

Silk Diary

by Mad Scientist Ed Park

What follows is the diary kept by my father about his experience raising silkworms. The photos were taken by my nephew, Craig Park. Many thanks to them both, and to Susie Park and Melanie Marshall-Park for their help!



Oct 23, 2003

A 6 x 5 x 4 inch card board box arrived. It was packed with white packing peanuts that almost looks like a cocoon. A small plastic tube contained about 50 eggs that are about size of smallest seeds you can think of. The instruction says put the eggs in a petri dish and keep around 80°F. Of course, we do not have a Petri dish and do not know how to keep it 80°F.

Oct 26

After discussing many options, I decided to use glass pie dish for petri dish. And keep the eggs in the front of gas fireplace which has a pilot light on all the time. I put paper towel on the dish and sprayed with water. Now I think the dish is ready and my venture is started. The next morning, the paper towel is completely dry. I sprayed with water but it will be not be easy to keep it moist but not drown the eggs. We have to think something to keep it moist better. Suddenly I realized this job is like a baby sitting with responsibility and some expectations.

Oct 27

I check these eggs every two or three hours to see if it has grown since the last time. Of course, I want them to grow, so it seems eggs are getting bigger but may be not.

Oct 28

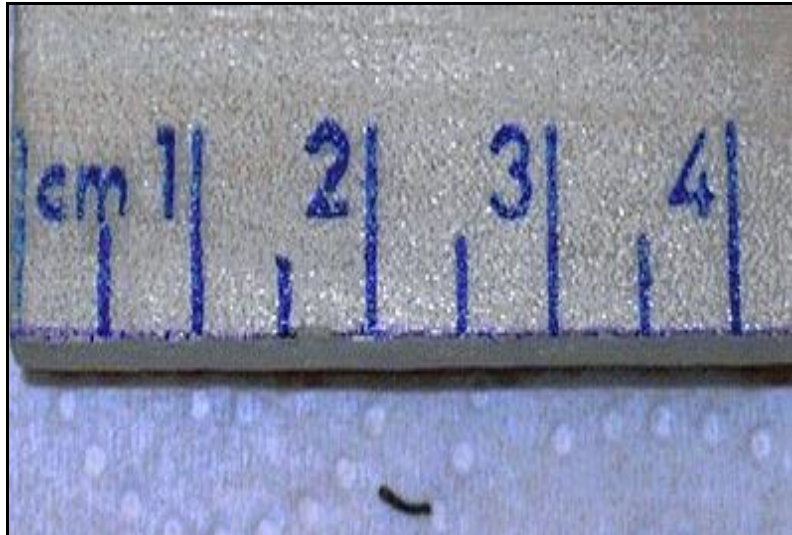
I keep checking how the progress is. I use magnifying glass to see the eggs. It is now size of pinhead. I feel our house is cool for the egg's growth. We keep our house around 68°F to conserve energy. Now I have to find a suitable house when it turns into moving animals. I thought a fish tank might be the right container but I don't have one. May be I go to PTA store or a garage sale. Not knowing the exact time table of the progress makes me anxious.

Oct 29

Suddenly I have to acquire knowledge on mulberry trees. Silkworms only eat young leaves thus it is not possible to get young leaves in fall season. However, I try to find some and I can tenderize before feeding it. I call North Carolina Botanical garden and one curator and I had a nice conversation. He said, "Yes, North Carolina has mulberry trees and usually you can find next to local highway." I said, "Do you know one around we live?" "No, I just cannot think of one now." I call a County Botanist. He is out and I leave phone message asking to call back.

Oct 30 (Day 1)

In the late afternoon, Oh my! There are three warms moving and can see clearly. It is about 1/8 inch long and has a blue shiny head which is bigger than other part, one white colored ring around the neck, gray body with wrinkles and some hair like things on the body. The tail is stuck to the paper towel and head is moving about looking for food.



Now, I am in trouble because I did not prepare the food yet.

Panic attack! I started to cook the food under duress. I have to cook and refrigerate then start to feed the baby. Food is not ready that 's too bad. The first three babies must wait until tomorrow to eat. Cooked the power in a pot steering continuously 15 minutes then put into a glass container. Plastic sheet covered the hot paste and pushed down onto the food to keep bacteria out. Cool the cooked paste and refrigerate. One problem is the smell of the food. It is unpleasant but not too offensive. Tomorrow I can start to feed the silkworms. I feel like a mother.

Oct 31 (Day 2)

All warms must talk to each other and they knew it is a new month. This morning about 25 eggs turn into a wiggly hungry worm. Once it turns into a worm, it looks for a nipple I guess. It moves shiny head up and down and around looking for something. I put some cooked green food next to the worms. It attacks the food and attaches to the

food and start to eat immediately and continuously. These worms are so small hard to see the features.

Nov 1 (Day 3)

Now the majority of eggs is hatched and wiggle around the dish. Small lump of green food is laid right next to the wiggling warms and it started to eat immediately. There are about 40 green lumps and one worm on each lump. Only problem is this food supposed to be a texture of soft cheese. Right after the feeding, the food is the texture of soft cheese, however, after two hours the food is started to harden. Now what? Am I suppose to take each hardened food away from each worm and replaced with soft food? What instrument can move small thread size worms from the food and replace to new food without hurting the worms?



It seems there are at the least, four kinds of mulberry trees. One is Weeping White Mulberry (*Morus alba pendula*) which grows into 25 to 30 feet. Another is Contorted Mulberry (*Morus australis*) which grows into a shrubbery of 10 feet. Third kind is White Mulberry (*Morus alba*) which came from China and grows into 40 ft. tall. Fourth kind is Red Mulberry (*Morus rubra*) which is a native American tree which grows into 60 ft. I guess the last kind is more abundant around here. Nothing else, I learned *Morus* means mulberry. Just finding one of these trees is my assignment.

Nov 2 (Day 4)

Since the first lump of food I gave is all dried up, now I have to give soft and moist food replacing old food. I sliced the green food into a wafer size and moved all worms to new food. It is a delicate operation which requires patience and soft touch. Using two tooth-picks, I gently lift the old food with a worm then I pick the worm and put on the top of new food. I took more than 30 minutes to do this task. These worms will turn into cocoon with roughly 30 days. This means I have to change food 30 times. This is one way to teach patience and gentle touch to an old grouch.

Nov 3 (Day 5)

I just flunked as a scientist or start of a major discovery. I think I killed the majority of worms. I just cannot figure it out how I did the murder. May be my water is

contaminated, food is too dry and I starved to death. Or I handled with my tooth-picks and poked them to death. I just could not figure it out. Then my wife gave me the right answer immediately. You dumb scientist! Any decent cook would know that you froze the worms to death. The worm food is stored in the refrigerator and it is 40 F. When I changed the food, I did not wait until the food is changed into the room temperature. As usual, my wife hits on the nose.

