene Matrix, p. 128
2x Master Mix for PCR, p. 129
DNA Electrophoresis Reagent Packs, p. 119
SsoAdvanced Universal SYBR® Green Supermix, p. 129
PCR Strip Tubes and Optical Flat Caps, p. 113

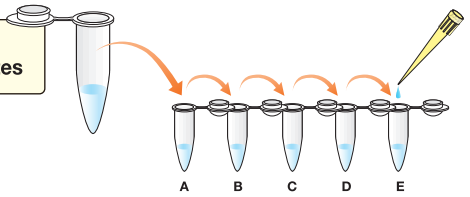
DNA Model, p. 118 (#1667015EDU)

Real-Time PCR Application Notes
Download our application notes for converting these kits into real-time PCR applications. Download free at **explorer.bio-rad.com.**

Web
Check This Out!

Lab 1

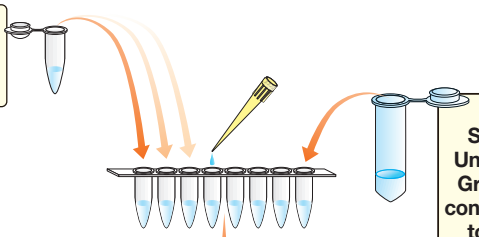
Obtain DNA templates



A No dilution
B 1/10
C 1/100
D 1/1,000
E 1/10,000

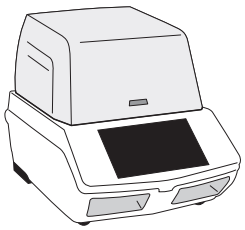
Optional: Perform dilution series of samples

Add DNA templates to all PCR tube strips



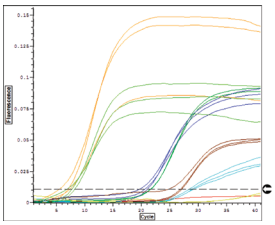
Add SsoAdvanced Universal SYBR® Green supermix containing primers to all samples

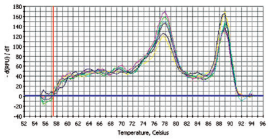
Place PCR tube strips with optical flat caps in real-time thermal cycler and amplify target DNA sequence



Set up PCR reactions and amplify using a real-time thermal cycler

Use dilution series to optimize real-time PCR conditions. Determine starting quantities using real-time PCR results





Perform melt-curve analysis to distinguish specific PCR products from nonspecific products such as primer dimers

Analyze the results

Extension: Electrophoresis of PCR products and gel staining

Compare and contrast data obtained from real-time PCR with data obtained from conventional PCR

Extension: Look more closely at DNA structure with the DNA model, p 118

Prepare your students for the real world of scientific research. Engage them with the opportunity to perform novel, relevant research that can actually contribute to scientific knowledge.

In this unique modular lab series, students are guided through an innovative research workflow identical to those performed in genomics labs worldwide. Over a multiple-week lab course, students will combine traditional and cutting-edge molecular biology techniques and bioinformatics. Your students will clone, sequence, and analyze a housekeeping gene from a plant of your choice, allowing each class to produce original data.

The real thing. As a research and diagnostics manufacturing company, Bio-Rad brings unique strengths to the education community including credibility, high-quality products (kits and equipment that work), novel inquiry-based curricula, cutting-edge kit applications, competitive pricing, superior teacher professional development programs, long-term strategic partners and allies, and strong personal endorsements from customers across all levels of education.

1 Nucleic Acid Extraction Module

- Genomic DNA extraction
- Cellular membrane disruption
- Isolation of genomic DNA

2 GAPDH PCR Module

- Nested PCR
- Degenerate primers
- Exonuclease treatment

3 Electrophoresis Module

- Agarose gel analysis
- PCR product visualization

4 PCR Purification Module

- Size exclusion chromatography

5 Ligation and Transformation Module

- Blunting of PCR products
- Ligation
- Generation of competent bacteria
- Bacterial transformation
- Sterile technique

6 Microbial Culturing Module

- Grow transformed cells
- Cell selection
- Ampicillin resistance

Section Contents

Cloning and Sequencing Explorer Series

Plasmid Purification Module

- Plasmid isolation
- Restriction enzyme digestion

DNA Sequencing Module

- Directional sequencing primers
- Automated sequencing

Bioinformatics Module

- Data analysis
- Contig assembly
- Intron/exon prediction
- Chromatogram analysis
- BLAST searches

"I have been using Bio-Rad kits for 19 years because they are the gold standard for biotechnology education. The resources provided with the kits are engaging, straightforward, and easily tailored to the needs of different student populations."

Joseph Oleniczak
Austin Community College/Liberal Arts and Science Academy, Austin, TX

Bio-Rad Explorer Teacher and Student Alumni

Equip your students with technical skills for entry-level lab positions or inspire them to pursue graduate degrees in scientific research. The Cloning and Sequencing Explorer series has been designed with the assistance of undergraduate and community college educators to meet the needs of biotechnology and biology course instructors who want their students to understand how molecular biology skills and techniques are applied to real-world research projects.

From DNA extraction to computer-based sequence analysis, this modular kit is designed as a six- to eight-week series of lab activities in which students clone and analyze a plant housekeeping gene: *glyceraldehyde 3-phosphate dehydrogenase (GAPDH).*

This lab course provides your students with the opportunity to perform novel research, allowing them to clone and sequence a gene from an uncharacterized plant species and to add to the body of scientific knowledge around the world. The series provides a fully developed and ready-to-go lab course including relevant background, protocols that work, and student assessment.

Students will extract genomic DNA from their chosen plant sources, use degenerate primers to perform nested PCR, and amplify a major portion of the *GAPC* gene — a housekeeping gene in the *GAPDH* family that is essential for the most basic of biological processes: respiration.

Students will then clone the gene fragment, transform it into bacteria, screen their clones using plasmid minipreps and restriction enzymes, and send positive clones to be sequenced (sequencing service not included).

On receiving their novel sequences, **students will perform extensive bioinformatics analysis** on their sequences, including BLAST searches, assembling forward and reverse sequences into contigs, identifying introns and exons, and transcribing gene sequences into protein with user-friendly, bioinformatics tools.

Upon completion of the lab course, students may elect to submit novel sequences to the National Institutes of Health National Center for Biotechnology Information (NCBI) databases, thereby making their research available to the worldwide scientific community.

This laboratory course is designed to ensure success for you and your students. Tailored controls permit the continuation of the experiment to its conclusion. This allows students to make mistakes, learn from them, and still be exposed to every step of the workflow within a specific time period.

Students will experience firsthand the satisfaction that comes from a completed and successful research project, which may encourage them to pursue a career in research.

Cloning and Sequencing Explorer Series

The Complete Cloning and Sequencing series supports 12 workstations.

See pages 84–91 for complete module descriptions or to order modules separately.

Cloning and Sequencing Explorer Series — All Eight Modules
Catalog # **1665000EDU**

Ships with both temperature sensitive and room temperature components. Immediately store temperature sensitive items at 4°C or –20°C as indicated.

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.

Workflow

The lab is presented over the next few pages in a series representing the experimental workflow:

1. **Extract genomic DNA from plants.**
2. **Amplify the G*APDH* gene using PCR and analyze.**
3. **Purify the PCR product.**
4. **Ligate the PCR product into a plasmid.**
5. **Transform the ligated plasmid into bacteria.**
6. **Grow minipreps of the transformed bacteria.**
7. **Isolate plasmid DNA and analyze by restriction digestion.**
8. **Sequence plasmid DNA. (Sequencing service not included)**
9. **Analyze *GAPDH* gene sequence using bioinformatics, now with Geneious Software.**

Modules Available Separately:
Each module within the series is also available as a stand-alone kit, providing the opportunity to use individual kits to update existing curricula or to design and develop your own unique series of experiments.

Lab Preparation Checklist

Lab contains sufficient materials for 12 student workstations (2–4 students per workstation).

Cloning and Sequencing Explorer Series Contents

Nucleic acid extraction module	1
GAPDH PCR module	1
Small DNA electrophoresis reagents module	1
PCR Kleen spin purification module	1
Ligation and transformation module	1
Microbial culturing module	1
Aurum plasmid mini purification module	1
Sequencing and bioinformatics module	1
1.5 ml EZ Micro test tubes, 500	1

Required Accessories Not Included in Kit:

Plant samples
95–100% lab grade ethanol
Horizontal gel electrophoresis chambers, pp. 117–118
Thermal cycler, p. 123
Adjustable micropipets, pp. 152–153
Pipet tips, aerosol barrier, p. 154
Incubation oven, p. 150
Water bath and dry bath, p. 150
Microcentrifuges capable of greater than 12,000 x g, p. 148
Power supplies, p. 155
Gel documentation system, p. 146–147
Shaking water bath or shaking incubator, p. 151

Recommended (Optional) Accessories:

Vortexer, p. 149
Microwave oven/autoclave
Spectrophotometer
Cuvettes, p. 156

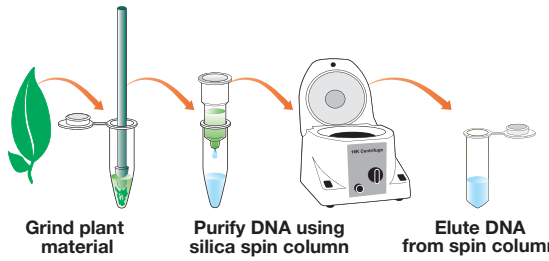
Available Separately:

Nucleic acid extraction module (#1665005EDU)
GAPDH PCR module (#1665010EDU)
Small UView DNA electrophoresis reagents module (#1660462EDU)
PCR Kleen spin purification module (#7326300EDU)
Ligation and transformation module (#1665015EDU)
Microbial culturing module (#1665020EDU)
Aurum plasmid mini purification module (#7326400EDU)
Sequencing and bioinformatics module (#1665025EDU)
1.5 ml EZ Micro test tubes, 500 (#2239480EDU)

Refresh Kit Components:

Please visit explorer.bio-rad.com and request bulletins 5872 (purchasing guide, printable), 5905 (interactive purchasing guide), and 5891 (large class/multiple class preparation guide) for more information.

Prepare DNA template using spin columns and centrifugation

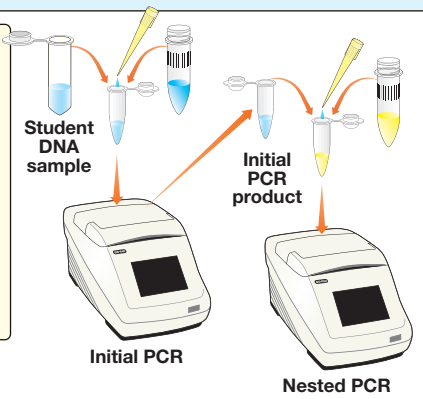


DNA extraction

Add master mix to student samples and positive control DNA

Amplify target sequences

Treat PCR sample with exonuclease I to remove primers



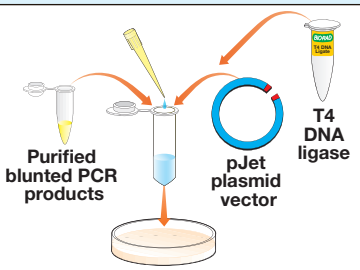
Add master mix and nested PCR primers to student initial PCR samples and positive control DNA

Amplify target sequences

Analyze via DNA electrophoresis

Two PCR steps and electrophoresis

Purify and blunt PCR products

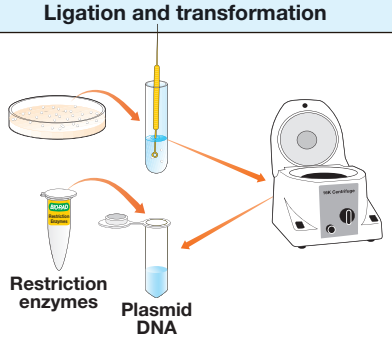


Combine PCR products, pJet plasmid vector, and T4 ligase. Ligate 10 min

Transform bacteria and incubate overnight at 37°C

Ligation and transformation

Grow liquid bacterial culture overnight at 37°C in shaking water bath

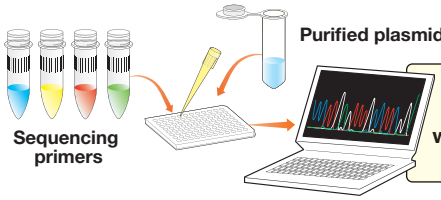


Purify plasmid DNA using alkaline lysis and miniprep spin column

Restriction digest analysis via DNA electrophoresis and positive clones

Miniprep: Restriction enzyme analysis and electrophoresis

Combine purified plasmid containing cloned gene with sequencing primers and mail to sequencing facility



Analyze sequences with Geneious Software

Sequencing and bioinformatics

Nucleic Acid Extraction Module

Nucleic Acid Extraction: As part of the Cloning and Sequencing Explorer series

To clone a gene, DNA must first be extracted from the organism. After choosing two plants to study, students collect plant tissue, grind the tissue in lysis buffer using micropestles, centrifuge the lysate to remove cellular debris, mix the lysate with ethanol, and apply to a silica spin column. Spin columns are washed three times and all nucleic acids are eluted from the column. The eluate can be used directly for PCR.

Different plants yield different quantities of DNA. Each extraction yields sufficient DNA for 16 PCR reactions. This protocol has been optimized for plant DNA extraction with reagents to reduce polyphenol inhibition of PCR — a list of plants demonstrated to yield amplifiable DNA with the *GAPDH* primers is provided, along with a list of plants that are less successful with this protocol — due to either issues with DNA extraction or lack of homology to *GAPDH* primers.

Alternatively, have your students experience the risks inherent to real-world research and use untested plants, or hedge your bets and use one recommended plant and one novel plant. The Cloning and Sequencing Explorer Series *GAPDH* PCR module contains purified genomic DNA from Arabidopsis as a control, which allows continuation of the experiment in the unlikely event that students' extracted DNA does not amplify!

On your own:
Use DNA extracted with this module for independent research projects and existing lab PCR protocols. Quantitate DNA concentration using fluorometry or examine the total nucleic acid content from cells by gel electrophoresis. Genomic DNA appears as a faint band at the top of the gel, while RNA is visible as two major bands much further down the gel. RNA can be removed from samples by treatment with RNase I, or similarly, DNA can be removed with DNase I treatment. For further RNA work, elution using DEPC-treated water is recommended.

Kit supports 12 student workstations.

Nucleic Acid Extraction Module

Catalog # **1665005EDU**

Ships at room temperature. Immediately store DTT at 4°C.

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.

Lab Preparation Checklist

Kit contains sufficient materials for 12 student workstations or 25 genomic DNA extractions.

Lysis buffer, 20 ml	1
Dithiothreitol (DTT), 0.3 g	1
Wash buffer, 20 ml	1
Sterile water, 2.5 ml	1
Micropestles	25
Spin columns	25
Microcentrifuge tubes, 2.0 ml	25
Microcentrifuge tubes, 1.5 ml	30
Colored microcentrifuge tubes, 2.0 ml	60
Instruction manual	1

Required Accessories Not Included in Kit:

Plant samples	
95–100% lab grade ethanol, 300 ml	1
Adjustable micropipets, pp. 152–153	
2–20 µl	1
20–200 µl	1–12
100–1,000 µl	1–12
Pipet tips, aerosol barrier, p. 154	
2–20 µl, Xcluda B	1 box
20–200 µl, Xcluda D	1–12 boxes
100–1,000 µl, Xcluda E	1–12 boxes
Microcentrifuges capable of greater than 12,000 x g, p. 148	1–4
Water bath, p. 150	1
Dry bath, p. 150	1

Recommended (Optional) Accessories:

Vortexer, p. 149
Spectrophotometer
Cuvettes, p. 156
DEPC-treated water, 100 ml (#7007253EDU)

Refresh Kit Components: (more info pp. 157–159)
Nucleic acid extraction reagent refill pack (#1665006EDU), includes DTT, lysis buffer, wash buffer, sterile water
Aurum mini columns, 50 (#7326826EDU)

GAPDH PCR Module

***GAPDH* PCR:** As part of the Cloning and Sequencing Explorer series

How do you amplify a gene when you do not know its sequence? The experimental goal of this module is to amplify a conserved gene from a novel genome. *Glyceraldehyde 3-phosphate dehydrogenases (GAPDHs)* are a family of enzymes essential for glycolysis — one of the most fundamental metabolic processes of life. They are found in all organisms and, because their enzyme function is so vital to life, their protein sequences are highly conserved both within the family and between organisms. Thus, to amplify a highly conserved gene from a novel plant should be simple; just design primers to the conserved regions and amplify — right?

As ever, biology is not so simple — protein sequence is not the same as gene sequence. What about the problems of noncoding introns and the degeneracy of the genetic code? **Your students will discover how using degenerate primer sequences** and multiple (nested) rounds of PCR can help solve these problems. Ultimately, students will learn how PCR is adapted in real-world research.

In this lab, **students will amplify genomic DNA**, via two rounds of PCR, from *Arabidopsis* (provided as a control) and purified genomic DNA from any two novel plants. The novel plant DNA is extracted using the nucleic acid extraction module.

The initial round of PCR uses degenerate primers to amplify a pool of *GAPDH* genes. These initial PCR reactions are then treated with the enzyme exonuclease I, which digests any remaining degenerate primers. A second round of nested PCR is then performed on this pool of templates, using primers inside the original target sequence and designed to specifically select a subfamily of *GAPDH* genes, *GAPC* genes.

Students then analyze their PCR products using agarose gel electrophoresis and visualize the *GAPC* gene they have isolated from their plant genome.

Students will observe the benefits of nested PCR compared to a single round of PCR and also learn that there can be great variability in the same gene between different plants. The portion of the *GAPC* gene amplified varies in size from 0.6 kb to more than 2 kb, primarily due to differences in intronic DNA rather than large differences in the coding sequence between different plants.

On your own:
This activity provides strong results and can be performed as a shorter stand-alone PCR lab to demonstrate applications of PCR in real research without going on to clone the gene. Use in conjunction with an electrophoresis module to visualize PCR results.

Visit **explorer.bio-rad.com** to view our comprehensive curriculum manual and see just how much you can do with this activity!

Kit supports 12 student workstations.

GAPDH PCR Module

Catalog # **1665010EDU**

Ships on blue ice. Immediately store reagents bag at –20°C.

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.

Lab Preparation Checklist

Kit contains sufficient materials for 12 student workstations.

Initial *GAPDH* PCR primers, blue, 50 µl	1
Nested *GAPDH* PCR primers, yellow, 50 µl	1
PCR master mix, 1.2 ml	3
Plasmid control DNA, 1 ml	1
Control *Arabidopsis* genomic DNA, 20 µl	1
Exonuclease I, 50 µl	1
500 bp Molecular weight ruler, 400 µl	1
UView 6x Loading Dye and Stain, 1 ml	1
Sterile water, 2.5 ml	3
PCR tubes, 0.2 ml	150
Capless PCR tube adaptors, 1.5 ml	150
Colored microcentrifuge tubes, 2.0 ml	120
Curriculum, including teacher's guide, student manual, and graphic quick guide	1

Required Accessories Not Included in Kit:

Adjustable micropipets, pp. 152–153	
2–20 µl	1–12
20–200 µl	1
Pipet tips, aerosol barrier, p. 154	
2–20 µl, Xcluda B	1–12 boxes
20–200 µl, Xcluda D	1 box
Thermal cycler, p. 123	1
Foam floating racks, p. 157	8

Recommended (Optional) Accessories:

Novel plant genomic DNA
Microcentrifuges, p. 148
Vortexer, p. 149

Refresh Kit Components: (more info pp. 157–159)

GAPDH PCR reagent refill pack (#1665011EDU), includes initial *GAPDH* PCR primers, nested *GAPDH* PCR primers, PCR master mix, plasmid control DNA, control *Arabidopsis* genomic DNA, exonuclease I, molecular weight ruler, UView 6x Loading Dye and Stain, sterile water
2x Master Mix for PCR, p. 129
UView 6x Loading Dye and Stain, p. 122

Kit contains UView 6x loading dye and stain — a safe nontoxic stain!

Electrophoresis Module

Electrophoresis: As part of the Cloning and Sequencing Explorer series

Pour superior agarose gels with our convenient DNA agarose gel electrophoresis reagent packs. Whether safety or sensitivity is your concern, there is an electrophoresis pack to meet your needs. Electrophoresis packs are provided in three sizes depending on your teaching needs: small (16–48 gels), medium (90–270 gels), and large (360–1,080 gels). Each pack contains the highest quality molecular biology certified agarose powder, convenient premixed 50x Tris/acetate/EDTA (TAE) buffer, and a DNA stain suitable for your students. For the safety conscious, the nontoxic Fast Blast DNA stain electrophoresis packs are recommended. For advanced student activities requiring increased sensitivity and using UV transillumination, the UView electrophoresis pack is recommended, or we have the classic ethidium bromide electrophoresis packs. Whichever electrophoresis pack you choose, your students are guaranteed to produce great results.

On your own:
Run your agarose gels in 10 minutes and extend your TAE running buffer using Bio-Rad's fast gel protocol. Request bulletin 5396 from Bio-Rad today.

Kits support 24–96 students. See p. 119 for details.

Electrophoresis Module

Catalog # **1660462EDU**

Ships and stores at room temperature.

Please refer to p. 119 for a complete description of all the electrophoresis reagent packs.

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.

Lab Preparation Checklist

Series contains 1660462EDU, UView DNA electrophoresis reagent pack. Please note, for the complete series, the UView 6x Loading Dye and Stain is included in the *GAPDH* PCR module.

Agarose powder, 25 g	1
Electrophoresis buffer, 50x TAE, 100 ml	2
UView 6x Loading Dye and Stain, 1 ml	1

Required Accessories Not Included in Kit:

Horizontal gel electrophoresis chambers, pp. 117–118	4–12
Adjustable micropipets, pp. 152–153	1–12
Pipet tips, p. 154	1–12 boxes
Power supplies, p. 155	3–6
Microwave oven	1

Recommended (Optional) Accessories:

Gel documentation equipment, pp. 146–147

Refresh Kit Components: (more info pp. 157–159)

Agarose powders, p. 119
Precast agarose gels, p. 120
DNA electrophoresis buffers, p. 120
DNA stains, p. 122

See Bulletin 5396
Visit **bio-rad.com/fastgel** for information on Bio-Rad's 10 minute Fast Gel Protocol.

10 Minute Gels

PCR Kleen Spin Purification Module

PCR Kleen Spin Purification Module: As part of the Cloning and Sequencing Explorer series

Demonstrate a real-world use of size exclusion chromatography. Ligation of PCR fragments is much more efficient when unincorporated primers, nucleotides, salts, and enzymes are removed from the PCR reaction. In this step, PCR products are purified using simple spin columns that remove small molecules like salts, enzymes, and primers by absorbing them into porous beads. Larger molecules, such as PCR products greater than 100 bp, cannot enter the beads and are eluted from the column.

Students first prepare the spin columns by eluting the storage buffer into a collection tube. PCR reactions are then applied to the columns, which are spun at 735 x g for 1 minute. The purified PCR reaction is collected in a microcentrifuge tube.

Following this step, both the unpurified and the purified PCR products can be viewed side by side using agarose gel electrophoresis to visually demonstrate the removal of oligonucleotide primers.

When performing the Cloning and Sequencing Explorer series, students will choose the *GAPDH* gene from one of their plants to continue their experiments, taking that gene through cloning and sequencing and using this module to purify their PCR product prior to ligation.

Kit supports 24 student workstations.

PCR Kleen Spin Purification Module
Catalog # **7326300EDU**

Ships and stores at room temperature.

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.

Lab Preparation Checklist

Kit contains sufficient materials for 24 student workstations or 25 PCR purifications.

PCR Kleen spin columns	25
Microcentrifuge tubes, 2.0 ml	25
Microcentrifuge tubes, 1.5 ml	25
Instruction manual	1

Required Accessories Not Included in Kit:

Adjustable micropipets, pp. 152–153	
20–200 µl	1–12
Pipet tips, p. 154	
20–200 µl	1–12 boxes
Microcentrifuges capable of greater than 12,000 x g, p. 148	1–2

Recommended (Optional) Accessories:

Horizontal gel electrophoresis chambers, pp. 117–118	4–12
Power supplies, p. 155	3–6

On your own:
This module can also be used in other experiments for cleaning up any PCR reaction prior to ligation, removing primers prior to subsequent nested PCR reactions, or removing nucleotides before direct DNA sequencing.

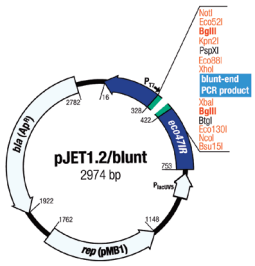
Ligation and Transformation Module

Ligation and Transformation: As part of the Cloning and Sequencing Explorer series

Ligate the PCR product into a plasmid and transform bacteria. Students directly clone their PCR products into the pJET1.2 vector, and immediately transform bacteria using a protocol that takes less than 2 hours to go from purified PCR product to transformed bacteria plated on agar.

Students first remove the 3'-dA overhang from their PCR product using a proofreading polymerase. The 3'-dA overhang results from the terminal transferase activity of Taq polymerase. A 10 minute protocol is then used to ligate the blunted PCR product into a pre-opened and blunted vector — pJET1.2. Successful insertion of a DNA fragment in pJET1.2 leads to the disruption of a lethal gene that would otherwise prevent bacterial growth, allowing for positive selection of recombinant plasmids. Bacteria that are transformed with religated vector activate the gene and are killed. This results in higher transformation efficiency than traditional blue-white cloning.

BglII restriction sites are located on either side of the pJET1.2 cloning site, which allow students to determine whether their gene of interest was successfully ligated once they have isolated candidate plasmids.



To transform the ligated plasmids into bacteria, students first inoculate specialized growth media and perform a series of microcentrifugations and washes in a specialized transformation buffer to make competent cells. These competent cells are then added to the ligation reactions on ice and plated directly on warm agar plates.

On your own:
This simple and short protocol can be used to clone any PCR product. It takes only about 2 hours and does not require commercial competent cells, a refrigerated microcentrifuge, or a –80°C freezer, making it the method of choice for educators worldwide!

Kit supports 12 student workstations.

Ligation and Transformation Module
Catalog # **1665015EDU**

Ships on blue ice. Immediately store reagents bags at –20°C.

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.

Lab Preparation Checklist

Kit contains sufficient materials for 12 student workstations.

T4 DNA ligase, 10 µl	1
2x ligase buffer, 100 µl	1
Proofreading DNA polymerase, 10 µl	1
Cloning vector, 10 µl	1
BglII restriction enzyme, 55 µl	1
10x restriction enzyme buffer, 100 µl	1
C-growth medium, 30 ml	1
Transformation A solution, 5 ml	1
Transformation B solution, 5 ml	1
Isopropyl β-D-1-thiogalactopyranoside (IPTG), 0.1 ml	1
Sterile water, 1 ml	1
Colored microcentrifuge tubes, 2.0 ml	120
Microcentrifuge tubes, 1.5 ml	30
Instruction manual	1

Required Accessories Not Included in Kit:

Adjustable micropipets, pp. 152–153	
0.5–10 µl	1–12
Pipet tips, p. 154	
0.5–10 µl	1–12 boxes
Water bath, p. 150	1
Microcentrifuge, p. 148	1
Incubation oven, p. 150	1
Shaking water bath or shaking incubator, p. 151	1

Refresh Kit Components: (more info pp. 157–159)
Ligation module reagent refill pack (#1665016EDU), T4 DNA ligase, ligase buffer, proofreading DNA polymerase, cloning vector, sterile water
Transformation module reagent refill pack (#1665017EDU), transformation A solution, transformation B solution, C-growth medium, IPTG
BglII reagent refill pack (#1665018EDU), BglII restriction enzyme, restriction enzyme buffer

Note: Bacterial culturing reagents such as LB broth and LB agar are contained in the microbial culturing module.

Microbial Culturing Module

Microbial Culturing: As part of the Cloning and Sequencing Explorer series

Select for positive ligations and grow bacterial minipreps. Students use this module to prepare media for their microbiological needs for the Cloning and Sequencing Explorer Series.

Starter cultures are required for competent cell preparation. Students will make LB agar plates and streak them with *E. coli* bacteria for single colonies. Students then prepare LB broth to make an overnight starter culture from their streaked plate, which is used to prepare competent cells using the ligation and transformation module.

LB ampicillin agar plates are required to select for bacteria that have been transformed with plasmids, like pJET1.2, which contain the β-lactamase gene conferring ampicillin resistance to bacteria. After transformation, bacteria are plated onto LB ampicillin agar plates and incubated at 37°C. Ampicillin-resistant bacterial colonies will grow overnight.

LB broth containing ampicillin is required to culture minipreps grown from colonies transformed with ligated plasmid. Plasmids are then isolated from the minipreps using the Aurum plasmid mini purification kit.

On your own:
Teach basic microbiology with all the reagents in one place. This kit contains the reagents necessary for teaching basic sterile technique, culturing *E. coli*, transforming ampicillin-resistant bacteria, and growing miniprep cultures. This module is great for existing microbiology protocols and independent study projects.

Kit supports 12 student workstations.

Microbial Culturing Module
Catalog # **1665020EDU**

Ships and stores at room temperature.

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.

Lab Preparation Checklist

Kit contains sufficient materials to pour 40 LB agar plates (with or without ampicillin) and inoculate and grow 75 miniprep cultures, as well as starter *E. coli* bacteria.

Ampicillin, lyophilized	2
LB broth capsules	12
LB nutrient agar powder	1
Petri dishes, 60 mm, sterile	40
Cell culture tubes, 15 ml, sterile	75
Inoculation loops, sterile	80
E. coli strain HB101 K-12, lyophilized	1
Disposable plastic transfer pipets	10
Instruction manual	1

Required Accessories Not Included in Kit:
Microwave oven or autoclave

Recommended (Optional) Accessories:

Incubation oven, p. 150	1
Tube roller, p. 149	1
Shaking water bath or shaking incubator, p. 151	1

Refresh Kit Components: (more info pp. 157–159)
Microbial culture kit reagent refill pack (#1665021EDU) includes ampicillin, LB broth capsules, LB nutrient agar powder, *E. coli* strain HB101 K-12

LB nutrient agar powder, 20 g (#1660600EDU) or 500 g (#1660472EDU)
Ampicillin (#1660407EDU)
E. coli strain HB101 K-12 (#1660408EDU)
Petri dishes, 60 mm, sterile, 500 (#1660470EDU)
Inoculation loops, 10 µl, sterile, 100 (#1660471EDU)
Disposable plastic transfer pipets, sterile, 500 (#1660474EDU)
Cell culture tubes, 17 x 100 mm, 14 ml, sterile, 25 (#1660476EDU)

Aurum Plasmid Mini Purification Module

Aurum Plasmid Mini Purification Module: As part of the Cloning and Sequencing Explorer series

Isolate plasmid DNA from transformed bacteria. Students inoculate minipreps with transformed bacterial colonies from their agar plates. They then isolate plasmid DNA using a three-step alkaline lysis procedure followed by mini column chromatography. Purification can be carried out in microcentrifuges or using the Aurum vacuum manifold.

Once plasmid DNA is eluted, students verify insertion of the PCR product into the plasmid vector using restriction enzyme digestion analysis and agarose gel electrophoresis. BglII restriction enzyme specific for screening the pJET1.2 plasmid is supplied in the ligation and transformation module. Students can also determine plasmid DNA concentration using spectrophotometry or fluorometry in an optional step.

On your own:
Purify up to 20 µg of plasmid DNA rapidly and inexpensively, without the use of toxic reagents or alcohol precipitations. Plasmid DNA is free of salts, bacterial chromosomal DNA, and RNA. The highly purified DNA makes it ideal for subsequent molecular biology–based applications such as automated sequencing, cloning, PCR, or restriction digestion analysis.

Kit supports 24 student workstations.

Aurum Plasmid Mini Purification Module

Catalog # **7326400EDU**

Ships and stores at room temperature..

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.

Lab Preparation Checklist

Kit contains sufficient reagents to purify DNA from 100 minicultures of plasmid-bearing bacteria.

