For students in Dr. Rebecca Grella’s high school research course, the outdoors is the classroom and nature is the textbook. Armed with budding curiosity and waterproof waders, her students explore the saltwater marshes on the northern coast of Long Island, New York looking for clues about biodiversity of the changing marsh landscape. Back in the lab, students characterize their samples and publish data for the scientific community. Dr. Grella uses her passion for science and infectious curiosity to help her students leap over social and economic barriers on a quest to understand their local ecosystems. The achievements of her students is testament to the power of self-driven discovery. Bio-Rad’s Explorer Program joins Dr. Grella in her mission to equip students with the skills to be successful both today and tomorrow.
Bio-Rad Explorer Program

We have stepped into an era of exceptional advancement in life science — one where incurable diseases written into our DNA may now be erased and where species once thought extinct may be brought back to life. The promise of new advances in biotechnology challenges our notions of what’s possible. Today, more than ever, students need to be equipped with the knowledge of how scientific discovery will impact their lives. They are the future voters, citizens, scientists, healthcare professionals, and stewards of our environment.

For more than two decades, Bio-Rad’s Explorer Program has collaborated with educators, researchers, and industry leaders to bring innovative, state-of-the-art technology into your classroom. Our hands-on laboratory activities prepare your students with foundational skills and expand their experience with cutting edge techniques like CRISPR — all in an appropriate format for the classroom. As we enter into this new era of what’s possible, Bio-Rad continues to make scientific discovery accessible to all your students as they lead us into new frontiers.

On the cover:
Welcome to the new frontier of scientific discovery.

CRISPR technology has shattered our understanding of what’s possible, and it exemplifies both the profound impact of fundamental science research and the excitement of life-changing breakthroughs. We join you in your mission to bring these same exciting moments of discovery into your classroom and to ensure all students can participate in their impact.
Exploring New Horizons
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Visit us on the Web at explorer.bio-rad.com
ThINQ! Investigation Kits
for AP and General Biology

Extended support for inquiry-based learning and discovery

ThINQ! Investigations
put your students at the center of learning
Developed in collaboration with master life science teachers, ThINQ! Investigation Kits make it easier to use an inquiry approach in your classroom. Each ThINQ! kit includes the essential resources and instructions to successfully guide your students and help them think like real scientists.

Available ThINQ! Investigation Kits

Photosynthesis and Cellular Respiration Kit for AP Biology
Design quantitative experiments to discover how environmental conditions impact both photosynthesis and cellular respiration — with algae beads!.............. 18

Photosynthesis and Cellular Respiration Kit for General Biology
Create models and design qualitative experiments with algae beads to explore photosynthesis and cellular respiration.............................................. 20

pGLO Transformation and Inquiry Kit for AP Biology
Investigate the functional elements of pGLO bacterial transformation, including heat shock, antibiotic selection, promoters, and satellite colony formation.............. 26

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Connect mushroom ecology and enzyme activity as students assume the role of bioengineer to optimize the function of cellobiase for biofuel production...... 40

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BIO-RAD
Classic Kits

Skills-based hands-on labs for life science and biotechnology

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Lambda DNA Kits
Use restriction enzymes and gel electrophoresis to analyze bacteriophage DNA .................................. 64

Advanced Kits and Topics

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Edit a bacterial gene with CRISPR-Cas9 and use PCR to verify the edit .................................................. 8

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Probe your Protein Profiler SDS-PAGE gel with antibodies to identify LC myosin ................................. 52

Rapid Blotting — V3 Western Workflow Starter Kit
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Crime Scene Investigator PCR Basics Kits
Use PCR and gel electrophoresis to solve a crime scene in your classroom ........................................... 68

PV92 PCR Informatics Kit
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Fish DNA Barcoding Kit
Use PCR, DNA sequencing, and bioinformatics to identify fish species .................................................. 72

GMO Investigator Kit
Use PCR and gel electrophoresis to determine if food you eat contains a GMO ........................................ 74

Real-Time PCR Kits
Use real-time PCR to quantify DNA in the GMO Investigator and Crime Scene Investigator kits ............... 76

Cloning and Sequencing Explorer Series
Extract DNA from a plant, clone the GAPDH gene, sequence, and publish to GenBank ............................ 80

Protein Expression and Purification Series
Express and purify human DHFR in E. coli using a real-world biomanufacturing workflow ..................... 90

Visit us on the Web at explorer.bio-rad.com
New and Featured Products
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“"I love teaching biotechnology and Bio-Rad is a big part of that. Their products bridge life science research and education in a way that is truly positive for my students.""

Mary Clark
Whitney Young High School
Chicago, IL
Do true CRISPR gene editing in your classroom!
Propel your students to the very cutting edge of life science research with Out of the Blue CRISPR and Out of the Blue Genotyping Extension Kits. Never before have researchers had the flexibility and control that CRISPR technology provides for 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!
Use CRISPR-Cas9 technology to disrupt the chromosomal lacZ gene in E. coli. A vibrant blue-white colony screening reveals the phenotype change associated with gene editing. The optional genotyping extension kit allows your students to confirm the genetic edit with PCR analysis and gel electrophoresis. Armed with experimental evidence, have your students explore the possibilities and ethics of CRISPR technology in therapeutic applications — and even hold a bioethics debate.
Out of the Blue Kits

Each kit supports 32 students.

Out of the Blue CRISPR Kit
Catalog # 12012608EDU

Out of the Blue Genotyping Extension
12012607EDU

Out of the Blue CRISPR and Genotyping Extension Kits
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.

Required Accessories not Included in kits
Adjustable-volume micropipets and tips, pp. 136 1–8
100–1,000, 20–200, 1–20 µl
Balance with 1–10 g range
Water bath or dry bath, p. 134

Recommended (optional) Accessories:
Incubation oven, p. 134
Pipet controller, p. 137
Autoclave or microwave oven

Refresh Kit Components: (see pp. 141–143)
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

Lab 3
Genotyping Extension*: Verify gene editing by PCR

Optional: Guided debate on the ethics of CRISPR technology applications

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.
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 17005297EDU

Science of Opioid Dependence Kit plus UView Electrophoresis Reagents 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 for download.

Required Accessories Not Included in Kit:
- Adjustable micropipets and tips, pp. 136–138
- 20–200 µl ... 1
- 1–20 µl ... 8
- or fixed volume micropipets, 50 µl ... 8
- Horizontal gel electrophoresis chambers, p. 106 ... 4–8
- Power supply, p. 139 ... 1–8
- UV transilluminator (if using UView 6x Loading Dye and Stain), p. 130 ... 1
- Gel staining trays, p. 141

Refresh Kit Components: (see pp. 141–143)
- Gel Staining Trays, 4 (#1660477EDU)
- UView 6x Loading Dye and Stain, p.111
- DNA Electrophoresis Reagent Packs, p. 108

Activity 1: Learning about Factors in Opioid Dependence
- Discuss opioid epidemic data

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
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.
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
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. 141–143)
Quick Start Bradford 1x Dye Reagent (#5000205EDU)
Protein Standard II (lyophilized BSA) (#5000307EDU)
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

Activity 2
Investigate protein content in food

Activity 3
Design a treatment for protein energy undernutrition

Consider constraints and revise initial proposals
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

**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.

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### Ordering Information

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<tr>
<td>Biotechnology: A Laboratory Skills Course Textbook, second edition</td>
<td>17004717EDU</td>
<td>$156.25</td>
<td>$125.00</td>
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<tr>
<td>Teacher edition, includes one student edition hardcover textbook and one teacher supplement</td>
<td>12008528EDU</td>
<td>$133.75</td>
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<tr>
<td>Teacher Edition</td>
<td>12008527EDU</td>
<td>$43.75</td>
<td>$35.00</td>
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<td>Laboratory Notebook</td>
<td>1661051EDU</td>
<td>$16.75</td>
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</tr>
<tr>
<td>Laboratory Notebook, classroom set of 32</td>
<td>1661053EDU</td>
<td>$600.00</td>
<td>$480.00</td>
</tr>
<tr>
<td>Digital edition — Visit bio-rad.com/ebook for ordering information</td>
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**New!** 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.
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.

Assessment rubrics help students understand what is expected of them and how to proficiently complete a task.

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.

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.
pGLO, GFP, Microbiology, and Model Organism Kits
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“Easy, reliable, and teacher friendly. Bio-Rad’s kits are the absolute best and my students love the experiments — that’s why I’ve used them for years! They’ve really allowed me to change my teaching trajectory.”

Thomas Martinez
Glenbard East High School
Lombard, IL
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.

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 CO₂ 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
- Ruler/meter or yard stick/measuring tape 1–8
- Thermometers (0–100°C) 2–8
- Water bath, p. 134 1
- Aquatic snail or other heterotroph

Refresh Kit Components: (see pp. 141–143)
- 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
- Debead an algae bead

Pre-lab #2
- Place samples under light

Pre-lab #3
- Monitor sample color change

Analyze results

Structured/guided/open inquiry extensions — materials included

Photosynthesis and Celluar Respiration Kits

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<td>Learning focus</td>
<td>Quantitative data collection and experimental design</td>
<td>Developing scientific explanations for observed phenomena 3-dimensional learning</td>
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<tr>
<td>Kit contents</td>
<td>Kit contents Materials for 8 student workstations to perform pre-lab activities and 6 inquiry investigations</td>
<td>Materials for 24 student workstations to perform pre-lab activities and 1 inquiry investigation sequence</td>
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** 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.

Visit us on the Web at explorer.bio-rad.com
Photosynthesis & Cellular Respiration Kit for General Biology — A ThINQ! Investigation

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.

**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.

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 #
1200534EDU
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).

Enzyme, cellobiase, 1 ml
1
Algae beads, 170 beads
1
10x CO₂ indicator, 50 ml
1
Debeading solution, 20 ml
1
0.2 ml PCR tubes with domed lids
60
Indicating 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
Paraffin or plastic wrap

Recommended (Optional) Accessories:
Microscopes
1–24
Microscope slides and coverslips
1–24

Refresh Kit Components: (see pp. 141–143)
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
Observe a color-change phenomenon
Make predictions about new scenarios

Lab 2
View algae from algae beads under a microscope (optional)
Dissolve an algae bead
View algae under a microscope

Lab 3
Conduct student experiments using algae beads
Set up samples and measure color change

Analyze results and revise models

Science and Engineering Practices
• Developing and using models
• Planning and carrying out investigations
• Constructing explanations and designing solutions
• Engaging in argument from evidence

Disciplinary Core Ideas
Organization for matter and energy flow in organisms
Cycles of matter and energy transfer in ecosystems

Crosscutting Concepts
Energy and matter
Systems and system models
Cause and effect

Photosynthesis and Cellular Respiration Kits

For General Biology (1200534EDU) For AP Biology (17001238EDU), p. 19

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

Visit us on the Web at explorer.bio-rad.com
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 AY 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.
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, p. 136
  - 2–20 µl (or 10 µl fixed volume) 8
  - 100–1,000 µl 1–8
- Pipet tips, p. 138
  - 2–200 µl, BR-35 1–8
  - 100–1,000 µl, BR-40 1–8
- Microwave oven, hot plate, or autoclave 1
- Incubation oven, p. 134 1

**Refresh Kit Components:** (more info pp. 141-143)
- *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

Visit OpenWorm to see the entire worm connectome — you can see every neuron within the worm and how they all connect!

---

**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

Dissecting microscope

**Life cycle observations**

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**

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

---
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!**
Literally!

**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 (CaCl₂) 1
- Petri dishes, 60 mm, sterile 40
- Inoculation loops, sterile 80
- Microcentrifuge tubes, 2.0 ml, sterile, color-coded 1
- Foam floats 8
- Disposable plastic transfer pipets 50
- UV pen light 1

Instructor's manual available online for download or printed and bundled with kit (#1660043EDU)

**Recommended (Optional) Accessories:**
- Incubation oven, p. 134
- Water bath or dry bath, p. 134
- UV lamps, p. 130 4–8

**Refresh Kit Components:** (more info pp. 141–143)
- Transformation Kit Reagent Refill Pack (#1660505EDU), includes pGLO plasmid, E. coli strain HB101 K-12, LB nutrient broth, transformation solution, ampicillin, arabinose, LB Nutrient Agar Powder, 20 g (#1660472EDU) or 500 g (#1660479EDU)
- 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**

Download the BioBusiness curriculum that embeds the pGLO transformation lab in topical case study scenario format, from the Morehead Planetarium and Science Center Mobile Labs Program. Visit bio-rad.com/partners to download the complete PDF.

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**Lab 1**

**Transformation**

1. Rehydrate bacteria and streak starter plates
2. Incubate overnight at 37°C
3. Collect cells, inoculate transformation and negative control tubes

**CONTROL**

- pGLO plasmid

**TRANSFORMATION**

- + pGLO plasmid

**Incubate both tubes on ice for 15 minutes**

- Add nutrient broth and incubate at room temperature for 10 minutes

**Spread bacterial suspensions onto plates**

- LB / amp
- LB / amp / arabinose
- LB / amp / pGLO plasmid
- LB / pGLO plasmid

**Incubate overnight at 37°C**

**Lab 2**

**Analyze and interpret results**

- White colonies
- Fluorescent green colonies under UV light
- No growth
- Bacterial lawn

**Extension:**

- GFP chromatography kit, see pp. 28
- pGLO kit SDS-PAGE extension, see p. 30

**For an inquiry approach**

- pGLO Transformation and Inquiry Kit for AP Biology, see p. 26

Visit us on the Web at explorer.bio-rad.com
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. 24) 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; lab 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).

Required Accessories Not Included in Kit:
- Plasmid (pGLO), lyophilized
- E. coli strain HB101 K-12, lyophilized
- LB broth capsule
- LB nutrient broth, sterile
- LB nutrient agar powder, 10 ml
- Ampicillin, lyophilized
- Arabinose, lyophilized
- Sterile transformation solution (CaCl2)
- Petri dishes, 60 mm, sterile
- Inoculation loops, sterile
- Blank disks, 6 mm, sterile
- Microcentrifuge tubes, 2.0 ml, sterile
- LB broth capsule
- LB nutrient agar powder, 10 ml
- Ampicillin, lyophilized
- Arabinose, lyophilized
- Sterile transformation solution (CaCl2)
- Petri dishes, 60 mm, sterile
- Inoculation loops, sterile
- Blank disks, 6 mm, sterile
- Microcentrifuge tubes, 2.0 ml, sterile
- Foam floats
- Disposable plastic transfer pipets
- UV pen light
- Inquiry curriculum, including teacher’s guide
- Student manual available online

Recommended (Optional) Accessories:
- Incubation oven, p. 134
- Water bath, p. 134
- UV lamps, p. 130
- Sterile transformation solution (CaCl2)
- LB broth capsule
- LB nutrient agar powder, 10 ml
- Ampicillin, lyophilized
- Arabinose, lyophilized
- Sterile transformation solution (CaCl2)
- Petri dishes, 60 mm, sterile
- Inoculation loops, sterile
- Blank disks, 6 mm, sterile
- Microcentrifuge tubes, 2.0 ml, sterile
- Foam floats
- Disposable plastic transfer pipets
- UV pen light
- Inquiry curriculum, including teacher’s guide
- Student manual available online

Refresh Kit Components:
- pGLO Inquiry Reagent Refill Pack
- Blank Disks 6 mm, sterile, 50 (#1660468EDU)
- For additional refresh components see pGLO Bacterial Transformation Kit, p. 25

ThINQ! pGLO Kit vs Classic pGLO Kit

<table>
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<tr>
<th></th>
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<td>Class type</td>
<td>AP Biology, inquiry-based</td>
<td>General Biology or Biotechnology, skills-based</td>
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<tr>
<td>Number of labs</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Inquiry type</td>
<td>Structured, guided, and open</td>
<td>Structured</td>
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<tr>
<td>Standards alignment</td>
<td>AP Biology</td>
<td>General</td>
</tr>
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</table>
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.