As the day started to warm up, I discovered wonderful scientific fact. You can chill silkworms to 40°F and it will stay in cryogenic state and it appears to be dead. Silkworms are hardy sort and will not die from little cold. It seems all worms survived a mad scientist's error. May be accidentally I produced stronger silkworms.

Nov 5 (Day 7)

Right after the hatch, worms had large blue head, one white band around the neck and gray body. With one week of growth after the hatch, the appearance is changed. Now the worms are about 1/4 long, body is size of thick thread, and body is as big as the head. Now the coloring is changed. There is blue head, larger white band, and whole body is light gray/black color. The worms seem to check on their neighborhood more often now. The tail is stuck to the food and head is up in the air and moving about often. I sure don't know what they are looking for. May be they are looking for a buddy or a girl friend.

Already these worms are producing silk thread or web. Practice makes perfect came from animals. Even though these worms are tiny and young, it attaches itself to food or whatever by producing a thin sticky silk thread. When I tried to move worm from old to new food, this fine thread is attached to worm's tail end. I can dangle a worm in air by this thread. But it makes my change of housing difficult. This thread is stuck to my tooth pick and it is hard to dislodge from my tooth pick.

Nov 6 (Day 8)

During the daytime hours, the worms attach itself to one position by the tail with a web and stick head up and look around. Then it lower the head and start to eat for a while. After that it moves to next area by wiggle and making a wave like motion. In between it rests or sleeps long time. That is just about all it does. When I check on around 5 A. M., all worms are sleep. Thus these worms do sleep and know day and night. Not all worms hatched on the same day. There was lapse of at the least six to seven days between the first hatching and the last hatching. I get confused easily what is going on between different development stages. It seems some worms sleep long time then active some days then sleep again.

The silkworms suppose to grow size of little finger or bigger. I guess I have to come up with a more space for 40 worms and enough space so they will not be crowded.

How much will it eat once it grew the size of a dragon? Do my supply of green food is sufficient? Suddenly I feel like I am a supply officer in Army who worries about housing supply, food, water, clean environment, and disposal of excrements.

Nov 7 (Day 9)

I wonder all scientists had problems like I have now. Should I read more materials on raising silkworms so that I know exactly what will happen. Then I will know the exact sequences and able to tell when any events are out of norm. This way I would worry less and enjoy events unfolding in the front of me. Or I should not read anything of how to raise silkworms. This way every event is new and exciting. Observer gives more attention to what's happening, The observer is unhindered by any preconceived notion and try his/her best to deduct what is happening. Both approaches have advantages and disadvantages. How can it be both approaches are acceptable? Lack of reading material on raising silkworm forces me to use the second approach and make it a happy adventure.

There is different personality to worms. Some worms are very active while some worms are shy and enjoy hiding under the curled up food. Also there are different stage of development now. Some lazy ones sleep long time while active ones move about days. There are $\frac{1}{2}$ inch long worms to $\frac{1}{4}$ inch long worms. I guess, I have some runt of litter.

Each food wafer is home to about 15 silkworms. Now I observed that the food wafer is covered with web. It appears that worms continuously spin a silk thread or cobweb like material. The exact source and the reason for these webs are not certain. The whole wafer is covered with spider web like material. The web strings are any which way and it is covered with black dots. The whole web can be lift up in one piece. Here is black lines crossing any which way with a lots of black dots, it sure gives an impression of army tank camouflage cover.

Nov 8 (Day 10)

Some worms are large enough to see distinct features. It has a black or blue shiny mouth, whitish head or chest about $\frac{1}{8}$ of inch, the rest of body about $\frac{3}{8}$ of inch which add up to be about $\frac{1}{2}$ inch. The body has seven or nine joints depending how I count joints. Under each joint is a protrusion made of the same material as the body which is legs. Not for sure, but I can find 14 leg like protrusions. At the tail end, there seems some kind of pinchers that help worms to attach to anything quick and pretty steady. I call these silkworm unicorn worms because it has a small horn on the topside of tail.

Nov 9 (Day 11)

Only instruction on how to raise silkworm is from the vendor who supplied eggs and food. It is one page instruction printed on both side of a sheet. Life cycle is process of growing and the instruction says:

Egg Larva Pupa Adult

First second third fourth fifth spinning

Instar instar instar instar instar cocoon forms & rest Emerges; female lays eggs

Approx. days 4 3.5 4.5 6 8 5 10 5

Instar means a stage of an insect or other arthropod between molt. What is wrong with common language already in use that is "stage"? May be each specialties must develop own language so they think they are difficult and important. I don't feel important just because I use "instar" instead of "stage."

By the chart above, the worms are in either the second or third stage. I cannot tell much from just looking at it when the animals go through one instar to another. Only difference is the oldest one is now about $\frac{3}{4}$ of inch and the youngest one is about $\frac{3}{8}$ inch.

Nov 10 (Day 12)

Discovery of mystery gives joy and happiness. I can imagine some scientists would jump up and down and shout for joy when they find a major event. But my discovery is not a major event. None the less, I can sleep better without having weird dreams. In the middle of night, I turn on light to see what's happening. The majority of worms are sleeping, but each time there are five to seven worms are not on the food wafer. They are moving about $\frac{1}{2}$ inch to one inch away from the food. Now I know where and how they discard their poops. Just like dogs, silkworms may not do things in their own house. It goes out and do their things.

Not only that discovery, it seems their discards are irregular rectangle and round shape and they do one piece in one sitting or many times in one day. Each day, there are roughly 100 small black dots all around the food wafer that houses about 13 worms. It turns out to be each worms do discards eight times per night. What a discovery and simple thing like this makes a mad scientist happy.

The master gardener from the Orange County Cooperative Extension Services of North Carolina called back which was much appreciated. She says that there are plenty mulberry trees around. It is consider a common tree around here. There can be black or white berry with looks of raspberry. However, the fall season is here and leaves are falling fast and she is not sure there are any left yet on trees. She told me that leaves of mulberry trees are very distinct and easily identifiable. Leave is shape of three prongs

how. It has one main shoot which is largest, and two side shoots which are smaller. The next time she finds a mulberry tree with leaves she will call back. She just could not place the exact location right this minutes.

