Sally is sick...
Blurry vision, headache...
She really needs YOUR HELP!

Authors
Suzanne Olds, PhD
Rebecca Daugherty, PhD
Emily Bullen
Megan Boyle
Michael Kennedy, PhD

Learn more about the Science Club initiative at www.scienceclub.northwestern.edu
About Science Club

Science Club is an afterschool science program developed by the Center for Genetic Medicine at Northwestern University and the Robert R. McCormick Boys & Girls Club in Chicago, Illinois.

It utilizes a mentor-based approach to provide fun, inquiry-based activities for middle school youth. On a weekly basis throughout the academic year, Northwestern science graduate students and staff travel to the McCormick Club to serve as youth mentors, guiding them through the initiative’s curriculum. Field trips and social activities also promote mentor-youth relationship development.

At the conclusion of each quarter, Science Club members have the opportunity to share the results of their inquiry with fellow students, Boys & Girls Club members, and parents.

Disclaimer
The information contained in this activity is intended as an instructional resource for informal science educators. It should in no way be construed as medical advice, opinion, diagnosis, or treatment. All activities in this guide should be closely supervised by knowledgeable adults, and recommended safety practices followed. Northwestern University and the National Institutes of Health cannot be held responsible for any injury or accident that may result from the activities in this guide.

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Center for Genetic Medicine
Northwestern University
Robert H. Lurie Medical Research Center, 7-125
303 East Superior Street
Chicago, IL 60611
cgm.northwestern.edu

McCormick Boys & Girls Club
4835 North Sheridan Road
Chicago, IL
bgcc.org

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Overview

About Medical Mystery

Medical Mystery is a project-based informal science education unit that challenges students to diagnose an illness and design a treatment plan for a fictional patient.

The objectives of the unit include learning about medical tests and disease diagnosis while providing a general introduction to medical professions.

The curriculum was designed for a mentor-led small group setting (3–4 youth per mentor). Mentors should feel free to adapt the activities and challenges according to the abilities and interests of the group. The activities have been used successfully for youth in grades 5–8.

Pedagogy

The curriculum follows the Legacy Cycle framework derived from How People Learn (Bransford, Brown, and Cocking, 1999). The Legacy Cycle helps ensure that the unit incorporates the four “centerednesses” of the How People Learn theory:

Knowledge-centeredness: Appropriate information is presented in a sequenced and organized way.

- Student-centeredness: The lesson seeks out students’ prior conceptions and helps students connect with prior knowledge.
- Assessment-centeredness: The learning experience provides students with opportunities to check their own understanding and provides mentors the opportunity to assess effectiveness of their teaching.
- Community-centeredness: Students are provided with opportunities to learn collaboratively.

All lessons in Medical Mystery allow students the opportunity to compile and discuss their current knowledge with warm-up questions and provide formative assessment through a concluding discussion.
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Vital Vitals: Introduction to Patients and Vitals
Students are introduced to ‘Sally’, a fictional 13-year-old patient with symptoms of fatigue, blurred vision and a headache. Students practice reviewing medical history, taking vital signs, and are challenged to determine normal vitals and compare this to Sally. (90 minutes)

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Brain Behavior: Neurological Exam and Imaging
Students are challenged to determine whether Sally suffers from a neurological problem. To further their understanding of neurology, students will have the opportunity to practice giving a neurological exam, experience vision changes resulting from various disorders. (90 minutes)

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Students learn about urinalysis and are challenged to design experiments to characterize Sally’s urine sample. (90 minutes)

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The last two sessions serve as a conclusion to the unit. Students compile their test results and diagnose Sally’s illness. They are also challenged to develop a treatment plan for the patient and summarize this in a comic strip. (two 90-minute sessions)

Visual Guide of Blood Cell Types

Pages marked in the upper right hand corner with a gear icon are designed to be shared with youth as worksheets or informational guides.
Lesson 1: Vital Vitals

Lesson Objectives
• Learn about our patient, Sally, and her symptoms
• Determine a normal range for a given vital and compare this to Sally’s health

What You Need to Know:
Doctors take care of sick people and to correctly treat a patient, doctors must first diagnose the illness. The process of diagnosing includes learning more about the patient’s medical history and performing medical tests to assess their current health. In this module, students will work together to diagnose the illness in a fictional teenage patient, Sally Liu. In this scenario, Sally, a 13-year-old girl, came into the pediatrician’s office complaining of fatigue, blurred vision, and a headache. The pediatrician was overwhelmed by the number of possible diagnoses and has asked for the students’ help.

Now it is the students’ job to figure out which condition is affecting Sally. In this unit, the students are part of the medical team. They must collect information from the patient and run tests to determine what is wrong. The end goal is to identify Sally’s illness and develop a treatment plan for her.

To begin, student’s will learn more about Sally’s health through a physical exam. Doctors and nurses collect a patient’s height and weight, blood pressure, heart rate, breathing rate and temperature everytime they go into the hospital. These assessments of size and vital signs give doctors information about a patient’s overall health and could indicate potential problems. Students will learn more about the tests in a physical exam and will learn about Sally’s health through her medical chart.

Materials
- Oral thermometer
- Blood Pressure Cuff
- Heart Rate Monitor
- Scale
- Measuring Tape
- Sally’s Medical Records (on clipboard)
- Copies of blank Student Medical Chart
- Copies of Lesson 1 Disease Table

Prep Work
- Collect supplies
- Print medical charts and tables

Time
60–90 minutes (total)

Pediatricians
Pediatricians are doctors that care for babies, children and teenagers. Their make sure those children grow into healthy adults. Pediatricians follow their patient’s growth, deliver immunizations to prevent disease, and treat common injuries or illnesses.

To become a pediatrician, a person must:
- Graduate from four years of high school
- Take four years of college with math and science courses
- Graduate from four years of medical school
- Complete one year of a pediatrics internship
- Finish two years of a pediatrics residency

So that adds up to about 15 years of school and training to become a pediatrician.
Lesson 1: Vital Vitals, continued

Warm-Up Questions
Have you ever been to the doctor?

