Basics of Moldmaking

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Introduction

Molds are frequently made of fossil specimens. They are made for a variety of reasons - to share information with others, to preserve a specimen in situ before disarticulation, and for black and white photography. The goal of moldmaking is to reproduce the information contained in the original detail as completely as possible without damage to the specimen. Bear in mind that often your cast may be all that a researcher may see of the specimen. It is very important, then, to represent the original as completely as possible. The preparation of a good mold is key to the molding, and demolding of precious fossils with the least amount of harm.

There are two basic kinds of molds, solid poured molds in silicone and thin-walled molds in either silicone or latex. The setup for both kinds of molds is similar as is the rationale for the decisions you will need to make to make a useful and safe mold. Solid molds in silicone are most often used for small specimens or those without a complex shape. A major consideration in the use of this kind of mold is cost. A very large solid mold may be prohibitively expensive. It may also be difficult to remove a solid and therefore quite stiff and unwieldy mass of rubber from deep undercuts or complex shapes. Large and complex shapes may require more flexibility in a mold to make demolding easier. These require a thin-walled mold of either latex or silicone.

No two molds will be done in exactly the same way. Each specimen is different and presents different problems. These directions are in several parts, according the type of mold needed. Each can be read independently. These are only generalized directions. I will try to give the reasons for each step, so that decisions can be made and directions adapted for each individual case. Read through the entire direction before beginning, so that you will be prepared for upcoming steps. Remember that any new technique will take a while to perfect. If possible, practice on an easy and unimportant specimen.

Make sure that the molding process is explained to the researcher. Putting consolidants, carbowax and molding rubbers on the specimen can make un-removable changes to the specimen and may preclude certain types of research later. If you are molding a specimen that belongs to another institution make sure that you have written permission to mold the specimen.

Always make sure that the name and number of the specimen and any other important information are noted before you begin working and that it is written on the jacket or otherwise noted on the mold. This can prevent much confusion later.

In addition, use care with these materials. Read the Material Data Safety Sheets. While silicone rubber, latex rubber, and plaster are fairly harmless, you will want to wear rubber gloves and an apron. Use a fume hood when casting polyester, as well as rubber gloves and an apron. Use common sense, and care. Any material can be dangerous if ingested. Don't eat or drink while you are working with these materials.

Beginning the mold

1. The first step in the making of any mold is to carefully look at the specimen. Will it stand up to the rigors of the moldmaking process? Where are its weak points? Are there deep recesses (undercuts) that will cause trouble when demolding or must absolute fidelity be sacrificed and should those deep holes be filled? If necessary, the specimen should be cleaned and any preparation completed before molding. There is no reason to make a mold of dirt, and excess glues and consolidants on the specimen. Breaks should be repaired and extra glue removed.

2. The specimen should then be coated with a thin but complete layer of a consolidant. Two coats of 2-3% Butvar B-76 in acetone are good. The layer of consolidant acts to help maintain the specimen and also acts as a release between the molding material and the specimen. Teeth, however are not usually consolidated, so as not to interfere with dental wear patterns, and other minute details.

3. Fossils usually contain many holes small and large that can cause trouble if the rubber is allowed to get into them. These holes such as weathering damage, foramina, and old breaks need to be covered, yet the mold must retain as much information as possible. When thought is being given to design of the mold these holes must be considered. Some deep recesses may contain important information and so should not be covered. The mold instead needs to be designed around them. A good clue as to which holes must be filled is to try to see if the hole is bigger on the inside than the outside. That is, is this a small area into which the liquid rubber can seep but out of which the hardened rubber cannot be pulled without breaking the specimen?

The filler should not cover any more of the bone than is absolutely necessary. Thinking of the fossil as information may help guide you. The filling should not hide any more information than is absolutely necessary to preserve the fossil against breakage. Remember that this cast may be all that a researcher is able to see of this specimen. Filled areas will read in the cast as solid surfaces that are the same as the rest of the bone. This is why it is important to keep the filling to the minimum that is needed to preserve the specimen.

Filling is usually done with Carbowax. Carbowax is a common name for polyethylene glycol. Not really a wax, Carbowax is soluble in water, making it easily removable from the specimen after molding. Carbowax comes in a variety of hardnesses, which can be mixed to form a wax that is easily workable. Carbowax may also be colored with a tiny bit of powdered pigment, to make it more easily readable against the bone. Filling may also be done with clay or microcrystalline wax, though these are more difficult to remove after molding. Melted Carbowax is applied to the hole and when cool, scraped flat with a tool. Smoothing can be done with a brush and acetone or alcohol. Very tiny holes can be filled by simply scraping a little of the hard wax into the hole and using acetone to smooth it. The surface of the filled area is usually slightly below the surface of the bone, to show as exactly as possible where the filled area begins.

Very deep or large apertures can be stuffed first with slightly dampened tissue and a thin layer of filler applied on top. The filler is usually scored or otherwise marked to distinguish filling from fossil. Care must be taken to remove any filling material that is not needed. You can often end up with a small lump on an important tooth cusp if not careful. A thin layer of consolidant is applied over the filling.

4. While filling is being done and you are becoming familiar with the specimen, thought can be given to the design of the mold itself.

A one piece poured mold for flat specimens

This is a good type of mold to make when the object has only one viewable side, for example a bone that is not completely removed from the matrix. This is about the simplest mold to make.

1. Make sure that all holes are filled in the specimen as noted above.

2. Roll out a clay bed. Clean, sulfur-free clay (silicone rubbers react with sulfur, inhibiting cure) can be heated slightly with a heat lamp to make it more workable. Then roll the clay out with a rolling pin to form a smooth bed on which to lay the specimen. An easy way to maintain an even thickness of clay is to roll the clay out between two sticks of the same depth. These sticks will keep the roller the same height all of the way across the clay. Press the clay up to the specimen, so that the rubber, which is liquid, will not seep under the specimen. This will form the top surface of the mold.
Remember that in terms of the mold, you are working upside down and in reverse. The cast will reproduce what you see in the original.

