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| **Learning Set 2: Why Do Thrills Make Us Feel Excited and Happy?** |

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| |  | | --- | | **Driving Question**  **for the unit:**  How can looking for thrills make me miserable?  **Sub-Driving Question**  **for the learning set:**  Why do thrills make us feel excited and happy? | | |  | | --- | | **Materials**  Science Take-out Kit: Is “Floratryp” addictive?<http://www.sciencetakeout.com/product/brain-reward-pathway-and-addiction/> (1:3 students)  Scrap materials from school or home for brain reward model- construction paper, tissue paper, yarn, string, Play-Doh or clay, bottle caps, licorice, balloons, let the students use their imagination of things that represent the reward pathway.  **Resources**  Science Take Out Kit- Addiction Teacher guide (with answers)  Read or revisit from the HiOH diabetes unit: [Why Do Scientists Use Animals in Research](#m095wes5nole)  For Optional Extension Activity Refer to the My SUD Modeling Chart: Teacher Version  **Handouts**  [Introduce the story of Ray](#RaysCaseStudyReading)  [Part 3: How does Floratryp affect dopamine levels in the brain reward region?](#ScienceTakeOutPart3)  [Part 4: Does Floratryp cause repetitive drug-seeking behavior?](#ScienceTakeOutPart4)  [The Brain Reward Pathway](#ReadingBrainRewardPathway).  Brain Reward System Model Rubric  The National Institute on [Drug Abuse’s definition of addiction.](#6p5l41fn9z02)  **Constructing a scientific explanation**: [Report to Ray](#ReporttoRay). What can we conclude about Floratryp? | | |  | | --- | | **Suggested learning set time**  7 Days | |

Student materials:

* [Introduce the story of Ray](#RaysCaseStudyReading)
* [Part 3: How does Floratryp affect dopamine levels in the brain reward region?](#ScienceTakeOutPart3)
* [Part 4: Does Floratryp cause repetitive drug-seeking behavior?](#ScienceTakeOutPart4)
* [Reading: The Brain Reward Pathway](#ReadingBrainRewardPathway).
* Constructing a Scientific Explanation: [Report to Ray.](#ReporttoRay) What can we conclude about Floratryp?
* **For Optional Extension Activities**
  + My SUD Modeling Chart
  + Integrated models

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| **Building Coherence** |

This unit guides students through a journey to figure out thrill seeking, and how thrill seeking evolved as a survival mechanism. Because of environmental changes and our modern lifestyle, thrill seeking can sometimes lead to addiction, misery and even death. Throughout the unit, students investigate several sub-driving questions to support them to gradually answer the *big* driving question, “How can looking for thrills make me miserable?” which encompasses these scientific ideas.

Guided by the sub-driving question, the journey unfolds as students figure out:

* In **LS1** - What gets us excited by examining the sub-driving question, “What do you do for thrills?”
* In **LS2** - The basic mechanism of the brain’s reward pathway which is responsible for the feeling of excitement through the sub-driving question, “Why do thrills make us feel excited and happy?”
* In **LS3** - The importance of thrill seeking to our survival and how the reward pathway evolved through the process of natural selection. Students investigate the sub-driving question, “Why do we all look for thrills?”
* In **LS4** - The risk for substance use disorders and behavioral addictions is caused, in part, by their environment. Students focus on both national and global trends related to SUD and behavioral addictions to understand the contribution of various environmental factors. and answer the sub-driving question, “What puts us at risk for substance use disorder (SUD) and behavioral addictions?”
* In **LS5** - Some genes might cause us to be at risk for substance use disorder (SUD), while others might protect us against it. Alcohol flush is a genetic mutation that causes discomfort following alcohol consumption. Alcohol use disorder is caused by the interaction of an individual’s genes and the environment. Taken together, with Learning Set 4, this information helps students answer the sub-driving question, “What are the environmental and genetic factors that put us at risk or protect us from SUD?”
* In **LS6** - What they can do to reduce the risk of addiction by designing and conducting a community action project focused on making a change in their environment. Students address the sub-driving question, “Can we make a change? What can we do to reduce the risk of Substance Use Disorder and behavioral addictions for ourselves and our community?”

To see more details, refer to the **Storyline**.

In this learning set, the students will focus on the questions about the biology of thrill seeking and discuss the relation of the reward pathway to the feeling of excitement when looking for thrills. This unit picks up from the previous learning set where the students generated a Driving Question Board (DQB) which includes questions that examine thrill seeking.

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| **Framing the Learning Set** |

**Purpose**

In this learning set, the students will discuss the brain’s reward pathway, the biological mechanism that underlies the excitement associated with looking for thrills and its importance. They will figure out how the reward pathway triggers us to initiate, engage, and persist in activities that are crucial for our survival and reproduction and why the feeling of excitement is an adaptive trait. In this learning set, the students build a physical model of the brain to explain and predict how the reward pathway functions and they will focus on the sub-driving question of this learning set, “Why do we feel excited when looking for thrills?”

**Learning Set Learning Goals (For instructional use)**

* The students obtain, evaluate, and communicate what it means to be addicted and to construct a definition of addiction/substance use disorders (SUDs) or behavioral addictions.
* The students carry out tests to figure out how the effect of dopamine levels in the brain rewards the region of the brain.
* The students carry out a lab test to figure out if Floraytryp causes repetitive drug-seeking behavior.
* The students obtain, evaluate, and communicate information about the mechanisms, causes, and effects of substance use disorders (SUDs) or behavioral addictions and the brain reward pathway.
* The students construct a scientific explanation about whether or not Floratryp is addictive.
* The students use physical models of the brain to explain and predict the reward pathway that leads to substance use disorders (SUDs) or behavioral addictions.

