EDUCATIONAL COMPANION FOR THE FILM

PROVIDED BY NATIONAL WILDLIFE FEDERATION

an inconvenient sequel
TRUTH TO POWER

LEARN LIKE YOUR WORLD DEPENDS ON IT

participant media

Paramount

A VIACOM COMPANY

an inconvenient sequel
TRUTH TO POWER

EDUCATIONAL COMPANION • WATCH KIT • MIDDLE-HIGH SCHOOL

Provided by National Wildlife Federation

INTRODUCTION

A decade after *An Inconvenient Truth* brought climate change into the heart of popular culture, comes the riveting and rousing follow-up, *An Inconvenient Sequel: Truth To Power*, that shows just how close we are to a real energy revolution. Vice President Al Gore continues his tireless fight traveling around the world training an army of climate champions and influencing international climate policy. Cameras follow him behind the scenes – in moments both private and public, funny and poignant – as he pursues the inspirational idea that while the stakes have never been higher, the perils of climate change can be overcome with human ingenuity and passion.

Photo Credit To Be Confirmed

As the film's education partner, National Wildlife Federation has teamed up with Participant Media and Paramount Pictures to provide educational resources to help students understand climate change while inspiring them to find ways to bring our nation across the finish line to a viable clean energy economy.

BEFORE, DURING AND AFTER: WATCHING *AN INCONVENIENT SEQUEL: TRUTH TO POWER*

LESSON SUMMARY

This **watch kit** is a viewing guide for the film and may be used over several class periods to introduce climate change or adapted as part of a larger unit to build greater understanding of the impacts of climate change and the civics, communications and economic issues and solutions that will shape the future health of our planet.

The activities presented below use systems thinking strategies to understand current climate change impacts locally and around the globe. Understanding how you think and what influences your decisions makes us better students, teachers, artists, musicians, athletes and citizens. Our goal is to help students develop critical thinking skills by leveraging the diverse perspectives and fact-based evidence shared in the film *An Inconvenient Sequel: Truth to Power.* Students will practice systems thinking as they share their own stories, analyze and reflect on biases, and construct new mental models about climate change solutions locally and globally -- supported by scientific facts and evidence from climate change effects in their own community and across their country.

We hope to **Engage**, **Educate** and **Empower** a world of "Systems Thinkers," who understand scientific principles and can discern truth from misinformation, who want to solve the problems of climate change and take advantage of the opportunities the new green economy affords.

Note: The **watch kit** is available for use by international audiences and may be adapted for non-commercial educational purposes. The **watch kit** is also available to our international Eco-Schools community. Please contact Eco-SchoolsUSA at nwf.org/Eco-Schools-USA if assistance is required.

LEARNING OBJECTIVES

STUDENTS WILL:

- Define and use scientific terms and climate change related vocabulary to discuss, reflect and write about current events.
- Identify and describe their current mental models about climate change.
- Develop their ability to discern scientific fact (truth) from misinformation.
- Adapt or construct new mental models about climate change based on facts presented in *An Inconvenient Sequel: Truth to Power*
- Use *An Inconvenient Sequel: Truth to Power* as a resource to increase climate change content knowledge.
- Use primary and secondary sources to discern fact from misinformation.
- Improve skills in reading and writing across the content areas, specifically the social studies, sciences and technical subjects.

TIME NEEDED

Several class periods or (2) two hour after school gatherings

- Before Watching Activity – 45-60 minutes
- Film Length – 100 minutes
- After Watching Activity – 45-60 minutes
- With various possible extensions

MATERIALS

- Website: *An Inconvenient Sequel: Truth to Power* Education www.inconvenientsequeleducation.org/
- Copy of Truth in 10 slide presentation: www.climaterealityproject.org/truth
- Video: DSRP Four Simple Rules of Systems Thinking: www.thinkwater.us
- Worksheet 1: Climate Reality - Impacts
- Worksheet 2: Climate Reality – Effects on My Behavior
- Vocabulary List
- Teacher Notes
- Science notebook
- MS/HS NGSS Standards
- Common Core Alignment

LESSON PLANS

BEFORE WATCHING

1. Define: Evidence | Mental Model | Distinction | Systems | Relationship | Perspective

   Ask students to define these terms in their science notebook. Then ask them to discuss in pairs or small groups. As a whole class, come to a consensus and define each term on a separate chart paper post-it. Post each term in the room. Changes can be made as thinking and understanding of the terms change.

