TEACHER'S MANUAL

This Suitcase Program provides the materials and lesson plans for teachers of grades 3-12 with content and activities increasing in difficulty by grade level. Activities in this Suitcase Exhibit may assist in meeting the Tennessee State Standards.

ACTIVITIES

TENNESSEE STATE STANDARDS FOR 3-12

GRADES 3-5

3.PS1.1	Describe the properties of solids, liquids, and gases and identify that matter is made up of particles too small to be seen.
3.PS1.2	Differentiate between changes caused by heating or cooling that can be reversed and that cannot.
3.PS1.3	Describe and compare the physical properties of matter including color, texture, shape, length, mass, temperature, volume, state, hardness, and flexibility.
3.PS2.1	Explain the cause and effect relationship of magnets.
4.PS4.2	Describe how the colors of available light sources and the bending of light waves determine what we see.

4.SP4.3	Investigate how lenses and digital devices like computers or cell phones use waves to enhance human senses.
4.ETS2.1	Use appropriate tools and measurements to build a model.
5.PS1.2	Analyze and interpret data to show that the amount of matter is conserved even when it changes form, including transitions where matter seems to vanish.
5.PS1.3	Design a process to measure how different variables (temperature, particle size, stirring) effect the rate of dissolving solids into liquids.
5.ETS2.2	Describe how human beings have made tools and machines (x-ray cameras, microscopes, satellites, computers) to observe and do things that they could not otherwise sense or do at all, or as quickly or efficiently.
5.ETS2.3	Identify how scientific discoveries lead to new and improved technologies.

GRADES 6-8

6.PS3.1	Analyze the properties and compare the sources of kinetic, elastic potential, gravitational potential, electric potential, chemical, and thermal energy.
6.PS3.4	Conduct an investigation to demonstrate the way that heat (thermal energy) moves among objects through radiation, conduction, or convection.
7.PS1.1	Develop and use models to illustrate the structure of atoms, including the subatomic particles with their relative positions and charges.
7.PS1.2	Compare and contrast elemental molecules and compound molecules.
7.LS1.1	Develop and construct models that identify and explain the structure and function of major cell organelles as they contribute to the life activities of the cell and organism.

GRADES 9-12

BIO1.LS1.2	Evaluate comparative models of various cell types with a focus on organic molecules that make up cellular structures.
BIO1.LS1.3	Integrate evidence to develop a structural model of a DNA molecule. Using the model, develop and communicate an explanation for how DNA serves as a template for self-replication and encodes biological information. (Teacher Background Information)
BIO1.ETS2.1	Obtain, evaluate, and communicate information on how molecular biotechnology may be used in a variety of fields.
PHYS.PS3.2	Investigate conduction, convection, and radiation as a mechanism for the transfer of thermal energy.

For the entire activity and materials and to reserve a Suitcase Exhibit, please call 901.636.2362.

ACTIVITY I: Exploring Measurement – Ruler

DURATION OF ACTIVITY: 25 minutes

LESSON OBJECTIVES

"Exploring Measurement – Ruler" is a hands-on activity investigating just how small a billionth of a meter is. Students attempt to cut a paper ruler down to a nanometer-sized sliver. They learn that nano is too small to see, and certainly too small to cut with a pair of scissors!

GUIDING QUESTION

How small is a nanometer?

TENNESSEE STATE STANDARDS

PHYSICAL SCIENCE CONTENT STANDARDS:

3-5 PS1:	Describe and compare the physical properties of matter including color, texture, shape, hardness, and flexibility.
3-5 PS1:	Analyze and interpret data to show that the amount of matter is conserved even when it changes form, including transitions where matter seems to vanish.
6-8 PS1:	Compare and contrast elemental molecules and compound molecules.

SCIENCE AND TECHNOLOGY CONTENT STANDARDS:

3-5 ETS2:	Use appropriate tools and measurements to build a model.
3-5 ETS2:	Describe how human beings have made tools and machines to observe and do things that they could not otherwise sense or do at all, or as quickly or efficiently.
9-12 ETS2:	Obtain, evaluate, and communicate information on how molecular biotechnology may be used in a variety of fields.