Nov 11 (Day 13)

My vanity has been hidden until this project is assigned to me. Do you think everyone think they are working on the “most’ and “best” project? This might be a mad scientist’s “normal” view of himself. But here is my claim. What animal grows biggest from baby to full grown in weight or size? Elephant, whale, kangaroo, and some large fish are some that can claim they grew biggest or largest from the baby to fully grown animal. However, I claim without proof that silkworm is the one animal with the highest percentage growth in weight or volume, or size. It will grow as much as 10,000 times bigger in size from the original egg. That means I am working on a project with the highest percentage change.

The largest silkworm is called Captain Unicorn because it is the largest worm and has a little horn on the tail and the smallest one is called Private Runt. Suddenly I start to have an emotional attachment to some of these worms. What kind of scientist am I? How can a scientist observe an experiment with scientific detachment when the observer starts to call objects with pet names?

Nov 12 (Day 14)

There are 35 silkworms now and I feel they are happy worms. They know the night time and sleep well and they know day time and eat well. They are doing what they are supposed to do which means they are happy. The coloring is changed from grayish tone to light brown tone. It has some white stripes or white skin intermittently. So the coloring is light brown mixed with white skin not molted look. All silkworms have the similar coloring now and it gives impression of wearing an official uniform.

Nov 13 (Day 15)

Moving each worm from the old food to new food is tedious repeated activities which takes about 30 minutes. Up to now, I have been picking each worms from old and placing on to the new food wafer. There must be a better way to accomplish this function.

A smart friend suggested that I supply new food wafers and just trust silkworm’s survival instinct, or advancement of smell or eye sight, or mouth to feel the new food.

Of course, this is much better approach than the way I have been doing. Just because I have been spending many hours on this project doesn’t mean that I know all answers. I have interest, passion, and dedication, but the mad scientist can be wrong or using an unwise approach. Thanks to my smart friend.

At six o'clock in the morning, all silkworms are sleep. No one is moving at all. Five new food wafers are introduced the next to the old dried food wafers where they are sleeping. Within 10 seconds, seven worms are on the new food. My guess is that they could smell new food. That is only way I could explain how fast some worms moved to the new food. Within five minutes, the majority of worms are on the new food. However, there are always some stubborn ones. At six o'clock evening, there are five worms still eating from the old dried up food. Now the whole environment is started to look like a village. It has five old and five new food wafers which means 10 housings. I feel like a real estate tycoon. How much should I charge for rent?

Nov 16 (Day 18)

Whoopee! These worms are growing big. The thickness is bigger than tooth-pick and head or chest portion is bigger than the body part. Now you can see clearly mouth, head, chest, body with joints, tail section and a horn on the tail. But the face is different matter. Yes, I would like to see the face but the detail is hard to see even with a magnifying glass. It seems it has forehead, two eyes, a nose, two cheeks, a mouth with two moving parts and a chin. Each part is so small it seems there are five or six lumps. So far the face looks like E.T.'s face flatten down. The face coloring is changed from black to brown. I cannot wait until I can see each part of the face. Then may be these worms will be adorable because I am their nursing mother.



Nov 17 (Day 19)

This morning I got an inspiration that gives a scientist happiness and unhappiness. Why can a scientist like me not learn from the previous scientific developments? Look closely what you have and there are much information that gives you the answer. The inspiration is look into the discards. Each food wafer has about 100 black dots while I was observing casually. The brilliant inspiration is to look closely what the silkworms

discard. The majority of item is excrements that are black and round and rectangular shape. As worms grow bigger their excrements are growing bigger too. But the biggest surprise is that there are many white discarded skins look like dandruff. The shape is very irregular and very thin and almost clear and translucent. There are hundreds of them from very small to large. The largest size is about $\frac{1}{4}$ inch and the smallest one is barely visible. What a discovery! Only acceptable explanation is that these white things are the results of molting. These are their old skins. Even though I have been looking for molting but I could not find the evidence. I am very happy because I find the results of molting but not happy because I did not realize this things earlier. Now I feel like an archeologist who digs through ancient discards.

Nov 18 (Day 20)

Sudden burst of growth is obvious and alarming. It starts to give impression that it will be quite large in short order. Within three days it has doubled its size. There is a problem of crowding. Now I have to separate those in fifth instar and those are not quite there. Decision is made to build an another apartment. My army supply officer has supplied the solution. A large plastic hamper is a neighborhood and two glass plates will be building. Now I have to separate larger one from the less large ones. Two separate housing gives a chance to separate big one from small one. Accurate count is a basic stuff of science is made of. Now I brought in a census counter who turns out to be me. The exact population count is 36. Cannot tell count of female or male. At this stage, there is no known method of decipher male from female worms. How many different job experiences do I get from this one project! This one process gives three different experiences in one setting. I can be a census counter, a landlord, and a peach picker. Peach picker grades peaches by size and put into a proper slot in a box. This is an humble job and gives an new experience of doing menial job. What a resume will I have after this project!

I got very excited and happy this afternoon. I have been looking for every opportunity to see a molting process. At the beginning of each instar, these worms suppose to molt. As you know, these worms are in the fifth instar (in my calculation) and suppose to be done with all molting. There should have been 144 (36 worms times 4 molting) molting but I missed all of them. Here may be the last opportunity to watch one in the process of actual molting. The feeling is as close to a gold prospector who finds the first nugget after long search. The worm itself is glistening with moisture and it molted from the head and end with the tail. Whole molting came out as one piece. It looks like a dried small fish with translucent color but has black side stripes. It is roughly $\frac{1}{4}$ in size compare with the actual silkworm. The molting is decorated with a small brown dot at the head because the head color is brown. This observation made me very happy and

gave me a smile. This proves to me that small things do make one very happy if you are looking for one.

Nov 20 (Day 22)

Coloring is very important from now on. One way to tell when the worms are ready to cocoon is coloring. Another way is number of days. Now just about every worm is white with silver tone. It gives impression of water vapor forming outside of cold water glass. It is my job to find one that will decrease in size and change color to translucent. May be I should go see an optometrist to check on my eye sight first.

Nov 22 (Day 24)

Today is one month anniversary since the box with eggs arrived. So many things have happened in just one month. Now I feel I can raise silkworms and become a reasonable scientific observer but not a scientific scribe. This project gave me many opportunities to solve problems and improved my imagination. Also it gave me opportunities to walk in some other profession's shoes. Joy, surprise, worry, panic, puzzled, and elation are some of emotion I felt during the last month. Strong expectation is attached to the beginning of cocoon making stage. Not only I am counting days to the beginning but also I have many worries go with it. A lack of knowledge makes me worry more than necessary. Now I feel silkworms talk to me and I talk to them when nobody around.

