



Kidney Dialysis

Teacher Information

..... just add students™

Summary

Students create a mini-model of a dialysis machine. They observe which substances diffuse from the bloodstream into the fluid in the dialysis machine. They determine what substances should be added to the dialysis fluid to maintain homeostasis.

Core Concepts

- The processes of diffusion and active transport are important in the movement of materials in living organisms.
- To maintain homeostasis the internal environment must be kept stable – within normal limits that are favorable for cell activities.
- Homeostasis in an organism is constantly threatened. Failure to respond effectively can result in disease or death.

Time Required

Two 40-minute class periods + homework

Kit contains

- Dialysis color print handout
- Dialysis tubing
- Plastic cup
- Simulated “Red Blood Cells”, “Glucose” and “Urea”
- Simulated “Protein” powder
- Salt
- Simulated test paper strips for protein, glucose and salt

Teacher Provides

- Access to tap water
- Safety goggles
- Paper towels for clean up

Warning: Choking Hazard

This Science Take-Out kit contains small parts. Do not allow children under the age of seven to have access to any kit components.

Reusing *Kidney Dialysis Kits*

Teachers will need to instruct students on how to handle clean-up and return of the re-usable kit materials. For example, teachers might provide the following information for students:

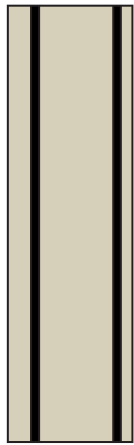
Discard	Rinse with water and dry with paper towel	Return to kit
<ul style="list-style-type: none"> • Used dialysis membrane and contents • Used test paper strips 	<ul style="list-style-type: none"> • Cup • Dropper 	<ul style="list-style-type: none"> • All labeled tubes • Labeled plastic bag for test papers • Cup (rinsed) • Dropper (rinsed) • <i>Hemodialysis and Peritoneal Dialysis</i> color handout*

* Note: Consider laminating color printed parts of the kits that will be reused.

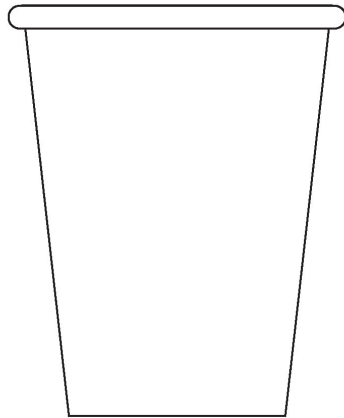
Refills for *Kidney Dialysis* kits are available at www.sciencetakeout.com. The **10 Kit Refill Pack** includes the following materials:

- 1 Quick Guide for refilling kit
- 10 pieces of dialysis membrane
- 15 ml of simulated “urea”
- 15 ml of simulated “glucose” powder
- 15 ml of simulated “protein” powder
- 20 ml of simulated “red blood cells”
- 10 packets of salt
- 10 strips of “glucose test paper”
- 10 strips of “salt test paper”
- 10 strips of “protein test paper”
- 1 graduated transfer pipet
- 1 funnel

Kit Contents Quick Guide



Dialysis Tubing



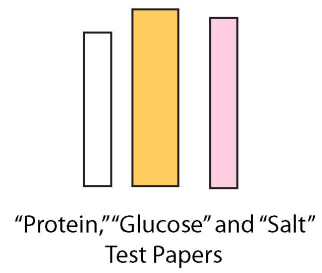
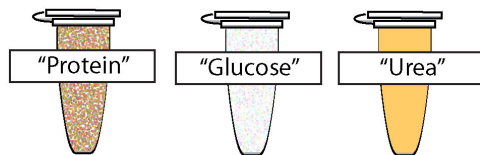
Cup



Simulated Red
Blood Cells



Salt



"Protein," "Glucose" and "Salt"
Test Papers

Read these instructions before using Science Take-Out kits

Parental or Adult Supervision Required

This kit should be used only under the supervision of an adult who is committed to ensuring that the safety precautions below, and in the specific laboratory activity, are followed.

