Photosynthesis

Time Required for Students to Complete:

- **Exercise #1** 10 min.
- **Exercise #2** 30 min.
- **Exercise #3** 45 min.
- **Exercise #4** 60 min.
- **Exercise #5** 10 min.
- **Exercise #6** 15 min.

Exercise #1—Light Activation of Chlorophyll

Materials	Per Class
• Chlorophyll extract in 16 x 150mm screw-cap test tube	1
• Desk lamp (high-intensity illuminator)	1
• Blue cellophane filter (rubber band holding cellophane on the end of the light)	1
• Long-wave UV light (optional)	
• Chlorophyll control (green food coloring in16x150mm screw-cap test tube)	1

Suggestions

Recipe for chlorophyll extract:

Step 1—In a blender, grind 10 large spinach leaves with 100mL acetone.
Step 2—Filter through cheesecloth.
Step 3—Store in capped, foil-wrapped test tube in refrigerator.

Exercise #2—Leaf Pigments

Materials	Per Class
• 25 x 150mm borosilicate cylinders	8
• 20 x 125mm strips of chromatography paper	8
• Scissors	8
• Fresh spinach leaves	8
• Penny (coin with wide edge)	8
• Cutting board	1
• Developing solvent in 125mL dropper bottle (place in fume hood)	1
• One-gallon jar, labeled “for used solvent,” with glass funnel (in fume hood)	1
• 15-cm ruler	1

Suggestions

1. Cut all of the chromatography paper at once. Put out only 10 per section at a time or students will go through it all.
2. Recipe for developing solvent (make 1 liter per semester):
   a. 92mL petroleum ether (460mL for 1 liter)
   b. 8mL acetone (40mL for 1 liter)

   Prepare in fume hood.
3. The chromatography apparatus consists of the 25 x 150mm test tube, and a cork with a paper clip suspended from it to hang the chromatography paper inside the test tube. Use a T-style dissecting pin to hang the paper clip. (Even better, use an ungraduated cylinder, 25 x 150mm.) **Note to students:** Do not get water in the test tubes! Water will interfere with the action of the developing solvent.
4. Chromatography apparatus, developing solvent, and one-gallon jar labeled for the disposal of used solvent must be kept in a fume hood. Directions for safe fume hood operation should be posted.

Exercise #3—CO_2 Uptake by Plants

Materials	Per Class
• Live *Elodea sp.* culture	1
• Cutting board	1
• Razor blades	8
• 25 x 150mm test tube	32
• #4 stopper with hole	32
• 150-watt light source	2
• 4000-mL beaker filled with water	2
• 25-mm test tube rack	3
• 500-mL phenol red	2 bottles
• Straws (wrapped)*	1 box
• Labeled pan or jar for used *Elodea*	1
• Masking tape	1 roll

Suggestions

1. Remind students to make a fresh cut in the *Elodea* stem end. This facilitates the release of O_2 from the leaves since this plant collects oxygen gas in the stems in order to float.
2. Always keep fresh cool water in the *Elodea* containers. The stems can be reused if rinsed well.
3. To prevent the live *Elodea* from overheating, put the 4000mL beakers filled with water between the light source and the test tube rack. Any 2-gallon jar works fine.
4. To make the phenol red, begin with 4 liters of pH-7 water, adjust as necessary with NaOH or HCl. Then add a pinch (0.05 gram) of phenol red dye. This is enough for 8 sections. Fine tune the phenol concentration so that it easily turns yellow when you exhale into it through a straw.

* **Note:** If you don't want to use straws in the lab, then students can loosely cup their hand around the phenol red tube and blow. This will be sufficient to charge the phenol with CO_2. However, we've found that the straws are really necessary! The phenol red doesn't get yellow very quickly with out them and/or students aren't patient enough to get it yellow.

Exercise #4—O_2 Production by Plants

Materials	Per Class
• Baary jar with tap water	1
• 1500-mL beaker	1
• Live *Elodea sp.* culture	1
• Glass funnel	1
• 100-mm latex tubing	1
• Pinchcock clamp	1
• 150-watt light source	1
• 4000-mL beaker filled with cool water	1
• Plastic funnel (same size as glass funnel)	1
• 15-cm rulers	1
• Disposable mouthpieces	1 bag
• Sharpie® marker on a string	1

Suggestions

1. The Pyrex Corning 6180 funnel with the 100-mL top diameter has a stem where 1mm = 0.02mL. Using this funnel prevents the need to calibrate the stem. The open top of the funnel also needs to have a short piece of latex tubing clamped off at the beginning of the experiment.
2. Put the 4000-mL beaker filled with water between the light source and the *Elodea* to prevent overheating.
3. Have a beaker of 3% sodium bicarbonate to "spike" the water if the rate of photosynthesis is too slow. Or, tell students to blow through a straw into the water to add carbon dioxide.
4. You will want to put a bottle of alchohol out for disinfecting the latex tubing; many mouths will be drawing water up it. Better yet, attach disposable mouthpieces onto the end of the latex tubing.

Exercise #5—Oxygen Demand for Humans

No prep required

Exercise #6—How Big of a Plant Does It Take to Keep You Alive?

Materials	Per Class
• Meter stick	8

Photosynthesis

Reusable Equipment	Per Lab	Supplier	Order Number	Cost
• High-intensity illuminator*	1	various sources	—	~$200.00
• Blue cellophane filter*	1	Ward's	15V9886	$2.50
• 25-mm x 150-mm test tubes	32	VWR	89000-490	$74.59
• Cork, size 10	8	VWR	23420-264	$7.14
• Borosilicate cylinders	8	Fisher Scientific	08-535A	$142.64
• 125-mL glass dropper bottle	1	VWR	16354-754	$22.01
• #4 rubber stopper (with hole)	32	VWR	59581-221	$47.13
• 150-watt light source	3	Ward's	36V4168	$47.85
• Battery jars	3	VWR	74280-020	$52.62
• 1500-mL beaker	1	VWR	89000-214	$27.02
• Glass funnel (100mm top diameter)	1	VWR	89001-420	$18.65
• Latex tubing	100mm	VWR	62996-509	$1.00
• Pinchcock clamp	1	Ward's	15V0650	$3.15

Suggestions

1. *The dissecting microscope "spot light" or high-intensity illuminator used to activate the chlorophyll solution is no longer sold. EBay has used B&L (Bausch & Lomb) and AO (American Optical) miscroscope illuminators for auction for about $20.00. Otherwise, a bright desk lamp works fine.
2. *A blue filter can be purchased from Edmund Scientific. However, blue cellophane will get the same effect.

Expendable Materials	Per Lab	Supplier	Order Number	Cost
• Masking tape	1 roll	Office Depot	666549	$2.69
• Sharpie® markers	2	Office Depot	355665	$2.00
• Chromatography paper	122 cm	VWR	21427-149	$0.62
• Fresh spinach leaves	10	grocery store	—	$0.25
• Hexanes	8 mL	VWR	JT9304-2	$0.45
• Acetone	92 mL	VWR	BDH1101-4L	$0.85
• Live culture of *Elodea**	Class of 30	Niles	—	$5.50
• Phenol red	0.5 gram	VWR	97062-478	$0.54
• Straws	8	grocery store	—	$1.40

Cost for Expendables: ***$14.30***

(less per lab if you have your own supply of *Elodea*)

Suggestions

1. *You can save quite a bit of supply money by having your own source for *Elodea*. One of our instructors grows it in an outdoor fishpond. In addition, the *Elodea* will be very fresh and healthy.
2. Recycle your *Elodea* every 2–3 days.