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. 24 or 26.

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.
**Resuspend cells, add lysozyme, and freeze overnight to rupture cell membranes.**

**Centrifuge bacterial lysate to pellet membranes and debris.**

**Start with pGLO bacterial transformation kit results.**

**Extension:** Use protein gel electrophoresis to conduct analysis of purity of fractions.

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**Lab Preparation Checklist**

<table>
<thead>
<tr>
<th>Kit contains</th>
<th>sufficient materials for 8 student workstations (2–4 students per workstation).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ampicillin, lyophilized</td>
<td>1</td>
</tr>
<tr>
<td>Arabinose, lyophilized</td>
<td>1</td>
</tr>
<tr>
<td>Lysozyme, lyophilized</td>
<td>1</td>
</tr>
<tr>
<td>LB nutrient broth capsule</td>
<td>1</td>
</tr>
<tr>
<td>Binding buffer</td>
<td>1</td>
</tr>
<tr>
<td>Column equilibration buffer</td>
<td>1</td>
</tr>
<tr>
<td>Column wash buffer</td>
<td>1</td>
</tr>
<tr>
<td>Elution buffer</td>
<td>1</td>
</tr>
<tr>
<td>HIC chromatography columns</td>
<td>8</td>
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<tr>
<td>Inoculation loops, sterile</td>
<td>20</td>
</tr>
<tr>
<td>Disposable plastic transfer pipets</td>
<td>40</td>
</tr>
<tr>
<td>Microcentrifuge tubes, 2.0 ml, clear</td>
<td>30</td>
</tr>
<tr>
<td>Cell culture tubes, 15 ml, sterile</td>
<td>25</td>
</tr>
<tr>
<td>Sample collection tubes, 5 ml</td>
<td>25</td>
</tr>
<tr>
<td>Curriculum, including teacher’s guide, student manual, and graphic quick guide</td>
<td>1</td>
</tr>
</tbody>
</table>

**Required Accessories Not Included in Kit:**

- Transformed bacterial colonies from pGLO bacterial transformation, p. 24 or 26
- UV lamps, p. 130 4–8
- Centrifuges, p. 132 1–2

**Recommended (Optional) Accessories:**

- Incubation oven, p. 134
- Rocking platform, p. 133
- Tube roller, p. 133
- Microwave oven

**GFP Lyophilized Components Refill Pack (#166016EDU), 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 (#1660483EDU)**

**Poly-Prep Columns, empty, 50 (#7311550EDU)**

**Macro-Prep HIC Support, 100 ml (#1560080EDU)**

**Load bacterial lysate onto columns**

1. GFP binds to chromatography matrix in high-salt buffer
2. Add medium-salt buffer to wash bacterial proteins from column
3. Add low-salt buffer to elute GFP

**Collect three fractions**

**Separate GFP from bacterial proteins**

**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/partners to download the complete PDF.**
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 (#166003EDU) 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!

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
• 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.
Start extension with pGLO bacterial transformation results

Prepare SDS-PAGE samples

- heat

+ heat

Cut the gel in half

Expose one half of the gel to UV light to visualize the GFP

Analyze the other half by staining with Bio-Safe Coomassie stain to visualize the entire E. coli proteome

Analyze and compare results

White colonies LB / amp

Fluorescent green colonies under UV light LB / amp / arabinose

Lab Preparation Checklist

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

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

**Required Accessories Not Included in Kit:**

- Amp (white) and Amp/ara (green), 4–8
- Colonies from a pGLO Bacterial Transformation, p. 24 or 26
- Any kD Mini-PROTEAN TGX Precast Polyacrylamide Gels, 10-well
- Vertical Gel Electrophoresis Chambers, p. 124
- Power Supplies, p. 139
- Water Bath or Dry Bath, p. 134
- Adjustable Micropipets, pp. 136–137
- Pipet Tips, p. 138
- 2-20 µl, 1 bag
- 100–1,000 µl, 1 bag
- 2-200 µl, BR-35
- 100-1,000 µl, BR-40, 1 bag
- 0.5–200 µl, Prot/Elec, 1 bag
- UV Lamps, p. 130
- Screwcap Microcentrifuge Tubes, 1.5 ml, 500, p. 141
- Gel Staining Trays, p. 141
- Foam Floating Racks, p. 141

**Recommended (Optional) Accessories:**

- Rocking platform, p. 133
- Gel documentation system, pp. 130–131

**Refresh Kit Components:** (more info pp. 141–143)

- 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. 126
- Precision Plus Protein Kaleidoscope Standards, p. 125
- Bio-Safe Coomassie Stain, p. 125
- 10x Tris/Glycine/SDS Electrophoresis Buffer, p. 126
- Laemml Sample Buffer, p. 126
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.

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
- LB nutrient agar tablets
- Petri dishes, 60 mm, sterile
- Inoculation loops, sterile
- Disposable plastic transfer pipets

Module 2: Protein Purification
- Ampicillin, lyophilized
- Arabinose, lyophilized
- Lysozyme, lyophilized
- LB nutrient broth capsule
- Binding buffer
- Column equilibration buffer
- Column wash buffer
- Elution buffer
- HIC chromatography columns
- Inoculation loops, sterile
- Disposable plastic transfer pipets
- Microcentrifuge tubes, 2.0 ml, clear
- Cell culture tubes, 15 ml, sterile
- Sample collection tubes, 5 ml
- Curriculum, including teacher's guide, student manual, and graphic quick guide

Required Accessories Not Included in Kit:
- UV lamps, p. 130
- Centrifuges, p. 132

Recommended (Optional) Accessories:
- Incubation oven, p. 134
- Rocking platform, p. 133
- Tube roller, p. 133
- Microwave oven

Refresh Kit Components: (more info pp. 141–143)
- 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 (#1660475EDU)
- 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)

Lab 1
- Resuspend cells, add lysozyme, and freeze overnight to rupture cell membranes
- Centrifuge bacterial lysate to pellet membranes and debris
- Resuspend cells, add lysozyme, and freeze overnight to rupture cell membranes

Lab 2
- Transfer cell culture to micro test tube, then centrifuge and pellet cells
- Load bacterial lysate onto columns
- Collect three fractions

Lab 3
- Extension: pGLO kit SDS-PAGE extension, see pp. 30–31
- Separate GFP from bacterial proteins
- Extension: Use protein gel electrophoresis to conduct analysis of purity of fractions

Lab 4
- Add high-salt chromatography binding buffer to bacterial lysate

Visit us on the Web at explorer.bio-rad.com
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.
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: 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. 134: 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. 141–143)
- Microbial Culture Kit Reagent Refill Pack: $49.00 (#1665021EDU)
  - 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: $129.00 (#1660470EDU)
- Inoculation Loops, 10 µl, sterile, 100: $20.00 (#1660471EDU)
- Disposable Plastic Transfer Pipets, sterile, 500: $108.00 (#1660474EDU)
- Cell Culture Tubes, 17 x 100 mm, 14 ml, sterile, 25: $18.00 (#1660476EDU)
- 15 ml Tube Racks, holds 60 tubes, set of 5 racks: $75.00 (#1660483EDU)

Lab Preparation Checklist

**Lab 1**

- Observe yogurt and milk using a microscope to identify potential yogurt-causing bacteria
- Grow bacteria cultures overnight at 37°C

**Lab 2**

- Observe bacterial colonies using a microscope
- Incubate overnight at 37°C

**Lab 3**

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

Define characteristics of yogurness: pH, consistency, and smell

Inoculate milk with bacteria from petri dish

Inoculate petri dish with yogurt

Observe yogurt and milk using a microscope to identify potential yogurt-causing bacteria
Protein Analysis Kits
Section Contents

Protein Analysis Kits
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“As a biochemist, I want my students exploring the frontier of new scientific knowledge. Real experimentation in my classroom is so much easier with Bio-Rad kits. They remove the hurdles and tedium so my students and I can focus on the best part — discovering new science!”

Dr. Joanne Figueiredo
Smithtown High School
Smithtown, NY
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 glucose 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
Catalog # 1665035EDU
Ships at room temperature. Store at 4°C.

Key Kit Features
- Aligns with AP Biology Big Idea 4; Lab 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
- Substrate, p-nitrophenyl glucopyranoside, 90 mg
- Standard, p-nitrophenol (1 mM, 4 ml)
- 2x stop solution, 100 ml
- 10x resuspension buffer, 50 ml
- Extraction buffer, 50 ml
- Disposable plastic transfer pipets
- 1.5 ml microcentrifuge tubes
- 15 ml conical tubes
- 1.5 ml standard disposable polystyrene cuvettes
- Curriculum, including teacher’s guide, student manual, and graphic quick guide

DNA Necklace Module
- Helix keepsake vials
- Silver screw caps
- Waxed string

Required Accessories Not Included in Kit:
- Deionized or distilled water
- Timers or stopwatches
- Thermometers
- Mortars and pestles
- Balance

Recommended (Optional) Accessories:
- Adjustable Micropipets, pp. 136-137
- 100–1,000 µl Pipet tips, p. 138
- 1.5 ml Standard Disposable Polystyrene Cuvettes, 100 (#1660483EDU)
- Conical Centrifuge Tubes, 15 ml, 50 (#1660475EDU)
- Disposable Plastic Transfer Pipets, nonsterile, 500 (#1660485EDU)
- 1.5 ml EZ Micro Test Tubes, 500 (#2239481EDU)
- 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

**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 — A ThINQ! Investigation

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
  - Substrate, p-nitrophenyl glucopyranoside, 90 mg
  - 2x stop solution, 100 ml
  - 10x Resuspension Buffer, 50 ml
  - Extraction Buffer, 50 ml
  - Disposable Plastic Transfer Pipets
  - 1.5 ml Microcentrifuge Tubes
  - 15 ml Conical Tubes
  - 100 ml Standard Disposable Polystyrene cuvettes
  - Inquiry curriculum, including teacher’s guide
  - Student manual available online

- Required Accessories Not Included in Kit:
  - Deionized or distilled water
  - Timers or stopwatches

- **Investigation 1: Mushroom Extracts**
  - Mushrooms, see instruction manual for recommended species
  - Mortars and pestles
  - Balance
  - Cheesecloth

- **Investigation 2: Effects of Temperature**
  - Thermometers

- **Recommended (Optional) Accessories:**
  - Adjustable Micropipets, p. 136, 100–1,000 µl
  - Pipet Tips, p. 138, 100–1,000 µl
  - Spectrophotometer
  - Water Bath or Dry Bath, p. 134
  - Incubation Oven, p. 134
  - Centrifuge, p. 132

- **Refresh Kit Components:** (see pp. 141–143)
  - Biofuel Enzyme Kit Temperature Sensitive
  - Reagent Refill Pack (#1665036EDU)
  - See p. 33 for details on reagent refill packs

---

**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**

<table>
<thead>
<tr>
<th>Investigation</th>
<th>Temperature</th>
<th>pH</th>
<th>Enzyme concentration</th>
<th>Substrate concentration</th>
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**ThINQ! Biofuel Kit vs Classic Biofuel Kit**

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<th>Classic Biofuel Kit (#1665035EDU), p. 38</th>
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</thead>
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<td>General Biology or Biotechnology, skills-based</td>
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<tr>
<td><strong>Inquiry type</strong></td>
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<tr>
<td><strong>Standards alignment</strong></td>
<td>AP Biology</td>
<td>General</td>
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</table>

Visit us on the Web at explorer.bio-rad.com
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
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

Refresh Kit Components: (more info pp. 141–143)

- 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 (#731150EDU)

Lab 1

Rehydrate hemoglobin and vitamin B₁₂ sample mixture

Electron micrograph showing individual size exclusion chromatography beads.

Load sample mixture onto size exclusion column

Add elution buffer

Collect fractions as molecules separate according to size. Naturally colored hemoglobin and vitamin B₁₂ allow easy visualization!

Collect 5 drops per fraction to isolate hemoglobin and vitamin B₁₂

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.
**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 -globulin standard set (2 sets of 7 standards, 0.125–2.0 mg/ml, 2 ml)
- 10x PBS, 100 ml
- 1.5 ml standard disposable polystyrene cuvettes, 100
- Curriculum, including teacher's guide, student manual, and graphic quick guide

**Required Accessories Not Included in Kit:**
- Adjustable Micropipets, p. 136
  - 2–20 µl 1–8
  - 100–1,000 µl 1
- Pipet Tips, p. 138
  - 2–20 µl, BR-35 1 box
  - 100–1,000 µl, BR-40 1 box
- Microcentrifuge Tubes, 1.5 ml, p. 141 1 bag
- Conical Centrifuge Tubes, 15 ml, p. 141 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. 141–143)
  - Quick Start Bradford Protein Assay Kit 4 (#5000204EDU) includes
    - 1x dye reagent (1 L), bovine -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)

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**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

**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**
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.
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 0
- Microplates with 12-well strips 3
- Yellow microcentrifuge tubes, 2.0 ml 60
- Colored microcentrifuge tubes, 2.0 ml 75
- Curriculum, including teacher’s guide, student manual, and graphic quick guide 1

**Required Accessories Not Included in Kit:**
- Adjustable micropipets, 20–200 µl, p. 136 12
- Or fixed volume micropipets, 50 µl, p. 136 12
- Pipet tips, 2–200 µl, BR-35, p. 138 1 bag

**Refresh Kit Components:** (more info pp. 141–143)
- 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 (9 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. 126

* Convenient lyophilized reagents.

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**Lab 1**

Optional outbreak activity: Students simulate spreading of a disease

**Student A**

**Student B**

**Student C**

**Students A + B**

**Students A + B + C**

**Student D**

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

- 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**

<table>
<thead>
<tr>
<th>Classic ELISA Immuno Explorer Kit (#1662403EDU)</th>
<th>ThINQ! A Giant Panda Problem Kit for AP Biology (#17002878EDU, p. 40)</th>
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</thead>
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<tr>
<td>Class type</td>
<td>General Biology or Biotechnology, skills-based</td>
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<tr>
<td>Inquiry type</td>
<td>Structured</td>
</tr>
<tr>
<td>Activities</td>
<td>12 workstations; one structured hands-on activity</td>
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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/partners to download the complete PDF.
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.

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.
Structured Inquiry Investigation #1 — Antibody detection ELISA

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

Add simulated panda urine samples. 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

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. 46–47

ELISA kit comparison

<table>
<thead>
<tr>
<th>Thino! A Giant Panda Problem Kit for AP Biology (#17002878EDU)</th>
<th>Classic ELISA Immuno Explorer Kit (#1662400EDU, p. 46)</th>
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<tr>
<td>Inquiry type</td>
<td>Structured, guided, and open</td>
</tr>
<tr>
<td>Activities</td>
<td>8 workstations; Two hands-on inquiry investigations</td>
</tr>
</tbody>
</table>

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, p. 136 12
- Or fixed volume micropipets, 50 µl, p. 136 12
- Pipet tips, 2–200 µl, BR-35, p. 138 1 bag
- Thermometers 1–8

Refresh Kit Components: (more info pp.141–143)

- 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. 47
- Convenient lyophilized reagents.
Comparative Proteomics Kit I: Protein Profiler Module — AP Big Idea 1: Does Molecular Evidence Support the Theory of Evolution?

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. 118)
Evidence Support the Theory of Evolution?