3. When the specimen is embedded in the bed and smoothed, specimen names and numbers may be punched into the bed to identify the specimen. They should be placed near the edge of the specimen, so that they are on what will become the top of the mold. This can be done with a needle, but remember that they will read in reverse in the mold. It helps if you can write backward.

4. A clay wall is made by rolling softened clay out to a thickness of about 1/8” or 2-3 mm. The clay can be cut into a long rectangle with clay tools. The wall is then placed around the specimen approximately 1/8” to 1/4” (3-5mm) away from the specimen. This wall should be 1/4” to 1/2” (5-10mm) higher than the specimen, depending upon the size of the original. The wall must be sealed well into the clay bed, so that liquid rubber does not seep out of the mold. This wall makes the edge of the mold. This also gives the finished cast depth, like the original.

5. Talc (talcum powder, like that used for babies) can be used as an additional separator. Using a soft brush, apply talc to the entire mold.

Then blow and brush away almost all of the talc. The rule here is: if you can see the talc, there is too much left on the specimen. This unbelievably thin layer of talc will help the rubber to pull away from the specimen.

6. These molds are almost always made in silicone, mixed according to manufacturers' instructions. There are various types of silicone rubbers, make sure yours has a long enough set time to allow for deairing and a slow pour. After mixing, the rubber should be deaired to prevent the inclusion of air bubbles in the mold. The cup holding the liquid rubber is placed inside a vacuum chamber and all air drawn off. This will cause the material to rise. Make sure there is enough room in the cup for the material to expand to 2-3 times its original volume. After the air is removed, the material will drop back to its original size and continue to bubble. It should be allowed to bubble for approximately 5-7 minutes, for all air to be eliminated. Allow the air to return slowly to the vacuum chamber and remove the cup.

7. The rubber is slowly poured into the mold from one corner in a small stream. The pouring should start in an area where there is no bone and the rubber be allowed to slowly move by itself over the specimen. It is important that the silicone not be poured in so fast that air cannot escape from between teeth and from small recesses. If there is an area where you are not sure the rubber has penetrated, the rubber can be gently pulled back with a brush or needle to allow air holes to fill. Allow the rubber to set. See manufacturers' directions, this time can be 6-8 hours or longer.

8. Small molds like these often do not need the support of a jacket. If the mold has thin, or large walls, or if you feel it would be better if supported, see Jacketing.

9. After the specimen is jacketed, it can be demolded, the specimen cleaned, and the mold cast. Some molds may have to be demolded in certain directions to avoid putting stress on raised parts of the specimen. It is useful to note this in some way on the clay bed or on the jacket. It is very difficult to remember the exact shape of a bone under a layer of rubber. See Demolding, Final cleaning, and Casting.

A one piece poured mold for small specimens

1. A one piece mold is usually made when the object is small or partial, such as a single tooth, or a fragment of jaw. This type of mold is good when the specimen is viewed from one side, or is relatively conical. Remember that any object that is molded must also be removed from the mold. Even with a single tooth it may be necessary to make a more complex mold if it will endanger the specimen to pull it out of a one piece mold.

2. It is desirable, though not always possible, to place the object on a small platform, to create a base, or a “handle” for the specimen. Clean, sulfur-free (silicone rubbers react with sulfur, inhibiting cure) clay can be softened with a heat lamp. Roll out the clay to form such a base, which is cut with a tool to a size a little larger than the specimen.

3. This base should then be placed upon another flat bed of clay, which will form the top surface of the finished mold. Remember that in terms of the mold, you are working upside down and in reverse. The cast will reproduce what you see.

4. The specimen can then be placed above the topmost bed and a hole the approximate size of the object cut into it. The specimen is then set down into this hole to the desired depth.

5. The clay is then pressed tightly and neatly up to the specimen, leaving no small hole through which the liquid rubber may bleed. It is always important to smooth the clay within the mold, not solely for esthetic reasons, but so as not to cover or mar important information on the specimen. Final cleaning and smoothing are best done under a microscope. Small needles and other clay tools will help to remove excess clay. Alcohol on a fine brush can be used for final cleaning and smoothing.

6. When the specimen is embedded in the base and smoothed, specimen names and numbers may be punched into the base (handle) to identify the specimen. This can be done with a needle, but remember that the information will read in reverse in the mold and the same way you see it now in the cast.

7. From this point on follow directions above in: <u>A one piece poured mold for flat specimens</u>

Two (or more) part poured molds

1. On complex or larger shapes, more complex molds are needed. It is necessary to divide the specimen into two or more parts, making each part individually. Decide where the seam lines will occur. This is where the parts of the mold will meet. The goal in placing the seam lines is to separate the specimen into parts so that there is the least possible amount of stress on any part of the specimen. It is useful to envision the rubber being pulled away from the mold. Where is the greatest stress going to be? What are the thinnest or most fragile areas? Try to work so that these areas are protected. An attempt should be made to divide the specimen as evenly as possible. One example is a limb bone such as a femur: this is usually divided lengthwise, in effect drawing an imaginary line all around the long and short sides of the bone.

Often there are projections such as pterygoids. Decisions then need to be made about the possibilities of additional mold parts, of filling, or of shimming.

Usually seam lines are placed in a way that is as unobtrusive as possible and so as to cover the least amount of information. Therefore, seam lines almost never cut across teeth, and interference with sutures and foramina should be avoided. A good place to put a seam is at the edge of an existing break, or along a natural edge in the bone: for example, along the top or bottom of a zygomatic arch. Remember when placing seam lines that there will be one or more additional sections of the same mold. Some sections may need to be angled in a way that allows the other parts to be easily worked.

Some thought should be given as well to casting while designing the mold. Although consideration of the specimen is most important, it must also be possible to use the mold to make a good cast. Some areas, if very thin, may be difficult to fill with casting material. Other areas may be difficult to reach if they are deeply recessed in the mold. Mold design can help to alleviate some of these problems.