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| **Overview of the Learning Set** |

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| **Instructional sequence overview** | **What students figure out**  **(DCI)** | **Instruction days** |
| **Lesson 1 - How do you know if a substance is addictive?**  Students are introduced to a student named Ray who has been using a substance called Floratryp. As a class, students brainstorm about what it means to be addicted and construct a definition of addiction. | Each sense receptor responds to different inputs, transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories.  (LS1.D: Information Processing) | 1 day |
| **Lesson 2 - How does Floratryp affect dopamine levels in the brain reward region?**  Students perform tests to figure out how Floratryp affects dopamine levels in the brain reward region.  **(Science Take Out Part 3)** | 1 day |
| **Lesson 3 - Does Floratryp cause repeated drug-seeking behavior?**  The students will perform a lab test to figure out if Floraytryp causes repeated drug-seeking behavior.  **(Science Take Out Part 4)** | 1 day |
| **Lesson 4- How can the brain reward pathway lead to happiness and misery?**  The students read scientific texts to describe patterns in and evidence about mechanisms and cause and effect of substance use disorders (SUDs) or behavioral addictions as related to the brain reward pathway. | 1 day |
| **Lesson 5- How do we show that Floratryp is addictive?**  The students write a scientific explanation based on the evidence in the form of a lab report to explain the results of two tests performed on Floratryp. | 1 day |
| **Lesson 6- How does the reward system lead to addiction?**  Students develop physical models of the brain that can be used to explain the reward system that leads to substance use disorders (SUDs) or behavioral addictions. | 1-2 days |
| **Wrap up - Revisiting the Driving Question Board**  The students will revisit the Driving Question Board (DQB**)** and reflect upon their learning. | ½ day |
| **Optional Extension Activity- Modeling: Why do we feel excited when looking for thrills?**  The students revise their models of thrill seeking to explain the mechanism of substance use disorders (SUDs) or behavioral addictions and the reward pathway. Then, they share their models with the whole class, discuss similarities and differences among the components of their models, and evaluate the relationships presented. The students revisit the Driving Question Board (DQB) and reflect upon their learning. | 1 day |
| **Optional Extension Activity - Constructing a scientific explanation to answer the sub- Driving Question**  Students will construct scientific explanations using integrated models to explain the phenomenon of SUDs and behavioral addictions by answering the sub-Driving Question of the learning set. | SUDs and behavioral addictions are caused by the interaction of genes and the environment. | 2 day |

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| **Resources** |

1. Learn Genetics website - <http://learn.genetics.utah.edu/content/addiction/>
   1. This website gives a wealth of background information and activities primarily aimed in this curriculum for teachers. Be careful, many of the materials are at a high school level. If using materials, ascertain that they are middle school level and address middle school performance expectations or adapt them for middle school.

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| **NGSS connection to assessment** |

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| **Target Performance Expectations**  [MS-LS1-8.](https://www.nextgenscience.org/pe/ms-ls1-8-molecules-organisms-structures-and-processes) Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories. |
| **Learning Performance for Learning Set 2 to be assessed**  The students construct a scientific explanation about how the use of a substance relates to addiction.  The students develop models of the brain reward system and how it can lead to addiction.   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Disciplinary core idea** | | **Science and engineering practices** | | **Crosscutting concepts** | | **LS1.D: Information Processing**  - Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories. | **Constructing a scientific explanation**  - Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events.  - Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion.  **Developing and using models**  - Develop and/or use a model to predict and/or describe phenomena | | **System and system models**  - Models can be used to represent systems and their interactions - such as inputs, processes and outputs - and energy and matter flows within systems.  **Cause and effect**  - Cause and effect relationships may be used to predict phenomena in natural systems. | | |
| **How these elements are integrated and embedded in this learning set**  Students will figure out if a substance is addictive by performing lab tests and analyzing the results. Students will obtain and communicate information about the mechanisms, causes, and effects of addiction and the brain reward pathway. Then they will write a scientific explanation about how the use of a substance is related to substance use disorders (SUDs) or behavioral addictions. Students will also develop physical models to explain the brain reward system and how it can lead to SUDs or behavioral addictions. |

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| **Connection to Students’ Lives** |

**Link to out-of-school activity and everyday life**

* The brain’s dopamine r*eward pathway* is central in making us feel good when we do activities that are beneficial for our survival, like eating, drinking, and reproduction.

**Link to career-awareness**

* **Neuroscience researchers** - A scientist who studies the nervous system including the brain, spinal cord, and nerve cells to understand, prevent, and treat disease, including mental mental illnesses.

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| **Instructional Sequence** |

**Introducing the Learning Set**

1. **Keeping coherence using the DQB** - Remind students of their questions related to looking for thrills and excitement on the Driving Question Board (DQB). Tell students that in this learning set they will further investigate thrill seeking and that they should pay particular attention to the questions that they had clustered around that Sub-Driving Question, **“Why do thrills make us feel excited and happy?**
2. **Link to career-awareness**
   1. **Neuroscience researchers** - A scientist who studies the nervous system including the brain, spinal cord, and nerve cells to understand, prevent, and treat disease, including mental illnesses.

