

Dear Educator,

Thank you for booking a tour with the Museum of Glass. We look forward to your visit!

We're sending you this curriculum to help enhance the museum visit for you and your students. These activities have been carefully prepared to go with the exhibit you will visit. You can use them as pre-visit materials or post-visit, but we strongly encourage that you spend some time with the packet before your visit. We've found that students understand and learn so much more if they are prepared before they come.

Along with this packet, we have extensive curriculum and interactive activities on our website about glassblowing and working with hot glass as an art form. Please visit www.museumofglass.org and click "**Learn**" on our home page. From there, visit the **Virtual Hot Shop**, where your students will get a chance to experience glassblowing by creating a **macchia**. Participants walk through the process step-by-step until they get a finished work of art! Along the way they can also choose to learn more about glass. You and your students can even watch the Hot Shop Live, by clicking "**Watch**" on our home page and selecting the "**Live Web Streaming of the Hot Shop**" link.

We sincerely hope you enjoy these materials and your visit to the Museum of Glass.

School of Fire: the Museum of Glass Hot Shop

Essential Academic Learning Requirements (EALRs)

Reading:

1. The student understands and uses different skills and strategies to read.
 - 1.1 Use word recognition skills and strategies to read and comprehend text.
 - 1.2 Use vocabulary (word meaning) strategies to comprehend text.
 - 1.3 Build vocabulary through wide reading.
 - 1.4 Apply word recognition skills and strategies to read fluently.
2. The student understands the meaning of what is read.
 - 2.1 Demonstrate evidence of reading comprehension.
 - 2.2 Understand and apply knowledge of text components to comprehend text.
 - 2.3 Expand comprehension by analyzing, interpreting, and synthesizing information and ideas in literary and informational text.
3. The student reads different materials for a variety of purposes.
 - 3.1 Read to learn new information.
 - 3.2 Read to perform a task.
 - 3.3 Read for career application.

Science:

1. Systems: The student knows and applies scientific concepts and principles to understand the properties, structures and changes in physical, earth/space, and living systems.

The system concept includes inputs, outputs, and transfers of matter and energy, and information to understand how the natural universe functions. Systems of the Natural World can be understood in terms of the following three components of physical, earth /space and living systems:

- 1.1 Properties: Understand how properties are used to identify, describe, and categorize substances, materials, and objects; and how characteristics are used to categorize living things.

1.2 Structures: Understand how components, structures, organizations, and interconnections describe systems.

1.3 Changes: Understand how interactions within and among systems cause changes in matter and energy.

Students develop an understanding of the scientific concepts and principles in the contexts of physical, earth/space, and living systems that can be applied to solve human problems.

2. Inquiry: The student knows and applies the scientific ideas, skills, processes of investigation, and the nature of science.

Inquiry describes the skills necessary to investigate systems and asks students to understand the nature of science which gives integrity to scientific investigations. Inquiry represents the application of science concepts and principles to the scientific investigative processes that aims to answer scientific questions about the natural world. These concepts, principles, and processes are expressed in two components:

2.1 Investigating Systems: Develop the knowledge and skills necessary to do scientific inquiry.

2.2 Nature of Science: Understand the nature of scientific inquiry

3. Application: The student knows and applies science ideas and inquiry to design and analyze solutions to human problems in societal contexts.

Scientific design process skills are used to develop and evaluate scientific solutions to problems in real world contexts. The application of an understanding of systems and inquiry is comprised of two components:

3.1 Designing Solutions: Apply knowledge and skills of science and technology to design solutions to human problems or meet challenges.

3.2 Science, Technology and Society: Analyze how science and technology are human endeavors, interrelated to each other, to society, and to the workplace and the environment.

Arts:

1. The student understands and applies arts knowledge and skills.

To meet this standard, the student will:

1.1 Understand arts concepts and vocabulary

1.2 Develop arts skills and techniques

1.3 Understand and apply arts styles from various artists, cultures and times

2. The student demonstrates thinking skills using artistic processes.

To meet this standard, the student will:

2.1 Apply a creative process in the arts:

- Conceptualizes the context or purpose
- Gather information from diverse sources
- Develop ideas and techniques
- Organize arts elements, forms, and/or principles into a creative work
- Reflect for the purpose of elaboration and self evaluation
- Refine work based on feedback
- Present work to others

3. The student communicates through the arts.

To meet this standard, the student will:

- 3.1 Use the arts to express and present ideas and feelings
- 3.3 Develop personal aesthetic criteria to communicate artistic choices

Communications:

1. The student uses listening and observation skills and strategies to gain understanding.

To meet this standard, the student:

- 1.1 Uses listening and observation skills and strategies to focus attention and interpret information.
- 1.2 Understands, analyzes, synthesizes, or evaluates information from a variety of sources.

3. The student uses communication skills and strategies to present ideas and one's self in a variety of situations.

To meet this standard, the student:

- 3.2 Uses media and other resources to support presentations.

Social Studies – Geography:

2. The student understands the complex physical and human characteristics of places and regions.

To meet these standards, the student will:

- 2.2 Describe the patterns humans make on places and regions

3. The student observes and analyzes the interaction between people, the environment, and culture.

To meet this standard, the student will:

- 3.3 Examine cultural characteristics, transmission, diffusion and interaction

Social Studies – History:

1. The student examines and understands major ideas, eras, themes, developments, turning points, chronology, and cause-effect relationships in United States, world, and Washington State history.

To meet this standard, the student will:

- 1.1 Understand and analyze historical time and chronology

- 1.2 Understand events, trends, individuals, and movements shaping United States, world, and Washington State history

- 1.3 Examine the influence of culture on United States, world, and Washington State history

2. The student understands the origin and impact of ideas and technological developments on history.

To meet this standard, the student will:

- 2.2 Understand how ideas and technological developments influence people, culture, and environment

Health & Fitness:

2. The student acquires the knowledge and skills necessary to maintain a healthy life: Recognize patterns of growth and development, reduce health risks, and live safely.

To meet this standard the student will:

- 2.2 Understand the concept of control and prevention of disease.

- 2.3 Acquire skills to live safely and reduce health risks.

3. The student analyzes and evaluates the impact of real-life influences on health.

To meet this standard the student will:

- 3.1 Understand how environmental factors affect one's health. (air, water, noise, chemicals)

Introduction

When you visit the Museum of Glass, one of the most exciting and important things to see is the Hot Shop. This is where artists are working with hot glass everyday. This curriculum is all about the basics of glass, glassblowing in the Hot Shop and a little about glass painting techniques based on the Cappy Thompson work in our Grand Hall called *Gathering the Light*.

Activities that accompany the hot glass portion of the lessons are available on our website – www.museumofglass.org – and will have links printed in the lesson when appropriate.

Glassblowing: An International Language

Over 2000 years of history and glassblowing has become an art in and of itself. Sometimes it is referred to as a dance or simply ‘poetry in motion.’ Watching a maestro at work is a joy and pleasure to behold. The fluidity of their movements and grace they bring to the material is inspiring, captivating and nothing short of pure alchemy. The methods they use to create beautiful works of art are in many ways just like a form of music or type of language. At first it may seem strange or foreign, but after a while you begin to recognize certain components that begin to make sense. The more familiar you become with it, the more you can grow an appreciation for all of the nuances that it has to offer. This section examines the international nature of the contemporary studio glass movement and the countries that have contributed to the ever-expanding vocabulary of hot glass.

Glassblowing has undergone many changes throughout time. The techniques of manufacture have been heavily influenced by the people and cultures that have embraced it, nurtured it, and developed it beyond their own expectations.

Glassmaking is a global activity today. There are some universal principles that govern the behavior of hot glass and that we all must abide by (every glassblower has to deal with getting burned!). There are, however, many stylistic variations and "dialects" out there. Each country seems to have it's own unique way of doing things. Many styles of glassblowing are the product of trade secrets passed down through families and guilds throughout the centuries. The techniques that they developed were in virtual isolation from the countries that bordered them. Can you guess why?

With the advent of the jet airplane and international commerce on a global scale, the borders and differences that separate our countries are getting thinner and more transparent every day (still far from “crystal clear” mind you).

The studio glass movement that began in the United States some thirty years ago established some lines of communication that continue strong today. The sharing of information is at an all-time high, and it seems to be getting better every day. How this

came about, who the major players are, and what it's all about will be addressed in the following pages.

Origins of Glassmaking

Most historians agree that glassmaking probably began some 5,000 years ago in the area that is now the Middle East, in and around Syria. They believe that actual glassblowing with a blowpipe started around the birth of Christ, over 2,000 years ago. Glassblowing is highly addictive, so its no wonder that the 'disease' spread like wildfire and inflicted people throughout the Mediterranean.

The **Romans** in their globetrotting/conquering days brought with them not only the art of war, but also the art of glassblowing. Glassmaking "factories" were established in ever further reaches of the empire. Glass was a hot commodity to trade.

Islamic glass is one of the results that developed and blossomed after the Romans faded from the landscape (in the area that is presently Iran). The objects that were created some 600 – 1000 years ago are incredible even by today's standards (all done without 'advanced technology'). Islamic glassmakers exhibited skills not just in glassblowing, but in carving, etching and enameling as well.

Stained Glass windows began to appear around the 12th century in Western Europe. The windows became a form of communication themselves. The majority of people at that time were not trained to read or write, but they could look at the picture in the window and understand something about the word of God and/or the life of Christ. Glass at this point reached an architectural scale and its popularity grew exponentially. From the 11th to 13th century, two dominant styles of glassmaking emerged in Europe: Waldglas in the north and Venetian Cristallo in the south.

Waldglas or "forest glass" houses were scattered throughout northern and central Europe. Their style of blowing differed than their Italian counterparts. Their focus was on creating objects for everyday use, not just one-of-a-kind specialties for the nobility. They made bottles and containers for various liquids, including beer. Large drinking vessels would be adorned with all sorts of bits, blobs and trails of glass, the "prunt" (a little knob) being the most easily recognizable form of surface embellishment. Typically Waldglas products had a blue/green tint to it. The color came from trace amounts of iron in the sand that they melted to make their glass.