2. Assuming that you have cleaned and filled the specimen, the next step is to set it up in clay. Find a clean, flat piece of wood that is at

least 6-8" bigger than your specimen. Cover with clean paper. This piece of wood makes a good, sturdy base for your work, and allows you to turn the work around as needed. Clean, sulfur-free clay (silicone rubbers react with sulfur, inhibiting cure) can be softened with a heat lamp and rolled out to the approximate depth of one-half of the specimen. An easy way to maintain an even thickness of clay is to roll the clay out between two sticks of the same depth. These sticks will keep the roller the same height all of the way across the clay. If the specimen is large, pieces of wood can be used to raise the clay bed to the desired height. The clay bed should be large enough on all sides to allow room for locks, walls and with about 1/2” to 3/4” for the edge of the jacket. In general, about 2”-3” should be left all around the specimen.

3. Imagine the specimen as dropped in to the clay bed up to the seam line. The specimen can be laid on the clay bed and a line drawn with a point into the clay, marking the edges of the specimen. A hole can be cut out along that line and the specimen laid into the clay bed. Small bits of clay can be used to prop up the specimen where needed, so that the edge of the clay bed is approximately even with the seam line. Since skulls and other bones are not squares, it is really unlikely that the flat clay bed will agree completely with the seam line. Use soft clay to build up the bed where necessary or cut away the clay bed if the seam line dips lower. More clay is used to fill in the clay bed right up to the specimen. The clay should meet the seam line at as nearly a 90° angle as possible. Again, skulls and bones are not squares. It will not be possible to make the seam line meet the bone at a 90° angle, just be as close as possible. This will help the parts of the mold to meet evenly.

4. The clay should fit tightly and smoothly all along the seam line. No small holes should be left for rubber to seep through. Here it is very important to make the surface of the clay smooth, particularly at the point where the clay meets the specimen. There will be another part of the mold fitting right up against this part. Seemingly small indentations and lumps can interfere with the fit of the two parts when casting.

5. Make sure no excess clay is on the surface of the specimen. It is useful to work at this point under a microscope, using small needles to

clean away undesired clay. Any excess clay that is not removed will become part of the final cast, hiding or disguising information. Use alcohol and a fine brush for a final cleaning and smoothing.

6. A lock is now made around the specimen. This insures that the parts of the mold will fit together well and prevents the soft rubber mold from misaligning when cast. One good way to create the lock is to roll out a rod of clay approximately 1/4" in diameter, long enough to go all of the way around the specimen. Cut it in half lengthwise with an X-acto blade, and press it onto the clay bed about 1/8" to 1/4" away from the specimen on all sides. A looped clay tool can also be used to cut a trough into the clay bed. The lock should be fairly smooth and free of undercuts.

7. A wall is made and erected about 1/8" to 1/4" away from the lock. This determines the size of the mold. The wall can be made by rolling out a layer of clay to about 1/8" thick and cutting it into a long rectangle. The top of the wall should be about 1/4" to 1/2" higher than the topmost point on the specimen. Several pieces can be joined together to completely enclose the specimen. This wall must be well pressed down into the clay bed, to prevent seepage of the liquid rubber.

8. The specimen can now be coated with talc as an additional separator. The talc is liberally applied with a soft brush, and almost all blown and brushed away. To repeat: if you can see the talc, there is too much on the specimen.

9. These molds are almost always made in silicone, mixed according to manufacturers' instructions. There are various types of silicone rubbers, make sure yours has a long enough set time to allow for deairing and a slow pour.

After mixing the rubber should be deaired to prevent the inclusion of air bubbles in the mold. The cup holding the liquid rubber is placed inside a vacuum chamber and all air drawn off. This will cause the material to rise. Make sure there is enough room in the cup for the material to expand to 2-3 times its original volume. After the air is removed, the material will drop back to its original size and continue to bubble. It should be allowed to bubble for approximately 5-7 minutes, for all air to be eliminated. Allow the air to return slowly to the vacuum chamber and remove the cup. (An alternative to using a vacuum chamber is to use a painters "pressure pot" to put the material under pressure and so remove all air from the rubber.)

10. The rubber is slowly poured into the mold from one corner in a small stream. The pouring should start in an area where there is no bone and the rubber be allowed to slowly move by itself over the specimen. It is important that the silicone not be poured in so fast that air cannot escape from between teeth and from small recesses. If there is an area where you are not sure the rubber has penetrated, the rubber can be gently pulled back with a brush or needle to allow air holes to fill. Allow the rubber to set.

11. After the rubber is set, this portion of the mold should be jacketed. The jacket holds the soft rubber firmly, allowing the parts to be fit together tightly. Usually the top edge of the set rubber is cut away at about a 45° angle with a sharp X-acto blade. This helps the jacket to release more easily from the mold. Notches can also be cut into the rubber at this time to help the jacket align better. See Jacketing.

12. The second, and if necessary, additional parts of the mold are then made, using the first part as if it were the original clay bed. All clay is removed from the rubber that now encloses the specimen. Care should be taken to clean the area of the seam line very well, using small needles, and a brush and alcohol.

13. Silicone rubber will stick to itself. If the parts are not separated the rubber will form a solid mass, which will need to be cut away from the specimen. B-76 Butvar in acetone is a good separator, forming a thin barrier. Vaseline or green soap are also used, but care must be taken not apply too much, so the separator forms a thick layer. This will make the seam line thicker as well.

14. A wall is created as before, and placed at the edge where the rubber meets the plaster jacket. It must again be tightly sealed to the base to prevent seepage of the rubber. Sometimes the inner edge can be sealed with slightly thick B-76 Butvar. See step #7.

15. The specimen is then covered with talc as before. See step #8.

16. And the rubber mixed, deaired, and poured. See steps #9 and #10

17. The second half is then jacketed. See step #11 and Jacketing. See Demolding, Final cleaning, and Casting. Some molds may have to be demolded in certain directions to avoid putting stress on raised parts of the specimen. It is useful to note this in some way on the clay bed or on the jacket. It is very difficult to remember the exact shape of a bone under a layer of rubber.