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| **Lesson 1 – How Do You Know If a Substance is Addictive?** |

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| **Learning Goal** | Students obtain, evaluate, and communicate what it means to be addicted and construct a definition of addiction/substance use disorders (SUD) or behavioral addictions. |
| **Connection to NGSS** | DCI: LS1.B: Growth and Development of Organisms |
| Practice: Obtaining, evaluating, and communicating information |
| CCC: Cause and effect |

1. **Introduce the story of Ray -** Students [read the story of Ray](#RaysCaseStudyReading) who has been using a substance called Floratryp.
2. **Small group discussion** - Have students discuss what it means to be addicted and brainstorm their own definition of addiction in small groups.
   1. How does an addicted person act? (i.e. sleeps a lot, hungry, grumpy, mood swings, always looking for the drug/alcohol/to play video games/sweets)
   2. How does addiction affect a person’s:
      1. Life - They can lose interest or forget their goals in school and other activities (playing sports, dancing).
      2. Health - They can lose weight, act dangerously, become sick, be depressed or tired, or not want to go outside.
      3. Loved ones - They may avoid being with family or friends, lose friends, make family feel angry or hurt.
   3. Why do you think people engage in addictive behaviors?
   4. Based on your answers above, how would you define addiction?
3. **Whole class discussion**
   1. Each group shares main ideas and a definition of addiction.
   2. Students create a whole class definition of addiction.
      1. According to our definition of addiction, is Ray addicted?
      2. Explain using evidence from the class definition and the medical report.

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| **Note to the teacher** | * Drug addiction is defined as “uncontrollable, compulsive drug seeking and use, even in the face of negative health and social consequences,” says scientists from the National Institute on Drug Abuse. * Don’t expect students to come up with this definition of addiction at this point. We will return to the definition of addiction/substance use disorders (SUDs) or behavioral addictions after Lesson 2 in this learning set. |

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| **Lesson 2 - How Does Floratryp Affect Dopamine Levels in the Brain Reward Region?** |

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| **Learning Goal** | The students perform tests to figure out how the effect of dopamine levels in the brain rewards the region. |
| **Connection to NGSS** | DCI: LS1.D: Information Processing |
| Practice: Analyzing and interpreting data |
| CCC: System and system models |

1. **Perform lab.** From the Science Take Out Kits (teacher guide with answers). NOTE: HiOH has revised the Science Take Out Kits. PLEASE follow our version and **NOT** the version in the kits. Students perform the “lab” and follow along to complete [Part 3: How does Floratryp affect dopamine levels in the brain reward region?](#ScienceTakeOutPart3)
2. **Discussion -** Compare and share results.
   1. Students can answer the questions on pages 2 and 3 of Part 3 either in small groups or individually for homework.
   2. Optional: Sometimes students express concerns about rats being used in research. You can read or revisit from the HiOH diabetes unit: [Why Do Scientists Use Animals in Research](#m095wes5nole) and discuss ethical issues in this research design.

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| **Lesson 3 – Does Floratryp Cause Repeated Drug-Seeking Behavior?** |

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| **Learning Goal** | The students perform a lab test to figure out if Floraytryp causes repetitive drug-seeking behavior. |
| **Connection to NGSS** | DCI: LS1.A: LS1.D: Information Processing |
| Practice: Analyzing and Interpreting data |
| CCC: System and system models |

1. **Perform lab.** From the Science Take Out Kits, students complete [Part 4: Does Floratryp cause repetitive drug-seeking behavior?](#ScienceTakeOutPart4)
2. **Discussion on methodology and data analysis** 
   1. Read page 1 of Part 4 together as a whole class.
   2. Students complete questions 1-4 in small groups and then come together to share about methodology.
   3. Students complete questions 5-7 in small groups and then come together to share about the lab results.
   4. Use questions 8-10 as prompts for the whole group to discuss or as individual work/homework.

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| **Lesson 4 – What is the Brain Reward Pathway and What is Addiction? Reading** |

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| **Learning Goal** | The students obtain, evaluate, and communicate information about the mechanisms, causes, and effects of addiction/substance use disorders (SUDs) or behavioral addictions and the brain reward pathway. |
| **Connection to NGSS** | DCI: LS1.D: Information Processing |
| Practice: Obtaining, evaluating, and communicating information |
| CCC: System and system models |

1. **Obtaining information from the reading -** Students read [The Brain Reward Pathway](#ReadingBrainRewardPathway)[.](https://docs.google.com/document/d/1e_QsjvusKMB14QtCQhIJi6rUdvx3N8sl_DzsultxCEM/edit?usp=sharing)

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| **Note to the teacher** | According to the [NGSS@NSTA](https://ngss.nsta.org/CrosscuttingConcepts.aspx?id=4), models can be used to represent systems and their interactions such as inputs, processes and outputs, and energy and matter flows within systems. In this Learning Set, students are figuring out the Brain Reward Pathway which is a system in the human body, and students are later asked to model this system in My SUD modeling chart. For example, the **input** for the Brain Reward System is the outside stimuli that can occur (vaping or roller coaster riding). The **process** is the way in which the signal is sent through the brain and the **output** is the excitementthat is produced from the input. |

1. **Discussion on the definition of addiction**
   1. Go back to students’ initial definition of addiction and review it. Guide them to reconsider their conclusions and make revisions as necessary.
   2. Show students the National Institute on [Drug Abuse’s definition of addiction.](#6p5l41fn9z02)
      1. How does it compare to our definition of addiction?
      2. Do we agree/disagree? Why?
      3. Do we want to revise our definition of addiction based on this new information? Revise if necessary.
      4. At this point we want to introduce the terminology “substance use disorders (SUDs) and behavioral addictions instead of “addiction.”
         1. Some students may have already brought up the term substance use disorder. Discuss where they first heard the term?
         2. If not, introduce the term, substance use disorder and ask- What does the term “disorder” mean?
         3. Ask why might we want to use the term “SUD” rather than using the term “addiction?” What is different about saying someone is an addict versus someone has substance use disorder?
         4. What do you think “behavioral addiction” means? Can you think of any? (Note: behavioral addiction is also sometimes referred to as micro-addictions.)
         5. Discuss that from this point forward, we will be using this new term. Students should go back and revise their definition of “addiction” to reflect this updated term.