Further to the south in **Italy**, in 1291, by governmental decree, the glassmakers and their hot shops were moved from the city of **Venice** to the nearby island of **Murano**. One reason was to keep the threat of fire at bay (so to speak), and the other reason was to keep a lid on all their unique glassblowing techniques. Glassmaking was (and continues to be) a moneymaker, and trade secrets were as good as gold. Techniques were handed down from father to son and kept within in the 'family' and/or factory. With each passing generation

improvements were made all along the way. The Venetian style ruled. The work that they produced were typically thin-walled vessels, expertly crafted goblets and all types of cane work that bedazzled the kings, queens, and heads of state throughout Europe. Venetian glass was highly sought-after. It was not without its fair share of rewards; the glassblowers of Murano attained nobility status during their heyday from the 14th through 18th centuries.

The only problem with Venetian glass (besides being wickedly fragile) was that demand far exceeded production. Consequently other groups of people started copying techniques and producing work in their own interpretation of the Venetian-style. These reproductions or "fakes" were not just limited to blown glass.

Colorful trade beads, first pioneered in Murano, were duplicated, appropriated, or downright "ripped-off" by the Bohemian glassmakers and others. This, in turn, sprouted another glassmaking movement throughout Europe. The quantity went up and the quality went down, nevertheless, the glass they made became a form of currency good all over the new world and beyond. (Hey, wasn't the island of Manhattan reportedly purchased for a handful of beads way back when?)

Glass Arrives in America

Did you know that glassblowing was America's first industry? In 1609, the colony that was formed in Jamestown, Virginia had a small glasshouse. It was not too dissimilar from a typical Waldglas house built of rocks and fired with wood. The objects that they produced were utilitarian - bottles and jars for storage of spirits and beer and "bull's eye" windows for houses. It was predominantly English-style glassmaking techniques they employed, England being the country from which they emigrated. Indeed for the first few centuries of glassmaking in North America, the influence from mother England was particularly strong.

During the industrial revolution, glass objects were being mass-produced (still by hand) by the thousands. Refinement in fuels and tools increased production dramatically. Mold blowing (a technique developed by the ancient Romans) is a quick and easy way to produce hundreds of objects that are identical in shape and style. Virtually any person can be trained to do it. The Romans first perfected mold blowing in Caesar's time (there are still a few commemorative gladiator mugs made in the first century B.C kicking about in a few museums across the globe).

Mold blowing reached its zenith when the first fully automated bottle-making machine was produced nearly 100 years ago. The infernal contraption was capable of making over a quarter million bottles a day, by itself! How could any glassblower compete with a thing like that?

The industrial revolution certainly put a dent in the glassblower's art, but fortunately didn't kill it altogether. Glassblowers are a tough lot, and don't disappear too readily. Luckily there

has been, and continues to be, support for hot glass. There have always been patrons of the arts who are willing to pay top dollar for the most unique objects made by the hand of man. And there will always be people getting hooked on glass and trying to out-do what's been done before. Which brings us to the present-day scene where glassblowing has become a worldwide phenomenon.

The Studio Glass Movement

The studio glass movement of the past 30 something years has taken the best of glassmaking traditions out of the factories and placed it in the hands of artists. These artists coupled centuries old techniques with unbridled enthusiasm and American "know-how". They explored avenues of glassmaking free from the constraints of mass production.

Glass pieces produced in the late 1960's through the 1970's were crude by today's standards, but nevertheless opened enough people's eyes to make them stop and take a closer look. Even the Europeans, long considered the masters of the medium, became intrigued by what they saw. This curiosity grew on both sides of the Atlantic.

The impetus for the Studio Glass movement came in 1962 with Harvey Littleton's discovery that glass could be melted at lower temperatures and in smaller furnaces than were traditionally used in large factories. Littleton and Dominick Rabino are commonly considered the founders of the modern studio glass movement.

Fulbright scholarships helped fund travel for a number of American artists to study glassmaking abroad, students like **Dale Chihuly**, **Ben Moore**, and **Richard Marquis**. They traveled to Italy, and on the island of Murano became infected with the "Venetian Virus." Naturally, they brought it back home.

Dante Marioni, a Seattle native, was only 15 years old when he started blowing glass in the mid-seventies. Back then nobody except Ben Moore could blow anything on-center. It was pretty crude. Then Dale invited maestros **Checco Ongara** and **Lino Tagliapietra** over from Murano to the Pilchuck Glass School in Stanwood, Washington (started by Chihuly and his compatriots). They blew everyone away.

The Italian Influence

It is Lino Tagliapietra that has had the longest lasting impact on the U.S. glass scene. He has taught classes and workshops throughout the United States and all over the globe. His philosophy is the more that we share information and collaborate with each other, the better the glass world becomes.

Lino can make just about anything. The tissue-thin goblets he pumps out seem like they grow right out of his hands. Venetian-style goblet making is fast, yet, delicate work, much like the work a surgeon performs. It demands impeccable timing, dexterity and precision.

Making “cups”, as Dante Marioni calls them, (traditional Venetian goblets) requires incredible skill that takes years of practice to perfect.

Lino’s talents only begin with fine goblets. He is a master of cane work and overall blowing skills. He is also an excellent designer in his own right, as can be seen in the vast quantity of different sculptures that grace galleries and collections worldwide. He has produced a remarkable body of work in the past half century, and it just keeps getting better and more elaborate as time goes by. Last, but not least, he is a phenomenal yet humble chef, and made one of the tastiest pasta dinners that I have ever had the pleasure to eat. No wonder that his popularity is known far and wide and his influence is so strong!

Solid working is a technique of sculpting hot glass on a blowpipe or punty. It is another whole ball of wax. It is quite a bit different than “popping bubbles.” It has its own set of rules and “grammar” that dictate how you can achieve a particular form. Again, through the influence of other Muranese maestros, most notably **Loredano** and **Dino Rosin**, and **Pino Signoretto**, the shape and vocabulary of the American glass language has changed forever.

Central and Northern European Influences

Italy isn’t the only country in Europe to influence the American glass scene. German and Czech glassmaking techniques were brought over by the likes of **Erwin Eisch** from Frauenau, and **Stanislav Libenský** and **Jaroslava Brychtová** from Prague and **Petr Novotny** from Novy Bor.

The Bohemian/Czech style of glassblowing is done standing up versus the Italian style where the gaffer sits at a bench. The Bohemian method also makes use of molds to speed up the process of forming an object.

Further to the north, Scandinavian glassworkers have adopted and nurtured their own style of blowing. They, too, use blocks and molds to shape their glass, working with as much of the original heat from out of the furnace as they can. Every movement is calculated and precise. Their sleek designs and tight forms, coupled with their innovative use of colored (and colorless) glass, require such accuracy. They have created an undeniable presence in the contemporary glass scene. More and more small studios are popping up in the hillsides and above the fiords in Norway, Sweden and Finland as the studio movement continues to spread.

Most European glassmakers work in a team. This was something almost revolutionary for the artists in the U.S. during the 70’s and 80’s. During that time, it was thought the only way you could be free and do what you wanted to do, was to do it solo. You could also claim full credit for the effort. And what an effort it was, and is, to blow glass all by yourself! The team approach made sense and it became instrumental in developing not only better glass art and highly complicated forms, but it drew artists and technicians together to

create a community.

The Language

There are a few interesting things that I have noticed when watching these European masters at work: first, the language barrier. There is none. Granted, I may not speak the same native tongue as they do, but I visually comprehend (almost) 100% of what they are doing. It is when the subtle nuances reveal themselves that the captivating grab of the hot glass sucks you in.

The Hands do the Talking

Ultimately, it is the duty of the hands to execute the majority of the glass forming process (not your lungs like most people think). Watch them and you will learn a whole new form of sign language. The hands are guided by the mind, experience and intuition of the maestro. The fluidity of their movement is deliberate, yet graceful. It is a continuous flow from the first gather to the final tap-off into the annealer.

Watch a team in action, such as the Museum of Glass team. Look for the subtle nods and winks that transpire among the team members. Notice how few words need to be exchanged during the process. See if you can spot what style of glass they are making, and where that technique may have originated. Above all, keep an eye on their hands. The fingers may do the walking, but it's the hands that do the talking.

The Misnomer – Clarifying glass terms

Q. When's a glass not a glass?

A. When it's made of plastic.

Q. When is crystal not a crystal?

A. When it's made of glass.

In plain old English we call this conundrum a **misnomer**. Essentially a misnomer occurs when we accept a word or term on face value when in fact it is incorrect or somewhat misleading. Often the word has undergone some change in meaning throughout time and culture(s); so much so that it's original description is lost or construed.

For example, you may drink water out of a glass, yet today the 'glass' that you reach for off the shelf may be made of plastic, ceramic, glass, metal, or even paper. We refer to the cup or vessel as a 'glass' regardless of the material from which it is made.

Crystal is another misnomer. Originally crystal referred to the colorless rock formations of quartz or other rare minerals. In the fifteenth century the Italian glassmakers discovered

how to make glass truly colorless, (with no more blue or greenish tints). It was very similar in appearance to pure quartz crystal and aptly named in "Cristallo" in Italian, or "crystal" in English. The name is still in use today.

Now a little later a scientist in England by the name of Ravenscroft discovered that if you add lead oxide into the glass recipe, you get a really brilliant form of glass with terrific optical qualities. It is suitable for cutting and polishing, as well creating lenses for various scientific instruments. The formula is known as "lead crystal." There are a few famous factories known worldwide for their products using this type of glass such as: Schott, Waterford, Stuben, Orrefors, and Daum. You'll learn more about the chemical properties of lead crystal later.

Finally, there is another meaning for crystal: glassblowers will often refer to the glass they are blowing as "crystal," even though the recipe is actually soda-lime based. Most studios melt a clear "crystal" batch or cullet in their furnace and add colors later. Whoa! Confused? Not only glass, but also language, can sometimes be difficult to decipher which is why you must make sure that your intentions and explanations are absolutely crystal clear.