Lab Preparation Checklist

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

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

Required Accessories Not Included in Kit:
- Fish Samples
- Adjustable Micropipets, 2–20 µl
- Power Supplies
- Water Bath or Dry Bath
- Gel Staining Trays
- Foam Floating Racks

If Using Polyacrylamide Gel Electrophoresis:
- Required Accessories
  - Vertical Gel Electrophoresis Chambers
  - Mini-PROTEAN TGX Precast (or stain-free)
  - If using GelDoc Go or ChemiDoc Imaging System
  - polyacrylamide gels, 4–20%, 10-well each

If Using Agarose Gel Electrophoresis:
- Required Accessories
  - Horizontal Gel Electrophoresis Chambers
  - Pipet Tips, 2–20 µl
  - Acetic Acid, 100 ml
  - Reagent Alcohol/ethanol, 400 ml

Recommended (Optional) Accessories:
- Sample loading guides
- Gel Documentation system

Refresh Kit Components: (more info pp.141–143)
- Protein Profiler Temperature-sensitive Reagent Refill Pack (#1662701EDU), includes Precision Plus Protein Kaleidoscope standards, actin and myosin standard, and DTT
- Actin and Myosin Standard (#1660010EDU)
- Gel Staining Trays, 4 (#1660477EDU)
- Jellyfish Foam Floating Racks, 8 racks (#1660479EDU)
- Laemmli Sample Buffer, 126
- Precision Plus Protein Kaleidoscope standards, 500 µl
- 10x Tris/glycine/SDS Electrophoresis Buffer
- Bio-Safe Coomassie Stain
- DTT

Extra Curriculum for Proteomics on the Web

Download From Finches to Fishes curriculum that embeds the Protein Profiler lab in a topical case study scenario from the Morehead Planetarium and Science Center Mobile Science Labs Program. Visit bio-rad.com/partners to download the complete PDF.

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

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

Analyze results and create cladograms from gel data

Extension 1: Western Blot Module, see pp. 52–53

Extension 2: Conduct Web-based bioinformatics studies and compare student results to published phylogenetic data
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 quantify 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.
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
- Secondary Antibody (goat anti-mouse polyclonal antibody conjugated to horseradish peroxidase, or HRP), lyophilized
- HRP Color Detection Reagent A
- HRP Color Detection Reagent B
- 10x Tris/Glycine, 1 L
- Nonfat Dry Milk Blocker
- 10x Phosphate Buffered Saline (PBS), 100 ml
- 10% Tween 20, 5 ml
- Nitrocellulose, 0.45 µm
- 10x Tris/Glycine, 1 L
- Blotting Paper
- Reagent Tubes
- Curriculum, including teacher’s guide, student manual, and graphic quick guide

Required Accessories Not Included in Kit:
- Comparative Proteomics Kit I: Protein Profiler Module, p. 50
- Mini-PRESTAAN TGX Precast Polyacrylamide Gels, 4–20%, 10-well each, p. 124
- Vertical Gel Electrophoresis Chambers, p. 120
- Adjusting Micropipet, 2–20 µl, p. 136
- Water Bath or Dry Bath, pp. 134
- Rocking Platform, pp. 133
- Reagent Alcohol or Ethanol
- Fish Samples

Recommended (Optional) Accessories:
- Electroblotter, pp. 122–123
- Western Blot Temperature-sensitive Reagent Refill Pack (#1662801EDU)
- Primary Antibody (anti-myosin light chain antibody), 200 µg, lyophilized (#1662804EDU)
- Secondary Antibody (goat anti-mouse HRP), 2 ml (#1721011EDU)
- Blotting-grade Blocker, nonfat dry milk, 300 g, p. 123
- Precision Plus Protein Kaleidoscope standards, p. 125
- Bio-Safe Coomassie Stain, p. 125

Refresh Kit Components: (more info pp. 141–143)

Lab 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

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. 54–55

Laboratory and Equipment Checklist
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

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Tank blotting</th>
<th>Rapid blotting (staining required)</th>
<th>V3 Western Workflow (stain-free rapid blotting)</th>
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<tbody>
<tr>
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<td>Immunoblotting</td>
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<td>45</td>
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<tr>
<td>Color detection</td>
<td>all 10 min–overnight</td>
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<tr>
<td><strong>Total hands-on time</strong></td>
<td><strong>5 hrs 43 min – 7 hrs 25 min</strong></td>
<td><strong>4 hrs 48 min</strong></td>
<td><strong>1 hr 51 min</strong></td>
</tr>
</tbody>
</table>

**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.**

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-PREPROTEIN 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. 120
- Power Supplies, p. 139 2–4
- Dry Bath, p. 134 1
- Rocking Platform, p. 133 1
- Adjustable Micropipettes, 2–20 µl, p. 136 4–8
- Trans-Blot Turbo Transfer System, p. 122 1–4
- Fish Samples 5–8 types
- Gel Staining Trays, p. 141 4–8

**Recommended (Optional) Accessories:**
- Gel Imaging System with White Light Sample Tray, p. 130
- Sample Tray Holder, p. 131
- Pipet Controller, p. 137
- Gel Cutter (1703760EDU) or Gel Releasers, p. 121
- Blot Roller, p. 123

**Refresh Kit Components** (more info pp. 141–143)
- 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)

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**Lab 1**

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

**V3 Western Workflow** (stain-free rapid blotting)

**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**

**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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Visit us on the Web at explorer.biorad.com
DNA Analysis and Agarose Gel Electrophoresis Kits
“Bio-Rad's Forensic DNA Fingerprinting Kit transformed my DNA unit into a real success for me and my students. I had always used paper activities, but now my students actually use real pipets, gels, and electrophoresis! Bio-Rad is my go-to for new labs.”

**Todd Meador**
Hoffman Estates High School
Chicagoland Township, IL

Section Contents

**DNA Analysis and Agarose Gel Electrophoresis Kits**

- Genes in a Bottle Kit ............................................................ 58
- IDEA and STEM Electrophoresis Kits .................................. 60
- Forensic DNA Fingerprinting Kit ....................................... 62
- Lambda DNA Kits ............................................................... 64
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: Make Biology Personal
Lab Preparation Checklist

Lab 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

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, 1 360 ml

Recommended (Optional) Accessories:
Water Bath or Dry Bath with thermometer, p. 134
Rack to hold 15 ml tubes in water bath (need space for 36 tubes) (#1660483EDU)

Refresh Kit Components: (more info pp. 141-143)
Genes in a Bottle DNA Extraction
Reagent Refill Pack (#1662001EDU) includes lysis buffer and powdered protease + salt
Conical Centrifuge Tubes, 15 ml, 50 (#1660475EDU)
Disposable Plastic Transfer Pipets, nonsterile, 500 (#1660480EDU)
15 ml Tube Racks, holds 60 tubes, set of 5 racks (#1660483EDU)

I Love Your DNA Tattoos, 200 temporary tattoos (#1662004EDU)
DNA Model, p. 107 (#1667015EDU)

Lab 1

Transfer precipitated DNA to helix keepsake

Rinse mouth to obtain cheek cells for DNA extraction

Expel sample into 15 ml conical tube

Add cell/lysis buffer

Add protease/salt solution

Overlay DNA extract with ice-cold alcohol

Let stand for 5 min undisturbed — watch DNA precipitate!

Invert tube to mix phases and complete DNA precipitation reaction

Extension: Create DNA necklace

Insert DNA into helix keepsake

Screw on cap and assemble helix keepsake
**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.

### Ordering Information

<table>
<thead>
<tr>
<th>Description</th>
<th>100 ml 50x TAE and 5 g Agarose</th>
<th>IDEA Kit Reagent Refill*</th>
<th>10 µl Fixed Volume Micropipets</th>
<th>STEM Electrophoresis Engineering Module**</th>
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* 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

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

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IDEA and STEM Electrophoresis Kits

IDEA Kit Starter Pack supports 8 student workstations.

STEM Electrophoresis Kit Starter Pack supports 8 student workstations.

---

**STEM and IDEA Kits**

- Biodiversity
- Role, place, limits, and possibilities of science and technology
- Nutrition
- Populations, ecosystems, and human impacts
- Gel electrophoresis
- Perception of color
- Evolution
- Food allergies
- Ecosystems, Environment, and Interactions
- Genomes and Heredity
- Cellular Processes
- Molecules to Organisms
- Science and Engineering Practices
- Coupled reactions and free energy changes
- Chemical properties of molecules
- Buffers, solubilities, and pH

---

IDEA and STEM Electrophoresis Kits

IDEA Kit Starter Pack supports 8 student workstations.

STEM Electrophoresis Kit Starter Pack supports 8 student workstations.
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

Required Accessories
Not Included in IDEA Kit:
- Horizontal Gel Electrophoresis Chambers, p. 106 or STEM kit
- Adjustable Micropipets, p. 136
- Pipet Tips, p. 138
- Power Supplies, p. 139

Required Accessories
Not Included in STEM Electrophoresis Kit:
- 9 V Batteries | 3–5 per workstation
- Pipet Tips, p. 138
- Plastic Rulers or Plastic Card to cut gels
- Eye Droppers

IDEA Kit Reagent Refill Pack (1665078EDU) 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)

Lab 1
Inquiry Dye Electrophoresis Activity kit
- Extract dye from various candies
- Prepare extract samples using the IDEA kit
- Electrophoresis using Sub-Cell® system
- STEM Electrophoresis kit

Lab 2
Prepare and assemble electrophoresis chamber. Cast gel
- Load reference dyes and dye extracts
- Electrophorese dye samples at 45 V (STEM gel box) or 200 V (Mini-Sub® cell GT cell) for 20 min
- Electrophorese samples, visualize and document gels
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.
Lab contains sufficient materials for 8 student workstations (2–4 students per workstation).

DNA Size Standard

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>HindIII lambda DNA digest, 100 µl</td>
<td>1</td>
</tr>
<tr>
<td>DNA Samples, lyophilized, 60 µg each</td>
<td>1</td>
</tr>
</tbody>
</table>

Crime scene sample

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>EcoRI/PstI Restriction Enzyme Mix, lyophilized, 3,000 units</td>
<td>1</td>
</tr>
<tr>
<td>Sample Loading Buffer, 5x, 1 ml</td>
<td>1</td>
</tr>
<tr>
<td>Electrophoresis Buffer, 50x TAE, 100 ml</td>
<td>1</td>
</tr>
<tr>
<td>Sterile Water, 2.5 ml</td>
<td>1</td>
</tr>
<tr>
<td>Agarose Powder, 5 g</td>
<td>1</td>
</tr>
<tr>
<td>Fast Blast DNA Stain, 500x, 100 ml</td>
<td>1</td>
</tr>
<tr>
<td>Colored Microcentrifuge Tubes, 2.0 ml</td>
<td>60</td>
</tr>
<tr>
<td>Microcentrifuge Tubes, 1.5 ml</td>
<td>30</td>
</tr>
<tr>
<td>Foam Flats</td>
<td>8</td>
</tr>
</tbody>
</table>

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, p. 106
- Pipets, p. 136
- Pipet Tips, p. 138
- Power Supplies, p. 139
- Gel Staining Trays, p. 141
- Water Bath or Dry Bath, pp. 134
- Mini Centrifuge, p. 132
- Gel Support Film, p. 108
- Gel Documentation System, p. 130
- Rocking Platform, pp. 133

Refresh Kit Components: (more info pp. 141–143)

- DNA Fingerprinting Kit Reagent Refill
- Digest DNA samples with EcoRI/PstI restriction enzyme mix

Lab 1

Rehydrate DNA samples and restriction enzymes

- 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 did 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. 107

See Bulletin 5396

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

Forensic DNA Fingerprinting Curriculum

Download the Get a Clue curriculum from Morehead Planetarium and Science Center Mobile Science Labs Program. Visit bio-rad.com/partners to download the complete PDF.
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.

Band 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 bacteriophage to carry out the same infection process. Bacteriophage lambda is harmless to humans and other eukaryotic organisms and therefore makes an excellent source of DNA for experimental study.

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

Lambda DNA Kits — AP Big Idea 3: How’s This for a Slice of Life?
Lab Preparation Checklist

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

**1 DNA Extraction Module**

- 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 1
  - (HindIII lambda DNA digest)
  - 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

**Required Accessories Not Included in Kit:**

- Horizontal Gel Electrophoresis Chambers, p. 106
- Adjustable Micropipettes, p. 136
- 2–20 µl 4–8
- 20–200 µl 1
- Pipet Tips, p. 138 1 bag
- 2–200 µl BR-35 1
- Power Supplies, p. 139 2–4
- Gel Staining Trays, p. 141 4–8

**Recommended (Optional) Accessories:**

- Water Bath or Dry Bath (for Restriction Digestion and Analysis of Lambda DNA kit), p. 134
- Rocking Platform, p. 133
- Gel Support Film, p. 108
- Gel Documentation System, pp. 130
- Microwave Oven

**Refresh Kit Components:** (more info pp. 141–143)

- 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, p.111
- Gel Staining Trays, 4 (#1660477EDU)
- Jellyfish Foam Floating Racks, 8 racks (#1660479EDU)
- DNA electrophoresis Reagent Packs, p. 108

**See Bulletin 5396**

Visit bio-rad.com/fastgel for information on Bio-Rad’s 10 minute Fast Gel Protocol.

**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

**Stain gel with Fast Blast DNA stain**

Monitor migration of loading dyes

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 107
PCR Amplification Kits
Section Contents

PCR Amplification Kits

Crime Scene Investigator PCR Basics Kit ........................................... 68
PV92 PCR Informatics Kit .................................................................. 70
Fish DNA Barcoding Kit .................................................................. 72
GMO Investigator Kit ...................................................................... 74
Real-Time PCR Kits ........................................................................ 76

“My students have plunged into rivers and explored forests gathering samples to learn about our local ecosystems. Bio-Rad’s kits allow my students to make discoveries in the classroom and join the conversation within the scientific community. We couldn’t have done that without Bio-Rad.”

Ray Cinti
Green Mountain Valley School
Waitsfield, Vermont
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].

\[
\ldots CCC\ TCA T\ TCA T\ TCA T\ TCA T\ AAA \ldots
\]

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

<table>
<thead>
<tr>
<th>Allele 1</th>
<th>Allele 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>5'</td>
<td>3'</td>
</tr>
<tr>
<td>C C C C C A A A</td>
<td>C C C C C A A A</td>
</tr>
</tbody>
</table>

* 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

<table>
<thead>
<tr>
<th>Item</th>
<th>List Price</th>
<th>EDU Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1662600EDU</td>
<td>195.00</td>
<td>114.00</td>
</tr>
</tbody>
</table>

Small Fast Blast DNA Electrophoresis Reagent Pack 1660400EDU

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 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.

- Use of PCR and gel electrophoresis for DNA profiling
- Use of experimental controls
- Interpretation of experimental results
- Use of forensic evidence in the courts

Additional features:

- DNA replication and the polymerase chain reaction (PCR)
- Chemical properties of biological molecules
- DNA structure and function
- Chemistry of electrophoresis

- Mendelian genetics
- Polymorphic loci and multiple alleles
- Genetics of noncoding DNA
- Short tandem repeats (STRs)
- Genetic identity
- Structure and function of the human genome

- Evolution
- Eukaryotic cell structure and organization
- Tissue types and biological sampling

- Cellular Processes
- Genetics and Heredity
- Population genetics
- Genetic screening
- Genetic databases
- Role, place, limits of science and technology
- Privacy of information issues

- Molecules to Organisms
- Genetics and Heredity
- Population genetics
- Genetic screening
- Genetic databases
- Role, place, limits of science and technology
- Privacy of information issues

- Science and Engineering Practices
- Chemistry of electrophoresis
- DNA structure and function
- Chemical properties of biological molecules
- DNA replication and the polymerase chain reaction (PCR)
- Use of experimental controls
- Interpretation of experimental results
- Use of forensic evidence in the courts

- Ecosystems, Environment, and Interactions
- Population genetics
- Genetic screening
- Genetic databases
- Role, place, limits of science and technology
- Privacy of information issues
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
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

Required Accessories Not Included in Kit:
Horizontal Gel Electrophoresis   4–8
DNA Electrophoresis Reagent Pack, p. 108  1
Horizontal Gel Electrophoresis   4–8
Chambers, p. 106
Adjustable Micropipets, p. 136
2-20 µl   1-8
20–200 µl   1
Pipet Tips, aerosol barrier, p. 138
2-20 µl Xcuba B   1 box
20–200 µl Xcuda D   1 box
Microcentrifuges, p. 132   1–4
Thermal cycler, p. 112   1
Power Supplies, p. 139   2–4
Gel Staining Trays, p. 141   4–88

Recommended (Optional) Accessories:
Adjustable Micropipets, p. 136
100–1,000 µl   1
Pipet Tips, aerosol barrier, p. 138
100–1,000 µl Xcuda E   1 box
Rocking Platform, p. 133
Gel Documentation System, pp. 130–131
Microwave Oven

Refresh Kit Components: 
(more info pp. 141–143)
Crime Scene Investigator PCR Basics Kit Reagent Refill Pack (#1662801EDU) 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 (#1660251EDU)
Gel Staining Trays, 4 (#1660477EDU)
2x Master Mix for PCR, p. 117
DNA Electrophoresis Reagent Packs, p. 108
UView 6x Loading Dye, p. 111

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

Crime Scene Investigator PCR Basics Brand Name Genes Curriculum
Web Check This Out

Download the topical case study scenario from Morehead Planetarium and Science Center Mobile Science Labs Program. Visit bio-rad.com/partners to download the complete PDF.