Safety Goggles and Gloves Strongly Recommended

We encourage students to adopt safe lab practices, and wear safety goggles and gloves when performing laboratory activities involving chemicals. Safety goggles and gloves are not provided in Science Take-Out kits. They may be purchased from a local hardware store or pharmacy.

Warning: Choking and Chemical Hazard

Science Take-Out kits contain small parts that could pose a choking hazard and chemicals that could be hazardous if ingested. Do not allow children under the age of seven to have access to any kit components. Material Safety Data Sheets (MSDS) provide specific safety information regarding the chemical contents of the kits. MSDS information for each kit is provided in the accompanying teacher instructions.

Chemicals Used in Science Take-Out Kits

Every effort has been made to reduce the use of hazardous chemicals in Science Take-Out kits. Most kits contain common household chemicals or chemicals that pose little or no risk.

General Safety Precautions

1. Work in a clean, uncluttered area. Cover the work area to protect the work surface.
2. Read and follow all instructions carefully.
3. Pay particular attention to following the specific safety precautions included in the kit activity instructions.
4. Goggles and gloves should be worn while performing experiments using chemicals.
5. Do not use the contents of this kit for any other purpose beyond those described in the kit instructions.
6. Do not leave experiment parts or kits where they could be used inappropriately by others.
7. Never taste or ingest any chemicals provided in the kit – they may be toxic.
8. Do not eat, drink, apply make-up or contact lenses while performing experiments.
9. Wash your hands before and after performing experiments.
10. Chemicals used in Science Take-Out experiments may stain or damage skin, clothing or work surfaces. If spills occur, wash the area immediately and thoroughly.
11. At the end of the experiment, return ALL kit components to the kit plastic bag. Dispose of the plastic bag and contents in your regular household trash.

No blood or body fluids from humans or animals are used in Science Take-Out kits. Chemical mixtures are substituted as simulations of these substances.

Kidney Dialysis: *Teacher Answer Key*

Introduction:

Your patient is experiencing kidney failure. Her kidneys are not removing wastes and other undesirable substances from her body. She will need dialysis treatments.

Dialysis treatments use selective (semipermeable) membranes that allow small molecules, like urea, to diffuse out of the blood. The membranes block the diffusion of larger molecules and blood cells so that these will remain in the blood.

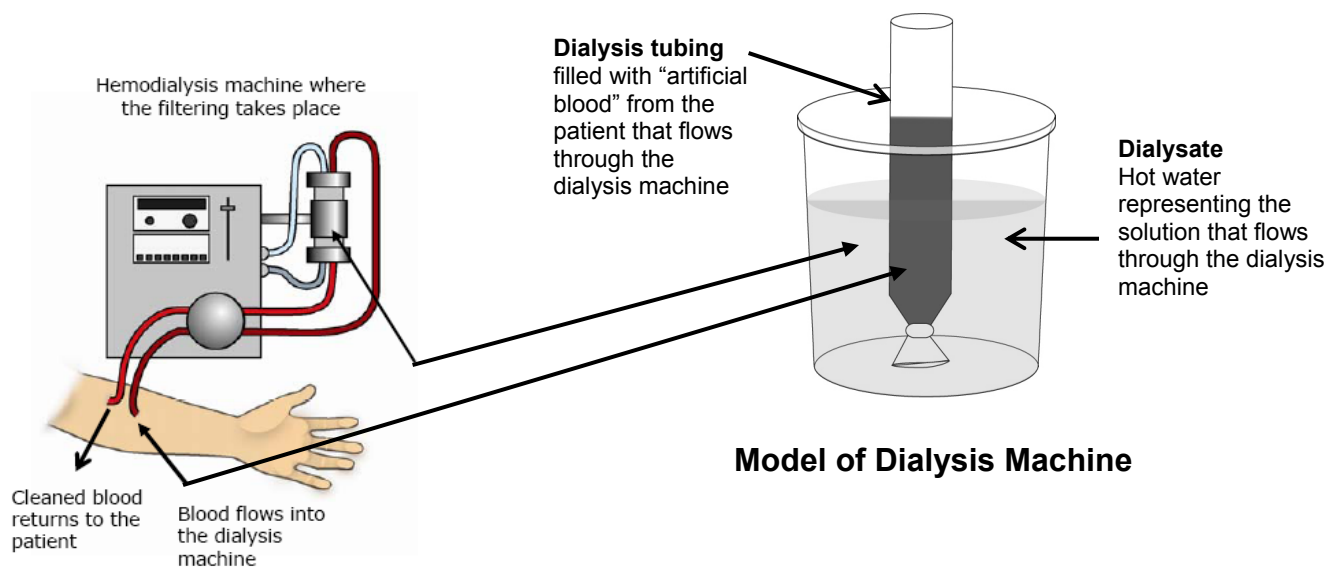
One type of dialysis, called hemodialysis, uses a dialysis machine to clean the blood of patients who have problems with their kidneys. **Read the colored sheet titled “Hemodialysis.”**