Layered molds

The molds described above are best used for smaller or simpler specimens. For those specimens that are larger or are very complex shapes it is usually best to make a layered mold. These molds are made in either silicone rubber or in latex rubber. Silicone is used where replication of very fine detail is important, for example on the skull of a mammal. Latex in used where detail is not as important, as on the limb bones of large dinosaurs. Silicone picks up finer details, but is easier to tear, making it less practical for extremely large molds. Latex is very difficult to tear, in fact it may break some bones before tearing. An awareness of the differences of these materials, and of the different requirements for different specimens may make it easier to make a decision as to which material will be best in a given situation.

A Five - Layer Method for Silicone Molds

This method helps ensure a thin, even and strong mold wall while minimizing air bubbles. A thin walled mold is important in molding large or complex specimens as it allows for the flexibility necessary to make demolding easier and less dangerous to the specimen. Adjustments can be made to tailor-make a mold for a particular specimen, for example a very deep pocket can be covered thinly to make it possible to remove the mold or a large flat area can be covered more thickly to give the mold the necessary rigidity to hold its shape.

1. The set-up for a layered mold is the same as that for Two (or more) part poured molds. After filling holes and cracks with Carbowax, set the specimen up in a clay bed with the usual locks. A clay wall approximately 1/8” high is placed around the perimeter of the desired mold area, that is, where the rubber should end. This defines the edge of the mold as well as giving a guide for the finished thickness of the mold edge. The specimen and the clay are now “talced”, that is, talcum powder is brushed on with a soft brush and blown and brushed off. This thin layer of talc acts as a separator. The talc should be removed to the point where it is no longer visible, except as a thin layer when seen under the microscope - if you can see it there is too much powder left on the specimen.

2. Use a good, fairly thin viscosity silicone rubber that comes with a thixotropic agent. You will need both thin and thick types of rubber for thi

process. Some companies make two different thicknesses of silicone that can be mixed together to make a desired thickness, while others companie make an additive which when added to the rubber causes it to thicken. Mix according to manufacturer's directions. Do not use a silicone rubber thinner as this causes the rubber to tear more easily and to degrade more quickly.

3. Mix only a small amount of thin rubber - 10-20 grams of material will cover a good sized specimen. After mixing the rubber should be deaired to prevent the inclusion of air bubbles in the mold. The cup holding the liquid rubber is placed inside a vacuum chamber and all air drawn off. This will cause the material to rise. Make sure there is enough room in the cup for the material to expand to 2-3 times its original volume. After the air is removed, the material will drop back to its original size and continue to bubble. It should be allowed to bubble for approximately 5-7 minutes, for a air to be eliminated. Allow the air to return slowly to the vacuum chamber and remove the cup. (An alternative to using a vacuum chamber is to use painters "pressure pot" to put the material under pressure and so remove all air from the rubber.)

4. The first coat of rubber is brushed on extremely thinly using a small brush. This coat should be so thin that it is essentially see-through. The goal with this layer is to get the fine detail of the specimen, without trapping air bubbles. Do not allow material to puddle in cavities or low lying areas. Using the microscope, look over the entire specimen. Any small air bubbles can be broken at this point with a small stream of air or by pulling them open with a needle or brush tip. Allow to set, depending on weather and the age of the catalyst, approximately 4-6 hours. The next coat may be added the next day with no problems in adherence. While waiting for the rubber to set keep the mold away from dust. The brush is cleaned with either acetone or rubber cement thinner.

5. A second coat of thin rubber is applied in the same way as the first. This coat adds to the depth of the detail layer, but because the layers are very thin, no bubbles can be trapped under a thick layer of rubber.

6. The third layer is created using a mixture of rubber that is slightly thickened. This mix can be adjusted if additional thickness or thinness is needed. It is not necessary to evacuate any layer after the second. This coat is brushed on like layers 1 and 2. This third layer should start to even

the rubber over the specimen. Because of the thicker material, it will star to fill in some of the small undercuts on the specimen. This is important because the gauze used in layer 4 will not bend easily into very tiny crevices. It will also begin building up a little thickness around the edge of the mold. The layered rubber should no longer be so thin that the specime is seen clearly through the rubber. Even though some high points may still look thin, there will be no problem with the gauze showing through them int the cast. If desired, the rubber can be encouraged to stay on the high points by pulling it up with the brush as the material thickens.

7. The fourth layer is the reinforcing coat. The reinforcement helps th mold to retain its shape and to be very flexible without tearing. The reinforcement can be nylon stocking, or fiberglass, but we most often use a thin surgical gauze. Small pieces of gauze are cut, varying in size depending on the size of the specimen. Using thin rubber, first paint a small area with rubber and then with the brush tamp a small piece of gauze into the liquid. Extending this area tamp additional pieces of gauze, slightly overlapping each piece. The gauze should lay fairly flat. More silicone can be used to help soak each piece and help it to lie down. When the entire specimen is covered with gauze, the remainder of the rubber can be drizzled over the whole, to thoroughly impregnate this layer with rubber. I is important that the gauze be placed evenly and lay flat, there should be few lumps and no air pockets under the gauze (there may be a few strings from the gauze sticking up - these can be cut off when this layer has set). It is possible to smooth the gauze with a spatula as it thickens.

8. The fifth and usually the final layer is again a slightly thicker mixture The specimen should by now be covered evenly with a layer approximately 1/8” thick. The edge of the mold can be brought to the level of the outer 1/8” high wall. If there are especially thin sections on high points the silicone mixture can be adjusted or additional layers placed only in selected spots. This layer serves to smooth the entire surface, so that the jacket will release well. It is still important to watch that the mold does not become too thick or build up unevenly. A very thick section can cause difficulty and breakage during demolding. It is better to have a thin and even mold and make blocks to help the jacket lift.

9. On very complicated specimens the rubber may have to be pulled off in certain directions only. For example, if there is a large protruding shape which angles toward the front of the specimen. The rubber may have to b

pulled up from the back of the specimen toward the front in order to prevent breakage. Notes can be made or arrows drawn on the jacket to indicate this. It can be very difficult to remember these details after making several parts to a mold and having the specimen obscured by layer of rubber.

