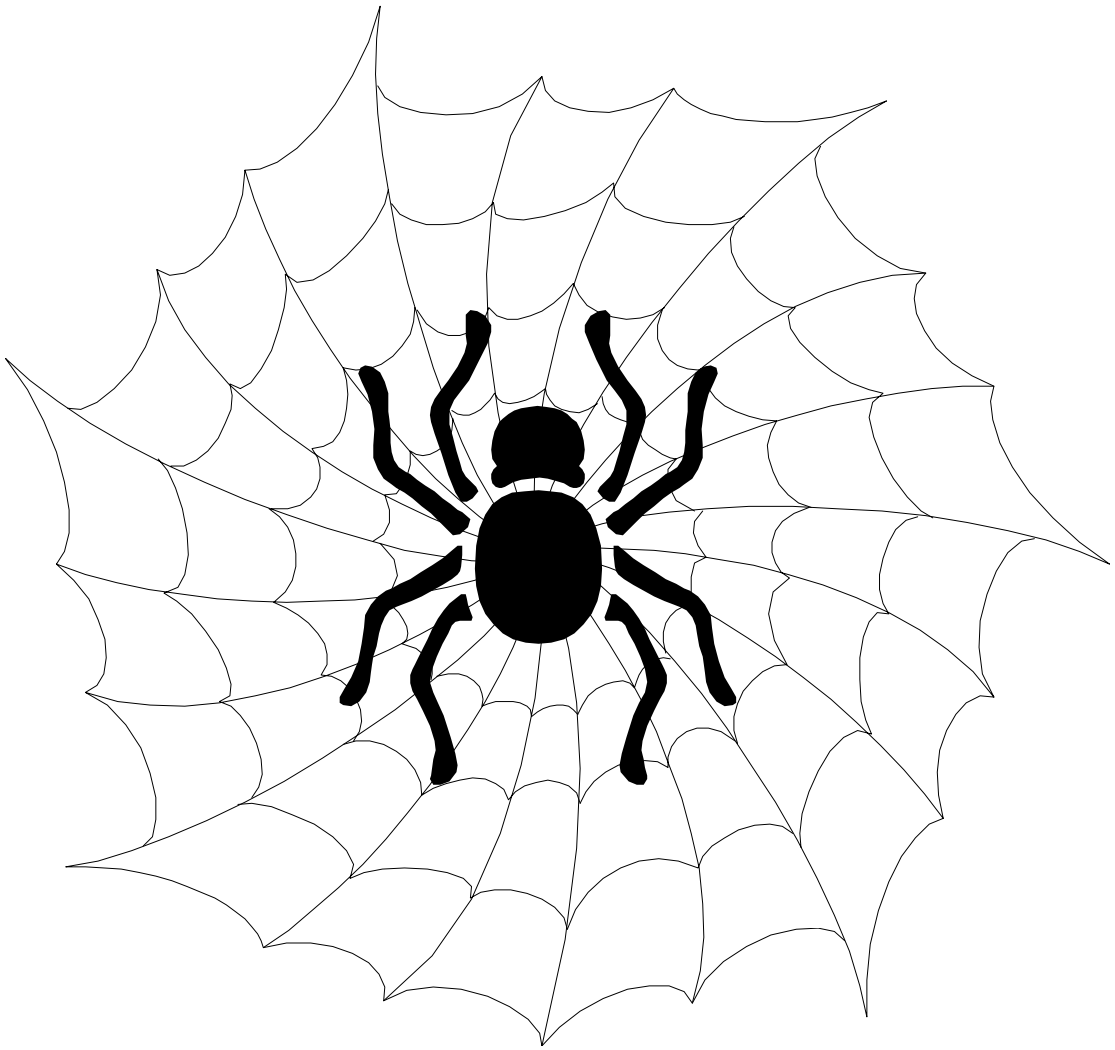

RET 2000 Curriculum Project

The Spider Silk Project

Sally Horak
Cortland Junior Senior High School
Grade 7 Science

Summary Page The Spider Silk Project

Grade- 7th
Subject- Life Science, Animal Kingdom Unit
Theme- What can humans learn from other living things?
Level- 5 heterogeneous classes which includes a Special Education population and an increasing Ukrainian population who have a wide range of language skills
Outline of Project:

A. Anticipatory Set- Complete the fact sheet on spiders. This can be done in class or at home. I would encourage students to work with family to prompt questions and interest. (10 minutes)

B. Homework and Lab Experience- Have students bring in some spider silk to view under the microscope in pairs. They may wish to compare to human hair or fibers of some sort. Students draw their findings and write out their observations. (20 minutes)

C. Lecture- Students take notes on the characteristics of spiders. (30 minutes)

D. Lab Experience- In groups of four, compare the strength and elasticity of spider silk. Gather data from **all** classmates. Graph data from data tables. Complete lab. Summarize the qualities of spider silk in class discussion. (60 minutes)

E. Demonstration- Take part in the activity and discuss what a polymer is and how its structure pertains to its characteristics. Relate this to spider silk. (15 minutes) If time allows, make some silly putty or do some molecule building with gumdrops and toothpicks. (40 minutes)

F. Assessment- In pairs, students will create an advertisement for spider silk using the research from the lab and lectures. Students will select one of 4 possible modes- a Power Point presentation, a commercial to be videotaped, a poster, or a pamphlet.

Or, individually create a word-processed science fiction story based on the findings (40 class minutes, 40 minutes computer lab, 80 minutes at home).

Presentations will be done in class. (40 minutes)

Summary of objectives

Skills- (letters correspond to parts of the project outlined above)

A. application of prior knowledge

B. specimen collection, observation, microscope manipulation, size estimation, drawing

C. note taking, listening

D. Metric measurement, data collection, calculation, graphing, analysis of data, error analysis, brainstorming

E. observation, brainstorming, application of data

F. application of data, computer skills, presentation

Concepts-

A. Unique facts about spiders

B. Examination of a natural material

C. Connections between structure and function in a spider (anatomy), reproduction and development in spiders, classification of spiders, behavior of spiders, nutrition, movement, uses of spider silk to the spider

D. Properties of spider silk

E. Polymers- what they are, how the molecule is structured, how structure relates to its characteristics, (possibly make a polymer and build a polymer molecule), how this relates to spider silk

F. Possible technological applications of spider silk by humans

Modifications for the Special Education and Ukrainian populations-

A. Encourage family involvement

B. Assist with manipulation of microscope and size estimation

C. Distribute a note taking outline with some portions filled in already

D. Contrive groups of four.

Model the measuring process.

Distribute data table and graph to be completed

Allow extra time for completion (perhaps in Supplant Math or ESL)

E. Distribute a note taking outline partially completed

F. Assist in pairing students

Assist in finding research

Allow extra time for completion (perhaps in Supplant English or ESL)

Materials Required-

A. Xerox copies of “Fun Facts on Spiders”

B. spider silk samples, human hair, other fibers, microscope

C. Xerox note outlines (for those who need them)

D. microscope slides, tape, buckets, Metric ruler or meter stick, weights, clamps, fibers- cotton thread, embroidery floss (1 of 6 strands), jute, 28 gauge (or less) wire, nylon (from stockings), thin strips of paper and plastic bags
triple beam balance

E. bandannas (for activity)
white glue, cups, stirring rods, food coloring, borax solution in dropper bottles, baggies (to make silly putty)
gumdrops and toothpick (to build polymers)

F. paper, poster board, colored pencils and markers
computer lab time

Schedule-

A. Given as homework the week before the Spider Silk Project.

B. Done at beginning of a double block.

C. Completed in a single block.

D. Done in conjunction with “B.”

E. Done at the beginning of a double block.

F. Done in conjunction with “E” with some class time allotted to begin.
Presentation completed at the start of double the following week.

Collecting spider webs-

You will need- spray lacquer, black paper, scissors

Find a web and spray it 3 to 4 times. When it dries place the paper behind it and cut it free. Spray it lightly once more to adhere it to the paper.