Nov 24 (Day 26)

Silkworm starts to show itself off to me. Just discovered it has seven black dots on the bottom side of each joint on both sides. What's purpose of these decorations are unknown to me except a vanity. But somewhere I vaguely remember that these might be breathing holes. Silkworm decorates itself with very definite brown/orange eyebrow that looks like a crown upside down. Two black dots just out side of the eyebrow crown are another decoration. At the top of seventh joint from the tail, there are two half moon shaped decorations and two more at the fourth joint. Both of these decorations are not the exact same color. One is darker brown then the other. These are not the all decorations. The top of all decoration is the horn on the top of the tail. It is pointed backward and threatening and pronounced. It stick up head and look around long time as though it says look at me. Silkworm says " Am I not pretty?"

Cleaning the house is not a simple job anymore. Once it became a good size worm, it started to eat more and produce black dots more and larger. It now produces roughly 30 excrements per day per worm which turns out to be more than 1000 of them.

Actually the rate of production is increasing as worms are growing big. Moving worms from old to new house means moving all 35 worms. The majority of worms are moved with old food wafers but about 1/3 of them ends up moving individually. Only problem is their legs and tail stick to the paper pretty strongly. The legs are like a

suction cup and attached to anything immediately and forcefully. Some force and repeated coaxing are required to dislodge them from the paper. These worms refuse to move to new house. I can see these legs and tail force is used to hang on to leaves they eat in nature and they must stick to leaves even when there are strong wind. It impresses me that nature is made wonderfully and amazingly.

Every project should have a serendipity discovery. Worm's food is placed on paper towel. Moisture is introduced by spraying paper towel all around outside of the food wafers. Spray nozzle from water bottle makes some mist and worms are used to water mist. So I know these worms are getting moisture from different sources. Usually some worms are not on food wafer and walk around outside of food wafers. It is looking for a proper place to do their things. Accidentally I gave extra water just in the front of the mouth of worm. It started to eat water from the paper towel. So I gave extra water, sure enough it made repeated motion of eating water. Now I got embolden, gave water to some other worms. Wow! they did the same motion of eating water. Suddenly I got inspiration that may be I can train them. Here comes dancing silkworm and a former mad scientist in a circus.

One person important in my life is very strong willed person and very venture some in many ways. She is my wife and she is helpful to me many ways. But right now, her mental state is not happy state. She has a major phobia related to a large grub type worms. I am sure there is some fancy name for that but I don't know that the term. She can feel presence of worms from two blocks away. Her muscle stops functioning, breathing stops immediately, brain stops functioning, starts to sweat, gets anxiety attack when she encounters just one large grub. After one encounter, she would have many unusual dreams that could make many horror films. She made a major concession just to have silkworms in the house.

Beginning of this experiment, she thought eggs were cute. She tolerated small worms until the fourth instar. As long as the worms are less than one inch she could look at them with a minor anxiety. Somehow she can concentrate to look at only face but not whole body. This feat is not easy feat unless you have a major phobia. Now the worms are three inch long, and fat, her attitude is beyond anything I can imagine. She refuses to talk about worms, refuses turn on light where the worms are, refuses to let me bring it into kitchen or anywhere near where she is around. It seems she had one very bad experience when she was very young. To this date, she has this phobia closer to madness if you are not seen her react. Now I have a deeper understanding and sympathy for this kind of phobia that I did not had before. However, it seems that this experiment in the house for the last 30 days softened the degree of obsession. This

lessening of phobia of my wife is definite side benefit that I did not count on. No wonder the color of silkworms is silver lining.

My curiosity forces me to look up the term of my wife's phobia. Someone with phobia of creepy, crawly things has phobia called herpetophobia. While some one with phobia of moths has phobia called mettephobia. I wonder these terms are from Latin or Greek.

Nov 26 (Day 28)

Starting of cocoon making stage is very close now. My anticipation is keeping me awake and imagining many disasters. Now I am observing more frequently and closely. Captain Unicorn is almost 3 ½ inches and almost as fat as pencil. The silkworms sleep from 10 P.M. to 8 A.M. continuously. During the daytime, they do five different activities. They eat some, move one place to another, sleep or rest, go outside of the house and do their things, or lift up head looking around turning head up and down and sideways. I do not know the function of looking around but they must be enjoying this activity. Once they lift their head, they look around as much as 1/2 hour. These worms never wonder out far from the food. The maximum distance of wondering is about 2 inches. My early phobia of worms escaping the box is not worth worrying.

This is direct quote from the instruction sheet. It says "During the sixth to eighth day of the fifth instar, the bodies of the silkworms shrink slightly and become somewhat transparent. This indicates the silkworms are ready to spin their cocoons." Suddenly I start to feel uneasiness on my stomach. Can I visually see the difference in size? What happen if I cannot tell the color change? There are large to small worms. I know Captain Unicorn because it is the largest but there are others which are not as big as the biggest one. With all these different state of developments, how do I know when is the eight day of the fifth instar? Now I wish I am a fortune teller who can tell future.



Nov 27 (Day 29)

The worms need a dark space and little higher temperature during the cocooning process. For five days, they will not eat anything and spin cocoon. Are they spin continuously for five days without sleep? Are they ever rest? Do they create excrements? To observe their activities, I need a housing that can be opened and closed quickly without disturbing their activity. The Army supply office came up with two options. The first one is egg crates. Since there are places for 12 eggs what I need is three crates. The second one is a toilet roll. A small window can be cut into the side of toilet roll so that I can peek into it. This window can be covered with see through material such as clear plastic sheet. Two worms will volunteer into black dungeon so I can be Peeping Tom. What I do for development of science!

Today is Thanksgiving Day. It is time to reflect on the year and count our blessings. This project has been blessing to me. It gave me many problems that I can solve and gave me opportunities to see areas that I probably never delve into. This project gave me multiple opportunities to fill other people's shoe including silkworms. Many emotional elation gave me new experiences. And learning and viewing a nature in an intimate environment is something that I treasure as a blessing.

Nov 28 (Day 30)

Today is a special day for the archeologist in me. Just like real archeologist who finds a whole mummy from the ancient time, I found my mummy today. A molt that is completely whole is found today. It is from a large silkworm and not a single section is missing. What a pleasant surprise to find one! The whole section includes cover form the head with brown color, old skin of mouth pinchers with black color, old skin from legs exactly shaped like legs with transparent color, whole body skin with black side stripes, and extra tail section with transparent color "U" section. One perfect specimen given to archeologist is the ultimate gift for Thanksgiving.