Photo Credit To Be Confirmed

2. Watch in class -DSRP-Four Simple Rules of Systems Thinking, 11:55 – www.thinkwater.us, then consider revising terms in number one. *See **Teacher's Notes** for more background.*

3. Based on their current mental models, have students complete **Worksheet 1. Climate Reality - Impacts.**

4. Have students answer questions in science notebook (Students need to generate their own opinions/responses), then pair up and discuss. Next have a whole class discussion.

   a. Do you think your actions impact our environment?

   b. Do you think your actions impact climate?

   c. How do you know what to believe as true or false?

   d. When determining an argument's validity, how do you determine whether or not a sources is credible?

WHILE WATCHING

Encourage students to jot down key words, phrases, quotes or sketches throughout the film. Students will use their notes following the film to reflect, answer questions and have discussions.

AFTER WATCHING

1. Review your notes and reflect on the evidence presented and the stories shared leading up to the Paris Climate Agreement.

2. Hand students back their completed **Worksheet 1. Climate Reality - Impacts** (if you took them up). Ask students to review their responses and compare them to their notes and the questions they answered prior to viewing the film. Focus on any mismatches of information and changes in prior mindset that may have occurred as a result.

3. Based on current mental models, have students complete **Worksheet 2. Climate Change Impacts – Effects on My Behavior.**

4. Ask students if they recall or wrote down any memorable quotes from the film. A list of quotes from the film and other notable sources is provided below. Read the quotes aloud to students or post them around the classroom for students to read and think about. Instruct students to use a quote from the list below or select their own and write a short paragraph on what it means in the context of the film and current events; or lead a classroom discussion asking students to share their thoughts and ideas about the meaning of each quote in the context of climate change issues and solutions.

   "After the final no there comes a yes and on that yes the future world depends." - *Wallace Stevens*

   "All beauty of the world is at risk" - *Al Gore*

   "There have been times in my work with climate change, I have to admit, when my optimism was in some measure an act of will. But we're changing, we're changing." - *Al Gore*

   "An individual has not started living until he can rise above the narrow confines of his individualistic concerns to the broader concerns of all humanity." - *Martin Luther King, Jr.*

   "The next generation, if they lived in a world of floods and storms and rising sea levels and droughts and refugees by the millions escaping unlivable conditions, destabilizing countries around the world, they would be well justified in looking back and asking, 'What were you thinking'?" - *Al Gore*

   "The gravest effects of attacks on the environment are suffered by the poorest." - *Pope Francis*

   "We shall require a substantially new manner of thinking if mankind is to survive." - *Albert Einstein*

   " I try to answer to the truth of what needs to be done. Each of us in our own ways has the obligation and some ability to feel what is more likely to be true than not… that's not arrogance, that's a feeling I think everyone is familiar with, and I've been working on this long enough that I feel very, very deeply about what the right thing is. I'm not confused about it." - *Al Gore*

5. A) The film concludes with:

   - **Use your Choice**
   - **Use your Voice**
   - **Use your Vote**

   Have students design posters about the behaviors and actions they will take based on seeing the film and their updated mental models.

   B) Using the DSRP system posters www.thinkwater.us/downloadable-resources or the answers to their Worksheet 2, have students create their own posters using climate change to invoke mental models for distinctions, systems, relationships and perspectives.

   Once complete, hang in the hall and have students conduct a "gallery walk" and see how student's mental models compare and how their ideas are similar and unique.

6. Taking into consideration your distinctions, systems, relationships and perspectives, answer the movie's final question, "What issues or solutions are you interested in learning more about?" Have students make a personal behavior list and brainstorm solutions for your entire school and greater community. (Consider student answers when choosing which lessons you will use in the corresponding *An Inconvenient Sequel: Truth to Power* curriculum. These investigations will help you enter our Truth To Power: School Climate Solutions Challenge.)

TEACHER REFLECTION

Based on the film and student discussions and activities:

a. How have students' or the groups' views changed?

b. What information had the greatest impact on them?

c. What thinking has remained the same?