The following Skills and Concepts are covered in this unit and appear as they are stated in the NYS Intermediate Level Science Standards (Core Curriculum, Grades 5-8):

General Skills-

#2. Safely and accurately use the following measurement tools- Metric ruler, triple beam balance

#3. Use appropriate units for measured or calculated values

#4. Recognize and analyze patterns and trends

Living Environment Skills

#1. Manipulate a compound microscope to view microscopic objects

#2. Determine the size of a microscope object, using a compound microscope

#9. Identify structure and function relationships in organisms

Standard 1. Analysis, Inquiry and Design: Engineering Design

Key idea 1- Engineering design is an iterative process involving modeling and optimization; this process is used to develop technological solutions to problems within given constraints

T1.1 Identify needs and opportunities for technical solutions from an investigation of situations of general or social interest

T1.1a identify a scientific or human need that is subject to technological solution which applies scientific principles

T1.2 Locate and utilize a range of printed, electronic, and human information resources to obtain ideas.

Ti.2a use all available information systems for a preliminary search that addresses the need

Key idea 2- Analysis, Inquiry, and Design: Scientific Inquiry - Beyond the use of reasoning and consensus, scientific inquiry involves the testing of proposed explanations involving the use of conventional techniques and procedures and usually considerable ingenuity.

S2.3 Carry out their research proposal, recording observations and measurements

S2.3c collect quantitative and qualitative data

Key idea 3- Analysis, Inquiry and Design: Scientific Inquiry - The observations made while testing proposed explanations, when analyzed using conventional and invented methods, provide new insights into phenomena.

S3.1 Design charts, tables and graphs, and other representations of observations in conventional and creative ways to help them address their research question or hypothesis

S3.1a organize results, using appropriate graphs, diagrams, data tables, and other models to show relationships

S3.1b generate and use scales, create legends, and appropriately label axes

S3.2 Interpret the organized data to answer the research question or hypothesis and to gain insight into the problem

S3.2b identify sources of error and the limitations of data collected

S3.2h use and interpret graphs and data tables

Standard 2 Students will access, generate, process, and transfer information, using appropriate technologies

Key idea 1 Information Systems- Information technology is used to retrieve, process, and communicate information as a tool to enhance learning.

1.1 Use a range of equipment and software to integrate several forms of information in order to create good-quality audio, video, graphic, and text-based presentations.

1.3 Systematically obtain accurate and relevant information pertaining to a particular topic from a range of sources, including local and national media, libraries, museums, governmental agencies, industries and individuals.

Standard 4- Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

Key idea 1 Living things are both similar to and different from each other and from non-living things.

Performance indicator 1.1 Compare and contrast the parts of plants, animals and one-celled organisms.

1.1g Multicellular animals often have similar organs and specialized systems for carrying out major life activities.

Key idea 3 Individual organisms and species over time.

Performance indicator 3.1 Describe sources of variation in organisms and their structures and relate the variation to survival.

3.1a The processes of sexual reproduction and mutation have given rise to a variety of traits within a species.

Performance indicator 3.2 Describe factors responsible for competition within species and the significance of that competition.

3.2a In all environments, organisms with similar needs may compete with one another for resources.

Key idea 4 The continuity of life is sustained through reproduction and development.

Performance indicator 4.3 Observe and describe developmental patterns in selected plants and animals.

4.3d Patterns of development vary among animals. In some species the young resemble the adults, while in others they do not. Some insects and amphibians undergo metamorphosis as they mature.

Key idea 5 Organisms maintain a dynamic equilibrium that sustains life.

Performance indicator 5.1 Compare the way a variety of living specimens carry out basic life functions and maintain dynamic equilibrium.

5.1a Animals and plants have a great variety of body plans and internal structures that contribute to their ability to maintain a balanced equilibrium.

5.1b An organism's overall body plan and its environment determine the way that the organism carries out the life processes.

5.1d The methods for obtaining nutrients vary among organisms. Consumers, such as animals, take in energy-rich foods.

5.1 e Carnivores obtain energy from animals.

5.1 f Regulation of an organism's internal environment involves sensing the internal environment and changing physiological activities to keep conditions within the range required for survival. Regulation includes a variety of nervous and hormonal feedback systems.

5.1g The survival of an organism depends on its ability to sense and respond to its external environment.

Standard 7- Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions.