10. Layered molds are also usually multi-part molds. Where silicone meets silicone the parts are separated by a thin layer of Butvar B-76 and talc.

11. Because of the thinness of the walls of this type of mold a plaster jacket must be made. Blocks will probably be needed as the thin walls do not fill in most undercuts. See Block-making, Jacketing. See Demolding, Final cleaning, and Casting.

Latex molds

Latex molds are usually made of large specimens, where tiny details are nc as important. Latex is a natural rubber and shrinks somewhat on drying. There are various types of latex rubber. You will want a high solids, self-vulcanizing mold rubber, without ammonia.

1. The specimen is filled and set up as usual. It is sometimes good to spray the specimen with a mold release. Latex can be stored, tightly closed, in a wide mouthed jar.

2. Use a soft bristle brush. The brush will clean up more easily if you di it into dish detergent and dry it before beginning. Latex is painted on to the specimen in thin layers. Do not paint the latex too thickly. Latex, unlike silicone rubber, is air dried. Therefore, if the rubber is too thick it will dry unevenly. Start in one section of the specimen and paint fairly quickly. Do not brush back and forth, but rather in one direction. If you paint over the rubber as it starts to dry, you will pick up the rubber on you brush. Keep painting from wet areas into the unpainted parts of the specimen. Allow this layer to completely dry. Latex will change color as it dries, becoming more translucent. When the entire mold is the same translucent, creamy color, it is dry. This may take an hour or two. Drying can be speeded by using a fan. Do not use heat, this can cause the rubber to shrink dramatically.

Clean the brush with soapy water. Latex will probably build up in the brush It can be removed with a wire brush. For larger brushes make a cleaning device by driving a number of small nails through a board. Scrape the brus through the nails to clean.

3. Latex will be built up in layers. About 10 - 12 layers are needed for a medium sized mold and up to 20 for a really large specimen. Make the brush strokes on succeeding layers in different directions. This will allow an even build up of rubber. Allow each layer to completely dry before proceeding to the next.

It is a good idea to make a test strip on a scrap of board. The test strip can be peeled up to test the thickness of the rubber. Keep track of the number of layers.

4. After about layer #7, you will need to add a layer of gauze. This can be thin surgical gauze or even nylon stocking. Cut it into convenient strips Paint on a layer of latex, and tamp the gauze into it. Use more latex to thoroughly impregnate the gauze with rubber.

5. Deep undercuts in the mold can be filled by stuffing them very tightl with cotton. Make a patch of gauze with latex over the filling to keep the cotton in place. This should be done at about layer 9 or 10. You can also use blocks for deep undercuts. Ground rubber can also be mixed into the latex to fill small undercuts.

6. Latex molds will always need a jacket. For very large molds, you can make a fiberglass jacket. DO NOT USE VASELINE AS A SEPARATOR. Petroleum deteriorates latex rubber - it will become a nasty, sticky mess. You can use green soap. put on a layer and let it dry. Or you can use a vegetable-based cooking grease like Crisco.

Jacketing

Jackets for one part molds

Jackets or mother molds are used to help support the soft rubber of the mold. They are usually made of plaster, although very large jackets are sometimes made of fiberglass.

1. On simple, one part molds with straight walls, jacketing is simple. After the rubber has set, remove the clay walls. Cut the edge of the rubber to about a 45° angle with a sharp X-acto blade. This will help the jacket to release better from the mold. If the mold has a very symmetrica shape notches can be cut into the rubber to help the jacket to align well. Except for about 1/2 " - 5/8" (depending on the size of the specimen, mor space is needed for larger jackets) cut away the clay bed which extends away from the mold. Smooth the clay bed. Use Vaseline as a separator, applying a good, but fairly thin coat to the entire surface.

2. Plaster is made, usually in a rubber bowl, by adding plaster to water. The amount of plaster you will need is dependent on the size of the mold. Fill the rubber bowl to no more than 1/2 full of water. Add plaster to the water slowly, sifting it in all around the bowl until it begins to make islands. That is until the plaster has filled the water to just above the surface.

3. Allow the plaster to sit for a minute for the plaster to become fully soaked with water. Stir the plaster into the water. The mix should be fairly thick, about like sour cream or yogurt. More plaster can be added if the mix is too thin. Do not over mix plaster, this can affect the hardening

4. Using an artists' spatula, apply the plaster to the mold. Make sure the plaster fills in the corners of the mold, without large air bubbles. Depending on the type of plaster and its thickness, some speed may be necessary. Plaster will get thicker as it hardens. This can be a useful feature, and allows you to control its shape. As the plaster thickens, appl more on top of the mold where needed. The plaster should be shaped to cover all of the rubber at least approximately 1/4" deep, deeper where necessary. You can always make more plaster if needed. The plaster may be smoothed with the spatula and sometimes with a little water and the hand. Smoothing the surface of the jacket is mainly esthetic, but it does make the mold nicer to hold when casting.

5. Plaster creates a small amount of heat as a part of the chemical reaction involved in setting. This will take approximately 30 to 45 minutes Allow the plaster to heat and to cool before trying to lift off the jacket. Lift the jacket just slightly while the plaster is still damp, and then place it back on the mold to dry completely. The jacket should lift off fairly easily. If you feel the jacket catching on the mold, don't try to force it, you may break the specimen. It is far better to chop apart the jacket and make a new one than to risk breaking the specimen. If there are deep undercuts i the rubber, see below for Block making.

Jackets for multi-part molds

More complex, multi-part molds require more complex, multi-part jackets. Jackets help in the alignment of multi-part molds, ensuring a tight fit of al of the parts and a thin seam line.

The main difference between jackets for one piece and for multi-part mold is the necessity for the inclusion of a lock in the jacket. This can be a raised lock, such as that in the mold, or simply a notch cut into the cleane smoothed clay bed. You can use your finger or the round end of a large brush to make a number of divots into the clay bed. These will be the lock for the jacket. These locks will make all the pieces fit well together withou sliding. They should not have undercuts that can lock the two parts of the jacket together.

