Toxicity

Exploring the physical science of chemical reactions and patterns in the periodic table of elements via lessons on toxicity.

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SUBJECT/GRADE LEVEL

Subject Area: Science

Grade Level: High School

Materials

- Goggles
- Computers: Laptops
- Microsoft's HoloLens: What You Don't Know - YouTube
- Meta: The VR Chemistry Lab
- Build molecule models with molecular models
- Balance
- NaCl (table salt)
- Distilled water
- Petri dishes
- Filter paper
- Seeds
- 1000 ml beaker (or other 1 liter container)
- 100 ml graduated cylinder
- Pipet
- Toxicology Choice Board

STANDARDS

Next Generation Science Standards

- HS-PS1-1: Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.
- HS-PS1-2: Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

Mathematics Standards | Common Core State Standards

- HSN-Q.A.1: Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2)
- HSN-Q.A.3: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-2)

English Language Arts Standards | Common Core State

- RST.9-10.7: Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)
- WHST.9-12.5: Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2)
- WHST.9-12.5: Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

LESSON OBJECTIVE(S)

Students will be able to:

- Students will gain deep understanding of what toxicity is by analyzing scientific articles, doing science assays, engaging in a podcast, participating in a digital escape room, conducting webinars and making Cornell notes from their studies from various websites.
- Students will use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. [Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.
- Students will construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.
- Students will recognize and recall specific vocabulary:
    - (for example, atom, atomic mass, atomic nucleus, atomic number, bond, electron, element, element stability, elements of matter, main group element, model, neutron, outermost energy level, pattern, periodic table, predict, property, proton, reaction reactivity, relative, relative mass, weight of subatomic particles.
    - (for example, acid/base reaction, atom, atomic configuration, atomic reaction, carbon, chemical property, chemical properties of elements, chemical reaction rate, hydrogen, main group element, outcome, outermost electron state, pattern, periodic table, reaction, simple chemical reaction, sodium, trend).

CAREER CONNECTION(S)

Mentor Background: Dr. Fudge Dylan, Research Chemist, Aberdeen Proving Ground, Maryland

Dr. Dylan Fudge is a research chemist working at DEVCOM Chemical Biological Center (CBC) with a focus on molecular toxicology with the threat agent sciences division. Dylan's current research aims to benefit the modern-day warfighter faced with biological and chemical threats by utilizing and advancing organ-on-a-chip (OOC) technology.

STEM Careers: Toxicology is a field that offers a variety of career paths[123]. Some of the types of jobs in toxicology include: Forensic toxicology (working in police stations, morgues, government agencies, and at crime scenes)[12,] Medical toxicology (working in medical facilities)[12], industrial or occupational toxicology[2,] Regulatory toxicology[2,] Environmental toxicology: working in laboratories and in the field[12,] Teaching[3,] Research[1]

ENGAGEMENT

Brief Description: In this first phase of the cycle, the teacher aims to **assess students prior knowledge and/or identify possible misconceptions about toxicity and molecules.** This student-centered phase is a **motivational period** that hopefully creates a desire for students to learn more about toxicity and molecules.

Procedures: Teachers can provide a choice board for students to complete a variety of activities.

a. Students **brainstorm** an opening question about what chemicals are made of.
b. Next, students complete a **KWL**. They are asked "What do I already know about toxins?" A graphic organizer, KWL chart is included to create interest or generate curiosity. This KWL asks students to brainstorm and record what they Know about toxicity, what they want to know, and (eventually) have Learned about a toxic train spill in Ohio. This KWL chart is used to pre-assess the students prior knowledge and will be referred to throughout the duration of the lesson.
c. Students follow up with visual representation of molecules in Holo-lens2 or Meta and they build models of simple molecules. Students will draw what they see in their science notebook.
d. If you have more time, and depending on student ability, there are also instructions/ ideas to further engage students with:
    - Creative Writing Activity
    - Stakeholder Role Play Activity

The link above includes examples and questions for:

1. KWL activity
2. Links for building and visualizing molecules
3. Video link for train derailment
4. Reading link
5. Writing prompt with suggested graphic organizer

If you have more time, and depending on student ability, there are also instructions/ ideas to further engage students with:

- a Creative Writing Activity and
- a Stakeholder Role Play Activity.

EXPLORATION

Brief Description: Students will conduct hands-on labs (assays) that meet the standards of the NGSS. It also includes work that meets the English language arts standards whereby students read, write and critically analyze scientific text and articles. They meet the math standards when students measure and solve multi-step math problems involving the periodic table and chemicals.

Procedures:

a. **Bioassay**: It should take 1-2 days to do the assay and 5 days to collect observations and form conclusions. Students expose radish seeds to various concentrations of sodium chloride to measure toxicity.
b. **Science Articles and webquest on toxicity:** Students critically analyze science articles and form claims-evidence-reasoning statements.. Students should be able to complete this work in 1-2 weeks.