DNA-binding mini columns	100
Capless collection tubes	100
Resuspension solution, 25 ml	1
Lysis solution, 25 ml	1
Neutralization solution, 40 ml	1
5x wash solution, 25 ml	1
Elution solution, 16 ml	1
Instruction manual	1

Required Accessories Not Included in Kit:

95–100% lab grade ethanol, 100 ml	1
Microcentrifuge capable of greater than 12,000 x g, p. 148	1
Shaking water bath or shaking incubator (for growth of cultures), p. 151	1
Adjustable micropipets, pp. 152–153	
20–200 µl	1–12
100–1,000 µl	1–12
Pipet tips, p. 154	
20–200 µl	1–12 boxes
100–1,000 µl	1–12 boxes

Sequencing and Bioinformatics Module

Sequencing and Bioinformatics Module: As part of the Cloning and Sequencing Explorer series

Sequence and analyze your cloned DNA. Students combine plasmid DNA containing PCR products with sequencing primers on a 96-well plate and send them to a sequencing service.*

The portion of the *GAPDH* gene to be cloned using the Cloning and Sequencing Explorer series can vary from 0.6 to more than 2 kb in length. To ensure complete coverage of the gene, four sequencing primers are provided: one forward and one reverse primer specific to either side of the pJET1.2 cloning site, and one forward and one reverse primer homologous to different regions in the middle of the *GAPDH* gene. Thus four independent sequences will be generated for each plasmid. These sequences can be assembled into a contig using the bioinformatics module. We recommend each student team submit two plasmids for sequencing with all four primers.

The ultimate goal of the Cloning and Sequencing Explorer series is to generate sequence data that can be uploaded into NCBI's GenBank database to be used by other scientists. To ensure the data are as accurate as possible, it is important to guard against sequencing errors by having as many sequence reads as possible. Fortunately, since this is a class project, it is probable that multiple groups will independently clone the same *GAPDH* gene, resulting in the desired repetition needed to confirm the sequence. Additionally, sequencing primers are provided to allow for sequence reads in both forward and reverse directions, providing another method of sequence confirmation.

On your own:
Sequence any PCR product cloned into pJET1.2. The sequencing primers specific for pJET1.2 will allow students to sequence PCR fragments up to 1 kb cloned into pJET1.2 using the ligation and transformation module. Longer fragments would require the design of internal sequencing primers due to the limitations of sequencing reads. Also, sequence the pGAP positive control plasmid and use the bioinformatics software to analyze the data.

Kit supports 25 licenses.

Sequencing and Bioinformatics Module
Catalog # **1665025EDU**

Ships on blue ice. Immediately store reagents bag at –20°C.

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.

Lab Preparation Checklist

Kit contains sufficient materials for 12 student workstations or 96 sequencing reactions.

pJETF primer, blue, 50 µl	1
pJETR primer, yellow, 50 µl	1
GAPSEQF primer, red, 50 µl	1
GAPSEQR primer, green, 50 µl	1
Control plasmid, 100 µl	1
Barcoded 96-well plate	1
Sealing film	1
Colored microcentrifuge tubes, 2 ml	120
Curriculum, including instruction manual	1

Required Accessories Not Included in Kit:

Adjustable micropipets, pp. 152–153	
2–20 µl	1–12
Pipet tips, p. 154	
2–20 µl	1–12 boxes
Sequencing service*	
Computers and Internet access	1–12

Refresh Kit Components: (more info pp. 157–159)
Sequencing module reagent refill pack (#1665026EDU), includes pJETF primer, pJETR primer, GAPSEQF primer, GAPSEQR primer, control plasmid

* Sequencing is not included. However, in the U.S., Bio-Rad has partnered with Eurofins MWGIOperon, a worldwide ISO9001 certified company ensuring high quality, in order to offer a deeply discounted rate for sequencing services to educators using the Cloning and Sequencing Explorer series. Eurofins MWGIOperon provides sequencing data within 1–2 days. For more information on other sequencing options, visit **www.operon.com/bio-rad** or contact us at explorer@bio-rad.com.

Bioinformatics: As part of the Cloning and Sequencing Explorer series

Once the plasmid has been cloned and sequenced, the real work begins — interpreting the sequence data. This final portion of the Cloning and Sequencing Explorer Series teaches students essential bioinformatics skills needed to link biology with computers. The sequencing and bioinformatics module includes a three month subscription for Geneious bioinformatics software for your class. The program gives students access to the latest tools in bioinformatics data mining.

Raw sequence files are uploaded and students are guided through a series of activities. They will view and edit the original chromatograms of their sequences, screen out vector sequences, confirm their sequences are *GAPDH*, perform NCBI BLAST searches on their data to identify and find related sequences, assemble their forward and reverse sequences into contigs, predict intron and exon structure, transcribe and translate the *GAPDH* sequence and compare it to known gene, mRNA, and protein sequences.

This module serves the needs of educators and students by combining the bioinformatics power of Geneious with Bio-Rad's expertise in wet-lab technology. With a subscription to Geneious software, teachers and students have access to a state-of-the-art commercial software system that supports the process of scientific discovery.

Geneious is known around the globe for high-quality, reliable software that helps customers manage genetic data and further their goals in DNA diagnostics and research and in running laboratory-based businesses. Used by laboratories and core facilities in universities, government, biotechnology, and pharmaceutical companies, these bioinformatics software systems have established an international reputation for usability and performance.

On your own:
Download free Geneious tutorials at **geneious.com/tutorials** for hands-on training to make even a novice an expert.

geneious

Protein Expression and Purification Series

Move beyond DNA to the exciting world of proteins!
One of the great promises of the biotechnology industry is the ability to provide biopharmaceuticals to treat human disease. Producing novel proteins in bacteria or other cell types is not simple. Active proteins are often composed of multiple chains of amino acids with complex folding and strand interactions. Commandeering a particular cell to reproduce the native form presents many challenges. Considerations of cell type, plasmid construction, and purification strategy are all part of the process of developing a recombinant protein.

In the Protein Expression and Purification series students will explore the process of producing a recombinant protein by inducing *E. coli* to express the protein of interest, dihydrofolate reductase (DHFR), which is a target for certain cancer treatments. Students will learn how to recover the protein from other cellular components and then purify it away from other proteins in the cell using the leading form of purification today — affinity chromatography.

The Bio-Rad Explorer program has a long history of partnering with educators to create laboratory experiences that prepare students for today's careers and provide the understanding that is required for citizens in the rapidly advancing technologies that impact our daily lives. The Protein Expression and Purification series was developed in response to educators' desire to provide studentswith authentic protein-based laboratory experiences relevant to research and industrial applications.

DHFR Enzymatic Assay Module

Purification Module

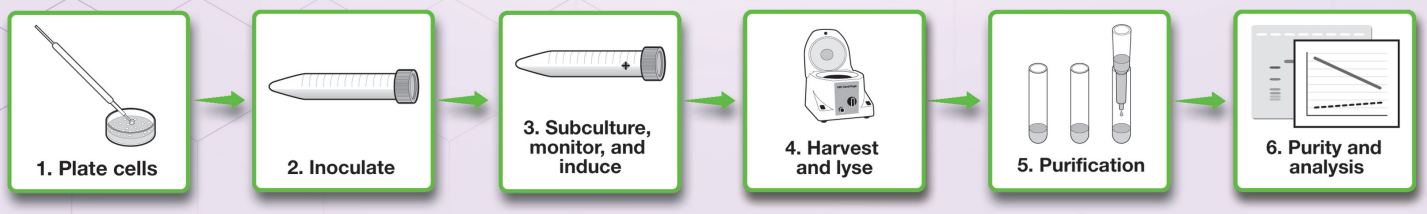
Growth and Expression Module

SDS-PAGE Electrophoresis Module

How can you teach these concepts all at once?
- Protein purification (chromatography)
- Enzymatic analysis
- Research and development processes
- Biomanufacturing
- Cancer treatment targets

Bio-Rad Explorer makes it easy for you and your students to experience each of the above concepts in an integrated workflow. Teach the core process of expression and purification of bioengineered proteins using this clear and concise modular lab series. Help your students gain hands-on experience and give them the confidence that they need to work with proteins. The modular design of the new Protein Expression and Purification series allows you to teach the basics of protein purification and then proceed to the more advanced concepts.

The scalability of this particular affinity purification process provides an adaptable set of techniques and content to match the goals of the beginning protein educator up to an advanced college-level course in biomanufacturing. The series provides a fully developed and ready-to-go lab course, including relevant background and protocols that work. A module on student assessment is available as well. Discover more about this unique series, including how DHFR is a target for certain cancer treatments and how the protein expression and purification process is vital to the world of biomanufacturing.



Section Contents

Protein Expression and Purification Series

Option 1

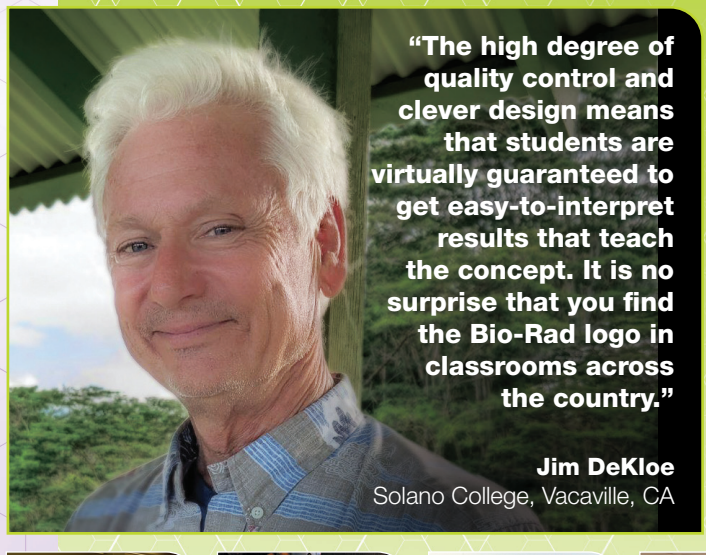
Centrifugation Purification Module

Option 2

Hand-Packed Column Purification Module

Option 3

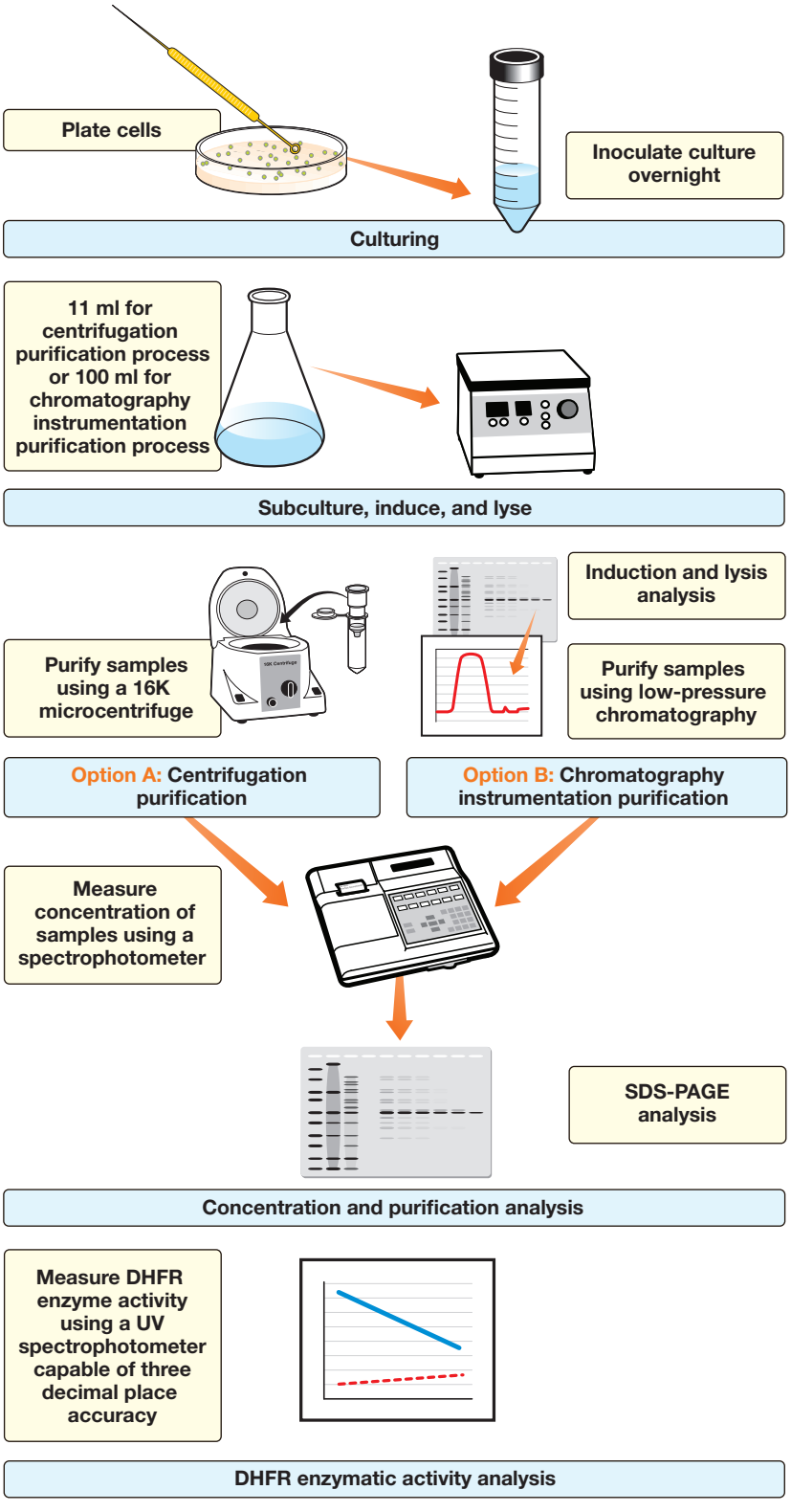
Prepacked Cartridge Purification Module



"The high degree of quality control and clever design means that students are virtually guaranteed to get easy-to-interpret results that teach the concept. It is no surprise that you find the Bio-Rad logo in classrooms across the country."

Jim DeKloe
Solano College, Vacaville, CA

Bio-Rad Explorer Teacher and Student Alumni



Protein Expression and Purification Series

The Complete Protein Expression and Purification series centrifugation purification process supports 12 workstations while the chromatography instrumentation hand-packed column and prepacked cartridge processes each support 4 workstations.

Protein Expression and Purification Series — All Four Modules (choose option)

Option 1: **Centrifugation Purification Process**
Catalog # **1665040EDU**
(for purification using a 16K microcentrifuge)

Option 2: **Hand-Packed Column Process**
Catalog # **1665045EDU**
(for use with chromatographic purification instrumentation and allowing students to pour their own columns)

Option 3: **Prepacked Cartridge Process**
Catalog # **1665050EDU**
(providing the best experience with chromatographic purification instrumentation through the quality of prepacked cartridges)

Ships with both temperature sensitive and room temperature components. Immediately store temperature sensitive items at 4°C or –20°C as indicated.

Assessment Module (optional)
This unique assessment guide provides ideas for using formative assessment in your class to guide and increase learning while students perform the lab activities. At the end of the lab series use the summative assessment to evaluate the final learning levels of students. The assessment tool is arranged according to learning levels so that you can choose what level best evaluates the comprehension of your students.

Catalog # **1665070EDU**

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.

Workflow

The lab is presented over the next few pages in a series representing the experimental workflow:

1. **Plate cells.**
2. **Inoculate.**
3. **Subculture, monitor, and induce.**
4. **Harvest and lyse cells.**
5. **Purify.**
6. **Measure purity and perform enzymatic activity analysis.**

Modules Available Separately:
Growth and Expression (#1665055EDU)
SDS-PAGE Electrophoresis (#1665060EDU)
Centrifugation Purification (#1665041EDU)
Hand-Packed Column Purification (#1665046EDU)
Prepacked Cartridge Purification (#1665051EDU)
DHFR Enzymatic Assay (#1665065EDU)
Assessment (#1665070EDU)

Protein Purification Is Essential!

Lab Preparation Checklist

Lab contains sufficient materials for 12 student workstations when using the centrifugation process or 4 student workstations when using either the hand-packed column or prepacked cartridge process.

Protein Expression and Purification Series Contents

Growth and Expression Module	1
SDS-PAGE Electrophoresis Module	1
Purification Module (one of the following)	1
Centrifugation Purification Process	
Hand-Packed Column Purification Process*	
Prepacked Cartridge Purification Process*	
DHFR Enzymatic Assay Module	1
Instruction Manual	1

Required Accessories Not Included in Kit:

Dry ice
Ethanol
Adjustable Micropipets, 2–1,000 µl, pp. 152–153
Pipet Tips, p. 154
Parafilm Sealing Film
UV Compatible Submicrovolume Cuvettes
1.5 ml Standard Disposable Polystyrene or Quartz Cuvettes, p. 156
10 ml Syringes
22 Gauge Syringe Needles
Fraction Collection Tubes (#2239751EDU)
1 L Erlenmeyer flask or autoclavable bottle
Beakers for dry ice/ethanol bath
Microwave Oven
–20°C freezer
Incubation Oven, p. 150
Tube Roller, p. 149
Mini Rocker, p. 149
Dry Bath or Water Bath, p. 150
UV/Vis Spectrophotometer capable of reading to three decimal places
Pipet Controller, p. 153
10 ml Serological Pipets
Power Supply, p. 155
Vertical Electrophoresis Chambers, pp. 134–135
Mini-PROTEAN TGX polyacrylamide gels, 4–20%, 10-well, p. 138
Microcentrifuge with variable speed setting (up to 16,000 x g), p. 148

* Hand-packed and prepacked column processes require chromatography instrumentation

Chromatography Instrumentation Process Only:

500 ml Erlenmeyer Flasks
Shaking Incubator or Shaking Water Bath capable of holding 4 x 500 ml flasks
Centrifuge capable of 16,000 x g with rotors that hold 250 ml centrifuge bottles and 30–50 ml centrifuge tubes
Centrifuge Bottles (250 ml) capable of withstanding 4,500 x g
Centrifuge Tubes (30–50 ml) capable of withstanding 16,000 x g

Hand-Packed Column Process Only:

Flow Adaptor, 1.0 cm column ID, 1–7 cm functional length (#7380014EDU)

Recommended (Optional) Accessories:

Autoclave
Vortexer, p. 149
Gel Documentation System, pp. 146–147
50 ml Tube Racks, set of 5 racks, p. 156

Refresh Kit Components:
Please visit explorer.bio-rad.com and download bulletin 1665067 for more information.

Growth and Expression Module

As part of the Protein Expression and Purification series

To be used for research, industrial, or pharmaceutical purposes, proteins need to be purified in large quantities. Some proteins can be easily extracted from a readily available source in large quantities. However, most proteins are not naturally produced in a form and in amounts that allow easy purification. The techniques of genetic engineering overcome the limitations of naturally produced proteins by making cells synthesize specific proteins in amounts that can be purified for use in fundamental research or for industrial and therapeutic applications.

The starting point in the Protein Expression and Purification Series is lyophilized BL21(DE3) *E. coli* containing pDHFR, which will be rehydrated and plated to generate individual colonies. An initial culture is grown to saturation from a single colony. This culture is used to initiate a larger culture that is grown to mid-log phase, at which stage expression of the recombinant protein is induced by addition of IPTG to the medium. After induction has been completed, cells are recovered by centrifugation, and protein is extracted from the cell pellet.

On your own:
Delve into protein expression using the pDHFR plasmid and see how glucose affects the lac operon system so that no T7 RNA polymerase and subsequent GST-DHFR-His is leaked. Explore the effects of IPTG concentration on induction levels.

Kit supports 4–12 student workstations, depending on the size of the cultures used.

Growth and Expression Module
Catalog # **1665055EDU**

Ships at room temperature. Immediately store temperature sensitive reagents bag at –20°C as indicated.

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.

Lab Preparation Checklist

Kit contains sufficient materials for 4–12 student workstations, depending on the size of cultures used.

2 ml EZ Micro Test Tubes (microcentrifuge), clear	500
Petri Dishes	20
Inoculation Loops, sterile	20
Sterile Conical Tubes, 50 ml	25
Screwcap Microcentrifuge Tubes, 1.5 ml	50
Ampicillin, lyophilized	2
LB Nutrient Agar Powder	1
LB Broth Capsules	12
Lysozyme, lyophilized	1
E. coli Strain BL21(DE3) containing pDHFR, lyophilized	1
IPTG, 1 M, 0.1 ml	1
10x PBS, 100 ml	1
Imidazole Stock Solution, 200 ml	1
20% Sterile Glucose, 4 ml	1
Sterile Water, 2.5 ml	1
Instruction Manual	1

Required Accessories Not Included in Kit:

Adjustable Micropipets, 2–1,000 µl, pp. 152–153	1–12
Pipet Tips, 2–1,000 µl, p. 154	1–12
Pipet Controller, p. 153	1
10 ml Serological pipets	
Spectrophotometer	1
Semi-microvolume Cuvettes, p. 156	
Water Bath, p. 150	1
Incubator and Tube Roller, Shaking Water Bath, or Shaking Incubator pp. 148–151	2–4
Autoclave, Microwave, or Hot Plate and Stir Bar	
Dry Ice/ethanol	
16K Microcentrifuge, p. 148	1–12
10 ml Syringes and 22 Gauge Syringe Needles	

Recommended (Optional) Accessories:

Vortexer, p. 149	1–12
Dry bath, p. 150	1–12

Refresh Kit Components: (more info pp. 157–159)
Growth and Expression Reagent Refill Pack (#1665057EDU) includes ampicillin, LB agar, LB capsules, lysozyme, BL21(DE3) with pDHFR, IPTG, sterile water, 10x PBS, imidazole stock solution, and 20% sterile glucose solution

SDS-PAGE Electrophoresis Module

SDS-PAGE Electrophoresis Module:
As part of the Protein Expression and Purification series

In this lab, the induced expression of GST-DHFR-His, solubility of the expressed GST-DHFR-His, and **success of purification will be analyzed by SDS-PAGE**.

Kit supports 12 student workstations.

SDS-PAGE Electrophoresis Module
Catalog # **1665060EDU**

Ships at room temperature. Precision Plus Protein Dual Color standards should be stored at –20°C. All other reagents should be stored at room temperature.

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.

On your own:
Save time and money running SDS-PAGE gels using the highest quality standards and buffers available. Check out the long shelf life Mini-PROTEAN TGX precast gels that can run up to 30% faster and have up to a 12-month shelf life.

Lab Preparation Checklist

Kit contains sufficient materials sufficient materials for 12 student workstations.

10x Tris/glycine/SDS Buffer, 1 L	1
Laemmli Sample Buffer, 30 ml	1
Bio-Safe Coomassie Stain, 1 L	1
Precision Plus Protein Dual Color Standards, 500 µl	1

Required Accessories Not Included in Kit:
Vertical Gel Electrophoresis Chambers, pp. 134–135
Mini-PROTEAN TGX Polyacrylamide Gels, 4–20%, 10-well, p. 138
Water Bath or Dry Bath, p. 150
Adjustable Micropipets, pp. 152–153
Pipet Tips, p. 154
Power Supplies, p. 155
Gel Staining Trays, p. 157

Recommended (Optional) Accessories:
16K Microcentrifuge, p. 148
Gel Documentation System, pp. 146–147

Three Purification Module Options

Purification Module: As part of the Protein Expression and Purification series

Protein purification is an important step in biotechnology workflows. It is the isolation of a protein of interest so that it may be used in subsequent research, for diagnostic tests, or for pharmaceutical production. The purity needed depends on the protein's end use. For proteins used in research, 90–95% purity may be sufficient, but for proteins used for pharmaceutical applications, much higher purity levels (up to 99.99%) must be reached. How purification is done will depend on the type of protein engineered, the volume of protein to be purified, the degree of purity required, and the availability of special laboratory equipment. Each of these purification modules will allow you to purify GST-DHFR-His using affinity chromatography. Which module you choose depends on the experience you want your students to have and the equipment that you have on hand. Choose the centrifugation purification module to learn about spin column chromatography using a 16K microcentrifuge. If you have chromatographic purification instrumentation such as Bio-Rad's BioLogic LP or NGC chromatography systems, then the hand-packed purification and prepacked purification modules are for you!

On your own:
For independent research opportunities use these modules to purify any polyhistidine tagged proteins. See how each protein behaves differently and has a different purification profile.

Protein Purification Is Essential!

Kit supports 12 student workstations.

Option 1: Centrifugation Purification
Catalog # **1665041EDU**

Kit supports 4 student workstations.

Option 2: Chromatography Instrumentation Hand-Packed Column Purification
Catalog # **1665046EDU**

Kit supports 4 student workstations.

Option 3: Prepacked Cartridge Purification
Catalog # **1665051EDU**

Each module ships at room temperature. Store at 4°C.

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.

Lab Preparation Checklist

Kit contains sufficient materials for 4–12 student workstations, depending on which process is used.

Centrifugation Purification Module	
Profinity IMAC Ni-charged Resin, 1.5 ml	1
Micro Bio-Spin Empty Columns	12
Micro Bio-Spin 6, Tris Columns	12
Screwcap Microcentrifuge Tubes, 1.5 ml	50
Spin Column Wash Tubes	25
Hand-Packed Column Purification Module	
Profinity IMAC Ni-charged resin, 10 ml	1
1.0 cm x 5 cm, 2-pk glass Econo-Column Columns	2
Micro Bio-Spin 6, Tris columns	25
Prepacked Cartridge Purification Module	
Bio-Scale Mini Profinity IMAC cartridge	4
Micro Bio-Spin 6, Tris columns	25

Required Accessories Not Included in Kit:
16K Microcentrifuge, p. 148
Water Bath or Dry Bath, p.150
Adjustable Micropipets and Tips, pp. 152–154
Tube Roller or Rocker Platform, p. 149
UV Spectrophotometer
UV Compatible Cuvettes, p. 156
NGC Medium Pressure or BioLogic LP Chromatography System, (required only for hand-packed column and prepacked cartridge purification modules), p. 141

Recommended (Optional) Accessories:
Bench Top Centrifuge
Cuvette Racks, set of 5 racks (#1660485EDU)

Three Purification Module Options

DHFR Enzymatic Assay Module:
As part of the Protein Expression and Purification series

Dihydrofolate reductase (DHFR) is a critical enzyme necessary for the conversion of dihydrofolate (DHF) to tetrahydrofolate (THF). This reaction also requires the presence of the cofactor nicotinamide adenine dinucleotide phosphate (NADPH). The concentration of purified GST-DHFR-His will be calculated using the proteins' intrinsic absorbance of UV light at 280 nm. This known concentration of GST-DHFR-His will be combined with a known quantity of NADPH, which absorbs at 340 nm. Since no DHF substrate is present, the NADPH should not be reduced and the absorbance at 340 nm should be constant over time. Once the substrate DHF is added to the solution containing the purified GST-DHFR-His and NADPH, the absorbance at 340 nm should decrease over time as the reaction occurs, converting NADPH to NADP+ and DHF to THF.

Kit supports 12 student workstations.

DHFR Enzymatic Assay Module
Catalog # **1665065EDU**

Ships on blue ice. Immediately store at –20°C.

Educational discounts apply only to items ordered with an EDU suffix. EDU price discounts are for qualified educational institutions and educators only.

Lab Preparation Checklist

Kit contains sufficient materials for 12 student workstations.

Dihydrofolic Acid Substrate (DHF), 1 mg	1
NADPH, cofactor, 1 mg	1

Required Accessories Not Included in Kit:
Adjustable Micropipets, pp. 152–153
Pipet Tips, p. 154
UV Spectrophotometer capable of three decimal place accuracy
UV Compatible Cuvettes, p. 156
Parafilm

Recommended (Optional) Accessories:
Cuvette Racks, set of 5 racks (#1660485EDU)

On your own:
Measure the activity of any DHFR enzyme with this module. Perfect for use with independent research to determine what happens if the DHFR source is changed or the actual enzyme is mutated. What effects will these changes have on DHFR activity?

Biotechnology: A Laboratory Skills Course — Textbook

Section Contents

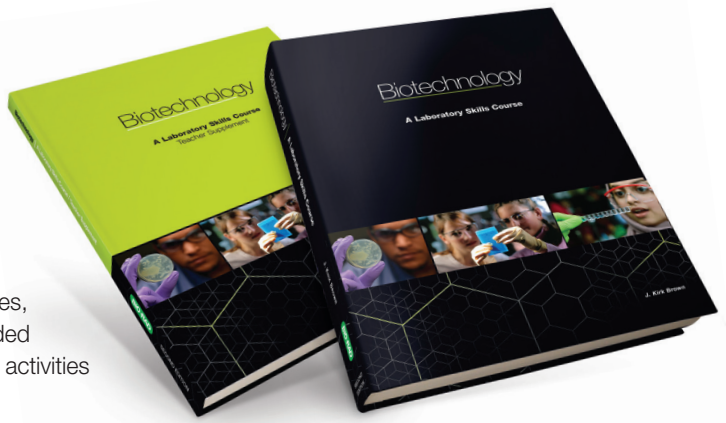
Biotechnology: A Laboratory Skills Course — Textbook

"The Biotechnology: A Laboratory Skills Course textbook has been the cornerstone of my students' success on our state certification exam."

Jeff Bush
Vero Beach High School
Melbourne Beach, FL

Bio-Rad Explorer Teacher and Student Alumni

Biotechnology: A Laboratory Skills Course, second edition



Starting a biotechnology course has never been easier!
Biotechnology: A Laboratory Skills Course is a ready-to-go solution for your biotechnology course, or to start a new one right away! This laboratory textbook provides you and your students with background information about the methods and techniques used in today's exciting research and manufacturing laboratory environments.

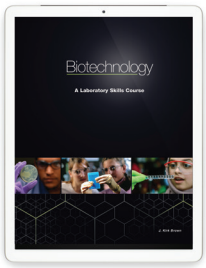
36 activities provide the backbone for this textbook. Foundational activities, such as pipetting and solution making, address core competencies needed in all areas of a molecular biology laboratory. Intermediate and advanced activities build key skills such as electrophoresis, PCR, and immunoassays.

Student Edition: Over 400-page combined textbook and lab manual includes both background and laboratory protocols. The student edition provides essential biology review points, detailed lab skill descriptions, 36 hands-on activities, and a guide for students to understand how they can be evaluated for skills proficiency.

Each student chapter includes:

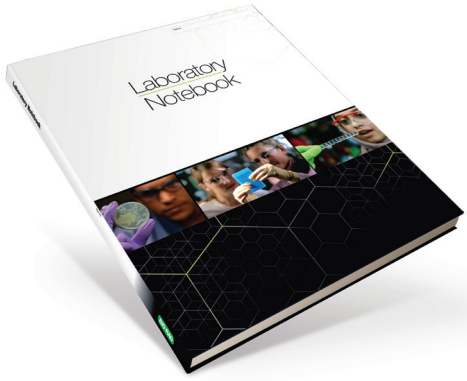
- An introduction and background of fundamental molecular biology concepts
- Real-world vignettes about careers, bioethics, key skills, and case studies
- Hands-on activities that progressively build science proficiency
- A self-evaluation guide for students to assess their own skill development

Table of Contents



Now available in digital format!
All the exciting cutting edge science in the student edition is now available in digital format. Visit **bio-rad.com/ebook** for more information about features and ordering.

Teacher Supplement: Over 200-page softcover book to guide you through setup and assessment of the textbook activities. The teacher supplement includes activity preparation, pacing and stopping points, materials lists, skills assessment, question answers, and more. Supplemental teaching materials including presentation slides, images, and training videos are available free online.