MATERIALS INCLUDED

Photocopy master for rulers, in Supplementary Materials Section of Teacher's Manual

MATERIALS PROVIDED BY TEACHER

Scissors
A copy of the paper ruler for each student

For the entire activity and materials and to reserve a Suitcase Exhibit, please call 901.636.2362.

ACTIVITY II: Exploring Measurement – Human Body

DURATION OF ACTIVITY: 45 minutes

LESSON OBJECTIVES

"Exploring Measurement – Human Body" is a hands-on activity in which students mark their height on a height chart and discover how tall they are in nanometers. They learn that although being a billion nanometers tall sounds impressive, it doesn't mean they're super tall: it means a nanometer is super small. Students can also measure their hands in nanometers.

GUIDING QUESTION

How small is a nanometer?

TENNESSEE STATE STANDARDS / NATIONAL SCIENCE EDUCATION STANDARDS

PHYSICAL SCIENCE CONTENT STANDARDS:

3-5 PS1:	Describe and compare the physical properties of matter including color, texture, shape, hardness, and flexibility.
6-8 PS1:	Compare and contrast elemental molecules and compound molecules.

MATERIALS INCLUDED

"How Tall Are You?" height chart
Photocopy master "How Big Is Your Hand?" worksheet, in Supplementary Materials Section of Teacher's Manual
Photocopy master for "I am nanometers tall" worksheet, in Supplementary Materials Section of Teacher's Manual

MATERIALS PROVIDED BY TEACHER

Pencils
Masking tape
Copy of "How Big is Your Hand?" worksheet for each student
Copy of "I am nanometers tall" worksheet for each student

For the entire activity and materials and to reserve a Suitcase Exhibit, please call 901.636.2362.

ACTIVITY III: Exploring Tools – SPM

DURATION OF ACTIVITY: 30 minutes

LESSON OBJECTIVES

"Exploring Tools – SPM" is a hands-on activity in which students use a flexible magnet as a model for a scanning probe microscope. They learn that SPMs are an example of a special tool that scientists use to work on the nanoscale.

GUIDING QUESTION

What do nanostructures look like?

TENNESSEE STATE STANDARDS / NATIONAL SCIENCE EDUCATION STANDARDS

PHYSICAL SCIENCE CONTENT STANDARDS:

3-5 PS2: Explain the cause and effect relationship of magnets.

SCIENCE AND TECHNOLOGY CONTENT STANDARDS:

3-5 ETS2: Use appropriate tools and measurements to build a model.

3-5 ETS2: Describe how humans beings have made tools and machines (x-ray cameras, microscopes, satellites, computers) to observe and do things that they could not otherwise sense or do at all, or as quickly or efficiently.

MATERIALS INCLUDED

Large demonstration magnet
Small magnets
Magnetic field diagram (2 versions), in Supplementary Materials Section of Teacher's Manual

MATERIALS PROVIDED BY TEACHER

None

For the entire activity and materials and to reserve a Suitcase Exhibit, please call 901.636.2362.

ACTIVITY IV: Exploring Forces – Gravity

DURATION OF ACTIVITY: 30 minutes

LESSON OBJECTIVES

"Exploring Forces – Gravity" is a hands-on activity in which students discover that it's easy to pour water out of a regular-sized cup, but not out of a miniature cup. They learn that size can affect the way materials like water behave.

GUIDING QUESTION

What's different at the nanoscale?

TENNESSEE STATE STANDARDS / NATIONAL SCIENCE EDUCATION STANDARDS

PHYSICAL SCIENCE CONTENT STANDARDS:

3-5 PS1:	Describe the properties of solids, liquids, and gases and identify that matter is made up of particles too small to be seen.
3-5 PS1:	Describe and compare the physical properties of matter including color, texture, shape, length, mass, temperature, volume, state, hardness, and flexibility.
6-8 PS1:	Compare and contrast elemental molecules and compound molecules.

SCIENCE AND TECHNOLOGY CONTENT STANDARDS:

3-5 ETS2:	Use appropriate tools and measurements to build a model.

Materials Included
Regular teacup
Miniature teacup
Container for water (box containing the materials in the suitcase may be used)

Materials Provided By Teacher
Water

For the entire activity and materials and to reserve a Suitcase Exhibit, please call 901.636.2362.