The first part of the jacket is made, after the first part of the mold has set, in the same manner as for a one part mold. After that the jacket is treated as if it were a replacement for the clay bed. Each succeeding part of the jacket is made up against the previous part. Lift each part of the jacket slightly as you proceed to ensure that it will release easily when the jacket is finished.

The walls of the parts may have to be angled, so that the pieces do not loc against each other, making it difficult to pull apart the parts of the mold. This requires picturing how the future parts of the mold will fit together.

Multi-part molds often have undercuts. See Blockmaking.

Block making

Molds made for complex shapes may have deep undercuts or crevasses, even after the rubber has been applied. These complicated molds may require making blocks to fill in undercuts that might cause the jacket to be difficult to remove. A block, usually made of plaster, is used to fill in undercuts with small removable pieces which make the surface less irregular.

1. A good way to judge if blocks will be needed is to look straight down on the mold from above. This is the way that the jacket will be lifted off. Try to picture the jacket being lifted straight off the mold and notice if there are recesses on which the jacket may catch. Those are the undercuts that you will need to fill.

2. Blocks are made in a similar manner to the jacket. Vaseline is applie to the rubber and slightly thick plaster spatulated into the undercut.

3. The surface of the block must be made smooth, to prevent catching of the jacket. This can be done with the spatula or after the block has hardened, by sanding.

4. Sometimes several blocks may be needed to fill very complex undercuts. They must fit snugly against each other and yet not lock each other in. Blocks need to be separated from each other with Vaseline.

5. After the plaster has hardened, try to remove each block. If it is very difficult, chop the block out and redo it. This is always better than damaging the specimen.

6. After you have made all the blocks needed, the jacket may be prepared as usual. Make sure a good coat of Vaseline covers all of the blocks. Plaster will tend to stick to itself.

Other materials may also be used. Foam rubber, silicone rubber, latex rubber mixed with vermiculite, these are only a few. The material used matters less than supporting the mold, and enabling easy removal of the jacket.

Demolding

Demolding the specimen is the scariest part of moldmaking. This is the time when it is possible to break the specimen. Great care must be taken at this stage.

Demolding a one part mold

1. After the rubber has set, jacket the specimen if necessary. After the jacket is dry, gently remove the jacket. Wipe off any remaining Vaseline or separator. In a clean area gather together: a small spatula, alcohol, a fine brush and a box for the specimen. Working slowly around th entire edge, use the spatula to gently pry up just the very edge of the rubber. Just loosen the edge at first.

2. Proceeding around the mold, continue lifting. As the mold begins to lift, you can work your fingers under the rubber to lift it away from the specimen. It is important to remember that you want to pull the rubber away from the specimen equally in all directions to avoid putting stress on any one spot. This is particularly true in thin areas. The rubber should be lifted up from both sides.

Some molds may have to be demolded only in certain directions to avoid putting stress on raised parts of the specimen. It is useful to note this in some way on the clay bed or on the jacket. It is very difficult to remembe the exact shape of a bone under a layer of rubber.

3. If the rubber seems to want to stick to the specimen, apply a little alcohol with the brush to the edges of the rubber where it is in contact wit the mold. Working under the microscope can help you to see how the rubber is lifting.

4. Continue gently lifting the rubber from the specimen. If you work slowly and in a quiet place you can feel how the rubber is lifting away from the specimen. If it sticks, try the alcohol, but do not force it. That can break the specimen. If the rubber is sticking in one place, try working fror another direction. Sometimes the rubber will pull off better in one direction.

5. In general, the idea is to loosen the rubber from the specimen, and allow it to pop off. Small specimens can be loosened and the rubber pulled down slightly to allow the specimen to push itself out of the mold.

6. Check the mold for air bubbles and for any broken pieces of the specimen. Check the specimen for breaks and return it to its box.

<u>Demolding two (or more) part molds</u>

This is similar to demolding one part molds. Demold one part at a time, allowing the other parts to remain supported by the jacket until you are ready to demold them. Sometimes multi-part molds will need to be demolded in a certain order. This can be noted on the jacket.

<u>If it breaks</u>

If the specimen breaks, don't panic. This is why glue was invented. Some breaks can be glued together with Acryloid B72 or Butvar B76 in the mold. The adhesive will not stick to the mold. Otherwise, carefully remove all pieces and place them in a clean box. Remove all of the specimen from the mold. Carefully look over the specimen for any other breaks or loose pieces. Reassemble any breaks without glue first, it is sometimes necessary to put one piece back first before others can be joined. Also some pieces may fit in a way that blocks others. By fitting the pieces together dry you can decide how to proceed. Use thick Butvar or B-72 Acryloid as a glue. You want a glue that is easily removable in case pieces need to be moved.

<u>Final Cleaning</u>

Specimens that have been molded should be as clean or cleaner than they were originally. After the specimen has been safely removed from the jacket, it is important to clean it right away before returning it to the collection. Acryloid or Butvar can be removed with alcohol or acetone. Cla and wax must be gently removed with a needle, and cleaned with a brush and either alcohol or acetone. Carbowax dissolves in water. Remove as much as possible first with a needle, and use a brush with water to remove the remainder. For specimens in water soluble matrix, use alcohol to remove the Carbowax.

Make sure the number and any other pertinent information is in place on the specimen.

Casting in plaster

Plaster is easier to cast than polyester resin, but will not have the quality of detail that a resin can capture. In addition, plaster will be opaque. Most bone is slightly translucent. It is difficult to color plaster before mixing. I is better to have white cast and paint it in the desired manner later. Before painting a plaster cast, put two or three thin coats of Butvar on th cast and allow it to completely dry. This will keep the paint from soaking into the cast.

1. After the mold is finished, the jacket made, and the specimen removed and cleaned, the mold should be well cleaned with alcohol, using a clean lint free rag. The cleaning removes any traces of separator and any dirt left from the specimen. The mold should then be left for 1-2 days for the rubber to completely cure. If you are casting into a silicone mold no special mold preparation is necessary. If you are casting into a latex mold spray the mold with mold release.