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| **Lesson 5 - How Do We Prove that Floratryp is Addictive?** |

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| **Learning Goal** | The students write a scientific explanation based on the evidence in the form of a lab report to explain the results of two tests performed on Floratryp. |
| **Connection to NGSS** | DCI: LS1.D: Information Processing |
| Practice: Constructing a Scientific Explanation |
| CCC: System and system models |

1. **Constructing a scientific explanation (**[**Report to Ray handout**](#ReporttoRay)**)-** Tell students that in their role as a scientist, they will write a lab report to share with colleagues on their findings about Floratryp. The lab report will be in the form of a scientific explanation (see the box below). The lab report will include answers to the following questions.
   1. **Claim**: What do the tests show about whether Floratryp is an addictive substance?
   2. **Evidence**: What data do you have to support your claim?
   3. **Reasoning**: How can we show that Floraytryp is addictive using scientific ideas and concepts we have studied?

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| idea.png | **What is a *scientific explanation?* How can it be used?**  Scientists try to explain how and why a natural phenomenon occurs. A scientific explanation consists of a claim, evidence, and reasoning (CER). The claim is a testable statement that expresses the answer or conclusion to a question or problem. Evidence is scientific data that supports the claim. The reasoning describes how or why the evidence can be used to support the claim by using scientific ideas and principles. |

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| **Lesson 6 - Physical Model Building: Explaining the Brain to Ray** |

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| **Learning Goal** | The students use physical models of the brain to explain and predict the reward pathway. |
| **Connection to NGSS** | DCI: LS1.D: Information Processing |
| Practice: Developing models |
| CCC: System and system models |

1. **Introducing the context** - Students have created a science lab report in the previous lesson. Tell them that in this lesson, they will explain how the brain works and how Floratryp affects the brain of Ray, a 9th grade student. One way to help Ray understand the brain and how Floratryp works is for students to construct physical models of the reward pathway. Students can use materials in class or around their homes. Materials might include noodles, play doh or clay, string or yarn, construction paper, bottle caps, etc. Let students use their imagination to represent the various parts of the brain. At the end of their model building, students will be expected to use their models to explain to Ray how Floratryp works in the brain and why Floratryp would be considered an addictive substance, using their definition of addiction/SUD or behavioral addictions.

The purpose of this activity is to help students 1) understand how the brain functions and how addictive substances affect that functioning, and 2) communicate their knowledge to others.

To complete this task, student posters or physical models should include:

* The poster or 3D model will be a combination of drawing and material
* The different components which are actually different resolutions to look at the brain: 1) The brain as a whole with the different parts, 2) neurons net, and 3) synapse. After sharing ideas with students, tell them that how they arrange their model is up to them. **Remember, the Brain Reward System is an example of a system with inputs, processes and outputs. Encourage students to use those terms in their models.**
* Each model should have a legend/key that labels and describes the different components
* Students should produce a written or verbal explanation (i.e. Letter, short video or audio to Ray) that accompanies their model.
* Brain Reward System Model Rubric

The students can use all their worksheets for support. Computers may also be useful to find supplemental sources of information and images.

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| **Wrapping-up the Learning Set - Revisiting the Driving Question Board** |

With the class, revisit the **Driving Question Board** **(DQB)**. Prompt the students to reflect upon their learning using the following prompts, and adjust the DQB as appropriate:

1. Which questions on the DQB have we answered, and which remain open?
   1. Students should attach their answers/artifacts of investigation onto the DQB next to the questions they relate to.
2. After completing the lessons in the learning set, do you have any additional questions?
   1. Add new questions to the board near the SDQ they relate to.
3. Ask students some transitional questions that are related to the next learning set, **“Why do we all look for thrills?”**
   1. Why do people search for thrills?
   2. How can thrills benefit me? How can thrills benefit us (as humans)?

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| **Optional Extension Activity - Modeling: Why do Thrills Make Us Feel Excited and Happy?** |

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| **Learning Goal** | The students develop models of the reward system that leads to substance use disorder (SUD). |
| **Connection to NGSS** | DCI: LS1.D: Information Processing |
| Practice: Developing models |
| CCC: System and system models |

**Developing models for the Unit -** How can looking for thrills make me miserable?

In this lesson, students develop one part of the model that will focus on the sub-driving question of this learning set, **“Why do thrills make us feel excited and happy?”**

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| **Note to the teacher** | According to the [NGSS@NSTA](https://ngss.nsta.org/CrosscuttingConcepts.aspx?id=4), models can be used to represent systems and their interactions such as inputs, processes and outputs, and energy and matter flows within systems. In this Learning Set, students are figuring out the Brain Reward Pathway which is a system in the human body and students are later asked to model this system in My SUD modeling chart. For example, the **input** for the Brain Reward System is the outside stimuli that can occur (vaping or roller coaster riding). The **process** is the way in which the signal is sent through the brain and the **output** is the excitementthat is produced from the input. |