Your Tasks:

- Create a simple miniature model of a kidney dialysis machine.
- Determine which molecules can diffuse through the dialysis membrane.
- Explain what substances should be included in the dialysate to ensure that essential and beneficial small molecules are not lost from the blood.

PART 1: Create a Model Dialysis Machine

1. Moisten one end of the dialysis tubing by dipping about one-third of its length into tap water. (DO NOT place the entire dialysis tubing into the water, just wet one end of it.)
2. Close the wet end of the dialysis tubing by tying a knot at the end to make a membrane bag as shown in the diagram on the next page. This bag represents the dialysis machine tube through which a patient's blood flows.
3. Prepare "artificial blood" by adding the following ingredients to the large test tube that contains simulated red blood cells (red glitter):
 - Glucose – one small tube of glucose powder
 - Simulated Urea – one small tube of yellow food color
 - Salt – 1 packet of salt
 - Protein – 1 small tube of protein powder
 - Enough hot tap water to fill the large test tube about half full
4. Screw the lid firmly on the tube of "blood." Wrap a piece of paper towel around the tube, just in case the tube leaks. Gently invert the tube several times to mix the contents. Then immediately use the plastic dropper to transfer the contents into the dialysis tubing bag.
5. Place the dialysis tubing bag into the large cup. Add enough hot water to fill the cup approximately three-quarters full. The hot water represents the liquid in the dialysis machine. This liquid is called **dialysate**.



6. You have now created your own model dialysis machine! Set your model dialysis machine aside for 10 minutes to allow materials to diffuse through the dialysis membrane. While you wait, complete step 7.
7. The substances in the “artificial blood” in the tube are listed in the chart below. Some of these substances will diffuse from the blood, through the semipermeable membrane, and into the dialysate. Complete **Column 1** in the chart below by **predicting** which substances will diffuse through the semipermeable membrane and into the dialysate. You will complete the other columns later in this lab.

	Column 1	Column 2	Column 3
Substances in the blood	Will the substance diffuse through the membrane? (yes or no)	Diffused through dialysis membrane into the dialysate (yes or no)	Should be added to the dialysate to maintain homeostasis (yes or no)
Urea (waste)	<i>Yes</i>	<i>Yes</i>	<i>No</i>
Red Blood Cells	<i>Yes</i>	<i>No</i>	<i>No</i>
Proteins	<i>Yes</i>	<i>No</i>	<i>No</i>
Glucose	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>
Salts	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>

PART 2: Which molecules can pass through the dialysis membrane?

1. Did the yellowish urea wastes diffuse into the dialysate liquid in the cup? Explain how you could determine this. Record the results in Column 2 of the chart on the previous page.

Yes, the fluid in the cup turned yellow.

2. Did the red blood cells diffuse into the dialysate liquid in the cup? Explain how you could determine this. Record the results in Column 2 of the chart.

No, there is no red glitter in the fluid in the cup.

3. To determine whether protein diffused through the membrane, dip one white protein test strip into the dialysate. If protein is present, the white paper will turn dark red. Record the results of the protein test results in Column 2 of the chart.

4. To determine whether glucose diffused through the membrane, dip one orange glucose test strip into the dialysate. If glucose is present, the orange paper will turn dark blue or green. Record the results of the glucose test results in Column 2 of the chart.

