

The Effect of Temperature on the Rate of Photosynthesis

By: AnnMarie, Genie, and Rachel

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Mrs. Courtsunis

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Purpose: To determine the affect temperature has on the rate of photosynthesis.

Background: The rate of photosynthesis is influenced by temperature. Usually the higher the temperature, the greater the rate of photosynthesis (due to increased collisions with enzyme and substrate). However, if the temperature is too high, the rate of photosynthesis can decrease. Enzymes are sensitive proteins, and their active site can easily denature when there is too much heat stress. This can inhibit its ability to work. The enzyme rubisco catalyzes carbon fixation reactions, but it will not do its work if its active site is denatured. Rubisco is the necessary enzyme in order for photosynthesis to occur. It catalyzes the Calvin cycle, which converts CO₂ into carbohydrates.¹ High temperature can rapidly inhibit the activation of rubisco, which will decrease the amount carbon fixation, therefore CO₂ fixation decreases by moderately high temperature stress.² The decrease in carbon fixation from inorganic compounds to organic compounds is linked with the prevention of the activation of rubisco.³ Photosystem II is the primary site of heat damage to the photosynthetic function. Adding too much heat to winter spinach leaves will kill them because it will not be able to perform photosynthesis. Lowering the temperature too much will slow or even kill process of photosynthesis as well. Winter spinach is known to be a cool weather crop. Winter spinach grows the best when temperatures range between 16°C and 18°C. According to the article 16°C, is the best temperature to grow winter spinach.⁴ If the temperature is too cold enzymes will move slowly to their substrate and the reaction will occur slower.

Hypothesis: In the range from 16°C-18°C, its is expected that the most photosynthesis will occur at around 16°C.

Materials: Three styrofoam containers, three beakers, hot water (35°C), cold water (10°C), and room temperature water (16°C-18°C), thermometer, lamp, winter spinach leaves, timer, soap, baking soda, syringes, pipettes, ice, hole punchers, ruler.

Procedure: Take cold water (10°C), hot water (35°C), and room temperature water (16°C-18°C) and place into three different beakers, each with a styrofoam insulation system. Add a pinch of baking soda, and five drops of soap to each beaker. Punch 30 holes into spinach leaves (10 disks per beaker), and insert into syringes. From each beaker, insert 5cc of solution into syringes and take all the air out. Create a vacuum in the syringes by holding top nozzle and pulling back the plunger. Repeat this process until all leaf disks have sunken. Pour the disks and the solution from the syringe into appropriate beaker, and start timer. Use thermometer, ice and hot water to make sure temperature is constant. Record how many disks have risen after every minute for 15 to 20 minutes. Repeat process three times. Adding leaf disks to solutions of water and baking soda at different temperatures will test the hypothesis to see which temperature is best for photosynthesis to occur in. The baking soda will provide carbon dioxide, which is essential for photosynthesis to occur.

Data:

Trial 1

Number of Leaf Disks Risen

Time (in minutes)	Median Temperature (16°C-18°C)	Cold Temperature (10°C)	Hot Temperature (35°C)
1	0	0	0
2	0	0	0
3	0	0	0
4	0	0	0
5	2	0	0
6	3	0	0
7	4	0	0

8	4	0	0
9	4	1	0
10	5	1	0
11	7	2	0
12	8	3	0
13	9	5	0
14	9	5	1
15	9	5	1
16	9	6	1
17	9	6	0
18	9	6	1
19	9	7	1
20	9	7	0

Trial 2

Number of Leaf Disks Risen

Time (in minutes)	Median Temperature (16°C-18°C)	Cold Temperature (10°C)	Hot Temperature (35°C)
1	0	0	0
2	0	0	3
3	0	0	5
4	0	0	10
5	0	0	9
6	4	0	9
7	8	0	8
8	8	0	8
9	9	0	7
10	10	0	7
11	10	2	7
12	10	4	7
13	10	6	7
14	10	6	7
15	10	5	7

Trial 3

Number of Leaf Disks Risen

Time (in minutes)	Median Temperature (16°C-18°C)	Cold Temperature (10°C)	Hot Temperature (35°C)
1	0	0	0
2	0	0	0
3	0	0	0
4	0	0	7
5	0	0	9
6	3	0	10
7	6	0	10
8	8	1	10
9	9	2	10
10	10	3	10
11	10	3	10
12	10	4	10
13	10	6	10
14	10	8	10
15	10	9	10
16	10	9	10
17	10	9	10
18	10	9	10
19	10	9	10
20	10	9	10

Results: For trial one, the leaf disks in the temperature range of 16°C-18°C, rose quickest. Then the leaf disks with the cold water began to rise. The leaf disks in the hot water barely rose. In trial two, the leaf disks with hot water began to rise quickest, but some soon fell afterwards. Then the leaf disks in the temperature range of 16°C-18°C, and then the leaf disks in cold water. In trial three the leaf disks in the hot water also rose quickest, then the leaf disks in the temperature range of 16°C-18°C, and then the leaf disks in cold water.

Conclusion: The hypothesis was in the temperature range of 16°C-18°C, the most photosynthesis is expected to occur at 16°C. However, from the data of the experiments, the most photosynthesis happened at the higher temperatures in spinach leaves, thus rejecting the hypothesis. Two out of the three trials, the leaf disks rose quickest in the hottest water. This could

have occurred because the leaves could have been damaged during the set up of the lab. Also, enzymes could've already denatured because of the heat during the creation of the vacuums.

References:

1. Principles of Life Second Edition for the AP Course Hillis Sadava Hill Price
2. Moderately High Temperatures Inhibit Ribulose-1,5-Bisphosphate
Carboxylase/Oxygenase (Rubisco) Activase-Mediated Activation of Rubisco by Urs
Feller, Steven J. Crafts-Brandner*, and Michael E. Salvucci
3. Photosynthesis, photoinhibition and low temperature acclimation in cold tolerant plants;
©1993 Kluwer Academic Publishers
4. Spinach Growing Tips by Steve Albert on August 27 in Gardening Tips, Leaf
Vegetables. Tips