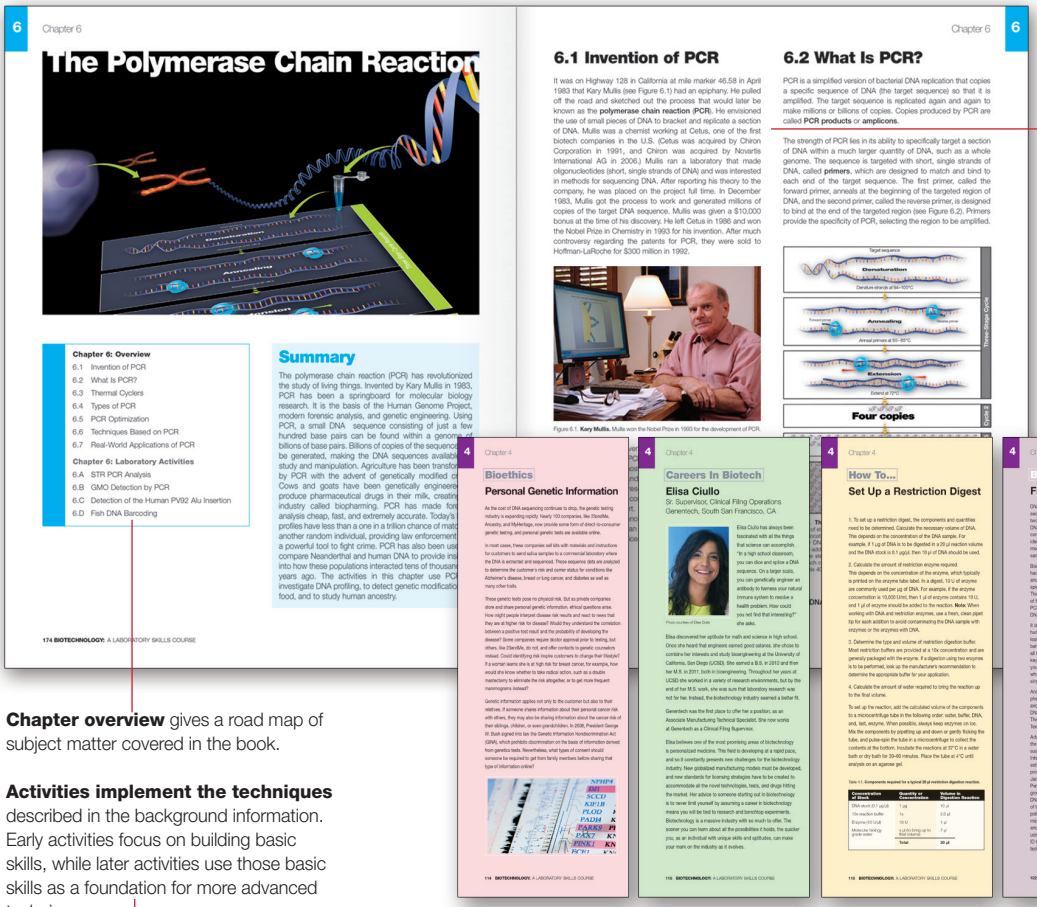
Laboratory Notebook

- 200 pages (includes signature page, table of contents pages, and pages with gridlines for record keeping)
- Preprinted spaces for proper documentation, control, and traceability

Visit **bio-rad.com/textbook** for more information.

Ordering Information

Description	Catalog #
Biotechnology: A Laboratory Skills Course Textbook, second edition	
Teacher edition, includes one student edition hardcover textbook and one teacher supplement	17004717EDU
Student Edition	12008528EDU
Teacher Supplement	12008527EDU
Laboratory Notebook	1661051EDU
Laboratory Notebook, classroom set of 32	1661053EDU
Digital edition — Visit bio-rad.com/ebook for ordering information	



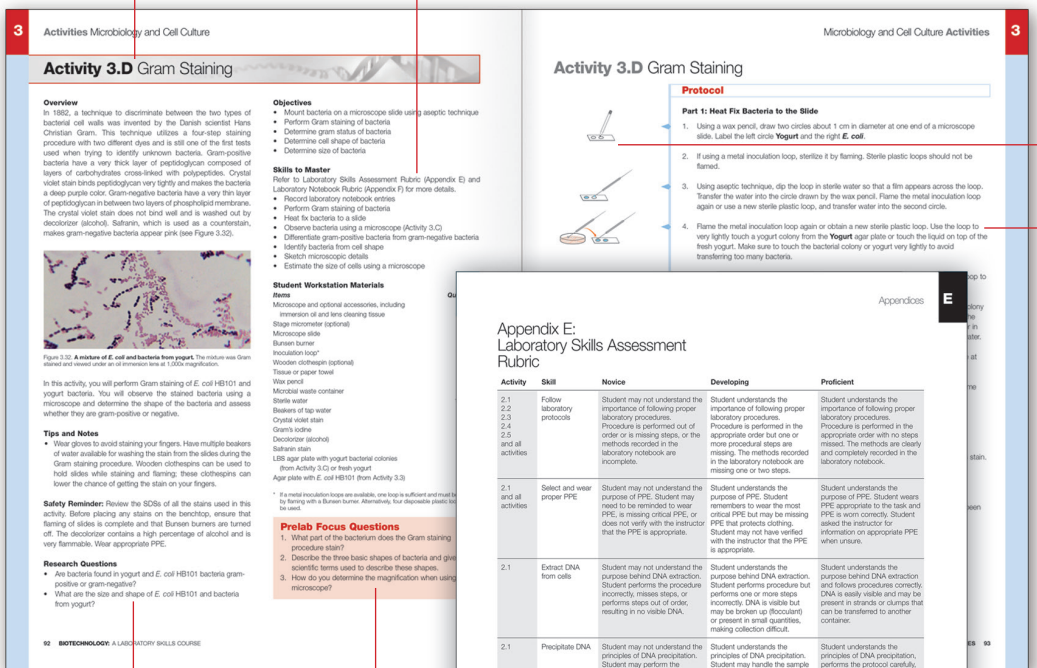
Chapter overview gives a road map of subject matter covered in the book.

Activities implement the techniques described in the background information. Early activities focus on building basic skills, while later activities use those basic skills as a foundation for more advanced techniques.

Background sections for each chapter include biological theory behind the techniques and descriptions of the techniques themselves.

Essay questions follow the background section for each chapter and act as starting points for independent literature research beyond the textbook.

Four types of vignettes show how biotechnology concepts covered in the chapter play a role in our daily lives. Vignette topics include discussions about bioethics, careers, spotlights on key skills, and real-life case studies.



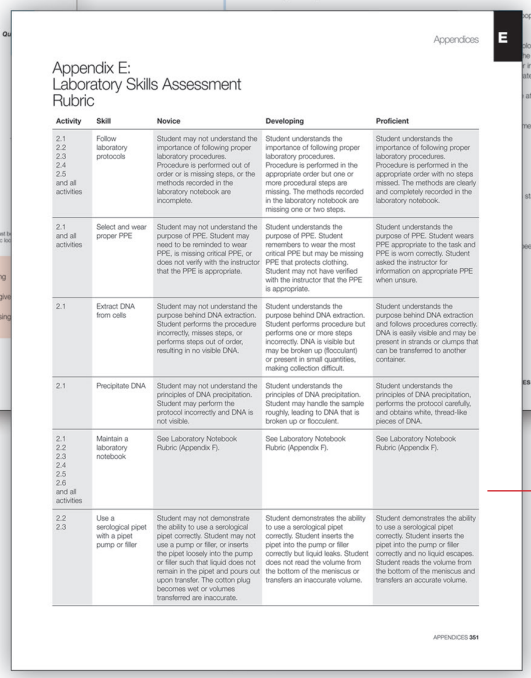
Laboratory skills are acquired by performing the activity. The requirements necessary to claim proficiency in those skills are described in the Laboratory Skills Assessment Rubric in Appendix E.

Graphics illustrate the hands-on activities to help students learn techniques.

Step-by-step protocols lead students through procedures and provide guidance on results analysis.

Research questions and objectives outline the experiments.

Prelab focus questions ensure students' understanding of the activity, and postlab focus questions help students analyze their results and generate conclusions.

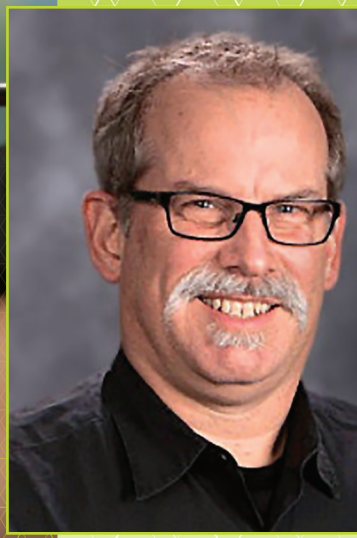


Assessment rubrics help students understand what is expected of them and how to proficiently complete a task.


BIO-RAD
Mini-Sub Cell GT

Section Contents

Instructional Laboratory Equipment Sets



"The gift that Bio-Rad labs give me is flexibility. I can take the protocol, follow it, and get perfect results. To bring additional concepts into focus, I can modify the protocol and still get the same stellar results."

Jamie Allison
Loveland High School and
GrowNextGen, Loveland, OH

Bio-Rad Explorer Teacher and Student Alumni

Advanced Biotechnology Lab Equipment Set

This equipment package supports all Bio-Rad Explorer kits and most biotechnology and molecular biology laboratory applications. For 220/230 V equipment sets, contact your local Bio-Rad representative or sales office.

Includes:

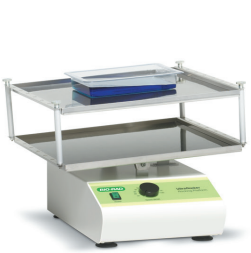
8 Mini centrifuge
1 TPC Tempo thermal cycler*
1 UltraRocker rocking platform
1 Incubation oven
1 Water bath
1 Benchtop shaking incubator expanded set (Includes one petri dish shelf and clamps for 4 x 1,000 ml, 5 x 500 ml, 9 x 250 ml, and 16 x 125 ml flasks)
1 Tube roller
2 Digital dry bath
2 Trans-Blot Turbo transfer system
1 Professional pipet controller
1 Package agarose gel support film, 50
1 BR-2000 vortexer
4 PowerPac Basic power supply
8 Mini-Sub cell GT electrophoresis chamber (each cell includes one 7 x 10 cm tray and two 8-well combs)
8 10-well gel loading guide
8 Mini-PROTEAN Tetra cell 2-gel system for TGX precast gels
1 GelDoc Go imaging system*
1 MicroPulser electroporator
2 16K microcentrifuge
2 PCR tube adapter for the 16k microcentrifuge
8 UV lamp
8 Professional adjustable-volume micropipet, 0.5–10 µl
8 Professional adjustable-volume micropipet, 2–20 µl
8 Professional adjustable-volume micropipet, 20–200 µl
8 Professional adjustable-volume micropipet, 100–1,000 µl
10 Rack of pipet tips (2–200 µl), 200 tips/rack
10 Rack of pipet tips (100–1,000 µl), 100 tips/rack
5 Rack of Prot/Elec pipet tips (1–200 µl), 200 tips/rack
1 Jellyfish foam floats, pack of 8
2 Green racks, set of 5 racks
2 Storage boxes, set of 5 boxes, multicolored
2 96-place PCR-tube rack and cover, set of 5
4 Gel staining trays, pack of 4

* Varies depending on package chosen.

Ordering Information

Description	Catalog #	**with set of 32 textbooks (p. 100)** Catalog #
Advanced Biotechnology Lab Equipment Set (120 V) with easy-to-use GelDoc Go imaging system with UV sample tray	17006116EDU	17006134EDU
Advanced Biotechnology Lab Equipment Set upgraded with PTC Tempo Thermal Cycler (120 V) with dual 48/48 heat block and GelDoc Go imaging system with UV sample tray	Inquire	Inquire

This package is not available outside the U.S.



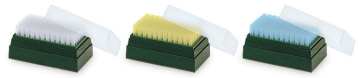






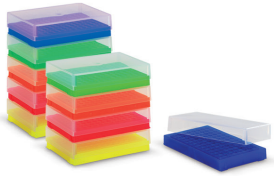
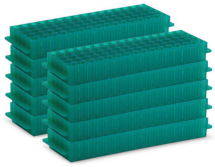






0.5–10 µl | 2–20 µl | 20–200 µl | 100–1,000 µl

Customize your equipment Sets

Contact your local account manager, who can help you mix and match equipment to create your own set. Be sure to ask about Bio-Rad's educational discount. Call **1-800-4BIORAD** to get started.

Complete Biotechnology Lab Equipment Set

This equipment set supports all Bio-Rad Explorer kits and most biotechnology and molecular biology laboratory applications. For 220/230 V equipment sets, contact your local Bio-Rad representative or sales office.

Includes:

4 Mini centrifuge
1 T100 thermal cycler*
1 UltraRocker rocking platform
1 Incubation oven
1 Water bath
1 Digital dry bath
1 16K microcentrifuge
1 PCR tube adaptors for the 16K microcentrifuge
1 UView Mini Transilluminator
1 Tube roller
1 BR-2000 vortexer
4 PowerPac Basic power supply
4 Mini-Sub cell GT electrophoresis chamber (each cell includes one 7 x 10 cm tray and two 8-well combs)
4 Mini-PROTEAN Tetra cell 2-gel system for TGX precast gels
4 Mini Trans-Blot module
4 10-well gel loading guide
8 UV lamp
1 Package agarose gel support film, 50
9 Professional adjustable-volume micropipet, 2–20 µl
9 Professional adjustable-volume micropipet, 20–200 µl
1 Professional adjustable-volume micropipet, 100–1,000 µl
2 Gel staining trays, pack of 4
1 Jellyfish foam floating racks, pack of 8
2 Green racks, set of 5
2 96-place PCR tube racks with covers, set of 5
10 Rack of pipet tips (2–200 µl), 200 tips/rack
10 Rack of pipet tips (100–1,000 µl), 100 tips/rack
5 Rack of Prot/Elec pipet tips (1–200 µl), 200 tips/rack

* Varies depending on package chosen.



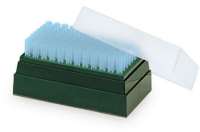












1,000
1–200 µl pipet tips

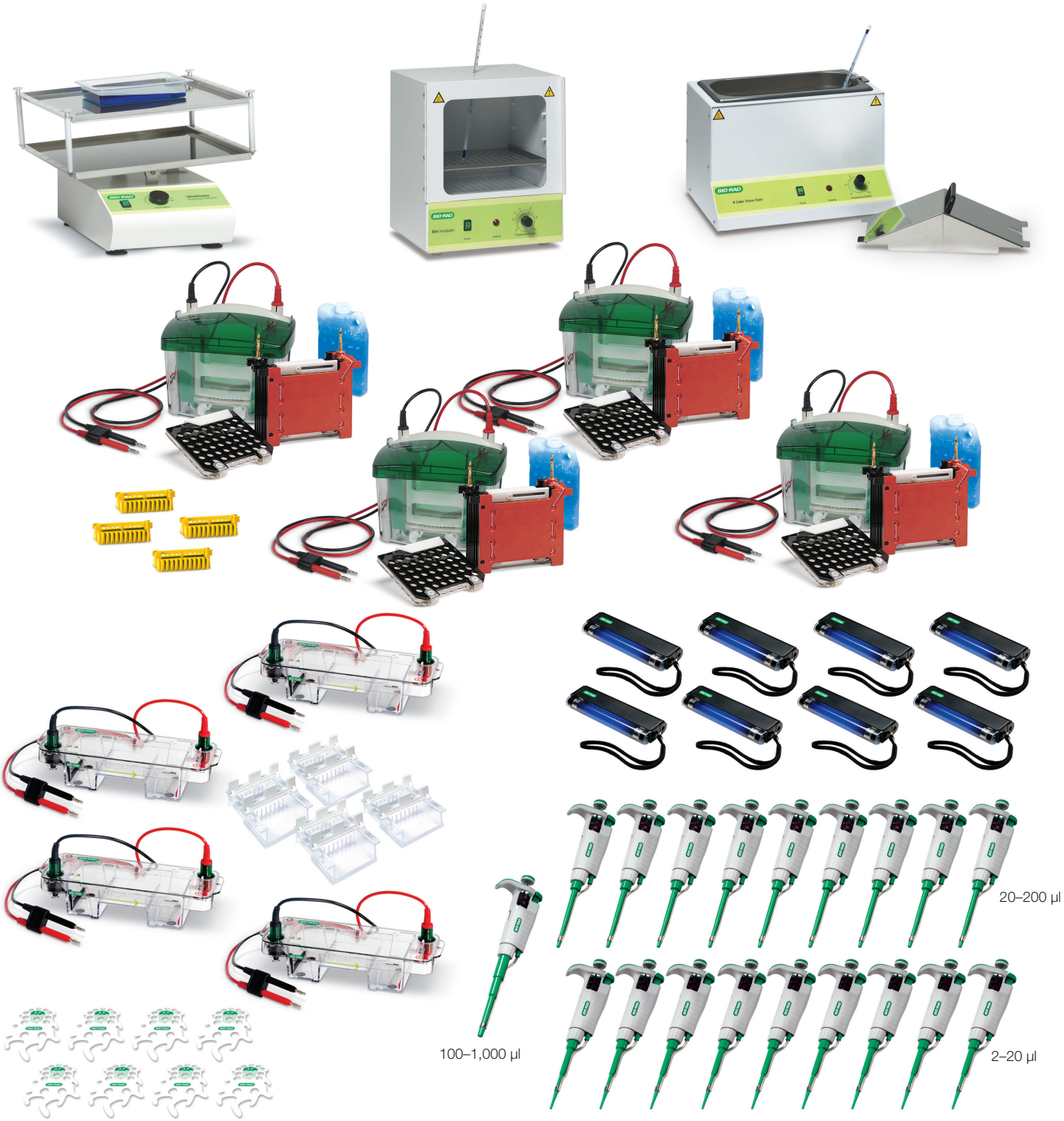
2,000
2–200 µl pipet tips

1,000
100–1,000 µl pipet tips

Ordering Information

Description	Catalog #	**with set of 32 textbooks (p. 100)** Catalog #
Complete Biotechnology Lab Equipment Set (120 V)	17006118EDU	17006133EDU
Complete Biotechnology Lab Equipment Set (120 V) Upgraded with PTC Tempo Thermal Cycler with dual 48/48 heat block	Inquire	Inquire

This package is not available outside the U.S.



Customize your equipment Sets

Contact your local account manager, who can help you mix and match equipment to create your own set. Be sure to ask about Bio-Rad's educational discount. Call **1-800-4BIORAD** to get started.

Basic Biotechnology Lab Equipment Set

Build up your biotechnology laboratory step by step with research-quality lab equipment sets. Provide the very best molecular biology experiences for your students, year after year. For 220/230 V packages contact your local Bio-Rad representative or office.

Includes:

2 PowerPac Basic power supply
1 Mini incubation oven
1 Water bath
1 UltraRocker rocking platform
8 UV lamp
2 Mini centrifuge
8 50 µl fixed-volume pipet
9 Classroom digital micropipet, 2–20 µl
1 Classroom digital micropipet, 20–200 µl
1 Classroom digital micropipet, 100–1,000 µl
4 Mini-Sub cell GT electrophoresis cell (each cell includes one 7 x 10 cm tray and two 8-well combs)
2 Mini-PROTEAN Tetra cell 2-gel system for TGX precast gels
2 10-well gel loading guide
10 Rack of pipet tips (2–200 µl), 200 tips/rack
10 Rack of pipet tips (100–1,000 µl), 100 tips/rack
5 Rack of Prot/Elec pipet tips (1–200 µl), 200 tips/rack
1 Package agarose gel support film, 50
2 Gel staining trays, pack of 4
1 Jellyfish foam floating racks, pack of 8
2 Green racks, set of 5

For custom package quotes to best suit your needs, please contact your local account manager.

Basic Biotechnology Lab Equipment Set supports the following skills:

- ELISA
- Bacterial transformation and culture
- DNA gel electrophoresis
- Protein gel electrophoresis
- DNA restriction digestion
- Pipetting

* Varies depending on package chosen.

Ordering Information

Description	Catalog #	**with set of 32 textbooks (p. 100)** Catalog #
Basic Biotechnology Lab Equipment Set (120 V)	17006120EDU	17006113EDU
Basic Biotechnology Lab Equipment Set Upgraded with Professional Pipets (120 V)	17006119EDU	17006114EDU

For 220/230 V packages contact your local Bio-Rad representative or office.

PCR Lab Equipment Set

Build up your PCR lab step by step with research-quality lab equipment sets. Provide the very best molecular biology experiences for your students, year after year. For 220/230 V packages contact your local Bio-Rad representative or office.

Includes:

1 T100 thermal cycler*
1 PowerPac Basic power supply
2 Mini centrifuge
1 Digital dry bath
9 Classroom digital micropipets, 2–20 µl
1 Classroom digital micropipet, 20–200 µl
1 Classroom digital micropipet, 100–1,000 µl
4 Mini-Sub cell GT electrophoresis cells (each cell includes one 7 x 10 cm tray and two 8-well combs)
1 Gel staining trays, pack of 4
1 Green racks, set of 5 racks

For custom package quotes to best suit your needs, please contact your local account manager.

PCR Lab Equipment Set supports the following skills:

- PCR
- DNA gel electrophoresis
- DNA restriction digestion
- DNA Extraction
- Pipetting

Customize your equipment Sets

Contact your local account manager, who can help you mix and match equipment to create your own set. Be sure to ask about Bio-Rad's educational discount. Call **1-800-4BIORAD** to get started.

* Varies depending on package chosen.

Ordering Information

Description	Catalog #
PCR Lab Equipment Set (120 V)	17004232EDU
PCR Lab Equipment Set Upgraded with Professional Pipets (120 V)	17004212EDU
PCR Lab Equipment Set Upgraded with PTC Tempo Thermal Cycler (120 V) with dual 48/48 heat block and Professional Pipets	Inquire

For 220/230 V packages contact your local Bio-Rad representative or office.

DNA Electrophoresis Starter Lab Equipment Set

Build up your biotech lab step by step with research-quality electrophoresis lab sets. Provide the very best molecular biology experiences for your students, year after year. Add modules as your program grows.

* Varies depending on package chosen.

Includes:

1 PowerPac Basic power supply
4 Classroom digital micropipet, 2–20 µl range
2 Mini-Sub cell GT system — each system includes gel tank with easy-to-replace electrode cassettes, lid with 3 ft power leads, 7 x 10 cm UV-transparent gel tray with fluorescent ruler, and two 8-well fixed-height drop-in combs for ease in casting gels
1 Gel staining trays, pack of 4

Ordering Information

Description	Catalog #
DNA Electrophoresis Starter Lab Equipment Set	17004213EDU
DNA Electrophoresis Starter Lab Equipment Set with Upgraded Pipets	17004214EDU

DNA Electrophoresis Lab Equipment Sets support instruction of the following skills:
- DNA gel electrophoresis
- Restriction digest analysis
- Pipetting

DNA Electrophoresis Expanded Lab Equipment Set

* Varies depending on package chosen.

Includes:

2 PowerPac Basic power supply
9 Classroom digital micropipet, 2–20 µl range
1 Classroom digital micropipet, 20–200 µl range
1 Classroom digital micropipet, 100–1,000 µl range
1 Digital dry bath
8 Mini-Sub cell GT system — each system includes gel tank with easy-to-replace electrode cassettes, lid with 3 foot power leads, 7 x 10 cm UV-transparent gel tray with fluorescent ruler, and two 8-well fixed-height drop-in combs for ease in casting gels
2 Gel staining trays, pack of 4
2 Green racks, set of 5 racks

For custom package quotes to best suit your needs, please contact your local account manager.

Ordering Information

Description	Catalog #
DNA Electrophoresis Expanded Lab Equipment Set (120V)	17004215EDU
DNA Electrophoresis Expanded Lab Equipment Set with Upgraded Pipets (120V)	17004207EDU

Protein Electrophoresis Starter Lab Equipment Set

Includes:

1 PowerPac Basic power supply
4 Classroom digital micropipet, 2–20 µl range
2 Mini-PROTEAN Tetra cell 2-gel system for TGX precast gels includes electrode assembly, tank, lid with power cables, mini cell buffer dam
2 10-well gel loading guide
1 Gel staining trays, pack of 4

* Varies depending on package chosen.

Ordering Information

Description	Catalog #
Protein Electrophoresis Starter Lab Equipment Set	17004208EDU
Protein Electrophoresis Starter Lab Equipment Set with Upgraded Pipets	17004209EDU

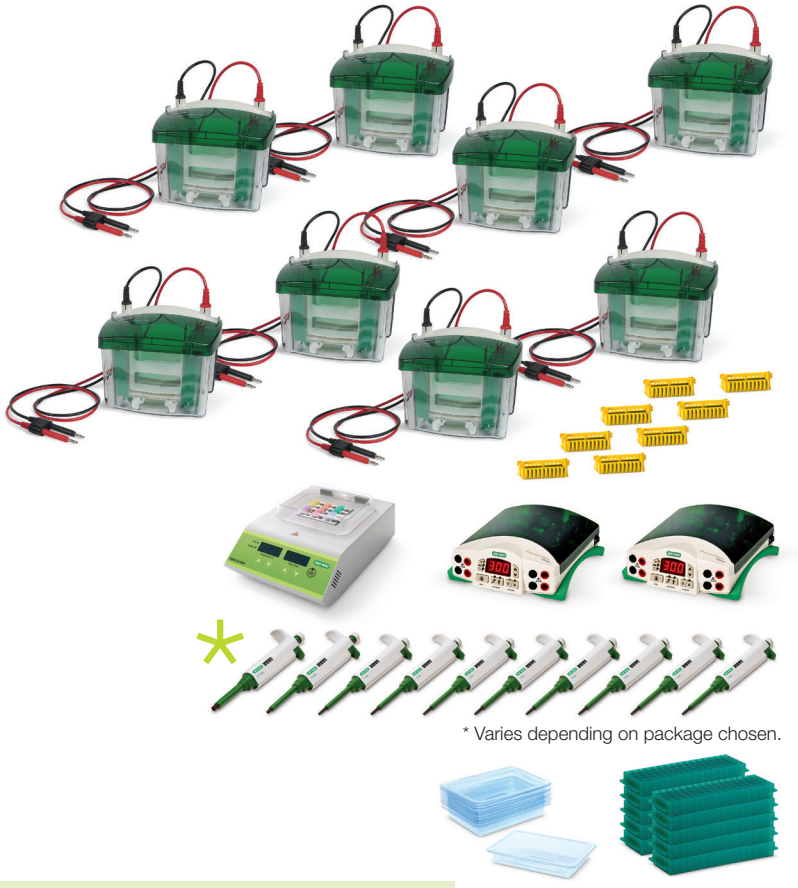
Protein Electrophoresis Lab Equipment Sets support instruction of the following skills:
- Protein gel electrophoresis
- Pipetting

Protein Electrophoresis Expanded Lab Equipment Set

Includes:

2 PowerPac Basic power supply
9 Classroom digital micropipet, 2–20 µl range
1 Classroom digital micropipet, 20–200 µl range
1 Classroom digital micropipet, 100–1,000 µl range
1 Digital dry bath
8 Mini-PROTEAN Tetra cell 2-gel system for TGX precast gels; includes electrode assembly, tank, lid with power cables, mini cell buffer dam
8 10-well gel loading guide
2 Gel staining trays, pack of 4
2 Green racks, set of 5 racks

For custom package quotes to best suit your needs, please contact your local account manager.



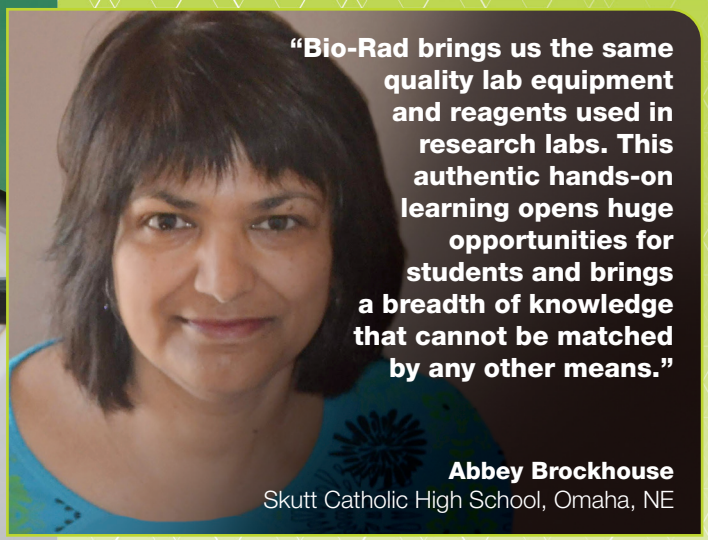
* Varies depending on package chosen.

Ordering Information

Description	Catalog #
Protein Electrophoresis Expanded Lab Equipment Set (120V)	17004210EDU
Protein Electrophoresis Expanded Lab Equipment Set with Upgraded Pipets (120V)	17004211EDU

Section Contents

DNA and Genomic Studies: Equipment and Reagents



"Bio-Rad brings us the same quality lab equipment and reagents used in research labs. This authentic hands-on learning opens huge opportunities for students and brings a breadth of knowledge that cannot be matched by any other means."

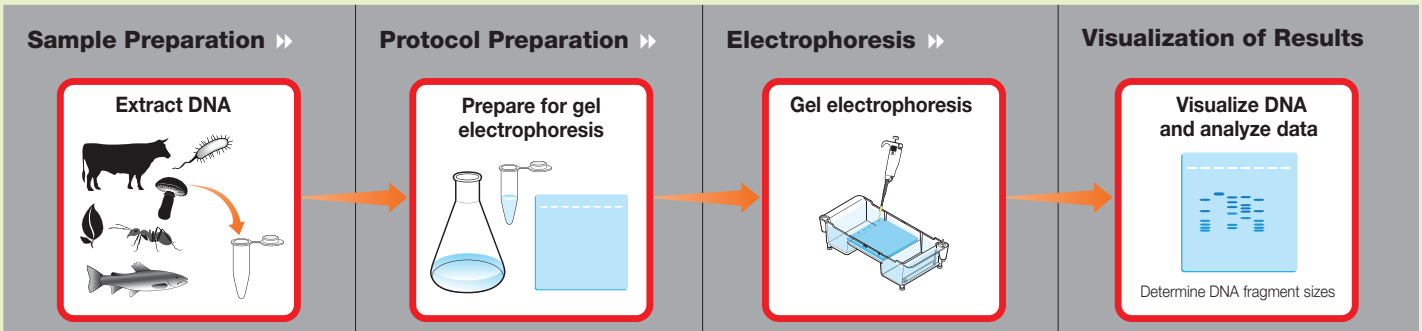
Abbey Brockhouse
Skutt Catholic High School, Omaha, NE

Bio-Rad Explorer Teacher and Student Alumni

DNA Gel Electrophoresis Workflow

DNA electrophoresis is a core technique in molecular biology used to separate pieces of DNA by size. It is used in myriad applications including gene cloning, forensic analysis, DNA barcoding, and diagnostics.

Bio-Rad Explorer DNA Analysis and Agarose Gel Electrophoresis Kits contain all the reagents necessary to perform these steps.



DNA Extraction
- InstaGene Matrix (p. 128)
- DNA Extraction Module (p. 128)

Samples may also be the products of PCR (see PCR workflow, p. 115)

Preparation of Samples
- DNA Electrophoresis Size Standards (p. 121)
- UView Loading Dye and Stain (p. 122)

Preparation of Electrophoresis Gels and Buffers
- Precast Agarose Gels (p. 120)
- Agarose Powders (p. 119)
- DNA Electrophoresis Reagent Packs (p. 119)
- DNA Electrophoresis Buffers (p. 120)

Agarose Gel Electrophoresis
- Horizontal Gel Electrophoresis Systems (p. 117)
- PowerPac Power Supplies (p. 155)

Run your agarose gels in 10 minutes using Bio-Rad's fast gel protocol. Refer to bulletin 5396.

Each PowerPac power supply can connect up to 4 electrophoresis cells.