Lab 1
Transfer crime scene or suspect DNA to 0.2 ml PCR tube
Add primers to master mix containing:
- Nucleotides
- Reaction buffer
- DNA polymerase
Add complete master mix to crime scene and suspect DNA samples
Place PCR tubes in thermal cycler and amplify target DNA sequence

Lab 2
Amplify DNA

Lab 1

Lab 2

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. 76–77). Available free on the Web: explorer.bio-rad-com

Extension: Look more closely at DNA structure with the DNA model, p 107
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. 106)
Lab Preparation Checklist

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

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

**Required Accessories Not Included in Kit:**
- Protease Solution (for extraction from hair follicles) 1
- Horizontal Gel Electrophoresis chambers, p. 106
- Adjustable Micropipets, p. 136, 20–200 µl
- Pipet Tips, aerosol barrier, p. 138
- Power Supplies, p. 139
- Thermal Cycler, p. 112
- Microcentrifuges, p. 132
- Gel Staining Trays, p. 141
- Foam Floating Racks, p. 141

**Recommended (Optional) Accessories:**
- Water Bath or Dry Bath, p. 134
- Rocking Platform, p. 133
- Gel Support Film, p. 108
- Vortexer, p. 133
- Gel Documentation System, pp. 130–131
- Microwave Oven

**Refresh Kit Components:** (more info pp. 141–143)
- PV92 PCR Kit TS Reagent Refill Pack (#1682119EDU) 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 (#1682139EDU) includes InstaGene matrix, Fast Blast DNA stain, agarose, 50x TAE
- Jellyfish Foam Floating Racks, 8 racks (#1650479EDU)
- 2x Master Mix for PCR, p. 117
- DNA Electrophoresis Reagent Packs, p. 108
- InstaGene Matrix, p. 116
- UView 6x Loading Dye, p. 111

**See Bulletin 5396**

Visit bio-rad.com/fastgel for information on Bio-Rad’s 10 minute Fast Gel Protocol.

**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

**Lab 1**

1. Obtain hair follicle cells for DNA extraction
2. Add protease to extract DNA from hair follicle
3. Incubate at 56°C for 10 min, then agitate vigorously
4. Incubate at 100°C for 6 min, then repeat vigorous agitation

**Lab 2**

1. Transfer supernatant with genomic DNA to 0.2 ml PCR tube
2. Add primers to master mix containing:
   - Nucleotides
   - Reaction buffer
   - DNA polymerase
3. Add complete master mix to student samples and positive controls
4. Place tubes in thermal cycler and amplify target DNA sequence

**Lab 3**

1. Electrophoresis PCR samples in agarose gels at 100 V for 30 min.
2. Satin with Fast Blast DNA stain
3. Determine student genotypes for Alu insertion and perform Hardy-Weinberg analysis on class results

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

Visit us on the Web at explorer.bio-rad.com
Fish DNA Barcoding Kit — AP Big Ideas 1, 2, 3, and 4: What Kind Is Your Fish?

The International Barcode of Life (iBOL) project is a global initiative to identify all species on Earth using a technology called DNA barcoding. DNA barcoding adds a level of genetic identification to species classification. Traditionally, a taxonomist would make species determinations based on observations of physical and environmental characteristics of a specimen. In some cases, DNA barcoding can help make the distinction between species that look and behave so similarly that they would be considered the same species based on the traditional taxonomical criteria. Since the slight nuances found through DNA sequencing reveal the uniqueness of a species, these sequences are essentially barcodes that can be used to help identify previously unclassified species. The cytochrome c oxidase 1 (COI) gene is a mitochondrial gene found in fish, birds, butterflies, flies, and other animal groups, making it a useful benchmarking tool for comparison between species.

DNA barcoding is also being actively used by the U.S. Food and Drug Administration (U.S. FDA) to monitor the labeling of fish in the marketplace. Once a fish has been processed for sale, it can be incredibly difficult for a consumer to tell the difference between the varieties available. Mislabeling might be done on purpose, for profit, or accidentally, but the end result to consumers is the same — they do not get what they pay for.

Investigate fish fraud! Your students will extract DNA from fish tissue, amplify the DNA through PCR, perform agarose gel electrophoresis to verify PCR products, sequence the COI gene, and then use bioinformatics to genetically identify the species using the sequence obtained. The unique COI sequence produced for a given fish sample is considered to be its DNA barcode. This exercise is an opportunity for students to perform an investigation in their local area to see if marketplace substitution is occurring, or to develop the skills to participate in the iBOL initiative and contribute scientific data to the Barcode of Life Database.

Fish DNA Barcoding Kit

- Aligns with AP Biology Big Ideas 1, 2, 3 and 4; Lab 3
- Extract and amplify DNA from up to 16 fish samples
- Amplify sample and positive control DNA using PCR
- Perform DNA electrophoresis
- Sequence DNA samples and carry out bioinformatics analysis, including BLAST, to identify the species
- Inquiry based

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

Fish DNA Barcoding Sequencing Module

- Use of PCR and DNA gel electrophoresis in DNA profiling
- Use of positive experimental controls
- Use of bioinformatics databases
- Apply the Hardy-Weinberg equation to student data

Fish DNA Barcoding Kit — Each kit supports 32 students.

Catalog # List Price....... EDU Price
1665100EDU $311.25............ $249.00

Includes reagents for DNA extraction and PCR for up to 16 fish samples. Sequencing module sold separately. Ships at room temperature. Immediately store temperature-sensitive reagents at -20°C or 4°C as indicated.

Catalog # List Price....... EDU Price
1665115EDU $161.25.............. $126.00

Includes prepaid sequencing service for up to 9 samples. Includes shipping of samples within the U.S. (50 states). Valid for use only with 1665100EDU. U.S. only.

Ecosystems, Environment, and Interactions
- Evolution
- Eukaryotic cell structure and organization
- Tissue types for biological sampling

Science and Engineering Practices
- DNA extraction techniques
- DNA replication and PCR
- DNA structure, function, and chemistry
- Chemical properties of biological molecules

Molecules to Organisms
- Genetics and Heredity
- Mendelian genetics
- Homozygous vs. heterozygous alleles
- Inheritance of dimorphic loci
- Genetics of noncoding DNA
- Short repetitive interspersed elements, SINEs

Cellular Processes
- Function of genetic diversity
- Genetic variation in the human genome
- Selective advantages of heterozygous alleles
**Lab Preparation Checklist**

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

- Resuspension Solution, 5 ml  
- Lysis Solution, 5 ml  
- Neutralization Solution, 5 ml  
- Matrix, 5 ml  
- Wash Buffer, 10 ml  
- Spin Columns  
- Master Mix for PCR, 1.2 ml  
- Fish Primer Mix, 50 µl  
- UView 6x Loading Dye, 0.2 ml  
- pCOI Control for PCR, 25 µl  
- Sterile Water, 2.5 ml  
- PCR Molecular Weight Ruler, 0.2 ml  
- PCR Tubes, 0.2 ml  
- Microcentrifuge Tubes, 2 ml  
- Curriculum including teacher’s guide, student manual, and graphic quick guide

**Required Accessories Not Included in Kit:**

- Adjustable Micropipets, p. 136  
- Pipet Tips, p. 138  
- Pipet Tips aerosol barrier  
- Molecular Biology Grade Agarose, 5 g, p. 108  
- Power Supplies, p. 139  
- Horizontal Electrophoresis Chambers, p. 106  
- Microcentrifuge Tube Racks, p. 140  
- Microcentrifuge with variable speed setting capable of 14,000 x g, p. 132  
- Marking Pens  
- Razor Blades or Plastic Knives (new)  
- Weigh Boats  
- Ethanol, 95%  
- Graduated Cylinders; 100 ml, 500 ml, 3 L  
- Microwave Oven or Magnetic Hot Plate with stir bar  
- Distilled Water  
- Beakers for ice bath  
- Gloves, latex or nitrile  
- Beakers for ice bath  
- Obtain fish samples locally  
- Parafilm  
- Zipper Sealed Bag for mailing sequencing samples

**Recommended (Optional) Accessories:**

- ReadyAgarose Precast Mini Gels, p. 107  
- Gel Staining Trays, p. 141  
- Gel Documentation System, pp. 130–131

**Refresh Kit Components:** (more info pp. 141–143)

- DNA Extraction Refill Pack, includes resuspension, lysis, and neutralization solutions, wash buffer, matrix, and 20 spin columns (1665105EDU)  
- Fish DNA Barcoding Temperature-Sensitive Refill Pack, contains 2x master mix for PCR, fish primer mix, pCOI positive control DNA, UView 6x loading dye, sterile water (1665106EDU)  
- 0.2 ml PCR Tubes (IW2001EDU), p. 113  
- 2 ml Microtubes (2293430EDU), p. 141  
- 2x Master Mix for PCR, p. 117  
- UView 6x Loading Dye, p. 111

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**Lab 1**

**Sample preparation**

- Acquire fish sample

**DNA extraction**

- Prepare an eraser-head sized block of fish tissue

- Prepare fish DNA samples using extraction buffers and centrifugation

**PCR amplification and electrophoresis**

- Purify DNA using spin DNA column

- Elute DNA from spin column

**PCR Results analysis**

- Add master mix to fish DNA samples and control DNA

- Amplify target sequences

- View results on a UV transilluminator

- Use UView 6x loading dye for instant results

**Sequencing and bioinformatics for species identification**

- Ship PCR products to sequencing facility

- Analyze sequences using DNA bioinformatics platform

**Bioinformatics analysis**

- Analyze DNA via electrophoresis

**Extension:** Look more closely at DNA structure with the DNA model, p. 107

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Visit us on the Web at explorer.bio-rad.com
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 GM sequences.

The GMO Investigator kit uses PCR and DNA electrophoresis to test for the presence of two different GMO-associated DNA sequences: the 3SS 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?
Lab Preparation Checklist

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

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

Required Accessories Not Included in Kit:

- DNA Electrophoresis Reagent Pack, p. 108
- Horizontal Gel Electrophoresis Chambers, p. 106
- Adjustable Micropipets, p. 136
- Pipet Tips, aerosol barrier, p. 138
- Water Bath or Dry Bath, p. 134
- Microcentrifuges, p. 132
- Power Supplies, p. 139
- Mortars and Pestles
- Balance with range 0.5–2 g
- Gel Staining Trays, p. 141
- Foam Floating Racks, p. 141

Recommended (Optional) Accessories:

- Rocking Platform, pp. 133
- Gel Documentation System, pp. 130–131
- Microwave Oven

Refresh Kit Components: (more info pp. 141–143)

GMO Investigator Kit Refill Pack (#1662501EDU) includes:

- PCR master mix, GMO primers, plant PSI 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. 116
- 2x Master Mix for PCR, p. 117
- DNA Electrophoresis Reagent Packs, p. 108
- UView 6x Loading Dye, p. 111

See Bulletin 5396

Visit bio-rad.com/fastgel for information on Bio-Rad’s 10 minute Fast Gel Protocol.

Lab 1

Grind food samples

Add food sample to InstaGene matrix

Incubate at 100°C for 5 min

Centrifuge samples for 5 min to pellet matrix

Set up polymerase chain reaction and amplify DNA samples

Lab 2

Red master mix with GMO primers

Green master mix with plant primers

Place tubes in thermal cycler and amplify target DNA sequences

Lab 3

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. 76–77). Available free on the Web: explorer.bio-rad.com

Extension: Look more closely at DNA structure with the DNA model, p 107

See Bulletin 5396

Visit bio-rad.com/fastgel for information on Bio-Rad’s 10 minute Fast Gel Protocol.
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.

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.

1 DNA Extraction Module
Crime Scene Investigator PCR Basics Kit or GMO Investigator Kit (based on which package chosen)
iQ SYBR Green Supermix, 2.5 ml
Agarose powder, 25 g
Electrophoresis Buffer, 50x TAE, 100 ml
Fast Blast DNA Stain, 500x, 100 ml
Sterile Water, 500 ml
PCR Tube Strips
Optical Flat caps
Curriculum, including teacher’s guide and student manual

Required Accessories Not Included in Kits:
Horizontal Gel Electrophoresis Chambers, p. 106
Adjustable Micropipettes, p. 136
2–20 µl 1–8
20–200 µl, 100–1,000 µl 1 each
Disp Tips, aerosol barrier, p. 138
2–1,000 µl, Xcluda B, D, and E
Power Supplies, p. 139
Real-time Thermal Cycler, p. 114
Microcentrifuges, p. 132

Additional Required Accessories Not Included in GMO Investigator Real-Time PCR Starter Kit:
Obtain food samples locally
Water Bath or Dry Bath, p. 134
Mortars and Pestles 1–8
Balance with range 0.5–2 g 1
Weigh Boats or paper 16

Recommended (Optional) Accessories:
Rocking Platform, p. 133
Gel Documentation System, pp. 130–131
Microwave Oven

Refresh Kit Components: (more info pp. 141–143)
Crime Scene Investigator PCR Basics Kit Reagent Refill Pack (#1662601EDU), see p. 69
GMO Investigator Kit Reagent Refill Pack (#1662501EDU), see p. 75
Sterile Water, 500 ml (#1632091EDU), 96-Place PCR Tube Rack and Cover, 5 (#TRC0501EDU)
Gel Staining Trays, 4 (#1660477EDU)
InstaGene Matrix, p. 116
2x Master Mix for PCR, p. 117
DNA Electrophoresis Reagent Packs, p. 108
iQ SYBR Green Supermix, p. 118
PCR Strip Tubes and Optical Flat Caps, p. 113

DNA Model, p. 107 (#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.

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

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. 107

Visit us on the Web at explorer.bio-rad.com
Cloning and Sequencing Explorer Series

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.

GAPDH PCR Module
- Nested PCR
- Degenerate primers
- Exonuclease treatment

PCR Purification Module
- Size exclusion chromatography

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

Microbial Culturing Module
- Grow transformed cells
- Cell selection
- Ampicillin resistance

Nucleic Acid Extraction Module
- Nested PCR
- Degenerate primers
- Exonuclease treatment

Electrophoresis Module
- Agarose gel analysis
- PCR product visualization
Section Contents

Cloning and Sequencing Explorer Series

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Electrophoresis Module .............................................................. 83
PCR Kleen Spin Purification Module ............................................. 84
Ligation and Transformation Module .............................................. 84
Microbial Culturing Module ......................................................... 85
Aurum Plasmid Mini Purification Module ....................................... 86
Sequencing and Bioinformatics Module ........................................ 86

DNA Sequencing Module

• Directional sequencing primers
• Automated sequencing

Bioinformatics Module

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

Plasmid Purification Module

• Plasmid isolation
• Restriction enzyme digestion
Cloning and Sequencing Explorer Series: Cloning Pieces of the Puzzle

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.