Within two to three days, the Captain Unicorn should start the cocoon stage. If I am wrong, the Captain Unicorn will starve longer then the nature intended. He will go into a dark chamber and I will raise the heat pad setting to the medium heat to insure 81 F. There is no easy method to introduce moisture. Some spray bottle that makes mist is what I needed. The water bottle that I have been using shoots water streams and spread minimal mist. One more thing that worms orders me to do.

Nov 29 (Day 31)

This scientist got a message today out of blue. May be silkworms developed a new message medium. I got the message that says silkworms would like to find a dark place to start cocooning process. It is my job to find a way. Of course, there are many solutions to this problem. Move whole operation to a dark room is one option. Or cover

the dish with card board so the whole dish is dark is another option. But silkworms say that is not good enough. After some thought, I agree with silkworms that imitating nature is a better approach. I found some dried curled up leaves and wash them thoroughly. It turns out that brown fall leaves stays in shape even when they are wet. Only leaves with curled shapes are collected. Then I covered silkworms with multiple layers of leaves. It is the best I can do to imitate the nature. May be only a mad scientist can see it but he swore he saw happy look on silkworm's face.

Only problem with covering those worms with leaves close to cocooning stage is my impatience. Now I lift the leaves up every two to three hours to see what is happening. I am sure silkworms are saying "Give us peace, or go find another project." A little kid in me is so anxious that I just cannot resist peeking. My Christmas just had to come sooner or my impatience is going to ruin the whole project. Is it possible that I bother silkworms so much that they could boycott the cocooning step? Is it possible my peeking make silkworms nervous that they just abort the whole thing? When a mad scientist must grow up and learn to be patient? May be what I need is a psychologist.



Nov 30 (Day 32)

By my count based on the instruction, the early worms should be ready to cocoon. So far they are eating well, resting well, and doing their things very well. The color change or decrease in size is not discernable even though I watch diligently. May be silkworms will feel sorry for me and give me better signs. It is my job to transfer worms to dark chambers I created for them. Inside of three different boxes are walled and divided into chambers so they can have their privacy and almost total darkness. Now I am very anxious this process to start. What is keeping them from start the cocooning process? Do you think they need some kind of strong reminder from the mad scientist?

More I watch the worms, more I get this uneasy feeling something is not right. The glass plates I used has a rounded lip that keeps worms inside the plate, and the plastic box sidewalls are slippery and far from natural things. Suddenly, I get this urge to change the housing set up closer to nature. The plastic box have been replaced with a medium size cardboard box and glass plates have been eliminated with paper towels directly on the bottom of the cardboard box. Now I am happier that I did something for worms.

Dec 1 (Day 33)

Silkworms have to store energy to spin webs for five days without easing. I can see they are working toward it. In the early stage, I started with three food wafers. The last night there were 30 food wafers but this morning these are only small crumbs left over. It means sometime in the night, they ate the food with gusto. The whole box is covered with numerous black discards. Silkworms look well fed and fatter than my little finger now.

Woke up with a great expectation that this is the day cocooning stage will start. Silkworms are laughing at me for my impatience. The Captain Unicorn says; "You just have to wait until we are ready." The cocooning stage is behind five days now based on what the instruction says. Lower temperature, not natural leaves, not enough moisture all contributed to delaying the full development. But I believe, my peeking too often make them uncomfortable and the worms decided to teach me lesson. Just to show me that do not trust anything written. You have to learn that nature has its own rhythm, and it will decide when the time is.

Dec 3 (Day 35)

Fat and tight skin gives impression of transparent skin. Its color is off white with blue line where joints used to be. There is one more very interesting blue line going from the head to the tail at the middle of the top of the body. It is blue color and what is moving inside is blue also. This is the bloodline with blood moving back and forth constantly. The heart must be somewhere but not sure where. It reminds you of the HAL with intelligent and feeling. Now it is sending message saying quite saying we are fat and no feeling.



Dec 4 (Day 36)

Finally silkworm decided to give me a signal that they are ready to cocoon. It is 10 days behind the schedule. But worms choose a method that brings my worse nightmare back. My fear is these worms getting out of the box and escape to somewhere free.

Today, one brave worm decided to scale the wall of the cardboard box where they are imprisoned. This worm was half way up the wall and almost escaped. This is the message that says the worms are ready. I can feel that this worm is looking for a suitable place to cocoon. The place I supplied is not good enough or not privacy enough.

Just because I am mad and mean giant, I put nine fat buddies of the brave worm into isolation booth I made out of a cardboard box. It is divided into nine individual chambers about 4 inch by 4 inch. Nine buddies are co-conspirators who encouraged one brave one to scale the wall. They are about equal size with the brave one and fat and round. This box is sitting on a heating pad with medium heating. Also the whole box is covered a cardboard and a towel. This is the how I give privacy, extra heat, and as dark as possible. My ingenious dark isolation chamber got me into a corner. How can I watch closely the webbing process in dark chamber? May be I will ask a night vision goggle from my Army supply officer.

Even though the instruction said clearly, I have been blind or did not want to find the sign that the instruction stated. Clearly the cocoon stage is here and there should be change in color to "slightly transparent." My prejudice kept me from seeing the change. Since there is no denying that the cocoon stage is here, I could not avoid now. I stared very hard and long for every worm. Yes, a lightning struck my brain and it cleared my blind spot. The color of this worm changed from silver white to light beige. You can almost feel that you can see through the whole body. One can describe it as delicate light skin color. How can a scientist have a prejudice when nobody is checking over the project? Now I can see how real scientific discoveries could be hindered by prejudice.

Captain Unicorn has volunteered to go into a glass jar for the benefit of the species so that I can observe easily. Just about all nine worms in isolation booth are tempting to escape by climbing the walls. Just cannot figure out what and why they climb the walls. My excuse for the isolation chambers is to give a warm and cozy place to start to web. It is not what they need then I don't know what to do. If the climbing wall is not the sign for the next step then silkworms might be mountain climbers in the previous life.

Dec 5 (Day 37)

Omigosh! I have two babies this morning. What a relief and joy! I feel like a mother just delivered beautiful twin. One in the glass jar and one in the cardboard box weaved white silk cocoons. Two cocoons are not quite the same in shape or size. The one in the glass jar started with thread stuck on the glass



walls and very loose thread in outer layer. The cocoon in the isolation booth is shaped like an egg and not so loose as the other one. The color of the tread is shiny white that gives feeling of very thin silver thread. The cocoon in the glass jar is size of a small orange while the other one is size of a large egg. In one night, two silkworms produced enough silk thread that it is difficult to find the worm inside the mesh of white threads.