Toxicology Exploration Activities: These activities get students to:

1. Exploring standards and vocabulary
2. Toxicity labs
3. Reading selections on toxicity in the real world
4. Tips for students when analyzing two articles
5. Toxicology webquest
6. Various simulations in the context of various fields of toxicology, forensics, ethics, etc.
7. Interactive work from Tales from the Poisoner's Handbook

8. Wood Alcohol poisonings and impact on toxicology
9. Organ chip technology
10. Transfer journal
11. Metacognitive strategies
12. Real world toxicology investigations
13. Digital escape challenge: Toxicology and Cracking the Code

EXPLANATION

Brief Description: Students will do online science work at ck12.org and begin to refine what it is they are supposed to have learned from their activities. They begin to test their own knowledge.

Procedures:

a. **CK12:** These activities can be done in or outside of the classroom. The activities can be added to the Google classroom and the grades can be imported into a student information system. CK12 activities are NGSS aligned. They involve videos, online activities and assessments of knowledge. Students are asked to take notes on what they learn in their Cornell notes graphic organizer or in a science notebook. .
b. Students define what toxicology is. Students then create Cornell notes that explain what is outlined in the standards and what it is that they have learned. They then take that information and create spaced-repetition notecards to study for assessments. They highlight a toxicology career that they find interestng The time frame for this work is one week. Teachers guide and check the work that students are completing. Students can compare and share their notes with fellow students.Students can work in groups to test their knowledge with fellow students. The teacher can ensure that students are capturing pertinent information that meets the standards.

Explain-Toxicology Activities: This link includes 4 overarching questions/ vocabulary that can be used as a standalone review or broken up into exit tickets over a course of a few days.

EXTEND

Brief Description: These are a series of lessons where students further their understanding of what toxicology and toxicity is. Advanced students can take preliminary college level courses and there are assessments to begin to inquire about what students know and are able to do.

Procedures:

a. Toxicology Lab: Introduction to Toxicology Lesson Plan: This lesson plan serves as an introduction to toxicology for the high school classroom. This lesson utilizes students' prior knowledge and engages them in the study of toxicology. Students will explore the differences between man-made and natural toxic substances. Students will learn the basics of the dose-response principle and obtain information they can use in the future to make wise decisions for themselves and their families. This lesson plan is useful in chemistry, physical sciences, and biology as you begin to talk about all things chemical and the importance of chemical reactions in our everyday lives, as well as the effects of chemicals on all living organisms.
b. Students investigate people who were harmed from toxins.
c. Students investigate milkweeds and pesticide toxicity.
d. Students who want to take advanced courses can study the National Library of Medicine Toxicology Courses.
e. Students take formative assessments

Extend-Toxicology activities: This link directs teachers to the following activities:

1. Toxicology lab (useful for those who need extra support)
2. Lethal Dose Toxicity Calculations: determining and understanding lethal dosage
3. Mini-research on celebrities who have died from a toxin-related death
4. Milkweed plants and pesticides (for those interested in Monarch butterflies and pollinators)
5. Toxicology courses online (links)
6. Khan academy: periodic table and formative assessment

EVALUATION

Brief Description:

Assessments of student learning includes level score work that in addition to score 3.0 performance, the student demonstrates in-depth inferences and applications that go beyond what was taught. **(Claims-Evidence-Reasoning). This is done with Data Nuggets. Students complete level 2 vocabulary and level 3 work for the two chemistry standards.**

Procedures:

Students analyze data in the Data Nuggets and reason during the claims-evidence-reasoning portion of the document.

Level 2 work is vocabulary work and level 3 is done to find patterns in the periodic table and diagramming electron dot diagrams.

Evaluation-Toxicology: This link directs teachers to the Data Nuggets, Rubric, and Vocabulary.

REFERENCES

Career Connections: Toxicology Careers:

1. Forensic toxicology: working in police stations, morgues, government agencies, and at crime scenes
2. Medical toxicology: working in medical facilities
3. Industrial or occupational toxicology
4. Regulatory toxicology
5. Environmental toxicology: working in laboratories and in the field
6. Teaching
7. Research
8. What does a toxicologist do? - CareerExplorer
9. Toxicology Career Paths for Science Enthusiasts | GCU Blog
10. How To Become a Toxicologist: Education and Career Requirements | Indeed.com
11. Becoming a Toxicologist—Society of Toxicology
12. Toxicology 101: What they test for and why - YouTube
13. (280) Find out more about careers in toxicology - YouTube
14. (280) What are exciting career paths in toxicology? - YouTube
15. (280) The Unique Job of A Forensic Toxicologist - YouTube
16. (280) Applications of Toxicology | Part 1 | TL Chemistry - YouTube
17. Toxicology Career Paths for Science Enthusiasts | GCU Blog
18. Becoming a Toxicologist—Society of Toxicology
19. Toxicology 101: What they test for and why - YouTube
20. (280) Find out more about careers in toxicology - YouTube
21. (280) What are exciting career paths in toxicology? - YouTube
22. (280) The Unique Job of A Forensic Toxicologist - YouTube
23. (280) Applications of Toxicology | Part 1 | TL Chemistry - YouTube
24. (280) Applications of Toxicology | Part 2 | TL Chemistry - YouTube
25. Molecular Toxicology degree at Berkley
26. The Toxicology Education Summit: Building the Future of Toxicology Through Education