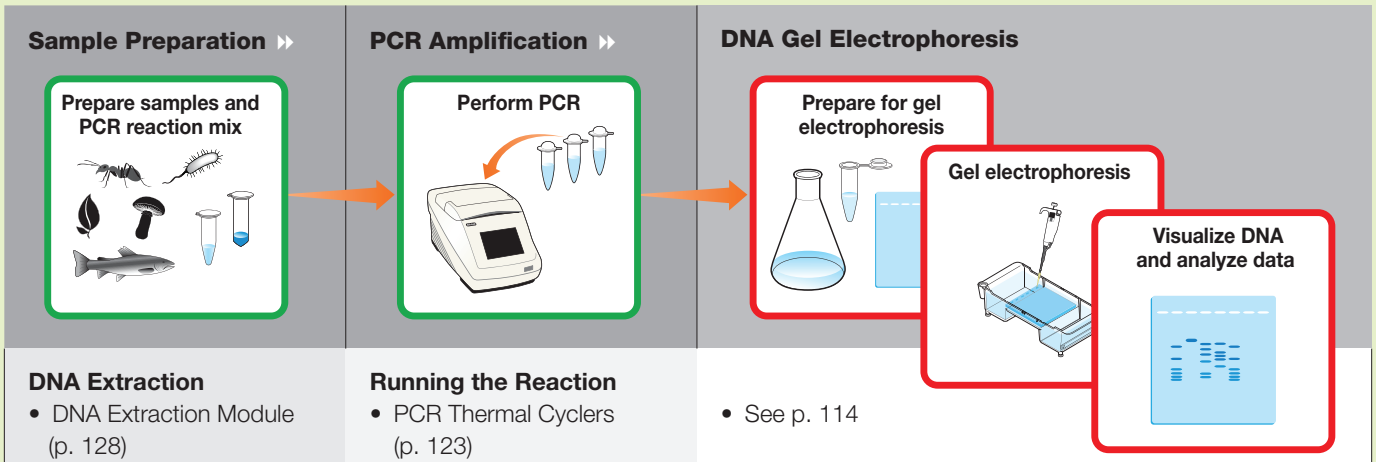
Visualization of DNA Fragments
- DNA Stains (p. 122)
- Gel Imaging and Documentation (p. 146)

Other Downstream Applications
- Purifications
- Restriction Digestion
- Sequencing
- Other

PCR Workflow

Polymerase chain reaction (PCR) amplification allows researchers to make more copies of specific pieces of DNA for diagnostic and engineering applications.

Bio-Rad Explorer PCR Amplification Kits contain all the reagents neccessary to perform these steps.



DNA Extraction

- DNA Extraction Module (p. 128)
- InstaGene Matrix (p. 128)
- Quantum Prep Plasmid Miniprep Kit (p. 128)
- Aurum Plasmid Mini Purification Kit (p. 128)
- PCR Kleen Spin Purification Columns (p. 128)

Preparation of Samples for PCR

- PCR Plastic Supplies (p. 124)
- Amplification/PCR Reagents (p. 129)

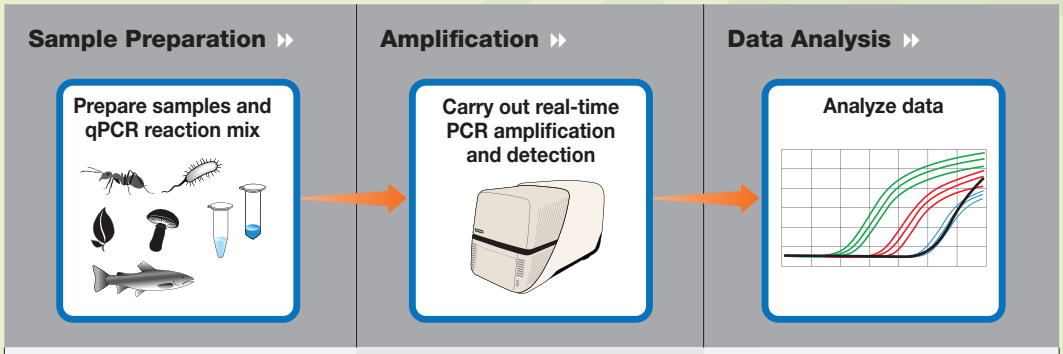
Running the Reaction

- PCR Thermal Cyclers (p. 123)

- See p. 114

Real-Time PCR Workflow

Real-time PCR, also known as quantitative PCR (qPCR), enables simultaneous amplification of a target DNA molecule. It is an extremely powerful technology for not only determining which DNA is present but also how much. Bio-Rad Explorer Real-Time PCR Kits contain all the reagents necessary to perform these steps; see p. 80. To learn more about our solutions for teaching real-time PCR, refer to Bulletin 3332.



DNA Extraction
- DNA Extraction Module (p.128)
- Instagene Matrix (p. 128)
- Total RNA Isolation: Aurum Total RNA Mini Kit (p. 128)

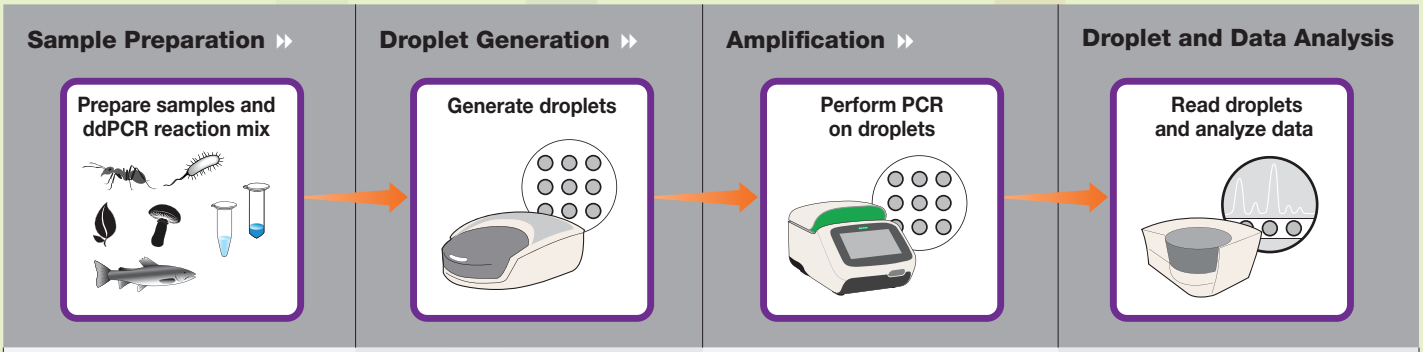
Preparation of Samples for PCR
- PX1 PCR Plate Sealer (Optional) (p. 125)
- PCR Plastic Supplies (p. 124)
- SsoAdvanced Universal SYBR® Green Supermix (p. 129)

Performing Real-Time PCR
- Real-Time PCR Detection Systems (p. 125)

Data Analysis
- CFX Maestro Software (p. 125)

Droplet Digital PCR™ (ddPCR™) Workflow

Droplet Digital PCR (ddPCR) provides the highest levels of sensitivity as well as absolute quantification, enabling simultaneous detection and quantification without the need for a standard curve. ddPCR makes PCR "digital" by partitioning samples into tiny droplets prior to amplification. To learn more about our solutions for teaching ddPCR, refer to Bulletin 3333.



DNA Extraction
- DNA Extraction Module (p. 128)
- Instagene Matrix (p. 128)
- Total RNA Isolation: Aurum Total RNA Mini Kit (p. 128)
- ddPCR Reagents and Kits

Droplet Generation
- QX200 Droplet Generator (p. 126)
- QX200 Droplet Generation Oil
- DG8 Cartridge and Gasket

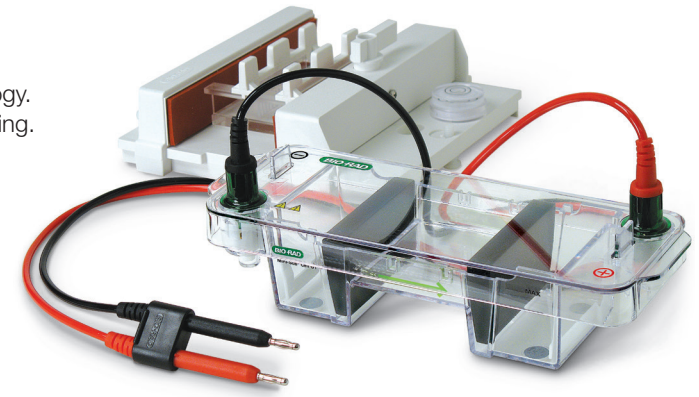
Amplification of Targets
- PX1 PCR Plate Sealer (p. 125)
- PTC Tempo Deep-Well System (p. 123)
- PCR Plastic Supplies (p. 124)

Reading Droplets
- QX200 Droplet Plate Reader (p. 126)
- Droplet Reader Oil

Horizontal DNA Electrophoresis Gel Boxes

Agarose gel electrophoresis is a primary procedure in molecular biology. Designed for research, our Mini-Sub cell GT gel boxes are the real thing.

Teaching applications include:
- Out of the Blue Genotyping Extension, pp. 18–19
- Science of Opioid Dependence Kit, pp. 66–67
- IDEA kit, pp. 64–65
- Forensic DNA fingerprinting kit, pp. 68–69
- Lambda DNA restriction digestion and analysis kits, pp. 70–71
- Crime Scene Investigator PCR Basics kit, pp. 74–75
- PV92 PCR informatics kit, pp. 76–77
- DNA barcoding kit, pp. 10–11
- GMO Investigator kit, pp. 78–79
- Cloning and Sequencing Explorer series, pp. 82–91



Mini-Sub Cell GT Cell
with optional casting gates and Mini-Gel Caster

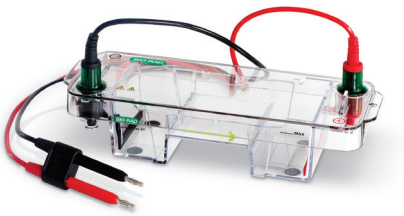
Mini-Sub and Wide Mini-Sub Cell GT Cells

Fast and flexible, the Mini-Sub cell GT cell is our most popular classroom gel box. The Min-Sub cell GT cell will hold either a 7 x 7 cm or a 7 x 10 cm gel tray. A 10 cm gel poured with two 8-well combs (see photo below) easily accommodates two student teams at a time. The wide Mini-Sub cell GT cell provides a larger (15 cm) platform to handle more samples. Using the 15- or 20-well combs, this cell has two to four times more sample capacity than the Mini-Sub cell. Put a whole class on one gel!

Wide Mini-Sub Cell GT Cell
runs up to four student groups' samples at once.

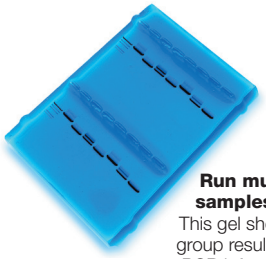
ReadySub-Cell GT Cells

ReadySub-Cell GT gel boxes are similar to our Mini-Sub cells GT but are dedicated to running ReadyAgarose precast gels (p. 120). ReadyAgarose gel trays lock into the ReadySub-Cell GT chambers so that gels will not move or float during electrophoresis runs. Available in both mini and wide mini sizes, ReadySub-Cell systems offer economy, consistency, and the utmost convenience.



Mini ReadySub Cell GT Cell
runs two student groups' samples at once.

Additional supplies:
- Power supplies, p. 155
- ReadyAgarose precast gels, agarose powders, and DNA electrophoresis reagents pp. 119–120
- DNA size standards, p. 121
- DNA stains, p. 122



Run multiple group samples on one gel!
This gel shows two student group results from the PV92 PCR informatics kit (p. 76).

Mini-Sub Cell GT Cell Features

Easy-to-clean electrodes — QuickSnap electrodes are easy to remove and simplify cleaning

Leakproof system — electrode design prevents buffer leaks from the base

Intuitive setup — arrow on the side of the base indicates the direction of the run, ensuring proper gel orientation

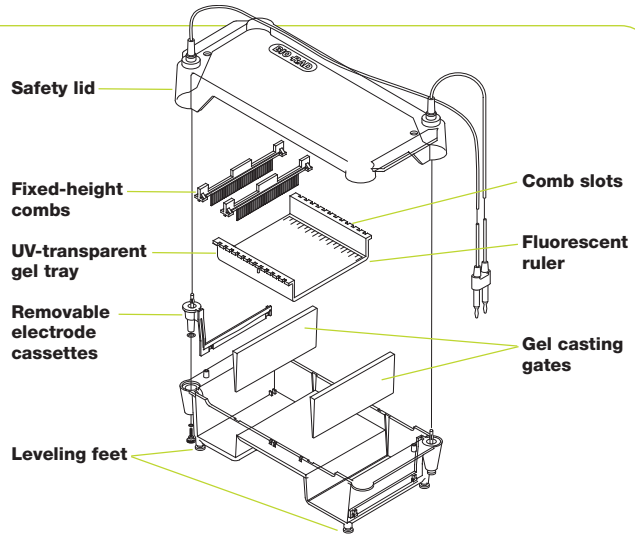
Simple assembly — color-coded, labeled electrodes and labeled base guarantee correct positioning of the lid on the base

Easy lid removal — longer tabs on the base prevent incorrect lid positioning and enable easy removal of the lid, reducing buffer spillage

Flexible design — UV-transparent gel trays, combs, and other accessories are compatible with both new and old models

Environmentally friendly system — less plastic is used in manufacturing the redesigned model and results in a more durable system

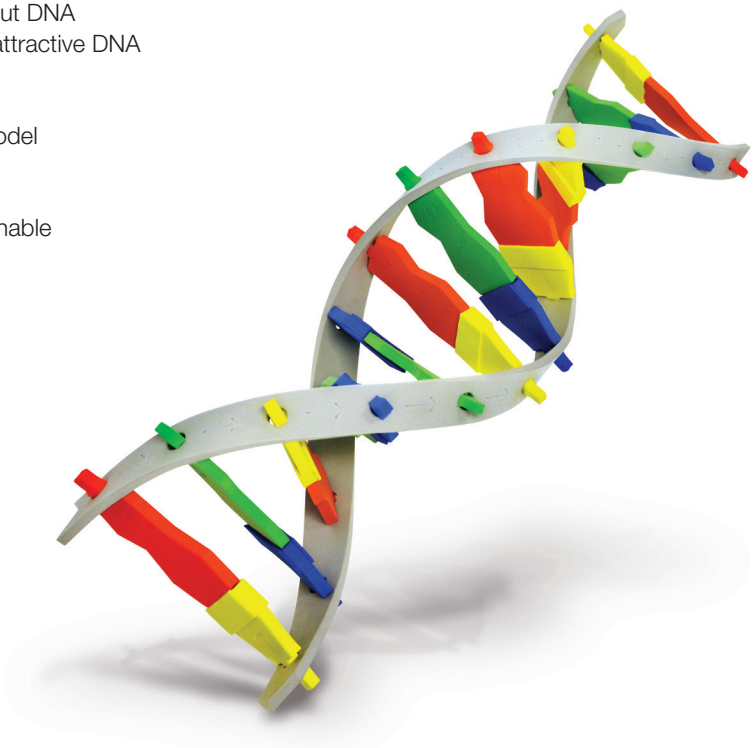
Safety certification — all Bio-Rad electrophoresis equipment is IEC 1010-1 certified. You are assured that our gel boxes are the safest you can buy!



Foam DNA Model

DNA is everywhere, but it can still be a difficult molecule to visualize. Constructing DNA models is a great way to learn about DNA structure, function, and replication. This colorful and attractive DNA model is a fun way for students to play with DNA!

- All the pieces to build a biologically correct DNA model
- Over 2 feet tall
- A great way to incorporate modeling
- Soft foam construction is easy to use and approachable



Ordering Information

Description	Catalog #
Mini-Sub Cell GT Systems	
Mini ReadySub-Cell GT Cell, for precast ReadyAgarose gels, tank and lid only	1704487EDU
Mini-Sub Cell GT Cell, with 7 x 10 cm tray, two 8-well combs (no casting gates)	1664000EDU
Mini-Sub Cell GT Cell, with 7 x 10 cm tray, two 8-well combs, mini-gel caster	1664288EDU
Mini-Sub Cell GT Cell, with 7 x 7 cm tray, one 8-well comb, casting gates	1664270EDU
Mini-Sub Cell Accessories	
Mini-Gel Caster, for Mini-Sub and wide Mini-Sub Cell trays	1704422EDU
Mini-Sub Cell GT Casting Gates, for 7 x 7 cm tray only, 2	1704434EDU
UV-Transparent Gel Tray, 7 x 7 cm	1704436EDU
UV-Transparent Gel Tray, 7 x 10 cm	1704435EDU
Fixed-Height Comb, 8-well, 1.5 mm	1704463EDU
Fixed-Height Comb, 15-well, 1.5 mm	1704465EDU
Wide Mini-Sub Cell GT Systems	
Wide Mini-Sub Cell GT Cell, with 15 x 10 cm tray, 15-well and 20-well combs	1704468EDU
Wide Mini-Sub Cell GT Cell, with 15 x 10 cm tray, 15-well and 20-well combs, gel caster	1704469EDU
Wide Mini-Sub Cell Accessories	
UV-Transparent Gel Tray, 15 x 7 cm	1704426EDU
UV-Transparent Gel Tray, 15 x 10 cm	1704416EDU
Fixed-Height Comb, 15-well, 1.5 mm	1704446EDU
Fixed-Height Comb, 20-well, 1.5 mm	1704448EDU
DNA Model	
DNA Model	1667015EDU
DNA Model Small Classroom Set – pack of 4 DNA models	1667016EDU
DNA Model Classroom Set – pack of 8 DNA models	1667017EDU

Mini-Sub cell and wide Mini-Sub cell GT systems include: cell tank and lid (gel box), casting accessories as specified above, leveling bubble, one or two 1.5 mm fixed-height combs as specified (8-well for the Mini-Sub cell, 15- and 20-well for the wide Mini-Sub cell), and a UV-transparent gel tray. Please order power supplies, additional trays, combs, and accessories as needed. For complete details about Bio-Rad gel boxes and accessories for electrophoresis, visit explorer.bio-rad.com and request bulletin 2660.

DNA Electrophoresis Reagent Packs

Our DNA electrophoresis reagent packs are available in small, medium, and large sizes to cover all your agarose gel needs and allow you to pour your own gels with ease. (UView Loading Dye and Stain comes only in the small electrophoresis reagent pack size.) Choose from our new UView loading dye and ultrasensitive nontoxic fluorescent stain, sensitive nontoxic Fast Blast DNA stain, or the ultimate in sensitivity ethidium bromide solution. Convenient premixed buffers ensure reproducible results.

Agarose Gel Drying Film and Agarose Powders

Gel support films are a convenient, low-cost way to document and preserve agarose gels. Simply lay a wet, stained agarose gel on a piece of film and let the moisture evaporate overnight. The result is a durable dried gel.

Certified Molecular Biology Agarose

This special agarose formulation provides exceptional DNA separation and more durable gels, providing the sharpest resolution of fragments of 20–20,000 base pairs. The gels are easy to handle and are recommended for low-percentage gels (0.8–3.0%).

Certified PCR Low-Melt Agarose

This agarose has a high sieving capacity and yields excellent resolution of fragments ≤1,000 bp in a low-melt or preparative format, ideal for digestion by agarose and for all in-gel applications.

Ordering Information

Description	Catalog #
Small UView DNA Electrophoresis Reagent Pack Makes 48 1% or 16 3% 7 x 10 cm agarose gels; includes 25 g agarose powder, 1 ml UView 6x Loading Dye and Stain, 100 ml 50x TAE electrophoresis buffer	1660462EDU
Small Fast Blast DNA Electrophoresis Reagent Pack Makes 48 1% or 16 3% 7 x 10 cm agarose gels; includes 25 g agarose powder, 100 ml 500x Fast Blast DNA stain, 100 ml 50x TAE electrophoresis buffer	1660450EDU
Medium Fast Blast DNA Electrophoresis Reagent Pack Makes 270 1% or 90 3% 7 x 10 cm agarose gels; includes 125 g agarose powder, 100 ml 500x Fast Blast DNA stain, 1 L 50x TAE electrophoresis buffer	1660455EDU
Large Fast Blast DNA Electrophoresis Reagent Pack Makes 1,080 1% or 360 3% 7 x 10 cm agarose gels; includes 500 g agarose powder, 2 x 100 ml 500x Fast Blast DNA stain, 5 L 50x TAE electrophoresis buffer	1660460EDU
Small Ethidium Bromide DNA Electrophoresis Reagent Pack Makes 48 1% or 16 3% 7 x 10 cm agarose gels; includes 25 g agarose powder, 10 ml ethidium bromide, 200 ml 50x TAE electrophoresis buffer	1660451EDU
Medium Ethidium Bromide DNA Electrophoresis Reagent Pack Makes 270 1% or 90 3% 7 x 10 cm agarose gels; includes 125 g agarose powder, 10 ml ethidium bromide, 1 L 50x TAE electrophoresis buffer	1660456EDU
Large Ethidium Bromide DNA Electrophoresis Reagent Pack Makes 1,080 1% or 360 3% 7 x 10 cm agarose gels; includes 500 g agarose powder, 10 ml ethidium bromide, 5 L 50x TAE electrophoresis buffer	1660461EDU
Agarose Gel Drying Film Gel Support Film, for drying agarose gels, 65 x 125 mm, 50 sheets	1702984EDU
Agarose Powders	
Certified Molecular Biology Agarose, 5 g	1613116EDU
Certified Molecular Biology Agarose, 25 g	1613100EDU
Certified Molecular Biology Agarose, 125 g	1613101EDU
Certified Molecular Biology Agarose, 500 g	1613102EDU
Certified PCR Low-Melt Agarose, 25 g	1613113EDU
Certified PCR Low-Melt Agarose, 125 g	1613114EDU
Certified PCR Low-Melt Agarose, 500 g	1613115EDU

Small Fast Blast DNA Electrophoresis Reagent Pack

Small Ethidium Bromide DNA Electrophoresis Reagent Pack

Small UView DNA Electrophoresis Reagent Pack

Gel Support Film

Certified Agarose Powders

DNA and Genomic Reagents are perfect for use with:

- Virus Detection and Transmission kit (#17008261EDU)
- Science of Opioid Dependence kit (#17005316EDU)
- Forensic DNA fingerprinting kit (#1660007EDU)
- Analysis of precut lambda DNA kit (#1660001EDU)
- Restriction digestion and analysis of lambda DNA kit (#1660002EDU)
- Crime Scene Investigator PCR Basics Kit (#1662600EDU)
- PV92 PCR informatics kit (#1662100EDU)
- DNA Barcoding kits (pp. 10–11)
- GMO Investigator kit (#1662500EDU)
- Comparative proteomics kit I: protein profiler module (#1662700EDU)
- Cloning and Sequencing Explorer Series (#1665000EDU)

DNA Electrophoresis Buffers

Careful selection of both equipment and reagents can affect the quality of your electrophoresis results. Bio-Rad pioneered the production of reagents specifically designed for electrophoresis. Save preparation time and ensure reproducible results.

Premixed DNA Electrophoresis Running Buffers

Just dilute and run. Our complete line of premixed buffers is made with Bio-Rad electrophoresis-purity reagents.

Premixed DNA Electrophoresis Sample Loading Buffer

Bio-Rad's concentrated premixed DNA sample loading buffer contains two electrophoresis tracking dyes (xylene cyanole FF and bromophenol blue) and glycerol in Tris buffer. Add directly to liquid DNA samples and load your gels with ease.

DNA Electrophoresis Buffers
in convenient 1 L bottles

DNA Electrophoresis Buffer
in multiple-class sized 5 L cubes

Precast Agarose Gels

Our convenient ReadyAgarose gels are individually packaged precast agarose gels.

Precast Agarose Gel Features

- UV-transparent tray with fluorescent lane numbers and ruler
- Tray locks into Bio-Rad electrophoresis cells of corresponding size
- Mini 7 x 10 cm and wide mini 15 x 10 cm formats
- Mini size fits most manufacturers' mini gel boxes
- Made with TAE (TBE buffer options available online)
- Gel percentages for optimal resolution: 1.0%, 200 bp–10 kb or 3.0%, 20 bp–1 kb
- Shipment and storage at room temperature
- One year shelf life

ReadyAgarose Precast Mini Gel

Precast Polyacrylamide Gels for DNA

Mini-PROTEAN polyacrylamide precast gels are designed to fit the Mini-PROTEAN Tetra cell and are ready to run. Mini-PROTEAN TBE gels provide high-resolution separation of nucleic acids from 50 to 1,750 base pairs (higher resolution than agarose gel) — ideal for analyzing the purity of PCR fragments. See p. 138 for more details and ordering information.

Ordering Information

Description	Catalog #
DNA Electrophoresis Buffers*	
50x TAE, 100 ml	1660742EDU
50x TAE, 1 L	1610743EDU
50x TAE, 5 L cube	1610773EDU
10x TBE, 1 L	1610733EDU
10x TBE, 5 L cube	1610770EDU
Sample Loading Dye, 6x, 1 ml	1660401EDU
Buffer Reagent Components	
Tris, 500 g	1610716EDU
Bromophenol Blue, 10 g	1610404EDU
Xylene Cyanole FF, 25 g	1610423EDU
ReadyAgarose Precast Mini Gels, TAE, 7 x 10 cm	
1.0%, 2 x 8-well	1613057EDU
1.0%, 8-well	1613015EDU
3.0%, 8-well	1613017EDU

Buffers, reagents, and ReadyAgarose gels ship and store at room temperature. Visit us on the web at discover.bio-rad.com for a complete listing of our varieties of ReadyAgarose gels, including gels with ethidium bromide, and buffers.

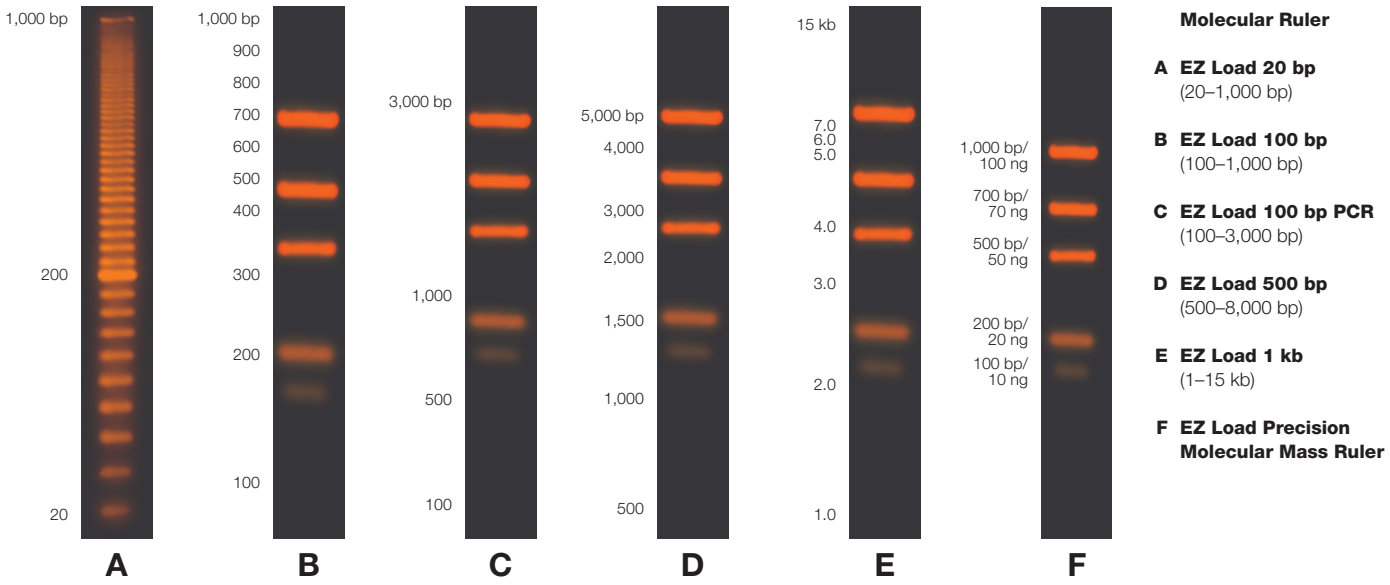
* See p. 122 for dual-function UView Loading Dye and Stain.

Additional supplies:
- DNA electrophoresis cells, pp. 117–118
- DNA size standards, p. 121
- DNA stains, p. 122

DNA Electrophoresis Size Standards

Bio-Rad's high-quality DNA size standards are essential tools for every classroom molecular biologist. DNA size standards can be used as positive controls for electrophoresis and are used as references to determine the sizes of unknown DNA fragments.

EZ Load molecular rulers cover all your needs for sizing DNA fragments, from oligonucleotides to PCR products to plasmids. Our PCR ruler is a 100 bp ladder that extends to 3 kb — ideal for even the longest PCR products. To ensure easy and correct measurement of the sizes of your samples, most of these ladders include a visually distinct reference band.



Ordering Information

Description	Catalog #
DNA Electrophoresis Size Standards	
EZ Load 20 bp Molecular Ruler, 20–1,000 base pairs, 50 bands, 500 µl	1708351EDU
EZ Load 100 bp Molecular Ruler, 100–1,000 base pairs, 10 bands, 500 µl	1708352EDU
EZ Load 100 bp PCR Molecular Ruler, 100–3,000 base pairs, 30 bands, 500 µl	1708353EDU
EZ Load 500 bp Molecular Ruler, 500–8,000 base pairs, 16 bands, 500 µl	1708354EDU
EZ Load 1 kb Molecular Ruler, 1,000–15,000 base pairs, 15 bands, 500 µl	1708355EDU
EZ Load Precision Molecular Mass Ruler, 100–1,000 base pairs, 5 bands, 500 µl	1708356EDU

DNA standards are shipped at room temperature. Store in the freezer upon receipt. Detailed protocols, applications, and ordering information for all Bio-Rad DNA size standards are available online. Visit us on the Web at **discover.bio-rad.com**.

Additional supplies:
- DNA electrophoresis cells, pp. 117–118
- ReadyAgarose precast gels, agarose powders, and DNA electrophoresis reagents pp. 119–120
- DNA stains, p. 122

DNA Stains

Fast Blast DNA Stain

Fast Blast DNA stain is an ultrasensitive, convenient, inexpensive, and nontoxic alternative to ethidium bromide for the detection of DNA. This unique product stains DNA deep blue in both agarose and polyacrylamide gels, providing vivid, consistent results.

Fast Blast DNA stain is packaged as 100 ml of a 500x concentrate that must be diluted before use. Use Fast Blast to:

- Stain DNA in agarose gels after electrophoresis, in less than 15 minutes or overnight
- Stain DNA during electrophoresis
- Teach students basic principles of electrophoresis
- Stain nuclei in intact cheek cells

Fast Blast dye molecules are positively charged and when placed in an agarose gel will migrate toward the negative electrode during electrophoresis, providing a striking and inexpensive visual demonstration of the movement of molecules during electrophoresis.

UView Loading Dye and Stain

UView 6x Loading Dye and Stain is a fluorescent nucleic acid stain and loading dye that enables immediate visualization of your DNA postelectrophoresis without staining or destaining or incorporating into the agarose prior to electrophoresis. It is nontoxic for easy disposal and nonmutagenic so will not interfere with downstream applications. Its sensitivity is close to that of ethidium bromide (>10 ng). This product is available in 200 µl or 1 ml volumes.

UView Loading Dye and Stain Time Savings

Step	Other Stains (postelectrophoresis stain), min	Other Stains (in gel prep), min	UView 6x Loading Dye and stain, min
Add stain to agarose gel prep	NA	5 ← Time Savings	0
Add loading dye to sample, load sample, run gel	26	26	26
Stain/destain	≥20 ←	0 ← Time Savings	0
See results	1	1	1
Total time	>45 min	>32 min	>27 min

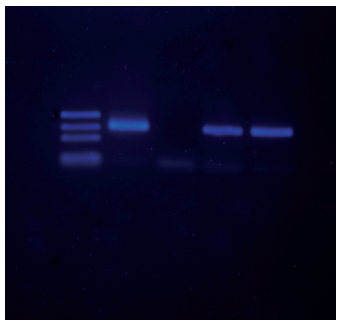
Ethidium Bromide Solution

When sensitivity is a must, Bio-Rad's premixed ethidium bromide solution eliminates preparation steps and minimizes exposure to hazardous ethidium bromide.

Silver Stain Plus Kit

Silver Stain Plus is our most sensitive and easiest to use silver stain — ideal for staining both nucleic acids and proteins in polyacrylamide and agarose gels. Sensitivity is better than 100 ng/band.