Inside the cocoon, the silkworm is upside down and placed itself shaped like letter "C" or "S." The mouth is moving left and right about 3/8 inch continuously. Then it changes the position to another area. It seems it goes from bottom to up then top to down so it covers the whole inside evenly. It is difficult to locate silkworm inside the cocoon due to worm's white body and white thread all around. Only thing I can see is the black mouth moving. When you hold the glass jar up against window where bright light is, you can see the silkworm weaving. The feeling of looking into X-ray picture on TV just like seeing unborn baby in mother's womb that gives guilty feeling of breaking privacy of silkworm. Silk thread is so thin and so fine you get the feeling that you are seeing something never seen before. What a privilege to see the nature in progress!

Four more worms in the cardboard box are in a different stage of making cocoons. Now the worms are telling me what they are doing and why. They are looking for someplace where they can start the cocooning process. It climbs the wall looking for a suitable place to start. It turns out to be someplace with a corner where they can cast starting scaffold webs. Some webs are glued on adjoining walls and loose webs are stretched across the starting webs. It seems some threads are thicker than others. The starter scaffold threads are thicker while in between threads are thinner. There are just a few scaffold thread while the in between threads are numerous. Outside layer is puffy, numerous, and unorganized. When there are enough webs to hang themselves on, they

start the cocooning process seriously. Thus outer layer seems to be haphazard, loose, without direction looking like frizzy hair. Whole ball is larger than the core cocoon that is tight and size and shape like a grape. Whole ball of cocoon is about 3 inch by 3 inch while the core cocoon is about 1 ½ inch to 1 inch oval shape.

Dec 6 (Day 38)

As of this morning, there are 15 late bloomers that are not fully grown and still eating hearty. Something that was obvious has missed by this observer. These worms have been eating enormous amount of food for the last five to six days. For the last two days, I noticed that the consumption rate is decreased drastically. My guess is that this is another indicator that indicates the beginning of the cocoon stage. What I missed is these worms have been eating for few days and sleeping few days. There are so many different stages mixed in together I did not notice the cycle. Right in front of me to observe but I missed.

As of this evening, there are 24 worms in the isolation booth and 10 worms in the food area. Of the 24 in the isolation booth, 15 of them are in some stage of making cocoons. Silkworm starts the cocoon stage by creating very thin strand that is hard to see. The thickness can be as thin as 1/100 of my hair. They produce these thin strands all over the area they selected. About 3 inch area is completely covered with these thin unorganized strands. It gives impression of multi-layers of cobwebs.



Then they choose the middle of this hairball as the center of their world. These thin webs carry the weight of the silkworm. Silkworm weaves tighter knit to make weather proof or temperature controlled environment that is the cocoon. Thus the center area is clearly visible white with shape like grape. White cocoon is covered with loosely knit strands thus the whole ball has look of unfinished and unkept fluffy ball.

Dec 9 (Day 41)

Do the right thing! It sounds just great but I am not sure right now. For the benefit of science, I should know what is happening inside cocoon. It means I cut open cocoons and look into the status of silkworms. But I am torn between for science versus my queasy stomach, torn between hurting animal versus obtaining more cocoons, torn between my curiosity versus privacy of silkworms. It seems the doing right thing means

living with mixed feeling of doing the right thing and some uneasy feelings. Decision is made today that one or two cocoons will be cut open and see the progress of silkworms and pupas. Only hope is this invasion of the privacy does not end up with killing silkworms. Even though I will be killing all pupas, I am not comfortable doing damages before the last stage.

One cocoon that has been weaving four days is selected to increase my knowledge. When I discarded all outer fuzzy thin webs, I end up with one clean cocoon. The core cocoon looks like a wrinkled white skin but it feels like very dry hard cardboard. I can tap the cocoon and it makes a thumping noise. It is very light, delicate, but it is strong. Trying to cut a thin line at the one edge with razor blade was difficult and messy. The wall is tougher than I expected. Finally, a small fine scissors opened oval small hole where I can peek. There was a small silkworm about 1 inch in length and ¼ inch round all curled up. It has seven wilted joints about 1/8 inch long. Only one feature is still obvious. The mouth was moving continuously making silk thread. While I peeked into the hole, the silkworm did not stop from weaving continuously. So far, my cutting a hole did not hurt the silkworm at all. This hole will be used for the future observations especially the pupa and the moth developing stages. However the worm might object to my continuous invasion of privacy. Does the worm will close the hole as soon as possible?

The instruction sheet says, “When you are sure pupation is complete, you can remove some pupae from the their cocoons for observation. ... The female are larger than the male....” So far I have seen two stages of silkworms: egg stage and worm stage. If I decide to observe all four morphosis of silkworms, I have to observe pupa stage, moth stage and egg creating stage. Of course, the nature states that there must be at the least one female and one male. To do this, I have to open as many cocoons until I find the one female and one or more male. How do I know when the pupation stage is complete? How many cocoons have to be opened before the proper combination can be found? Can I tell difference in sizes? Can I tell difference between male and female? Even though my mother instinct tells me go ahead and produce eggs but my chance of finding the right combination is very small unless I open many cocoons. Who will help me find the just one female and one male? Now what need is a clairvoyant?

Dec 10 (Day 42)

One opening to one cocoon to look inside is closed completely. The small silkworm used the last energy to close the opening. I invaded the private space and the silkworm did not accept the intrusion. The hole is covered with the threads and some extra silk threads had been pushed into the opening. The silkworm says a strong statement that

says stay away from me. If I want to peek into cocoons, I have to cut a new hole. These silkworms are making the Peeping Toms' like difficult.

Am I satisfying a scientific mind or Peeping Tom's curiosity? As usual conscience is not completely clear. Just have to satisfy with mixed up state of mind.

The silkworm in the cocoon with the opening developed into pupa and it contributed to scientific knowledge by jumping out of the cocoon. The whole body is about 1 inch long and 3/8 inch around mid section and oval. It gives impression of a small toy imitating Indian baby wrapped in a blanket. One unusual feature is the front and back is quite different. The front section has a head and three round wrinkles and a tail section. The head is peeking out of wrapped skin with two eyes and mouth. While the back section has six round wrinkles from the six joints during silkworm stage. It is light brown in color. The pupa was not very happy that I pulled it out of the house and wiggled furiously saying get me back into my house.

Dec 11 (Day 43)

Today is selected as the D-day. Just one cocoon will be boiled then see what is inside and find the end of single thread. Upon find the beginning of the thread, I will try to see if I can pull 2400 feet of silk thread without breaking it. I wonder a hangman felt guilty feeling when he cut of a head off or pull the lever. Just because I raised worms to produce silk threads, is it okay to kill pupas? Where is a priest who removes my guilty feeling? Can I wait just couple more days? Just waiting two or three more days make me less guilty? Who is going to encourage me to go ahead with the execution.