What do doctors do? Have you ever thought about becoming a doctor?

Procedure
1. Spend some time getting to know the kids in your group. Use the warm-up questions above to get them thinking about the medical profession.

2. Introduce the group to Sally through the comic book. Discuss the objective of this module: to perform medical tests, collect data, and synthesize the results to diagnose Sally’s illness.

3. Review the Lesson 1 Disease Table. The table contains 12 possible illnesses that may account for Sally’s symptoms. Students will use this table and other disease tables in subsequent lessons to inform their diagnosis.

4. Today, each group will have the opportunity to perform several tests that are typically performed by a nurse or doctor during a physical exam. Students can administer the following tests on themselves, each other, or their group leader, as appropriate. **Note:** being a subject for the exam activities, especially body weight, may be uncomfortable for some kids. Make sure they understand this is OPTIONAL.

   - **Height:** have each student stand against a wall. Mark the top of the student’s head on the wall and measure using a ruler or yardstick. Record results in student’s "medical record".
   - **Weight:** have student step on scale and record their weight in the student’s medical record. Height and weight information can be used to calculate BMI at [http://www.nhlbisupport.com/bmi/](http://www.nhlbisupport.com/bmi/)
   - **Respiration rate:** sit down and breathe normally. Have an observer carefully count the number of breaths the subject takes in a minute. Record in medical record.
   - **Heart rate:** show kids how to take their own pulse using two fingers from their left hand, placing them over their right wrist and count pulse beats for a minute. Have the students rest for a minute prior to taking their resting heart rate. Record resting heart rate in student’s medical record. Ask the kids do jumping jacks for a minute and retest heart rate. Record the active heart rate in medical record.
   - **Blood pressure:** take blood pressure using cuff. Record in medical record
   - **Temperature:** use the thermometer to take each person’s temperature. Record in medical record

5. Review Sally’s physical exam chart. What were her results on these tests?

   6. Discuss the meaning of the results. How do you know if a result is “normal”? Normal is typically defined as the average for a population. This can be illustrated by plotting all of the students’ heights on a class chart. See the attached sheet for further instructions.

   7. Compare Sally’s results to the Lesson 1 Disease Table. How does her health compare? Do any of the disease look more or less likely based on the physical exam results?

   8. Upload any pictures you took and ask the kids to record their experience as a journal entry on the Science Club website.

Concluding Discussion
Looking over her medical chart, what have we learned about Sally?

Are there any conditions that seem less likely after today’s experiments?

Additional Resources

Pulse measurement [http://www.webmd.com/heart-disease/pulse-measurement](http://www.webmd.com/heart-disease/pulse-measurement)

**MEDICAL HISTORY**

FORM 2012MH

<table>
<thead>
<tr>
<th>NAME</th>
<th>DOB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sally Liu</td>
<td>8-15-96</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>ID #</th>
<th>GENDER</th>
</tr>
</thead>
<tbody>
<tr>
<td>SC 983661</td>
<td>Female</td>
</tr>
</tbody>
</table>

**DATE 12-2-2011**

**ASSESSMENT**

- Height: 5’0”
- Weight: 130 lbs.
- Pulse: 65
- Temperature: 98.7
- Blood Pressure: 125/82
- Respiration Rate: 13
- Breath Sounds: normal

**HISTORY**

<table>
<thead>
<tr>
<th>Illness</th>
<th>Y</th>
<th>N</th>
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<tbody>
<tr>
<td>Asthma</td>
<td>X</td>
<td>N</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>X</td>
<td>N</td>
</tr>
<tr>
<td>Freq. colds</td>
<td>X</td>
<td>N</td>
</tr>
<tr>
<td>Freq. sore throat</td>
<td>X</td>
<td>N</td>
</tr>
<tr>
<td>Headaches</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>Seizures</td>
<td>X</td>
<td>N</td>
</tr>
<tr>
<td>Tonsilitis</td>
<td>X</td>
<td>N</td>
</tr>
<tr>
<td>Other (specify)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Allergies**

- None known
- Nuts
- Dairy
- Shellfish
- Insect
- Medication

**Appetite**

- Good
- Fair
- Poor
- Anorexic

**Injuries:** none

**Pain:** headaches

**SUMMARY OF CONDITIONS**

Patient complains of blurred vision, fatigue, and headaches.

Onset of symptoms approximately 3 weeks ago. Patient’s grandmother called about worsening symptoms.

**Attending Physician:** J. Walters

**Record Number:** SC 983661
<table>
<thead>
<tr>
<th>STUDENT PHYSICAL EXAM</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAME</td>
<td></td>
</tr>
<tr>
<td>DOB</td>
<td></td>
</tr>
<tr>
<td>GROUP NUMBER</td>
<td></td>
</tr>
<tr>
<td>GENDER</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>ASSESSMENT</td>
<td></td>
</tr>
<tr>
<td>Height</td>
<td>Weight</td>
</tr>
<tr>
<td>Pulse</td>
<td>Temperature</td>
</tr>
<tr>
<td>Respiration Rate</td>
<td>Breath Sounds</td>
</tr>
<tr>
<td>Disease</td>
<td>About the Disease</td>
</tr>
<tr>
<td>---------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Mononucleosis (Mono)</td>
<td>Viral infection characterized by prolonged fatigue and swollen lymph nodes</td>
</tr>
<tr>
<td>Lupus</td>
<td>Autoimmune disease (where the body's immune system attacks healthy cells)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>Disease in which there are high levels of sugar in the blood</td>
</tr>
<tr>
<td>Leukemia</td>
<td>Cancer of the blood or bone marrow</td>
</tr>
<tr>
<td>Anemia</td>
<td>Low iron levels in the blood</td>
</tr>
<tr>
<td>Migraines</td>
<td>Chronic severe headaches</td>
</tr>
<tr>
<td>Brain Tumor</td>
<td>Cancer in the brain</td>
</tr>
<tr>
<td>Concussion</td>
<td>Brain injury caused by impact to the head</td>
</tr>
<tr>
<td>Meningitis</td>
<td>Bacterial infection of membranes covering spinal cord and brain</td>
</tr>
<tr>
<td>Dehydration</td>
<td>Body doesn't have enough water</td>
</tr>
<tr>
<td>Influenza</td>
<td>Contagious respiratory virus</td>
</tr>
<tr>
<td>Urinary Tract Infection</td>
<td>Infection of the bladder, kidney or tubes connecting them</td>
</tr>
</tbody>
</table>
What does it mean to have normal height?