Chemistry and the Hot Shop

Two common questions that have plagued glassworkers worldwide for centuries are:

"Where do you get the glass?" and **"How do you get the colors in the glass?"**

Honestly, you don't have to be a rocket scientist to make glass (although when you get down to the nitty gritty of glass chemistry - it looks a lot like rocket science!). The process of making batch is not much different than whipping up cookies from scratch (not that phony stuff which comes from a plastic tube). Now don't get me wrong, pioneering new colors and reproducing glass melts consistently does take a considerable amount of skill and knowledge in chemistry.

When developing a glass recipe, you have to answer a few questions right from the get-go: How will it be used? Is it going to be blown, cast, pressed, extruded or...what? What type of working characteristics are you looking for: short or long, soft or stiff? How clear does it have to be? Or, if you are making a color, what type of colorant will you employ? How toxic is it? Will it be compatible with any other glass? How much money do you have to spend? Yes, factors such as price and availability of natural resources come into play. You want to be able to reproduce your recipe consistently (by the ton) if you have to. Simple economics dictate that you do it with the least expensive and most readily available ingredients as possible.

The following information will introduce you to the main ingredients used in making a soda-lime based glass suitable for blowing and casting. It 's a basic overview of what does what

without too much techno-mumbo jumbo.

You may already be familiar with some glass chemistry, or at least a little bit familiar with making cookies, so let's take a closer look at what's involved.

Soda-lime Glass Recipe

72.0% Silica sand SiO_2
14.9% Soda Na_2O
7.9% Lime CaO
1.8% Alumina Al_2O_3
1.0% Lithium Li_2O
1.0% Zinc Oxide ZnO
0.5% Barium BaO
0.4% Potassia K_2O
0.2% Antimony Sb_2O_3

Chocolate Chip Cookie Recipe

2 cups flour
3/4 cup white sugar
3/4 cup brown sugar
2 eggs
2 sticks of butter
1/2 teaspoon salt
3/4 teaspoon baking soda
2 teaspoon vanilla extract
1 bag of chocolate chips

The Sand (the flour in our cookie recipe)

OK, we all know that sand (a.k.a. silica, or silicon dioxide) is the main ingredient in glass. (Just like flour is the main ingredient in a cookie mix.) It is also called a *network former* by chemists.

Now we don't melt just any old beach sand to make glass - it has way too many impurities in it. If we melted a batch like that the results wouldn't be crystal clear, rather it would be tinted blue or green. The key to batching good clear glass is selecting the sand with the most desirable characteristics. The sand's chemical composition, its size, shape and method by which it combines with the other ingredients, all play important roles in melting glass. In the United States, areas in Pennsylvania, West Virginia, and the Mississippi Valley are mined for their quality and purity of glassmaking sand. It is often milled to the coarseness of 100 mesh (roughly the size of sandbox sand) or into flour which helps accelerate the melting process.

For a typical soda-lime glassblowing batch such as melted by the Museum of Glass, the recipe calls for about 72% of silica sand by weight.

Now simply heating sand to 2450°F will not make a suitable glass. (Heating flour up to 350°F does not make a suitable cookie either!) Sand by itself melts at 3110°F, so it's a good idea to try and lower the sand's melting temperature. You need something to make it flow. You need what's known as a flux.

The Flux-Soda & Lime (like the wet ingredients in your cookie recipe)

Fluxes are present in virtually all glass formulae. To flux the sand, or lower its melting temperature, we use soda ash (Na_2O) - 14.9% soda to be precise. (With cookies you might add 2 sticks of butter). Problem is, if we just used only soda in the glass, the results would be water-soluble. Water, as you know, is an acid and can be quite corrosive or destructive in certain situations.

The other half of our soda-lime equation is the lime. It is also a fluxing agent (or network former) and increases the chemical stability and strength of the glass. In our recipe we call for an addition of 7.9 % calcium oxide, CaO (a.k.a. in their other raw states as: whiting, limestone or dolomite).

The Trace Ingredients

These are the "walk softly, but carry a big stick" constituents. Small additions of other chemicals are included in the batch to sweeten it, balance it and give it some complexity. These "intermediates" are not capable of forming glass alone; rather they assist in strengthening the glass and increasing the working time.

Alumina (Al_2O_3) is added in small amounts (1-3%) to increase the chemical durability of the glass.

Feldspar ($\text{KNaO Al}_2\text{O}_3 \text{ SiO}_2$) is another compound that can impart alumina into the melt, with additional silica and potassium hitching a ride.

Lithium (Li_2O) is also a powerful flux. It is added to soften the glass, decrease its viscosity, and lower its melting temperature.

Barium oxide (BaCO_3) lowers the melting temperature, decreases the tendency towards devitrification (the formation of crystals within a glass) and offers a higher refractive index. It is also toxic.

Zinc oxide (ZnO) is added to increase the brilliance of the glass. It works well with colors, extends the working time and also reduces devitrification.

Fining Agents

No they are not related to tax collectors, rather fining agents are added to batch to assist in the melting process. When you heat batch to melting temperature of 2450°F there is a great deal of off-gassing by the oxides in the batch. This is a natural and beneficial way the chemicals will combine with each other, insuring a homogeneous mixture. The stuff actually foams up quite a bit! Right after charging the batch looks just like a mélange of marshmallow and cottage cheese. Yum, Yum!

As the batch begins to melt, it creates and traps air bubbles. Glassblowers do not consider these air bubbles desirable. They can be annoying to work with as well as visually

distracting to the finished product. A chemical fining agent is added to the mix that will bind with the air/oxygen in the melt and either dissolve it or cause it to rise to the surface and burst.

Arsenic (As_2O_3) and **antimony** (Sb_2O_3) are the two most common fining agents, and both of them are highly toxic. In spite of the tiny amounts used (less than a teaspoon), their inclusion into the batch must be handled with care and only by trained personnel.

Decolorants

Regardless of how pure your source of sand and other chemicals are, you may still end up with a glass that has a subtle tint of color in it. So before I discuss how to get the color in the glass, I must mention something about how to get the color out of the glass.

Some thousand years ago glassmakers in northern Europe lived as close to their natural resources as possible. One such group, mentioned in the history section, were the Waldglas (forest glass) blowers who developed very distinctive styles of drinking and storage vessels. (Not surprising, considering their affinity for beer!) Their sand and other chemicals came from local sources as well, often being less-than-pure by today's standards. So along with the sand and batch mix some trace amounts of **iron**. The iron imparted a characteristic green tint to the glass and Waldglas products became easy to identify.

Further to the south, and a few centuries later the Venetians discovered a valuable trade secret. If you add a small amount of **manganese** (MnO_2) to the batch, the resulting color it creates will filter and mask the color generated from the iron and other impurities. This yields a truly colorless glass, which they named "Cristallo" (because it looked as pure as rock crystal – you should know all about 'crystal' by now).

What's the big deal with Lead Crystal? (Kind of like the happy accident that gave rise to the Tollhouse cookie.)

Ravenscroft (whom we mentioned before), in the late 1600s, discovered if you add lead oxide (PbO) to the batch, it acts as a powerful flux (not-too-mention a toxic one). It also added clarity and brilliance to the finished product.

Other interesting factors that make lead glass so unique: it's much "softer" and has a longer working time, meaning you can blow and manipulate the glass longer with less frequent need to reheat. It also weighs a bit more, so the gathers feel heavier. Lead off-gasses toxic fumes when you melt it, so extra precautions in ventilation must be made so you don't kill whoever gets to charge it.

Colorants (The special ingredients that make it really tasty)

There are several ways to impart color into glass. Most color is created by mixing a specific oxide into the batch and allowing it to react with the other constituents during the melting

process. The results depend on a good number of variables, some of which you have control over and some of which you don't. There is still a tremendous amount of trial and error going on in the field of colored glass chemistry as we develop new glasses and try to nail down what does what, and "Can we do that again?" or "I hope we never make that mistake again!" It is not surprising that only a small percentage of glassworkers make their own colors. Batching and melting color takes time, money, space, and extensive knowledge of glass chemistry. There are some serious health risks to think about as well.

Most glassblowers today use a pre-manufactured form of concentrated color that is compatible with the clear glass that they are melting in their furnace. These "pigments" that are specifically formulated for applications in hot glass. The colors come in every color of the rainbow, and are either transparent or opaque.

Color is manufactured into rod, frit and powdered forms, and can be applied in a million different ways (or more). That's the fun part. We get color from "Reichenbach", "Kugler" and "Zimmermanni" in Germany, "Gaffer" from New Zealand and "Flying Colors" out of New Mexico just to name a few (they are the glassblowers version of "Crayola" crayons). Here's a run-down of the most commonly used colorants. The bulk of them may be found on the periodic chart numbers 23-29, with numbers 47,48,50,60,68,70, and 92 offering additional color possibilities.

Cobalt (CoCO₃) - a very small addition of cobalt carbonate will turn your melt a deep dark blue, thus creating the all-time best selling color for glass blowers, cobalt blue. Other blues can be achieved with copper.

Chromium (Cr₂O₃) - adding this to the melt will yield an emerald green color

Copper (CuCO₃) - Copper is one of those freaky chemicals that react quite differently with the other constituents of the melt. It is also highly susceptible to the atmospheric conditions of the melting chamber. So, depending on how you melt it, and with what, you can obtain: blues, greens, and even some tasty ruby reds (or if you're off by a fraction, a nauseous liver-brown).

Manganese (MnO₂) - chemists refer to this as a fugitive colorant. It gives rise to: purples, blue/violets, and some browns. Can also be affected by sunlight and U/V light.

Silver (AgNO₃) - can yield a variety of colors, from yellows to blues, and a wild mix of others depending on how you introduce it to the melt.

Gold (AuCl₃) - the most beautiful ruby-red you may ever see. (a.k.a "granny-grabber pink" for its inherent ability to attract a certain member of our society) Gold must be introduced in a chloride form, and it too is very tricky to melt.