**Based on their experience in this learning set, ask students to complete the My SUD Modeling Chart Student Version (not filled in) / Teacher’s complete version. Remember, the Brain Reward System is an example of a system with inputs, processes and outputs. Encourage students to use those terms in their models.**

1. **REFLECT upon learning in pairs**
   1. **Identify the sub-driving question -** What is the sub-driving question that students were asked to think about during the Learning Set?
   2. **Identify the questions** - What questions did students pose at the beginning of the Learning Set?
   3. **Identify the Main Message (**Whole group discussion) - **What** did students figure out from the Learning Set? Use the following prompts:
      1. What do you think are the take-home messages from the learning set?
      2. What did you learn in this learning set?
2. **REFLECT upon learning as a whole group/class.** Review students’ answers for the first three sections of the table.
3. **PLAN as a whole group/class.** 
   1. **Identify the components** - Start with a class discussion to remind the students of the different components of **the brain reward pathway** as they discussed when creating the Driving Question Board, for example: stimuli (inputs), brain, nerve cells, chemicals (processes), feeling of excitement, etc. (outputs).
   2. Be sure to use the My SUD Modeling Chart: teacher version for the Learning Set to support the discussion about components. These are just suggestions; students will likely come up with many more on their own and through the discussion.
4. **PLAN in small groups.**
   1. **Generate different components** - Write each component on its own sticky note. Each component should be relevant. (At this point, components in a student's model may not be measurable. It is fine even if they cannot come up with the components that are measurable.)
   2. **Organize the components** - Organize the components in categories such as positive consequences, negative consequences, etc.
5. **BUILD in small groups: Connect the components (demonstrate to the class before students go into small groups)** - Connect the components in a **causal relationship** from the cause to the effect. Students should use arrows to show the directionality of the connection.
6. **TEST/REVISE in small groups**: **Evaluate models** - Instruct students to switch off in the roles of presenter and listener. Explain the phenomenon by explaining how the components thrill people. Have the students test their models by applying the following questions:
   1. Does your model explain and predict?
   2. Does your model make sense?
   3. Are the components in your model relevant to the brain reward pathway?
   4. Does your model show cause-effect relationships?

Together, make any changes needed to make their models more clear and complete.

1. **SHARE as a whole group/class -** Collectively, share the models with the class such as a gallery walk. Use the questions above, e.g. one per small group, to have students present to the large group.
   1. When sharing models, discuss with the students:
      1. The similarities and differences between the models
      2. The models’ strengths and weaknesses
      3. Ways to improve the various models
2. **REVISE in small groups** - Based on feedback and observing other models, have the students revise their models. Once they finish, they can document (e.g take a picture of) their group’s model and send it to their teacher. These models can be used for formative assessment, and for students’ to examine and reflect upon their model development process at the end of the unit.

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|  | While the students model, move around the class, support the students, and encourage them to share their thinking and consult with their peers about their models. Students’ models can vary. However, since the models need to explain the relationships among the components, make sure the models include:  **Components**   * Brain * Thrills * Memories * Stimuli * Behavior/repeated behavior * Activation of reward pathway * Release of dopamine in the brain * Nerve cells * Dopamine * Sense of pleasure * Sends signal * Misery   **Relationships and labels**   * The relationships among the components * The relationship between the components and reward pathway |

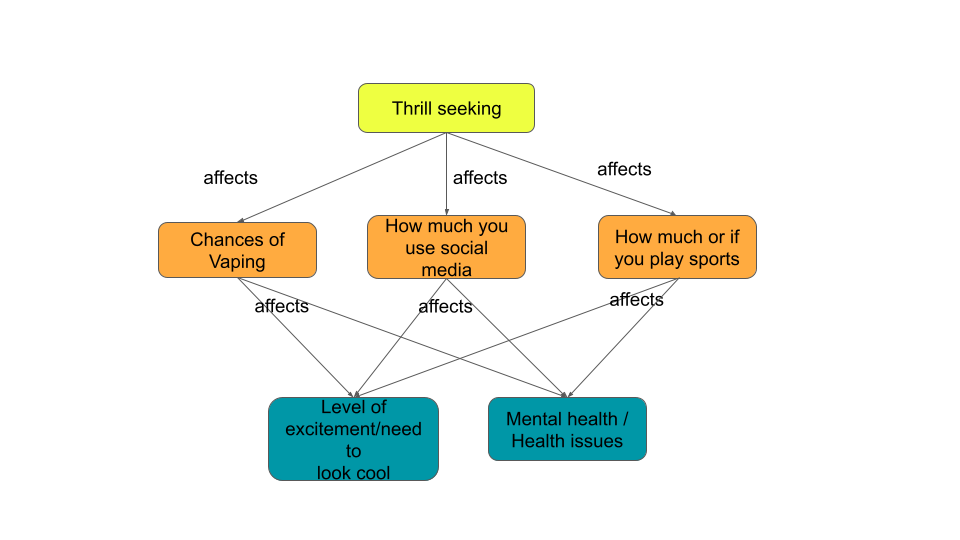
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| discussion.jpg | A discussion which shares insights from the various models and compares among them is extremely important as it will scaffold the students’ second revision of their models in the following step. Use questions to prompt the students to critically examine their peers’ models.  **Components**   * **Components identity**- What components are included in each model? Are key components included? * **Number of components** - How many components are indicated in the model? Are MORE components necessarily better? * **Grouping of components** - How can we group the various components? Why should we group components—does it improve our models? Is the grouping meaningful?   **Relationships among components**   * **Explicit relationships among the components** - Are the relationships among the components indicated? Do these relationships make sense? Are the indicated relationships important?   **General features**   * **Complexity of the model***-* How complex is the model? * **Organization**- How well is the model organized? Is the organization meaningful? |