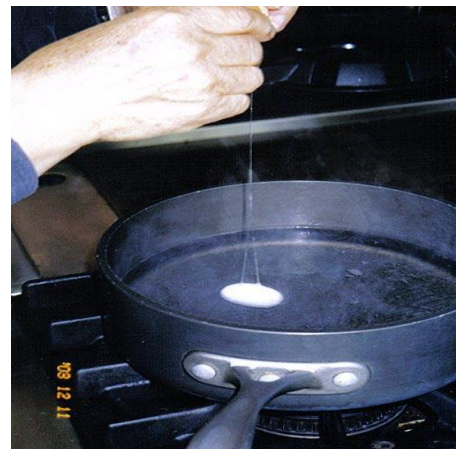
Cocoons are roughly grouped by starting date of the cocooning stage. There are three boxes with about 10 cocoons each. I selected one cocoon from the first starter box. All fuzzy thin threads have been removed and ends up a clean cocoon. This will be boiled first to see if there is pupa and find the beginning of single thread. If I boiled too soon, then I will end up with silkworms inside and if I boiled too late, then I will end up with moths. If I find the beginning of the thread, I will pull the thread to the end to see if that is possible. Expectation and anticipation give me unease feeling and want to postpone the actual execution. Did I know I am a procrastinator?

How can a belief be right and wrong at the same time? I had two options before and decided both ways can be interesting and correct approach. The options were should I have fuller knowledge before each stage? My choice was that either ways are acceptable and interesting. Based on that belief the choice was made not to read much and observe the event carefully and enjoy the nature. But now that belief is under attack. The instruction sheet has very short instruction how to pull thread from a cocoon after

boiling. It says "Using dissecting needle to pick up strands until you find a single strand of silk that pulls away easily." Sound so easy but in practice I need more information.

Should I cool cocoons before starting to pull thread? Or should I pull thread inside or outside of water? Or should I boil water continuously while pulling thread? If I wanted thicker thread, do I pull one thread at a time and braid later? Or should I combine two or more thread while pulling from cocoons? Or which approach is easier when pulling thread rolling onto small pencil or large roll? There are some more questions related to temperature of boiling water and finding the beginning of thread. Here I need someone with experiences who can supply information related to this process. Thus the more knowledge option is definite advantages. If I had large supply of cocoons, experimenting with different approaches and finding the best approach can be fun and add to knowledge. The total of 34 cocoons is not sufficient to experiment if I wanted to see moths and produce eggs. Where is a silk thread monger who can supply more information?

A scientific mind should be able to figure out a solution when there is a problem. What we have here is a tightly woven very thin thread into a small ball. The final results we desire is unravel it and ending up with one long thread. It is reasonable assumption that these thread is put together with some kind of natural substance that acts as a glue. The instruction says to boil it. The best guess is boiling will weaken the natural glue that hold thread. As thread is unraveled gradually, there is more glue still. Thus a scientific logic recommends boil continuously while pulling thread. Only unknown is temperature of water as pulling thread?



Just coming up with a solution is not enough when the major objective of the project is to obtain threads. When I have only about 23 cocoons to make thread if I use 10 cocoons for moths. Two cocoons have hole so I can peek into thus cannot use for thread. Search for an expert is launched. I talked to anyone who might have any information. My wife called her 77 year old older sister who might have



experience. Luckily she had helped her mother make silk yarns when she was little child. She remembered many details. The best advises were to use worm water while threading and use a rough leave to snag ends of cocoons. I am very grateful to Kim, Jung Ae who had many helpful suggestions. Here a real silk monger came to rescue this project.

Bobbing, Bobbing, cannot turn it over! Sounds like a child's song. I don't know what I expected but one cocoon bobbed on hot water and could not turn it over at all. The cocoon is completely sealed watertight which made it to bob. And a pupa inside is stuck to one wall so weight is heavy to one side which made turning over not possible. Just had to hold it down and drown the pupa. After five minutes of cooking, there were some threads on water and one small stick is used to pick up the end of the thread. The thread is so thin it is hard to see and seems there is no color. Only thing you can see is light shine on the thread so you can see glimpse of thread. It looked just like spider web. When you pull this thin thread, one thread came out continuously but just a few times three or four threads joined together to form one thread in the early stage. There is some strength to the thread but it is so thin it was easy to break the line. As I continuously pulling, the thread broke often because I was anxious and in a hurry.

A wooden spool is used to wind the thread. While left hand is holding the thread lightly, right hand rotate the spool while the thread is winded on the spool. If I do this job slowly, the thread did not break. But If I tried to speed up the winding, the thread broke often. Then I had to find the beginning of the thread and start over. Nothing else, this project says there is a proper speed for a good job and you just cannot speed it up just because you wanted to end the job in a hurry.

After three hours of pulling and breaking thread, the cocoon started to look like a thing tissue paper. It has some light and dark pattern but I can see through it. There appears a brown shadow that I know it is the corpse of the pupa that I executed. Immediate physical reactions occurred when I gazed the pupa inside thin cocoon. A unpleasant stomach pain and choke on my throat appeared instantly. And I do not want to see the result of my act that created the corpse. As I pull the thread, the cocoon bobs and the pupa moved with it. It seems the pupa is still living. My arm says the thread is endless while the cocoon stay white color the majority of time. It took three and half hour to reach the end and free the corpse. The cooked pupa is brown and shaped perfectly and can see every detail. Is it my job to bury this brave soldier?

Dec 12 (Day 44)

Pulling thread was exciting and memorable experience. It revealed one precious nature's secret to me. The length of thread is 10 times longer than I imagined. My wife and I switched often so we can pull continuously. Five strings put together barely made

a thin thread. It seems ten strings might make a normal thread. To make a thread, as many cocoons as desired are cooked together and threads are pulled together. A decision has to be made now how many strings should be pulled together to form a thread. Five strings might be easier to pull together but 15 strings might be the proper answer but difficult to do. Five strings can be pulled together then three of those can be braided together later. However, here I am talking about at the least 15 hours of work. What I need here is a cheap laborer? Luckily I can find one cheap laborer who will work for free. Can I volunteer for this job?

Dec 13 (Day 45)

Just because something is easier should not be criteria for selecting a scientific method. But it seems I can justify anything now. I hide behind that I do not have enough cocoons to experiment different methods. Five strands extraction method is selected for the first serious try. This is the safest pulling method I can think now. If this approach turns out to be easy extraction, then maybe I will select 10 thread pulling method. Is this an experiment or just hide behind a clever excuse. Fortunately, I am the project manager and the sole decision maker of this project. Still, I get this uneasy feeling I am not making tough decisions.