Iron (Fe₂O₃) - greens and browns

Cadmium Sulfide (CdS) – yields oranges, also a challenging color to melt.

Cadmium selenium (CdSe) - deep ruby reds. Another tricky color to melt, in that the right temperature and atmosphere must be present in the furnace otherwise it will turn livery/brown.

Opacifiers (makes the glass opaque)

You can add **fluorides (CaF₂)** and **phosphates (Ca₃(PO₄)₂)** to opacify the melt. Opal glass falls into this category. Fluorine or Fluorspar is used to make white glass. The fumes are toxic, so adequate ventilation must be provided when melting this color.

Specialty glasses

Uranium (UO₃) - can produce yellows, which fluoresce under U/V light. It is no longer produced in the mass quantities of yesteryear for reasons which should seem obvious to you.

Neodymium (Nd₂O₃) - a dichroic glass is made by using this colorant – Neodymium glass will show up as different colors in different light. Some of the sculptures created by the Libenský and Brychtová team incorporate this type of glass with spectacular results.

Dichroic glass can also be made by a different process where a film of metal is deposited on the surface of the glass by an elaborate and expensive process

Photosensitive glass - this glass was pioneered over 60 years ago. The Gaffer Glass Company in New Zealand has recently reintroduced it to today's glassworkers. It allows you to create photo-realistic effects within a piece of glass. The artistic potential of this glass is just now being explored, and will undoubtedly yield some extraordinary works in the future.

Coefficient of Expansion

No discussion of glass chemistry would be complete without some mention of this "bad boy." So far the glass chemistry described here seems fairly simple and straightforward. There is one more factor that you must take into account when preparing a batch formula, namely how the resulting glass will heat up and cool down. One can measure how much the material expands (or in this case how much it shrinks upon cooling) over a given period of time. This measurement is what chemists and physicists refer to as the **coefficient of expansion**. The glass melted by the Museum of Glass has a coefficient of expansion (COE) of $94-96 \times 10^{-7}$.

The COE is dependent upon the ingredients in the batch. When adding extra oxides into the batch in order to achieve a particular color, you have to realize that those heavy metal additions are somehow going to tweak the balance a little or a lot. Virtually every gram of every constituent has to be accounted for in any given glass formula. Each and every chemical compound within the batch influences the rate at which the glass heats and cools. This is vitally important when trying to combine two or more colors together. They must have compatible COEs or it will put too much stress or strain in the resulting glass and cause it to crack or (in extreme cases) even explode!

Hot Shop Health and Safety

Outlined below are some of the major health and safety issues confronting the contemporary glassblower. We will examine "A day in the life of a glassblower" from an industrial hygienist's point of view. An industrial hygienist is a specially trained scientist/technician hired to study health and safety in the workplace. They can perform on-site tests to evaluate the safety of a given workspace. They can insure that you work in a situation that does not harm you, impair you or your co-workers, or place your life in jeopardy. They can offer suggestions for improvement or how to comply with local, state or federal regulations.

From start to finish there are a number of things to look out for in the melting and blowing process. Some hazards are blatantly obvious, while other hazards are so small or undetectable you cannot even see them with the naked eye!

Why is it that some of the most beautiful glass colors are also some of the most toxic to humans? Whatever the case may be the fact is that there are numerous health risks involved in mixing, storing, and melting glass batch. How you are affected depends upon the nature of the chemical, its route of entry, and the length of your exposure to it. There are different methods employed in dealing with the hazards involved, but if proper precautions are taken you can mix and melt batch with little or no exposure to "the elements." Here are a few of the biggies:

Mixing and Storing Batch

Activities such as mixing and storing of batch should be done in a room dedicated solely for this purpose. The room should be easy to clean (and kept so), dry, and well ventilated. All chemicals should be stored in airtight bins (moisture can wreak havoc in batch). They should be clearly labeled and easy to identify. In terms of chemical exposure, the two main routes of entry are through inhalation or ingestion.

Clear glass batch contains silica sand (or silica flour) calcium carbonate, and sodium bicarbonate, plus a few other small additions of other chemicals. In its raw state, batch looks remarkably similar to white play sand, however it is hardly as benign. Silica is the main ingredient in batch. Silica is one of the biggies we've got to look out for, even though its particle size can be smaller than you can see. Silica in this form is tiny in size and hook-shaped in form. It goes in your lungs and doesn't come out. The more you breathe, the worse it gets. It can take years of minimal exposure to develop symptoms related to silicosis.

The best personal defense against these airborne nuisances is the respirator. A properly fitted and tested respirator rated for dusts and mists can protect the user against harmful particles and chemicals that are likely to be inhaled.

Batchers should also avoid direct contact with the materials, so using measuring scoops is a good idea. Some chemicals are quick to react with the human body, such as arsenic or antimony, which have an acute affect on the internal organs and tissues. In other words, it'll make you sick or kill you in short order. Other chemicals such as freeborn silica (from that nice clean white sand we're melting) have a more long-term or chronic affect on the human respiratory system.

At the Museum of Glass we melt 'soda-lime batch' manufactured by a regional supplier. The batch has been palletized and preheated by the factory to cut down on airborne particles and to aid in shipping and storing. It looks like small white or light brown marbles in this state. It is vital that batch be stored in a clean and dry area to prevent contamination by moisture or other agents.

Charging and Melting

The first thing the charger does when they come in for work is to turn the furnace up to around 2400°F. Besides a respirator, the charger can protect themselves by wearing leather gloves, which usually offer enough protection for most charging situations, however if encountering extreme heat, some chargers will wear Kevlar gloves - similar to what fire fighters wear. A face shield is usually a good idea to protect against extreme radiation (in the form of blasting heat in excess of 2400' F). Adequate ventilation in the furnace area is also a must, especially during charging. You don't want to stir up any more dust than is absolutely necessary. This is why some studios will bag up their batch in 10-50 lbs. sacks.

They can then just chuck the whole kit and caboodle into the furnace with no fuss or muss. The bag disintegrates in the high heat and most of the dust stays contained.

The other method people use to charge their furnace is to shovel it in, one scoop at a time. It can be quite messy when you spill, and a big chore to clean up. Charging duty is usually the entry-level position in any glass shop and relegated to the lowest man on the totem pole. After the first couple of times the novelty wears off and the backbreaking, hot-'n'-sweaty nature of the job hits home. It's grunt work, but if you wanna play, you gotta pay!

Some do's and don'ts of batching

Do:

- Play it safe when mixing batch.
- Get a proper fitting respirator rated for the chemicals you are going to be exposed to.
- Wear clothing appropriate for mixing the batch, and don't take them home with you.
- Keep the ventilation fans running while measuring and mixing batch. Please try and keep the ingredients in the containers and not on the floors, or anywhere else. Cross contamination of chemicals is not only easy to do, it's a hazard and catastrophe that's easy to avoid.
- Be sure to follow the recipe to the letter when mixing batch. Each and every addition counts. A mistake can be quite costly! I know of one instance where late one night a batcher/charger "forgot" to add the flux to the mixture, and ended up the next morning with a pot full of scummy sand. What a mess and a royal pain to ladle out of the furnace! Needless to say, that young man lost his job, and won't ever work there again!
- Once again, for the audience at home, **DO handle batch with care!**

Don't:

- You definitely don't want to wear your street clothes when mixing up batch.
- Don't eat your lunch in the batch room.
- Don't smoke (there are already plenty of reasons not to do that anyway, but it just gets compounded when exposed to the elements of raw glass).

Exposure

As with most areas of industrial hygiene, the amount of exposure to a particular hazard has an impact on how it will affect you overall. Illness or injury can be long in coming or happen in a flash. Some nuisances such as free-born silica have a cumulative affect on human respiration. On the other hand, the pain you get from a burn is instantaneous. It only takes a split-second of exposure to fry yourself on hot glass, hot tools or equipment.

One of the top ten questions asked of glassblowers is: "Do you ever get burned?" "Man," quipped the old glassblower, "if I had a dollar for every time someone asked me that question, I could retire in comfort and luxury right now!" The answer is, of course you get burned! The results of the burn can take weeks to heal. The lesson you learn is painful, usually unforgettable, and quite possibly preventable. Most glassblowers will suffer at least one severe burn in their life, which is enough to make them painfully aware of the nature of the beast.

Cuts and burns are common injuries suffered by artists working with glass. It comes with the territory so to speak. Out on the streets they say "if you play with fire you're gonna get burned." So it is. The key to success and a long life of blowing glass is to be aware of the potential hazards in all phases of the process. If proper safety measures are followed, glassblowing can be a fun and rewarding activity with little or no ill effect to the aspiring artist.

Other Hazards

Radiation, in the form of heat and light, is one of the by-products of the glass melting/blowing process. It is also one of the most harmful. Education is the key to working safely. Let's begin by discussing HEAT. Once you understand where the heat is and where it is coming from, you can take measures to prevent getting burned or overheated. The furnace and glory holes are the two main sources of heat in the studio.

The heat from the furnace can be intense - so much so that most people wouldn't want to go near it (for fear of getting burned). Yet when you watch glassblowers working, it seems like they're getting awfully close to the hot stuff. Either they're crazy, fearless, or completely desensitized to pain, (or all of the above.) In fact, glassblowers learn from Day 1 how close they dare get to the furnace or hot glass, without getting burned.

Simple common sense! Just like when you were a little kid and you learned that it's not a good idea to put your hand on the hot stove. You may do it once, and that painful memory (and valuable lesson) will never leave you. "If you can't stand the heat, stay out of the kitchen!" So the old saying goes. It is true for the hot shop. You can however limit your exposure in many different ways.

Protection in one form or another is one of the best ways to shield the glassblower from harmful heat or light. You may find protection available along three lines: personal, semi-stationery, and mobile 3rd party. These are merely options, and not every glassblower will use them. Everybody's threshold for pain is different. Sometimes a glassblower will endure a little heat or pain in order to execute a move as swiftly as possible with no interference.

Working with "the lava"!

Glassblowing is not your average 9 to 5 job. You certainly want to "dress down" when

showing up for work.