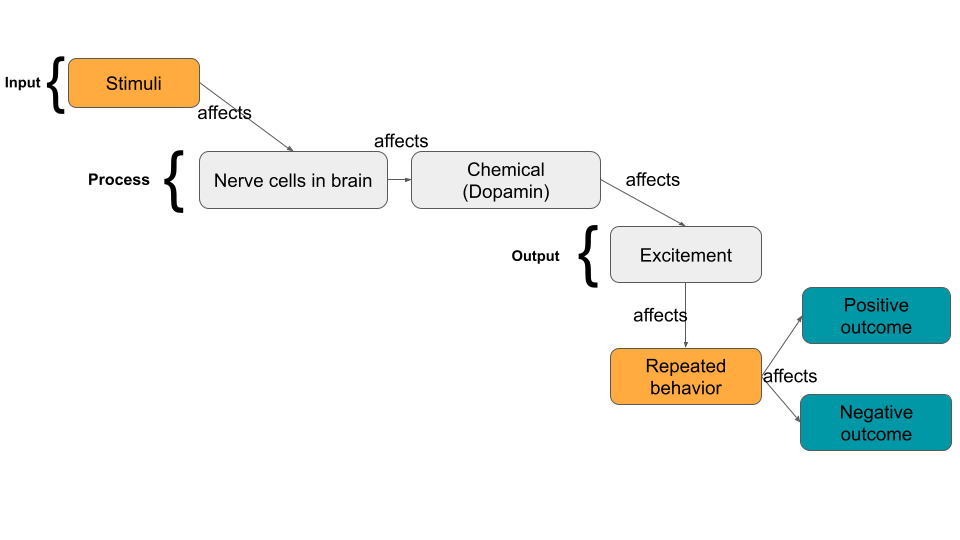
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| **Optional Extension Activity – Constructing a Scientific Explanation to Answer the Unit Driving Question**  **End of Learning Set Assessment** |

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| **Learning Goal** | Students develop (evaluate and revise) a model to explain how looking for thrills can make us miserable.  The students construct a scientific explanation that explains why looking for thrills can make me miserable. |
| **Connection to NGSS** | DCI: LS1.B: Growth and Development of Organisms |
| Practice: Developing a scientific model  Constructing a scientific explanation |
| CCC: Cause and effect |

Through class discussion, the students, guided by the teacher, will develop integrated models which connect consensus models from different learning sets to construct scientific explanations (CER) to explain the phenomenon of SUD / behavioral addiction and gene-environment interaction by answering the Driving Question of the unit, “How can looking for thrills make me miserable?”

1. **Teacher and students complete this model link together (**integrated models teacher version is found below and integrated models student worksheet**).** The following list of questions and My SUD Modeling chart (teacher version / student version) can guide connecting the two models and coming up with a CER.
   1. To support linking two different models to make a claim:
2. What are the common components between the two learning sets?
3. Where do the two models link together?
4. What are the main ideas of each learning set? How can they be linked?
5. How does one model help explain, expand, and elaborate another?
   1. To support the evidence:
6. What activities did we do in each learning set?
7. What videos did we watch?
8. What experiment did we conduct?
9. What data (i.e. from maps, charts, simulation, interview) did we collect or use?
10. What are some specific examples, shown in your models, that can be used as evidence to support your claim?
    1. To support the reasoning:
11. What are the underlying scientific ideas shown in your models and in the unit that can explain how your claim and evidence are connected?
12. **Integrated model as a whole class with teacher guidance: LS1 and LS2**
13. **Main idea to include Linking various thrill-seeking activities to the brain reward pathway mechanisms**
    1. Various behaviors (vaping, using social media, playing sports, and etc.) represented in the LS1 model can be linked as stimuli in the LS2 model that triggers the brain reward pathway.
    2. The examples of positive and negative consequences in the LS1 model can be what is shown as positive and negative outcomes in the LS2 model.
    3. Exemplar model





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| **Sub-Driving Question: Why do thrills make us feel excited and happy?** | |
| **Claim** | Thrill seeking activities affect the reward system in the brain. Some of those thrill-seeking activities can cause negative consequences and make people miserable. |
| **Evidence** | In our unit, we watched a video where we saw that over exposure to vaping can cause SUD in teens. We also learned from our lab experiment that a substance called Floratryp was an addictive substance which could lead to SUD. We also made lists of different thrill-seeking activities that could have both positive and negative consequences. |
| **Reasoning** | Stimuli from thrill-seeking activities trigger nerve cells to release chemicals (dopamine) which make people feel excited and can cause them to repeat the same behavior that can lead to SUD. |

**Discussion:** Help students make the generalization from ***Ray*** to ***us/my***, and from ***thrill seeking*** to ***health***, for example:

* + 1. Ask students “Do the stories of Ray and Floratryp apply only to ***Ray***, or can they be generalized to ***other people*** as well?”
    2. Original: Why do thrills make us feel excited and happy?
       1. How can this sub-driving question apply to our own thrill-seeking and our health?