5. To determine whether salt diffused through the membrane, dip one pink salt test strip into the dialysate for 10 seconds. If salt is present, the pink paper will turn a light purple. Record the results of the salt test in Column 2 in the chart on the previous page.

6. Apply your knowledge of diffusion through a membrane to explain why some substances diffused through the membrane and into the dialysate liquid and others substances did not.

***Red blood cells and protein were too large to pass through the membrane.
Urea, salt and glucose are small enough to pass through the membrane.***

PART 3: What substances should be included in the dialysate to maintain homeostasis?

Read the information below and then answer the questions that follow:

Maintaining Homeostasis

To maintain **homeostasis** (a state of balance in the body) the concentrations of water and dissolved substances in the body's internal environment (blood and body liquids) must be kept stable - within normal limits that are favorable for cell activities.

Kidneys help maintain homeostasis by regulating the flow of substances into and out of the bloodstream and by removing wastes from the bloodstream. The cell membranes in the kidneys use a process known as active transport to pump essential materials such as glucose and salts back into the bloodstream.

The dialysis membrane cannot carry out active transport like real kidneys do because it is not a living organ. To maintain homeostasis, the dialysate (liquid) in a real dialysis machine must have the same concentrations of solutes such as glucose and salts as those in normal blood plasma. Therefore:

- If the patient's blood contains excess concentrations of any solutes, these solutes will diffuse into the dialysate.
- If the patient's blood plasma lacks the ideal concentration of any solutes, these solutes will diffuse into the patient's blood.
- Because the dialysate liquid does not contain any waste products such as urea, the wastes diffuse into the dialysate.

Use the information in the box above to answer the following questions:

1. Explain why the membrane in a dialysis machine cannot carry out active transport.

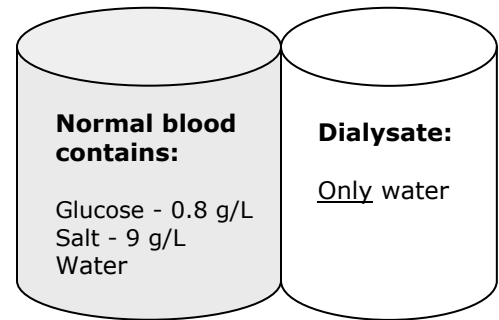
A dialysis membrane is not living.

2. Name two essential body substances that diffuse out of the blood but are needed in the blood to maintain homeostasis.

glucose and **salt**

3. Observe the diagram on the right. Explain why glucose and salts would be lost from the patient's blood if the dialysate contained only water.

Glucose and salt would diffuse from an area where they have a high concentration to a region where the concentration is low.



4. According to the diagram, what concentration of glucose and salt should be present in the dialysate to prevent the diffusion of these substances from the patient's blood?

Glucose - 0.8 g/L Salt - 9 g/L

5. Explain why urea is not added to the dialysate liquid.

The dialysate liquid does not contain any waste products such as urea so the wastes diffuse into the dialysate.

6. Complete Column 3 in the chart on page 2 to indicate the substances that should be added to the water in the dialysate to maintain homeostasis.

In addition to using a hemodialysis machine, there is another option for cleaning waste substances from blood. This technique is called peritoneal dialysis.

Use the information in the colored sheet titled "Peritoneal Dialysis" to answer the following questions.

7. Describe two ways that hemodialysis and peritoneal dialysis are similar.

They both: use membranes, use dialysate, remove wastes from blood, are used to treat kidney failure.

8. Describe two ways that hemodialysis and peritoneal dialysis are different.

Hemodialysis uses an artificial membrane and a dialysis machine. Peritoneal dialysis uses a body membrane and does not need a dialysis machine.

9. Explain one reason why a patient might choose hemodialysis instead of peritoneal dialysis.

It is done by a trained professional who can watch for problems or it does not need to be done every day or it reduces the risk of infection of the peritoneum.

10. Explain one reason why a patient might choose peritoneal dialysis instead of hemodialysis.

It can be done at home and by the patient. It does not require a machine or can be done inside the body.