Engage:

1. Hololens 2: For example: Microsoft's HoloLens: What You Don't Know - YouTube
2. Molecules can be visualized with Meta: The VR Chemistry Lab
3. Students make models of molecules with: OLD NOBBY Organic Chemistry Model Kit (239 pc) - Molecular Models Kit with Atoms, Bonds
4. Release of toxic chemicals from train derailment in Ohio prompts broader safety concerns
5. Residents concerned about toxic gases from Ohio train derailment
6. Role playing activity for train derailment

Explore:

1. How to analyze a scientific Article: Paul, Richard & Elder, Linda (2015). The Thinker's Guide to Scientific Thinking: Based on Critical Thinking Concepts and Principles. The Foundation for Critical Thinking.
2. Drying Great Salt Lake Could Expose Millions to Toxic Arsenic-Laced Dust
3. U.K. Killer Whale Contained Staggering Levels of Toxic Chemical
4. How does reducing air pollution help birds?
5. Our water was poison.
6. A resource for more articles: Breakthrough Information on Public Health - Research | Environmental Working Group (ewg.org)
7. www.ck12.org
    a. HS-PS1-1
        i. Non-metals:
        ii. Metals:
        iii. Modern Periodic Table:
        iv. Periodic Law:
        v. Periodic Trends:
        vi. Noble Gases:
        vii. Valence Electrons:
    b. HS-PS1-2
        i. Synthesis Reaction:
        ii. Decomposition Reaction:
        iii. Electron Dot Diagrams:
8. Modified Lab: Salt toxicity in seed germination:
9. Bioassay Test for Toxicity | Bioassay Experiment and Science Project (homesciencetools.com)
10. NIH - Toxicology
11. Forensic Science Simplified - Toxicology
12. https://www.youtube.com/watch?v=jHkrS4aFaWc
13. https://www.youtube.com/watch?v=U2ta63MPlCk
14. https://www.youtube.com/watch?v=fRFA64bWfQQ
15. https://www.youtube.com/watch?v=0bvKDbdnFGo
16. https://www.youtube.com/watch?v=tG5S-aMLug
17. https://demo.wgbhdigital.org/poisonershandbook/home.html
18. Organs on a chip

19. Microsoft Word - METACOGactivitiesFOLDER.docx (gmercyu.edu)
20. Poisoner's Handbook-A
21. How Wood Alcohol Poisonings Advanced Toxicology

Explain:

1. (280) What is toxicology? - YouTube
2. cornell note graphic organizer.

Extend:

1. Microsoft Word - Introduction to Toxicology Lesson Plan.doc (uga.edu)
2. Free Principles of Toxicology Course
3. Free Principles of Genetic Toxicology
4. Free Pathophysiology Course
5. Free Applied Systems Toxicology Course
6. Free Biochemistry and Molecular Genetics Course
7. Free Regulatory Toxicology Course

Evaluation:

Data Nugget A : Salty sediments? What bacteria have to say about chloride pollution Featured scientist: Lexi Passante from the University of Wisconsin-Milwaukee

Data Nugget B: Salty sediments? What bacteria have to say about chloride pollution Featured scientist: Lexi Passante from the University of Wisconsin-Milwaukee

Data Nugget C: https://datanuggets.org/wp-content/uploads/2022/03/Salty_Sediments_StudentC.pdf

Scoring Guide: Data Nugget Grading Rubric (datanuggets.org)

HS-PS1: Periodic Trends Guided-Inquiry Activity

HS-PS2: Wksht - Chemical Bonds - ionic bonds.docx (live.com)

Bohr models_lewis-dot-diagram_ions 2017.pdf (cusd80.com)

HS-PS1-1 and 2: Vocabulary

See: www.edulastic.com for HS-PS1-1 and HS-PS1-2 assessments

See: HS-PS1-1 assessment:
Wonder of Science: HS-PS1-1 assessment

See: HS-PS1-2: A New Medical Device
Wonder of Science: HS-PS1-2 assessment