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TEACHERS NOTES

National Wildlife Federation's educational programming believes in the power of systems thinking and the importance of building students' knowledge and skills as systems thinkers. This is why we are using the work of THINKWATER to help students develop a systems thinking mindset. Below are notes taken directly from THINKWATER's video, *DSRP: Four simple rules of systems thinking.* To learn more about THINKWATER and ways you can nurture systems thinking in your students, visit: www.thinkwater.us.

4 SIMPLE PATTERNS OF SYSTEMS THINKING

1. **DISTINCTIONS** between things and other things.
2. We organize things into **SYSTEMS**, systems of parts and wholes.
3. We identify **RELATIONSHIPS** with actions and reactions or cause and effect.
4. We take **PERSPECTIVES** from a point to a view.

All four patterns are happening all together, simultaneously, all the time within us and those around us.

Mental models are knowledge. They are what we build when we make meaning out of information, memories and experience. Our mental models are unique to each individual. Mental models are powerful because they determine how you feel.

Making distinctions is easy. Everything has an identity. Distinctions come from the other, the thing that is not that thing, i.e. beverages versus food, doors versus windows, a small cup versus a large cup. We make distinctions with all of our senses and they are probably different from everyone else's distinctions. Making distinctions is seeing what an object or idea is or is not.

Another way thinking works is by organizing things into systems, systems of parts and wholes, they can be really big or really small, complicated or simple. Systems give us a framework in which to see the world.

Relationships don't just exist amongst people, but also between objects and ideas. A relationship is an interaction, a cause and effect, an action and reaction. To see the importance of how ideas effect each other, is to see things differently, to build new knowledge, to solve problems that matter. Relationships exist everywhere.

Our point of view shapes how we think about something, the mental model we build to understand it. Perspective determines not just what we look at, but what we really see. Perspective is at the root of so many things that matter in society, empathy, compassion, connectedness. It determines how we relate to people in the world around us.

Understanding how you think makes you a better student, artist, musician, athlete, and citizen. You just have to pay attention to the way your brain is already operating, thinking about thinking.

TEACHER MODELED-WHOLE CLASS

Optional: If you want students to have more practice in developing mental models and DSRP, use the DSRP systems posters and lesson plans around the topic of water resources. www.thinkwater.us/downloadable-resources, to facilitate more conversations and opportunities to practice.

WORKSHEET 1. CLIMATE REALITY - IMPACTS

Use your mental models about climate change to complete the chart below and document your current thinking about the impacts of climate change. What do you know about the following concepts? What do you believe to be true and how do you know it is true. What is the evidence? The first one is done for you as an example.

CLIMATE REALITY	CURRENT MENTAL MODEL WHAT DO I BELIEVE?	EVIDENCE
16 of the 17 hottest years ever measured with instruments have occurred since 2001 and 2016 was the hottest year ever recorded.	True, I believe 2016 was the hottest year ever recorded.	My teacher shared current events with the class; I have read articles online;quote from the film; and I follow @nasaclimate on twitter.
Miami, Florida is the number one city in the world, in terms of assets, that is at risk from impacts associated with sea level rise and number nine in the world in terms of population at risk.		
110 million tons of manmade global warming pollution is released into the atmosphere every 24 hours and is building up and trapping heat.		
The main source and cause of the rising global temperatures we see today is the result of the burning of fossil fuels.		
On a global basis, more than 90% of all the extra heat energy trapped by our atmosphere in going into the oceans.		
The extra heat being trapped in our atmosphere is changing our precipitation patterns causing extreme flooding and drought in places around the world.		
Higher temperatures have a direct effect on the incidence and severity of wildfires.		

CLIMATE REALITY	CURRENT MENTAL MODEL WHAT DO I BELIEVE?	EVIDENCE
In 2016 extreme weather catastrophes, such as extreme temperatures, droughts, fires, floods, mudslides and storms, caused $175 billion in losses.		
Heat stress is beginning to decrease crop yields from rice, corn and soybeans and exposure to higher levels of CO2 is decreasing the nutrient content of many staple crops such as rice, wheat and soy.		
As our world gets warmer and wetter, the range of tropical diseases expands, meaning there are more places for tropical diseases to take root. Tropical diseases include, West Nile Virus, Chikungunya, Chagas Disease, Dengue Fever and Zika Virus.		
Climate change, along with other factors such as habitat loss, is contributing to the worst extinction event since the extinction of the dinosaurs 65 million years ago.		
Globally, wind could supply our electricity consumption needs 40 times over.		
Every hour the Earth gets as much energy from the sun as we need to run the entire global economy for a year.		
The Paris Climate Accord is an agreement between most every country in the nation to phase down greenhouse gas pollution to net zero emissions as early in the second half of this century as possible.		