Instructions

1. In a prominent place in the room (bulletin board, white board), draw and label an x-axis with heights ranging from 57 to 73 inches. It should look similar to the diagram below.

   ![Diagram of x-axis with heights ranging from 57 to 73 inches]

   - 57  59  61  63  65  67  69  71  73
   - height (inches)

2. Invite each group to place a marker such as a thumb tack or small circular magnet above the number corresponding to the height of each member of the group. Use separate colors for girls and boys (i.e. red and blue). The markers should form a pattern that somewhat resembles the normal curve (pictured below), centered around the average height for girls and boys.

   ![Diagram of normal curve with markers for girls and boys]

3. Try creating separate distributions for girls and boys. Discuss the concepts of mean (average) and median.
Lesson 2: Brain Behavior

Lesson Objectives
- Determine whether Sally suffers from a neurological problem
- Practice giving a neurological exam and explore certain disorders through simulated vision changes
- Learn about brain imaging techniques through a fun activity

**Refresher:** In the last lesson, the students met Sally, a 13-year-old girl complaining of fatigue, blurred vision, and a headache. The students were challenged to come up with a diagnosis. To begin solving this problem, students learned about physical exams.

**What You Need to Know**
Almost all of our body’s functions are controlled by the nervous system. The nervous system has two parts: the central nervous system (CNS) which includes the brain and spinal cord, and the peripheral nervous system (PNS) that is comprised of all the other nerves in our bodies. Together, the CNS and PNS help us to sense when something touches our skin, to understand what we see, to move our muscles, and to feel pain, among many other things.

The nervous system sends messages throughout our body. A special type of cell in the brain, called a neuron, relays these messages throughout the nervous system. When neurons do not work correctly, health problems arise.

Sally reported blurred vision and headaches, which could indicate a neurological problem. The pediatrician referred her to a neurologist, who performed a variety of tests to determine if there is a problem with Sally’s brain or nerves. In this lesson, students will explore some neurological tests and will learn more about Sally’s neurological diagnosis.

**Materials**
- Vision distorting goggles: prism goggles, retinopathy, blurred vision (see attached)
- Eye chart
- Bean bag toss game
- Penlights
- Pointy calipers or forceps
- Arm and hand map
- Red and green markers
- Eye chart
- Bean bag toss (or similar game)
- Copies of Sally’s Neurological Exam
- Copies of Lesson 2 Disease Table

**Prep Work**
- Make vision distorting goggles
- Set up eye chart and area for bean bag toss
- Collect supplies for two-point discrimination test

**Neurologists**
Credit: medicalhealthdoctor.com

Neurologists are doctors that treat disorders of the brain and nervous system. They directly examine patients during a neurological exam, testing such traits as

- mental status
- motor function
- reflexes
- skin sensation
- coordination

They also look at X-rays, MRIs, and CT scans of the person’s head and brain.

After graduating from medical school, a neurologist must complete four years of neurology residency. That means it would take 16 more years of school and training after middle school to become a neurologist.

**Time**
60–90 minutes (total)
Lesson 2: Brain Behavior, continued

Warm-Up Questions
What did we learn last week about Sally?

What do you know about your brain?

Procedure
1. Begin with a discussion about Sally. Refresh the kids’ memories about what was learned last week. Some of the patient’s symptoms (blurred vision, headache) indicate that there might be something wrong with her brain and nervous system. Tell them that this week, we are going to determine if the patient has a neurological disorder.

2. Introduce some basic information about the nervous system. Discuss the function of the brain and peripheral nerves.

3. Doctors that study the brain are called neurologists and to evaluate the brain, these doctors have a special set of tests. Together, these tests are called a neurological exam. Your group will have the opportunity to try out some of these tests. Once they have tried everything out, then they will learn about how Sally performed on those tests.

4. There are four different activities available for your group today but you do not need to do all of them.
   a. Visual Acuity Exam
   b. Pupil Dilation Test
   c. Eye-brain Coordination Test
   d. Two-Point Discrimination Test

5. Allow your group to pick activities based on their interests and ability level. The attached sheets give suggestions on how to do the tests and also provide information about how these tests are used in medicine.

6. Once your group has tried out some of the neurological tests, then show them the neurological exam chart for Sally. How did she do on these tests?

7. Examine the Lesson 2 Disease Table. Compare the neurological symptoms for each disease to Sally’s results. Do you think that any of the neurological disorders are less likely based on this data?

Concluding Discussion
What did we learn about Sally today?
Are any of the diseases less likely based on the data from her chart?

Additional Resources
Neurological Exam
http://cloud.med.nyu.edu/modules/pub/neurosurgery/

Visual Acuity Exam
http://en.wikipedia.org/wiki/Snellen_chart

Two Point Discrimination Test
http://www.dls.ym.edu.tw/chudler/twopt.html

Brain Imaging Techniques
Computed Tomography (CT) scans use radiation to collect a series of X-ray images. The patient lies on a table and the doughnut-shaped CT scanner moves around the patient. Sometimes, a dye is injected into the patient to help make some structures easier to see.

Magnetic Resonance Imaging (MRI) is used to see soft tissues in the body. Large magnets are used to image structures dense with hydrogen atoms. An MRI image will show you where the water and fat is located in your body. MRI machines are shaped like long tubes and the patient lies in the center of the tube.