**Medical Report**

Ray is a 9th grader who loves playing video games, hanging out with his friends, and playing basketball. Lately, Ray has been feeling horrible. He’s feeling depressed and nervous. He has a headache and nausea, and is having trouble sleeping. Ray has experienced some of these symptoms in the past, but they seem to disappear when he uses “Floratryp,” a mixture of store-bought and herbal medications.

Ray doesn’t think his symptoms are caused by Floratryp addiction. “I know other kids at school who use Floratryp. It’s not illegal. It’s not addictive. What’s wrong with feeling good?” He likes using Floratryp because it makes him feel excited, happy and confident. “I only take it when I’m feeling low or stressed out. A little Floratryp and I feel great.”

Ray has been using Floratryp for about a year. Over the past few months his use of Floratryp has increased from once a day to five or more times each day. Ray has not been able to use Floratryp for the past few days because he ran out of money to buy more. This week, his grades in school took a downturn, he hasn't turned in his homework. Some of his friends said he doesn't hang out with them anymore and only hangs out with other kids using Floratryp. His mom has been worried and asked him why he seems to be more grumpy and sleepy than usual.

According to our class-created definition of addiction, is Ray addicted?

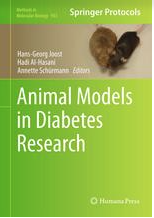
Explain using evidence from the class definition and the medical report.

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| Write your answer here: |

**Reading: Why Do Scientists Use Animals in Research?**

New and better ways for treating diseases are found by using animals in scientific research. Scientists can learn more about health problems and make sure new medical treatments work safely. Many different types of animals can be used as models for studying diseases in humans. Rats, mice, rabbits, dogs, cats, frogs, and fish are some examples of animals used in research.

**Why animals?**

Scientists can only study certain health problems in living organisms. Some animals are very similar to humans. They can share many of the same health problems. Many animals have a much shorter lifespan than humans. Sand rats live about 1–1.5 years and they can reproduce at the age of 3–7 months. They are easy to study because they can be observed throughout their lifespan or for many generations. 

Scientists can also control the diet, temperature, or lighting in the animal’s environment. This would be hard to do with humans. Sand rats live in desert areas, and their main diet is a plant called the saltbush. This plant gives them food that is low in calories. When they eat regular laboratory food with higher calories, they gain too much weight. They also develop Type 2 diabetes very quickly. Scientists who want to learn about the relationships between food, weight gain, and Type 2 diabetes investigate sand rats.

**Is there any other way?**

Scientists try not to use animals for their research. Sometimes computer models can be used to develop and test new medicines. Scientists look for ways to reduce the number of animals used for research. They also try to replace animals with other research methods whenever possible.

### Science Take Out Kits Part 3: How does Floratryp affect dopamine levels in the brain reward region?

### A screenshot of a cell phone Description automatically generated

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| **Rat c- Floratryp** | |
| **Time After Being Given Substance** | **Concentration of dopamine in rat brain (picograms/mL)** |
| **0 min.** |  |
| **30 min.** |  |
| **60 min.** |  |

Create a bar graph of your results so you can visualize the patterns. Base your answers to the following questions on your bar graph from the data in **Data Table 1: Concentration of Dopamine in Rat Brain Fluid Samples** on page 4.

* 1. What happens to the level of dopamine in the brain when a rat is given sugar (a normal rewarding substance)?

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| Write your answer here: |

* 1. Compare the levels of dopamine in the rat given Floratryp with the levels of dopamine in the rat given sugar.

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| Write your answer here: |

* 1. Compare the levels of dopamine in the rat given Floratryp with the levels of dopamine in the rat given cocaine.

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| Write your answer here: |

* 1. Based on the results of this experiment, do you think that Floratryp is addictive? Explain why or why not.

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| Write your answer here: |

A close-up of a paper

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### Part 4: Does Floratryp cause repeated drug-seeking behavior?

To be considered addictive, a drug must activate the reward center and produce the repetitive drug-seeking behavior associated with addictive drugs. To determine if Floratryp is addictive, scientists can do experiments to see whether it results in repetitive drug-seeking behavior.

A close up of a logo

Description automatically generatedIn this activity you will analyze data collected by a scientist who investigated drug-seeking behavior in rats.

For this experiment, rats were placed in individual cages with a lever they could press that delivered a rewarding substance.

* + - When Rat A pressed a sugar lever, it received an injection of sugar solution.
    - When Rat B pressed a cocaine lever, it received an injection of cocaine.
    - When Rat C pressed a Floratryp lever, it received an injection of Floratryp.

Each day (for 6 readings over 20 days), the rats were placed in the appropriate cages and scientists observed and recorded the number of times the rats pressed the levers in 5 minutes.

The results of the experiment are presented in Data Table 3 on the next page.

##### Data Table 3: Effect of Sugar, Cocaine, and Floratryp on Rat Lever Pressing Behavior

A paper with numbers and a grid

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**Independent variable** (or manipulated variable) is the variable (factor) you change in the experiment. The independent variable is chosen before you conduct the experiment. It is usually associated with the “If” part of the hypothesis.

**Dependent variable** (or responding variable) is the variable that may change as a result of the independent variable. The dependent variable is the data that is observed and measured in an experiment. It is usually associated with the “then” part of the hypothesis.