2. Plaster is made, usually in a rubber bowl, by adding plaster to water. The amount of plaster you will need is dependent on the size of the mold. Fill the rubber bowl to no more than 1/2 full of water. Add plaster to the water slowly, sifting it in all around the bowl until it begins to make islands. That is, until the plaster has filled the water to just above the surface.

3. Allow the plaster to sit for a minute for the plaster to become fully soaked with water. Stir the plaster into the water. The mix should not be too thick, about like melted ice cream. More plaster can be added if the mix is too thin. Do not over mix plaster, this can affect the hardening.

4. Paint a thin layer of plaster into the mold. Use a small brush and make sure not to trap air bubbles under the plaster. Shake or bang the mold to release more air bubbles. Add more plaster on top of the first layer while it is still wet, to make a layer approximately 1/16" thick. Clean the edges of the mold. Let this layer harden.

5. After the first layer has hardened, add another layer to make the cast to the desired thickness. You can make the cast solid, if you choose not to make a solid cast the walls of the cast should be thick enough to be sturdy. You can use burlap to strengthen a plaster cast.

6. After the plaster has completely dried, remove the cast from the mold. Clean the mold with water. Clean up of a plaster cast is easy. Use sandpaper or an X-acto knife.

Casting in polyester resin

Many molds are cast in polyester resin. Polyester resin is the same material used in making fiberglass boats. It is quite strong and can be adapted for many uses. It can be colored with powdered pigments, oil pain or resin colors to almost any color, making it very useful for reproducing fossils. Other materials such as talc, Cab-O-Sil, matting agents, wood pulp sand, in fact, almost any dry material can also be added, extending the range of effects that can be achieved.

A neutral, medium grey is the most commonly used color here for making scientific research casts. This color shows the detail well and photograph well also.

Casts can be colored any other bonelike color for display purposes. Casts for display are usually painted as to resemble the real object as closely as possible, in order to give the viewer a feeling for the real object.

1. After the mold is finished, the jacket made, and the specimen removed and cleaned, the mold should be well cleaned with alcohol, using a clean lint-free rag. The cleaning removes any traces of separator and any dirt left from the specimen. The mold should then be left for 1-2 days for the rubber to completely cure.

2. Colors can be mixed at any time before casting. If you are making a display cast generally mix the color to match the lightest color in the foss that you are reproducing. The ratio of color to resin should be no more than 5%. While sometimes you can get away with a little more color too much color interferes with the setting of the resin. Generally, all colors w have some talc or other thickener mixed in as well. This can affect the color. The thickener can be added when the color is mixed and the mix catalyzed later. Catalyze to the original weight, not the weight that includes the thickener.

3. POLYESTER RESIN AND THE CATALYST ARE NOXIOUS MATERIALS. Always work in the fume hood and wear rubber gloves and an apron. Be careful of breathing the dust from hardened resin and also of breathing in the talc or Cab-O-Sil powders. Polyester can be stored in a tightly closed

glass or nalgene jar and kept in a flammable liquid storage cabinet. Keep the catalyst separate.

4. In the fume hood lay the open mold and gather together: tongue depressors for mixing, rubber gloves and apron, clean paper cups, brushes a spatula, a scale, the premixed polyester and the catalyst. You will want to have talc or Cab-O-Sil on hand for thickening the resin.

5. If you are casting into a silicone mold no special mold preparation is necessary. If you are casting into a latex mold spray the mold with mold release.

6. In a clean cup, measure a quantity of resin sufficient for one thin coat of the inside of your mold. Add enough talc or other thickener to make the resin about as thick as melted ice cream. The idea is that the resin will be thick enough to stay up on the sides of the mold, yet not so thick as to make blobs.

The resin for most large molds will be painted on in layers, allowing one layer to gel before proceeding with the next. In some smaller molds one layer may be enough to fill the entire mold. But be aware, polyester resin shrinks and shrinks more if it becomes hot. Polyester resin creates heat during the chemical reaction which makes it set. If the material is too thic the heat generated can cause the cast to shrink, or in extreme cases can cause the cast to crack. Therefore, resin should as a rule not be more then 1/4 -1/2" thick for each layer.

Remember that you can always make more.

7. Add the catalyst to the resin. The ratio is 2-3% of catalyst to resin That is, if you make 100 grams of resin you will add 2-3 grams of catalyst for 10 grams of resin you will add .2-.3 grams of catalyst. Mix catalyst into resin well. The catalyst is colorless and as you are adding quite small amounts, mixing well becomes important. Mixing in a pattern is the easies scraping the sides and the corners of the cup well.

8. Using a brush of the appropriate size, paint a thin layer of mixed material into the mold. Make sure to paint it in thinly, do not allow large blobs of material to gather in corners. This can cause air bubbles on the

finished cast. Use a spatula to clean the edges of the mold. You will need to keep the edges of the mold very clean until the final layer.

Clean the brush and the spatula with acetone. Keep the cup in the hood unt the resin has completely hardened.

Allow this layer to gel. This will take about 20-30 minutes, or up to an hour, depending on the catalyst, it's age, and the weather.

Resin, like plaster, thickens as it sets. You will have 10 - 15 minutes in which to work. Some very large molds may require 2 or more mixings of resin. Remember that you can always make more.

9. A second layer is applied in the same way and allowed to gel.

10. The third layer should be thickened with talc, Cab-O-Sil, or some othe dry thickener and again painted in. The edges should be cleaned after each layer.

11. The number of layers needed depends on the size of the mold. Very large molds need the addition of fiberglass strand or mat for extra strength. The additional layers should build up the walls of the cast, especially on the edges.

Fiberglass is added in the following manner. Paint a layer of fairly thin polyester into the mold. Add the fiberglass, and using more polyester quickly tamp down the fiberglass with a brush to thoroughly impregnate th fiber with resin. You can use more resin to smooth the fiberglass. Make the mixture about 2%, so that it is slower to gel.