Key idea 1- Interdisciplinary Problem Solving: Connections-The knowledge and skills of mathematics, science, and technology are used together to make informed decisions and solve problems, especially those relating to issues of science/technology/society, consumer decision making, design and inquiry into phenomena.

1.2 Make informed consumer decisions by seeking answers to appropriate questions about products, services, and systems; determining the cost/benefit and risk/benefit tradeoffs; and applying this knowledge to a potential purchase

1.3 Design solutions to real-world problems of general social interest related to home, school, or community using scientific experimentation to inform the solution and applying mathematical concepts and reasoning to assist in developing a solution.

Key idea 2- Solving interdisciplinary problems involves a variety of skills and strategies, including effective work habits; gathering an processing information; generating and analyzing ideas, realizing ideas; making connections among the common themes of mathematics, science, and technology; and presenting results.

2.1 Students participate in an extended, culminating mathematics, science, and technology project.

Resources

Book and Periodical Sources

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Resnick, Jane. Eyes on Nature: Spiders. Kids Books, Inc., Chicago, IL: 1996.

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"Spider Webs and Silks," Scientific American. March 1992.

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http://jsdnt.claremont.edu/spiderweb/

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www.sciencenews.org/sn_edpik/ps_5.htm

http://stfx.ca/~edemont/abstracts/spider.html

www.xs4all.nl/~ednieuw/Spiders/Info/spindrad.html

Contact resources and Contributors

*Professor David Grubb, Faculty Advisor in Microscopy- discussions of spider silk
*Ken Finkelstein, Senior Research Associate, CHESS facility- discussion of spider silk
*Jen Gaudioso, Graduate Student- polymer model-making
*Emily Hackett, Graduate Student- polymer labs
*Professor Chris Ober- silly putty recipe
*Sven Pederson, Research Computing Facility- computer assistance
*Josh Pomeroy, Graduate Student- molecule building
*R. Barry Robinson, Research Computing Facility- computer assistance
*Nev Singhota, CCMR Educational Outreach Coordinator- coordination and support
*Professor Robert Thorne, Physics Professor- how a spider walks
*Paul Urayama, Visiting Graduate Student- science fiction writing
*Pat Viele, Librarian of Physical Science Library- locating resources

*Mark Mondanaro, Building Principal of Cortland Junior Senior High School
*John Pilato, Junior High Principal of Cortland Junior Senior High School
*David Newton, Science Department Chairman of Cortland Junior Senior High School

Name _____ Date _____

Fun Facts on Spiders Group ____

1. The biggest spiders are how wide across? 1mm 10cm 25cm

2. What do you suppose roasted tarantula tastes like? chicken nuts spicy

3. Spiders can regenerate new legs. Yes No

4. Some spiders camouflage as _. leaves bird droppings beehive

5. How many times it's own body length can a male European house spider run? 3 33 330

6. What can spiders do to capture prey?
fishing lasso drop a net gummy spit attacking with other spiders

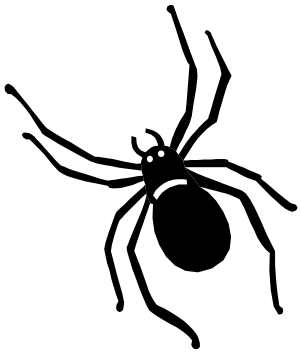
7. How long have spiders been on the earth?
1000 years 200,000 years 3,000,000 years

8. Do spiders have fangs? Yes No

9. Which are close relatives to spiders? mites insects scorpions

10. All spiders spin webs? Yes No

11. Male spiders are larger than females. Yes No



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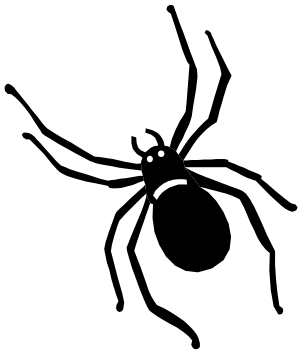