The first line of defense for the glassworker is proper clothing. Cotton is the first choice in fabrics suitable for glass working, and white works better than black. Cotton is light, breathable, and relatively non-flammable (as compared with synthetics). Synthetic clothing has the tendency to melt around heat, and that's the last type of that clothing you'll ever want to wear. Save your polyester for the disco-dance floor.

Shop clothes help protect your street clothes from getting exposed to the elements, not too mention telltale sweat stains.

Closed-toed shoes, not sandals or flip-flops, are a wise choice in footwear. You don't want to risk burning your feet from hot falling glass. Trust me on this one, more than one glassblower through the years has regretted wearing sandals to work and performed that impromptu wild fire high-steppin'-hot-toe-tappin' dance of pain.

Some glassblowers will wear a protective Kevlar Sleeve on their arm or a long-sleeved T-shirt to shield them from excess heat. Other less attractive but equally effective measures include cutting a hole in a sock and wearing that on your arm for protection. Eye protection in the form of glasses completes the basic glassblower ensemble.

Eye Protection

You only have 2 eyes, and it's a good idea to take care of them as best you can. In the hot shop it's real easy. You put on a pair of safety glasses.

Glassblowers have eyewear specially designed for the process. They offer first protection against flying hazards and second protection from radiant heat and harmful light.

The furnaces and glory holes emit intense amounts of ultra-violet and infrared radiation. Prolonged exposure leads to a condition known as glassblowers cataracts. It's like looking at the sun for extended periods of time. Eventually you'll go blind. The lenses in their eyeglasses are coated with U/V and infrared filters which cuts down on nearly all of the harmful rays, but still allows the gaffer enough light to see what's going on.

Eye protection only works if you put your glasses on your head where they belong, not around your neck or lying on the bench like I see so many foolish glassblowers do. It's kind of like the seatbelt in your car. If you don't wear it, it has no opportunity to save you in the event of an accident. So, for a small amount of "inconvenience" it offers you a lifetime of protection.

Heat and Stress

A major issue confronting the glassblower is heat illness. Heat stress, heat fatigue, and heat exhaustion, though not common, do pose a threat to glassworkers. The human body is

susceptible to dehydration and heat illness after long (or even short) exposure to excessive amounts of heat and humidity. It is most common in the summer months where temperatures in the hot shop can exceed 130° F. It's a good idea to eat plenty of food and drink plenty of liquids before showing up to work. You can burn a lot of calories and sweat buckets while blowing glass, so its best to store up before you start.

Each person has their own threshold for how much heat they can take. Some symptoms of heat illness include dizziness, nausea and vomiting, reduced urine output, followed by collapse, unconsciousness, coma and death.

The key is to limit your exposure, know when to say "when," and go home cool off and come back and do it all over again. This is why most hot shops shut off their furnaces and close their doors in the summer months.

Ergonomics

Ergonomic issues confronting the glassblower include repetitive motion and muscle fatigue. While focusing on blowing glass it's easy to forget about things like good posture and healthy work habits. That stuff creeps up on you, similar to the afflictions millions of computer users have experienced worldwide. After a full day (or week or year) of work, you may notice your wrists are sore and your back and neck are killing you. Much of that type of pain can be avoided by using the following tips:

Avoid repetitive motion (like turning the pipe only in one direction). Break up monotonous activities as much as possible. Try making different pieces if you can. Don't sit at the bench and make stoppers for eight hours straight. That's a sure ticket for carpal tunnel syndrome, and believe me you wouldn't be the first glassblower to get it.

Get some anti-fatigue mats for the shop. Sure they're smelly if you drop hot glass on 'em - don't do that. Or if some hot glass does fall on the mat, pick it up with some tongs right away!

Anti-fatigue mats can save your back. I know from personal experience that concrete floors will suck the life force right out of you. Take breaks every so often, especially if you are feeling tired. Exercise and build up strength, the same way an athlete will train to get stronger, and develop your endurance that way.

Finally, if you are doing heavy work, seek assistance or assistants. Take a tip from the pros: Get a mobile yoke and save your wrists. Hire a pole turner and save your wrists. Wear wrist braces and support those wrists. In other words take care of your wrists, and watch out while you're snowboarding too!

Too Hot to Handle

Hot glass is extremely difficult to manipulate and control. It behaves unlike anything else.

Since it'll fry your hands if you touch it directly, many specialized tools and pieces of equipment have been developed to handle it safely.

Blowpipes and punties are used to gather, blow and wield the glass during manufacture. They are made of steel or stainless steel, and are prone to getting hot as well, but in a very predictable fashion. The heat is most intense where the hot glass is (on the tip of the blowpipe). Some of the heat is transferred down through the blowpipe, but because steel does not transfer heat very effectively, the glassblower can grip fairly closely to the hot glass without burning their hands.

During the forming and blowing process, the main thing to look out for is the hot glass on the end of the stick. The glass radiates heat in every direction it possibly can. Just like the sun. The amount of heat it radiates is proportional to its mass and internal temperature. Hot glass has one objective: to get everything near it as hot as it is, as quick as it can - simple physics in action. It would even like to get you hot if it were given the chance.

Feel the Heat: Gathering

Your first steps in the hot shop will be cautious. The "pad" can seem a bit intimidating to the uninitiated. You'll immediately feel the heat and see the light coming from the furnace and glory holes, even though the doors may be closed at the time. The door is the glassblower's second line of defense against the heat. It offers semi-stationery protection. The door to the gathering port of the furnace is only open as much as you need to gather and exit the furnace. It can be adjusted to shield the person gathering. The gathering process is usually fairly quick (less than minute), so the exposure time is minimal, yet the heat can be phenomenally intense.

The glory hole also has doors on it. They allow the glassblower to reheat large pieces without getting blasted by excessive heat. The doors can be opened and adjusted to allow access and the reheating of specific sections of the glass object being created.

Heat shields are often employed near the glory hole or furnace. They look like metal doors mounted on a set of wheels. They can be positioned between the glassblower and the source of heat to greatly reduce the amount of heat exposure. A heat shield is a semi-stationery form of protection.

Teamwork: The Solution, not the Problem

Before you even pick up a blowpipe to make a piece of glass, you need to make some decisions about not only what you want to make, but also how you are going to do it. Basically you have two options: do it all by yourself or get some assistants to help you. There are pros and cons to each method, as outlined in the following paragraphs.

Blowing glass solo is not only extremely challenging, it's fraught with danger and peril. During the process of forming, the piece could check, crack or explode if one is not careful.

Naturally, accidents happen, even in teamwork situations, but (in teamwork) at least you have an extra pair of eyes to help notice things before they happen.

Solo glassblowers have to be one part octopus, two parts marathon athlete, and all but a little crazy. When you consider that there may be hundreds of small steps involved in the making of a single piece of glass, you begin to realize that it is quite a complicated process indeed! There's a phrase; "many hands make work light." There is a fair amount of truth to that statement, and in glassblowing, teamwork is the way to go.

The gaffer calls the shots. She or he is the team leader, not necessarily the oldest member of the team, but usually they're the most experienced and/or most skilled. The gaffer must pay attention not only to what they are doing, but also keep a third eye on what the rest of the team is doing. It all boils down to trust and communication.

A gaffer and his/her crew can crank out not only quantity, but also quality. There is no substitute for a team of highly skilled hands. Professional glassworkers move like a well-oiled machine. Once the plan is laid out (via a sketch or prototype), they go to work silently and smoothly.

In glassblowing there's a million ways to make something, and in glassblowing there's also a million and one ways to screw things up. Anyone can do it. Mistakes happen on a daily basis. For the most part, they go unnoticed. Lino says it's not how you make the piece, but how you save it (from destroying itself).

The gaffer trusts that the member they select for a particular task can not only do it, but also do it exactly how and when they are told. It's a lot like being the back-up band for the rhythm and blues legend James Brown. When he tells you to jump, you jump. When he tells you solo, you solo. When he tells you to hit the bridge, you hit it. When he signals you to stop, you quit!

The gaffer's signals are sometimes hard to spot, particularly if you are not accustomed to noticing them. For example, when the gaffer needs a bit of air (or a "puff"), he may just nod his or her head indicating that the assistant should blow. Another nod of the head might be the signal for a punty, or simply a clue that the piece needs a short reheat. Timing in glassblowing is extremely critical and there's very little room for error.

Other times the gaffer's signals are hard to miss. If the gaffer's face is turning red and there's smoke pouring out of their ears, it might be a sign that somebody screwed up and is moments away from getting their butt kicked.

There's safety in numbers. The team can have as few as two members or as many as eleven or more. It all depends on the design and/or designer. Some pieces are so complicated that they require the extra hands to pull it off. On other occasions, like production, you have a series of glassblowers that do the same task all day long, and the pipe gets passed from hand to hand, straight down the line. A massive quantity of similar

objects can be created in this fashion, like when Dale Chihuly has his team make chandelier components (as seen on TV, in “Chihuly over Venice”).

A gaffer doesn't necessarily execute his or her own designs all the time. They can be hired (with the crew) to assist in creating someone else's work. It is fairly common practice in the art world to seek out the best workers you can find to help accomplish the vision you have in mind.

It is up to the gaffer to designate what duties the crew will perform. Listed below are basic job descriptions for positions on a team. When visiting the Museum of Glass in Tacoma, or any other hot shop, see how many team members you can spot and what their duties may be.

Gaffer

Most skilled member of the team. Usually sits at the bench. Guides or directs all other team members. Will perform the most difficult or crucial maneuvers when it's time.

1st Assistant/Pole Turner

Most trusted member of the team, after the gaffer. They may do the majority of the reheats, take final gathers or simply 'turn pole' (rotate the blowpipe). They must follow each and every movement, and direction, of the gaffer. Years of experience required.

2nd Assistant/Starter

Do initial gathers and starts the piece. They may be asked to shield the gaffer, torch the piece, bring bits and wraps, or stand by to bench-blow.