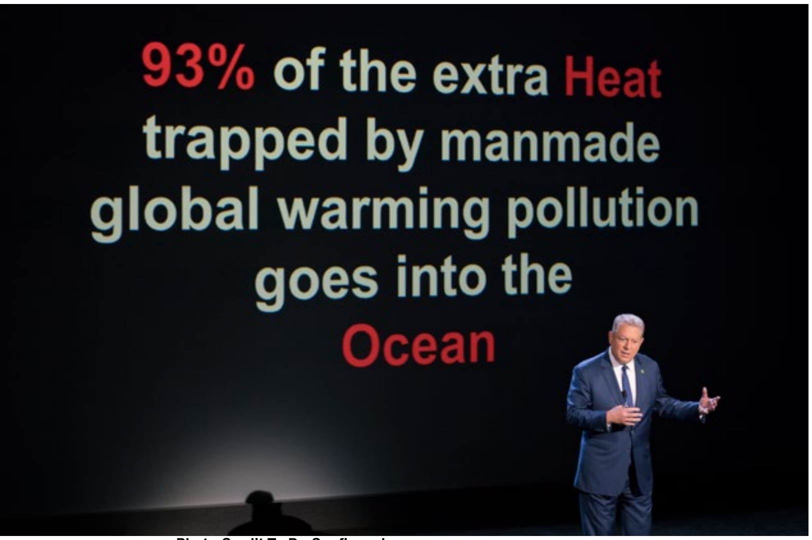
See **References** linking each fact to its primary source.

WORKSHEET 2 - TEACHER'S NOTES

CLIMATE REALITY – EFFECTS ON MY BEHAVIOR

Read through the instructions on **Worksheet 2. Climate Reality - Effects on my Behavior**. Talk through the example below with your students before they complete the worksheet that follows.

REALITY MISMATCH WITH MY PREVIOUS MENTAL MODEL	HOW IS OR HAS MY THINKING OR BEHAVIOR CHANGED(ING)? HOW AM I RESHAPING MY MENTAL MODEL?	WHAT ACTIONS AM I PREPARED TO TAKE AS I CONSTRUCT NEW MENTAL MODELS?
My mental model: Climate change is cyclical. This is just a natural part of how the Earth system functions and is not caused by carbon emissions from human activity (burning fossil fuels, deforestatin, etc...) Reality: Climate has natural cycles, but current climate changes are not natural and are caused by human activity.	I am learning more about the science behind climate change and how different Earth systems are changing. I am learning to distinguish between fact and opinion and to rely on credible, multiple, fact-based sources before coming to my own conclusions.	I will take a more active role in discerning facts from opinions - not believing everything I hear. I will use my voice for change and I will think about my choices. I will register to vote as soon as I am eligible. I will find ways to use my talents to better the environment. I will learn about the green economy and career paths.



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WORKSHEET 2

CLIMATE REALITY – EFFECTS ON MY BEHAVIOR

After completing **Worksheet 1. Climate Reality - Impacts**, watching the film and conducting investigations, is there a mismatch in the reality presented and your previous mental models? If so, are there modifications you can make in your thinking and your behavior? What actions will you take? An example is provided to help you get started. There is not a maximum, minimum or average for the number of mental model mismatches one may have. Think critically as this exercise is based on your knowledge and mental models and no one else's. Use the facts presented in Worksheet 1 as a guide or start with the strongest fact that lead to a change in your thoughts and actions.

REALIZING THAT WHAT I THINK AND REALITY ARE NOT THE SAME What is the mismatch?	LEADS TO	CHANGE IN MY BEHAVIOR What will I think and do differently now?
	LEADS TO	
	LEADS TO	
	LEADS TO	
	LEADS TO	

REFERENCES

16 of the 17 hottest years ever measured with instruments have occurred since 2001; 2016 was the hottest year of all.