Lecture- The Biology of Spiders

I. Classification
   A. Kingdom
   B. Phylum
   C. Class
   D. Number of species
II. Anatomy
   E. Exoskeleton
   F. Eight legs
   G. Eyes and sensing
   H. Spinnerets
III. Life processes
   I. Food-getting
   J. Growth
   K. Excretion
   L. Respiration
   M. Response
   N. Reproduction
   O. Movement
   P. Secretion
IV. Other
   Q. Evolution
   R. Arachne
   S. Navajo legend
   T. Safety
   U. Contribution

Lecture- The Biology of Spiders

I. Classification

A. Kingdom- Animal Kingdom (multicellular heterotrophs), related to mites, ticks and scorpions and less closely to insects, millipedes, centipedes and crustaceans

B. Phylum- Arthropoda (jointed appendages with an exoskeleton)

C. Class- Arachnida (cephalothorax, exoskeleton, 8 legs), Two main groups- wandering and web builders

D. Number of species- 35,000 with probably 3X that yet to identify

II. Anatomy

E. Exoskeleton- cephalothorax= fused head and thorax contains head, stomach and poison glands, abdomen= heart, lungs and silk glands

F. Eight legs- have 7 joints, walk by means of flexors with fluid bags for extension

G. Eyes and sensing- generally poorer eyesight in web builders than in wanderers, do not require great sight as prey comes to them, smell and taste with legs, sense vibrations ("hear") with hairs, vibrations can de discerned by spider

H. Spinnerets- have up to 6, 7 known kinds of silk, used for wrapping prey, egg sacs, dragline home, ballooning, snaring prey, nursery, several types for web, releases silk as a liquid which solidifies quickly, spiders gently pull it out spinnerets with 2 hind legs

III. Life processes

I. Food-getting- carnivorous, bites prey by injecting venom into it, wraps it, pre-digests with a drop from their intestines than it sucks it down, repeats until consumed, usually eat insect but sometimes eat birds, frogs,fish and rodents, can be eaten by wasps and birds

J. Growth- molts up to 12 times in a lifetime, hangs upside down by a thread until exoskeleton splits and then uses muscular motions to pull out of it, usually live less than a year

K. Excretion- water conserving uric acid

L. Respiration- moist membranes in the abdomen

M. Response- social behavior is limited to mating, otherwise they are solitary and anti-social

N. Reproduction- the male can pluck a strand on the web in the courting process, internal fertilization, the father is often eaten by the mother-to-be, within a few weeks she lays eggs in silk (a few dozen to several hundred), spiderlings hatch and silk lines will allow them to balloon into the air to get up to 100's of miles away, females are larger than males

O. Movement- slowed by their heart which is insufficient to allow walking and maintenance, ability to select silk strands that are non-sticky on which to climb

P. Secretion- spider silk has some special properties sought after by scientists currently

IV. Other

Q. Evolution- evidence from 380mya, one of first terrestrial organisms, here before dinosaurs

R. Arachne- the Greek goddess Arachne was a wonderful weaver who bragged that she could weave better than Athena the goddess of wisdom, Athena turned her into a spider left to her weaving

S. Navajo legend- Spider woman who lived in a hole showed a Navajo woman how to weave and the Navajo have been weavers ever since

T. Safety- Two poisonous kinds in US are black widow and brown recluse, clean the area, apply ice, contact medical facility for antivenin and treatment

U. Contribution- control insect numbers

Name _____ Date _____

Lab- The Spider Silk Project Group ____

Title- (come up with your own creative title)_____

Purpose- the purpose of this lab is to research the physical qualities of spider silk

Materials-

Compound microscope	Meter stick or ruler	2 Clips
Spider silk sample	Samples of nylon,	Ringstand
Paper, graph paper	cotton, jute,	Bucket
Pencil, pen	paper, wire	Weights
Colored pencils	plastic	Triple beam
Microscope slide	Tape	

(as getting a large amount of spider silk would be difficult, we will use nylon as a substitute material which is very similar to spider silk)

Procedure-

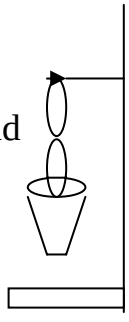
I. Microscope Observations- Work in pairs. Draw the spider silk under low and high power. Draw in pencil, color, label in ink. Describe it in words. Compare to a human hair or some fibers, if you have time.