3rd Assistant, “Bit Boy”, “punty boy” or Slave-first class

They may take gathers, do starts, bring bits, clean pipes, run errands, shield the gaffer, open doors to the furnace, glory hole and annealer, clean-up, sweep floors or other chores, and take the blame for everything when stuff goes wrong. Entry-level position, no previous experience necessary.

Colorist (optional)

Prepares the rods, frit or powders needed for any particular piece. They may heat and “drop” color, or lay out certain patterns of color for pick-up, or come-up with award winning combinations of color.

For additional information and a chance to discover the value of communication and trust, make the following group project exercises.

Teamwork Games for Groups of 8 or More

- **Telephone**

Gather your group in a circle and hold hands. The leader sends a "Signal" by squeezing the hand of the person to his/her left. The signal travels from person to person until the leader receives the signal back. Increase the difficulty of this game by sending signals both directions at the same time, sending more than one signal (two or three squeezes) in one direction, etc. Do this until clear signals are being sent and received. Increases simple communication skills.

- **Word/Sentence Telephone**

Played exactly the same as the above game except instead of sending a signal you're sending a word or a short sentence. The leader whispers a word or short sentence into the ear of the person to his/her left. That person passes this on to the next person and so on until the leader receives the message. Increase the length of the sentence to increase difficulty.

- **Pattern**

This game has three parts:

Part One

Gather group in a circle. Pick a topic such as "cities." The leader starts by saying the name of a city to another person in the circle. That person receives that city and says the name of a new city to a new person and so on until everyone has a city. The last person to receive a city says a new city to the Leader. Everyone in the circle now has a city they've been "given" and a city that they "give." You have just created a pattern. Repeat the pattern over and over until everyone feels like they have the pattern memorized.

Part Two

Put that pattern away. We're going to come back to it, though so don't forget it. Pick a new topic such as "food." Once again, the leader (same person) starts by saying a food to a NEW person in the group. That person receives that food and thinks of another food to say to a NEW person. Repeat until everyone has a food. The last person who receives a food must think of a new food to give to the leader. Same idea as above. Now we've created a NEW pattern, this one with food. Repeat until everyone has this new pattern memorized.

Now, try to repeat the city pattern. Do this until everyone feels like they have it down. Repeat the food pattern. Try to do the patterns together. In both cases, the leader starts the pattern. It's also up to the leader to know when a topic has been dropped and to start it up again.

Part Three

The third phase increases difficulty and should only be tried when both patterns are being repeated successfully. The leader starts a new pattern this time using only the word, "You" and pointing to a NEW person. Brand new pattern, brand new person, this time only using "you" and a point. When the "you" pattern is going around successfully, try to combine all three patterns at once. Ideally, the patterns should repeat without a break. The leader decides when the game is over based on the success of each pattern being repeated.

This is an excellent game for listening and creating group dynamics. Hint: yelling is a detriment to this game. However, insistence and persistence are key. If a person doesn't hear their cue, repeat the word over and over until they receive the information. It is each person's responsibility to make sure that the information has not only been said, but also received.

Some Frequently Asked Questions about the Hot Shop

How Hot is It?

At working temperature the furnace interior is about 2150°F. Hot enough to fry your skin (or your kin) instantly.

How do you get the furnace that hot?

We use a combustion/burner system, which runs on natural gas and forced air. This fuel mixture ignites and burns inside the furnace, which in turn makes the glass hot. Basically the burner is a big torch. In a crude sense it's like a giant hair dryer that blasts a big flame, or super heated air.

How come the furnace itself doesn't melt or burn?

The furnace is constructed of special materials, which resist the adverse effect of high temperatures. Certain types of clay, rock, glass, and ceramic compounds can withstand temperatures well above 3000°F. They are used to make the refractories, insulating bricks, and components used in the furnace construction, and in all sorts of industrial applications including the space shuttle. In time, however the furnace does begin to dissolve. Hot glass is a corrosive and eats away whatever it comes in contact with. Eventually the structure or interior of the furnace begins to fail at which point the operation is shut down and the necessary parts get replaced.

Where does the furnace come from?

The hot shop technicians at the Museum of Glass constructed it. Like many pieces of glassmaking equipment, it has to be specially built, usually on site, to meet the specific needs of the hot shop.

How much glass is in there?

When fully charged, the furnace holds about 1000 pounds of molten glass.

I don't see any flames. How can you be sure the furnace is being fired?

The combustion of the air/fuel mix is quite efficient and well contained. It is rare that you'll see any flames emanating from the furnace. Exhaust and unburned fuel is also invisible and potentially harmful, but are dealt with by the ventilation system. The telltale orange glow of the furnace is one indicator that things are running o.k. The other is a pyrometer, which can give us a digital readout of the furnaces temperature.

Artists and the Hot Shop

The Riddle: "I can be as clear as crystal, red as rubies, or blacker than the darkest night. When hotter than dragon's breath I turn to liquid light. When cold, I'm like ice and more solid than the rock or steel. What am I?"

So let's start with some helpful questions. If you have not seen glassblowing, or even if you have but do not remember what the glassmakers were doing, these questions will give you a better idea about what to ask when you come to visit us.

If you have seen glassblowing, try to answer the following questions first:

- Have you ever seen glass in a museum, gallery, or somewhere else? Where?
- Can you remember what the glassmakers were doing?
- Can you describe a little of what you saw?
- Do you know any glassblowers? Who?
- Would you like to try glassblowing? Why?
- If you could make anything out of glass, what would that be? Why?

The next section of questions will both quiz knowledge from the previous sections and get your class thinking about glass before they visit the Museum.

Guideline Questions:

- Where does glass come from?
- At what temperature does glass melt?
- How can you get something that hot?
- How can you color glass?
- What dangers are involved in glass? What scares you about glass?

- Glass is one of the top 5 collected items in the world. What would you collect (made of glass) if you could afford it? Why?
- Glass as a material is cheap (25-50cents/lb.). Art made from glass on the other hand tends to be very expensive. Why is that?
- Glass can be incredibly hard, yet if you drop it, it breaks. Why is that?
- Glass can be very clear (or see-through/transparent). What are some other things that have this quality?
- Glass can be made very dark or opaque (you cannot see through it). Can you name some other things that do this?
- When glass is hot enough, you can cut it with scissors (we call it “trimming with shears”-just like cutting hair or fixing the hedge). When glass is at room temperature it’s as hard as rock or steel. What cuts through such hard substances?
- Glass has many qualities or properties. Describe three of them (for example, it may appear shiny, or rough or...also it can be made into many things-like.....).
- How do eyeglasses work? How about telescopes and microscopes?
- How do the reflectors on a bike work compared to glass?
- Do you have any Pyrex glass at home? What makes it so special?
- Why do scientists love Pyrex or boro-silicate glass?
- Speaking of love, why do grandmas love glass Christmas ornaments?
- What’s your favorite color of glass?
- How do prisms work?
- How would you make a bottle or jar?
- What’s the smallest and/or largest piece of glass that you have seen?
- Volcanoes produce glass naturally. What do scientists call this? What does it look like?
- Lightning strikes to the Earth can also make glass. How? Why? What’s it called?
- When hot, you can stretch glass (just like bubble gum or taffy). When pulled very thin, (thinner than a human hair), we get a useful telecommunication material. What do we call it?
- Very, very thin glass, all bunched-up like cotton candy can be very useful in other ways-do you know what for? (Hint: sometimes it’s pink- like the panther or yellow in color).
- What part of a neon sign is glass? How does neon glow? What do you need to make it work?
- How old do you think glassblowing is?
- Where in the world did glassblowing begin?
- Who is recognized as contributing significantly to the development of glass?
 - The Phoenicians
 - The Egyptians
 - The Romans and Venetians

The Middle East
Dale Chihuly

- What's an excellent activity to do, if you want to become a great glassblower? (Hint: you can use a pen or a pencil and it doesn't require access to the www.)

A quick look around the gallery will immediately reinforce the fact and knowledge that glass can take many forms and exhibit many qualities.

Topics for Discussion

Compare and Contrast: What do you see?

The following questions are guidelines for better understanding the art at the Museum and the process of making glass.

Size and Scale:

Why make it this size? What if it were smaller? Larger?

Shape:

Why was it formed so? Does it remind you of something? What process was used to make it?

Color:

Why this color(s), not another? What process was used to achieve the color?

Light:

How does light affect the work? What if it were lit differently? Is the light reflective or refractive or other?

Surface & Texture:

Describe the surface of the work. How was it done? What difference does the surface or texture make to this pieces overall look?

Installation/Presentation:

Notice how and where the object is. How does lighting affect the work? What if the piece were displayed in another space, or on another surface? Higher or lower? Are there other materials used in conjunction with the glass? Why were these materials chosen over some others?

Artwork:

Does this qualify as art? Do you agree? Why did the museum choose this particular work over others? How does this piece make you feel? Does it remind you of something?

When viewing contemporary art, it is natural for people to experience different things. The experience can be extraordinarily moving and beautiful for some while being threatening,

disturbing or downright intimidating for others. Some works of “art” may be regarded with apathy or indifference. We can feel the same way when hearing a foreign language that we do not comprehend. Just because you don’t understand the language, it doesn’t mean you should dismiss the person as having nothing valuable to say.

“I don’t get it” are four little words often heard in museums and galleries worldwide. Contemporary artworks and pieces “on the cutting edge” have throughout time dumbfounded the general viewing public. Most works of art selected for exhibition have been chosen by the curator to enlighten, not confuse the viewer. Nevertheless, some sculptures do remain questionable, e.g. “Is it art,” or “ Why is that ‘thing’ here?” and of course the question on everybody’s mind: “Wonder how much that costs?” Usually these questions, and others like them, go unanswered and the ignorance continues. The solution to the problem is information and education.

This article will introduce you to some terms, techniques and concepts of contemporary sculpture using glass as the medium. Understanding the depth and complexities of the sculptor’s ‘vocabulary’ is an excellent way to begin a foundation in art appreciation. There are reasons why glass is such a hot item and the medium of choice for so many artists today. Glass is seductive and strong, elusive and fragile. It offers the purest of colors and interacts with light in ways no other medium can. Even when it’s completely colorless, it can speak volumes. Sculpture, like most forms of art, has its roots in communication, and it is there that we begin.