MATERIAL SAFETY DATA SHEET

1. PRODUCT AND COMPANY IDENTIFICATION

Product Name (as printed on the label): "Glucose" and "Protein" (simulated)

Product identity: Sodium Bicarbonate (Baking Soda)

Manufacturer: Church & Dwight Co., Inc.
469 N. Harrison Street
Princeton, NJ 08543
Telephone number for information: (609)683-5900 (USA)

Manufacturer's Issue date of this MSDS: 9/17/02

Medical emergency phone number (Chemtrec): (800) 424-9300

2. COMPOSITION/INFORMATION ON INGREDIENTS

Chemical Ingredient: Sodium bicarbonate % by Weight: 100%
CAS Number: 144-55-8
Not hazardous under OSHA Standard 29 CFR 1910.1200.
Not a WHMIS controlled substance.

3. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW

White crystalline powder; no odor. Not a fire hazard.
No significant health or environmental effects associated with this material.
HMIS Rating Health 0, Fire 0, Reactivity 0

Potential Health Effects

EYE: Not an eye irritant. **SKIN CONTACT:** Not a skin irritant.
INGESTION: Material is practically non-toxic. Small amounts (1-2 tablespoons) swallowed during normal handling operations are not likely to cause injury as long as the stomach is not overly full; swallowing larger amounts may cause injury.
INHALATION: None known.
SUBCHRONIC EFFECTS/CARCINOGENICITY: Based on published studies on its effects in animals and humans, sodium bicarbonate is not teratogenic or genotoxic. Only known subchronic effect is that of a marked systemic alkalosis. The material is not listed as a carcinogen or potential carcinogen by IARC, NTP, OSHA, or ACGIH.

4. FIRST AID MEASURES

EYES: Check for and remove contacts. Flood eyes with clean flowing water, low pressure and luke warm (not hot) if possible, occasionally lifting eyelids.

INGESTION: If large amounts of this material are swallowed, do not induce vomiting. Administer water if person is conscious. Never give anything by mouth to an unconscious person.

NOTE TO PHYSICIAN: Large doses may produce systemic alkalosis and expansion in extracellular fluid volume with edema.

5. FIRE FIGHTING MEASURES

FLAMMABLE PROPERTIES: FLASHPOINT: Not combustible METHOD USED: N/A
FLAMMABLE LIMITS: LFL: Not applicable UFL: Not applicable
EXTINGUISHING MEDIA: Non-combustible material. Use extinguishing media appropriate for surrounding fire.
FIRE-FIGHTING INSTRUCTIONS: Carbon Dioxide may be generated making necessary the use of a self-contained breathing apparatus (SCBA) and full protective equipment (Bunker Gear). Carbon dioxide is an asphyxiant at levels over 5% w/w. Sodium oxide, another thermal decomposition product existing at temperatures above 1564°F is a respiratory, eye, and skin irritant. Avoid inhalation, eye and skin contact with sodium oxide dusts.
UNUSUAL FIRE AND EXPLOSION HAZARDS: None known.

6. ACCIDENTAL RELEASE MEASURES

Scoop up into dry, clean containers. Wash away uncontaminated residue with water.

7. HANDLING AND STORAGE

Store in cool, dry areas and away from incompatible substances (see Section 10). Sodium Bicarbonate reacts with acids to yield carbon dioxide gas which can accumulate in confined spaces. Do not enter confined spaces until they have been well ventilated and carbon dioxide and oxygen levels have been determined to be safe.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

RESPIRATORY PROTECTION: Dust mask required if total dust level exceeds 10 mg/m³.
PROTECTIVE GLOVES: General purpose for handling dry product. Impervious gloves when working with solutions.
EYE PROTECTION: Safety glasses when handling bulk material or when dusts are generated.
OTHER PROTECTIVE CLOTHING OR EQUIPMENT: Full cover clothing. Apron where splashing may occur when working with solutions.
PROTECTIVE WORK/HYGIENIC PRACTICES: No special requirements with respect to chemical exposure beyond those provided above.

Requirements with respect to specific equipment and applications are the responsibility of the user.