Functional MRI (fMRI) is used to measure changes in brain activity. An fMRI looks at changes in blood flow in the brain. Areas of activity receive more oxygen-rich blood and the fMRI picks up the increase in blood flow.
Two-Point Discrimination Test

A two-point discrimination test is performed as part of a neurologic exam to understand how many skin sensory receptors you have and what connections they make in your brain. Here is a video demonstrating the test: http://www.youtube.com/watch?v=sQsYVwGUPCA

**Directions:**
With a partner, use your tweezer/calipers to touch the skin on their arm beginning at the top of the arm and slowly moving down to their hands and fingers. Touch the skin with the caliper sometimes using only one point, and sometimes using both points. Ask your partner to close their eyes and tell you whether it feels like one or two points are touching their skin. When your partner answers correctly, mark those places on the arm diagram below with a green dot. When your partner guesses incorrectly, mark those places with a red dot. Make sure to test all the way down the arm to the tips of the fingers.
Instructions for Neurological Tests

Vision Tests

Directions for preparation of vision distortion goggles:

*Prism goggles:* Can be purchased from http://www.psychkits.com/perception_goggles.html
*Retrognaphy goggles:* Place round stickers randomly on a pair of lab goggles.
*Blurred vision goggles:* Smear a thin layer of vaseline inside a pair of lab goggles.

**Visual Acuity Test**

*Changes to a patient’s vision could indicate problems with the brain, nerves leading to the eyes, or the eye itself. Neurologists perform basic vision test to determine how well the patient can see. In this exercise, students will wearing different goggles simulating vision problems and experience how that changes their ability to see.*

1. Set up an eye chart on one wall of the room.
2. Mark a line 20 ft. away from the chart.
3. Stand at the line and try to read the letters on the chart.
4. Make a note of the smallest letters you can read.
5. Put on the retinopathy goggles. Try to read the letters on the chart. Note the smallest letters you can read clearly.
6. Repeat with the blurred vision goggles. Which letters can you clearly read?

**Eye-Brain Coordination Test**

*The brain processes and responds to information perceived with the eyes. For example, during a bean bag toss, your eyes and brain are working together to help you hit the target. A person with brain damage might not exhibit normal eye-brain coordination and would have difficulty coordinating responses to visual information. Prism goggles can be used to simulate brain injury.*

1. Set-up a bean bag toss in an open space.
2. Stand about 8 ft. from the target.
3. Put on the prism goggles.
4. Try to toss one of the bean bags to the target. Did you hit it? If not, where did you throw it?
5. Keep tossing the bean bags until you get one in the target. Make a note of the number of tosses it takes before you land a bean bag in the target.
6. Now take off the prism goggles. Try to toss a bean bag to the target without the goggles on. Did you hit it? Where did the bean bag go?

**Pupil Dilation Test**

*The iris (colored part) of each eyeball controls how much light enters the eye. In response to bright light, the iris constricts, making the pupil of the eye smaller. The reverse happens in dim light. When there are problems with the nerves connecting the brain to the eye, this reaction to light will not be normal. The iris may fail to constrict or could fail to dilate. The left and right eyeballs may also react differently to light.*

1. This activity will require two people, sitting so that they are facing each other. One person will be the tester and the other will be the subject.
2. The subject should stare at the bridge of the tester’s nose.
3. The tester shines a penlight into the left eye of the subject. They then quickly shine the light on the right eye. Watch for constriction of the pupils as the light is shone on the eye and for dilation of the pupils when the light moves away.
**PATIENT CHART**

**NEUROLOGICAL EXAM**

<table>
<thead>
<tr>
<th>Psychological</th>
<th>Vision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of consciousness</td>
<td></td>
</tr>
<tr>
<td>Confusion Present Not present</td>
<td>Correction</td>
</tr>
<tr>
<td>Mental Status</td>
<td>Left eye Normal</td>
</tr>
<tr>
<td></td>
<td>Right eye Normal</td>
</tr>
<tr>
<td>Depression Recent Long term None</td>
<td>Pupil Dilation (circle one)</td>
</tr>
<tr>
<td>Memory</td>
<td>1 2 3 4 5 6 7 8 9</td>
</tr>
<tr>
<td>appears normal</td>
<td>Normal</td>
</tr>
</tbody>
</table>

| Sensation | Reflexes and coordination |
| Two point discrimination test | Patellar Reflex No response Normal |
| Left extremity X Normal Low | Delayed | Hyper-reactive |
| Right extremity X Normal Low | Uncoordinated | |
| Object discrimination test | Gait X Normal Uncoordinated |
| X Normal Low | Unstable Signs of weakness |
| Position Sense | Hand-eye coordination X Normal Uncoordinated |
| X Normal Low | Unstable Signs of weakness |

**NOTES**

- Visual perception normal
- Brain MRI shows no indication of lesion or abnormality
<table>
<thead>
<tr>
<th>Disease</th>
<th>Vision</th>
<th>Sensation</th>
<th>Reflexes</th>
<th>Coordination</th>
<th>Other</th>
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</thead>
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<tr>
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<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td>Lupus</td>
<td>No change</td>
<td>Tingling in hands and feet</td>
<td>Tingling in hands and feet</td>
<td>Normal</td>
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<tr>
<td>Diabetes</td>
<td>No change</td>
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<tr>
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</tr>
<tr>
<td>Anemia</td>
<td>No change</td>
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</tr>
<tr>
<td>Migraines</td>
<td>No change</td>
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</tr>
<tr>
<td>Brain Tumor</td>
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</tr>
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<td>No change</td>
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<td>Dehydration</td>
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</tr>
<tr>
<td>Urinary Tract Infection</td>
<td>No change</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
</tr>
</tbody>
</table>
Lesson 3: Tinkle Testing

Lesson Objectives
- Conduct experiments to characterize the patient’s urine sample
- Students will learn about including both positive and negative controls in their experiments and about controlling variables

Refresher
In the last lesson, students used various tests study the brain and nerves in order to investigate whether Sally may have a neurological problem.

What You Need to Know
When a person goes to the doctor for a routine check-up, the doctor might ask for a urine sample. Why would anyone want to have a sample of pee? To see if urine good health – of course! When urine is collected and examined, that’s called urinalysis. Urinalysis can help identify problems in many parts of the body and can sometimes help detect a disease before symptoms occur.