Communication

When you want to communicate an idea or feeling to another person on this planet, you have many options. The simplest thing to do is to just go ahead and say it. Maybe that person will get the message - if they are close enough to hear it and “speak your language.” You can affect how the sender receives their message and the overall impact of it by whispering it or shouting it out at the top of your lungs. This is known as **presentation**.

What if the person isn’t close enough to hear you directly? You still have many options. You can phone, fax or e-mail the message if the receiver is connected along those lines of communication. You could write your message on the wall or type it in a letter, in hopes someone will read it. What if the person doesn’t speak your language? How do you get the message across then? Well, you can try sign language or using symbols or other objects to represent the things or ideas that you have in mind. Every culture recognizes certain shapes and elements of human emotion and endeavor. These are referred to as **universals** because just about everybody in the universe knows what you’re talking about. The image or sculpture of a mother and child is one such example.

It occurs in every culture in one fashion or another – each has a tradition for how certain images are displayed or presented. Today, in our globalized society, there are many options available, more than ever before.

Medium or Media

Remarkably, the discovery of glassmaking is over 5,000 years old and actual glassblowing is at least 2,000 years old. In that time we have amassed quite a bit of knowledge about the material itself and the way it behaves. Glassblowing has its own set of rules and traditions that artists can choose to work within or escape from.

When you start out to make work of art (in order to express yourself), you often take a moment to decide what material you want to use to say or depict what you have envisioned. Throughout time, the material has generally been what we have at hand at any given moment. Aboriginal artworks are almost exclusively made of natural materials garnered from the environment. With the advent of technology and industrialization, some “not-so-natural” materials have become available for people to use in creating artworks.

Selecting the right material for the job is no simple task when you consider how many different substances we, as modern society, have been able to produce. Artists throughout history have worked in “traditional materials and methods,” often learned from a master or close relative. Stone, wood, clay and natural fibers were amongst the first on the scene. Can you guess why?

As man's knowledge of fire and the elements developed, metal in its various forms became a material to work with and master (glass in the early days was referred to as a “metal”). Still, the selection of the correct material to work with is often the one that's the most readily available and easiest to control. It may also be the material that you, as an artist, are the most familiar with.

Qualities and Characteristics

Each and every material has a set of qualities that separates it from the rest. Some of the characteristics are purely visual, while others may relate to mass, texture, hardness, temperature, or ability to be manipulated. For example, look at work in the gallery at the Museum of Glass and ask yourself “Is the work”:

- Shiny or dull?
- Light or heavy?
- See-through (transparent/translucent) or dark(opaque)?
- Rough or smooth?
- Inviting or scary?
- Fragile or solid?
- Stationary or moving?
- Natural or man-made materials?

Scale

Bigger is better, or so the saying goes in the United States. On that note a thing or two

about scale. **Scale** is a sculptural term for size; size in relationship to other objects (or more commonly man). There are small-scale or **miniature** works which can easily fit inside the palm of your hand. There are mid-sized pieces that may easily be displayed on a pedestal or (heaven-forbid) a coffee table.

There are works that are human in scale or **life size**, and others which are larger-than-life or **monumental** in stature. There are increasing numbers of architectural applications of glass that go well beyond the confines of traditional stained glass and only attest to the dynamic and ever-evolving nature of this material. Glass does have some limitations that might influence the size to which you can make any given piece.

Hot worked glass objects, made on a pipe or punty, can only be made so large. It is physically next-to-impossible to blow or sculpt objects larger than a human being on a blowpipe, although there are a handful of artists who are pushing this very envelope. They have designed and built some very special equipment allowing them to make pieces well over 120lbs(50kg) and over nine feet in length (3m), with the aid of three or four trained assistants.

The casting process, however, offers artists an avenue to create colossal sculptures made in one piece or in several interlocking pieces. Works by artists such as Howard Ben Tre', Stansilav Libenský and Jaroslava Brychtová have pushed the envelope in terms of what is possible in the area of cast glass.

Some monumental or **architectural works**, (including **installations**), will incorporate a multitude of smaller objects exhibited together on a massive scale. These works command your attention by filling your field of vision with virtual 'eye-candy'. Naturally, the bigger the piece, the higher the price tag, both for manufacture and for sale. Often, teams of people are involved in the creation of such works with big budgets and ever-shrinking time-tables (not-too-dissimilar to what happens on a movie-set.)

Scale plays an important role in how people view your artwork. Small-scaled micro-mosaics, highly detailed lamp worked inclusions and colorful murrine are some examples of glass sculpted in tiny forms. These pieces can focus your attention to things that might have otherwise gone unnoticed. They may even require that you get a magnifying glass in order to view them thoroughly! For example, a paperweight by Paul Stankard can contain literally hundreds of individual stringers and blobs of glass to simulate some form of botanical beauty. Looking at these pieces, you'd swear there were real plants encapsulated in the crystal. Or a section of murrine smaller than a postage stamp may contain the entire Lord's Prayer in it (as made by Richard Marquis over thirty years ago).

An object easily slipped into your pocket has a preciousness and intimacy that people throughout time have cherished. An installation of small-scaled works can have a tremendous impact on a large viewing audience, and should not be overlooked

when engaging in the pursuit of fine art or creative endeavors. Bigger is definitely not better, it's simply more noticeable.

Form and Composition

Form and composition are major elements to consider in both discussing and creating sculpture. When you get inspired to create a new work of art, you have to make some decision as to the form and shape of the object you have in mind.

Let's say, for example, that you have a powerful dream one night that is equestrian in nature. It's not enough to say, "I want to sculpt a horse-thing." It's simply too vague. There are practical things to consider such as how big (see previous paragraphs on scale), or in what position should the horse be posed? Size and positioning have a tremendous influence on how people view your work and the reaction that they may have to it. This is what we refer to as composition. If the horse is depicted as rearing-up on its hind legs, we may see the animal as victorious, or raging in anger, or merely celebrating its life as a free roaming creature: unattached by the bonds of man.

On the other hand, if the horse is rendered lying on its side, we may see it as being sick or even deceased. This evokes a much different feeling than the previous example, yet they both depict the exact same subject. Even slight changes in the horse can have significant meaning or impact. These stylistic variations are the key components of composition.

Balance, weight, thrust, angles/curves, interaction in space, and the environment are other major players in determining composition. Exactly how the piece sits, or even the material or structure on which the sculpture rests upon is integral to its presentation.

Why Choose Glass?

Even though glassmaking has been around for thousands of years, it is only in the past thirty or so years that its value as an art medium has been nurtured and developed. Breaking free from the confines and traditions of craft and industrial applications, artists in the mid-to-late 1960's took glassmaking out of the factory and into the studio. There they explored the amazing complexities that this medium has to offer.

Glass is a pretty unique substance as far as art materials go. It can be dull or shiny, transparent, translucent or completely opaque. It can seem as warm as the hottest fires of Murano, or colder than Antarctica's glacial ice formations. The surface of glass can be made rough or smooth, sharp or jagged and dangerous to handle.

Glass when cold is very hard, yet also very fragile. It will outlast virtually all other art forms (provided it doesn't break) in that it resists age and weathering from the environmental conditions of planet Earth. Art historians refer to this property as **archival**, or in other words, likely to stick around long after we're dead and gone. Glass when molten can be quite soft and extremely versatile. You can stretch it, squash it, and blow it into

smithereens (or virtually anything else you can think of!). You can poke it, punch it, press it, cast it, spin it, quench it, smash it or sculpt it. What you can't do is touch it! Darn! (Yet that is one of the reasons glass is so attractive to work with; it's so forbidding!) When molten, the material is so seductive and yet so elusive. It defies most attempts to master it. The prohibitive nature of direct handling requires the use of specialized tools and elaborate procedures. It can be extremely complicated and intense. Yet hot glass is one of the most immediate of all art-making processes. Most pieces of blown glass are made in 90 minutes or less (after some 10-20 years of practice by the gaffer and team).

Optics are another great property of glass to work with. Using clear or crystal glass immediately sets your work apart from the rest. There are only a few other substances that are transparent or completely colorless and can play with light like glass.

You can incorporate many scientific principles on the behavior of light within the realm your artwork by exploiting the optical qualities of glass (see Libenský, Weinberg, Reis, and Kallenberger for a few examples). The focus of the work may be simply using the brilliance of the material and the way it interacts with natural or artificial lighting.

Adding color will just expand the beauty of glass. The ability of glass to capture and transmit light is unparalleled by virtually all other substances. This is another reason glass is so attractive, and why many painters have been lured away from their oils and watercolors. Dale Chihuly paints with color both on paper and in glass. As easily as the acrylics flow from his squirt bottles, the colors of his glass compositions explode on the scene - capturing the eye and sending it on a roller-coaster ride through the spectrum.

Sculpting Glass - A Hard Road Ahead

Sculpting glass has its pros and cons. There are many good reasons to select glass as a material to sculpt; yet there are a few reasons why it isn't the most popular or commonly used.

First, glass isn't easy to work with. Molten glass is very elusive. It takes a great deal of skill to make an amorphous blob of hot glass retain a specific shape. Especially if the piece is one that has virtually every color of the rainbow in it, or a series of twisting/spiraling lines of gossamer threads interwoven by some mind-boggling process.

It takes years of practice just to be good at glassblowing, and decades of service and hard work to even come close to mastering the material. You've got to pay your dues, just like in professional sports or becoming a world-class musician. Only a few get to be on top and make the megabucks, but you know that they have worked very hard at it each and every step of the way. Glassblowers also make it look so easy! They respond with a fluidity and familiarity within their movements so that there is little effort wasted and the results are nothing short of poetry in motion.

Second, it isn't easy to melt glass either. You need special equipment and tools (which cost in the thousands of dollars) to make glass molten. Often the equipment is very expensive to build. It is horrifically expensive to run and maintain, plus it has the added benefit of being highly flammable. Yet another reason you don't see hot shops on every street corner, it isn't cheap!