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**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 GAPDH 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.
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

Required Accessories Not Included in Kit:

- Plant samples 95–100% lab grade ethanol
- Horizontal gel electrophoresis chambers, p. 106
- Thermal cycler, p. 112
- Adjustable micropipets, p. 136
- Pipet tips, aerosol barrier, p. 138
- Incubation oven, p. 134
- Water bath and dry bath, p. 134
- Microcentrifuges capable of greater than 12,000 x g, p. 132
- Power supplies, p. 139
- Gel documentation system, p. 130
- Shaking water bath or shaking incubator, p. 135

Recommended (Optional) Accessories:

- Vortexer, p. 123
- Microwave oven/autoclave
- Spectrophotometer
- Cuvettes, p. 140

Available Separately:

- Nucleic acid extraction module (#1665005EDU)
- GAPDH PCR module (#1665010EDU)
- Small DNA electrophoresis reagents module (#1660462EDU)
- PCR Kleen spin purification module (#7328300EDU)
- Ligation and transformation module (#1665015EDU)
- Microbial culturing module (#1665020EDU)
- Aurum plasmid mini purification module (#7328400EDU)
- 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.
Cloning and Sequencing Explorer Series: Cloning Pieces of the Puzzle

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.

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, p. 136 2–20 µl 1
20–200 µl 1
100–1,000 µl 1
Pipet tips, aerosol barrier, p. 138 2–20 µl 1
Xcluda B 1 box
Xcluda D 1–12 boxes
Xcluda E 1–12 boxes
Microcentrifuges capable of greater than 12,000 x g 1
Water bath, p. 134 1
Dry bath, p. 134 1

Recommended (Optional) Accessories:

Vertelex, p. 133
Spectrophotometer
Cuvettes, p. 140
DEPC-treated water, 100 ml
(#7007253EDU)

Refresh Kit Components: (more info pp. 141–143)
Nucleic acid extraction reagent refill pack (#1665005EDU), includes DTT, lysis buffer, wash buffer, sterile water
Aurum mini columns, 50 (#7326826EDU)

On your own:

For more information, visit explorer.bio-rad.com.

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.
**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.

**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
- Color 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, p. 136
- Pipet tips, aerosol barrier, p. 138
- Pipet tips, Xcluda B 1–12 boxes
- Pipet tips, Xcluda D 1 box
- Thermal cycler, p. 112
- Foam floating racks, p. 141
- Capless PCR tube adaptors, 1.5 ml 150
- Colored microcentrifuge tubes, 2.0 ml  120

**Recommended (Optional) Accessories:**
- Novel plant genomic DNA
- Microcentrifuges, p. 132
- Vortexer, p. 133
- Microcentrifuge tubes, 2.0 ml 120

**Refresh Kit Components:** (more info pp. 141–143)
- 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. 117
- UView 6x loading dye and stain, p. 111

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

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**GAPDH PCR Module**

Catalog #

1660462EDU

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.

**Electrophoresis Module**

Catalog #

1660462EDU

Ships and stores at room temperature.

Please refer to p. 106 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.

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**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.
Cloning and Sequencing Explorer Series: Cloning Pieces of the Puzzle

**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.

**Lab Preparation Checklist**

- **Kit contains** sufficient materials for 24 student workstations or 25 PCR purifications.
- **PCR Kleen spin columns**
- Microcentrifuge tubes, 2.0 ml
- Microcentrifuge tubes, 1.5 ml
- Instruction manual
- **Required Accessories Not Included in Kit:**
  - Adjustable micropipets, p. 136
  - Pipet tips, p. 138
  - Microcentrifuges capable of greater than 12,000 x g, p. 132
- **Recommended (Optional) Accessories:**
  - Horizontal gel electrophoresis chambers, p. 106
  - Power supplies, p. 139

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!
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.

Starters 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.

Microbial Culturing Module
Catalog # 1665020EDU
Ships and stores at room temperature.

Please refer to p. 106 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

Kit contains sufficient materials for 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. 134 1
Tube roller, p. 133 1
Shaking water bath or shaking incubator, p. 135 1

Refresh Kit Components:
Visit us on the Web at explorer.bio-rad.com

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 (#1665032EDU) or 500 g (#1665072EDU)
Ampicillin (#1665047EDU)
E. coli strain HB101 K-12 (#1665085EDU)
Petri dishes, 60 mm, sterile, 500 (#1665047EDU)
Inoculation loops, 10 µl, sterile, 100 (#1665071EDU)
Disposable plastic transfer pipets, sterile, 500 (#1665047EDU)
Cell culture tubes, 17 x 100 mm, 14 ml, sterile, 25 (#1665047EDU)

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.

Note: Bacterial culturing reagents such as LB broth and LB agar are contained in the microbial culturing module.
Cloning and Sequencing Explorer Series: Cloning Pieces of the Puzzle

Aurum Plasmid Mini Purification Module

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.

Sequencing and Bioinformatics Module

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.
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.

Visit us on the Web at explorer.bio-rad.com
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 students with authentic protein-based laboratory experiences relevant to research and industrial applications.

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.
Protein Expression and Purification Series
Assessment Module ..................................................... 89
Protein Expression and Purification Series ..................... 90
Growth and Expression Module ...................................... 91
SDS-PAGE Electrophoresis Module ............................... 92
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  Option 2: Hand-Packed Column Purification Module ..... 92
  Option 3: Prepacked Cartridge Purification Module ..... 92
DHFR Enzymatic Assay Module ................................. 93

Assessment Module
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.
Protein Expression and Purification Series: From Industrial Enzymes to Cancer Therapy —

Protein Expression and Purification Series — All Four Modules (choose option)

Option 1: Centrifugation Purification Process
Catalog # List Price ............... EDU Price
1665040EDU $799.00 .................. $579.04
(for purification using a 16K microcentrifuge)

Option 2: Hand-Packed Column Process
1665045EDU $916.25 .................... $733.00
(for use with chromatographic purification instrumentation and allowing students to pour their own columns)

Option 3: Prepacked Cartridge Process
1665050EDU $916.25 .................... $733.00
(providing the best experience with chromatographic purification instrumentation through the quality of prepacked cartridges)

Assessment Module (optional)
1665070EDU $63.75 .................... $51.00
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. 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!

Growth and Expression Module

As part of the Protein Expression and Purification series, the Growth and Expression Module is designed to help users learn about the process of protein biogenesis. This module includes a series of protocols and experiments that allow users to understand the different stages of protein expression and purification体系.

Kit supports 4–12 student workstations, depending on the size of the cultures used.

Lab Preparation Checklist

The Lab Preparation Checklist is a list of materials and equipment needed for the successful completion of the experiments. It includes a variety of items such as pipets, glassware, and reagents. The checklist is a valuable resource for ensuring that all necessary materials are available for the experiments.

Growth and Expression Reagent Refill

The Growth and Expression Reagent Refill includes a variety of reagents necessary for the experiments. It contains reagents such as 2 M EZ Micro Test Tubes, Microcentrifuge, and Sterile Water.

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.

Protein Expression and Purification Series Contents

The Protein Expression and Purification Series contains a variety of modules and reagents necessary for the successful completion of the experiments. It includes modules such as Growth and Expression, Centrifugation, and Purification.

Hand-Packaged Column Purification Process*

The Hand-Packaged Column Purification Process is a process that allows users to use a hand-packed column to purify proteins. This process is suitable for small-scale purification and can be used in conjunction with other purification techniques.

Required Accessories Not Included in Kit:

The Required Accessories Not Included in Kit section lists materials that are not included in the kit. These materials include pipettes, glassware, and reagents. The section also includes instructions for ordering additional materials.

Purification Module (one of the following) 1

The Purification Module is a module that allows users to perform purification experiments. It includes a variety of reagents and equipment necessary for successful purification.

Recommended (Optional) Accessories:

The Recommended (Optional) Accessories section lists materials that are recommended for use with the experiments. These materials include pipettes, glassware, and reagents.

Required Accessory:

The Required Accessory section lists a single material that is required for the experiments. This material is necessary for successful completion of the experiments.

Lab Preparation Checklist

The Lab Preparation Checklist is a list of materials and equipment needed for the successful completion of the experiments. It includes a variety of items such as pipets, glassware, and reagents. The checklist is a valuable resource for ensuring that all necessary materials are available for the experiments.

Growth and Expression Reagent Refill

The Growth and Expression Reagent Refill includes a variety of reagents necessary for the experiments. It contains reagents such as 2 M EZ Micro Test Tubes, Microcentrifuge, and Sterile Water.

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.

Protein Expression and Purification Series Contents

The Protein Expression and Purification Series contains a variety of modules and reagents necessary for the successful completion of the experiments. It includes modules such as Growth and Expression, Centrifugation, and Purification.

Hand-Packaged Column Purification Process*

The Hand-Packaged Column Purification Process is a process that allows users to use a hand-packed column to purify proteins. This process is suitable for small-scale purification and can be used in conjunction with other purification techniques.

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Purification Module (one of the following) 1

The Purification Module is a module that allows users to perform purification experiments. It includes a variety of reagents and equipment necessary for successful purification.

Recommended (Optional) Accessories:

The Recommended (Optional) Accessories section lists materials that are recommended for use with the experiments. These materials include pipettes, glassware, and reagents.

Required Accessory:

The Required Accessory section lists a single material that is required for the experiments. This material is necessary for successful completion of the experiments.
Protein Expression and Purification Series: From Industrial Enzymes to Cancer Therapy —

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.

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.

SDS-PAGE Electrophoresis Module
Catalog #: 1665060EDU

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.

Lab Preparation Checklist

Kit contains sufficient materials sufficient materials for 12 student workstations.
10x Tris/glycine/SDS Buffer, 1 L
Laemmli Sample Buffer, 30 ml
Bio-Safe Coomassie Stain, 1 L
Precision Plus Protein Dual Color Standards, 500 µl

Required Accessories Not Included in Kit:
Vertical Gel Electrophoresis Chambers, p. 120
Mini-PROTEAN TGX Polyacrylamide Gels, 4–20%, 10-well, p. 124
Water Bath or Dry Bath, p. 134
Adjustable Micropipets, p. 138
Pipet Tips, p. 138
Power Supplies, p. 139
Gel Staining Trays, p. 141

Recommended (Optional) Accessories:
16K Microcentrifuge, p. 132
Gel Documentation System, pp. 130–131

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.

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.
Protein Purification Is Essential!

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-DHF-His will be calculated using the proteins’ intrinsic absorbance of UV light at 280 nm. This known concentration of GST-DHF-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-DHF-His and NADPH, the absorbance at 340 nm should decrease over time as the reaction occurs, converting NADPH to NADP+ and DHF to THF.

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.
DHFR, cofactor, 1 mg

Required Accessories Not Included in Kit:
Adjustable Micropipets, p. 136
UV Spectrophotometer capable of three decimal place accuracy
UV Compatible Cuvettes, p. 140
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?
Instructional Laboratory Equipment Sets
Section Contents

**Instructional Laboratory Equipment Sets**

- Advanced Biotechnology Lab Equipment Set ................... 96
- Complete Biotechnology Lab Equipment Set ................... 98
- Basic Biotechnology Lab Equipment Set ........................ 100
- PCR Lab Equipment Set .................................................. 101
- DNA Electrophoresis Lab Equipment Sets ...................... 102
- Protein Electrophoresis Lab Equipment Sets .................. 103

“I’m so grateful that I stumbled upon Bio-Rad those 20 years ago. Bio-Rad’s individualized support and tremendous kits have helped me grow my program in spectacular ways. I get to be a rockstar and my students get the highest quality laboratory experience.”

Jennifer Barnes
SUNY
Long Island, NY
Instructional Laboratory Equipment Sets

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 T100 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

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This package is not available outside the U.S.
INSTRUCTIONAL LABORATORY EQUIPMENT SETS

Customize your equipment sets

Contact your local sales rep, 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.

Visit us on the Web at explorer.bio-rad.com
Instructional Laboratory Equipment Sets

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.

Ordering Information

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<td>Complete Biotechnology Lab Equipment Set Upgraded with C100 Touch Thermal Cycler (120 V)</td>
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This package is not available outside the U.S.
Customize your equipment sets

Contact your local sales rep, 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.

Visit us on the Web at explorer.bio-rad.com
Instructional Laboratory Equipment Sets

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 sales representative.

Basic Biotechnology Lab Equipment Set supports the following skills:

• ELISA
• Bacterial transformation and culture
• DNA gel electrophoresis
• Protein gel electrophoresis
• DNA restriction digestion
• Pipetting

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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 sales representative.

PCR Lab Equipment Set supports the following skills:
• PCR
• DNA gel electrophoresis
• DNA restriction digestion
• DNA Extraction
• Pipetting

* Variance depending on package chosen.

Customize your equipment Sets

Contact your local sales rep, 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.

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For 220/230 V packages contact your local Bio-Rad representative or office.
Instructional Laboratory Equipment Sets

**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.

**Includes:**
1. PowerPac Basic power supply
2. Classroom digital micropipet, 2–20 µl range
3. 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
4. Gel staining trays, pack of 4

**Ordering Information**

<table>
<thead>
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**DNA Electrophoresis Lab Equipment Sets**

support instruction of the following skills:

- DNA gel electrophoresis
- Restriction digest analysis
- Pipetting

**DNA Electrophoresis**

**Expanded Lab Equipment Set**

**Includes:**
1. PowerPac Basic power supply
2. Classroom digital micropipet, 2–20 µl range
3. Classroom digital micropipet, 20–200 µl range
4. Classroom digital micropipet, 100–1,000 µl range
5. Digital dry bath
6. 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
7. Gel staining trays, pack of 4
8. Green racks, set of 5 racks

For custom package quotes to best suit your needs, please contact your local sales representative.

**Ordering Information**

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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

Ordering Information

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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
2 Gel staining trays, pack of 4

For custom package quotes to best suit your needs, please contact your local sales representative.

Ordering Information

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DNA and Genomic Studies: Equipment and Reagents
Section Contents

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- DNA Model .................................................................... 107
- DNA Electrophoresis Reagent Packs ............................. 108
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"A Bio-Rad kit isn’t just a kit. It’s a way to launch my students into the next level of questions. This is how we get the next generation of students to participate in scientific discovery and understand how it’s shaping their future.”

Dr. Rebecca Grella
Brentwood High School
Brentwood, NY
DNA and Genomic Studies: Horizontal DNA Electrophoresis Gel Boxes • DNA Model

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, p. 8
- Science of Opioid Dependence Kit, p. 10
- IDEA kit, pp. 60–61
- Forensic DNA fingerprinting kit, pp. 62–63
- Lambda DNA restriction digestion and analysis kits, pp. 64–65
- Crime Scene Investigator PCR Basics kit, pp. 68–69
- PV92 PCR informatics kit, pp. 70–71
- Fish DNA barcoding kit, pp. 72–73
- GMO Investigator kit, pp. 74–75
- Cloning and Sequencing Explorer series, pp. 78–87

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 Mini-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!

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. 110). 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.

Additional supplies:
- Power supplies, p. 139
- ReadyAgarose precast gels, agarose powders, and DNA electrophoresis reagents p. 108–109
- DNA size standards, p. 110
- DNA stains, p. 111

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

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<th>Catalog #</th>
<th>List Price</th>
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<td>Wide Mini-Sub Cell GT Systems</td>
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<td>Wide Mini-Sub Cell GT Cell, with 15 x 10 cm tray, 15-well and 20-well combs</td>
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<td>Wide Mini-Sub Cell Accessories</td>
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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 and Genomic Studies: DNA Electrophoresis Reagents • Precast Agarose Gels

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

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Agarose Powders

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DNA and Genomic Reagents are perfect for use with:

- 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 (#1662600EDU)
- PV92 PCR Informatics kit (#1662100EDU)
- Fish DNA Barcoding kit (#1665100EDU)
- 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.