Over confidence is a dangerous trait that brings a disaster. Just because I extracted one thread from one cocoon does not mean I can do multiple thread extraction easily. The first attempt to extract 5 threads started badly. While boiling, white jelly like things appear around each cocoon. I gathered to see where it leads me. Four out of five cocoons shed their skin rather than giving me a single thread. The end of thick ropes and flat stripes were four broken up cocoons with pupas sticking out. My guess is that I did not wait 5 minutes before I touched the white soup. Within the first five minutes I lost four cocoons.

A cautious approach is selected this time. I boiled one cocoon at a time and more than 7 minutes. Then I lifted jelly like substance with a stick while dangling the cocoon. By giving gentle shake, the cocoon started to give smaller number of threads. Eventually, it gave up a single thread. Once the single thread is found, that cocoon was moved to another pot with warm water. After finding four beginnings of thread, I decided it is enough for the first multiple extraction. While four cocoons are bobbing in the warm water, four thread pulling business got started. Holding four threads from the cocoons in left hand, four threads are rolled together onto a paper roll. Right hand made circular motion rapidly while the thread is pulled. Four strands make a very thin thread. About 15 times, the thread broke due to couple reasons. The major reason is the paper roll came too close to the left hand and cut threads or rolling speed exceeded the strength of four strands. After two hours of rolling, the end of possible single thread came.

When you come almost to the end of thread, cocoon is covered with something looks like a thin wet paper. Pupa started to be visible and move with pulling. I had to stop before the end of cocoon is reached. The thin skin close to pupa tangled with pupa and I gave up pulling any more thread. The cooked pupas looked it is still living because I can see every detail of pupas. A small neat white sack with two or three dots came with pupa. It must be discards made during the cocooning stage.

Dec 16 (Day 48)

Extraction of thread is small accomplishment. Now the next problem is how to make these different strands of thread into useful thread. My writer daughter wants to embroider something from these threads. As of now, I have five very thin threads that are not useable. My wife is an embroiderer who has enough experience and knowledge to make proper decisions. Here I am glad I have a knowledgeable assistance who volunteered to solve my problem.

Dec 19 (Day 51)

Now I end up with 22 pupas and three early stage moths. Pupas are well formed and all light brown color. It has a head, four joints, and a tail from one side while the other side has a head, six joints, and a tail. The instruction



sheet says "The female are larger than the males, and their next-to-last abdominal segment has a ventral interruption." Now census count is carried out. Either I could not recognize ventral interruption easily or my eye sights are not good enough but I did find what I was looking for. One pupa was definitely larger than others. This pupa was almost one and half times bigger than others. This was the definite sign it is a female. The total male count is 21, and the total female count is one. Now tell me which sex is more important?

Dec 21 (Day 53)

Without understanding DNA construction, or DNA function, or even with some understanding, I am awed by what small egg which is barely visible with naked eye can carry enough information to produce four phases of silkworm. What form are these instructions? Are they just chemical composition? What makes one bigger than other? What makes more male than female? How do they know when to change to next phase? This project gave me some answers but really give me more questions to answer. Is this not funny nature give some answers then gives more questions so that you get into deeper tunnel of quest with no end.

This project uncovered many things that I did not realized before. Silkworms are programmed for one purpose only and it will reach the ultimate goal trying. They are resilient, predictable, work hard, and nothing will stop them trying to reach the goal. Some qualities that I wish I can possess. But one surprise is finding about myself. Some traits in me are suspected but not wanting to admit or ignored because those are socially unacceptable. This project brought forth my dormant traits and magnified it. Some of those qualities are worry about everything, wanting to act like a mother, delay making tough decisions, and wanting the results to be just right. The last trait may be considered as controlling others. I justify those traits as necessary things to accomplish anything. But the real benefit is that I know I have those traits and those traits are neither good or bad. The same trait can be good in some situation and bad on another situation. Now, I know that I have them and decide to enjoy them as a part of me.

Dec 22 (Day 54)

Dec 23 (Day 55)

It might be some kind of predestination. This project has to be completed by today just before Christmas. I am leaving to visit my grandkids in Kansas City for ten days. A new generation arrived just before Christmas is more than coincidence. What made me start the project on October 23? How come this project lasted just two months and finished on the day before Christmas. May turn out that I may be a conspiracy theorist who thinks every thing has hidden forces. It was a wonderful experience for me and enjoyed tremendously. This project gave me many unexpected pleasures and experiences.

Conclusions

This project has started as a fun science project to supply information for a writer. A prejudice, a phobia, pre-conceived notions, and attachment did not help scientific observation. Just as in a nature, it just turns out to be a different project than expected but it turns out to be exciting and learning project. Since I had no capability to change any variables, this is not a scientific project. This observer did things that did not help

the progress of silkworms. I did such things as: tried to kill the specimens by freezing them, tried to starved to death by food was not ready, tried to kill by dehydrate, tried hinder the progress by keeping low temperature in the house.

Many questions were not resolved but many facts could be explained. Silkworms are not pretty but it become pretty as you watch long time and give them names. More you take care of them, more you got emotionally attached to these not pretty animals. Despite my fumbling effort, these resilient silkworms produced beautiful cocoons, and developed into moths.

It is beyond my imagination to comprehend one small muster seed size egg contained all generic information. It carried information how to be worm, how to make a single thread and use it to form cocoon. After that turn itself into pupa then to moth. It also carried how to mate, how to produce eggs and die. DNA of this simple creature must contain many billion of information. Does DNA carry all information from the beginning or as silkworm grows it develop more information? The answer to this must be worth a Nobel prize.

This project gave me many opportunities to solve problems which challenged me to observe closely what's going on. It gave me many feeling that I would never have opportunities to experience. I had many opportunities to experience different job requirements. It was fun and added to my wholeness. It tried to develop patience in me and gave me many menial jobs to develop humbleness.

One of the unexpected benefits is reducing my wife's phobia and my understanding of that phobia. The degree of phobia is much more severe than I imagine and my appreciation of that phobia is one of the major benefits of this project. Another benefit is finding about myself which was hiding.

Some events that I watched are unique events that I will talk the rest of my life. Such as watching the first hatching, watching molting process, watching cocooning process, and emerging of moths are closest to miracles that I can imagine. It was previlate to work on a project with the largest % increase in physical size and was thrill to watch four morphosis of one animal.

This project gave me an opportunity to watch a nature in close range and wonder many questions that increased my appreciation for nature. My job turns out to be an interested observer. This observer now feels closer to nature and appreciates this unique opportunity to watch a nature close and involved way. What a lucky mad observer.