A routine Urinalysis typically consists of several tests, including a visual exam, pH, specific gravity (density of a liquid divided by the density of water), glucose, electrolytes, and protein.

Today, students will perform several tests on Sally’s urine sample, including pH, glucose concentration, and a protein test. Throughout the lesson, students will learn about the importance of including controls in their experiments and about controlling variables.

Materials
- Albumin
- Glucose
- Yellow food coloring
- Biuret solution
- Benedict’s solution
- pH strips
- urine sample cups
- hot water baths (hot plates and beakers or microwaved water)
- pipettes
- test tubes

Prep Work
- Make patient and control urine samples
- Set up hot water baths
- Collect supplies
- Print copies of Urinalysis Patient Chart
- Print copies of Lesson 3 Disease Table
- Watch urine production video at http://www.youtube.com/watch?v=qxb2_d9iIEw

Time
60–90 minutes (total)

Nurses
Nurses are a critical part of the medical team. They help doctors during medical exams, help educate patients, and perform some medical tests. Nurses also provide emotional support since they often see a patient more than the doctors.

There are several ways to become a nurse:

- Licensed Practical Nurse (LPN)- nurses that provide basic care for patients. Requires a degree from a one-year vocational program.
- Registered Nurse (RN) – nurses that perform a broad number of tasks related to patient care. Most RNs have a four year college degree and special certification.
- Nurse Practitioners – nurses that perform many of the same functions as doctors. Requires a Master’s or Doctoral degree.
Lesson 3: Tinkle Testing, continued

Warm-Up Questions

Have you ever been asked to provide a urine sample?
Why would a doctor want to a patient’s urine sample?

Procedure

1. Begin a discussion about urine using the warm-up questions and video about urine production. Stop this video at 2:56.

2. Introduce the process of urinalysis and the usefulness of these tests. The students will be performing four tests today: a visual exam, pH test, glucose test, and protein test.

3. Begin by performing a visual exam of the sample urine. Is the sample urine clear or cloudy? Normal urine is clear. Cloudiness could indicate infection, since cloudy urine often indicates the presence of bacteria. What color is the sample urine? Compare to color sheet. Normal urine is pale yellow. Urine that is dark yellow could indicate dehydration while urine that is red or brown could indicate blood in the urine. Record results in patient chart.

4. Perform a pH test of the sample urine by dipping a pH strip into the sample. A pH of 7 is common, but normal pH can range between 4.5 and 8. Record the pH on the patient chart.

5. Perform a glucose test using Benedict’s reagent and the attached instructions. Ask the students, “What would make a good control for this experiment?” Guide them towards testing the sample urine along with a negative control and a positive control. Normal urine should contain very little glucose.

6. Perform a protein test using Biuret solution and the attached instructions. Test the sample urine, a negative control, and a positive control.

7. Compare Sally’s test results to the Lesson 3 Disease Table. Do her results help inform the diagnosis? Are any of the diseases more or less likely based on the data?

8. Summarize your findings in a Science Club journal post.

Concluding Discussion

Based on your urine tests, what diseases are less likely for this patient?

Extension: If the students have time, they can perform a dipstick test on the patient sample using the urinalysis dipsticks. Have them compare their results to the chemical tests they performed.

Why is Pee Yellow?

Urine is yellow because it contains chemicals called urobilins. These chemicals come from the body’s natural breakdown of hemoglobin.

When red blood cells are recycled by the spleen, hemoglobin is released and metabolized to form bilirubin. Bilirubin is then further metabolized by the liver into chemicals called urobilins, which are yellow. The kidneys recognize urobilins as a waste product and excrete them – causing your pee to be yellow.

If you are properly hydrated, your urine will be pale yellow in color. Deeper yellow urine may result if you are dehydrated, which leads to urine that is more concentrated.

People taking a multivitamin that contains riboflavin (Vitamin B2), may have pee that is extremely yellow. That’s because riboflavin is yellow in color and excess riboflavin is excreted by the body via urine.

Additional Resources

National Kidney Foundation:

Urinalysis Article (Medicine.net):
http://www.medicinenet.com/urinalysis/article.htm
Instructions for Urinalysis Tests

Perform the following tests using the patient sample as well as the provided positive and negative control samples.

**Glucose Test Using Benedict's Reagent Directions:**

Positive control samples: water with glucose
Negative control samples: water

1. Make the positive and negative control samples.
2. Collect one test tube for each sample. Label each test tube with the sample name.
3. Measure 4mL of each sample into the test tube.
4. Add 1mL of blue Benedict's solution to the test tube.
5. Cover the tubes with Parafilm and gently invert the tubes to mix.
6. Place the test tubes in a 70°C water bath and allow them to incubate for 10 minutes.
7. Remove the test tubes from the water bath and carry them back to your table.
8. Observe the color of the solutions in the test tubes. Record your data in the patient medical chart.

The color change serves as a guide to the amount of glucose in the sample: blue - glucose absent; green - 0.5% glucose; yellow - 1% glucose; orange - 1.5% glucose; brick red - 2% glucose or more)

**Protein Test Using Biuret Solution:**

Positive control sample: water with protein (albumin)
Negative control sample: water

1. Collect one test tube for each sample. Label each test tube with the sample name.
2. Measure 1mL of each sample into the test tube.
3. Add 1mL of Biuret solution to the test tube.
4. Cover the tubes with Parafilm and gently invert the tubes to mix.
5. Observe the color of the solutions in the test tubes. Record your data in the patient medical chart.
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<thead>
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</thead>
<tbody>
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<tr>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Color of positive control</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Color of negative control</td>
</tr>
<tr>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Appearance</strong></td>
<td>[ ] Clear [ ] Cloudy</td>
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<td>Color of positive control</td>
</tr>
<tr>
<td>Color of negative control</td>
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<th>3</th>
<th>4</th>
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<td>Normal</td>
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<td>Can be low</td>
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<td>Normal</td>
<td>Sweet</td>
<td>Normal</td>
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<tr>
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<td>Normal</td>
</tr>
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<td>Normal</td>
<td>Cleart</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
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</tr>
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<td>Brown, red</td>
<td>Foul</td>
<td>Foul</td>
<td>Brown, red</td>
<td>Foul</td>
</tr>
</tbody>
</table>
Lesson 4: Hematology Help

Lesson Objectives
- Learn about blood and its collection
- Introduce students to different blood tests that may point out medical problems

What You Need to Know
Blood plays many important roles in our bodies. One of its main responsibilities is to transport oxygen and nutrients to the cells in our body. Blood is also helpful when it comes to defending the body since some cells protect you from infection.