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

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. 124 for more details and ordering information.

Ordering Information

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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. 111 for dual-function UView loading dye and stain.

Additional supplies:

• DNA electrophoresis cells, p. 106
• DNA size standards, p. 110
• DNA stains, p. 111
DNA and Genomic Studies: DNA Electrophoresis Size Standards • DNA Stains

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

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<th>Description</th>
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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.
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 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.

<table>
<thead>
<tr>
<th>UView Loading Dye Time Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step</td>
</tr>
<tr>
<td>Add stain to agarose gel prep</td>
</tr>
<tr>
<td>Add loading dye to sample, load sample, run gel</td>
</tr>
<tr>
<td>Stain/destain</td>
</tr>
<tr>
<td>See results</td>
</tr>
<tr>
<td>Total time</td>
</tr>
</tbody>
</table>

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.

Ordering Information

<table>
<thead>
<tr>
<th>Description</th>
<th>Catalog #</th>
<th>List Price</th>
<th>EDU Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>UView Loading Dye and Stain</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UView 6x loading dye and stain, 0.2 ml</td>
<td>1665111EDU</td>
<td>31.25</td>
<td>25.00</td>
</tr>
<tr>
<td>UView 6x loading dye and stain, 1 ml</td>
<td>1665112EDU</td>
<td>95.00</td>
<td>76.00</td>
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<tr>
<td>DNA Stains</td>
<td></td>
<td></td>
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<tr>
<td>Fast Blast DNA Stain, 500x, 100 ml</td>
<td>1660420EDU</td>
<td>31.25</td>
<td>25.00</td>
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<tr>
<td>Ethidium Bromide Solution, 10 mg/mL, 10 ml</td>
<td>1610433EDU</td>
<td>45.00</td>
<td>36.00</td>
</tr>
<tr>
<td>Silver Stain Plus Kit</td>
<td>1610449EDU</td>
<td>256.00</td>
<td>204.80</td>
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</tbody>
</table>

Detailed protocols for Fast Blast DNA stain are available at explorer.bio-rad.com.

Additional supplies:
- DNA electrophoresis cells, p. 106
- ReadyAgarose precast gels, agarose powders, and DNA electrophoresis reagents, pp. 108–109
- DNA size standards, p. 110
DNA and Genomic Studies: PCR Thermal Cyclers • PCR Plastic Supplies

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

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.

**Specifications**
- **Sample capacity**: 96 wells x 0.2 ml
- **Speed of ramping**: Up to 4°C/sec
- **Temperature range**: 4–100°C
- **Reaction volumes**: 1–100 µl
- **Gradient capability**: Included
- **Display**: 5.7 inch VGA color touch screen
- **Ports**: 1 USB A
- **Memory**: 500 typical programs onboard; unlimited with USB flash drive expansion
- **Dimensions**: 26 x 47 x 23 cm (10 x 18 x 9 inches) (W x D x H)

C1000 Touch Thermal Cycler — Fast, Friendly, and Flexible

The C1000 Touch thermal cycler maximizes what a thermal cycler can do for your teaching laboratory. This state-of-the-art instrument accommodates multiple sample formats, has an easy-to-use graphical interface and, for truly sophisticated applications, can be upgraded for real-time quantitative PCR. Visit us at [bio-rad.com/cyclers](http://bio-rad.com/cyclers) for more information on the modular C1000 Touch thermal cycler system, including the interchangeable sample blocks and the real time upgrade.

- Precision temperature control
- Fast and easy protocol programming — including the protocol autowriter that automatically generates protocols
- Interchangeable block options include 2 x 48 x 0.2 ml sample block and 96 x 0.2 ml sample block
- Gradient design for maximum reagent optimization
- Able to save protocols to USB flash drive

**Specifications**
- **Sample capacity**: 2 x 48 x 0.2 ml or 96 wells x 0.2 ml
- **Speed of ramping**: Up to 5°C/sec with 96-well fast reaction module
- **Temperature range**: 0–100°C
- **Heated lid**: Adjustable to 110°C
- **Reaction volumes**: 15–100 µl
- **Gradient capability**: Included
- **Display**: 12 x 9 cm, high-resolution, color
- **Ports**: 5 USB A, 1 USB B
- **Memory**: >1,000 typical programs onboard, unlimited with USB flash drive expansion
- **Dimensions**: 33 x 46 x 20 cm (13 x 18 x 8") (W x D x H)

### PCR Thermal Cycler Selection Guide

<table>
<thead>
<tr>
<th></th>
<th>T100</th>
<th>C1000 Touch</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of wells</strong></td>
<td>96</td>
<td>Dual 48/48</td>
</tr>
<tr>
<td><strong>Touch screen</strong></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Gradient capability</strong></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Heated lid</strong></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Fast PCR protocol templates</strong></td>
<td>✓</td>
<td>✓</td>
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<tr>
<td><strong>Power failure restore</strong></td>
<td>✓</td>
<td>✓</td>
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<tr>
<td><strong>Programmable ramp rates</strong></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>USB flash drive compatibility</strong></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Upgrade to real-time PCR</strong></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Interchangeable reaction modules</strong></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Protocol autowriter</strong></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Networking capability</strong></td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

The T100 and C1000 Touch each feature a 1-year warranty.
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.

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.

Ordering Information

<table>
<thead>
<tr>
<th>Description</th>
<th>Catalog #</th>
<th>List Price</th>
<th>EDU Price</th>
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<tbody>
<tr>
<td><strong>Thermal Cyclers</strong></td>
<td></td>
<td></td>
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<tr>
<td>T100 Thermal Cycler, 120/240 V</td>
<td>1861096EDU</td>
<td>$5,059.00</td>
<td>$2,456.00</td>
</tr>
<tr>
<td>C1000 Touch Thermal Cycler with Dual 48/48 Fast Reaction</td>
<td>1851148EDU</td>
<td>9,223.00</td>
<td>6,917.25</td>
</tr>
<tr>
<td>C1000 Touch Thermal Cycler with 96-Well Fast Reaction Module, includes thermal cycler chassis, 96-well fast reaction module, USB flash drive</td>
<td>1851196EDU</td>
<td>8,437.00</td>
<td>6,327.75</td>
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<tr>
<td>C1000 Touch 48-Well Reaction Block</td>
<td>1840148EDU</td>
<td>3,371.00</td>
<td>2,666.80</td>
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<tr>
<td>C1000 Touch 96-Well Reaction Block</td>
<td>1840196EDU</td>
<td>3,032.00</td>
<td>2,425.60</td>
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<tr>
<td><strong>PCR Plastics</strong> (T100, and C1000 Touch thermal cyclers)</td>
<td></td>
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<tr>
<td>0.2 ml Tubes with Flat Caps, clear, 1,000</td>
<td>TFI0201EDU</td>
<td>65.00</td>
<td>52.00</td>
</tr>
<tr>
<td>0.2 ml Tubes with Domed Caps, clear, 1,000</td>
<td>TWI0201EDU</td>
<td>65.00</td>
<td>52.00</td>
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<tr>
<td>Domed 8-Cap Strips, for 0.2 ml tubes and plates, clear, 120</td>
<td>TCS0801EDU</td>
<td>92.00</td>
<td>73.60</td>
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<tr>
<td>0.2 ml 8-Tube Strips Without Caps, clear, 125</td>
<td>TBS0201EDU</td>
<td>109.00</td>
<td>87.20</td>
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<tr>
<td>Domed 12-Cap Strips, for 0.2 ml tubes and plates, clear, 200</td>
<td>TCS1201EDU</td>
<td>79.00</td>
<td>63.20</td>
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<tr>
<td>0.2 ml 12-Tube Strips without Caps, clear, 100</td>
<td>TBS1201EDU</td>
<td>142.00</td>
<td>113.60</td>
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<tr>
<td><strong>Multiplate PCR Plastics</strong> (for C1000 Touch thermal cyclers)</td>
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</tr>
<tr>
<td>Multiplate Low-Profile 48-well Unskirted PCR Plates, white, 50</td>
<td>MLL48S1EDU</td>
<td>158.00</td>
<td>126.40</td>
</tr>
<tr>
<td>Multiplate 96-well Unskirted PCR Plates, clear, 25 (also for T100 Thermal Cycler)</td>
<td>MLP9601EDU</td>
<td>119.00</td>
<td>95.20</td>
</tr>
<tr>
<td><strong>PCR Accessories</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>PCR Tube Capless Adaptors, 500</td>
<td>2239500EDU</td>
<td>24.50</td>
<td>19.60</td>
</tr>
<tr>
<td>Easy Cap Tool</td>
<td>ECT1000EDU</td>
<td>16.00</td>
<td>12.80</td>
</tr>
<tr>
<td>PCR Strip Cap Tool</td>
<td>ECT2000EDU</td>
<td>45.00</td>
<td>36.00</td>
</tr>
</tbody>
</table>

See pp. 116–117 for PCR and nucleic acid purification reagents.
DNA and Genomic Studies: Real-Time PCR Detection Systems • Fluorescent Cell Imaging •

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. 76–77) the CFX Real-Time PCR Systems are easy to set up with software that is easy to use.

CFX Opus Real-Time PCR Systems — Coming soon!
The CFX Opus systems are the newest addition to the the Real-Time PCR lineup. The CFX Opus Systems have an improved physical and digital user experience and are the first system to integrate with with BR.io cloud platform. Visit bio-rad.com/EDUOpus for more information.

CFX Connect Real-Time PCR Detection System
The CFX Connect Real-Time PCR Detection System is an affordable and dependable two-target qPCR instrument that incorporates industry leading performance with the most user friendly software on the market. Includes the CFX Manager software.

CFX96 Touch Real-Time PCR Detection System
The CFX96 Touch system’s solid-state optical technology (six filtered LEDs and six filtered photodiodes) maximizes fluorescence detection for specific dyes in specific channels, providing sensitive detection for precise quantitation and target discrimination — all behind the easy-to-use touch screen interface.

| PCR Thermal Cycler Selection Guide |
|-----------------|-----------------|-----------------|
| **Feature** | **CFX Connect** | **CFX96 Touch** |
| Excitation range | 450–535 nm | 450–684 nm |
| Light source | 3 LEDs in optics shuttle | 6 LEDs in optics shuttle |
| Optical detection | 3 photodiodes | 6 photodiodes |
| Detection range | 515–580 nm | 515–730 nm |
| Multiplex capability | Up to 2 targets | Up to 5 targets |
| Base thermal cycler | CFX Connect | C1000 Touch |
| Touch screen | — | 8.5” VGA color touch screen |

Ordering Information

<table>
<thead>
<tr>
<th>Description</th>
<th>Catalog #</th>
<th>List Price</th>
<th>EDU Price</th>
</tr>
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<tbody>
<tr>
<td>CFX Connect Real-Time PCR Detection System</td>
<td>1855200EDU</td>
<td>$28,083.00</td>
<td>$22,466.40</td>
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<tr>
<td>CFX96 Touch Real-Time PCR Detection System and Components</td>
<td>1855196EDU</td>
<td>$39,453.00</td>
<td>$31,562.40</td>
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<tr>
<td>PCR Plastics (for CFX Systems)</td>
<td>TLS0851EDU</td>
<td>126.00</td>
<td>100.80</td>
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<tr>
<td>Optical Flat 8-Cap Strips, for 0.2 ml tubes and plates, ultraclear, 120 (CFX Connect and CFX96 systems)</td>
<td>TCS0803EDU</td>
<td>42.00</td>
<td>33.60</td>
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<tr>
<td>Multiplate PCR Plastics (for CFX Systems)</td>
<td>MLL4851EDU</td>
<td>158.00</td>
<td>126.40</td>
</tr>
<tr>
<td>Multiplate Low-Profile 96-Well Unskirted PCR Plates, white, 25</td>
<td>MLL9651EDU</td>
<td>137.00</td>
<td>109.60</td>
</tr>
</tbody>
</table>

For real-time PCR kits please refer to pp. 76–77
For PCR reagents please refer to p. 117
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. 111). Visit [bio-rad.com/explorerZOE](http://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](http://bio-rad.com/ZOEactivities) for activity ideas for your classroom.

**Cell Counting**

**C20 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](http://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!

**Ordering Information**

<table>
<thead>
<tr>
<th>Description</th>
<th>Catalog #</th>
<th>List Price</th>
<th>EDU Price</th>
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</thead>
<tbody>
<tr>
<td>ZOE Fluorescent Cell Imager and Accessories*</td>
<td>1450031EDU</td>
<td>$14,627.00</td>
<td>$9,800.09</td>
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<tr>
<td>VivaFix 363/442 Cell Viability Assay</td>
<td>1351111EDU</td>
<td>295.00</td>
<td>236.00</td>
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<tr>
<td>VivaFix 498/551 Cell Viability Assay</td>
<td>1351109EDU</td>
<td>295.00</td>
<td>236.00</td>
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<tr>
<td>VivaFix 547/573 Cell Viability Assay</td>
<td>1351116EDU</td>
<td>295.00</td>
<td>236.00</td>
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<tr>
<td>VivaFix 583/603 Cell Viability Assay</td>
<td>1351117EDU</td>
<td>295.00</td>
<td>236.00</td>
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<tr>
<td>CFDA, SE</td>
<td>1351201EDU</td>
<td>175.00</td>
<td>140.00</td>
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<tr>
<td>PureBlu DAPI Nuclear Staining Dye</td>
<td>1351303EDU</td>
<td>119.00</td>
<td>95.20</td>
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<tr>
<td>PureBlu Hoechst 33342 Nuclear Staining Dye</td>
<td>1351304EDU</td>
<td>119.00</td>
<td>95.20</td>
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<tr>
<td>TC20 Automated Cell Counter with Printer</td>
<td>1450103EDU</td>
<td>5,349.00</td>
<td>4,011.75</td>
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<tr>
<td>TC20 Automated Cell Counter</td>
<td>1450102EDU</td>
<td>4,755.00</td>
<td>3,469.69</td>
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<tr>
<td>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</td>
<td>1450015EDU</td>
<td>306.00</td>
<td>244.80</td>
</tr>
<tr>
<td>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</td>
<td>1450021EDU</td>
<td>48.00</td>
<td>38.40</td>
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<tr>
<td>TC20 Verification Kit, kit for validation of TC20 automated cell counter functionality, includes TC20 verification slide, protocol</td>
<td>1450014EDU</td>
<td>1,050.00</td>
<td>840.00</td>
</tr>
</tbody>
</table>

* Visit [bio-rad.com/explorerZOE](http://bio-rad.com/explorerZOE) for more information about the VivaFix cell viability assays.
DNA and Genomic Studies: Nucleic Acid Purification Kits • Amplification/PCR Reagents

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.

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.

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.

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.

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.

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 either 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.

Ordering Information

<table>
<thead>
<tr>
<th>Description</th>
<th>Catalog #</th>
<th>List Price</th>
<th>EDU Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>InstaGene Matrix, 20 ml</td>
<td>7326030EDU</td>
<td>$61.00</td>
<td>$48.80</td>
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<tr>
<td>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</td>
<td>7326820EDU</td>
<td>$262.00</td>
<td>$209.60</td>
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<tr>
<td>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</td>
<td>7326100EDU</td>
<td>$218.00</td>
<td>$174.40</td>
</tr>
<tr>
<td>PCR Kleen Spin Purification Columns, 25</td>
<td>7326300EDU</td>
<td>$100.00</td>
<td>$80.00</td>
</tr>
<tr>
<td>Aurum Plasmid Mini Purification Kit, 100 preps, includes plasmid-binding mini columns, 100 capless collection tubes, reagents, protocol overview, instructions</td>
<td>7326400EDU</td>
<td>$217.14</td>
<td>$152.00</td>
</tr>
</tbody>
</table>

Detailed protocols, applications, and ordering information for all Bio-Rad nucleic acid purification products are available online.
• Gene Transfer

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 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 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.