NASA, www.nasa.gov/press-release/nasa-noaa-data-show-2016-warmest-year-on-record-globally
USA Today, www.usatoday.com/story/weather/2017/01/18/hottest-year-on-record/96713338/

Miami, Florida is the number one city in the world, in terms of assets, that is at risk from impacts associated with sea level rise and number nine in the world in terms of population at risk.

Assets at Risk, Nichols et al. 2007, OECD

110 million tons of manmade global warming pollution is released into the atmosphere every 24 hours and is building up and trapping heat.

EcoWatch, www.ecowatch.com/al-gore-3-questions-we-have-to-answer-about-climate-change-1882181044.html

The main source and cause of the rising global temperatures we see today is the result of the burning of fossil fuels.

NASA, www.climate.nasa.gov/causes/
UCSUSA, www.ucsusa.org/global_warming/science_and_impacts/science/global-warming-faq.html#.WW5cxYfrvIU

On a global basis, more than 90% of all the extra heat energy trapped by our atmosphere in going into the oceans.

L.Cheng, K.E. Trenberth, et al., “Improved estimates of ocean heat content from 1960 to 2015.” Science Advances. 10 March 2017.

The extra heat being trapped in our atmosphere is changing our precipitation patterns causing extreme flooding and drought in places around the world.

Marvel, Kate and Celine Bonfils, “Identifying external influences on global precipitation”. Proceedings of the National Academy of Sciences of the United States of America. 11 November, 2013.

Higher temperatures have a direct effect on the incidence and severity of wildfires.

NOAA, USFS-Climate Central,
Barbero, R.; Abatzoglou, J.T.; Larkin, N.K.; Kolden, C.A.; Stocks, B. 2015. Climate change presents increased potential for very large fires in the contiguous United States. International Journal of Wildland Fire.

In 2016 extreme weather catastrophes, such as extreme temperatures, droughts, fires, floods, mudslides and storms, caused $175 billion in losses.

Data: Insurance Information Institute, January 2017.

Heat stress is beginning to decrease crop yields from rice, corn and soybeans and exposure to higher levels of CO2 is decreasing the nutrient content of many staple crops such as rice, wheat and soy.

U.S. Department of Defense, 2014 Climate Change Adaptation RoadmapTeixeira, Edmar I., Guenther Fischer, Harrij Van Velthuizen, Christof Walter, and Frank Ewert. “Global Hot-spots of Heat Stress on Agricultural Crops Due to Climate Change.” Agricultural and Forest Meteorology 170 (March 15, 2013): 206-15. Web. 7 July 2017.

As our world gets warmer and wetter, the range of tropical diseases expands, meaning there are more places for tropical diseases to take root. Tropical diseases include, West Nile Virus, Chikungunya, Chagas Disease, Dengue Fever and Zika Virus.

Jr., Donald G. McNeil. “U.S. Becomes More Vulnerable to Tropical Diseases Like Zika.” The New York Times. The New York Times, 04 Jan. 2016. Web. 18 July 2017.

Climate change, along with other factors such as habitat loss, is contributing to the worst extinction event since the extinction of the dinosaurs 65 million years ago.

Stern, Nicholas. The Economics of Climate Change. Cambridge University Press, 2007.
Ceballos, Gerardo, Paul R. Ehrlich, and Rodolfo Dirzo. “Biological Annihilation via the Ongoing Sixth Mass Extinction Signaled by Vertebrate Population Losses and Declines.” Proceedings of the National Academy of Sciences (2017): n. pag. Web. 18 July 2017. www.pnas.org/content/early/2017/07/05/1704949114.full?tab=author-info>.

Globally, wind could supply our electricity consumption needs 40 times over.

Earth Policy Institute/BNEF

Every hour the Earth gets as much energy from the sun as we need to run the entire global economy for a year.

Science in Society, www.i-sis.org.uk/windPowerElectricity.php
Lu X, McElroy MB and Kiviluoma J. Global potential for wind- electrical system in 2008, generated electricity. PNAS 2009,106, 10933-8, www.pnas.org/cgi/doi/10.1073/pnas.0904101106

The Paris Climate Accord is an agreement between most every country in the nation to phase down greenhouse gas pollution to net zero emissions as early in the second half of this century as possible.