Blood is a mixture of cells and plasma. There are two main types of cells: red blood cells and white blood cells. Red blood cells work hard to deliver oxygen to the body and white blood cells protect the body by fighting off infections. Plasma is 90% water and the remaining 10% contains proteins and electrolytes.

A lot of information about a patient's health can be determined from their blood. Tests can help determine if there are too much or not enough of particular nutrients in the blood. Anemia is a disease where patient's lack enough iron in their blood while people with diabetes have too much sugar. Information about the number of different types of blood cells could also indicate disease, such as infection or leukemia.

In this lesson, the students will learn about blood analysis. They will do a simulation of a blood draw using juice packs. They also have the opportunity to perform three tests on Sally's blood: 1) a blood iron test, 2) a blood glucose test, and 3) a complete blood count.

Materials
- Patient blood samples and control samples
- Kool-Aid jammer juice packets
- Small gauge syringes
- Small beaker
- Transfer pipet
- Blue food coloring
- Small gauge syringes
- Liberty blood glucose meters and test strips
- Blood smear slides (normal blood and leukemia)
- Light microscope
- Laptop computer
- Phlebotomy video: youtube.com/watch?v=H64vQBSLme4

Prep Work
- Make patient blood samples
- Collect supplies

Phlebotomist

Phlebotomists are technicians responsible for drawing blood from patients. After graduating from high school, most phlebotomists earn a special certificate from a trade school where they learn basic anatomy and safe blood collection techniques.

Certification requires about 4 months of work and includes both class and clinical time.

Once the phlebotomist has drawn a patient's blood, the blood sample is sent to a lab for analysis. A pathologist and a team of technicians often conduct this analysis.

- Make copies of Hematology Patient Chart and Lesson 4 Disease Table
- Load phlebotomy video on computer

Time
60–90 minutes (total)
Lesson 4: Hematology Help, continued

Warm-Up Questions
What did we learn about Sally last week?
Why would a doctor want to collect a patient’s blood?
Have you ever had blood drawn?

Procedure
1. Ask the kids the warm-up questions. Discuss the fact that blood analysis can tell you many things about the health of the patient.
2. Ask kids about the different components of blood. Discuss that different types of cells in the blood. Talk about blood as a mixture of plasma and cells instead of a pure liquid. Discuss the two major categories of cells (red blood cells and white blood cells) but acknowledge the fact that there are many different types of white blood cells that each have their own specific function in the blood.
3. Talk about drawing blood. Use the video about phlebotomists to stimulate discussion.
4. Discuss the rules for handling needles. Remind kids to KEEP THE PROTECTIVE CAP ON THE NEEDLE UNTIL IT IS TIME TO USE IT. When it is time to use the needle, pay attention to the direction the needle is pointed.
5. Give each student a chance to practice drawing “blood” from a kool-aid jammer. Discuss what is different when actually working with a patient – finding veins, not puncturing a vein more than once, avoiding major nerves, tendons, etc.
6. Working with the fake blood, complete the iron test using the attached directions. Drop one drop of blood into the blue test solution. Does the blood sink? Blood that lacks sufficient iron will fail to sink or disperse quickly. Record observations in medical record.
7. Test the blood glucose level of the patient’s blood using the attached directions. Place a drop of blood on a small piece of wax paper or Parafilm. Touch the proper end of the test strip to the drop; the blood will be drawn into the test strip by capillary action. Insert the strip into the glucose meter to read the glucose level. Make sure to discuss the units of blood glucose measurement: milligrams of glucose per deciliter of blood. A fasting blood glucose – meaning blood glucose levels measured after not eating for at least 8 hours – over 120mg/dL could indicate diabetes.
8. If there is still time, have students look at the patient blood smears and calculate a complete blood count using the attached directions. High levels of white blood cells could indicate leukemia or an infection.
9. Review the Lesson 4 Disease Table. Compare Sally’s blood results to the table. Do any of them look similar? Do any look different?
10. Write up a Science Club journal post about what you’ve learned today.

Concluding Discussion
What is important to remember when drawing blood?
What did we learn about Sally today?
Based on our results, are any of the conditions less likely?

Additional Resources
Blood cells
http://www.fi.edu/learn/heart/blood/red.html
Blood cells are formed from stem cells in the bone marrow. You have many different blood cells in your body.

White blood cells, or leukocytes, are a group of related cells that are involved in immune function—fighting off viruses or infections and helping our body to heal.

Red blood cells, or erythrocytes, transport oxygen throughout the body. They make up 40-50 percent of your blood volume.

Platelets, or thrombocytes, are small, colorless cell fragments in the blood whose main function is to help your blood clot. This stops bleeding.

Image adapted from University of Minnesota Cancer Center website
http://www.cancer.umn.edu/cancerinfo/NCI/glossary/CDR46124.html
Instructions for Blood Tests

Perform the following tests using 1) the patient sample, 2) a positive control, and 3) a negative control.

**Blood Iron Test Directions:**

Positive control sample: use vial labeled “Normal sample”
Negative control sample: use vial labeled “Anemia sample”

1. Collect your supplies, including the blue test solution in a beaker, a transfer pipet, and the samples.
2. Carefully drop one drop of the positive control sample in the blue test solution. It is best if the tip of the transfer pipet is close to the surface of the test solution. Make sure that the solution is still before dropping in samples.
3. Observe the sample as it drops through the solution. Does it sink? Does the drop stay together or does it disperse?
4. Repeat steps 2 and 3 with the remaining samples.
5. Record your observations in the medical chart.