SYBR® Green
iQ SYBR® Green supermix is formulated for optimal results in real-time PCR based on SYBR® Green I detection. It contains SYBR® Green I dye, hot-start iTaq DNA polymerase, optimized buffer, and dNTPs qualified for quantitative PCR. Alternately, Bio-Rad’s iScript one-step RT-PCR kit with SYBR® Green allows cDNA synthesis and PCR to be conveniently carried out in the same tube.

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.

Ordering Information

<table>
<thead>
<tr>
<th>Description</th>
<th>Catalog #</th>
<th>List Price</th>
<th>EDU Price</th>
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<tbody>
<tr>
<td><strong>Amplification/PCR Reagents</strong></td>
<td></td>
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<tr>
<td>2x Master Mix for PCR, 90 units, 1.2 ml, includes 0.075 U/µl Taq DNA polymerase (recombinant), reaction buffer, 4 mM MgCl₂, 0.4 mM of each dNTP (dATP, dCTP, dGTP, dTTP)</td>
<td>1665009EDU</td>
<td>92.50</td>
<td>74.00</td>
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<tr>
<td>iProof HF Master Mix for PCR, 100 x 50 µl reactions, premixed PCR reagents, includes 2x master mix (0.04 U/µl), DMSO</td>
<td>1725310EDU</td>
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<td>196.80</td>
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<td>iProof GC Master Mix for PCR, 100 x 50 µl reactions, premixed PCR reagents, includes 2x master mix (0.04 U/µl), DMSO</td>
<td>1725320EDU</td>
<td>322.00</td>
<td>285.60</td>
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<tr>
<td>iTaq DNA Polymerase, 5 U/µl, includes 250 U polymerase, 1.25 ml of 10x PCR buffer, 1.25 ml of 50 mM MgCl₂ solution, dNTP Mix, 200 µl premixed solution, contains 10 mM each dNTP (dATP, dCTP, dGTP, dTTP)</td>
<td>1708870EDU</td>
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<td>MgCl₂ solution, 50 mM, 1.25 ml</td>
<td>1708872EDU</td>
<td>29.00</td>
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<tr>
<td>iQ SYBR Green Supermix, 100 x 50 µl reactions, 2x mix contains 100 mM KCl, 40 mM Tris/HCl, pH 8.4, 0.4 mM each dNTP (dATP, dCTP, dGTP, dTTP), 50 U/ml iTaq DNA polymerase, 6 mM MgCl₂, SYBR® Green I, 20 nM fluorescein, stabilizers</td>
<td>1708880EDU</td>
<td>196.00</td>
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<td>Chill-out Liquid Wax, clear, optical grade, 100 ml</td>
<td>CHO1411EDU</td>
<td>67.00</td>
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<td><strong>MicroPulser and Accessories</strong></td>
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<tr>
<td>MicroPulser Electroporator, 120/220 V, includes chamber with leads, 10 sterile cuvettes (5 each of 0.1 cm and 0.2 cm electrode gap)</td>
<td>1652100EDU</td>
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<td>Gene Pulser/MicroPulser Cuvettes, includes chamber with leads, 10 sterile cuvettes (5 each of 0.1 cm and 0.2 cm electrode gap)</td>
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<td>Gene Pulser/MicroPulser Cuvettes, 0.2 cm, 5/pk</td>
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Visit us on the Web at discover.bio-rad.com for more information on the MicroPulser system.
Proteins and Proteomic Studies: Equipment & Reagents
Section Contents

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“The first time I used Bio-Rad’s ELISA Immuno Explorer Kit, my students had a blast and it was a fantastic springboard into so many other topics. I’ve used the kit for years now and my students love it every time. Bio-Rad makes science fun!”

Suzanne Fetherling
Hoffman Estates High School
Chicagoland Township, IL

Visit us on the Web at explorer.bio-rad.com
Proteins and Proteomic Studies: Vertical Protein Electrophoresis Gel Boxes

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
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. 124 for a complete selection of precast polyacrylamide gels

Teaching applications include:

• Comparative Proteomics Kit I: Protein Profiler Module, p. 50
• pGLO kit SDS-PAGE extension, p. 30
• Protein Expression and Purification Series, p. 88

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

Fast and Easy Tetra Module Assembly

1. Drop in cassettes.
2. Pour in buffer and load samples.
3. Close the lid and start your run.

Criterion Electrophoresis Cell Assembly Made Easy
Mini-PROTEAN Tetra Cell Configuration Comparison Chart

<table>
<thead>
<tr>
<th>Mini-PROTEAN Tetra Cell Configurations</th>
<th>2-gel system (1658005EDU)</th>
<th>4-gel system (1658004EDU)</th>
<th>10-well, 0.75 mm thickness, 2-gel system (1658002EDU)</th>
<th>10-well, 1.0 mm thickness, 2-gel system (1658003EDU)</th>
<th>10-well, 0.75 mm thickness, 4-gel system (1658000EDU)</th>
<th>10-well, 1.0 mm thickness, 4-gel system (1658001EDU)</th>
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<tr>
<td>Supported gels format</td>
<td>Precast mini</td>
<td>Precast mini</td>
<td>0.75 mm thickness hand-cast mini</td>
<td>1.0 mm thickness hand-cast mini</td>
<td>0.75 mm thickness hand-cast mini</td>
<td>1.0 mm thickness hand-cast mini</td>
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<td>Tank and lid with power cables</td>
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<td>1</td>
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<td>Electrode assembly</td>
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<td>1</td>
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<tr>
<td>Companion electrode assembly</td>
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<td>Mini cell buffer dam</td>
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<td>Casting frames</td>
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Ordering Information

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<th>EDU Price</th>
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<tr>
<td>Mini-PROTEAN Tetra Cell and Accessories</td>
<td>1658005EDU</td>
<td>$530.00</td>
<td>$424.00</td>
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<td>Mini-PROTEAN Tetra Cell for Bio-Rad Precast Gels, 2-gel system includes electrode assembly, tank, lid with power cables, mini cell buffer dam</td>
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<tr>
<td>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</td>
<td>1658004EDU</td>
<td>$694.00</td>
<td>$555.20</td>
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<tr>
<td>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</td>
<td>1658002EDU</td>
<td>$838.00</td>
<td>$668.80</td>
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<tr>
<td>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</td>
<td>1658003EDU</td>
<td>$838.00</td>
<td>$668.80</td>
</tr>
<tr>
<td>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</td>
<td>1658000EDU</td>
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<td>$844.00</td>
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<tr>
<td>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</td>
<td>1658001EDU</td>
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<tr>
<td>Mini-PROTEAN Tetra Electrode Assembly</td>
<td>1658037EDU</td>
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<td>Mini-PROTEAN Tetra Companion Running Module</td>
<td>1658038EDU</td>
<td>$203.00</td>
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<td>Buffer Tank, replacement</td>
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<tr>
<td>Buffer Tank and Lid, replacement</td>
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<td>Cell Lid With Power Cables</td>
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<td>10-Well Gel Sample Loading Guide</td>
<td>1653146EDU</td>
<td>$30.00</td>
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<tr>
<td>15-Well Gel Sample Loading Guide</td>
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<td>$24.00</td>
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<td>Buffer Dams, 2</td>
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<td>Replacement Power Cables</td>
<td>1653493EDU</td>
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<td>Gel Cutter, 1</td>
<td>1703760EDU</td>
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<td>Gel Releaser, 5</td>
<td>1653320EDU</td>
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<tr>
<td>Criterion Cell</td>
<td>1656001EDU</td>
<td>$861.00</td>
<td>$528.80</td>
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<tr>
<td>Criterion Cell, includes electrophoresis buffer tank, lid with power cables, 3 sample loading guides (12-well, 18-well, 26-well)</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

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

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

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

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.

Proteins and Proteomic Studies: Western Blotting • Antibodies • Blotting Membranes and Reagents

Mini Trans-Blot System

Colorimetric Detection of Proteins

Specific enzymatic detection of membrane-bound antigens

1. A membrane with unoccupied binding sites is incubated with primary 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 blower. 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.

New! 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.

Ordering Information

<table>
<thead>
<tr>
<th>Description</th>
<th>Catalog #</th>
<th>List Price</th>
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<tbody>
<tr>
<td>Mini Trans-Blot Systems and Accessories</td>
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<td></td>
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<tr>
<td>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</td>
<td>1660827EDU</td>
<td>$1,081.50</td>
<td>$690.11</td>
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<tr>
<td>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</td>
<td>1660828EDU</td>
<td>$1,977.60</td>
<td>$1,442.07</td>
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<td>Mini Trans-Blot Module, lower buffer tank and lid not included</td>
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<td>Mini gel holder cassette</td>
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<td>Blue cooling Unit for Mini-PROTEAN Tetra tanks</td>
<td>1703919EDU</td>
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<td>Roller, 1</td>
<td>1651279EDU</td>
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<td>Criterion Blotting Systems</td>
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<td>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</td>
<td>1704070EDU</td>
<td>$1,016.00</td>
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<td>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</td>
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<td>Trans-Blot Turbo Transfer System</td>
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<tr>
<td>Trans-Blot Turbo transfer system for rapid semi-dry transfer</td>
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<td>Blotting-Grade Blocker, nonfat dry milk, 300 g</td>
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<td>1x PBS/1% Casein, 1 L</td>
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<td>1x TBS/1% Casein, 1 L</td>
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<td>Blotting Membranes and Trans-Blot Turbo Packs</td>
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<td>Thick Blot Paper, 50 sheets, 7.5 x 10 cm</td>
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<td>0.45 µm Nitrocellulose, 7 x 8.5 cm, 10 sheets</td>
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<td>0.45 µm Nitrocellulose (8 sheets)/Filter Paper Pack (16 sheets)</td>
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<td>Visit bio-rad.com/EDUantibodies for ordering information</td>
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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.
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 4°C
- Bottom-open cassette design for simple gel handling and blotting

### Mini-PROTEAN Precast Gel Migration Charts

<table>
<thead>
<tr>
<th>TGX</th>
<th>7.5%</th>
<th>10%</th>
<th>12%</th>
<th>4–15%</th>
<th>4–20%</th>
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<tbody>
<tr>
<td></td>
<td>7.5%</td>
<td>10%</td>
<td>12%</td>
<td>4–15%</td>
<td>4–20%</td>
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<td>200</td>
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Protein migration on TGX precast gels. Percentages refer to acrylamide percentages. The molecular mass of each band is given in kD.

### Ordering Information

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<td>Mini-PROTEAN TGX Precast Gels</td>
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<td>Mini-PROTEAN TGX Stain-Free Precast Gels</td>
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<td>Criterion Tris-HCl Gels</td>
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Criterion Tris-HCl precast gels ship on blue ice and should be stored at 4°C. Shelf life is 3 months from date of manufacture. Additional freight charge for blue ice (see p. 146).

**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.

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.

Ordering Information

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<td>Precision Plus Protein All Blue Standards, 500 µl</td>
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<td>Silver Stain Plus Kit</td>
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<td>Coomassie Brilliant Blue R-250 Kit, includes 1 L stain solution, 2 L destain solution</td>
<td>1610435EDU</td>
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Protein standards are shipped at room temperature. Store in freezer upon arrival.
Proteins and Proteomic Studies: Protein Electrophoresis Buffers • Chromatography Systems

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.

Ordering Information

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<td>Native PAGE Sample Buffer, 30 ml</td>
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<td>Tris, 500 g</td>
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<td>Urea, 250 g</td>
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<td>Glycine, 250 g</td>
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<td>10% Tween 20, 5 ml</td>
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Buffers and reagents ship and store at room temperature.
Chromatography Reagents and Purification Systems

Column chromatography is one of the most common methods for scientific discovery in the purification of biomolecules.

**BioLogic LP System**
The Biologic LP low-pressure chromatography system offers high performance, versatility, ease of use, and affordability for biomolecule purification. Its compact design minimizes the workspace required in the coldroom or on the laboratory bench.

**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.

**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, hydroxypatite, 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 sales representative about educational pricing.

### Ordering Information

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<th>Description</th>
<th>Catalog #</th>
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<td><strong>BioLogic LP Systems</strong></td>
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<tr>
<td>Standard BioLogic LP System, 100/120 V, includes BioLogic LP controller,</td>
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<td>BioLogic rack, accessory kit with inject valve (MV-6), proportioning valve</td>
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<tr>
<td>/mixer, UV optics, conductivity cell, tubing and fittings kit, column</td>
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<td>and conductivity cell holder, starter kit, and instruction manual</td>
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<tr>
<td>Standard BioLogic LP System, 220/240 V, includes BioLogic LP controller,</td>
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<td>/mixer, UV optics, conductivity cell, tubing and fittings kit, column</td>
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<tr>
<td>and conductivity cell holder, starter kit, and instruction manual</td>
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<td>BioLogic LP System with BioFrac™ Fraction Collector, 100/120 V, includes</td>
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<td>BioLogic LP Data View Software</td>
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<td><strong>NGC Chromatography Systems</strong></td>
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<td>NGC Quest 10 Chromatography System includes two-tier base frame, 2 F10</td>
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<td>$31,514.40</td>
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<td>pump modules, mixer module, single-wavelength detector module, sample</td>
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<td>injection valve, ChromLab software, buffer tray, connection adapter</td>
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<td>for BioFrac fraction collector</td>
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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.

Train on Your Purification Systems with the Protein Expression and Purification Series (pp. 88–93)
General Laboratory Equipment
Section Contents

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“I use Bio-Rad kits to bring Nobel-winning, cutting edge science into my classroom, and my students have deeper and richer discussions as a result.”

Mary Wurth
Tamalpais High School
Mill Valley, CA
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.

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.

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 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 (p.109) 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).

GelDoc Go Imaging System
The New 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

GelDoc Go Imaging System supports the following Bio-Rad Explorer kits:
- Forensic DNA fingerprinting kit (see pp. 62–63)
- Lambda DNA kits (see pp. 64–65)
- PCR Amplification kits (see pp. 66–77)
- pGLO kit SDS-PAGE extension (see pp. 30–31)
- Comparative proteomics kits I and II and V3 Western Workflow (see pp. 50–55)
- Cloning and Sequencing Explorer Series (see pp. 75–87)
- Protein Expression and Purification Series (see pp. 88–93)
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.

Ordering Information

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<th>Description</th>
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<td>Fluorescence Mini PVDF Filter Paper Sets (10/pk), 4–20% TGX Stain-Free</td>
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<td>15-Well Precast Gel Pack (10/pk), 1 L 10x Tris/glycine/SDS running buffer,</td>
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General Laboratory Equipment: Centrifuges • Mixing Devices

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 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

Ordering Information

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<th>Description</th>
<th>Catalog #</th>
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<td>Mini Rocker</td>
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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.

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: 4–45°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.

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.

Specifications
- Speed: 24 rpm
- Motion/Pitch: 3-D/fixed 5º
- Maximum load: 0.8 kg (1.75 lb)
- Operating range: 4–40°C
- 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.

Specifications
- Speed range: 8–40 rpm
- Motion: Tilting, ±7.5º
- 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
General Laboratory Equipment: Temperature Control Devices

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

Specifications
- Temperature range: 5°C greater than room temperature to 150°C
- Temp. uniformity: ±0.2°C at 37°C
- 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

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

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.

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

**Ordering Information**

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General Laboratory Equipment: Micropipets • Micropipet Racks • Pipet Controller

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

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).

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

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 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

Designed for the lab benchtop with wipe-and-clean surface and a non-skid base.

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.