II. Elasticity Test

1. Work in groups of 4.
   Work with some samples to see how they stretch and when they do and do not come back to their original size. **You will want your tested samples to resume their original size.**
2. Cut at equal lengths and record the length of each in cm.
   Then pull each fiber until it is tight (try not to break it!) and record the length in cm on your own data table.
3. Calculate elasticity by dividing the difference by the initial length and multiplying by 100 to produce a percentage. Show work.
4. Collect data from all other groups.
5. Set up graph and plot all the data from each sample.
6. Analyze the results on the graph.

III. Strength Test

7. Continue to work in groups of 4.
8. Set up equipment as shown and note weight of bucket.
9. Test each strand for strength by adding weights one by one and noting the mass just before it breaks.
10. Collect data from all other groups.
11. Set up a second graph and plot the data for each sample.
12. Analyze the results on the graph.



IV. Brainstorming

In an open classroom forum, have each group report on the qualities most evident from their research. Then, gather ideas as to how this material could best be used to make something. Take notes on these ideas.

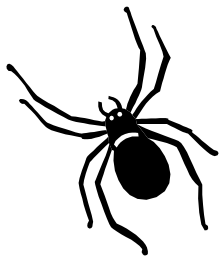
Results-

I. A. Draw spider silk under low and high microscope. Color. Label in ink.

B. Describe the spider silk and compare to human hair if you viewed it.

II. A. Make a data table for the unstretched length and stretched length. Use a ruler. Label with units.

B.Calculate the elasticity of each fiber. Show your work.



C. Graph on separate paper. Use a ruler and color. Make a key. Plot % by sample.
D. Describe the information on the graph in your own words.

III. A. Make a data table for the strength of each fiber. Use ruler. Label with units.

B. Graph on separate paper. Use ruler and color. Graph mass each held by sample.
C. Describe the information on the graph in words.

IV. Brainstorming- Keep track of the ideas mentioned in class. You will need this information!

Conclusion-

I. What is an advantage of elasticity in spider silk?

II. What is an advantage of strength in spider silk?

III. Knowing the special qualities of spider silk, what use could you speculate for it if it could be produced in big quantities.

Spider Silk Information

- Also called Biosteel (by Nexia Technologies)
- It is a biopolymer- made of protein- mostly glycine and alanine
- Called fibroine- molecular weight of 200,000-300,000- with regular orientation
- It comes from spigots of spider spinnerets in a liquid form and hardens immediately- polymerizing as it comes out
- It can be produced in aqueous solution at room temperature
- Environmentally friendly
- Almost as strong (or up to twice as strong) as Kevlar with 4 times the elasticity
- Can stretch 25%-30% longer than its original length
- It supercontracts (shrinks when wet)
- It is stronger than steel- tensile strength of 300,000 pounds per square inch- and 5 times as strong
- Has one of the highest known energies to break of any known substance
- It is not attacked by bacteria
- Attempts have been made to produce it in goats milk, bacteria and plant cells (soy and corn) as hosts. Best luck to date is in *E. coli*.
- Dupont is working to produce 100-1000 lb. batches within the next 4 years and eventually produce batches of 1 million pounds. To be competitive it must sell at $12-$15 per pound.
- Uses- tires, non-allergic surgical sutures, tissue repairs (implants or artificial skin and blood vessels), neurosurgery, artificial tendons and ligaments,

spacesuits, flak jackets that can withstand any weather, parachute or bungee cord that would hold in any temperature, climbing rope, seat belts, nets, wear-resistant shoes, rustfree panels and bumpers for cars conveyor belt material, body armor, stockings

- It has been said that a pencil thick strand of spider silk could stop a Boeing 747 in flight
- Scientists hope to also alter the color of the silk genetically
- "Bio-inspired materials are providing a new frontier for the fiber business," Lynn W. Jelinski (biophysicist at Cornell). "Someone's going to hit a home run in this field. But I am not sure yet who it will be."

