Karen McCann
Level 1 Lesson Plan
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# Title: Toothpickase Activity

## a. Description of topics:

1. Enzyme activity
2. Enzyme reaction rates/slopes
3. Use of the TI-83
4. Use of Excel
5. Regents Living Environment Standard 1 and 4

## b. Description of the activity

**Background information:**
They participate in a dialogue about enzymes, substrates, and the calculation of rates of reaction. Then, the students become the enzyme, toothpickase, which breaks toothpicks in timed intervals. Calculations are completed to determine how many toothpicks are broken per second to determine the rate of reaction of the enzyme toothpickase.

**Teacher Preparation:**
Purchase flat toothpicks (each student or student group needs approximately 250 toothpicks. Toothpicks for each group will be divided into six piles of 40 toothpicks each and a few left over.) Two boxes of toothpicks is enough for six lab groups (or six students if completed individually). I always have the students count out the stacks of 40. Obtain a few "competitive inhibitors" which are the approximate shape of a toothpick but do not break easily (twisties from garbage sacks or dissecting pins).

**Discussion/Demonstration:**
The vocabulary and processes of an enzyme reaction are modeled with hands and toothpicks. The enzyme is a student's hands with a particular shape (it actually demonstrates quaternary structure with the two subunits coming together). The active site is the portion of the thumbs and index fingers which form a space within which the toothpick fits. The substrate is the toothpick. A toothpick can be broken into two products.

The rate of the reaction can be measured by counting the amount of product produced or by counting the amount of substrate remaining. There are many factors that affect the rate of an enzyme reaction. Break a toothpick. Can a toothpick be broken faster? Can it be broken infinitely faster? Given a pile of toothpicks (substrate) and ideal conditions, it still takes some time for the enzyme to break the toothpick....that is the enzyme's V-max. If the room were filled with toothpicks, the rate would not increase, at least initially. Would

it take longer to break the toothpick if it was across the room on the floor (lower substrate concentration)? If it was surrounded by look-alikes (competitive inhibitors)? What would happen to the amount of time to break toothpicks if two people were breaking at the same time? (Enzyme concentration).

The stacks of toothpicks will then be broken for selected time intervals: 0 sec, 10 sec., 30 sec., 60 sec., 120 sec. 180 sec.
The results recorded in a data table in the TI-83, noting time and toothpicks metabolized.

| Time (in sec) | Toothpicks Metabolized |
|---|---|
| 0 | |
| 10 | |
| 30 | |
| 60 | |
| 120 | |
| 180 | |

The students will graph on the TI-83 the number of toothpicks metabolized over time in seconds to establish the different rates of reactions in the different time intervals. We know that the rates change because the line does not have the same slope. The students also calculate using the graphing calculator the average rate of reaction at each of the time intervals using the formula for a slope:

$$\frac{M2-M1}{T2-T1}$$

and graph these results as well on the TI-83.

An average initial rate of reaction is .7 toothpicks/ sec. If taken to 180 seconds, the rate of reaction for the interval between 120 and 180 seconds is almost always 0 toothpicks/second. An interesting note is that invariably when the students are breaking toothpicks for 60 seconds, some student will anxiously say that they are out of toothpicks. Of course, that is the point because their rate will decrease as it becomes harder to find toothpicks to break. They have a sense of one of the factors that affect an enzyme.

Students will then transfer their data onto an Excel spreadsheet and graph their results to hand in with their lab.

These possible extensions make me think of a Stella model for this activity so that we can then change the results!!

**Possible extensions:**

Numerous and dependent upon the time allowed for the exercise. They can search for scattered toothpicks around the room. Students can put their hands in ice water for a minute before trying to break. Students can break in groups. They can have many competitive inhibitors in their stacks. There can be stacks with fewer toothpicks. They can model denatured enzymes by crossing their fingers. ..etc.

## c. Set of Questions:

1. **.What happens to the reaction rate as the supply of toothpicks runs out?**

**2. What would happen to the reaction rate if the toothpicks were spread out so that the "breaker" has to reach for them?**

**3. What would happen to the reaction rate if more toothpicks (substrate) were added?**

**4. What would happen to the reaction rate if there were two "breakers" (more enzymes)?**

**5. What happens if the breaker wears bulky gloves (active site affected) when picking up toothpicks?**

d. Scoring

Activity:18 points—scored by partner

Conclusion-12 pts

Initial Data Table-10pts

Initial Graph—10 pts

2nd Data Table on Rates—15pts

2nd Graph—15 pts

Conclusion Questions—30pts