12. If you are making a one piece mold the mold can be finished wheneve the layers are built up to a sturdy thickness, approximately 1/8"

If you are making a multi-piece mold, when the walls of the cast have been built up to an appropriate thickness, it is time to close the mold. Using a slightly thickened mixture paint the entire inside of the mold as well as ove the edges about 1/8". Put good bead of resin all around the edges of the mold. This will glue together the seams. Put the parts of the mold together and band tightly with rubber bands.

13. Allow the mold to set at least overnight for the resin to completely cure. Polyester resin doesn't completely cure on the side that is against the mold. This can result in a shiny appearance in the cast. A more complete cure can be achieved by further drying the mold in the oven at a very low heat for about an hour. This can be important for research casts where a completely matte appearance is desired.

14. Open the mold and remove the finished cast. Seam lines can be removed with an X-acto, or with sandpaper. Seams lines are not usually completely removed on research casts, so as not to disguise any information.

Step	<u>**Moldmaking Checklist**</u>
1.	Get written permssion from the lending institution to mold the specimen. Document all materials used and all changes to the specimen. Carefully look at the specimen. Clean and, if needed, prep the specimen.
2.	Coat the specimen with a thin but complete layer of a consolidant. Two coats of 2-3% B-76 Butvar in acetone are good.
3.	Fill small holes with Carbowax and large holes with dampened tissue sealed with Carbowax. Holes should be filled to just below the level of the bone. Clean the Carbowax with acetone.
4.	Decide where the seam lines will occur.
5.	Set the specimen up in clay on a clean, flat piece of wood that is at least 6-8" bigger than your specimen, covered with clean paper. Soften clay with a heat lamp and roll out between two sticks to the approximate depth of one-half of the specimen. Make clay bed large enough to leave about 2”-3” all around the specimen.
6.	Lay the specimen on the clay bed and draw a line with a point into the clay, marking the edges of the specimen. Cut hole out along that line. Drop the specimen in to the clay bed up to the seam line. Use small bits of clay to prop up the specimen where needed, so that the edge of the clay bed is approximately even with the seam line. Use soft clay to build up the bed where necessary or cut away the clay bed if the seam line dips lower. More clay is used to fill in the clay bed right up to the specimen.
7.	Smooth the entire surface of the clay, especially along the seam line. No small holes should be left for rubber to seep through. Under the microscope smooth clay right at the seam line.
8.	Use alcohol and a fine brush for a final cleaning and smoothing.
9.	Roll out a rod of clay approximately 1/4” in diameter, long enough to go all of the way around the specimen to make a lock. Cut it in half lengthwise with an X-acto blade, and

	press it onto the clay bed about 1/8” to 1/4” away from the specimen on all sides. The lock should be fairly smooth and free of undercuts.
10.	Erect a wall about 1/8” to 1/4” away from the lock. Make the wall by rolling out a layer of clay to about 1/8” thick and cutting it into a long rectangle. The top of the wall should be about 1/4” to 1/2” higher than the topmost point on the specimen. This wall must be well pressed down into the clay bed, to prevent seepage of the liquid rubber. Use extra clay if needed to securely seal wall to clay bed.
11.	Apply talc. Coat the specimen liberally and blow and brush away the excess. If you can see the talc, there is too much on the specimen.
12.	Mix the rubber. Compare the size of the cup to the size of the set-up specimen and determine the amount of rubber needed. Using the scale, pour out the base into the cup and add the catalyst at a 10:1 ratio. Mix very well, scraping sides of the cup. Deair the rubber in the vacuum chamber. The rubber will rise and fall. Allow the rubber to bubble for about 5 minutes more.
13.	Pour the rubber slowly into the mold from one corner in a small stream. The pouring should start in an area where there is no bone and the rubber be allowed to slowly move by itself over the specimen. Allow the rubber to set.
14.	Jacket side 1 of the mold. After the rubber has set, remove the clay walls. Cut the edge of the rubber to about a 45° angle with a sharp X-acto blade. If the mold has a very symmetrical shape notches can be cut into the rubber to help the jacket to align well. Cut away the clay which extends away from the rubber, except for about 1/2 " - 5/8". Smooth the clay bed. Make several divots into the clay bed as locks for the jacket. Use Vaseline as a separator.
15.	Make plaster in a rubber bowl by adding plaster to water. The amount of plaster you will need is dependent on the size of the mold. Fill the rubber bowl to no more than 1/2 full of water. Add plaster to the water slowly until the plaster has filled the water to just above the surface.
16.	Allow the plaster to sit for a minute for the plaster to

	become fully soaked with water. Stir the plaster into the water. Plaster should be slightly thick, about like yogurt.
17.	Apply the plaster to the mold. Smooth the plaster with a spatula and sometimes with a little water and your hand.
18.	Allow the plaster to heat and to cool before trying to lift off the jacket. The jacket should lift off fairly easily.
19.	The second, and if necessary, additional parts of the mold are then made, using the first part as if it were the original clay bed. All clay is removed from the rubber that now encloses the specimen. Care should be taken to clean the area of the seam line very well, using small needles, and a brush and alcohol.
20.	Silicone rubber will stick to itself. Brush B-76 Butvar or B-72 in acetone onto rubber edge as a separator.
21.	A wall is created as before, and placed at the edge where the rubber meets the plaster jacket. It must again be tightly sealed to the base to prevent seepage of the rubber. Use extra clay to securely seal wall to plaster.
22.	The specimen is then covered with talc as before.
23.	The rubber is mixed, deaired, and poured.
24.	The second half is then jacketed.
25.	After the plaster has set, demold the specimen. Open the jacket carefully, removing only one side of the jacket. Using the "golf club" tool work open outside edge of rubber. Proceed around the specimen opening the rubber gently. Use your fingers to lift rubber away from specimen. Alcohol can help release the mold.
26.	Remove 2nd side of mold from jacket. Pull rubber gently away from specimen. Don't pull specimen from mold, allow the specimen to pop free of the mold on its own.
27.	Clean mold with alcohol. Remove Carbowax from specimen and clean specimen with alcohol. Check to make sure all numbers and info are on specimen. Return molds to lending institution after casts are made.