ACTIVITY V: Exploring Properties – Surface Area

DURATION OF ACTIVITY: 30 minutes

LESSON OBJECTIVES

"Exploring Properties – Surface Area" is a hands-on activity demonstrating how a material can act differently when it's nanometer-sized. Students compare the reaction rate of an effervescent antacid tablet that is broken in half with one that is broken into many pieces.

GUIDING QUESTIONS

What's different at the nanoscale?

TENNESSEE STATE STANDARDS / NATIONAL SCIENCE EDUCATION STANDARDS

PHYSICAL SCIENCE CONTENT STANDARDS:

3-5 PS1: Describe the properties of solids, liquids, and gases and identify that matter is made up of particles too small to be seen.

3-5 PS1: Analyze and interpret data to show that the amount of matter is conserved even when it changes form, including transitions where matter seems to vanish.

SCIENCE AND TECHNOLOGY CONTENT STANDARDS:

3-5 ETS2: Use appropriate tools and measurements to build a model.

3-5 ETS2: Identify how scientific discoveries lead to new and improved technologies.

MATERIALS INCLUDED

2 100 mL graduated cylinders
2 small plastic measuring cups (small plastic cups may be used instead)
Pitcher
Effervescent antacid tablets
Food coloring

MATERIALS PROVIDED BY TEACHER

Water

For the entire activity and materials and to reserve a Suitcase Exhibit, please call 901.636.2362.

ACTIVITY VI: Exploring Materials – Liquid Crystal

DURATION OF ACTIVITY: 45 minutes

LESSON OBJECTIVES

"Exploring Materials – Liquid Crystals" is a hands-on activity demonstrating that the way a material behaves on the macroscale is affected by its structure on the nanoscale. Students investigate the properties of a heat sensitive liquid crystal and make their own liquid crystal sensor to take home.

GUIDING QUESTION

What's different about nanomaterials?

TENNESSEE STATE STANDARDS / NATIONAL SCIENCE EDUCATION STANDARDS

PHYSICAL SCIENCE CONTENT STANDARDS:

3-5 PS1: Describe the properties of solids, liquids, and gases and identify that matter is made up of particles too small to be seen.
3-5 PS1: Differentiate between changes caused by heating or cooling that can be reversed and that cannot.
6-8 PS3: Analyze the properties and compare the sources of kinetic, elastic potential, gravitational potential, electric potential, chemical, and thermal energy.
6-8 PS3: Conduct an investigation to demonstrate the way that heat (thermal energy) moves among objects through radiation, conduction, or convection.
9-12 PS3: Investigate conduction, convection, and radiation as a mechanism for the transfer of thermal energy.

SCIENCE AND TECHNOLOGY CONTENT STANDARDS:

3-5 ETS2: Use appropriate tools and measurements to build a model.
3-5 ETS2: Identify how scientific discoveries lead to new and improved technologies.

MATERIALS INCLUDED

Liquid crystal sheet, in Supplementary Materials Section of Teacher's Manual
Vial of liquid crystal mixture
2 paint brushes
Printed cards with black squares (if you run out of cards a template to print more is provided in Supplementary Materials Section of Teacher's Manual)
Stickers, in Supplementary Materials Section of Teacher's Manual (squares of packing tape may be substituted)
Self-laminating pouches
Safety glasses
Liquid crystal mixture Material Safety Data Sheets (MSDS), in Supplementary Materials Section of Teacher's Manual

MATERIALS PROVIDED BY **Teacher**

None

For the entire activity and materials and to reserve a Suitcase Exhibit, please call 901.636.2362.

Activity VII: Exploring Materials – Ferrofluid

DURATION OF ACTIVITY: 30 minutes

LESSON OBJECTIVES

"Exploring Materials – Ferrofluid" is a hands-on activity demonstrating that a material can act differently when it's nanometer-sized. Students investigate the properties of ferrofluid and magnetic black sand, learning that the surprising difference in the behavior of these two materials is due to size.

GUIDING QUESTION

What's different about nanomaterials?

TENNESSEE STATE STANDARDS / NATIONAL SCIENCE EDUCATION STANDARDS

PHYSICAL SCIENCE CONTENT STANDARDS:

3-5 PS1:	Describe the properties of solids, liquids, and gases and identify that matter is made up of particles too small to be seen.
3-5 P21:	Explain the cause and effect relationship of magnets.
6-8 PS1:	Develop and construct elemental molecules and compound molecules.