**Blood Glucose Test Directions:**

Positive control sample: use vial labeled “Diabetic sample”
Negative control sample: use vial labeled “Normal sample”

1. Collect the supplies for this test, including a glucose meter, at least three test strips, a piece of wax paper or Parafilm, a transfer pipet, and the samples.
2. Place one drop of the positive control sample on the parafilm.
3. Place a test strip in the glucose meter. Make sure that the strip is fully engaged and the blood drop icon is flashing on the screen.
4. Apply the sample to the test strip. Place the test strip next to the sample drop. The sample should move into the test strip by capillary action.
5. Wait until the glucose meter beeps. Record the number on the screen. **Make sure your group members understand the units associated with the measurement (milligrams of glucose per deciliter of blood).**
6. Repeat steps 2-5 with the remaining samples.

**Complete Blood Count Directions:**

Samples: Patient smear, normal blood smear, leukemia smear

1. Collect the sample slides and a light microscope.
2. Look at the slide with a normal blood smear. Observe the different types of cells on the slide and compare them to the “Visual Guide of Blood Cell Types” handout (previous page). What types of blood cells do you see?
3. If you’d like to try counting the number of cells, focus on one field of view. Count the number of red blood cells and white blood cells. Record your observations on the medical chart.
4. Observe the patient and leukemia smears. What kinds of cells do you see on these slides?
<table>
<thead>
<tr>
<th>IRON TEST</th>
<th>BLOOD GLUCOSE TEST</th>
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<tbody>
<tr>
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</tr>
<tr>
<td>Disperse?</td>
<td>□ Yes □ No</td>
</tr>
<tr>
<td>Anemia sample</td>
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<tr>
<td>Sink?</td>
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<td>Sink?</td>
<td>□ Yes □ No</td>
</tr>
<tr>
<td>Disperse?</td>
<td>□ Yes □ No</td>
</tr>
</tbody>
</table>

**COMPLETE BLOOD COUNT** - _draw types of cells in blood samples and count total number of each cell in microscope field_

**NAME** | **DOB**
--- | ---

**ID #** | **GENDER**
--- | ---

**DATE**
<table>
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<tr>
<th>Disease</th>
<th>Iron Levels</th>
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<th>Complete Blood Count (CBC)</th>
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<tr>
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<td>Normal</td>
<td>Decreased platelets</td>
</tr>
<tr>
<td>Diabetes</td>
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<td>High</td>
<td>Normal</td>
</tr>
<tr>
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<tr>
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<td>High</td>
<td>Normal</td>
<td>High white blood cell count</td>
</tr>
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<tr>
<td>Urinary Tract Infection</td>
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</table>
Lessons 5 & 6: Putting it All Together

Lesson Objectives
• Compile test results and determine a patient diagnosis
• Develop a treatment plan for the patient’s disease
• Summarize the treatment plan in a comic strip

Refresher
In the last few lessons, each group has collected information about Sally’s health.

What You Need to Know
The process of identifying a patient’s disease is called “diagnosing” and this process is very similar to the scientific method. Based on the symptoms indicated by the patient, doctors make a prediction about what illness might be making the patient sick. Doctors then order a number of medical tests to collect data about the patient’s health and to determine which aspects are abnormal. This patient information can be used to either confirm or eliminate diseases as possible causes for illness.

Each group has spent the last four sessions learning about Sally’s health after she presented symptoms of dizziness, blurry vision, and headache. Medical tests were performed to learn about the patient’s vitals, her neurological function, characteristics of her urine, and her blood.

In the next two lessons, students will analyze the results from Sally’s medical tests and should arrive at the conclusion that Sally is sick with diabetes. Students will then develop a treatment plan for the patient and each group’s plan will be summarized in a comic-strip style photo story.

Materials
- Sally’s medical charts from previous lessons
- Disease Diagnosis Cards and Disease Treatment Information Cards
- Laptop computers
- ComicLife software available to each group
- If laptops and ComicLife are not available, large format paper, markers, and health magazines as a source of health-inspired photos

Prep Work
- Print and cut out Disease Diagnosis Cards and Diabetes Treatment Information Cards
- Install ComicLife 2 software on laptop computers

Time
Two sessions, 60–90 minutes each

What is diabetes?
Diabetes is a disease where there is too much sugar in a person’s blood. Normally, an organ in the body called the pancreas produces a hormone called insulin after a meal. Insulin tells cells to absorb the sugar so that the body can use it for energy. If you have diabetes, your pancreas makes little or no insulin, so the sugar stays in the blood. Having too much sugar in the blood can damage the heart, eyes, kidney and nerves.

There are two different types of diabetes. Type 1 diabetes occurs when a person’s immune system attacks the pancreas. This type of diabetes is most often diagnosed during childhood and scientists believe it is caused by a genetic mutation. Once a person has type 1 diabetes, it does not go away and requires lifelong treatment. Type 2 diabetes results when the body can’t respond to insulin normally. It develops gradually and, most often, is caused by poor diet and lack of exercise. Changes to a person’s diet and exercise routine can help.
Lessons 5 & 6: Putting it All Together, continued

Warm-Up Questions
What did we learn about Sally during the previous lessons?
What did we learn about her vitals? Brain function? Urine? Blood?
How can we pull together all the medical data we’ve collected to diagnose Sally’s illness?

Procedure
1. Begin a discussion with your group using the warm-up questions. Help the kids develop a plan to review the information and diagnose Sally’s illness.

2. Review Sally’s medical charts from the four previous lessons. What were the conclusions from each medical test? Write down your results.

3. Compare your results to the known symptoms for the candidate diseases. Do any of Sally’s symptoms or medical results match the diseases on the chart? Based on your results, which diseases are less likely? Which diseases are more likely?

4. If needed, the Disease Diagnosis Cards can help narrow down the possibilities. Start with all disease cards face up. As the medical data for each test is reviewed, turn over cards whose symptoms are not consistent with the observed medical test results.

5. Discuss with your group- what is the diagnosis for Sally? Note: your group should arrive at the conclusion that Sally has diabetes.

