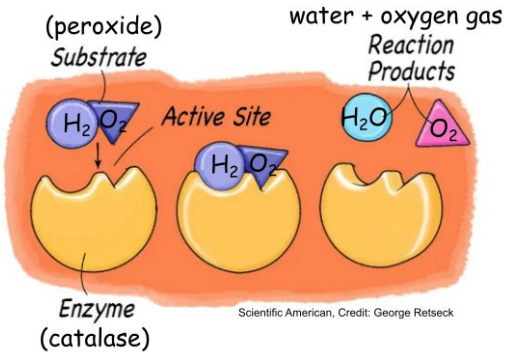
Molecules of Life: Enzymes

Speeding chemical reactions[1]

- **Enzymes** are proteins inside living cells that speed up chemical reactions. They work as machines to convert **substrate** molecules into **products**.
- Enzymes themselves do not get used up. Once they convert one substrate molecule, they are ready to work on another.
- Yeast cells contain an enzyme called **catalase**. It converts the toxic chemical **peroxide** (H_2O_2) into harmless water (H_2O) and **oxygen gas** (O_2).



1. Use the graduated cylinder to pour **60 mL of warm water** into a bowl.
2. Sprinkle **1 teaspoon dry yeast** into the bowl, mix it up and set it aside for at least 5 minutes.

The dry yeast granules are made of millions of live dehydrated yeast cells. In warm water, the cells wake up and the **enzymes** inside them begin to function.

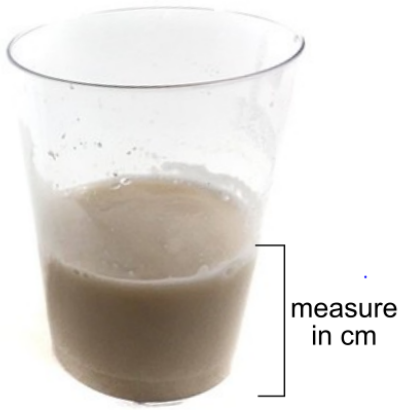
3. While you wait for the yeast to wake up, label the 3 large cups (#1, #2, #3)
4. Use the ruler to mark a line **6cm above the base** of each cup.
5. Put a **squirt of dish soap** inside each cup.
6. Use a graduated cylinder to measure out peroxide and add it to each cup, as listed in the table below. If you pour in too much, use a pipette to take out the extra and squirt into the waste disposal bowl. <u>Do not add the yeast yet!</u>

	Cup #1	**Cup #2**	**Cup #3**
amount of peroxide (H_2O_2)	15 mL	30 mL	30 mL
amount of yeast	5 mL	5 mL	10 mL
max foam height	observed:_____ cm	predicted: _____ cm observed: _____ cm	predicted: _____ cm observed: _____ cm
Time to reach 6 cm	xxxxxxx	observed: _____ sec	predicted: _____ sec observed: _____ sec

1 This activity is modified from Scientifc American: https://www.scientificamerican.com/article/exploring-enzymes/

7. Take a look at the bowl of yeast again.
Describe what you see:

The awakened live yeast should have started metabolizing (burning) the sugar, producing CO_2 gas. This is the same gas our cells produce when metabolizing food, and we get rid of it by breathing out CO_2. The gas bubbles make the yeast puff up a little.



8. Use the syringe to add 5mL of yeast mixture to Cup #1.
Describe what you see:

9. Feel the outside of Cup #1 with your hand. Compare it to Cup #2 (which has had no reaction yet). Do you notice a difference?

Which cup is warmer? Cup #1 Cup #2

10. Let the reaction go for a minute or two until the foam stops rising. Measure how far it rose above the base of the cup, in cm. Fill the number in your table.

What gas is being produced from peroxide (H_2O_2) to make the rising foam?
Oxygen gas (O_2) carbon dioxide gas (CO_2) chlorine gas (Cl_2)

Yeast contains the enzyme **catalase** which breaks up peroxide into water and hydrogen. This reaction is **exothermic** – it releases energy in the form of heat.

Discuss: why do you think the foam stopped rising? What determines how high it rose?

11. Make a prediction:
How high do you think the foam will rise in Cup #2, which has twice as much peroxide?
_____ cm

12. Designate one student as the timer, another as the yeast-adder, another as the observer. Start the timer when the yeast is added ("Go!"). Stop the timer when the foam reaches the black line ("Stop!"). You may want to practice the timing before actually adding the yeast.

13. In the table, record how long it took for the foam to reach the black line. Also record the maximum height the foam reaches after it stops rising.

Was your prediction correct? Yes / No

The chemical reaction will go until the **substrate** (peroxide) runs out. Adding twice as much substrate means twice as much **product** (O_2 bubbles) is formed.

14. Make some predictions:
How high do you think the foam will rise in Cup #3, which has twice as much yeast? _____ cm
How much time will it take to reach the black line? _____ sec

15. Carry out the experiment in Cup #3. Add 10 mL of yeast mixture (quickly), start the timer, and time how long it takes for the foam to reach the black line. Fill in the rest of the table.
Were your predictions correct? Yes / No

More **enzyme** (catalase from yeast cells) means more machines to convert substrate into product. This will make the conversion go faster, but will not change the final amount of product formed when all the substrate is used up.

15. What do you think will happen if you add another 15mL of peroxide to Cup #1 (on top of the foam already there)?

_____
Test your prediction and see if you were right.

16. What do you think will happen if you add another 5 mL of yeast to Cup #2 (on top of the foam already there)?

_____
Test your prediction and see if you were right.

The chemical reaction stops when the **substrate** (peroxide) runs out. The **enzyme** does not get used up in a reaction. So adding more enzyme will not help if the substrate is already gone.