SCIENCE AND TECHNOLOGY CONTENT STANDARDS:

3-5 ETS2:	Use appropriate tools and measurements to build a model.
3-5 ETS2:	Identify how scientific discoveries lead to new and improved technologies.

MATERIALS INCLUDED

Ferrofluid display cell
Vial of black sand
Magnets
Ferrofluid Material Safety Data Sheet (MSDS), in Supplementary Materials Section of Teacher's Manual

MATERIALS PROVIDED BY TEACHER

None

For the entire activity and materials and to reserve a Suitcase Exhibit, please call 901.636.2362.

ACTIVITY VIII: Exploring Structure – Buckyballs

DURATION OF ACTIVITY: 30 minutes

LESSON OBJECTIVES

"Exploring Structures – Buckyballs" is a hands-on activity in which students fold up a precut shape to make a model of a buckyball. They learn that buckyballs are tiny, soccer ball-shaped molecules made of carbon.

GUIDING QUESTION

What do nanostructures look like?

TENNESSEE STATE STANDARDS / NATIONAL SCIENCE EDUCATION STANDARDS

PHYSICAL SCIENCE CONTENT STANDARDS:

3-5 PS1: Describe the properties of solids, liquids, and gases and identify that matter is made up of particles too small to be seen.

3-5 PS1: Analyze and interpret data to show that the amount of matter is conserved even when it changes form, including transitions where matter seems to vanish.

6-8 PS1: Compare and contrast elemental molecules and compound molecules.

SCIENCE AND TECHNOLOGY CONTENT STANDARDS:

3-5 ETS2: Use appropriate tools and measurements to build a model.

3-5 ETS2: Identify how scientific discoveries lead to new and improved technologies.

MATERIALS INCLUDED

Carbon Structures poster
Die-cut paper buckyballs

MATERIALS PROVIDED BY TEACHER

None

For the entire activity and materials and to reserve a Suitcase Exhibit, please call 901.636.2362.

ACTIVITY IX: Exploring Measurement – Molecules

DURATION OF ACTIVITY: 60 minutes

LESSON OBJECTIVES

"Exploring Measurement – Molecules" lets students use their sense of smell to explore the world on the nanoscale. They learn that we can smell some things that are too small to see, and that a nanometer is a billionth of a meter.

GUIDING QUESTION

How small is a nanometer?

TENNESSEE STATE STANDARDS / NATIONAL SCIENCE EDUCATION STANDARDS

PHYSICAL SCIENCE CONTENT STANDARDS:

3-5 PS1:	Describe the properties of solids, liquids, and gases and identify that matter is made up of particles too small to be seen.
3-5 PS1:	Analyze and interpret data to show that the amount of matter is conserved even when it changes form, including transitions where matter seems to vanish.
6-8 PS1:	Compare and contrast elemental molecules and compound molecules.

SCIENCE AND TECHNOLOGY CONTENT STANDARDS:

3-5 ETS2:	Use appropriate tools and measurements to build a model.
3-5 ETS2:	Identify how scientific discoveries lead to new and improved technologies.
9-12 ETS2: used	Obtain, evaluate, and communicate information on how molecular biotechnology may be in a variety of fields.

MATERIALS INCLUDED

5 round balloons in different colors
5 different flavored extracts
Balloon pump
Latex warning sign, in Supplementary Materials Section of Teacher's Manual

MATERIALS PROVIDED BY TEACHER

Overhead projector marker
Key matching balloon colors with scents (blank template in Supplementary Materials section of Teacher's Manual)

For the entire activity and materials and to reserve a Suitcase Exhibit, please call 901.636.2362.

ACTIVITY X: Exploring Fabrication – Self-Assembly

DURATION OF ACTIVITY: 30 minutes

LESSON OBJECTIVES

"Exploring Fabrication – Self-Assembly" includes several full-body interactive games students can play to model the process of self-assembly in nature and nanotechnology. Students learn that self-assembly is a process by which molecules and cells form themselves into functional structures.

GUIDING QUESTIONS

Can nanostructures build themselves?

