**Scientific Method**

*Zombie Apocalypse Lab CHEAT SHEET*

Goal

* Reinforce the scientific method
* Encourage students to use their observational abilities and senses
* Teach students how to use their mind and logic to plan experiments
* Debate for extra resources using data
* Break the habit of using vague terms or vague justifications and instead use hardcore quantitative data and use precise terms for their justifications
* Utilize basic arithmetic to solve unknowns

Synopsis

* Zombie virus is spreading
* Cure created but contamination of some occurred
* Contamination proceeds in 2 stages
	+ Stage #1 – sweet smell. Stage 1 contamination results in the pill causing hair loss but still cures the individual from the zombie virus.
	+ Stage #2 – cannot occur unless stage #1 fulfilled and results in pill enlargement (length and weight DO NOT VOLUNTEER INFORMATION but you can confirm if they come up with it themselves). Stage 2 contamination results in the pill causing death.

Logistics

* Walk through the entire protocol with the group using this time to assist, clarify and recognize their ability to think creatively and strategically in implementing their methodology to determine and justify which capsules are good, good with side effects, and bad.
* Do not mix and match lids, capsule, and bottles
* Smell, length and weight should be incorporated in their hypothesis
* There will either be 0 or 1 bad pill per 8 pills (DO NOT VOLUNTEER INFORMATION)
* Telling them that there is only 0-1 bad pill allows them to “cheat” on their protocol. The protocol needs to be made in such a way that it analyzes all pills. This is the most difficult part of the lab as it forces them to think through the process.
* Protocol or materials and methods must have a control or reference to a good capsule (DO NOT VOLUNTEER INFORMATION but confirm if they ask. The hope is that they realize their analysis must reference a good pill)

Directions

* Use the scenario of them giving the pills to loved ones. Putting it in this context and students tend to be more precise.
* Each pill must have a basic description/justification (they must incorporate their data) of why it is good, good with side effects or bad in their conclusion/discussion.
* The 8 pills will come into 2 containers containing 4 pills each. Once you open the container you should smell something sweet or plastic. The sweet smell is indicative of stage 1 contamination while the plastic smell is the normal. If a sweet smell is sensed the group must assume all 4 pills have entered into stage 1 contamination.
* The groups will analyze 2 sets of 8 pills and must use each protocol:
	+ Use of the balance 4X + calipers 2X
	+ Use of the balance 2X + calipers 4X
* Calipers can only be used on 1 pill as they must get precise measurements
* Balance can be used any way they see fit. When something or somethings are weighed that is considered one use of the balance.
* If they can justify one more balance or caliper give it to them with the understanding that they must detail this extra use of instrumentation in their write up.

Common Questions

* What if both bottles smell sweet?
	+ Answer with a question, “Is that going to be a problem with your analysis?” The hope is the students will debate with you that the only way to do this is to have a reference or control of a pill that is “good”.
* Neither container smells so they are all good. What do we do now as we are done?
	+ Answer with a question, “Are you going to base your assessment on your ability to smell or should you use more hard evidence?”

Sample Protocols

4 balances + 2 calipers

1. Smell – one or two containers will not smell. This gives the students their control or good pill
2. Balance (#1): Weigh 4 pills from the container that does not smell
3. Balance (#2): Weigh 2 pills from the sweet smelling container
4. Balance (#3): Weigh the other 2 pills from the sweet smelling container
5. At least one group of 2 pills has to be heavier when comparing to the average weight from Balance #1, unless it is from container 3A&B or 6A&B
6. Balance (#4): Weigh one of the pills from the group that was heavier. Subtract that amount from the total weight obtained from the previous balance to obtained the mass of the other pill
7. Caliper (#1): Measure the length of control or good pill
8. Caliper (#2): Measure the length of the last smelling pill that has not been analyzed
9. In this protocol the group may leave the bad pill for caliper #2. They will see an enlargement of 1mm and sometimes ask for one more balance to ensure the pill is heavy. Grant them this if you feel the argument is made using their data.

2 Balances + 4 calipers

1. Smell – one or two containers will not smell. This gives the students their control or good pill
2. Caliper (#1): Measure the length of control or good pill
3. Caliper (#2): Measure the length of a pill from the sweet smelling container
4. Caliper (#3): Measure the length of another pill from the sweet smelling container
5. Caliper (#4): Measure the length of another pill from the sweet smelling container
6. Balance (#1): Weigh 4 pills from the container that does not smell
7. Balance (#2): Weigh the last pill from the sweet smelling container

Pill Breakdown

|  |  |  |
| --- | --- | --- |
|  | Container 1: Pills 1-4 | Container 2: Pills 5-8 |
|  | Pill # | Pill # |
|  | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| 1A or 1B |   |   |   |   | S | S | S | SX |
| 2A or 2B | S | SX | S | S |   |   |   |   |
| 3A or 3B |   |   |   |   |   |   |   |   |
| 4A or 4B |   |   |   |   | S | S | SX | S |
| 5A or 5B | S | S | SX | S |   |   |   |   |
| 6A or 6B | S | S | S | S |   |   |   |   |
|  |  |  |  |  |  |  |  |  |
| Blank = Good  |  |  |  |  |  |  |  |
| S = Smell |  |  |  |  |  |  |  |  |
| X = Bad  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| **Type of Pill** | **AVG Length** | **AVG Weight** |  |  |  |  |
| Good | 23mm | 0.5 – 0.6 g |  |  |  |  |
| Good w/S | 23mm | 0.5 – 0.6 g |  |  |  |  |
| Bad | 24mm | 0.70 g and above |  |  |  |  |