9. PHYSICAL AND CHEMICAL PROPERTIES

APPEARANCE: White crystalline powder. ODOR: None.
PHYSICAL STATE: Solid pH AS IS: Not Applicable
pH (1% SOLN. w/v): 8.2 VAPOR PRESSURE: Not applicable.
VAPOR DENSITY: Not applicable. BOILING POINT: Not applicable.
FREEZING/MELTING POINT: Not applicable.
SOLUBILITY IN WATER: 8.6 g/100 ml @ 20°C.
BULK DENSITY (g/cc): 62 lb/Ft³ % VOLATILE: Not applicable.
VOLATILE ORGANIC COMPOUNDS: Not applicable. MOLECULAR WEIGHT: 84.02

10. STABILITY AND REACTIVITY

CHEMICAL STABILITY: Stable.
CONDITIONS TO AVOID: Temperatures above 65°C (150°F).
INCOMPATIBILITY WITH OTHER MATERIALS: Reacts with acids to yield carbon dioxide. Also may yield free caustic in presence of lime dust (CaO) and moisture (i.e., water, perspiration).
HAZARDOUS DECOMPOSITION PRODUCTS: Heating above 100°C may cause dangerous levels of carbon dioxide gas to be present in confined spaces. Yields sodium oxide if exposed to temperatures above 850°C. Avoid inhalation, eye and skin contact with sodium oxide.
HAZARDOUS POLYMERIZATION: Not applicable.

11. TOXICOLOGICAL INFORMATION

EYE EFFECTS: The material was minimally irritating to unwashed eyes and practically non-irritating to washed eyes (rabbits).
SKIN EFFECTS: Not a skin irritant or dermally toxic. Not a contact sensitizer.
ACUTE ORAL EFFECTS: Acute Oral-rat LD50 = 7.3 g/kg
ACUTE INHALATION: LC50 (rat) > 4.74 mg/l

12. ECOTOXICOLOGICAL INFORMATION

AQUATIC TOXICITY: Daphnids: EC50 = 4100 mg/l; Bluegill: LC50 = 7100 mg/l
Rainbow Trout: LC50 = 7700 mg/l

13. DISPOSAL CONSIDERATIONS

Bury in a secured landfill in accordance with all local, state and federal environmental regulations. Empty containers may be incinerated or discarded as general trash.

14. TRANSPORTATION INFORMATION

D.O.T. SHIPPING NAME: Not regulated D.O.T. HAZARD CLASS: None
TECHNICAL SHIPPING NAME: Sodium Bicarbonate
U.N./N.A. NUMBER: None HAZARDOUS SUBSTANCE/RQ: None
D.O.T. LABEL: None

15. REGULATORY INFORMATION

CLEAN AIR ACT SECTION 611: Material neither contains nor is it manufactured with ozone depleting substances (ODS).

FEDERAL WATER POLLUTION CONTROL ACT (40 CFR 401.15): Material contains no intentionally added or detectable (contaminant) levels of EPA priority toxic pollutants.

FOOD AND DRUG ADMINISTRATION: Generally Recognized As Safe (GRAS) direct food additive (21 CFR 184.1736).

US DEPARTMENT OF AGRICULTURE: List of Proprietary Substances - Permitted Use Codes 3A, J1, A1, G1, and L1.

CERCLA REPORTABLE QUANTITY: None

OSHA: Not hazardous under 29 CFR 1910.1200

RCRA: Not a hazardous material or a hazardous waste by listing or characteristic.

SARA TITLE III: Section 302, Extremely Hazardous Substances: None
Section 311/312, Hazardous Categories: Non-hazardous
Section 313, Toxic Chemicals: None

Sodium Bicarbonate is reported in the EPA TSCA Inventory List.

This material is listed on the Canadian DSL.

This material is not listed as carcinogen or potential carcinogen by NTP, IARC, OSHA, ACGIH or NIOSH.

This material is neither a volatile organic compound nor does it contain VOCs.

NATIONAL STOCKING NUMBER: 6810002646618, Contract No. DLA 40086C1831
NSF STANDARD 60: Corrosion and Scale Control in Potable Water. Max use 200 mg/l.