You don't have to melt glass in order to sculpt it. Many artists work with cold glass, cutting, grinding, polishing, and assembling it in variety of methods. Some artists mix their media (henceforth known as **Mixed Media**), combining glass with other materials in a multitude of fashions.

Design Your Own Vessel!

Materials: paper, Design Your Own Vessel forms, and any artistic materials you choose.

Using the terms and skills learned above, you could design your own work of art made with glass. Design your own glass vessel based on the work you see in the Hot Shop, the gallery or the Education Studio at the Museum of Glass, or from your own creativity. This can be a free form or symmetrical design. You are the artist. This is an opportunity for you to exercise your creative muscles and create a brand new design.

A form has been included at the end of this packet. If you would like to submit your drawing to the Museum, either individually or as a class, we will enter it into our monthly contest. Of all the designs submitted each month, two will be chosen and actually made in the Hot Shop! So be creative, and maybe your piece will soon be made into a real glass vessel.

If you are chosen you will be notified by phone and given the date and time when your design will become a work of art. The Museum may choose to make two examples from your design. One piece will be kept by the Museum for possible use in a Design Your Own Glass Vessel Children's Museum touring exhibition (2007). You get to keep the other.

Please note, due to the nature of glass blowing we cannot guarantee that your piece will be successfully realized in glass.

Please send designs to Meredith Hale, 1801 E. Dock Street, Tacoma, WA 98402.

Education: the Final Word

There is no substitute for the direct experience of seeing sculpture in person. Get out of the house and down to the Museum of Glass or your local gallery to see first hand what is out there. Ask yourself some questions (see Compare and Contrast Checklist). Try to come up with some answers on your own. Better yet, why not take a class in glassmaking?

Whatever method you choose in sculpting glass, you can expect an investment in time, energy and materials. It is wise to get as much instruction as you can tolerate or afford. Teachers and professional glass artists can save you an enormous amount of trial and error, and is well worth every penny you spend.

The rewards are numerous. You will encounter a community of like-minded individuals (they all share a fascination for glass) all coming from different backgrounds and levels of education. The information brought about by the Studio Glass Movement is nothing short of extraordinary. The developments of the past thirty years have opened up the book of past secrets that has been locked shut to “outsiders” for centuries. Glass continues to be transformed in ways that we could have only dreamed about decades earlier. The technological advances allow us to visualize and sculpt works of art second to none. The golden age of glass is now. Enjoy it while you can. The first steps to becoming a part of this amazing movement is through your own determination, participation and education.

Stained Glass and *Gathering the Light*

So far we've been focusing on hot glass and its properties. There is also a rich tradition of stained glass that might be more familiar to you. In the Grand Hall of the Museum of Glass you'll find a fantastic triptych called *Gathering the Light* by artist Cappy Thompson. Cappy's work is a form of stained glass called grisaille. Although *Gathering the Light* is comprised of flat panels, she also paints on glass vessels. This section will tell you about the artist and the process behind the work.

Cappy Thompson, Artist's Statement

As a painter, I combine two ancient lineages in my work: that of the medieval artists who painted on stained glass and that of the Greek artisans who painted clay pots. Like them, I paint pictorial narratives. My work is pulled in opposite directions by the panel and vessel forms. With a long history as a public art form, stained glass is an architectural medium that belongs to the collective. The vessel, on the other hand, exists on an intimate scale, relating to the individual in its form and function. This conflict finds expression in my work as a desire to communicate broadly on the one hand, and an impulse to go deeply into the personal on the other.

In college, I was drawn to stained glass as a perceptually compelling medium driven by light. I realized that if I wanted to paint on it, I would have to teach myself *grisaille*, the medieval technique of gray-tonal painting on glass. This technique involves painting and firing vitreous paints onto glass. First the black line work called *tracery* is painted onto the glass surface and permanently fixed by firing. Then a wash of black paint, called a *matt*, is applied over the tracery and removed in patterns by specially shaped bristle brushes. The tonality and patterning (*modeling*) created by this subtractive process is then fixed by firing.

My first panels were heavily influenced by the art of the Medieval period from many cultural sources—Hindu, Pagan, Judaic, Buddhist, Christian, Islamic. I loved the naïve naturalistic content and emotional expressiveness of that period. I began to design and paint panels based on the narrative content of European mythology, fables and folktales, drawn in oblique projection, with jewel-like colors.

I worked in stained glass for twelve years. Then in 1987, during a summer job at Pilchuck Glass School, I was handed a large transparent blown-glass bowl to paint and saw immediately—like the Greeks of antiquity—that a vessel combining cylindrical and spherical forms is a nearly perfect structure for painted narration. The glass vessel is a separate world for the story. Its transparency allows the painting to become sculptural, seen from one side through to the other, changing as the viewer circumambulates the structure.

This was the beginning of a thirteen-year period of vessel painting that continues in the present. I spent several years working in black and white, captivated by the compositional possibilities of images drawn on the vessel form. Gradually I came to appreciate how the qualities of blown glass, colored vitreous paints, and the metaphors hidden in the vessel form could bring more meaning to my work.

As a metaphor, the vessel can represent various objects and functions deeply embedded in our psyches and culture. For example, it embodies various concepts such as internal/external, center/rim, surface/interior, boundary/territory, open/closed, above/below, background/ foreground, male/female, container/content, and world/self—to name a few oppositions. The form itself is made from molten sand and constructed by the application of breath and turning—allegories for creation, planetary bodies and time. The ability of glass to hold space, color and light suggests the spiritual qualities of transparency, translucence and transcendence.

About ten years ago I found myself moving away from existing mythological narrative and toward compositions that drew upon images and themes from my personal life. Elements would drift up and assemble into picture-poems that seemed to have a life of their own. I began to "read" these works as reflections of the spiritual and psychological issues in my life. I painted members of my family and myself in a kind of autobiographical fantasy, working with the mythopoetic materials of my life. I cast myself into scenes from various world spiritual traditions.

I am currently working on the largest project of my career—one that brings me full circle back to stained glass—a painted window-wall measuring 33 feet high by 90 feet wide for the new south concourse at Seattle-Tacoma International Airport. Entitled "*I Was Dreaming of Spirit Animals . . .*" the design depicts a couple sleeping high in a tower-house. Behind them is the arc of the night sky, shining with 17 animal constellations of the Northern Hemisphere. Across the sky, winged horses Pegasus and Equilius draw a chariot bearing the Sun and the Moon, who sprinkle stars upon the dreamers and travelers below.

This project incorporates, into a stained-glass composition, what I have learned from vessel painting. The fabrication method allows me to float the imagery upon an expanse of color laminated onto plate glass. The building becomes a vessel, and stained glass washes the space with the brilliance of colored light.

More About Grisaille

The style of painting Cappy Thompson uses is called grisaille technique. It involves a subtractive process with dry brushes. It's the only way to achieve that gray tonal (shading) appearance in the painting. You can often see this style in stained glass creating shadows or facial features. The enamels are made from metal oxides and are fluxed with a low-melting lead glass. The paint fuses to the surface at the same temperature at which the lead glass melts, which is 1100 degrees F.

Cappy begins by drawing directly on the outside of the vessel or on the front of a panel with a black marker, letting the composition develop on the piece. She then mixes the paint, and traces the drawing from the bottom up. It's easiest to work on a light table and lay the vessel on its side, allowing the artist to work on a horizontal surface inside the vessel. Cappy cuts handles of her paintbrushes to fit inside. This first layer of black lines is called tracery give the work its medieval quality. The tracery is fired on, making it permanent, and the next step begins.

The matt, a wash of gray paint, is applied evenly over the entire surface of the drawing. The highlights are removed with dry brushes -- stipplers and scrubs. Stipplers are bristle brushes shaped into a dome by burning over a candle. They leave a dot pattern. Scrubs are flat bristle brushes that have been trimmed and burned. They leave a line pattern. This removal of paint gives texture and volume to the drawing. The artist will then remove the paint from all the background areas, very carefully clean the vessel, and fire it a second time.

Cappy fires to 1100 degrees, which is high enough to slump the pieces. You're on the verge of disaster, but with the use of an electronic controller, the kiln is programmed to ramp slowly to the annealing temperature of the glass, then quickly to the firing temperature of the glass paint, and quickly back down to the annealing temperature. The piece stays at this temperature for a while and is then slowly brought back down to room temperature.

Next, the colors are applied. Cappy works with transparent colors that change significantly when fired. She creates a watercolor rendering of the image to see how she wants the colors to appear. After making notes, and taking Polaroids, she applies the enamels to the piece accordingly. In some cases she layers enamels to change, enrich or blend a color. Because she usually fires the work twice for color, each piece requires a minimum of four firings.

The vessels are meant to be artworks, not functional objects. Because the transparent enamels are fluxed so heavily, the lead glass is soft. Direct contact with water will break

down the enamel over a period of time, but in theory these works should last for thousands of years if cared for properly.

Try Grisaille Painting:

Materials: transparencies, black Sharpie markers, poster paint, paintbrushes, and other hard dry brushes (either dry, hard, thick paintbrushes, inexpensive toothbrushes or the like). The Dollar Store carries paintbrushes and toothbrushes.

- Determine what to put on your glass or transparency. A story? A decoration? Pictures from the Dream Analysis activity?
- Sketch your idea on scratch paper until you are satisfied with it. Think carefully about depth and shading. This technique allows
- Using a black Sharpie marker, trace the outlines of your image and any permanent detail onto the transparency. Allow it to dry.
- Using black poster paint, paint in places to be shaded in black. When the paint has dried, use the hard brushes to tap on the paint, causing it to flake off in areas you want color to show through. You can also use the opposite end of the brush (handle) to scrape off the paint to show designs, etc.
- Now color in your design with the other colors of paint. The black marker should be on the bottom layer, next the black paint finished with the colored paint.
- Display near a window or other source of light.



Image Credit

Cappy Thompson
Gathering the Light
2003

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