DNA Stains



Gel with UView Loading Dye and Stain

Ordering Information

Description	Catalog #
UView Loading Dye and Stain	
UView 6x Loading Dye and Stain, 0.2 ml	1665111EDU
UView 6x Loading Dye and Stain, 1 ml	1665112EDU
DNA Stains	
Fast Blast DNA Stain, 500x, 100 ml	1660420EDU
Ethidium Bromide Solution, 10 mg/ml, 10 ml	1610433EDU
Silver Stain Plus Kit	1610449EDU

Detailed protocols for Fast Blast DNA stain are available at explorer.bio-rad.com.

Additional supplies:
- DNA electrophoresis cells, pp. 117–118
- ReadyAgarose precast gels, agarose powders, and DNA electrophoresis reagents, pp. 119–120
- DNA size standards, p. 121

PCR Thermal Cyclers

Bio-Rad offers a thermal cycler to meet your needs. Choose the sample capacity, upgrade options, and features that are right for you. Go to **bio-rad.com/cyclers** for more information.

T100 Thermal Cycler — Robust and economical for routine PCR

With its 96-well sample capacity and rapid heating and cooling technology, this compact thermal cycler provides high sample throughput in less time. This classroom-scale instrument also features a large 5.7 inch touch screen, intuitive programming, and real-time graphical display of your PCR protocol at an economical price.

T100 Thermal Cycler

Specifications

Format	96 wells x 0.2 ml
User interface	5.7 in. graphical touch screen
Performance	
Accuracy	±0.5°C
Uniformity	±0.5°C well-to-well within 30 sec
Max ramp rate	4°C/sec
Temperature range	4–100°C
Size (W x D x H)	26 x 47 x 23 cm (10 x 18 x 9 inches) (W x D x H)
Memory	<500 protocols; unlimited with a USB drive

PTC Tempo Thermal Cycler — Premium performance for demanding applications and multiple users

The PTC Tempo Thermal Cycler offers the latest in Bio-Rad amplification technology and features that make it one of the easiest to use, most robust PCR systems available. Unlike many other competing thermal cyclers, this modern platform offers the consistent thermal uniformity and accuracy of the C1000 Thermal Cycler but with new competitive features that include:

- Compact, industrial design — a cool new look that takes up less bench space in your classroom lab
- Bright, visible LED status lights — see the run status from across the room
- Intuitive touchscreen user interface — easy to use straight out of the box
- Programmable thermal gradient — optimize denaturation, annealing, and extension temperatures in a single run
- No instrument calibration needed — minimize your cost of ownership
- Added connectivity with WiFi, network drive access, and BR.io cloud accessibility — monitor run progress remotely from home or while out for lunch
- Choice of reaction block models — choose your favorite for your specific teaching applications
- Expanded memory — easily store more run protocols and reports

PTC Tempo Thermal Cycler

Specifications

Format(s)	96-well, 48/48-well, 384-well, Deepwell
User interface	8 in. graphical touch screen
Performance	
Accuracy	±0.2°C
Uniformity	±0.4°C well-to-well within 10 sec
Max ramp rate	up to 5°C/sec
Temperature range	4–100°C
Size (W x D x H)	28 x 50 x 26 cm (11 x 20 x 10 in.)
Connectivity	WiFi, BR.io, USB A 2.0, Ethernet, barcode scanner
Memory capacity	<100,000 protocols; unlimited with a USB drive

Ordering Information

Description	Catalog #
Thermal Cyclers	
T100 Thermal Cycler, 120/240 V	1861096EDU
PTC Tempo 96 Thermal Cycler, network-connected thermal cycler for PCR, includes PTC Tempo 96-well instrument, cables	12015382EDU
PTC Tempo Deepwell Thermal Cycler, network-connected thermal cycler for PCR, includes PTC Tempo Deepwell instrument, cables	12015392EDU
PTC Tempo 384 Thermal Cycler, network-connected thermal cycler for PCR, includes PTC Tempo 384-well instrument, cables	12015394EDU
PTC Tempo 48/48 Thermal Cycler, network-connected thermal cycler for PCR, includes PTC Tempo 48/48-well instrument, cables	12015309EDU
PTC Tempo Thermal Cycler WiFi Adapter, U.S. only, WiFi antenna enables WiFi connection for PTC Tempo Thermal Cycler in the U.S.	12018650EDU

The T100 and PTC Tempo Thermal Cyclers each feature a 1-year warranty. See pp. 128–129 for PCR and nucleic acid purification reagents.

PCR Plastic Supplies

Thin-Wall Microcentrifuge Tubes and Strips for PCR Applications

Bio-Rad's PCR tubes and strips are specially designed and engineered to maximize DNA amplification. A unique manufacturing process provides consistent, uniformly thin walls and bubble tops (200 µl sizes), allowing optimal heat transfer. To access our selection charts for help choosing the correct PCR tube based on your thermal cycler, reaction volume, and other application requirements, please visit us on the Web at **discover.bio-rad.com** or request bulletins 5258 and 6090.

Thin-Wall PCR Tubes

Thin-Wall PCR Tube and Cap Strips

Easy Cap Tool and PCR Strip Cap Tool

The multifunctional Easy Cap tool facilitates cap opening and closing. It prevents crushing of 0.5 ml and 0.2 ml thin-wall PCR tubes, and it properly seats domed caps on tubes or PCR plates. The PCR Strip Cap tool facilitates PCR strip cap closing. Ensures proper seating of strip caps on PCR plates.

PCR Strip Cap Tool and Easy Cap Tool

Ordering Information

Description	Catalog #
PCR Plastics (T100 and PTC Tempo thermal cyclers)	
0.2 ml Tubes with Flat Caps, clear, 1,000	TFI0201EDU
0.2 ml Tubes with Domed Caps, clear, 1,000	TWI0201EDU
Domed 8-Cap Strips, for 0.2 ml tubes and plates, clear, 120	TCS0801EDU
0.2 ml 8-Tube Strips Without Caps, clear, 125	TBS0201EDU
Domed 12-Cap Strips, for 0.2 ml tubes and plates, clear, 200	TCS1201EDU
0.2 ml 12-Tube Strips without Caps, clear, 100	TBS1201EDU
Multiplate PCR Plastics (for PTC Tempo thermal cyclers)	
Multiplate Low-Profile 48-well Unskirted PCR Plates, white, 50	MLL4851EDU
Multiplate 96-well Unskirted PCR Plates, clear, 25 (also for T100 Thermal Cycler)	MLP9601EDU
PCR Accessories	
PCR Tube Capless Adaptors, 500	2239500EDU
Easy Cap Tool	ECT1000EDU
PCR Strip Cap Tool	ECT2000EDU

See pp. 128–129 for PCR and nucleic acid purification reagents.

Real-Time PCR Detection Systems

Whether your students need to quantify DNA for their independent research or are closing in on the suspect of the Crime Scene Investigator PCR Basics Real-Time PCR Starter Kit (pp. 80–81) the CFX Real-Time PCR Systems are easy to set up with software that is easy to use.

CFX Opus Real-Time PCR System

CFX Opus Real-Time PCR Systems

Teach real-time quantitative PCR (qPCR) using this robust, easy-to-use system that is available in 96-well (5-color detection) and 384-well (4-color detection) formats. This next evolution in real-time PCR offers the reliability and performance you expect from Bio-Rad, all packaged in a sleek, modern instrument designed to fit into any classroom laboratory. The CFX Opus systems have improved physical and digital user experience and are the first system to integrate with the BR.io cloud platform. Visit **bio-rad.com/EDUOpus** for more information.

CFX Duet Real-Time PCR System

CFX Duet Real-Time PCR System

The CFX Duet System brings Bio-Rad qPCR technology to the hands of your students by offering the same performance characteristics as the CFX Opus platform but at a lower price point. Designed for 2-channel multiplex capability and without stand-alone operation, Wi-Fi connectivity, or BR.io compatibility, the CFX Duet System is the perfect choice for many teaching laboratories. Visit **bio-rad.com/EDUDuet** for more information.

PX1 Plate Sealer

PX1 Plate Sealer

Use the PX1 PCR plate sealer to melt sealing film or foil to the rims of PCR plate wells. This device provides consistent and uniform sealing across an entire microplate to minimize sample evaporation during PCR, qPCR, or ddPCR™ applications. This small-footprint heat sealer is ideal for classroom laboratories and is compatible with many PCR plates and different types of films and foils. Visit **bio-rad.com/EDUPX1** for more information and for compatible plates and sealers.

To learn more about our solutions for teaching real-time PCR, refer to Bulletin 3332.

	CFX Opus 96 Real-Time PCR System	CFX Opus 384 Real-Time PCR System	CFX Duet Real-Time PCR System
Features	For multiplex qPCR or when wireless connectivity is desired	For multiplex qPCR or when wireless connectivity is desired	For singleplex or duplex qPCR applications when wireless connectivity is not needed
Wells	96	384	96
Multiplex channels	5 plus FRET	4 plus FRET	2 plus FRET
Stand-alone operation	Yes	Yes	No; requires connection to a PC running CFX Maestro Software (not included)
Wireless connectivity	Yes	Yes	No
Reaction volume	1–50 ul	1–30 ul	1–50 ul

FRET, fluorescence resonance energy transfer.

Ordering Information

Description	Catalog #
CFX Duet Real-Time PCR System	
CFX Duet Real-Time PCR System,* 96-well, 2-color plus FRET real-time PCR detection system, includes CFX Duet base unit and cables	12016265EDU
CFX Opus Real-Time PCR Systems, Software, and Plate Sealer	
CFX Opus 96 Real-Time PCR System,* 96-well, 5-color plus FRET network-connected real-time PCR detection system, includes CFX Opus 96 base unit and cables	12011319EDU
CFX Opus 384 Real-Time PCR System,* 384-well, 4-color plus FRET network-connected real-time PCR detection system, includes CFX Opus 384 base unit and cables	12011452EDU
CFX Maestro 2.3 Software for Windows PC, 1 license, CFX Maestro 2.3, software for real-time PCR plate setup, data collection, statistics, and graphing of results; for Windows PCs	12013758EDU
PX1 Plate Sealer, includes heat sealing instrument, plate support block that holds 96-well and 384-well plates, sealing frame, and power cord	1814000EDU

* CFX Maestro software sold separately

For real-time PCR kits please refer to pp. 80–81
For PCR reagents please refer to p. 129

Droplet Digital PCR™ (ddPCR™)

Digital PCR is often considered the next evolution or third generation of PCR after end-point and real-time PCR. The distinctive feature of digital PCR is that samples are partitioned before amplification on a thermal cycler. This technique provides ultrasensitive detection of nucleic acids as well as absolute quantification without the use of standard curves.

Add Digital PCR to Your Curriculum

Bio-Rad's unique Droplet Digital PCR (ddPCR) technology uses microfluidics to partition samples into liquid droplets. Over the past decade, ddPCR has enabled breakthroughs in cancer biomarker, infectious disease, genomic alterations, and gene expression research. Its use is increasing rapidly in the areas of pathogen detection, food testing, and environmental and wastewater monitoring.

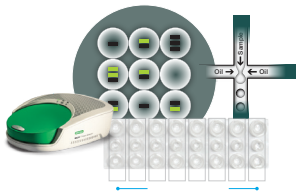
By introducing students to digital PCR, you can prepare them for the science and jobs of the future.

Through the Explorer program, Bio-Rad Laboratories offers products like its QX200™ Droplet Digital PCR System at a discount to educators for use in teaching laboratories. The goal is to ensure that students learn modern biotechnology techniques like ddPCR using the same equipment they might someday use on the job in research or diagnostic labs.

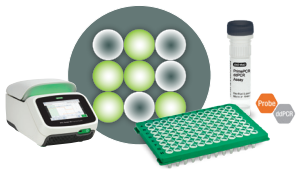
Bio-Rad and the Bio-Rad Explorer program also offer a broad range of training options and educational supports to empower your teaching of cutting-edge biotechnology techniques and their applications.

To view ordering options, refer to Bulletin 3333 or contact us at **explorer@bio-rad.com**.

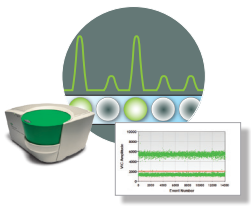
1 Prepare ddPCR reaction mix



2 Generate droplets



3 Perform PCR to amplify targets in each droplet



4 Read and analyze results

Ordering Information

Description	Catalog #
QX200 Digital Droplet PCR System	
QX200 Digital Droplet PCR System, includes droplet generator, droplet reader, computer software, assorted component consumables	1864001EDU
QX200 Digital Droplet Generator, 1 pkg of 24 DG8 cartridges, 2 cartridge holders, power cord	1864002EDU
QX200 Droplet Reader, includes droplet reader, 2 plate holders, USB cable, power cord	1864003EDU

Fluorescent Cell Imaging

ZOE Fluorescent Cell Imager and ZOE Dyes

Take cell imaging out of the darkroom and into your classroom! The ZOE Fluorescent Cell Imager is small and robust yet displays large crisp images of cell structures for your students without the limitations of a traditional microscope. With its large 10.1 inch screen and HDMI projector connectivity all of your students can view images at once. Plus, the Android-based operating system is easy to operate. The ZOE Fluorescent Cell Imager is a complete digital imaging system, allowing students to view samples, capture and store images, and create multicolor overlays. Applications include monitoring cell morphology, estimating transformation efficiency, and visualizing fluorescent protein expression. UView 6x Loading Dye and Stain can also be used to visualize cheek cell nuclei (p. 122). Visit **bio-rad.com/explorerZOE** for more information.

Bio-Rad's range of fluorescent dyes allow you and your students to selectively image the cell structures and morphology of your choice. Use VivaFix cell viability assays to assess cell viability, CFDA-SE cell-permeable dye for cell population health, or PureBlu dyes for nuclear DNA staining. Visit **bio-rad.com/ZOEactivities** for activity ideas for your classroom.

ZOE Fluorescent Cell Imager

Cell Counting

TC20 Cell Counter

The TC20 cell counter is an automated device that provides a total count of mammalian cells and a live/dead ratio in one simple step with accurate, reproducible results. Count cells prior to cell culture or before starting techniques that require an accurate and consistent number of input cells. The TC20 automated cell counter replaces the tedious task of counting cells with a microscope and hemocytometer. The TC20 automated cell counter demonstrates accurate counts of viable cells across a range of cell concentrations and cell sizes. Test drive the cell counter via the TC20 interactive demo by visiting **discover.bio-rad.com**.

- Count cells quickly, accurately, and consistently within 30 sec using the built-in auto-focus
- Conserve precious cells — use only 10 µl of suspended cells
- Print count results and dilution calculations from the TC20 thermal label printer
- Transfer counts and cell images using a USB key
- Trust your counts — confirm instrument functionality with the TC20 verification slide

Use the TC20 cell counter to determine total cell count without dye or use trypan blue dye to assess total cell count and cell viability. *Simply load sample, insert slide, and view results!*

TC20 Cell Counter with Printer

Ordering Information

Description	Catalog #
ZOE Fluorescent Cell Imager and Accessories*	
ZOE Fluorescent Cell Imager, 120/220 V	1450031EDU
VivaFix 353/442 Cell Viability Assay	1351111EDU
VivaFix 498/521 Cell Viability Assay	1351115EDU
VivaFix 547/573 Cell Viability Assay	1351116EDU
VivaFix 583/603 Cell Viability Assay	1351117EDU
CFDA, SE	1351201EDU
PureBlu DAPI Nuclear Staining Dye	1351303EDU
PureBlu Hoechst 33342 Nuclear Staining Dye	1351304EDU
TC20 Cell Counter	
TC20 Automated Cell Counter with Printer 100–240 V, includes instrument, USB flash drive and cable, TC20 thermal label printer, 1 roll of 185 labels, 30 TC20 dual-chamber counting slides (60 counts), 1.5 ml TC20 trypan blue dye	1450103EDU
TC20 Automated Cell Counter 100–240 V, includes instrument, USB flash drive and cable, 30 TC20 dual-chamber counting slides (60 counts), 1.5 ml TC20 trypan blue dye	1450102EDU
TC20 Counting Slides, 5 x 30 slide pack of dual-chamber slides (300 counts), each slide can provide counts for 2 separate samples or dilutions	1450015EDU
TC20 Trypan Blue Dye, 5 x 1.5 ml, sufficient for 750 counts (10 µl/count), 0.4% in 0.81% sodium chloride and 0.06% potassium phosphate dibasic solution, sterile filtered	1450021EDU
TC20 Verification Kit, kit for validation of TC20 automated cell counter functionality, includes TC20 verification slide, protocol	1450014EDU

* Visit **bio-rad.com/explorerZOE** for more information about the VivaFix cell viability assays.

Genomic DNA, RNA, and Plasmid Purification Kits

Bio-Rad offers a complete line of products for the isolation and purification of nucleic acids. From the purification of milligram quantities of plasmid DNA for restriction analysis or transformation to the rapid and efficient purification of PCR products, Bio-Rad provides you with high-quality kits that eliminate time-consuming, labor-intensive steps.

InstaGene Matrix

Crude Genomic DNA for PCR: InstaGene Matrix

InstaGene matrix, composed of specially formulated Chelex resin, makes DNA sample preparation fast, easy, and cost-effective, providing PCR-quality template DNA from crude genomic preparations in less than 1 hour. The InstaGene matrix adsorbs cell lysis products and removes inhibitors such as magnesium ions that interfere with the PCR amplification process. Simply place cells in a microcentrifuge tube, add the InstaGene matrix, boil, and spin. PCR-ready DNA is in the supernatant and can be transferred directly into PCR tubes.

DNA Extraction Module

DNA Extraction Module

Extract chromosomal DNA from prokaryotic and eukaryotic samples for various downstream applications including PCR amplification, DNA sequencing and barcoding, restriction endonuclease digestion, and cloning. This Quantum Prep spin column-based procedure can be completed in as little as 15 minutes, and DNA eluted into either water or TE (Tris/EDTA) buffer.

Total RNA Isolation: Aurum Total RNA Mini Kit

The Aurum total RNA mini kit produces DNA-free total RNA from a wide range of starting materials including cultured cells, bacteria, and yeast, as well as animal and plant tissues. The Aurum total RNA mini kit can also be used for RNA cleanup and desalting.

Aurum Total RNA Mini Kit

Quantum Prep Plasmid Miniprep Kit

Obtain optimal yield of plasmids for gene transfer, restriction, ligation, and cloning protocols. The Quantum Prep miniprep kit is tested to ensure at least 20 µg of high-copy plasmid yield from just 1.5 ml of bacterial culture. The Quantum Prep miniprep procedure takes less than 15 minutes from cell culture to purified plasmid, using an easy spin column–based procedure. DNA is recovered in water or Tris/EDTA buffer for immediate use in mapping, sequencing, transfection, transformation, PCR, or subcloning.

Quantum Prep Plasmid Miniprep Kit

PCR Kleen Spin Purification Columns

Try our prepacked spin columns for purifying PCR products and other DNA molecules >200 bp directly from reaction mixtures. A simple 4 minute spin effectively removes salts, nucleotides, enzymes, primers, and primer-dimers. Purified DNA fragments are eluted into a collection tube and are immediately available for secondary PCR, subcloning, restriction digests, ligations, sequencing, and other enzymatic manipulations.

PCR Kleen Spin Purification Columns

Aurum Plasmid Mini Purification Kit

Our easy-to-use Aurum plasmid mini kit improves the efficiency and throughput of plasmid purifications with a simple bind-wash-elute protocol using silica membranes. Lysed bacterial cultures can be cleared by centrifugation. The clarified lysates are applied to plasmid binding columns and plates where DNA is bound, then washed, and finally eluted — all in less than 10 minutes. The purified plasmid DNA can be immediately used in any downstream molecular biology application. For more information, request bulletin 2664.

Aurum Plasmid Mini Purification Kit

Ordering Information

Description	Catalog #
InstaGene Matrix, 20 ml	7326030EDU
DNA Extraction Module, reagents and plastic consumables for chromosomal DNA extraction, includes resuspension, lysis, and neutralization solutions, wash buffer, matrix, spin filters, and 2.0 ml microtubes for up to 16 extractions	12016408EDU
DNA Extraction Reagent Pack, Reagents for chromosomal DNA extraction, includes resuspension, lysis, and neutralization solutions, wash buffer, matrix, and spin filters for up to 16 extractions	1665105EDU
Aurum Total RNA Mini Kit, 50 preps, includes 50 RNA binding columns, 50 capless collection tubes, 100 capped sample tubes (2.0 ml), 50 capped sample tubes (1.5 ml), 1 vial lyophilized DNase I, RNase-free reagents, protocol overview instructions	7326820EDU
Quantum Prep Plasmid Miniprep Kit, 100 preps, includes 20 ml cell resuspension solution, 25 ml cell lysis solution, 25 ml neutralization solution, 20 ml Quantum Prep matrix, 63 ml wash solution, 100 spin columns, instructions	7326100EDU
PCR Kleen Spin Purification Columns, 25	7326300EDU
Aurum Plasmid Mini Purification Kit, 100 preps, includes plasmid-binding mini columns, 100 capless collection tubes, reagents, protocol overview, instructions	7326400EDU

Detailed protocols, applications, and ordering information for all Bio-Rad nucleic acid purification products are available online.

Amplification/PCR Reagents

Bio-Rad's reagents are specially formulated for both conventional and real-time applications and demonstrate high performance for cDNA, genomic DNA, and plasmid DNA over a wide dynamic range. Visit us at **bio-rad.com/pcrreagents** for more information.

2x Master Mix

2x Master Mix for PCR

Bio-Rad's 2x master mix for PCR is a concentrated solution of Taq DNA polymerase, dNTPs, and all the components required for PCR (except DNA template and primers). The absence of endodeoxyribonucleases, exodeoxyribonucleases, and ribonucleases is confirmed by appropriate quality control tests. The master mix is functionally tested in amplification of a single-copy gene from human genomic DNA.

iTaq DNA Polymerase

iTaq DNA Polymerase and dNTP Mix

iTaq DNA polymerase is an antibody-mediated hot-start DNA polymerase that is suitable for both conventional and real-time PCR applications and that ensures high specificity and sensitivity.

iProof High-Fidelity Master Mix

iProof High-Fidelity DNA Polymerase is a unique *Pyrococcus*-like proofreading enzyme fused to the Sso7d dsDNA-binding protein to create a thermostable fusion polymerase that accurately amplifies long products from a variety of DNA templates. iProof GC Master Mix is suitable for GC-rich templates.

iProof HF Master Mix

SsoAdvanced Universal SYBR® Green Supermix

SsoAdvanced Universal SYBR® Green Supermix is a high-performance supermix formulated for optimal results in real-time PCR based on SYBR® Green I detection. Based on Bio-Rad's patented* Sso7d fusion protein technology, it accommodates a wide range of real-time PCR applications and can be used with all ROX-dependent or -independent real-time PCR systems.

SsoAdvanced Universal SYBR® Green Supermix

Gene Transfer Technology with Shocking Efficiency!

Bio-Rad's gene transfer products allow gene transfer to bacterial, plant, fungal, and animal cells. Visit us at **bio-rad.com/genetransfer** for more information.

MicroPulser Electroporator and Electroporation Cuvettes for Microorganisms

The MicroPulser electroporator is a simple and versatile electroporator for safe and reproducible transformation of bacteria, yeast, and other microorganisms with high precision. For the best and most reproducible results, use the MicroPulser Electroporator with Bio-Rad's high-quality electroporation cuvettes.

MicroPulser Electroporator and Cuvettes

Ordering Information

Description	Catalog #
Amplification/PCR Reagents	
2x Master Mix for PCR, 90 units, 1.2 ml, includes 0.075 U/µl Taq DNA polymerase (recombinant), reaction buffer, 4 mM $MgCl_2$, 0.4 mM of each dNTP (dATP, dCTP, dGTP, dTTP)	1665009EDU
iProof HF Master Mix for PCR, 100 x 50 µl reactions, premixed PCR reagents, includes 2x master mix (0.04 U/µl), DMSO	1725310EDU
iProof GC Master Mix for PCR, 100 x 50 µl reactions, premixed PCR reagents, includes 2x master mix (0.04 U/µl), DMSO	1725320EDU
iTaq DNA Polymerase, 5 U/µl, includes 250 U polymerase, 1.25 ml of 10x PCR buffer, 1.25 ml of 50 mM $MgCl_2$ solution	1708870EDU
dNTP Mix, 200 µl premixed solution, contains 10 mM each dNTP (dATP, dCTP, dGTP, dTTP)	1708874EDU
$MgCl_2$ solution, 50 mM, 1.25 ml	1708872EDU
SsoAdvanced Universal SYBR® Green Supermix, 200 x 20 µl rxns, 2 ml (2 x 1 ml)	1725270EDU
Chill-out Liquid Wax, clear, optical grade, 100 ml	CHO1411EDU
MicroPulser and Accessories	
MicroPulser Electroporator, 120/220 V, includes chamber with leads, 10 sterile cuvettes (5 each of 0.1 cm and 0.2 cm electrode gap)	1652100EDU
Gene Pulser/MicroPulser Cuvettes, 0.4 cm, 5/pk	1652081EDU
Gene Pulser/MicroPulser Cuvettes, 0.2 cm, 5/pk	1652082EDU
Gene Pulser/MicroPulser Cuvettes, 0.1 cm, 5/pk	1652083EDU

Visit us on the Web at discover.bio-rad.com for more information on the MicroPulser system.

* U.S. patent 7,560,260.

Section Contents

Proteins and Proteomic Studies: Equipment & Reagents

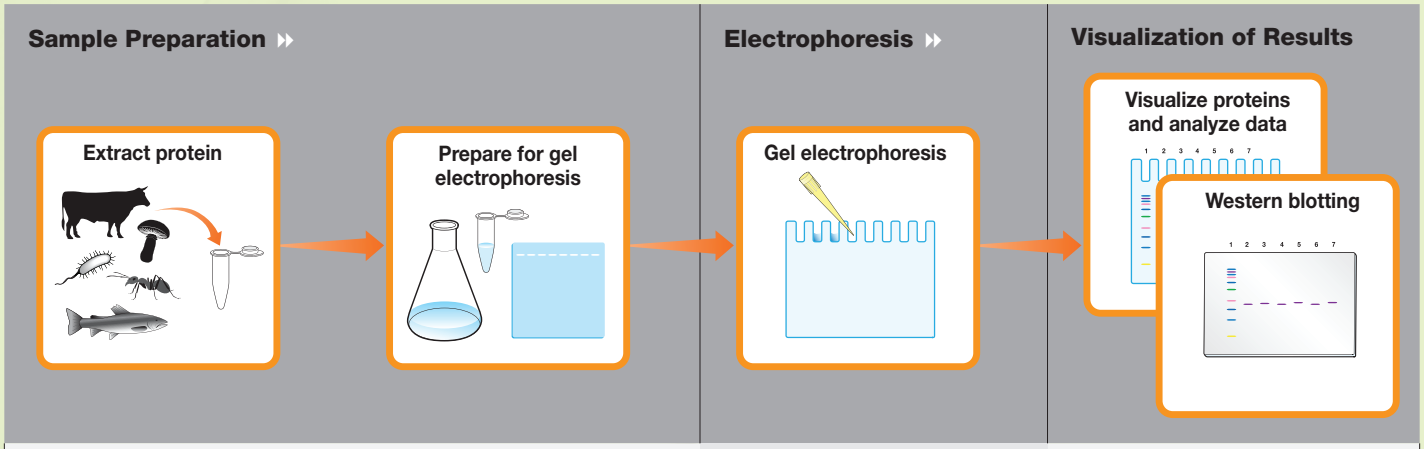
"I teach using project-based learning, where students can dream and solve problems with biotechnology. With Bio-Rad kits, students learn the skills that scientists use, such as transfection using the pGLO kit, enabling students to design biosensors to solve local environmental problems."

Nikki Wallace
Crosstown High School, Memphis, TN

Bio-Rad Explorer Teacher and Student Alumni

Protein Electrophoresis (SDS-PAGE) and Blotting Workflow

Protein electrophoresis is a core technique in molecular biology used to separate proteins by size. It is used in myriad applications including protein analysis, purification, and diagnostics. Western blotting enables detection of specific proteins after gel separation.



Preparation of protein samples and standards for electrophoresis
- Precision Plus Protein Standards (p. 139)
- Premixed Sample Buffer for Protein Electrophoresis (p. 140)

Preparation of gel and running buffer
- Precast Polyacrylamide Gels (p. 138)
- Premixed Buffers for Electrophoresis (p. 140)

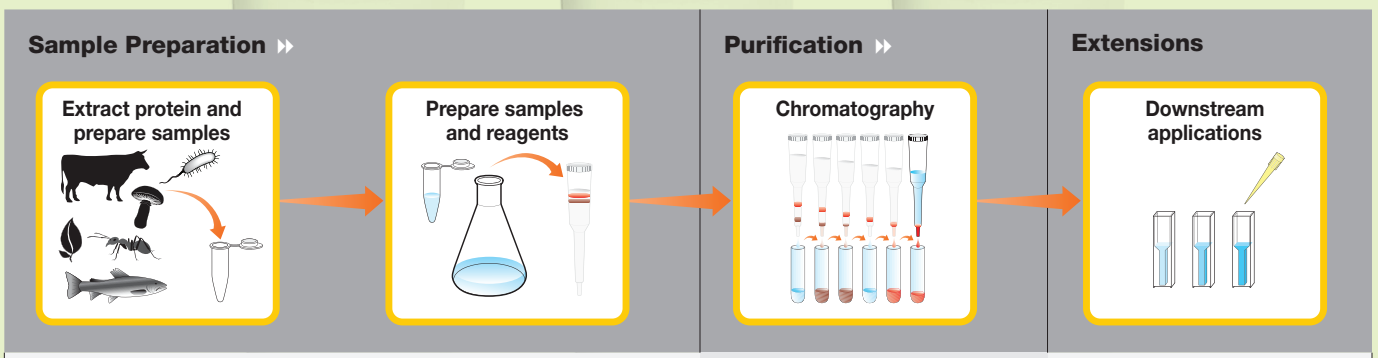
Performing Electrophoresis
- Vertical Gel Electrophoresis Systems (p. 134)
- PowerPac Power Supplies* (p. 155)

Visualization
- Protein Stains (p. 139)
- Gel Imaging & Documentation (p. 146)
- Blotting Membranes for Proteins (p. 137)
- Protein Blotting Buffer Reagents and Detection Kits (p. 137)
- Antibodies (bio-rad.com/EDUantibodies)

* Each PowerPac power supply can connect up to 4 electrophoresis cells

Chromatography Workflow

Chromatography enables separation and purification of protein mixtures by various protein proteins, including size, net charge, and affinity.



Performing Chromatography

- Chromatography Reagents and Purification Systems (p. 141)

Downstream Applications

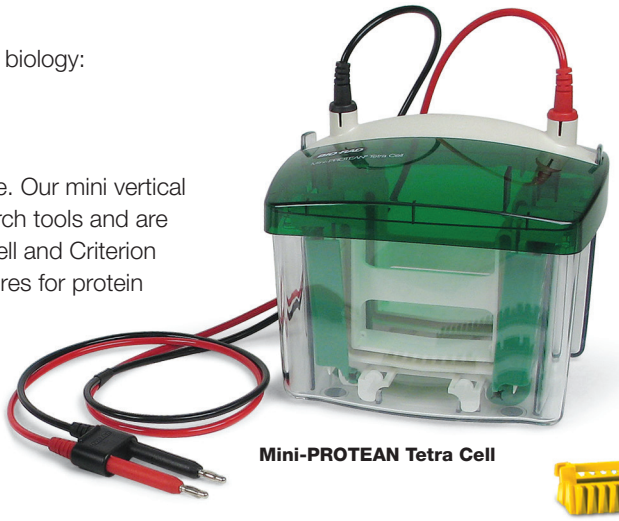
- Protein Quantitation (p. 140)
- Other

Vertical Gel Electrophoresis Systems

Move beyond DNA and explore the complete framework of molecular biology:

DNA ➤ RNA ➤ Protein ➤ Trait

Protein electrophoresis is the most frequently cited research technique. Our mini vertical polyacrylamide gel electrophoresis systems are state-of-the-art research tools and are perfectly adaptable to science education. The Mini-PROTEAN Tetra cell and Criterion cell provide rapid, high-resolution separation of complex protein mixtures for protein fingerprinting, identification, and sample purity analysis.