1. What is the **independent variable** in this experiment?

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| Write your answer here: |

1. What is the **dependent variable** in this experiment?

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| Write your answer here: |

1. Rat A and Rat B were **controls** in this experiment. They provided a basis of comparison.

Which rat provided a control (basis of comparison) to show the difference between a rat’s reaction to a normal rewarding stimulus and Floratryp?

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| Write your answer here: |

1. Which rat provided a control (basis of comparison) to show the difference between a rat’s reaction to an addictive drug and Floratryp?

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| Write your answer here: |

1. Why does the number of lever presses for sugar increase?

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| Write your answer here: |

1. Compare the number of lever presses for Floratryp with the number of lever presses for sugar.

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| Write your answer here: |

1. Compare the number of lever presses for Floratryp with the number of lever presses for cocaine.

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| Write your answer here: |

1. Does the data from the rat lever pressing support the hypothesis that Floratryp is addictive? Explain why or why not.

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| Write your answer here: |

1. State one way that the scientist’s experiment could be improved to make it more reliable.

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| Write your answer here: |

1. Based on the information and data from this lab activity, discuss the pieces of evidence you would provide to lawmakers considering classifying Floratryp as an illegal drug.

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| Write your answer here: |

### [[1]](#footnote-1)Part 2: The Brain Reward Pathway

**Box 2**

A diagram of a brain

Description automatically generated

###### Base your answers to questions 1 through 6 on the information in Box 2 above.

1. What is the function of the reward pathway of the brain?

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| Write your answer here: |

1. List two behaviors which cause impulses (electrical signals) to travel through the reward pathway in the brain.

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| Write your answer here: |

1. What causes animals to repeat behaviors that stimulate the brain reward region?

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| Write your answer here: |

1. Addictive drugs have been shown to increase the activity in the brain reward pathway. What chemical signal may be increased in the brain reward region during drug use?

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| Write your answer here: |

1. Do you think that shopping, smoking, and gambling may activate the reward pathway and lead to addiction for some people? Explain your answer.

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| Write your answer here: |

1. Some scientists who study the effects of addictive drugs on the brain use rats, instead of humans, in their experiments. What are two advantages of using rats instead of humans when conducting research on the effects of drugs on the brain?

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| Write your answer here: |

**Report to Ray**

Your role as a scientist is to write a lab report sharing the findings of your research on Floratryp. The lab report needs to include answers to the following questions.

**Claim:** What do the tests show about whether or not Floratryp is an addictive substance?

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| Write your answer here: |

**Evidence:** What data do you have to support your claim?

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| Write your answer here: |

**Reasoning:** How can we show that Floraytryp is addictive using scientific ideas and concepts we have studied?

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| Write your answer here: |

|  |  |  |  |
| --- | --- | --- | --- |
| **Model** | **Proficiency** | | |
| **Contains** | **Proficient** | **Developing** | **Beginning** |
| **Title** | Poster Contains a title | N/A | Poster does not contain a title |
| **Legend/Key** | Poster Contains a legend/key that is correct | Poster contains a legend/key with minor mistakes | Poster does not contain a legend/key |
| **Components are labeled** | Components are all labeled correctly   * Sending neuron * Dopamine * Receiving neuron | Components are mostly labeled correctly | Components are not labeled or have major errors |
| **Components include a description of their function/purpose** | Components descriptions are all correct   * Sending neurons sends out a signal * Dopamine is the chemical that sends messages between neurons * Receiving neurons detect the dopamine/chemical signal or message and the body reacts or the neuron might send the signal or message to the next receiving neuron. | Components descriptions are mostly correct | Components descriptions are missing or are mostly incorrect |
| **Brain Reward System Description** | Model contains correct references to the inputs, processes and outputs.   * Inputs are the messages being sent by the neurons * Processes are the way those messages/signals are sent through the neurons to one another via dopamine * Outputs would be the reaction of the person as a memory or action. | Model contains mostly correct references to the inputs, processes and outputs. | Model contains no references to the inputs, processes and outputs, or the references are mostly incorrect. |
| **Written or verbal explanation to Ray** | Model is accompanied by a written or verbal explanation, to Ray, that correctly explains:   1. How Floratryp works in the brain and    1. According to our experiment with rats, Floratryp seems to act like cocaine which is a known addictive drug. For a drug to be addictive, it means that it must activate the reward center and produce repetitive drug-seeking behavior. Floratryp does that to the rats and it seems like that is what it is doing to Ray because he says he needs it. 2. Why Floratryp would be considered an addictive substance- this explanation correctly uses their definition of addiction/SUD or behavioral addictions.    1. This response will vary slightly based on the class's final definition of addiction. But should include something like: **“uncontrollable, compulsive drug seeking and use, even in the face of negative health and social consequences,” says scientists from the National Institute on Drug Abuse.** | Model is accompanied by a written or verbal explanation, to Ray, that is mostly correct and explains:   1. How Floratryp works in the brain and 2. Why Floratryp would be considered an addictive substance- this explanation correctly uses their definition of addiction/SUD or behavioral addictions. | Model is accompanied by a written or verbal explanation, to Ray, that contains several errors or, is completely missing #1 or #2:   1. How Floratryp works in the brain and 2. Why Floratryp would be considered an addictive substance- this explanation correctly uses their definition of addiction/SUD or behavioral addictions. |

1. Modified from the Science Take Out kit - Brain Reward Pathway and Addiction found at: <https://www.sciencetakeout.com/product/brain-reward-pathway-and-addiction-group/> [↑](#footnote-ref-1)