Spiders- General Information

- Two groups- wandering and web builders
- Spider silk is used for constructing webs (walking threads, attaching threads and sticking threads), egg sacs, wrapping prey, a life line when jumping, a drop line for escape, transferring semen from abdomen to the male palp, in drag lines marked with pheromones, as a shelter for retreat
- The old web is eaten and recycled
- It takes about 30 minutes to make a web
- They make new webs each day
- Spiders are among the earliest land organisms with record fossils dating to 380 million years ago (200 million years before dinosaurs). The largest was *Megarachne servinei* which was 50 cm long (Upper Carboniferous- Brazil)

- The bigger the spider the thicker the web
- Spider silk is very acidic
- Used for fishing nets and as dressings for wounds

Golden Orb Spider

- In Family Araneidae with 3500 species
- Its scientific name is *Nephila clavipes*
- Has tufts of hair on its legs
- Its spider silk is the strongest natural fiber known (10 times)
- Lives in Florida and Panama
- The dragline silk has drawn the most attention from scientists for its strength, stretch and water resistance
- Can produce up to 1000 feet at once
- Bite their prey and carry it to the middle of the web
- Make huge webs of up to 39 inches which are used as fishing nets

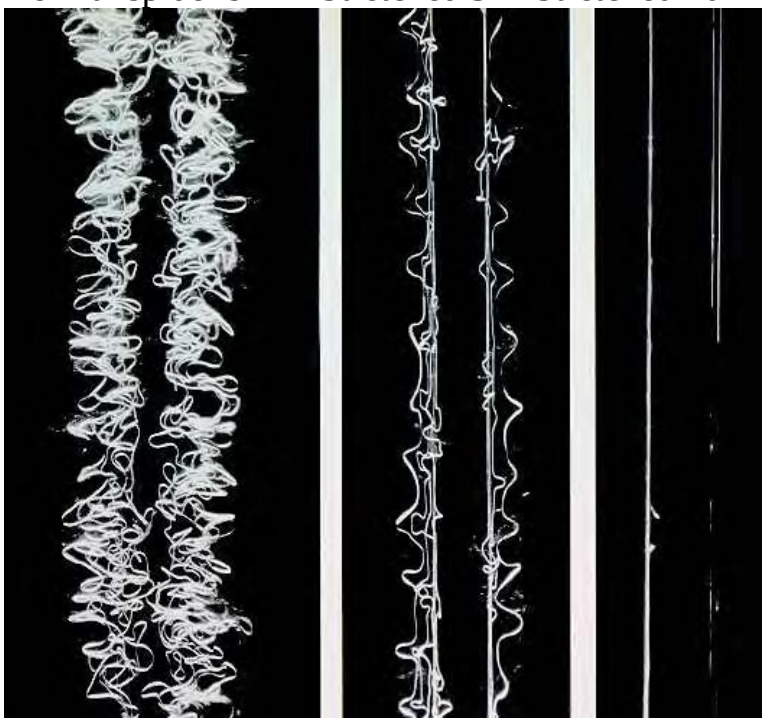
Polymers

I. Demonstration- do the Polymer Game from
www.msc.cornell.edu/~eh42/outreach.html

II. Make silly putty if time allows. Discuss its properties.

III. Take notes on some basics about polymers:
A. What are polymers?
B. What are the properties of polymers?
C. Examples of Polymers
D. Spider silk as a polymer

Normal spider silk Stretched 5X Stretched 10X



IV. Building Polymers

If time allows, build a polymer with gumdrops and toothpicks.

Name _____ Date _____
Spider Web Challenge Group _____

Option #1- Now that you have tested spider silk, you will apply your knowledge and select a feasible product for spider silk and create an advertising plan. Your audience will be a perspective company that will purchase your material for their product. Be convincing!

Who- In pairs
What- An advertisement
- Power Point presentation- 3-5 minutes, 5+ slides, research sited
- Videotaped commercial- 1-2 minutes, props and costumes, research sited
- Pamphlet- 4+ sides, color, word processed, research sited
- Poster- minimum 18" by 24", color, word processed, research sited

Option #2- You could write a science fiction short story of 500+ words or more if you choose. It should be word-processed after editing. Incorporate the facts from your research. Use planning sheet provided. (No Limits, pg. 11)

Timeline- Computer lab time-_____
Classroom time- _____
Presentations on _____