EUROPEAN INVENTORY (EINECS): 205-633-8

JAPANESE INVENTORY (MITI): 1-164

AUSTRALIAN INVENTORY (AICS): Carbonic acid, monosodium salt.

16. ADDITIONAL INFORMATION

The information provided in this Material Safety Data Sheet represents data from the manufacturer and/or vendor and is accurate to the best of our knowledge. By providing this information, Science Take-Out LLC makes no guarantee or warranty, expressed or implied, concerning the safe use, storage, handling, precautions, and/or disposal of the products covered or the accuracy of the information contained in this fact sheet. It is the responsibility of the user to comply with local, state, and federal laws and regulations concerning the safe use, storage, handling, precautions, and/or disposal of products covered in this fact sheet.

MATERIAL SAFETY DATA SHEET

1. PRODUCT AND COMPANY IDENTIFICATION

Product Name (as printed on the label): "Urea" (simulated)

Product identity: Yellow food coloring

Manufacturer/Distributor: McCormick & Co., Inc.
Hunt Valley, NY 21031
Telephone number for information: (800)632-5847

Preparation date of this MSDS: 10/5/08
Medical emergency phone number (Chemtrec): (800) 424-9300

2. COMPOSITION/INFORMATION ON INGREDIENTS

This product contains no hazardous materials as defined by the OSHA Hazards Communications Standard

Chemical Ingredient: Food coloring	Chemical Name: N/A
CAS Number: N/A	Formula: N/A
Synonyms: N/A	Principle Hazardous Components: No Data
TLV and PEL units: No Data	OSHA-PEL 10ppm(TWA): No Data

3. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW
Avoid skin and eye contact.

Potential Health Effects

EYES: May cause irritation. SKIN: May cause irritation.

4. FIRST AID MEASURES

EYES - Flush with water for at least 15 minutes, raising and lowering eyelids occasionally.
Get medical attention if irritation persists.
SKIN - Thoroughly wash exposed area.

5. FIRE FIGHTING MEASURES No data available

6. SPILL OR LEAK PROCEDURES

Wear proper eye and skin protection. Mop/wipe spill area. Rinse with water.

7. HANDLING AND STORAGE Avoid eye and skin contact

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Respiratory Protection: N/A Ventilation: N/A
Protective Gloves: Natural rubber, Neoprene, PVC or equivalent.
Eye Protection: Splash proof chemical safety goggles should be worn.
Other Protective Clothing or Equipment: None

9. PHYSICAL AND CHEMICAL PROPERTIES

Molecular Weight: No data	Melting Point: N/A
Boiling Point: No data	Vapor Pressure: No data
Vapor Density (Air=1): No data	Specific Gravity (H ₂ O=1): No data
Percent Volatile by Volume: No data	Evaporation Rate (BuAc=1): No data
Solubility in Water: Soluble	Appearance and Odor: Yellow liquid

10. STABILITY AND REACTIVITY

Stability: Stable	Conditions to Avoid: No data
Incompatibility (Materials to Avoid): None	Hazardous Decomposition Products: No Data
Hazardous Polymerization: Will not occur	

11. TOXICOLOGICAL INFORMATION

Toxicity Data: No data	Effects of Overexposure: See section 3
Target Organs: Eyes and skin	Primary Route(s) of Entry: Eye or skin contact.
Conditions Aggravated by Overexposure: See section 3	

12. ECOLOGICAL INFORMATION No data

13. DISPOSAL CONSIDERATIONS Can be disposed of in the trash or down the sink.

14. TRANSPORTATION INFORMATION D.O.T. SHIPPING NAME: N/A

15. REGULATORY INFORMATION N/A

16. ADDITIONAL INFORMATION

The information provided in this Material Safety Data Sheet represents data from the manufacturer and/or vendor and is accurate to the best of our knowledge. By providing this information, Science Take-Out LLC makes no guarantee or warranty, expressed or implied, concerning the safe use, storage, handling, precautions, and/or disposal of the products covered or the accuracy of the information contained in this fact sheet. It is the responsibility of the user to comply with local, state, and federal laws and regulations concerning the safe use, storage, handling, precautions, and/or disposal of products covered in this fact sheet.