United Nations: Treaty Collection. 12 December, 2015. www.treaties.un.org/pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-7-d&chapter=27&clang=_en

Photo Credit To Be Confirmed

VOCABULARY FOR ALL EDUCATION MATERIALS

Terms and definitions for *An Inconvenient Sequel: Truth to Power* watch kit, Truth in 10 slide presentation, Lesson Plans and Truth to Power School Climate Solutions Challenge.

atmosphere	green energy	pollution
battery storage	greenhouse gases	poverty
carbon dioxide	habitat loss	renewable resources
clean energy solutions	heat exhaustion	scientific community
climate change	heat stroke	sea level rise
climate refugees	heat trapping gases	solar energy
COP21	high tide	solar radiation
crystalline silicon solar cells	ice mass	statistically significant
drought	ice melt	stop gap measures
electric vehicles (EVs)	ice sheet	storm surge
electricity grid	infectious disease	stratosphere
EPA	infrared radiation	sustainable development
extreme weather events	IPCC	Sustainable Development Goals
financial assets	LED lights	troposphere
flood	mass extinction	water cycle
food shortage	NASA	water shortage
fossil fuels	NOAA	waterborne disease
glacier	ocean current	wildfire
global ocean heat	pandemic	wildfire season
global surface temperature	Paris Climate Accord	wind energy
global warming	People's Climate March	World Economic Forum

Listed below are the applicable **Next Generation Science Standards** teachers can use as they develop project-based learning experiences for their students in conjunction with the movie, *An Inconvenient Sequel: Truth to Power*, the presentation, Truth in 10 and National Wildlife Federation's educational resources.

SCIENCE AND ENGINEERING PRACTICES

Science is not just a body of knowledge that reflects current understanding of the world; it is also a set of practices use to establish, extend and refine that knowledge. Both elements-knowledge and practice-are essential. As in all inquiry-based approaches to science teaching, our expectation is that students will themselves engage in the practices and not merely learn about them secondhand. Students cannot comprehend scientific practices, nor fully appreciate the nature of scientific knowledge itself, without directly experiencing those practices for themselves.

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science and designing solutions for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating and communicating information

CROSSCUTTING CONCEPTS

The cross-cutting concepts have applications across all domains of science. These concepts help provide students with an organizational framework for connecting knowledge from the various disciplines into a coherent and scientifically based view of the world.

1. (1) Patterns
2. (2) Cause and Effect
3. (4) Systems and Systems Models
4. (5) Energy and Matter in Systems
5. (7) Stability and Change of Systems

DISCIPLINARY CORE IDEAS

An important role of science education is not to teach "all the facts" but rather prepare students with sufficient core knowledge so that they can later acquire additional information on their own.

PHYSICAL SCIENCE – MIDDLE SCHOOL

MS STRUCTURE AND PROPERTIES OF MATTER

MS-PS1-4. Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substances when thermal energy is added or removed. Clarification statement: Emphasis is on qualitative molecular-level models of solids, liquids, and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs. Examples of models could include drawings and diagrams. Examples of particles could include molecules or inert atoms. Examples of pure substances could include water, carbon dioxide and helium.

MS ENERGY

MS-PS3-1. Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object. Clarification Statement: Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed. Examples could include riding a bicycle at different speeds, rolling different sizes of rocks downhill, and getting hit by a wiffle ball versus a tennis ball.

MS-PS3-2. Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. Clarification Statement: Emphasis is on relative amounts of potential energy, not on calculations of potential energy. Examples of objects within systems interacting at varying distances could include: the Earth and either a roller coaster cart at varying positions on a hill or objects at varying heights on shelves, changing the direction/orientation of a magnet, and a balloon with static electrical charge being brought closer to a classmate's hair. Examples of models could include representations, diagrams, pictures, and written descriptions of systems.

MS-PS3-3. Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. Clarification Statement: Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup.

MS-PS3-4. Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample. Clarification Statement: Examples of experiments could include comparing final water temperatures after different masses of ice melted in the same volume of water with the same initial temperature, the temperature change of samples of different materials with the same mass as they cool or heat in the environment, or the same material with different masses when a specific amount of energy is added.

MS-PS3-5. Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. Clarification Statement: Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of object.

MS. WAVES AND ELECTROMAGNETIC RADIATION

MS-PS4-2. Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. Clarification Statement: Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.

LIFE SCIENCE – MIDDLE SCHOOL

MS-MATTER AND ENERGY IN ORGANISMS AND ECOSYSTEMS

MS-LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. Clarification Statement: Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources.

MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. Clarification Statement: Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.

MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. Clarification Statement: Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems.

MS-LS-2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services. Clarification Statement: Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.

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EARTH SCIENCE – MIDDLE SCHOOL

MS-EARTH SYSTEMS

MS-ESS3-1. Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes. Clarification Statement: Emphasis is on how these resources are limited and typically non-renewable, and how their distributions are significantly changing as a result of removal by humans. Examples of uneven distributions of resources as a result of past processes include but are not limited to petroleum (locations of the burial of organic marine sediments and subsequent geologic traps), metal ores (locations of past volcanic and hydrothermal activity associated with subduction zones), and soil (locations of active weathering and/or deposition of rock).

MS-HUMAN IMPACTS

MS-ESS3-2. Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.
Clarification Statement: Emphasis is on how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable. Examples of natural hazards can be taken from interior processes (such as earthquakes and volcanic eruptions), surface processes (such as mass wasting and tsunamis), or severe weather events (such as hurricanes, tornadoes, and floods). Examples of data can include the locations, magnitudes, and frequencies of the natural hazards. Examples of technologies can be global (such as satellite systems to monitor hurricanes or forest fires) or local (such as building basements in tornado-prone regions or reservoirs to mitigate droughts).

MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. Clarification Statement: Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact. Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land).

MS-ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems. Clarification Statement: Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.

MS-WEATHER AND CLIMATE

MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century. Clarification Statement: Examples of factors include human activities (such as fossil fuel combustion, cement production, and agricultural activity) and natural processes (such as changes in incoming solar radiation or volcanic activity). Examples of evidence can include tables, graphs, and maps of global and regional temperatures, atmospheric levels of gases such as carbon dioxide and methane, and the rates of human activities. Emphasis is on the major role that human activities play in causing the rise in global temperatures.

HIGH SCHOOL – ENGINEERING DESIGN

MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions

MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

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PHYSICAL SCIENCE – HIGH SCHOOL

HS-CHEMICAL REACTIONS

HS-PS1-5. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. Clarification Statement: Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules. Assessment Boundary: Assessment is limited to simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature.

HS-PS1-6. Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium. Clarification Statement: Emphasis is on the application of Le Chatlier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.

HS ENERGY

HS-PS3-1. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.

HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects). Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.

HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.

HS WAVES AND ELECTROMAGNETIC RADIATION

HS-PS4-1. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. Clarification Statement: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.

HS-PS4-4. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. Clarification Statement: Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias.

HS-PS4-5. Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy. Clarification Statement: Examples could include solar cells capturing light and converting

LIFE SCIENCE – HIGH SCHOOL

HS-MATTER AND ENERGY IN ORGANISMS AND ECOSYSTEMS

HS-LS2-4. Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. Clarification Statement: Emphasis is on using a mathematical model of stored energy in biomass to describe the transfer of energy from on trophic level to another and that matter and energy are conserved as matter cycles and energy glows through ecosystems. Emphasis is on atoms and molecules such as carbon, oxygen, hydrogen and nitrogen being conserved as they move through an ecosystem.

HS-LS2-5. Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere and geosphere. Clarification Statement: Examples of models include simulations and mathematical models.

HS-INTERDEPENDENT RELATIONSHIPS IN ECOSYSTEMS

HS-LS2-1. Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales. Clarification Statement: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.

HS-LS2-2. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.

HS-LS2-6. Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem. Clarification Statement: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.

HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.

HS-LS4-6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity. Clarification Statement: Emphasis is on designing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.

EARTH SCIENCE – HIGH SCHOOL

HS EARTH'S SYSTEMS

HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems. Clarification Statement: Examples should include climate feedbacks, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.

HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. Clarification Statement: Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids).

HS-ESS2-6. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. Clarification Statement: Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.

WEATHER AND CLIMATE

HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. Clarification Statement: Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition.

HS-ESS3-5. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems. Clarification Statement: Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).

HUMAN SUSTAINABILITY

HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.

HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios. Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.

HS-ESS3-3. Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. Clarification Statement: Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.

HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems. Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).

HS-ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity. Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.

HIGH SCHOOL ENGINEERING DESIGN – GREAT CONNECTION TO UPCOMING CONTEST

HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

HS-ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.