Mini-PROTEAN Tetra Cell

Mini-PROTEAN Tetra Cell

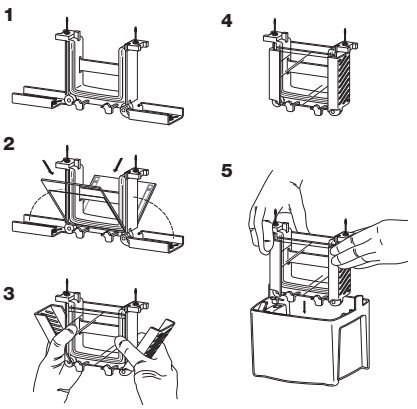
The Mini-PROTEAN Tetra cell makes running protein or DNA on polyacrylamide gels in your teaching lab easier than ever. This cell is durable, versatile, and easy to assemble. It can run either precast or handcast polyacrylamide gels in 30 minutes.

- Runs one to four mini gels (7 cm height x 8.5 cm width)
- Exclusive sample loading guides direct pipet tips into sample wells — no more missing or doubling-up samples in a lane
- Leak-free electrophoresis and gel casting
- Durable molded polycarbonate construction throughout
- Ability to run either precast (Mini-PROTEAN TGX or TGX Stain-Free precast gels) or handcast gels. Please see p. 138 for a complete selection of precast polyacrylamide gels

Gel Sample Loading Guides

Teaching applications include:
- Comparative Proteomics Kit I: Protein Profiler Module, p. 54
- pGLO kit SDS-PAGE extension, p. 32
- Protein Expression and Purification Series, p. 92

Fast and Easy Tetra Module Assembly



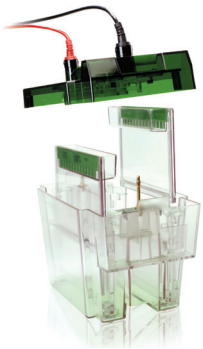
Midi Format Criterion Cell

The Criterion cell is designed to run up to two prepackaged midi-size gel cassettes (8.7 cm height x 13.3 cm width) with 18 or 26 wells, allowing for increased throughput as well as greater capacity and enhanced band resolution. The tank requires only 1 L of buffer with its optimized size. The drop-in precast gel cassettes with numbered wells make for quick and easy gel setup. Please reference bulletin 2710 for complete information on the Criterion system.

- Runs one or two midi-size gels (8.7 cm height x 13.3 cm width)
- Integrated buffer chamber
- Uses Criterion and Criterion XT gels

Criterion Cell and Criterion Precast Gel

Criterion Electrophoresis Cell Assembly Made Easy



1. Drop in cassettes.
2. Pour in buffer and load samples.
3. Close the lid and start your run.

Mini-PROTEAN Tetra Cell Configuration Comparison Chart

Mini-PROTEAN Tetra Cell Configurations	For Bio-Rad Precast Gels, 2-gel system (1658005EDU)	For Bio-Rad Precast Gels, 4-gel system (1658004EDU)	10-well, 0.75 mm thickness, 2-gel system (1658002EDU)	10-well 1.0 mm thickness, 2-gel system (1658003EDU)	10-well, 0.75 mm thickness, 4-gel system (1658000EDU)	0-well 1.0 mm thickness, 4-gel system (1658001EDU)
Supported gels format	Precast mini	Precast mini	0.75 mm thickness hand-cast mini	1.0 mm thickness hand-cast mini	0.75 mm thickness hand-cast mini	1.0 mm thickness hand-cast mini
Tank and lid with power cables	1	1	1	1	1	1
Electrode assembly	1	1	1	1	1	1
Companion electrode assembly		1			1	1
Mini cell buffer dam	1	1	1	1	1	1
Casting combs			5	5	5	5
Glass casting plates			5	5	5	5
Casting stand			1	1	1	1
Casting frames			2	2	4	4
Sample loading guide			1	1	1	1

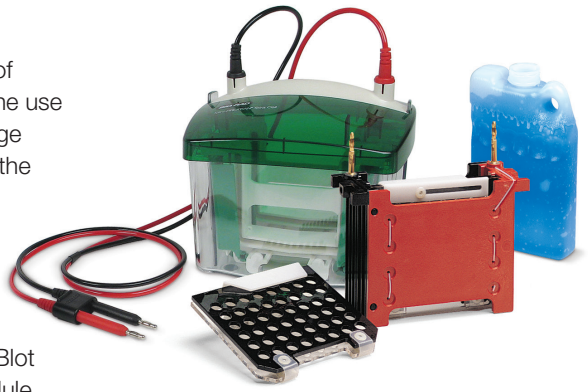
Ordering Information

Description	Catalog #
Mini-PROTEAN Tetra Cell and Accessories	
Mini-PROTEAN Tetra Cell for Bio-Rad Precast Gels, 2-gel system includes electrode assembly, tank, lid with power cables, mini cell buffer dam	1658005EDU
Mini-PROTEAN Tetra Cell for Bio-Rad Precast Gels, 4-gel system includes electrode assembly, companion running module, tank, lid with power cables, mini cell buffer dam	1658004EDU
Mini-PROTEAN Tetra Cell, 10-well, 0.75 mm thickness; 2-gel system includes 5 combs, 5 sets of glass plates, casting stand, 2 casting frames, sample loading guide, electrode assembly, tank, lid with power cables, mini cell buffer dam	1658002EDU
Mini-PROTEAN Tetra Cell, 10-well, 1.0 mm thickness; 2-gel system includes 5 combs, 5 sets of glass plates, casting stand, 2 casting frames, sample loading guide, electrode assembly, tank, lid with power cables, mini cell buffer dam	1658003EDU
Mini-PROTEAN Tetra Cell, 10-well, 0.75 mm thickness; 4-gel system includes 5 combs, 5 sets of glass plates, 2 casting stands, 4 casting frames, sample loading guide, electrode assembly, companion running module, tank, lid with power cables, mini cell buffer dam	1658000EDU
Mini-PROTEAN Tetra Cell, 10-well, 1.0 mm thickness; 4-gel system includes 5 combs, 5 sets of glass plates, 2 casting stands, 4 casting frames, sample loading guide, electrode assembly, companion running module, tank, lid with power cables, mini cell buffer dam	1658001EDU
Mini-PROTEAN Tetra Electrode Assembly	1658037EDU
Mini-PROTEAN Tetra Companion Running Module	1658038EDU
Buffer Tank, replacement	1658039EDU
Buffer Tank and Lid, replacement	1658040EDU
Cell Lid With Power Cables	1658041EDU
10-Well Gel Sample Loading Guide	1653146EDU
15-Well Gel Sample Loading Guide	1653132EDU
Buffer Dams, 2	1653130EDU
Replacement Power Cables	1652948EDU
Gel Cutter, 1	1703760EDU
Gel Releaser, 5	1653320EDU
Criterion Cell	
Criterion Cell, includes electrophoresis buffer tank, lid with power cables, 3 sample loading guides (12+2 well, 18-well, 26-well)	1656001EDU

For more information on the Mini-PROTEAN Tetra and related modules and on polyacrylamide gel-casting reagents and accessories, visit us on the Web at **bio-rad.com/verticalelectro** or request bulletin 5535.

Western Blotting Systems

Blotting expands the analytical possibilities for identification and characterization of proteins by immobilizing proteins on synthetic membrane supports, followed by the use of various methods for detection of specific molecules. Blotting offers an advantage over gel techniques by making proteins readily accessible to antibodies following the transfer to the support.



Mini Trans-Blot System

Mini Trans-Blot System

Following electrophoresis, use the Mini Trans-Blot module to transfer proteins from a gel to a membrane. Visualize proteins of interest on the membrane using one of Bio-Rad's colorimetric detection assays. The Mini Trans-Blot module is interchangeable with the Mini-PROTEAN Tetra cell electrophoresis module, so the same tank and lid can be used.

- Blots up to two mini gels simultaneously
- High field strength for rapid 1 hour transfers
- Can be run overnight at low voltage

Criterion Blotter
PowerPac HC power supply recommended

Criterion Blotter

The Criterion blotter can be used to transfer either mini- or midi-size gels, making it a flexible system for many lab setups.

- Transfer four mini gels or two midi gels
- Plate or wire electrode options

Trans-Blot Turbo Transfer System

The Trans-Blot Turbo system provides innovation in protein transfer and reduces transfer protocols for gels to as little as 3 minutes while maintaining high efficiency, high throughput, and the flexibility to run turbo or traditional semi-dry protocols. Please reference bulletin 6039 for complete information on the Trans-Blot Turbo system.

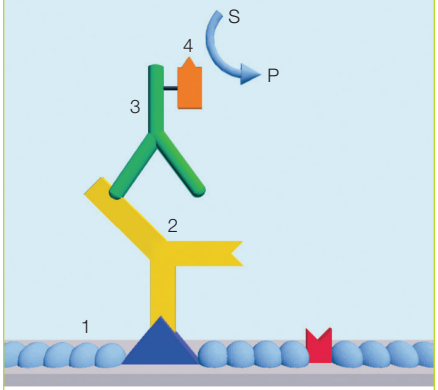
- Rapid transfer — transfers mini or midi gels in as little as 3 min
- High throughput — can transfer 1–4 mini or 1–2 midi gels in a single run
- Greater transfer efficiency — offers higher transfer efficiency compared to other transfer methods
- Flexible design — allows user to customize transfer conditions and is compatible with traditional semi-dry consumables
- Environmentally friendly — environmentally safe consumables eliminate disposal cost

Trans-Blot Turbo Transfer System
See pp. 58 for Rapid Blotting + V3 Western Workflow Starter Kit

V3 Western Workflow

Go from sample to visualized western blot results in less than two hours with the V3 Western Workflow. Visit **bio-rad.com/V3EDU** for details.

Colorimetric Detection of Proteins



Specific enzymatic detection of membrane-bound antigens

1. A membrane with unoccupied binding sites is incubated with rimary antigen.
2. Primary antibody to a specific antigen is incubated with the membrane.
3. A blotting-grade antibody-enzyme conjugate is added to bind to the primary antibody.
4. Color development reagent is added to the blot. The HRP or AP enzyme catalyzes the conversion of the substrate (S) to a colored precipitate (P) at the site of the antigen-antibody complex.

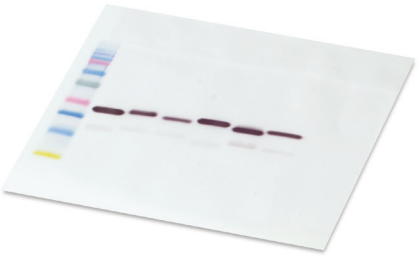
Blotting Membranes and Reagents

Blotting Membranes for Proteins

Bio-Rad offers a comprehensive line of blotting membranes available in rolls or in sheets cut to fit the Mini Trans-Blot module and Criterion blotter. Membranes are also available in preassembled blotting membrane/filter paper sandwiches. Visit us at **discover.bio-rad.com** for a complete list of blotting membranes.

Protein Blotting Buffer Reagents and Detection Kits

Select from a combination of binding conjugates and visualization reagents, including alkaline phosphatase (AP)- or horseradish peroxidase (HRP)-conjugated secondary antibodies and HRP-conjugated protein A or protein G. Visit us on the Web at **discover.bio-rad.com** for details about which kit is right for your application. Detailed protocols, applications, and ordering information for all Bio-Rad blotting equipment, detection kits, and reagents are available online.

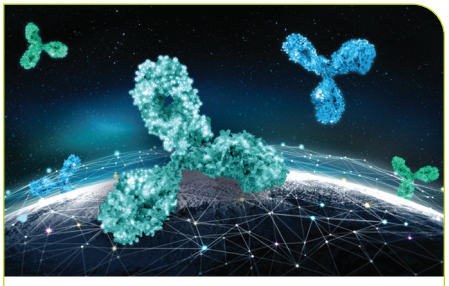


Western blot of protein profiler gel
reveals precise location of myosin light chain proteins (p. 56).

Ordering Information

Description	Catalog #
Mini Trans-Blot Systems and Accessories	
Mini-PROTEAN Tetra cell (2-gel) + Mini Trans-Blot module, includes 2 gel holder cassettes, 4 fiber pads, modular electrode assembly, cooling unit, lower buffer tank, lid with cables	1660827EDU
Mini-PROTEAN Tetra cell (2-gel) + Mini Trans-Blot module + PowerPac HC power supply, includes 2 gel holder cassettes, 4 fiber pads, modular electrode assembly, cooling unit, lower buffer tank, lid with cables	1660828EDU
Mini Trans-Blot Module, lower buffer tank and lid not included	1703935EDU
Mini gel holder cassette	1703931EDU
Blue cooling Unit for Mini-PROTEAN Tetra tanks	1703919EDU
Roller, 1	1651279EDU
Criterion Blotting Systems	
Criterion Blotter with plate electrodes, includes cell assembled with plate electrodes, lid with cables, 2 Criterion gel holder cassettes, 1 pack precut blot absorbent filter paper, 4 fiber pads, gel/blot assembly tray, roller, sealed ice block	1704070EDU
Criterion Blotter with wire electrodes, includes cell assembled with wire electrodes, lid with cables, 2 Criterion gel holder cassettes, 1 pack precut blot absorbent filter paper, 4 fiber pads, gel/blot assembly tray, roller, sealed ice block	1704071EDU
Trans-Blot Turbo Transfer System	
Trans-Blot Turbo transfer system for rapid semi-dry transfer	1704150EDU
Blockers for Blotting	
Blotting-Grade Blocker, nonfat dry milk, 300 g	1706404EDU
1x PBS/1% Casein, 1 L	1610783EDU
1x TBS/1% Casein, 1 L	1610782EDU
Blotting Membranes and Trans-Blot Turbo Packs	
Thick Blot Paper, 50 sheets, 7.5 x 10 cm	1703932EDU
0.45 µm Nitrocellulose, 7 x 8.5 cm, 10 sheets	1620145EDU
0.45 µm Nitrocellulose (8 sheets)/Filter Paper Pack (16 sheets)	1662807EDU
0.45 µm Nitrocellulose/Filter Paper Sandwich, 7 x 8.5 cm, 20 pk	1620214EDU
Mini Trans-Blot Fiber Pads, 8 x 11 cm, 4	1703933EDU
Trans-Blot Turbo Mini PVDF 10-Pack	1704156EDU
Trans-Blot Turbo Midi PVDF 10-Pack	1704157EDU
Protein Blotting Buffer Reagents and Detection Kits	
Visit **discover.bio-rad.com** for ordering information	
Antibodies	
Visit **bio-rad.com/EDUantibodies** for ordering information	

Buffers and reagents ship at room temperature. Store as directed on label. For more western blotting and immunodetection reagents, visit us on the Web at **discover.bio-rad.com**. For additional information on Criterion blotting system refer to bulletin 2558. The PowerPac HC power supply is recommended for Criterion blotting.



Antibodies

Bio-Rad now offers a wide range of validated antibodies for all your research and classroom needs. Visit **bio-rad.com/EDUantibodies** to browse the full catalog of monoclonal and polyclonal antibodies, assay reagents, antibody services, and exceptional support.

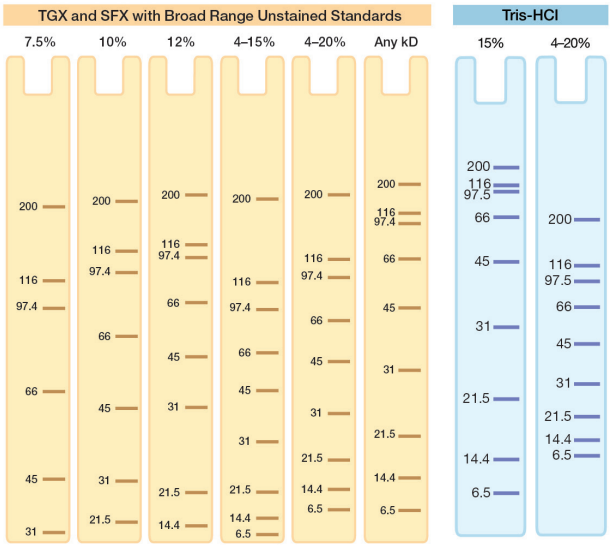
Precast Polyacrylamide Gels

Mini-PROTEAN TGX and TGX Stain-Free Precast Gels

The *long shelf life* Mini-PROTEAN TGX precast gels are part of an innovative gel system designed to provide Laemmli-like separation patterns using a standard Tris/glycine running buffer system and are compatible with Mini-PROTEAN electrophoresis cells. Save 3 hours of class time by eliminating the need to stain gels when using TGX Stain-Free precast gels. The gels include unique tri-halo compounds that allow rapid fluorescent detection of proteins with UV light. Benefits of all TGX gels include:

- Reduced run times — up to 30% faster
- Up to 12 months of shelf life at 4ºC
- Bottom-open cassette design for simple gel handling and blotting

Mini-PROTEAN Precast Gel Migration Charts



Protein migration on TGX precast gels. Percentages refer to acrylamide percentages. The molecular mass of each band is given in kD.

Precast Gels Are Available with Different Combs

- 10-well combs are most popular in teaching labs and accommodate samples up to 30 µl
- 15-well combs are designed for samples up to 20 µl

Outlined Sample Wells

After you remove the combs, the sample wells are outlined on the outside of the precast gel cassettes to simplify sample loading and eliminate loading errors. Only from Bio-Rad!

Mini-PROTEAN TGX Innovations

Ordering Information

Description	Catalog #
Mini-PROTEAN TGX Precast Gels	
7.5% Resolving Gel, 10 gels/box, 10-well, 30 µl	4561023EDU
7.5% Resolving Gel, 10 gels/box, 15-well, 15 µl	4561026EDU
10% Resolving Gel, 10 gels/box, 10-well, 30 µl	4561033EDU
10% Resolving Gel, 10 gels/box, 15-well, 15 µl	4561036EDU
12% Resolving Gel, 10 gels/box, 10-well, 30 µl	4561043EDU
12% Resolving Gel, 10 gels/box, 15-well, 15 µl	4561046EDU
4–15% Resolving Gel, 10 gels/box, 10-well, 30 µl	4561083EDU
4–15% Resolving Gel, 10 gels/box, 15-well, 15 µl	4561086EDU
4–20% Resolving Gel, 10 gels/box, 10-well, 30 µl	4561093EDU
4–20% Resolving Gel, 10 gels/box, 15-well, 15 µl	4561096EDU
Any kD™ Resolving Gel, 10 gels/box, 10-well, 30 µl	4569033EDU
Mini-PROTEAN TGX Stain-Free Precast Gels	
4–20% Stain-Free gels, 10 gels/box, 10-well, 30 µl	4568093EDU
Mini-PROTEAN TBE Precast Gels	
5% Resolving Gel, 2 gels/box, 10-well, 30 µl	4565013EDU
Criterion Tris-HCl Gels	
15% Resolving gel, 18-well, 30 µl	3450020EDU
4–20% Linear gradient, 18-well, 30 µl	3450033EDU

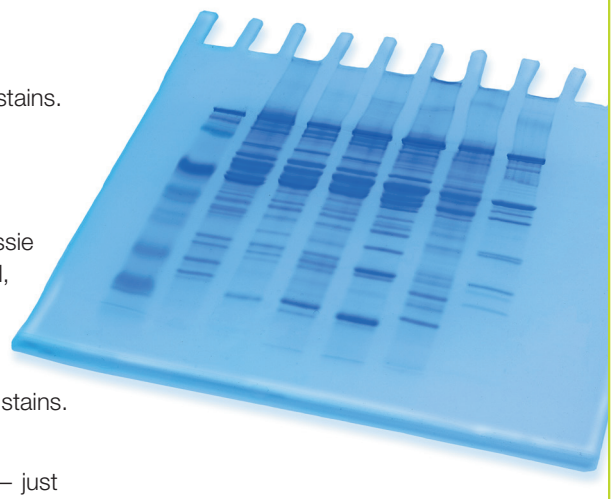
Criterion Tris-HCl precast gels ship on blue ice and should be stored at 4ºC.
Shelf life is 3 months from date of manufacture. Additional freight charge for blue ice (see p. 162).

Bio-Rad prescast gels are securely packaged individually

Best Selection at the Lowest Prices

TGX and Criterion precast gels are available in a wide selection of formulations for SDS-PAGE, native PAGE, and peptide separations. Visit us on the Web at **discover.bio-rad.com** for a complete listing. For more information, request bulletins 5871 (Mini-PROTEAN TGX Precast Gels), and 4110001 (Instruction Manual, Criterion Gel Application Guide).

Protein Stains



Proteins in electrophoresis gels can be seen using a variety of protein-specific stains. Visit us on the web at **explorer.bio-rad.com** for more detailed information and specifications about the stains described below.

Bio-Safe Coomassie Stain

By far our most popular stain for research and teaching labs, Bio-Safe Coomassie stain detects proteins in native, SDS-PAGE, and peptide gels without methanol, acetic acid, or any other hazardous reagents. Color development is extremely easy. Simply soak the gel in the stain and rinse with water — results begin to appear in 20 minutes. With sensitivity as low as 8 ng per band, you get better results without the solvent waste and toxicity problems of conventional protein stains.

Silver Stain Plus Kit

Silver Stain Plus stain is our most sensitive (ng) and easiest-to-use silver stain — just three simple steps complete in 1 hour. The Silver Stain Plus kit is ideal for both proteins and nucleic acids in polyacrylamide or agarose gels and stain 40 mini gels per kit.

Coomassie Brilliant Blue R-250 Solutions

Coomassie Brilliant Blue R-250 staining solution is an easy way to fix and detect proteins in polyacrylamide gels. Ready-to-use 1 L solutions eliminate the need to weigh powders or dilute solutions.

Bio-Safe Coomassie Stain

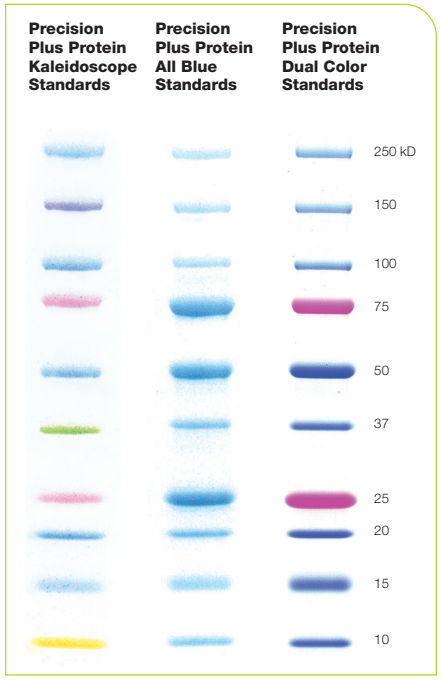
Precision Plus Protein Standards

Bio-Rad's Precision Plus Protein Standards allow your students to continuously monitor protein separation during electrophoresis and provide a quick and easy way to assess western blotting efficiency. Precision Plus Protein standards offer unsurpassed band sharpness, accurate molecular weight estimations, and lot-to-lot consistency.

Precision Plus Protein standards contain ten highly purified recombinant proteins in a range of bands from 10 to 250 kD, and are available in Kaleidoscope, unstained, all blue, and dual color options.

Bio-Rad protein standards contain bromophenol blue and glycerol, which allows easier sample loading, prevents the proteins from freezing at –20°C, and eliminates freeze/thaw degradation.

DUAL COLOR NOW Brighter



Ordering Information

Description	Catalog #
Protein Standards	
Precision Plus Protein Unstained Standards, 1,000 µl	1610363EDU
Precision Plus Protein All Blue Standards, 500 µl	1610373EDU
Precision Plus Protein Dual Color Standards, 500 µl	1610374EDU
Precision Plus Protein Kaleidoscope Standards, 500 µl	1610375EDU
SDS-PAGE Electrophoresis Module, includes 1L 10x TGS buffer, 30 ml Laemmli sample buffer, 1L Bio-Safe Coomassie stain, and 500 µl Precision Plus Protein Dual Color standards	1665060EDU
Protein Stains	
Bio-Safe Coomassie Stain, 1 L	1610786EDU
Bio-Safe Coomassie Stain, 5 L	1610787EDU
Silver Stain Plus Kit	1610449EDU
Coomassie Brilliant Blue R-250 Kit, includes 1 L stain solution, 2 L destain solution	1610435EDU

Protein standards are shipped at room temperature. Store in freezer upon arrival.

Premixed Buffers for Electrophoresis

Save preparation time and ensure perfect electrophoresis results every time with premixed electrophoresis buffers. Our buffers are made with electrophoresis-purity reagents and are quality controlled to ensure reproducible results. Electrophoresis buffers are available in two formulations:

- Tris/glycine/SDS buffer for standard vertical polyacrylamide gel electrophoresis (SDS-PAGE) applications
- Tris/glycine buffer for native or nondenaturing PAGE

Premixed Sample Buffer for Protein Electrophoresis

Simplify sample preparation and save time! Bio-Rad's Laemmli sample loading buffer contains the electrophoresis tracking dye bromophenol blue, SDS, glycerol, and Tris buffer. Add directly to samples to solubilize proteins, boil, and then load your gels with ease.

Protein Electrophoresis Reagent Pack

The SDS-PAGE Electrophoresis Module provides all of the reliability of Bio-Rad's high-quality size standards, buffers, and stains in a convenient reagent pack.

Bio-Rad's premixed electrophoresis buffers save time and ensure quality.

Protein Electrophoresis Reagent Pack

Protein Quantitation Assay Kits

The Bio-Rad Protein Assay Kit, derived from the Bradford method, is an industry standard for simple and sensitive colorimetric protein quantitation. In a typical application, the protein assay reagent is added to a sample and the color change is quantitated with a spectrophotometer or microplate reader. Protein standards provided in this kit allow generation of a standard curve based on the color intensities by known concentrations of protein. The amount of protein can also be accurately estimated by eye, making this a great low-tech alternative for the classroom. The ready-to-use Quick Start Bradford protein assay includes prediluted standards and quantitates samples quickly to reduce prep time.

Quick Start Bradford Protein Assay Kit

Ordering Information

Description	Catalog #
Electrophoresis and Blotting Buffers and Reagents	
10x Tris/Glycine/SDS, 1 L	1610732EDU
10x Tris/Glycine/SDS, 5 L cube	1610772EDU
10x Tris/Glycine, 1 L	1610734EDU
10x Tris/Glycine, 5 L cube	1610771EDU
Laemmli Sample Buffer, 30 ml	1610737EDU
Native PAGE Sample Buffer, 30 ml	1610738EDU
Tris, 500 g	1610716EDU
Urea, 250 g	1610730EDU
Glycine, 250 g	1610717EDU
Bromophenol Blue, 10 g	1610404EDU
Dithiothreitol (DTT), 1 g	1610610EDU
Dithiothreitol (DTT), 5 g	1610611EDU
2-Mercaptoethanol (BME), 25 ml	1610710EDU
10% SDS Solution, 250 ml	1610416EDU
10x TBE, 1 L	1610733EDU
10x TBE, 5 L cube	1610770EDU
10x Phosphate Buffered Saline (PBS), 1 L	1610780EDU
10x Tris Buffered Saline (TBS), 1 L	1706435EDU
10% Tween 20, 5 ml	1662404EDU
10% Tween 20, 1 L	1610781EDU
Blotting-Grade Blocker, nonfat dry milk, 300 g	1706404EDU
1x PBS/1% Casein, 1 L	1610783EDU
1x TBS/1% Casein, 1 L	1610782EDU
Protein Quantitation Assay Kits	
Bio-Rad Protein Assay Dye Reagent Concentrate	5000006EDU
Bio-Rad Protein Assay Kit I	5000001EDU
Protein Standard II	5000007EDU
Quick Start Bradford Protein Assay Kit 1	5000201EDU
Quick Start Bradford Protein Assay Kit 2	5000202EDU
Quick Start Bradford Protein Assay Kit 3	5000203EDU
Quick Start Bradford Protein Assay Kit 4	5000204EDU

Buffers and reagents ship and store at room temperature.

SDS-PAGE Electrophoresis Module

• See page 96

Chromatography Reagents and Purification Systems

Column chromatography is one of the most common methods for scientific discovery in the purification of biomolecules.

NGC Medium-Pressure Liquid Chromatography Systems

The customizable and expandable design of the NGC chromatography system lets you choose the best configuration for your teaching applications. Interchangeable modules make it easy to scale up your system and add functionality over time. Each system includes the ChromLab software, an easy-to-use and highly graphical software that responds dynamically to the unique configuration of your NGC system. Speak with your local sales representative about customizing your own NGC chromatography system.

Bio-Scale Mini Cartridges

Train on Your Purification Systems
with the Protein Expression and Purification Series (pp. 92–97)

Chromatography Columns and Media

Bio-Rad's range of prepacked columns and cartridges are the easiest and most consistent way to meet your purification needs. Applications range from desalting oligonucleotides, antibodies, enzymes, or protein solutions to buffer exchange or reaction cleanup.

Pair Bio-Rad's Poly-Prep or Econo-Column empty chromatography columns with our wide selection of media for greater flexibility. Bio-Rad's media choices include size exclusion, hydrophobic interaction, anion or cation exchange, hydroxyapatite, affinity columns, and more.

Visit us online at **bio-rad.com/chromatography** for more information on the chromatography systems. Be sure to speak with your local account manager about educational pricing.

NGC Chromatography System

Ordering Information

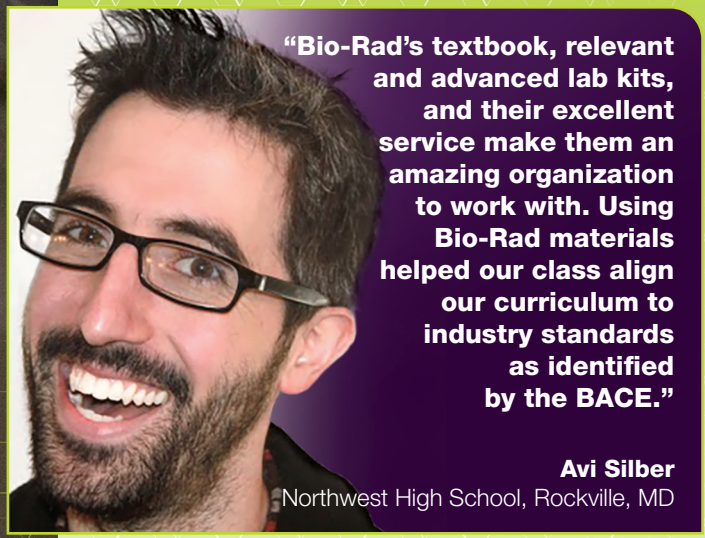
Description	Catalog #
NGC Chromatography Systems	
NGC Quest 10 Chromatography System includes two-tier base frame, 2 F10 pump modules, mixer module, single-wavelength detector module, sample injection valve, ChromLab software, buffer tray, connection adapter for BioFrac fraction collector	7880001EDU

Visit us on the Web at **discover.bio-rad.com** to view a complete listing of Bio-Rad's modular chromatography systems, columns, and media.