Ordering Information

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<td>Classroom Digital Micropipets</td>
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<td>2–20 µl Digital Micropipet</td>
<td>1660531EDU</td>
<td>$165.00</td>
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<td>20–200 µl Digital Micropipet</td>
<td>1660532EDU</td>
<td>$165.00</td>
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<tr>
<td>100–1,000 µl Digital Micropipet</td>
<td>1660533EDU</td>
<td>$165.00</td>
<td>$99.00</td>
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<tr>
<td>Professional Adjustable-Volume Digital Micropipets</td>
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<td>0.1–2 µl Digital Micropipet</td>
<td>1660545EDU</td>
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<td>0.5–10 µl Digital Micropipet</td>
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<td>2–20 µl Digital Micropipet</td>
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<td>20–200 µl Digital Micropipet</td>
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<td>100–1,000 µl Digital Micropipet</td>
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<tr>
<td>Professional Multichannel Pipet, B-channel, adjustable volume, 20–200 µl</td>
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<td>Micropipet Racks</td>
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<td>Micropipet Rack, holds 9 single micropipets</td>
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<tr>
<td>Carousel Pipet Rack, holds 6 single professional micropipets</td>
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<tr>
<td>Professional Pipet Backpack Starter Set</td>
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<tr>
<td>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</td>
<td>1660486EDU</td>
<td>$1,247.33</td>
<td>$994.00</td>
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<td>Professional Pipet Controllers</td>
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<td>Professional Pipet Controller, 120 V, includes charger, bench stand, wall mount, and 0.45 µm filter</td>
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<td>Professional Pipet Controller, 220 V, includes charger, bench stand, wall mount, and 0.45 µm filter</td>
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<td>Professional Pipet Controller, 220 V (for Australia), includes charger, bench stand, wall mount, and 0.45 µm filter</td>
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<td>Inline Filters for Pipet Controller, 0.45 µm, PTFE, 25 mm, 10 pack</td>
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<td>$48.75</td>
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</table>
**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 60Co 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**

<table>
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<tr>
<th>Tip Type, Quantity</th>
<th>Catalog #</th>
<th>Bio-Rad Micropipet Fit</th>
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<td>Fixed-Volume Micropipet</td>
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<td>Prot/Elec Tips, 1,000/bag</td>
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<td>Protein gel loading</td>
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<td><strong>Racked Pipet Tips</strong></td>
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<td>TBR-14 Tips, 1,000/box</td>
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<td>PCR, nucleic acids</td>
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<tr>
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<td>PCR, nucleic acids</td>
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<td>100–1,000 µl</td>
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<td>Seque/Pro Tips, 200/box</td>
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<tr>
<td>Prot/Elec Tips, 1,000/box</td>
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<td>Protein gel loading</td>
<td>$102.00</td>
<td>$81.60</td>
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</table>

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 Mini Power Supply (U.S. Only)
The PowerPac Mini is our lowest-priced power supply. This dedicated little workhorse provides the energy needed to run horizontal agarose or vertical polyacrylamide gel electrophoresis. Simply select the voltage and run.

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.

display.
Racks and Storage Boxes

Our plastic racks and storage units provide the ultimate in ease of storage and sample organization.

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
- 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.

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)

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.

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

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<thead>
<tr>
<th>Description</th>
<th>Catalog #</th>
<th>List Price</th>
<th>EDU Price</th>
</tr>
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<tbody>
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<td><strong>Plastic Racks and Storage Units</strong></td>
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<td>Green Rack, holds 80 tubes, 1.5/2.0 ml, set of 5 racks</td>
<td>1660481EDU</td>
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<tr>
<td>Storage Box, holds 100 tubes, set of 5 boxes, multicolored</td>
<td>1660482EDU</td>
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<tr>
<td>15 ml Tube Rack, holds 60 tubes, set of 5 racks</td>
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<tr>
<td>50 ml Tube Rack, holds 24 tubes, set of 5 racks</td>
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<td>$75.00</td>
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<td><strong>PCR Rack</strong></td>
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<tr>
<td>96-Place PCR Tube Rack and Cover, set of 5 racks, multicolored</td>
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<td>$35.20</td>
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<td><strong>Standard Polystyrene Cuvettes</strong></td>
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<td>3.5 ml Standard Disposable Polystyrene Cuvettes, 100</td>
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<td>Standard Cuvette, 3.5 ml, quartz</td>
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<td>Semimicrovolume Cuvette, 1.4 ml, quartz</td>
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<tr>
<td><strong>Cuvette Racks</strong></td>
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<tr>
<td>Cuvette Racks, holds 12 standard size cuvettes, set of 5 racks</td>
<td>1660485EDU</td>
<td>75.00</td>
<td>60.00</td>
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Plastic Refresh Kit 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); freezeable 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.

Gel Staining Trays
Bio-Rad's gel staining trays are disposable plastic trays ideal for staining mini gels.

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.

Jellyfish Foam Floating Racks
Perfect for cold and hot water baths, jellyfish foam floating racks hold up to 12 microcentrifuge tubes.

Disposable Plastic Transfer Pipets (sterile and nonsterile options)
These disposable plastic transfer pipets are made of polyethylene to manage your liquid-handling needs.

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.

Ordering Information

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<th>Description</th>
<th>Catalog #</th>
<th>List Price</th>
<th>EDU Price</th>
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<td>Plastic Refresh Kit Components</td>
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<td>Petri Dishes, 60 mm, sterile, 500</td>
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<td>Gel Staining Trays, 4</td>
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<td>Jellyfish Foam Floating Racks, 8 racks, 12 microcentrifuge tube wells</td>
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<td>1.5 ml EZ Micro Test Tubes, 500</td>
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<td>500 µl EZ Micro Test Tubes, 1,000</td>
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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. 113.
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<td>Ampicillin, 30 mg, lyophilized</td>
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TRANS-BLOT

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<td>732000</td>
<td>InstaGene Matrix, 20 ml</td>
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<td>Quantum Prep Plasmid Miniprep Kit, 100 preps</td>
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<td>Aurum Plasmid Mini Columns, 50</td>
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<td>White Light Sample Tray</td>
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<td>1200326EDU</td>
<td>Blue Light Sample Tray</td>
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<td>1200328EDU</td>
<td>UV and Stain-Free Sample Tray</td>
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<td>1200549EDU</td>
<td>Flask Clamp for Shaking Incubator, 250 ml</td>
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<td>Petri Dish Shelf for Shaking Incubator</td>
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<td>Flask Clamp for Shaking Incubator, 500 ml</td>
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<td>Flask Clamp for Shaking Incubator, 1,000 ml</td>
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<td>Flask Clamp for Shaking Incubator, 125 ml</td>
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<td>GelDoc Go Imaging System with Image Lab Touch Software</td>
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<td>UV Shield for GelDoc Go Imaging System</td>
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<td>White Tray for GelDoc Go Imaging System</td>
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<td>UV/Stain-Free Tray for GelDoc Go Imaging System</td>
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<td>Mini Centrifuge, 120 V</td>
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<td>BioLogic LP System with BioFrac Fraction Collector, 220/400 V</td>
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<td>17001403EDU</td>
<td>ChemiDoc V3 Western Workflow for Mini Gels</td>
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<td>17002978EDU</td>
<td>Giant Panda Problem Kit for AP Biology</td>
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<td>17002944EDU</td>
<td>Benchtop Shaking Incubator Starter Set, 120 V</td>
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<td>Benchtop Shaking Incubator Starter Set, 230 V</td>
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<td>Benchtop Shaking Incubator Starter Set for Europe and the UK</td>
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<td>PCR Lab Equipment Set upgraded with pipets and thermal cycler</td>
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<td>Protein Electrophoresis Starter Lab Set</td>
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<td>Science of Opioid Dependence Kit plus Fast Blast Electrophoresis Reagents</td>
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<td>Out of the Blue CRISPR and Genotyping Extension kits</td>
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<td>Basic Biotech Lab Equipment Set</td>
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<td>Catalog No.</td>
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<tr>
<td>17006119EDU</td>
<td>Basic Biotech Lab Equipment Set upgraded with Professional Pipets</td>
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<td>Complete Biotech Lab Equipment Set</td>
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<td>Complete Biotech Lab Equipment Set upgraded with C1000 thermal cycler</td>
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<td>Advanced Biotech Lab Equipment Set</td>
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<td>17006113EDU</td>
<td>Basic Biotech Lab Equipment Set with Textbooks</td>
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<td>17006114EDU</td>
<td>Basic Biotech Lab Equipment Set upgraded with Professional Pipets and Textbooks</td>
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<td>17006135EDU</td>
<td>Kit I: Protein Profiler Module plus 10 pack of Mini-PROTEAN TGX Stain-Free Precast Polyacrylamide Gels, 4-20%, 10-well each</td>
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<td>17006136EDU</td>
<td>Kit I: Protein Profiler Module plus 10 pack of Mini-PROTEAN TGX Precast Polyacrylamide Gels, 4-20%, 10 well each</td>
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<td>CHO1411EDU</td>
<td>Chill-out Liquid Wax, clear, optical grade, 100 ml</td>
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<td>ECT1000EDU</td>
<td>Easy Cap Tool</td>
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<td>ECT2000EDU</td>
<td>PCR Strip Cap Tool</td>
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<td>Multiplate Low Profile 48-well Unskirted PCR plates, white, 50</td>
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<td>Multiplate Low-Profile 96-well Unskirted PCR Plates, white, 25</td>
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<td>MLP9601EDU</td>
<td>Multiplate 96-well Unskirted PCR Plates, clear, 25</td>
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<td>TBS0201EDU</td>
<td>0.2 ml 8-tube Strips without Caps, clear, 125</td>
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<td>TBS1201EDU</td>
<td>0.2 ml 12-tube Strips without Caps, clear, 100</td>
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<td>TCS0801EDU</td>
<td>Domed 8-Cap Strips, for 0.2 ml tubes and plates, clear, 120</td>
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<td>TCS0803EDU</td>
<td>Optical Flat 8-Cap Strips, for 0.2 ml tubes and plates, ultraclear, 120</td>
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<td>Domed 12-Cap Strips, for 0.2 ml tubes and plates, clear, 200</td>
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<tr>
<td>TW0201EDU</td>
<td>0.2 ml Tubes with Domed Caps, clear, 1,000</td>
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<td>TLS0851EDU</td>
<td>Low profile 0.2 ml 8-tube Strips without Caps, white, 120</td>
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<td>TRC0501EDU</td>
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<td>0.2 ml Tubes with Domed Caps, clear, 1,000</td>
<td>113, 143</td>
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Meet the Bio-Rad Explorers

Team Members

Leigh Brown, Curriculum Training Specialist
George Chenaux, PhD, Senior Scientist
Leslie Dempsey, Sales Support Specialist
Delquin Gong, PhD, Senior Scientist
Cassie Granieri, Sales Support Specialist
Erin Handsfield, Sales Manager
Ian Harwood, PhD, Product Manager
Aaron Kallas, Education Account Manager
Yolanda Kowalewski, PhD, Product Manager Specialist
Ashleigh Miller, PhD, Senior Scientist
Ingrid Miller, PhD, Marketing Manager
Taylor Page, PhD, Product Manager
Bryony Ruegg, PhD, Director
Jeannie Spagnolo, PhD, R&D Manager
Tamica Stubbs, Curriculum Training Specialist
Damon Tighe, Curriculum Training Specialist

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Bio-Rad Teaching Awards

Realize your teaching dreams with teaching awards!
Bio-Rad sponsors two awards for teaching excellence. Teaching awards are a great way to realize your dreams to engage and excite your students! The Ron Mardigian Bio-Rad Explorer awards were established in memory of Ron Mardigian, the inspirational guru and founder of our education program.

The Ron Mardigian Memorial Bio-Rad Explorer Award
is a partnered award with the National Science Teachers Association (NSTA). Deadline November 30, awarded annually. (nstaa.org)

2019 NSTA Ron Mardigian Memorial Bio-Rad Explorer Award Winner
David Mangus
Brockton High School
Brockton, Massachusetts

The Ron Mardigian Biotechnology Teaching Award
is also a partnered award, this time with the National Association of Biology Teachers (NABT). Deadline March 15, awarded annually. (nabta.org)

2019 NABT Ron Mardigian Biotechnology Award Winner
Tatiana Parker
Saint Xavier University
Chicago, Illinois

Explorers Seen and Noted (From top left, clockwise)

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Whitney Young High School, Chicago, Illinois
Acalanes High School, Orinda, California
North Carolina A&T University, Greensboro, North Carolina
Sacred Heart School, San Francisco, California
Oral Roberts University, Tulsa, Oklahoma
The Bishop’s School, La Jolla, California
University of Florida, Gainesville, Florida

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Glenbard East High School, Lombard, Illinois
Austin Community College, Austin Texas
Heritage Middle School, Deltona, Florida
Stony Brook University, Stony Brook, New York
North Carolina SA, Winston-Salem, North Carolina
Tamalpais High School, Mill Valley, California
Brentwood High School, Brentwood, New York

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Smithtown High School West, Smithtown, New York
Palmer High School, Palmer, Alaska
Valley Christian High School, San Jose, California
Arizona State University, Tempe, Arizona
Flax Pond Marine Laboratory, East Setauket, New York
Terra Nova High School, Pacifica, California

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University of Texas at Austin, Austin, Texas
Waipahu, Hawaii
Flax Pond Marine Laboratory, East Setauket, New York
Silver Creek High School, San Jose, California
Whitney Young High School, Chicago, Illinois
Flathead Valley High School, Kalispell, Montana

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Stony Brook University, Stony Brook, New York
Anderson High School, Austin Texas
Franklin High School, Franklin, Massachusetts
Glenbard East High School, Lombard, Illinois
Fallkirk College, Fallkirk, Scotland
Germantown Friends School, Philadelphia, Pennsylvania
Chula Vista High School, Chula Vista, California

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Tracy High School, Tracy, California
Whitney Young High School, Chicago, Illinois
Mesa High School, Mesa, Arizona
Stanford University, Stanford, California
The Bishop’s School, La Jolla, California
Santa Fe High School, A歡joa, Florida
Brentwood High School, Brentwood, New York

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Flax Pond Marine Laboratory, East Setauket, New York
Leander High School, Leander, Texas
Fayetteville, Arkansas
Glenbard East High School, Lombard, Illinois
Solano Community College, Fairfield, California
Whitney Young High School, Chicago, Illinois
Monte Vista High School, Danville, California

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Jenks High School, Jenks, Oklahoma
Brentwood High School, Brentwood, New York
Texas A&M University, Corpus Christy, Texas
Stony Brook University, Stony Brook, New York
Tennessee State University, Nashville, Tennessee
University of San Francisco, San Francisco, California

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University of North Carolina, Chapel Hill, North Carolina
H. E. Robinson Ag Center, Kalispell, Montana
Whitney Young High School, Chicago, Illinois
Terra Nova High School, Pacifica, California
Stony Brook University, Stony Brook, New York
Juan Navarro High School, Austin, Texas

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University of North Carolina, Chapel Hill, North Carolina
Glendale Community College, Glendale, Arizona
Brentwood High School, Brentwood, New York
Nashville State Community College, Nashville, Tennessee
University of California at Davis, Davis, California
Montana State University, Bozeman, Montana

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Hong Kong Polytechnic University, Hong Kong, China
Austin Community College, Austin, Texas
Glenbard East High School, Lombard, Illinois
Flathead Valley Community College, Kalispell, Montana
Whitney Young High School, Chicago, Illinois
Santa Fe College, Gainesville, Florida

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For students in Dr. Rebecca Grella’s high school research course, the outdoors is the classroom and nature is the textbook. Armed with budding curiosity and waterproof waders, her students explore the saltwater marshes on the northern coast of Long Island, New York looking for clues about biodiversity of the changing marsh landscape. Back in the lab, students characterize their samples and publish data for the scientific community. Dr. Grella uses her passion for science and infectious curiosity to help her students leap over social and economic barriers on a quest to understand their local ecosystems. The achievements of her students is testament to the power of self-driven discovery. Bio-Rad's Explorer Program joins Dr. Grella in her mission to equip students with the skills to be successful both today and tomorrow.