TENNESSEE STATE STANDARDS / NATIONAL SCIENCE EDUCATION STANDARDS

PHYSICAL SCIENCE CONTENT STANDARDS:

3-5 PS1:	Describe the properties of solids, liquids, and gases and identify that matter is made up of particles too small to be seen.
3-5 PS1:	Analyze and interpret data to show that the amount of matter is conserved even when it changes form, including transitions where matter seems to vanish.
6-8 PS1:	Compare and contrast elemental molecules and compound molecules.

SCIENCE AND TECHNOLOGY CONTENT STANDARDS:

3-5 ETS2:	Use appropriate tools and measurements to build a model.
3-5 ETS2:	Identify how scientific discoveries lead to new and improved technologies.

MATERIALS INCLUDED

12 blue gloves
12 red gloves

MATERIALS PROVIDED BY TEACHER

Large open space for students to move around

For the entire activity and materials and to reserve a Suitcase Exhibit, please call 901.636.2362.

ACTIVITY XI: Exploring Materials – Nano Fabric

DURATION OF ACTIVITY: 30 minutes

LESSON OBJECTIVES

"Exploring Nano Fabric" is a hands-on activity exploring how the applications of nano-sized whiskers can protect clothing from stains. Students investigate the hydrophobic properties of pants made from nano fabric and ordinary fabric.

GUIDING QUESTIONS

What's different about nanomaterials?

TENNESSEE STATE STANDARDS / NATIONAL SCIENCE EDUCATION STANDARDS

PHYSICAL SCIENCE CONTENT STANDARDS:

3-5 PS1: Describe the properties of solids, liquids, and gases and identify that matter is made up of particles too small to be seen.

3-5 PS1: Describe and compare the physical properties of matter including color, texture, shape, length, mass, temperature, volume, state, hardness, and flexibility.

SCIENCE AND TECHNOLOGY CONTENT STANDARDS:

3-5 ETS2: Identify how scientific discoveries lead to new and improved technologies.

MATERIALS INCLUDED

Pants made of nanotechnology stain-resistant fabric
Pants made of ordinary fabric
Dropper bottle
Tray

MATERIALS PROVIDED BY TEACHER

Water

For the entire activity and materials and to reserve a Suitcase Exhibit, please call 901.636.2362.

SUITCASE EXHIBIT INVENTORY CHECKLIST

School: _____
Check Out: _____
Return Date: _____

MoSH Check In:	Teacher Check In:	Item	Books/Videos/Posters	Teacher Return:
		A	Teacher's Manual	
		B	Poster: "How Tall Are You?" Height Chart	
		C	Poster: Carbon Structures	
		D	Poster: Zoom into the Human Bloodstream	
		E	Poster: Scale Ladder	
		F	Poster: The Atom	
		G	Book: DragonflyTV Nano Educators Guide	
		H	DVD: DragonflyTV Nano	
		I	Signs Binder	

SUITCASE EXHIBIT INVENTORY CHECKLIST

MoSH Check In:	Teacher Check In:	Item	Materials	Teacher Return:
		1	Sign Holders (14)	
		2	Tray	
		3	Gloves (12 red and 12 blue)	
			Items 4 – 10 in container	
		4	Variety of Flavored Extracts (5)	
		5	Balloons (5 - different colors)	
		6	Ferrofluid Display Cell	
		7	Vial of Black Sand	
		8	Magnets	
		9	Regular Teacup	
		10	Miniature Teacup	
			Items 11 – 17 in container	
		11	Balloon Pump	
		12	Large Demonstration Magnet and Large Probe Strip	
		13a	35 Small Probe Strip Magnets	
		13b	35 Medium Magnets	
		14	Die-cut Paper Buckyballs	
		15	Nanotechnology Stain-resistant Fabric	
		16	Ordinary Fabric	
		17	Dropper Bottle	
			Items 18 – 27 in container	
		18	Vial of Liquid Crystal Mixture	
		19	Paint Brushes (2)	
		20	Printed Cards with Black Squares	
		21	Self-laminating Pouches	
		22	Safety Glasses	
		23	100 mL Graduated Cylinders (2)	
		24	Small Plastic Cups (2)	
		25	Pitcher	
		26	Effervescent Antacid Tablets	
		27	Food Coloring	