6. Once your group has arrived at their diagnosis, read the last comic page, showing the pediatrician’s diagnosis of Sally’s illness.

7. The next step is to determine the best treatment for Sally. Look at the treatment information cards and learn about the purpose for each treatment option. Which ones are the best for Sally? Use this as an opportunity to talk about how diabetics manage their disease.

8. Once your group has researched treatment options for Sally, summarize your treatment plan using a comic-strip style photo story. This short photo story will complete the Medical Mystery comic.

9. Begin by outlining the story for your comic page. Which pieces of information would you like to convey? It is not important to portray all possible treatments- pick one or two for your group’s comic. Keep in mind, the story should be short (no more than six images).

10. Use the internet to collect images for your comic. Convert your favorite photos to a comic using ComicLife.

11. Post your comic PDF on the Science Club website or in the Science Club lab space.

Concluding Discussion
What did you learn about diabetes?
What are some possible treatments for diabetes?

Additional Resources
American Diabetes Association
http://www.diabetes.org
## Disease Diagnosis Cards

<table>
<thead>
<tr>
<th>Mononucleosis</th>
<th>Lupus</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diabetes</strong></td>
<td><strong>Leukemia</strong></td>
</tr>
<tr>
<td><strong>Anemia</strong></td>
<td><strong>Migraine</strong></td>
</tr>
<tr>
<td><strong>Brain Tumor</strong></td>
<td><strong>Concussion</strong></td>
</tr>
<tr>
<td><strong>Meningitis</strong></td>
<td><strong>Dehydration</strong></td>
</tr>
<tr>
<td><strong>Influenza</strong></td>
<td><strong>Urinary Tract Infection</strong></td>
</tr>
</tbody>
</table>
## Glucose Monitoring

People with diabetes must check their blood glucose levels regularly. To do this, they use a glucose monitor. A person will prick their finger with a sharp needle in order to get a drop of blood. The glucose meter test strip measures the amount of sugar in the person’s blood. If the sugar levels are above 180mg/dL, then that person must take insulin. A person will check their blood glucose several times a day.

## Insulin Injections

Insulin is a hormone that helps cells absorb sugar from blood. People with Type 1 diabetes do not produce insulin and are required to take insulin shots to help control the amount of sugar in their blood. Some people with severe Type 2 diabetes also receive insulin. A person on insulin will often give themselves up to 4 shots of insulin a day, depending on how high their blood sugar goes. Sometimes, insulin injections are paired with a diabetes pill to help the insulin work better.

## Diet

A healthy diet helps keep blood sugar in the target range for diabetic patients. It is a critical part of diabetes management. Healthy diabetic eating includes:

- Limiting sugary foods
- Eating small portions, spread out over the day
- Being careful about when and how many carbohydrates you eat
- Eating a variety of whole-grain foods, fruits and vegetables every day
- Reducing the amount of fat (especially saturated) in your diet
- Reducing sodium (salt) intake

## Exercise

Exercise is an effective way for a person with Type 2 diabetes to control their blood sugar levels. Aerobic exercise helps the body use insulin more effectively and when combined with a healthy diet, it can help restore normal glucose levels. At least 30 minutes of aerobic exercise plus other forms of active movement throughout the day can help with diabetes management. It is also important for a diabetic to control their weight. Both aerobic exercise and strength training (lifting weights) can help a person lose weight and reduce the risk of Type 2 diabetes.

## Regular Doctor Visits

Regular doctor visits are an important part of diabetes treatment. Doctors want to closely monitor the patient’s health and detect changes before they become serious. At these appointments, the doctor will check the patient’s blood pressure and weight. They will also examine their feet since diabetes can cause nerve damage and it also prevents wounds from healing very quickly. As a result, it is common for diabetic patients to develop sores or cuts on their feet that can become infected. Doctors may also run lab tests, like the A1C test, to see if blood sugar levels are being properly managed.

## Hemaglobin A1c Tests

The A1C test is a blood test that a doctor performs on diabetic patients to determine how well they are controlling their blood sugar levels. The test measures the amount of glucose bound to hemoglobin, the protein that carries oxygen in red blood cells. This different form of hemoglobin is called A1C. By measuring the amount of A1C in the blood, the A1C test estimates the average amount of glucose in the blood over the last few months. The test can help diabetic patients and their doctors determine whether their treatment methods need to be improved.
SCIENCE CLUB presents...

MEDICAL MYSTERY

Sally is sick...
Blurry vision, headache...
She really needs YOUR HELP!

CAN YOU SOLVE THE CASE?
MEET... **SALLY!**

SHE IS A HAPPY, 12 YEAR-OLD GIRL...

SHE LOVES SCIENCE...

...AND SWIMMING...

BUT SOMETHING STARTED TO GO WRONG...
SALLY WASN'T FEELING HEALTHY ANYMORE.

HER GRANDMOTHER WAS CONCERNED AND CALLED... THE DOCTOR!
HE SAID... TELL ME WHAT'S WRONG.

SALLY REPLIED...

EVERYTHING LOOKS BLURRY

MY HEAD REALLY HURTS

...AND I'M TIRED ALL THE TIME."
"Based on your symptoms, there are at least 12 illnesses that could be making you sick."

He thought...

I don't have enough information to diagnose. I need to do more tests.

So he ordered some medical tests to learn more about Sally's health. But he needs your...

Help
YOU’LL PERFORM SEVERAL IMPORTANT TESTS

A PHYSICAL EXAM

A NEUROLOGICAL EXAM

URINALYSIS

AND BLOOD ANALYSIS.
LET'S GET TO WORK!

HELP THE DOCTOR COLLECT AND REVIEW THE INFORMATION FROM SALLY'S MEDICAL TESTS. THEN DIAGNOSE HER ILLNESS.

SALLY'S HEALTH IS IN YOUR HANDS!

- FOLLOW PROCEDURES
- MEASURE AND OBSERVE
- RECORD YOUR RESULTS
- ANALYZE YOUR DATA
- DISCUSS RESULTS WITH YOUR TEAM
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