BIO-RAD
Model 16K
Microcentrifuge
LID LOCK
HOLD
TIME
SPEED
quick
BIO-RAD

Section Contents

General Laboratory: Equipment and Supplies



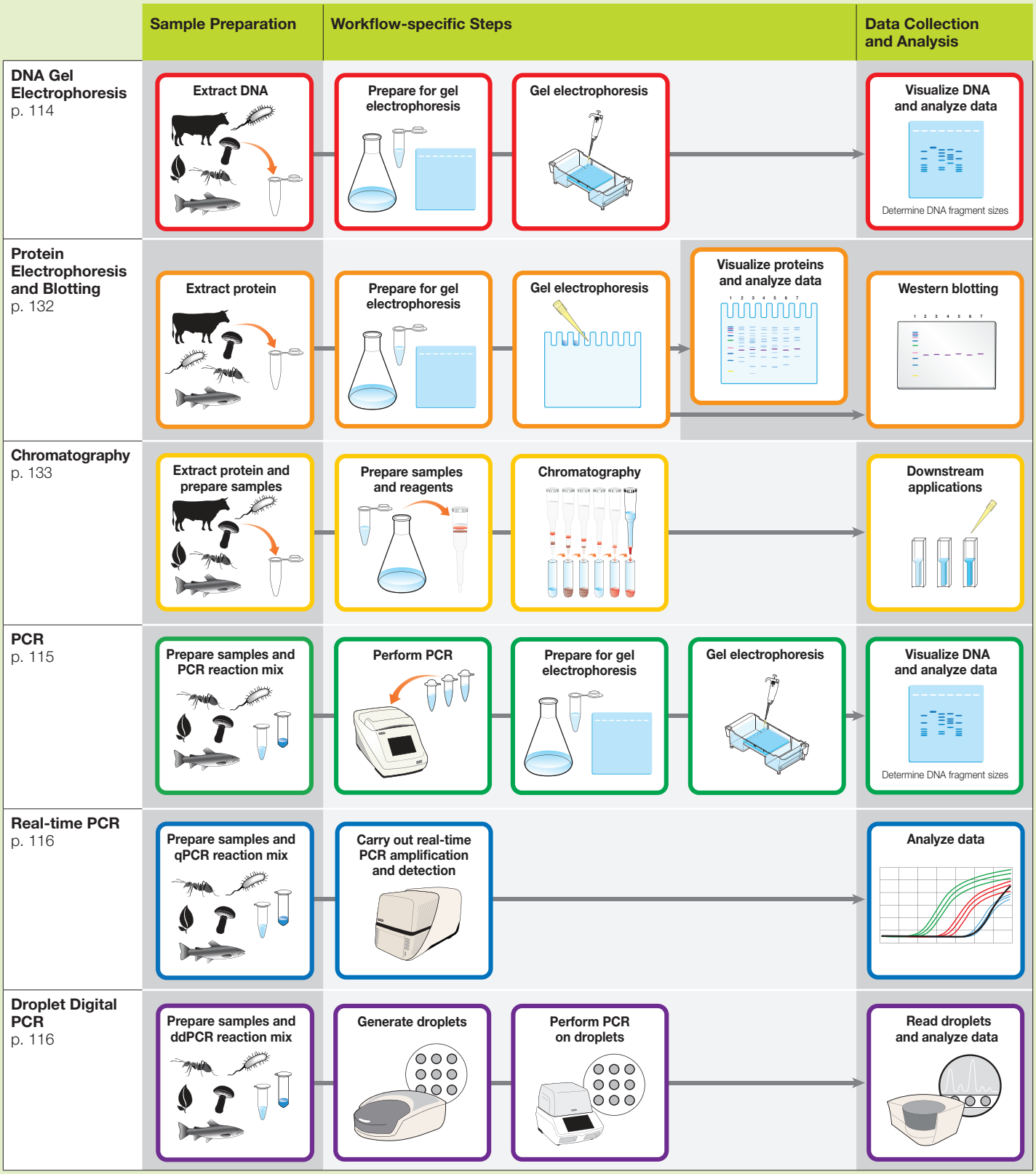
"Bio-Rad's textbook, relevant and advanced lab kits, and their excellent service make them an amazing organization to work with. Using Bio-Rad materials helped our class align our curriculum to industry standards as identified by the BACE."

Avi Silber
Northwest High School, Rockville, MD

Bio-Rad Explorer Teacher and Student Alumni

General Laboratory Equipment

Though not required for all classroom lab activities, general laboratory equipment enable and optimize sample preparation and other applications in almost all workflows. They are versatile and key additions to molecular biology labs.



General Equipment Usage in Workflows

This table summarizes the use of general laboratory equipment across various technical workflows.

	Micropipets	Mixing Devices	Centrifuges	Temperature Control Devices	PowerPac Power Supplies	Gel Imaging and Documentation
DNA Gel Electrophoresis p. 114	• DNA Extraction • Sample Preparation • Sample Loading	• DNA Extraction • Sample Preparation	• DNA Extraction • Sample Preparation	• DNA Extraction • Sample Preparation	• Gel Electrophoresis	• Visualization and Analysis
PCR p. 115	• DNA Extraction • Sample Preparation • Sample Loading	• DNA Extraction • Sample Preparation	• DNA Extraction • Sample Preparation	• DNA Extraction • Sample Preparation	• Gel Electrophoresis	• Visualization and Analysis
Real-time PCR and Droplet Digital PCR p. 116	• DNA Extraction • Sample Preparation • Sample Loading	• DNA Extraction • Sample Preparation	• DNA Extraction • Sample Preparation	• DNA Extraction • Sample Preparation		
Protein Electrophoresis p. 132	• DNA Extraction • Sample Preparation • Sample Loading	• Protein Extraction • Sample Preparation	• Protein Extraction • Sample Preparation	• Protein Extraction • Sample Preparation	• Gel Electrophoresis	• Visualization and Analysis
Chromatography p. 133	• DNA Extraction • Sample Preparation • Sample Loading • Downstream Applications	• Protein Extraction • Sample Preparation	• Protein Extraction • Sample Preparation	• Protein Extraction • Sample Preparation		• Visualization and Analysis
Kit Families						
Genetic Engineering, Microbiology, and Model Organism Kits pp. 16–37	✔		(Optional)	✔		(Optional)
Protein Analysis Kits pp. 38–59	✔	✔	✔	✔	✔	(Optional)
DNA Analysis and Agarose Gel Electrophoresis Kits pp. 60–71	✔	(Optional)	✔	(Optional)	✔	(Optional)
PCR and Real-Time Amplification Kits pp. 72–81	✔	(Optional)	✔	(Optional)		
Cloning & Sequencing Series pp. 82–91	✔	✔	✔	✔	✔	✔
Protein Expression and Purification Series pp. 92–97	✔	✔	✔	✔	✔	(Optional)

UV Illumination

UV Pen Light

This pocket-sized little disposable lamp has the power needed to illuminate your experiments. The wavelength is optimized for your green fluorescent protein activities, including our pGLO bacterial transformation, GFP chromatography, and Secrets of the Rainforest kits.

UV Light

Long-Wave UV Lamp

This convenient, handheld long-wave UV lamp runs on four AA batteries and has a wavelength output between 300 and 400 nm. Designed for excitation of green fluorescent protein (GFP), this lamp fits the bill for our pGLO bacterial transformation, GFP chromatography, pGLO kit SDS-PAGE extension, and Secrets of the Rainforest kits. The acrylic safety shield protects the bulb and the user's eyes.

UV Lamp

Gel Imaging and Documentation

Bio-Rad offers a complete suite of imaging systems for detecting, imaging, and quantitating colorimetric, chemiluminescent, fluorescent, and radioisotopic signals. Software provides automation for image acquisition with data analysis and validation. For more information visit us on the Web at **discover.bio-rad.com** and download bulletin 5888.

UView Mini Transilluminator

UView Mini Transilluminator

UView mini transilluminator is a small-format transilluminator that has an excitation peak of 365 nm and works well for visualizing DNA fragments when using the UView 6x Loading Dye and Stain (p.122) and others. The unit has a UV blocking shield and an auto shutoff when the shield is removed in order to reduce accidental UV exposure. The shutoff can be manually overridden to facilitate cutting bands out of gels while wearing appropriate UV protective wear. The viewing area can accommodate one mini gel lengthwise or two mini gels widthwise (viewing area is 8 x 15 cm).

UView Mini Transilluminator Specifications

Illumination type	UV lamp
Wavelength	365 nm
Dimensions (L x W x H)	24.7 x 13.2 x 4.9 cm
Viewing surface	15.0 x 8 cm
Weight	1.4 kg
Compatible gel sizes	5 x 6 cm, 10.5 x 6 cm, 12.5 x 6 cm
Power	12 V, 1.5 A
Input	115–240 V, 4 different country adapters included
Safety	Auto shutoff when lid is opened, capable of manual override

GelDoc Go Imaging System

The GelDoc Go Imaging System is small and easy to use with a large UV transilluminator that offers the flexibility to image many different types of gels of varying sizes. With just 3 clicks to capture, the onboard Image Lab Touch Software is as easy to use as your smartphone.

Available trays include a UV tray (for Stain-Free protein gels, ethidium bromide gel staining, and fluorescence imaging), a white tray (for Coomassie, copper, silver, and zinc stains), and a blue tray (for nucleic acid applications that use SYBR® stains).

GelDoc Go System Features:

- Easy to use — no need for manual control of filter, lights, or lenses
- Time-saving — get results quickly
- Space-saving — small footprint, large imaging area
- Modular design and flexible options — application-specific trays allow you to configure your system and upgrade when you want to

The GelDoc Go Imaging System

GelDoc Go Imaging System supports the following Bio-Rad Explorer kits:

- Forensic DNA fingerprinting kit (see pp. 68–69)
- Lambda DNA kits (see pp. 70–71)
- PCR Amplification kits (see pp. 72–79)
- pGLO kit SDS-PAGE extension (see pp. 32–33)
- Comparative proteomics kits I and II and V3 Western Workflow: (see pp. 54–59)
- Cloning and Sequencing Explorer Series (see pp. 82–91)
- Protein Expression and Purification Series (see pp. 92–97)

ChemiDoc Imaging System

The ChemiDoc Imaging System provides fast and easy chemiluminescent or colorimetric imaging of both gels and western blots. The instrument is simple to use and the Image Lab software included with the built-in touch screen guides you to success within minutes.

The system includes a UV tray for blotting and UV gel imaging applications. A white tray for Coomassie or silver stains and a blue tray for nucleic acid stains like SYBR® are also available.

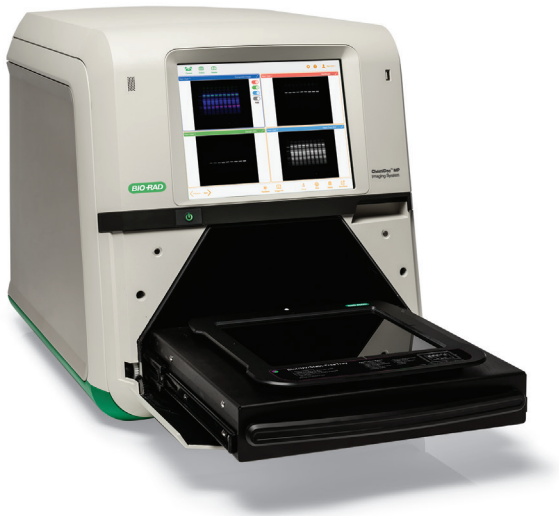
ChemiDoc Imaging System Features:

- Automatic imaging — software optimizes options for you
- Easy-to-use built-in 12" touch screen — preview your results immediately
- Intuitive Image Lab software — learn to use the instrument in minutes

Visit us on the web at bio-rad.com/imagingsystems for more information about the ChemiDoc and other imaging systems.

V3 Western Workflow

Take full advantage of the ChemiDoc Imaging System to go from protein sample to visualized western blot results in less than two hours with the V3 Western Workflow. Visit **bio-rad.com/V3EDU** for details.



ChemiDoc Imaging System

Ordering Information

Description	Catalog #
UV Lamps	
Long-Wave UV Pen Light	1660530EDU
Long-Wave UV Lamp, requires 4 AA batteries	1660500EDU
UView Mini Transilluminator	
UView mini transilluminator	1660531EDU
GelDoc Go Imaging System and Accessories	
GelDoc Go Imaging System with UV/Stain-Free Tray	12009077EDU
White Tray for GelDoc Go Imaging System	12012165EDU
Blue Tray for GelDoc Go Imaging System	12012160EDU
UV/Stain-Free Tray for GelDoc Go Imaging System	12012189EDU
UV Shield for GelDoc Go Imaging System	12012164EDU
Gel Alignment Template Kit	12012190EDU
Holder for Sample Trays and UV Shield	1708377EDU
XcitaBlue Viewing Goggles	1708185EDU
Gel Cutter Ruler	1703760EDU
Image Lab Software on a USB Drive	12012931EDU
ChemiDoc Imaging System and Accessories	
ChemiDoc Imaging System for Mac or PC includes: 12” touch-screen display with Image Lab Touch Software, Image Lab Software, Blot/UV/Stain-Free Sample Tray, Clarity and Clarity Max Substrates, Precision Plus Protein All Blue Standards, Precision Plus Protein Unstained Standards	17001401EDU
ChemiDoc V3 Western Workflow for Mini Gels includes: the ChemiDoc Imaging System components plus the Trans-Blot Turbo transfer system, Mini-PROTEAN Tetra Cell, PowerPac Basic power supply, Trans-Blot Turbo Mini nitrocellulose transfer packs (10/pk), Immun-Blot Low-Fluorescence Mini PVDF Filter Paper Sets (10/pk), 4–20% TGX Stain-Free 15-Well Precast Gel Pack (10/pk), 1 L 10x Tris/glycine/SDS running buffer, 1 L 1x tris buffered saline with 1% casein, 30 ml 2x Laemmli sample buffer	17001403EDU
UV and Stain-Free Sample tray	12003028EDU
White Light Sample Tray	12003026EDU
Blue Light Sample Tray	12003027EDU

Centrifuges

Model 16K Microcentrifuge

The Model 16K, the ultimate benchtop centrifuge, is designed for all your teaching lab applications. The motor is brushless, exceptionally quiet, and requires no routine maintenance.

- Quick-spin features
- Safe for coldroom operation

Specifications

Max. speed	14,000 rpm (16,000 x g)
Capacity	18-place rotor for 1.5 and 2.0 ml tubes
Safety	Safety interlock
Automation	30 minute timer or quick-spin button
Dimensions	21 x 23 x 18 cm (W x D x H)
Regulatory certification	CE compliant

Model 16K Microcentrifuge

Model 16K Microcentrifuge PCR Tube Adaptor (sold separately)

Model 16K Microcentrifuge PCR Tube Adaptor

This adaptor holds two PCR 8-tube strips or up to 16 individual 0.2 ml tubes. The adaptor fits on top of the standard 18-place rotor and is easily attached to and removed from the rotor. The PCR tube adaptor is sold separately.

Mini Centrifuge

This economical and reliable mini centrifuge handles most teaching lab applications, including quick sample spin-downs and cell pelleting. This unit is provided with a microtube rotor, a PCR strip tube rotor, and adaptors for 0.4 and 0.5 ml tubes.

Specifications

Max. speed	6,000 rpm (2,000 x g)
Capacity	8 x 1.5/2.0 ml, 0.5/0.6 ml, 0.4/0.25 ml, or 0.2 ml tubes, 32 x 0.2 ml PCR tubes
Dimensions	15 x 15 x 12 cm (W x D x H)
Regulatory certification	CE approved

Mini Centrifuge

Ordering Information

Description	Catalog #
Microcentrifuge and Mini Centrifuge	
Model 16K Microcentrifuge, 120 V	1660602EDU
Model 16K Microcentrifuge, 220 V	1660612EDU
PCR Tube Adaptor, for Model 16K microcentrifuge	1660620EDU
Mini Centrifuge, 100–240 V	12011919EDU
Tube Roller	
Tube Roller, 120 V, includes 3 tube carousels for 1.5, 15, and 50 ml tubes	1660711EDU
Tube Roller, 230 V, for Europe, includes 3 tube carousels for 1.5, 15, and 50 ml tubes	1660721EDU
Tube Roller, 230 V, for the UK, includes 3 tube carousels for 1.5, 15, and 50 ml tubes	1660722EDU
Vortexer	
BR-2000 Vortexer, 120 V	1660610EDU
BR-2000 Vortexer, 220 V	1660611EDU
BR-2000 Vortexer, 220 V, for the UK	1660621EDU
Flathead Dimpled Adaptor	1660622EDU
Mini Rocker	
Mini Rocker, 120 V, includes 2 blotting boxes	1660710EDU
Mini Rocker, 230 V, for the UK and Europe, includes 2 blotting boxes	1660720EDU
Rocking Platform	
UltraRocker Rocking Platform, 120 V	1660709EDU
UltraRocker Rocking Platform, 220 V	1660719EDU

Mixing Devices

Tube Roller

Dual orientation rotisseries allows mixing of samples both horizontally and vertically, and includes 3 easily interchangeable rotisseries. Its compact design allows it to fit inside our mini incubation oven, making it ideal for mixing liquids while incubating.

Tube Roller

Specifications

Capacity – standard	36 x 1.5/2.0 ml tubes, 10 x 15 ml tubes, or 6 x 50 ml tubes
Speed	24 rpm
Operating range	4–65°C
Maximum load	0.8 kg (1.75 lb)
Dimensions	21.3 x 10.2 x 12.6 cm (W x D x H)
Regulatory certification	CE compliant

BR-2000 Vortexer

The BR-2000 vortexer is the general-purpose mixer with a three-speed switch for a range of applications, from gentle sample mixing to resuspending cell pellets. The mixer can be operated continuously or by touch activation, and is equipped with rubber feet to avoid sliding even at maximum speed. A general-purpose cup attachment is included; the flathead dimpled adaptor, useful for mixing larger volumes, is sold separately.

BR-2000 Vortexer

Flathead Dimpled Adaptor
(sold separately)

Specifications

Speed range	0–3,000 rpm
Operating modes	Continuous operation or touch control
Operating range	4–65°C
Dimensions	12 x 15 x 13 cm (W x D x H)
Regulatory certification	CE compliant

Mini Rocker

The Mini Rocker provides the best three-dimensional mixing action with optimal fixed speed and tilt. Gentle yet thorough mixing makes it perfect for western blot incubations and staining of gels. Its compact design allows it to fit inside our mini incubation oven for temperature-controlled mixing.

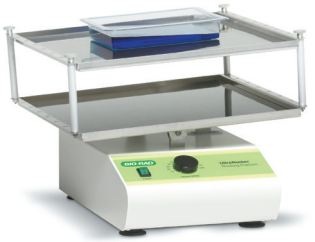
Mini Rocker

Specifications

Speed	24 rpm
Motion/Pitch	3-D/fixed 5º
Maximum load	0.8 kg (1.75 lb)
Operating range	4–40ºC
Dimensions	20.3 x 17.8 x 9.5 cm (W x D x H)
Capacity	Four 8 x 10 cm or two 10 x 20 cm blotting boxes
Regulatory certification	CE compliant

UltraRocker Rocking Platform

Features two corrosion-resistant rocking platforms lined with nonslip rubber mats. The tilt capacity and variable speed control of this rocker permit a broad range of mixing and agitation options overnight incubation of liquid bacterial cultures, staining and destaining of agarose and polyacrylamide gels and blots, and southern hybridization.



UltraRocker Rocking Platform

Specifications

Speed range	8–40 rpm
Motion	Tilting, ±7.5°
Platform dimensions	29 x 21 cm (W x D)
Platform clearance	9 cm
Dimensions with double platform	29 x 21 x 25 cm (W x D x H)
Maximum load	4.5 kg (10 lb)
Operating range	4–80°C
Regulatory certification	CE compliant

Temperature Control Devices

Digital Dry Bath

This digitally controlled dry bath is perfect for a multitude of laboratory procedures where incubation of samples is needed. It's accurate and built for safe, continuous operation. It's economical and versatile, too!

- Base unit includes one heat block for 1.5 ml tubes
- Digital display with timer
- Safety lid to avoid burns
- Easy user calibration
- Holds 24 microcentrifuge tubes
- Optional blocks for 0.5, 2.0, and 15 ml tubes

Digital Dry Bath

1.5 ml Block

Specifications

Temperature range	5° greater than room temperature to 150°C
Temp. uniformity	±0.2ºC at 37ºC
Block chamber	Stainless steel
Single block unit	One standard block
Dimensions	20 x 29.5 x 8.5 cm (W x D x H)
Regulatory certification	CE compliant

Dry Bath Block

Construction	High-grade, nonporous aluminum with anodized surface
Thermometer well	Required only for calibration purposes
Block capacity	24 x 0.5 ml tubes, 24 x 1.5 ml tubes, 24 x 2.0 ml tubes, or 12 x 15 ml tubes

0.5 ml Block

2.0 ml Block

1.5 ml Block

Water Bath

This temperature-controlled water bath is hot! It's built for accuracy, dependability, affordability, and safety.

- Easy-to-clean, seamless stainless-steel tank
- Stainless-steel gable cover
- Electrostatically applied finish that resists rust, corrosion, and scratches
- Over-temperature protection
- Thermometer

Water Bath

Specifications

Temperature range	Room temperature to 100°C
Capacity	6 L
Dimensions	
Exterior	36 x 28 x 32 cm (W x D x H)
Interior	32 x 17 x 18 cm (W x D x H)
Regulatory certification	CE compliant

Mini Incubation Oven

Simply the most economical and reliable incubator, this compact oven (0.5 cu. ft.) is thermostatically controlled for growth of bacterial cultures over a wide range of temperatures. The oven is now available with an accessory port in the rear of the unit to allow for the insertion of our tube roller (1.5/2.0 ml, 15 ml, and 50 ml tube options) or mini rocker for temperature-controlled mixing. This mini incubation oven will support a variety of classroom experiments.

Mini Incubation Oven

Specifications

Temp. range	Room temperature to 60°C
Temp. uniformity	±5°C
Capacity	Eighty 6.5 cm plates
Dimensions	
Exterior	28 x 29 x 34 cm (W x D x H)
Chamber	23 x 20 x 20 cm (W x D x H)
Regulatory certification	CE compliant

Benchtop Shaking Incubator

The Benchtop Shaking Incubator is an economic solution for liquid culture incubation. Its versatile features make it suitable for a variety of applications and topics. The incubator is included in two convenient bundles:

- **Benchtop Shaking Incubator Starter Set**
  Includes the Benchtop Shaking Incubator and clamps for 2 x 500 ml, 2 x 250 ml, and 2 x 125 ml flasks
- **Benchtop Shaking Incubator Expanded Set**
  Includes the Benchtop Shaking Incubator, 1 petri dish shelf, and clamps for 4 x 1,000 ml, 5 x 500 ml, 9 x 250 ml, and 16 x 125 ml flasks.

Specifications

Capacity	Up to 4 L — 16 x 125 ml, 9 x 250 ml, or 4 x 1,000 ml flasks or test tube racks
Temperature range	5° greater than room temperature to 70°C
Shaking speed range	30–300 rpm
Timer range	1 min to 99 hrs
Dimensions	37 x 53 x 40 cm (W x D x H)
Weight	21 kg
Regulatory certification	CE compliant

Benchtop Shaking Incubator

Ordering Information

Description	Catalog #
Digital Dry Bath	
Digital Dry Bath, 120 V, includes 1.5 ml heating block	1660562EDU
Digital Dry Bath with all 4 heating blocks, 120 V, includes 0.5, 1.5, 2.0, and 15 ml heating blocks	1660571EDU
Digital Dry Bath, 230 V, for the UK and Europe, includes 1.5 ml heating block	1660563EDU
Digital Dry Bath with all 4 heating blocks, 230 V, for the UK and Europe, includes 0.5, 1.5, 2.0, and 15 ml heating blocks	1660572EDU
Digital Dry Bath heating block, 0.5 ml, for 24 x 0.5 ml tubes	1660565EDU
Digital Dry Bath heating block, 2.0 ml, for 24 x 2.0 ml tubes	1660566EDU
Digital Dry Bath heating block, 15 ml, for 12 x 15 ml tubes	1660567EDU
Digital Dry Bath heating blocks, 3 pack, 0.5 ml, 2.0 ml, and 15 ml blocks	1660570EDU
Water Bath	
Temperature-Controlled Water Bath, 120 V	1660504EDU
Temperature-Controlled Water Bath, 220 V	1660524EDU
Mini Incubation Oven	
Mini Incubation Oven, 120 V	1660501EDU
Mini Incubation Oven, 220 V	1660521EDU
Mini Incubation Oven and Mini Rocker, 120 V	1660712EDU
Mini Incubation Oven and Tube Roller, 120 V	1660713EDU
Benchtop Shaking Incubator	
Benchtop Shaking Incubator Starter Set, Includes benchtop shaking incubator and clamps for 2 x 500 ml, 2 x 250 ml, and 2 x 125 ml flasks	17002944EDU
Benchtop Shaking Incubator Expanded Set, Includes benchtop shaking incubator, petri dish shelf, and clamps for 4 x 1,000 ml, 5 x 500 ml, 9 x 250 ml, and 16 x 125 ml flasks	17002945EDU
Benchtop Shaking Incubator Starter Set, 230 V for Europe and the UK Includes benchtop shaking incubator and clamps for 2 x 500 ml, 2 x 250 ml, and 2 x 125 ml flasks	17002946EDU
Benchtop Shaking Incubator Expanded Set, 230 V for Europe and the UK Includes benchtop shaking incubator, petri dish shelf, and clamps for 4 x 1,000 ml, 5 x 500 ml, 9 x 250 ml, and 16 x 125 ml flasks	17002947EDU
Flask Clamp for Shaking Incubator, 1,000 ml	12005512EDU
Flask Clamp for Shaking Incubator, 500 ml	12005511EDU
Flask Clamp for Shaking Incubator, 250 ml	12005490EDU
Flask Clamp for Shaking Incubator, 125 ml	12005514EDU
Petri Dish Shelf for Shaking Incubator	12005504EDU

Micropipets, Micropipet Racks, and Pipet Controller

The procedures used in molecular biology require precise manipulation of small volumes of solutions containing DNA, proteins, buffers, or enzymes. Micropipets are required to accurately measure and transfer solution volumes in microliter (µl) ranges. No biology teaching lab experience is complete without hands-on use of micropipets.

Fixed-Volume Micropipets

Fixed-Volume Micropipets

Get all the accuracy of standard adjustable-volume micropipets — but at a fraction of the price! These dedicated pipets accommodate sample volumes most frequently encountered in a teaching lab. Using standard pipet tips, each color-coded pipet will transfer a fixed volume of solution: 5 µl (red), 10 µl (green), 20 µl (yellow), or 50 µl (blue).

Professional Adjustable-Volume Micropipets

Classroom Digital Micropipets

These adjustable pipets deliver exceptional classroom performance. Four models are available: 0.5–10 µl, 2–20 µl, 20–200 µl, and 100–1,000 µl. Features include:

- 2-year warranty
- Adjustable digital dial with convenient tip ejector
- Accommodates standard pipet tips
- 0.1 µl volume increments for 0.5–10 µl pipets
- 0.5 µl volume increments for 2–20 µl pipets
- 1 µl volume increments for 20–200 µl pipets
- 5 µl volume increments for 100–1,000 µl pipets

Classroom Digital Micropipets

Professional Adjustable-Volume Digital Micropipets

Designed and engineered for research, these adjustable pipets deliver exceptional comfort, durability, and performance. Guaranteed to function efficiently and reliably for years — they're the real thing. Five models are available to cover all applications requiring transfers of small volumes of precious solutions: 0.1–2 µl, 0.5–10 µl, 2–20 µl, 20–200 µl, and 100–1,000 µl. Features include:

- 3-year warranty
- Now fully autoclavable micropipet that accommodates standard pipet tips
- Adjustable digital dial with locking mechanism, slender contoured grip, and ergonomic tip ejector
- 0.002 µl volume increments for 0.1–2 µl pipets
- 0.02 µl volume increments for 0.5–10 µl, 2–20 µl pipets
- 0.2 µl volume increments for 20–200 µl pipets
- 2 µl volume increments for 100–1,000 µl pipets

8-Channel Professional Micropipet
(Pipet tips not included)

8-Channel Professional Micropipets

Multichannel pipets offer an easy way to enjoy the efficiency of pipetting multiple samples at once. A great way to teach advanced pipetting skills for workforce development coursework. Each channel has an independent precision piston assembly to ensure accuracy and reproducibility from one pipetting series to the next as well as between channels. Features include:

- Precision designed tip cones provide leak-proof tip fit
- Continuously adjustable volume selection (5–50 µl or 20–200 µl) with thumbwheel or push button
- Curved ejector bar reduces ejection force
- Fully autoclavable

Micropipet Rack
Fits nine digital micropipets
(not included)

Micropipet Rack

Designed for the lab benchtop with wipe-and-clean surface and a non-skid base.

Carousel Pipet Rack
Fits six digital micropipets
(not included)

Carousel Pipet Rack

Six-place carousel rack conveniently rotates for easy access to your professional micropipets.

Professional Micropipet Backpack Starter Set

The professional micropipet backpack starter set is a complete liquid handling package that includes everything needed to get started with accurate and reproducible pipetting. Exceptional value includes:

- 4 professional adjustable-volume digital micropipets (0.5–10 µl, 2–20 µl, 20–200 µl, and 100–1,000 µl)
- Bio-Rad pipet tips (four racks including TBR-14, -35, -40, and Prot/Elec)
- 6-place carousel pipet rack
- Bio-Rad backpack

Professional Pipet Controller

The pipet controller is designed for operation with glass or plastic serologic pipets from 0.1 to 100 ml. With a slim, ergonomic handle design, the controller is comfortable and easy to use. It comes with a charger, bench stand, wall mount, and 0.45 µm filter.

Professional Micropipet Backpack Starter Set
(actual backpack provided may vary)

Ordering Information

Description	Catalog #	Includes classroom set of 8 micropipets Catalog #
Fixed-Volume Micropipets		
5 µl Fixed-Volume Pipet, red	1660511EDU	1660511BLK
10 µl Fixed-Volume Pipet, green	1660512EDU	1660512BLK
20 µl Fixed-Volume Pipet, yellow	1660513EDU	1660513BLK
50 µl Fixed-Volume Pipet, blue	1660515EDU	1660515BLK
Classroom Digital Micropipets		
0.5–10 µl Digital Micropipet	1660550EDU	1660550BLK
2–20 µl Digital Micropipet	1660551EDU	1660551BLK
20–200 µl Digital Micropipet	1660552EDU	1660552BLK
100–1,000 µl Digital Micropipet	1660553EDU	1660553BLK
Professional Adjustable-Volume Digital Micropipets		
0.1–2 µl Digital Micropipet	1660499EDU	1660499BLK
0.5–10 µl Digital Micropipet	1660505EDU	1660505BLK
2–20 µl Digital Micropipet	1660506EDU	1660506BLK
20–200 µl Digital Micropipet	1660507EDU	1660507BLK
100–1,000 µl Digital Micropipet	1660508EDU	1660508BLK
Professional Multichannel Pipet, 8-channel, adjustable volume, 5–50 µl	1660496EDU	
Professional Multichannel Pipet, 8-channel, adjustable volume, 20–200 µl	1660495EDU	
Micropipet Racks		
Micropipet Rack, holds 9 single micropipets	1660554EDU	
Carousel Pipet Rack, holds 6 single professional micropipets	1660487EDU	
Professional Pipet Backpack Starter Set		
Set includes four professional adjustable-volume digital micropipets (0.5–10 µl, 2–20 µl, 20–200 µl, and 100–1,000 µl), 4 racks of pipet tips (TBR-14, -35, -40, Prot/Elec), Carousel Pipet Rack, and Bio-Rad backpack	1660486EDU	
Professional Pipet Controllers		
Professional Pipet Controller, 120 V, includes charger, bench stand, wall mount, and 0.45 µm filter	1660490EDU	
Inline Filters for Pipet Controller, 0.45 µm, PTFE, 25 mm, 10 pack	1660493EDU	

Pipet Controller
(serologic pipet not included)

Pipet Tips

Bio-Rad's pipet tips are made from virgin polypropylene, are accurately molded for an airtight fit, and have a smooth interior surface — essential for precise pipetting.

- Available in bulk or in enclosed racks
- Special-purpose gel-loading and aerosol-barrier pipet tips available
- Pipet tips and racks autoclavable at a recommended temperature of 120°C at 15 psi for 15 min
- Presterilized by ^{60}Co gamma irradiation

Universal Pipet Tips

Available for all general pipetting applications, these tips are molded to fit 2, 10, 20, 200, or 1,000 µl micropipets.

Xcluda Aerosol Barrier Pipet Tips for PCR

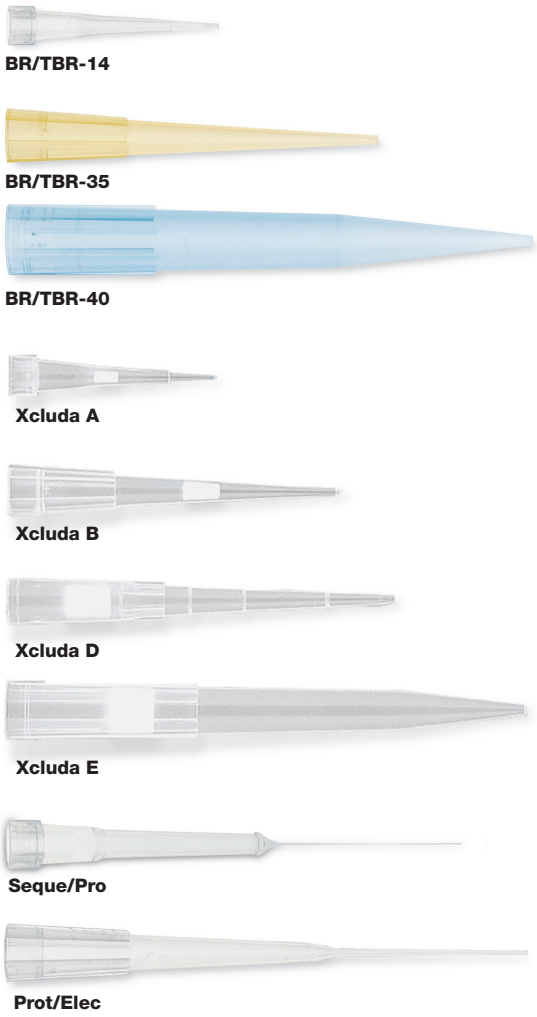
Xcluda aerosol-barrier pipet tips guard against aerosol contamination of samples, a feature particularly important in PCR experiments. Available presterilized in fully enclosed racks, they are independently tested and certified to be DNase, RNase, and pyrogen free. Molded to fit all 2, 10, 20, 200, and 1,000 µl micropipets.

Seque/Pro Capillary Pipet Tips

With an average diameter of less than 0.3 mm, these pipet tips are ideal for loading sequencing gels. Use with adjustable-volume 0.1–2 µl, 0.5–10 µl, and 2–20 µl micropipets for maximum performance.

Prot/Elec Protein Gel Loading Pipet Tips

These tips are designed to slide easily between mini vertical polyacrylamide gel plates or within cassettes with a 0.75 mm gap, yet they have a large bore for fast sample flow. The 200 µl capacity tips are molded to fit 2–20 µl and 20–200 µl micropipets.



Ordering Information

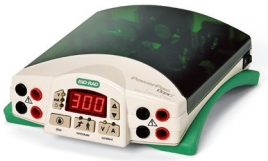
Tip Type, Quantity	Catalog #	Bio-Rad Micropipet Fit		Application
		Adjustable Micropipet	Fixed-Volume Micropipet	
Bulk Pipet Tips				
BR-14 Tips, 1,000/bag	2239014EDU	0.1–2, 0.5–10 µl	NA	General use
BR-35 Tips, 1,000/bag	2239035EDU	2–20, 20–200 µl	5, 10, 20, 50 µl	General use
BR-40 Tips, 500/bag	2239040EDU	100–1,000 µl	NA	General use
Prot/Elec Tips, 1,000/bag	2239915EDU	0.5–10, 2–20, 20–200 µl	5, 10, 20 µl	Protein gel loading
Racked Pipet Tips				
TBR-14 Tips, 1,000/box	2239354EDU	0.1–2, 0.5–10 µl	NA	General use
TBR-35 Tips, 1,000/box	2239347EDU	2–20, 20–200 µl	5, 10, 20, 50 µl	General use
TBR-40 Tips, 1,000/box	2239350EDU	100–1,000 µl	NA	General use
Xcluda A Tips, 960/box	2112001EDU	0.1–2, 0.5–10 µl	5 µl	PCR, nucleic acids
Xcluda B Tips, 960/box	2112006EDU	2–20 µl	2–20 µl	PCR, nucleic acids
Xcluda D Tips, 960/box	2112016EDU	20–200 µl	NA	PCR, nucleic acids
Xcluda E Tips, 960/box	2112021EDU	100–1,000 µl	NA	PCR, nucleic acids
Seque/Pro Tips, 200/box	2239911EDU	0.1–2, 0.5–10, 2–20 µl	5 µl	Sequencing gel loading
Prot/Elec Tips, 1,000/box	2239917EDU	0.5–10, 2–20, 20–200 µl	5, 10, 20, 50 µl	Protein gel loading

Visit us on the Web at **discover.bio-rad.com** to read more about Bio-Rad's pipet tips and packaging options.
NA, not available.

PowerPac Power Supplies

Boost classroom performance and energize your teaching lab with Bio-Rad's PowerPac power supplies.

No power supply offers better value and performance than the PowerPac series. Decades of experience in electrophoresis went into developing Bio-Rad's PowerPac power supplies. Designed to fit the complete range of teaching and research applications, all PowerPac power supplies are IEC 1010-1 certified, making Bio-Rad's the safest and most reliable electrophoresis power supplies in the world.



PowerPac Basic Power Supply

PowerPac HC Power Supply

PowerPac Universal Power Supply

PowerPac HV Power Supply

PowerPac Basic Power Supply

The PowerPac Basic power supply is designed for horizontal agarose gel electrophoresis of DNA and vertical acrylamide gel electrophoresis of proteins. Its design provides simple programming and a compact, stackable case. The PowerPac Basic offers timer control, constant voltage or constant current output, real-time monitoring of both voltage and current, and pause/resume run capability.

Visit us on the Web at **explorer.bio-rad.com** for more detailed specifications about power supplies.

Specifications	PowerPac Basic	PowerPac HC	PowerPac Universal	PowerPac HV
Output range	10-300 V, fully adjustable in 1 V steps	5-250 V in1V steps	10-500 V in 1 V steps	20-5,000 V in1 V steps
# Output terminals	4	4	4	4
Programmability	Yes	Yes	Yes	Yes
Current (works with Fast Gel protocol)	4-400 mA, fully adjustable in 1 mA steps	0.01-3.0 A in 0.01 A steps	0.01-2.5 in 1 mA steps	1-500 mA in 1 mA steps
Power	75 W maximum	300 W maximum	500 W maximum	400 W maximum
Type of output	Constant voltage or constant current with automatic crossover	Constant voltage, current, or power	Constant voltage, current, or power	Constant voltage, current, or power
Display	LED	LCD	Backlit graphic LCD	Backlit graphic LCD
Temperature control	NA	NA	NA	Optional probe available
Operating range	0-40°C	0-40°C	0-40°C	0-40°C
Dimensions (WxDxH)	21 x 24.5 x 6.5cm	25 x 28.5 x 8cm	27.5 x 34x10cm	27.5 x 34x10cm
Weight	1.1kg	2.0 kg	2.5 kg	2.5 kg

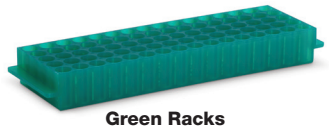
Ordering Information

Description	Catalog #
PowerPac Power Supplies	
PowerPac Basic Power Supply, 120/220 V	1645050EDU
PowerPac HC Power Supply, 120/220 V	1645052EDU
PowerPac Universal Power Supply, 120/220 V	1645070EDU
PowerPac HV Power Supply, 120/220 V	1645056EDU
PowerPac HV Power Supply with Temperature Probe	1645059EDU

Visit us on the Web at **explorer.bio-rad.com** for more detailed specifications about power supplies.

Racks and Storage Boxes

Our plastic racks and storage units provide the ultimate in ease of storage and sample organization.



Green Racks

Green Racks

- Durable polypropylene construction
- Capacity: 80 x 1.5/2.0 ml tubes
- Dimensions: 6.1 x 23.1 x 2.7 cm (W x D x H)

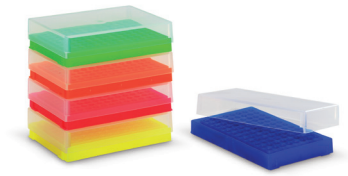
Storage Boxes

Storage Boxes

- Durable polypropylene construction with a three-point hinged lid and positive latch
- Capacity: 100 x 1.5/2.0 ml tubes
- Alphanumerically labeled translucent lid provides easy sample identification
- Dimensions: 14.2 x 14.2 x 5.5 cm (W x D x H)
- Colors: green, blue, pink, orange, yellow

96-Place PCR-Tube Rack and Cover

These stackable storage units for tubes and unskirted and semi-skirted PCR plates also provide a stable platform for preparing or centrifuging reactions.

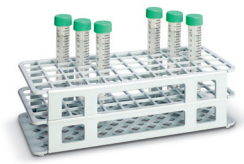


96-Place PCR-Tube Rack and Cover

15 ml and 50 ml Tube Racks

These economical tube racks are of durable polypropylene construction.

- Can be frozen or autoclaved
- Fold flat for space-saving storage
- Open design is ideal for use in a water bath
- The top of the rack contains an embossed alphanumeric grid for easy tracking of samples
- 15 ml rack — capacity: 60 x 15 ml tubes; dimensions: 10.5 x 25 x 7.2 cm (W x D x H)
- 50 ml rack — capacity: 24 x 50 ml tubes; dimensions: 11 x 30 x 8.5 cm (W x D x H)

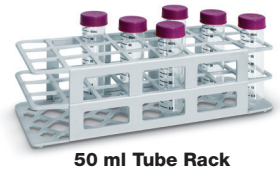


15 ml Tube Rack

Cuvettes

Standard Polystyrene Cuvettes

Bio-Rad's standard disposable polystyrene cuvettes are ideal for use with the Bio-Rad protein assay. Assays can be mixed directly in the cuvettes. Visit **bio-rad.com/proteinassays** for more information on Bio-Rad's complete line of protein assay kits.



50 ml Tube Rack

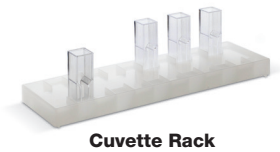
Cuvette Racks

These cuvette racks are essential for organizing cuvette samples and avoiding accidental spills.

- Capacity: 12 standard size cuvettes
- Dimensions: 5 x 17.2 x 1.5 cm (W x D x H)

Ordering Information

Description	Catalog #
Plastic Racks and Storage Units	
Green Rack, holds 80 tubes, 1.5/2.0 ml, set of 5 racks	1660481EDU
Storage Box, holds 100 tubes, set of 5 boxes, multicolored	1660482EDU
15 ml Tube Rack, holds 60 tubes, set of 5 racks	1660483EDU
50 ml Tube Rack, holds 24 tubes, set of 5 racks	1660484EDU
PCR Rack	
96-Place PCR Tube Rack and Cover, set of 5 racks, multicolored	TRC0501EDU
Standard Polystyrene Cuvettes	
3.5 ml Standard Disposable Polystyrene Cuvettes, 100	2239950EDU
1.5 ml Standard Disposable Polystyrene Cuvettes, 100	2239955EDU
Standard Cuvette, 3.5 ml, quartz	1702502EDU
Semimicrovolume Cuvette, 1.4 ml, quartz	1702503EDU
Cuvette Racks	
Cuvette Racks, holds 12 standard size cuvettes, set of 5 racks	1660485EDU



Cuvette Rack

Cuvettes

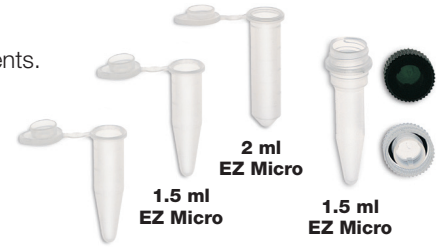
Plastic Refresh Kit Components

Reduce. Reuse. Refresh. Reduce packaging waste, refresh your kits, and reuse components.

Clear and Colored Microcentrifuge Tubes

Microcentrifuge tubes provide general-purpose sample containment, manipulation, storage, benchtop, and centrifuge use. Other features include:

- Molded from polypropylene with sturdy uniform walls that easily withstand up to 13,000 x g
- Autoclavable to 120°C (clear only); freezable to –80°C (clear and colored)
- 2 ml, 1.5 ml, and 0.5 ml sizes (clear only) include marked gradations, frosted marking area, and attached caps
- The colored microcentrifuge tubes come in six colors to easily identify reagents



Screwcap Microcentrifuge Tubes

Bio-Rad's polypropylene screwcap micro test tubes and caps provide a high level of sample security. O-rings are blended polyethylene/polypropylene (for solvent compatibility refer to standard compatibility table for polyethylene). These tubes have the following features:

- O-ring operating range: –55 to 150°C or caps without O-rings that are autoclavable
- Uniform walls for uniform heat transfer
- Conical bottoms for pellet formation and knurled caps for easy handling

Petri Dishes

Our petri dishes are ready-to-use polystyrene cell and bacterial culture petri dishes, 60 mm diameter, sterile, and come in a package of 500 — perfect for multiple classes or experiments.


Petri Dishes

Gel Staining Trays

Bio-Rad's gel staining trays are disposable plastic trays ideal for staining mini gels.


Gel Staining Trays

Inoculation Loops

Our sterile 10 µl inoculation loops make it easy to achieve uniform and smooth streaking without damaging the agar surface. Using disposable inoculation loops eliminates the risk of cross-contamination due to improper sterilization and the loops do not need flaming, making them safer to use.


Inoculation Loops

Jellyfish Foam Floating Racks

Perfect for cold and hot water baths, jellyfish foam floating racks hold up to 12 microcentrifuge tubes.

Jellyfish Foam Floating Racks

Disposable Plastic Transfer Pipets (sterile and nonsterile options)

These disposable plastic transfer pipets are made of polyethylene to manage your liquid-handling needs.

Disposable Plastic Transfer Pipets

Centrifuge and Culture Tubes

The 15 ml conical centrifuge tubes are made of polypropylene and have volume graduations and screw caps, making these tubes perfect for general-purpose benchtop work. The sterile cell culture tubes have round bottom snap caps and hold up to 14 ml of culture.


1.5 ml Microcentrifuge Tubes


Conical Centrifuge Tubes


Cell Culture Tubes

Ordering Information

Description	Catalog #
Plastic Refresh Kit Components	
Petri Dishes, 60 mm, sterile, 500	1660470EDU
Gel Staining Trays, 4	1660477EDU
Inoculation Loops, 10 µl, sterile, 100	1660471EDU
Jellyfish Foam Floating Racks, 8 racks, 12 microcentrifuge tube wells	1660479EDU
Disposable Plastic Transfer Pipets, sterile, 1 ml, graduated, 500	1660474EDU
Disposable Plastic Transfer Pipets, nonsterile, 1 ml, graduated, 500	1660480EDU
Microcentrifuge, Centrifuge and Culture Tubes	
2 ml EZ Micro Test Tubes, 500	2239430EDU
1.5 ml EZ Micro Test Tubes, 500	2239480EDU
500 µl EZ Micro Test Tubes, 1,000	2239503EDU
1.5 ml Conical Tubes, with separate O-ring screw caps, 500	2240100EDU
1.5 ml Conical Tubes, with installed O-ring screw caps, sterilized, 500	2240110EDU
Colored 1.5 ml Microcentrifuge Tubes, 6 colors, 600	1660473EDU
Conical Centrifuge Tubes, 15 ml, 50	1660475EDU
Cell Culture Tubes, 17 x 100 mm, 14 ml, sterile, 25	1660476EDU

For more information about liquid handling products, visit us on the Web at **discover.bio-rad.com** and request bulletin 1981.
For information on PCR plastic supplies and accessories please see p. 124.

Refresh Kit Components: Reduce. Reuse. Refresh.

Out of the Blue CRISPR Kit	Out of the Blue Genotyping Extension	Engineering Solutions for Global Health Kit	Photosynthesis and Cellular Respiration Kits	C. elegans Behavior Kit	pGLO Transformation and Inquiry Kit	pGLO Bacterial Transformation Kit	Green Fluorescent Protein Chromatography Kit	pGLO Kit SDS-PAGE Extension	Secrets of the Rainforest Kit	Microbes and Health Kit	Biofuel Enzyme Inquiry and Classic Kits	Size Exclusion Chromatography Kit	Got Protein? Kit	Giant Panda Problem and ELISA Immuno Explorer Kits	Comparative Proteomics Kit I: Protein Profiler Module	Comparative Proteomics Kit II: Western Blot Module	Rapid Blotting — V3 Western Workflow Starter Kit	Genes in a Bottle Kit	STEM Electrophoresis Kit	IDEA Electrophoresis Kit	Forensic DNA Fingerprinting Kit	Analysis of Precut Lambda DNA Kit	Restriction Digestion and Analysis of Lambda DNA Kit	Science of Opioid Dependence Kit	Virus Detection and Transmission Kit	Crime Scene Investigator PCR Basics Kit	PV92 PCR Infomatics Kit	DNA Barcoding Kits	GMO Investigator Kit	Crime Scene Investigator PCR Basics Real-Time PCR Starter Kit	GMO Investigator Real-Time PCR Starter Kit	Cloning and Sequencing Explorer Series	Protein Expression and Purification Series
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For reagent refill packs and more refresh items check out each individual kit page and the reagents and consumables pages throughout the catalog.

Description	Catalog No.
pGLO Plasmid, 20 µg, lyophilized	1660405EDU
Arabinose, 600 mg, lyophilized	1660406EDU
Ampicillin, 30 mg, lyophilized	1660407EDU
E. coli Strain HB101 K-12, lyophilized	1660408EDU
Transformation Solution, 15 ml	1660409EDU
LB Nutrient Broth, 10 ml	1660421EDU
LB Broth Capsule	1660412EDU
LB Nutrient Agar Powder, 20 g	1660600EDU
LB Nutrient Agar Powder, 500 g	1660472EDU
Petri Dishes, 60 mm, sterile, 500	1660470EDU
Inoculation Loops, 10 µl, sterile, 100	1660471EDU
Jellyfish Foam Floating Racks, 8 racks	1660479EDU
Long-Wave UV Lamp, 1	1660500EDU
Long-Wave UV Pen Light, 1	1660530EDU
Blank Disks	1660468EDU
50x TAE, 1 L	1610743EDU
50x TAE, 5 L cube	1610773EDU
Sample Loading Dye, 6x, 1 ml	1660401EDU
Certified Molecular Biology Agarose, 25 g	1613100EDU
Certified Molecular Biology Agarose, 125 g	1613101EDU
Certified Molecular Biology Agarose, 500 g	1613102EDU
Fast Blast DNA Stain, 500x, 100 ml	1660420EDU
Small Fast Blast DNA Electrophoresis Reagent Pack	1660450EDU
Medium Fast Blast DNA Electrophoresis Reagent Pack	1660455EDU
Large Fast Blast DNA Electrophoresis Reagent Pack	1660460EDU
Small UView DNA Electrophoresis Reagent Pack	1660462EDU
UView 6x Loading Dye. 0.2 ml	1665111EDU
UView 6x Loading Dye. 1 ml	1665112EDU
Gel Staining Trays, 4	1660477EDU
Genes in a Bottle DNA Extraction Reagent Refill Pack	1662001EDU
Lysis Buffer, 110 ml	1662002EDU
Helix DNA Necklace Module, 36 necklaces	1662250EDU
Master Mix for PCR, 2x, 90 units, 1.2 ml	1665009EDU
Disposable Plastic Transfer Pipets, sterile, 1 ml, 500	1660474EDU
Disposable Plastic Transfer Pipets, nonsterile, 1 ml, 500	1660480EDU
Colored 1.5 ml Microcentrifuge Tubes, 6 colors, 600	1660473EDU
1.5 ml EZ Micro Test Tubes, clear, 500	2239480EDU
2 ml EZ Micro Test Tubes, clear, 500	2239430EDU
Conical Tubes, 1.5 ml, O-ring screw caps, sterile, 500	2240110EDU
Conical Centrifuge Tubes, 15 ml, 50	1660475EDU
Cell Culture Tubes, 17 x 100 mm, 14 ml, sterile, 25	1660476EDU
0.2 ml Tubes with Domed Caps, clear, 1000	TWI0201EDU
PCR Tube Capless Adaptors, 500	2239500EDU

LB Nutrient Agar Powder

Petri Dishes

Gel Staining Trays

Inoculation Loops

Jellyfish Foam Floating Racks

Disposable Plastic Transfer Pipets

2 ml EZ Micro

1.5 ml EZ Micro

500µl EZ Micro

1.5 ml Microcentrifuge Tubes

Conical Centrifuge Tubes

Cell Culture Tubes

How to Order from Bio-Rad Laboratories

To place an order or request quotes and product information, contact your local Bio-Rad office. In the U.S., representatives are available Monday -Friday, from 5 AM to 5 PM Pacific time.

Bio-Rad Laboratories, Inc., 2000 Alfred Nobel Drive, Hercules, CA 94547

Toll-free telephone: **1-800-4BIORAD (1-800-424-6723)**
Toll-free fax: **1-800-879-2289**

Order placement: email **USOrders@bio-rad.com**
Order status / Ordering inquiries: email **Ask_Customer_Care@bio-rad.com**
Quote requests: email **lsg.quotes.us@bio-rad.com**

Customers outside the U.S., please refer to the back cover for your local contact information.

U.S. New Accounts
A Bio-Rad account number is required to place an order. To obtain an account number please contact your local Bio-Rad Customer Service office. In the U.S., representatives are available Monday-Friday, from 5 AM to 5 PM Pacific time.

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A Bio-Rad account number is required to place an order. To obtain an account number please contact your local Bio-Rad Customer Service office.

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To receive educational pricing when ordering on our website, you will need to establish an education account number with Bio-Rad and register online. Visit us on the Web at **explorer.bio-rad.com** to register for online ordering.

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- Your billing and shipping addresses
- Your purchase order or purchasing card number
- Product catalog number
- Product description
- Quantity
- Requested ship date

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Warranty extensions can be purchased for instruments including:
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Thermal cyclers
TC20 Cell Counter
MicroPulser electroporator
NGC Chromatography Systems
PowerPac power supplies
ZOE Fluorescent Cell Imager

For more information, contact your local Bio-Rad office.

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Within Reach Anytime, Anywhere
Whatever your experience, Bio-Rad's technical support specialists are available by phone and online to provide expert advice about products, techniques, or applications. Call our technical support team at your local Bio-Rad office or in the U.S. call **1-800-4BIORAD** (option 2) between 5 AM and 5 PM Pacific time, Monday–Friday.

Self-service technical support can be accessed 24 hours a day on the Web at **bio-rad.com/support**. You can submit a question and one of our specialists will contact you within one business day. We will be happy to help you with:

- Selecting the best product for an application
- Information on how to use Bio-Rad products
- Replacement parts information
- Safety data sheets (SDS) and other safety information

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Prices are in local currencies and are subject to change without notice. U.S. prices are in U.S. dollars and are subject to change without notice. Prices in effect when your order is received will apply. Freight charges and special packaging charges will be added to the invoice.

Call Bio-Rad for current prices. Standard payment terms are net 30 days.

FCA Points
Hercules, California. See outside back cover for points outside the USA.

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Orders in the U.S. received by 1 PM Pacific time ship the same day via three-day service. Overnight or two-day delivery is available upon request at an additional charge. Shipments containing dry or blue ice are automatically shipped for overnight delivery. In the U.S., for more information, contact customer care at 1-800-4BIORAD. Outside the U.S. contact your local Bio-Rad office.

U.S. Perishable and Hazardous Materials Surcharge
U.S. orders for products classified as dangerous goods and those requiring special packaging with blue ice or dry ice will be assessed the following charges:

Handling	$30.00
Dry ice packaging	6.00
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Hazardous goods surcharge	40.00

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Equipment must be accompanied by a decontamination certificate issued by Bio-Rad Technical Support. There is a nominal restocking fee on returned products. Bio-Rad cannot authorize return of products erroneously ordered by customers if the products contain reagents. When you call, be prepared to supply your account number, address, purchase order number, invoice number, shipping date, product description, and catalog number.

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Clarity Max Western ECL Substrate is manufactured by Cyanagen Srl and is the subject of patent application numbers US7855287, EP1950207, US9040252, AU2011202658, CA2742025, US8129136, and EP1962095, together with other equivalent granted patents and patent applications in other countries like CN102313732.

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Index: Alphabetical Subject

M

N

O

P

Q

R

S

T

U

V

W

X

Z

Index: Catalog Number

Index: Catalog Number

Index: Catalog Number

Index: Catalog Number

Meet the Bio-Rad Explorers

Explorer Team

Leigh Brown
Curriculum Training Specialist

Jean-Francois Chauvet
Vice President

George Chenaux, PhD
Staff Scientist

Leslie Dempsey
Sales Support Specialist

Kelly Miller, PhD
Scientist

Erin Handsfield
Sales Manager

Yolanda Kowalewski, PhD
Product Manager

Ashleigh Miller, PhD
Senior Scientist

Ingrid Miller, PhD
Marketing Manager

Saswat Patnaik
Product Manager

Poornima Rao
Product Manager

Bryony Ruegg, PhD
Director

Jeannie Spagnolo, PhD
R&D Manager

Tamica Stubbs
Curriculum Training Specialist

Damon Tighe
Curriculum Training Specialist

Bio-Rad Teaching Award

Realize your teaching dreams with teaching award!

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2023 Winner

Jim DeKloe
Solano Community College
Vacaville, CA

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The Bio-Rad Explorer Program collaborates with extremely talented educators around the world. These amazing educators participate in our Advisory Board and Marketing Advisory Panel to help design and test our curriculum to help ensure that we bring the most relevant, innovative, and impactful activities to your classroom. Our Teacher Fellows are highly trained educators who are able to provide professional development experiences for educators across the United States.

Bio-Rad Explorer Teacher and Student Alumni *(left to right)*

Page 1	*Brebeuf Jesuit Preparatory School, Indianapolis, Indiana*
Page 2	*Ohlone College, Newark, California*
Page 6	*Anderson High School, Austin Texas*
Page 8	*Ohlone College, Newark, California* *Acalanes High School, Orinda, California* *Arizona State University, Tempe, Arizona* *Germantown Friends School, Philadelphia, Pennsylvania* *University of North Carolina, Chapel Hill, North Carolina* *University of San Francisco, San Francisco, California* *Glenbard East High School, Lombard, Illinois*
Page 16	*Emeryville, California* *Chula Vista High School, Chula Vista, California* *Flathead Valley Community College, Kalispell, Montana* *Hoffman Estates High School, Hoffman Estates, Illinois* *Independence High School, Franklin, Tennessee* *Valley Christian High School, San Jose, California* *Glenbard East High School, Lombard, Illinois*
Page 38	*Brebeuf Jesuit Preparatory School, Indianapolis, Indiana* *Glendale Community College, Glendale, Arizona* *Heritage Middle School, Deltona, Florida* *Monte Vista High School, Danville, California* *NABT, Chicago, Illinois* *Rodriguez High School, Fairfield, California* *Whitney Young High School, Chicago, Illinois*
Page 60	*Brebeuf Jesuit Preparatory School, Indianapolis, Indiana* *Anderson High School, Austin Texas* *Bio-Rad Workshops, Hong Kong, China* *H. E. Robinson Ag Center, Kalispell, Montana* *Hoffman Estates High School, Hoffman Estates, Illinois* *NSTA, Philadelphia, Pennsylvania* *Sacred Heart School, San Francisco, California*
Page 72	*Bellarmine University, Louisville, Kentucky* *Austin Community College, Austin, Texas* *Hong Kong Polytechnic University, Hong Kong, China* *Bio-Rad Teacher Workshop, Hyderabad, India* *Mesa High School, Mesa, Arizona* *Nashville State Community College, Nashville, Tennessee* *Silver Creek High School, San Jose, California*
Page 82	*Jenks High School, Jenks, Oklahoma* *Montana State University, Bozeman, Montana* *North Carolina A&T University, Greensboro, North Carolina* *Palmer High School, Palmer, Alaska* *Bio-Rad Teacher Workshop, Cayey, Puerto Rico* *Solano Community College, Vacaville, California*
Page 92	*Leander High School, Leander, Texas* *Oral Roberts University, Tulsa, Oklahoma* *Santa Fe College, Gainesville, Florida* *AP Biology Workshop, Stanford, California* *Edward Teller Education Center, University of California, Davis, California* *Bio-Rad Teacher Workshop, Waipahu, Hawaii*
Page 98	*Bellarmine University, Louisville, Kentucky* *Glacier High School, Kalispell, Montana* *Shoreline Community College, Seattle, Washington* *Santa Fe High School, Alachua, Florida* *Tamalpais High School, Mill Valley, California* *Texas A&M University, Corpus Christy, Texas* *Whitney Young High School, Chicago, Illinois*
Page 102	*Ohlone College, Newark, California* *Biolink teacher training, Austin, Texas* *Bio-Rad Teacher Workshop, Sera, India* *Smithtown High School West, Smithtown, New York* *Terra Nova High School, Pacifica, California* *Sera Jey Monastery Workshop, Bylakuppe, India* *University of Texas at Austin, Austin, Texas*
Page 112	*Bellarmine University, Louisville, Kentucky* *Brentwood High School, Brentwood, New York* *Stony Brook University, Stony Brook, New York* *The Bishop's School, La Jolla, California* *Tokyo Technical College, Tokyo, Japan* *Tulsa Community College, Tulsa, Oklahoma* *University of Connecticut, Storrs, Connecticut*
Page 130	*Ohlone College, Newark, California* *Flax Pond Marine Laboratory, East Setauket, New York* *Bio-Rad Teacher Workshop, Veenendaal, Netherlands* *Tennessee State University, Nashville, Tennessee* *Tracy High School, Tracy, California* *University of California at Davis, Davis, California* *University of Tulsa, Tulsa, Oklahoma*
Page 142	*Bellarmine University, Louisville, Kentucky* *Franklin High School, Franklin, Massachusetts* *Bio-Rad Teacher Workshop, Heidelburg, Germany* *Lanier High School, Lanier, Texas* *Teacher training, Hot Springs, Arkansas* *University of California at Davis, Davis, California* *University of Florida, Alachua, Florida*

BIO-RAD Explorer

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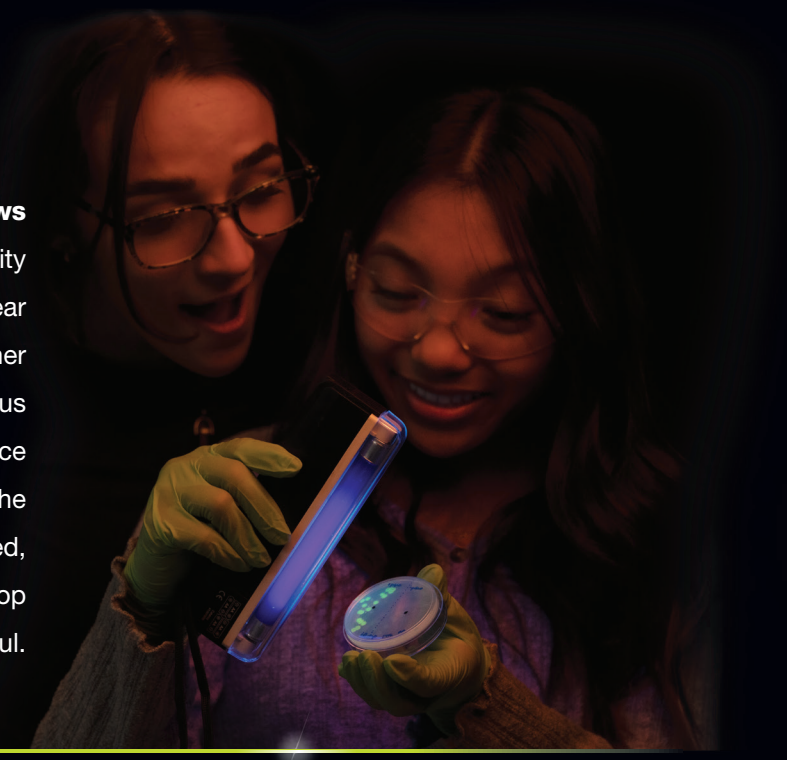

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Life Science Group

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